EAGLE GOLD PROJECT

HEAP LEACH AND PROCESS FACILITIES PLAN

Version 2017-01

DECEMBER 2017

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DOCUMENT CONTROL

Submission History

Version Number	Version Date	Document Description and Revisions Made
2014-01	Aug 2014	Original submission submitted August 2014 to the Department of Energy, Mines and Resources in support of an application for a Quartz Mining Licence and to the Yukon Water Board in support of an application for a Type A Water Use License for the full Construction, Operation and Closure of the Project.
2017-01	Dec 2017	Revisions made to reflect the current site general arrangement and submitted to the Department of Energy, Mines and Resources and the Yukon Water Board in advance of Heap Leach Facility construction.

Version 2017-01 of the Heap Leach and Process Facilities Management Plan (the Plan) for the Eagle Project has been revised in November 2017 to update Version 2014-01 submitted in August 2014. The table below is intended to identify modifications to the Plan and provide the rationale for such modifications

Version 2017-01 Revisions

Section	Revision/Rationale
1.1 Overview	▪ Updated Project overview to better describe the facilities based on the optimizations required to comply with license conditions.
1.2 Concordance Tables	▪ Updated cross references to sections of the Heap Leach and Process Facilities Plan and other relevant material. ▪ Inclusion of tables of concordance for the Type A Water Use Licence QZ14-041 and the Quartz Mining License QML-0011.
2.1 Permitting Considerations	▪ Replacement of text reference generic regulatory and permitting requirements with Project specific requirements imposed by QZ14-041 and QML-0011.
2.2 Design Requirements	▪ Minor test revisions to clarify the standards considered at all stages of design.
2.3 Design Basis	▪ Updated reference to the new Canadian Dam Association Guidelines and the Application of Dam Safety to Mining Dams Technical Bulletin. ▪ Text revisions to describe the results of the updated dam breach analysis undertaken to provide input into evaluating the embankment hazard classification.
2.4 Design Criteria	▪ Updated references to sections within the plan and appendices to the plan.
Table 2.4-1 HLF Design Criteria - Ore Quantities	▪ Revisions to ore quantities and stacking rate to account for optimizations required to comply with licence conditions. ▪ Removal of rows erroneously included in the previous plan version as they were not ore quantity considerations. ▪ Updates to dry density of ore based on the results of additional test work.

Section	Revision/Rationale
Table 2.4-2 HLF Design Criteria - Leaching	▪ Update of text to specify designed application rate and planned rate based on the results of additional test work. ▪ Update of text to specify designed leach cycle time and planned leach cycle time based on the results of additional test work.
Table 2.4-3 HLF Design Criteria - Geotechnical	▪ Inclusion of license criteria requiring removal and management of ice rich material.
Table 2.4-4 HLF Design Criteria - Hydrology and Storage	▪ Revision of text to specify that the overflow spillway has been sized to pass the PMF peak flow as required by licence conditions. ▪ Revision of text to specify that the Events Pond spillway is sized for routed PMF peak flow. ▪ Revision of text to specify that the Events Pond storage capacity has been increased to contain the full runoff volume from a PMF event.
Table 2.4-5 HLF Design Criteria - Liner	▪ Re-arrangement of table rows and minor text revisions to improve readability.
Table 2.4-6 HLF Design Criteria - Process Plant	▪ Updated text to describe refinement of process plant equipment.
3.1 Foundation Conditions	▪ Updated references to reports describing foundation conditions.
3.1.1 Subsurface Conditions	▪ Revisions of text describing subsurface conditions as glacial till and placer tailings are not found within the optimized HLF footprint.
3.1.1.1 Overburden	▪ Revisions of text describing subsurface conditions as placer tailings are not found within the optimized HLF footprint.
3.1.1.2 Bedrock	▪ Revisions of text to describe the bedrock conditions within the optimized HLF embankment and Events Pond footprint.
3.1.1.3 Groundwater	▪ Updated text to clarify the number of groundwater monitoring wells in the HLF footprint in response to comments provided by Yukon Government in November 2017. ▪ Updated discussion of depth to groundwater within the optimized HLF footprint.
3.1.1.4 Permafrost	▪ Updated test to describe frozen ground observations. ▪ Inclusion of reference to the requirements for identifying and removing ice-rich materials that are provided in the HLF Foundation Improvement Plan.
3.2.1 Construction Staging	▪ Revisions of text to improve readability. ▪ Update to the year of operations for each phase of the HLF due to optimized HLF capacity. ▪ Updates to dry density of ore based on the results of additional test work.
3.2.2 HLF Foundation Preparation	▪ Inclusion of cross reference to the HLF Foundation Improvement Plan. ▪ Update of text to describe the preparation requirements for the embankment location due to the optimization of the HLF. ▪ Removal of deep dynamic compaction as a foundation preparation technique.

Section	Revision/Rationale
	▪ Rearrangement of section to improve readability.
Table 3.2-1 HLF Material and Construction Requirements	▪ Removal of deep dynamic compaction as a foundation preparation technique. ▪ Inclusion of additional detail with respect to fill types and specifications. ▪ Inclusion of additional detail with respect to final subgrade preparation.
3.2.3 Foundation Drainage	▪ Revisions to text to reference information available in other sections of the plan. ▪ Section renumbered due to removal of deep dynamic compaction section.
3.2.4 HLF Confining Embankment	▪ Revision of text to describe the optimized HLF confining embankment. ▪ Removal of discussion regarding fill types and configuration as material is presented elsewhere in the plan.
3.2.5 Liner System	▪ Revisions of text to improve readability.
3.2.6 Overline Drain Fill	▪ Revisions of text to clarify material sources. ▪ Revisions of text to improve readability.
3.3 Construction Quality Assurance / Quality Control	▪ Updated cross references to locations of additional QA/QC material.
3.4.1 Slope Stability	▪ Text revisions to describe the results of the updated slope stability analyzes undertaken on the optimized HLF. ▪ Revisions of text to reference the 2014 CDA guidance.
3.4.1.1 Phreatic Conditions	▪ Revisions of text to describe the phreatic conditions within the footprint of the optimized HLF. ▪ Removal of references to deep dynamic compaction as a foundation preparation technique.
3.4.1.2 Stability Analysis	▪ Inclusion of results for updated stability analyses.
3.4.1.3 Dynamic Deformation	▪ Inclusion of results for updated dynamic deformation analysis.
3.4.2 Settlement Assessment	▪ Inclusion of results for updated settlement analyses.
3.5 Construction Schedule	▪ Inclusion of updated construction schedule for the Project.
3.5.4 Water Management Features	▪ Removal of Dublin Gulch Diversion Channel. ▪ Revision of text to improve readability and to update schedule assumptions.
3.5.5 HLF Pad Liner	▪ Revision of text to improve readability and to update schedule assumptions.
3.5.6	▪ Revision of text to update schedule assumptions.

Section	Revision/Rationale
Confining Embankment	
3.6 Heap Leach Pad and Confining Embankment	▪ Revisions of text to describe the optimized HLF. ▪ Revisions of text to improve readability. ▪ Inclusion of discussion on updated input assumptions for the HLF water balance modelling based on additional test work.
3.7 Solution Storage Facilities	▪ Revisions of text to describe the storage facilities and capacity associated with the optimized HLF.
3.7.1 In-Heap Pond Spillway	▪ Revisions of text to indicate that the spillway has been optimized to convey the full PMF flow as required by license conditions and to explain the configuration of the spillway.
3.7.2 Events Pond	▪ Revisions of text to explain the iterative modelling and design process for the Events Pond storage capacity and to provide the capacity and configuration of the facility.
3.8.1 Liner System Design	▪ Revisions of text to improve readability. ▪ Removal of details as they have been provided in other sections of the plan.
3.8.2 Overliner Drain Fill	▪ Revisions of text to improve readability. ▪ Clarification of ODF requirements for different areas of the optimized HLF.
3.9.1 Solution Collection System	▪ Revisions of text to improve readability. ▪ Revisions of text to describe the pipe spacing and sump size based on the optimized HLF and updated analyses.
3.9.2 Leak Detection and Recovery Systems	▪ Revisions of text to improve readability. ▪ Update of Alert Levels based on the optimized HLF and inclusion of Alert Levels for specific fluid elevations.
3.9.3 Underdrain System	▪ Revisions of text to improve readability.
3.9.4 Closure Drain System	▪ Revisions of text to improve readability. ▪ Inclusion of additional details with respect to pipe sizing.
3.10 Solution Conveyance and Pumping Systems	▪ Revisions of text to improve readability. ▪ Minor text revisions to better describe project operations.
3.11.1 Ore Crushing and Delivery	▪ Revisions of text to describe optimized crushing and delivery arrangement and practices. ▪ Updates to gold recovery estimates for each ore type.
3.11.2 Heap Leach Pad Stacking	▪ Revisions of text to describe stacking plans and assumptions due to the optimized HLF and additional test work.
3.12 Surface Water Management	▪ Revisions of text to improve readability. ▪ Removal of reference to the Dublin Gulch Diversion Channel
3.13	▪ Revisions of text to improve readability.

Section	Revision/Rationale
Metal Recovery and Processing Facilities	▪ Update of the description of metals recovery process and facilities based on detailed engineering and removal of unnecessary detail. ▪ Inclusion of heap leach metal recovery detail.
3.14 Borrow Sources	▪ Updates to proposed borrow sources for HLF structures.
3.15 Access Management	▪ Updates to other referenced material.
4 Heap Leach Facilities Operation	▪ Removal of text that is provided in other sections of the plan. ▪ Update to the HLF schedule.
4.1.1 Heap Leach Facility Water Balance	▪ Inclusion of additional detail with respect to operational solution storage and management. ▪ Update of text to describe the results of the advanced HLF water balance modelling.
4.1.2 Drain Down	▪ Revisions of text to improve readability. ▪ Update of figures and discussion of drain down period based on the results of the advanced HLF water balance modelling and optimized HLF.
4.1.3 Integration with Site Water Balance Model	▪ Revisions of text to improve readability.
4.1.4 Emergency Management	▪ Updated discussion of water balance modelling results during extreme events based on the optimized HLF.
4.2 Operations, Maintenance and Surveillance Plan	▪ Inclusion of text to discuss the update requirements for the OMS under the Type A Water Use Licence.
4.3 Adaptive Management and Emergency Management	▪ Inclusion of reference to the HLF Contingency Water Management Plan. ▪ Revisions of emergency scenarios based on the updated Failure Modes Effects Assessment.
5.1 Temporary Shutdown	▪ Updates to temporary shutdown conditions considered in the design of the HLF and the ADR.
5.2.2 Closure Measures	▪ Revisions of text to improve readability and acknowledge requirements for meeting discharge criteria. ▪ Update to assumed timeline for drain down based. ▪ Refinement of discussion on passive water treatment processes and closure cover systems based on ongoing reclamation and closure planning.
Appendices	▪ Rearrangement of appendix order and removal of Review and Approval submission required by regulatory approvals to decouple approval process.

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1 INTRODUCTION

This Heap Leach and Process Facilities Plan (Plan) describes the construction, operation and shut-down of the heap leach facilities. The Plan provides details about the design of the heap leach facility (HLF) including relevant components, phases and processes. Designs include plans, cross-sections, long-sections, detailed figures, process charts, ore stacking sequencing and other pertinent figures that illustrate how the proposed facilities will be constructed and operated. The detailed design report and analyses are included as Appendix A.

1.1 OVERVIEW

The HLF, including the embankment, will occupy an area 106 ha and contain an estimated 86 MT at the end of the life of mine.

The HLF is a valley fill design which incorporates a confining embankment (dam) with a double-lined upstream dam face, that will provide physical stability to the base of the heap and the stacked ore and containment of process solution in the In-Heap Pond. The In-Heap Pond leaching configuration provides storage capacity of pregnant solution within the pore spaces of the ore which eliminates the need for downstream process solution ponds. The major design components for the HLF includes the following:

- an embankment (dam) and the In-Heap Pond;
- a composite liner system;
- a leak detection and recovery system (LDRS);
- solution recovery wells;
- associated piping network for solution collection and distribution; and
- a down-stream Events Pond.

The in-heap solution storage area will act as an In-Heap Pond for the primary storage of pregnant leach solution (PLS). The In-Heap Pond (essentially a saturated zone within the lower extent of the HLF ore pile) is a cold-weather mitigation and has the added benefit that PLS will not be exposed during normal operations. Under typical operating conditions there will be minimal pregnant leach solution within the in-heap pond sufficient to maintain adequate head for proper pump function.

The heap leach pad will consist of a liner system, with an up-gradient liner and the In-Heap Pond liner. The single composite liner system in the upper portion of the pad (above the in-heap solution storage area) will be comprised of a double-side textured 2.0-mm (80 mil) linear low-density, polyethylene (LLDPE) liner over a geosynthetic clay liner (GCL). The double composite liner system in the lower portion of the pad (forming the in-heap solution storage area) will be comprised of two LLDPE liners, separated by a layer of geonet material to form the LDRS, over a GCL liner.

Process (barren) solution will be applied to the ore via drip irrigation (buried during winter). The resultant PLS will be captured in the solution collection system and flow to the In-Heap Pond. The PLS will be recovered using pumps within standpipes located in the sump. The PLS is pumped to the ADR plant for gold recovery.

The heap leach pad consists of a network of pipes distributed throughout the pad to facilitate PLS flow to the sump.

The downstream Events Pond will serve as an overflow containment area that provides additional solution storage in case the In-Heap Pond capacity is exceeded.

1.2 CONCORDANCE TABLES

The following tables of concordance summarize how commitments applicable to the HLF and made by StrataGold during the environmental assessment and regulatory approvals processes have been addressed.

Table 1.2-1: Table of Concordance for April 2013 Yukon Government Decision Document Relevant to this Plan

No.	Terms and Conditions	Where Addressed
To ensure process leach solution leakage through the liner system in the upper portion of the Heap Leach Facility (HLF) can be monitored, captured and controlled:		
29	The Proponent shall implement quality assurance and quality control (QA/QC) programs during construction of the HLF and liner system. QA/QC records should be retained for third-party review.	See Section 3 of the Project Technical Specifications provided as an to the HLF Design Report (Appendix A of this Plan)
30	The Proponent shall have appropriately qualified personnel: (i) review design and oversee construction of the HLF and liner system; (ii) approve the final construction; and (iii) provide documentation to responsible regulators that the facility and liner system has been built in accordance with regulatory approvals.	See Section 1 of the Project Technical Specifications provided as an to the HLF Design Report (Appendix A of this Plan)
31	The Proponent shall ensure that seepage collected in the underdrain system reports to a point of control (e.g. lined sump) to allow the Proponent to monitor, collect, and manage seepage. Seepage shall be sampled and monitored prior to discharge to surface water.	See Section 3.9.3 of this Plan See the Environmental Monitoring and Adaptive Management Plan
32	The Proponent shall sample water collected from: the proposed Leak Detection Recovery System; the underdrain sump; and additional surface and ground monitoring locations as dictated in the HLF Operations and Maintenance System plan required as part of the Water Use Licence and Quartz Mining License application guidelines.	See Sections 4.2 and 4.3 of this Plan See Section 18 of the Environmental Monitoring and Adaptive Management Plan See Operation, Maintenance and Surveillance Manual
33	Prior to completion of the HLF liner system, the Proponent shall develop a plan satisfactory to responsible regulators that includes sampling frequency, reporting timelines, and response measures.	See Sections 4.2, 4.3 and 3.9.3 of this Plan See Section 18 of the Environmental Monitoring and Adaptive Management Plan
34	In conjunction with responsible regulators, the Proponent shall evaluate the construction, QA/QC reports, and performance of the Phase 1 HLF liner system prior to construction of the Phase 2 and 3 HLF liner systems. Should the actual performance of the Phase 1 HLF liner system not meet predicted performance, the Proponent shall, in conjunction with responsible regulators, review the Phase 2 and 3 HLF liner systems and if necessary, modify their design.	See Section 4.2 of this Plan See Operation, Maintenance and Surveillance Manual Condition of Type A WUL QZ14-041.
To ensure process leach solution leakage through the liner system in the event ponds is minimized:		
35	Unless otherwise demonstrated to the satisfaction of the responsible regulators that a different liner system will adequately mitigate adverse effects from uncontrolled discharge, the Proponent shall construct double	See Section 2.4.5 of this Plan

No.	Terms and Conditions	Where Addressed
	geomembrane liner systems for the event ponds which include leak detection and recovery systems and allow for independent monitoring of each pond.	See Section 18 of the Environmental Monitoring and Adaptive Management Plan
To reduce uncertainties associated with the water balance model as well as provide sufficient basis for future monitoring:		
37	The Proponent shall update the site WBM and Heap Leach Facility (HLF) WBM with updated stream flow and climatic input estimates based on additional data collected since the proposal was submitted. This information shall be provided to responsible regulators during the regulatory approval process.	See The Mines Group (2017) for the HLF WBM See Lorax (2017b) for the site WBM
38	The Proponent shall revise the site WBM and the HLF WBM to account for direct precipitation (i.e. rain and snow) and evaporation to model components (e.g. event ponds and HLF) and run scenarios using a shorter time-step (e.g. weekly or daily rather than monthly time-step). The Proponent shall update the water management plan to account for revised predictions.	See The Mines Group (2017) for the HLF WBM See Lorax (2017b) for the site WBM See the Water Management Plan
To ensure stability of the HLF:		
39	The Proponent shall ensure the HLF and embankment are designed to the Probable Maximum Flood for long-term stability.	See Section 2.4.4
40	The Proponent shall review the assumptions and confirm the appropriateness of the application of the proposed weir discharge coefficient of 3.0 for the HLF embankment spillway. The spillway shall be sized accordingly.	See Section 3.7.1 of this Plan
To ensure the HLF in-heap pond and the event ponds are sized appropriately to manage emergency or upset conditions:		
41	In conjunction with responsible regulators, the Proponent shall develop an adaptive management plan to compare the actual on-site conditions to predicted conditions. The plan shall outline requirements for: a) monitoring (e.g. frequency, documentation, review procedures), defined thresholds, and management responses; b) refining the HLF WBM, site WBM, and water management plan based on results from on-site monitoring as well as any changes to the mine plan and site infrastructure during operations; c) reviewing the HLF WBM, site WBM, and water management plan prior to (i) the Phase 2 expansion of the HLF and (ii) the Phase 3 expansion of the HLF; and d) follow-up monitoring of management responses.	See Section 4.2 and 4.3 of this Plan See Section 18 of the Environmental Monitoring and Adaptive Management Plan
42	The Proponent shall ensure that the area identified for an emergency event pond (i.e. down gradient from the two proposed event ponds and north of the Dublin Gulch Diversion Channel) remains available in case a temporary or permanent event pond is required in the future.	There is sufficient area downstream of the Events Pond to build a second pond of comparable size. Reserved area is shown on all Project figures.
43	The Proponent shall, prior to the regulatory approval process, conduct a sensitivity analysis to assess the effect of infiltration on the HLF in-heap pond and event ponds volumes. Pond volumes and sizes shall be reviewed based on the results of the sensitivity analysis.	See The Mines Group (2017) for the HLF WBM; the effect of infiltration as a variable is evaluated by deterministic and stochastic modeling
To ensure stability of the event ponds:		
44	The Proponent shall construct the event ponds with emergency overflow spillways which are able to safely convey the Inflow Design Flood predicted by the water balance model.	See Drawings EGHLF-XD-08-01 to EGHLF-XD-08-03 in Appendix A for the Events Pond design details. The spillway

No.	Terms and Conditions	Where Addressed
		design flow is based on the results of HEC-HMS modeling.
To mitigate significant adverse effects related to permafrost degradation on environmental quality:		
81	As proposed, the Proponent shall submit the consolidated results from its subsurface investigations in conjunction with their applications for a Quartz Mining License and Type A Water Use Licence.	See the following: Site Facilities Geotechnical Investigation Factual Report; prepared by BGC Engineering Inc., Vancouver, for Victoria Gold Corp March 5, 2010 (BGC, 2010). 2010 Geotechnical Investigation for Mine Site Infrastructure Factual Data Report; prepared by BGC Engineering Inc., for Victoria Gold Corp. November 17, 2011 (BGC 2011). 2011 Geotechnical Investigation for Mine Site Infrastructure Factual Data Report (BGC 2012a). 2011 Geotechnical Investigation for Mine Site Infrastructure Foundation Report. Final Report (BGC 2012b). 2012 Geotechnical Investigation for Mine Site Infrastructure Factual Data Report (BGC 2012e) Eagle Gold Project 2016 Heap Leach Facility Geotechnical Investigation, June 2017 (BGC 2017a)
82	The Proponent shall ensure sufficient storage is available for temporary containment, management, and thawing of excavated ice rich soils/permafrost.	See the Frozen Material Management Plan
To mitigate significant adverse effects related to terrain and HLF instability on environmental quality:		
83	The Proponent shall implement the mitigations outlined in Section 6.0 of Appendix 4 to the Supplementary Information Report (VIT 2012a including additional information on Appendix 4 in VIT 2012b) regarding the stability of the HLF and embankment including: a) removal of loose or unsuitable materials from the HLF area; b) excavation of foundation to bedrock in area of HLF confining embankment and the diversion embankment; and c) installation of geotechnical instrumentation within and below the HLF to monitor and verify that the facility components are performing as expected and to provide sufficient warning in the event of problematic conditions.	For a) and b), see Section 3.2 of this Plan For c), see Section 4.2 of this Plan, the HLF Foundation Improvement Plan and the Environmental Monitoring and Adaptive Management Plan
84	The Proponent shall identify and excavate ice rich soils/permafrost beneath the footprint of the HLF rather than use other methods to manage ice rich soils/permafrost (e.g. fill blankets as insulation).	See Section 3.2 of this Plan, the HLF Foundation Improvement Plan and the Frozen Materials Management Plan.
85	The Proponent shall ensure that additional agglomeration test work is completed on sample ore representative of final crushing/processing output prior to loading the HLF.	See Section 3.11.1 of this Plan Type A WUL QZ14-041 requires the submission of an Agglomeration Test Plan prior to loading ore onto the HLF.
86	The Proponent shall ensure long-term column tests are initiated to study the effects to stability and permeability of the HLF. Consideration should	See Section 4.2 and 4.3 of this Plan

No.	Terms and Conditions	Where Addressed
	be given to the migration of fines and the behaviour of saturated of ore in the in-heap pond.	Type A WUL QZ14-041 requires the submission of an Ore Stability Test Plan meeting the requirements of this condition prior to loading ore onto the HLF.
87	The Proponent shall ensure the HLF and permanent structures associated with the HLF are designed to withstand seismic ground motions from the maximum credible earthquake for long-term stability.	See Sections 2.4.3 and 3.4 of this Plan

Table 1.2-2: Table of Concordance for Project Commitments (made June 2011) Relevant to this Plan

No.	Proponent Commitments	Where Addressed
Surficial Geology, Terrain, and Soils		
1	VIT will complete geotechnical investigations as part of detailed mine planning during the permitting stage, prior to construction. Once exact locations for Project infrastructure have been identified, qualified professionals will carry out on-site terrain stability assessments in areas identified as having potential terrain stability issues.	2011 Geotechnical Investigation for Mine Site Infrastructure Factual Data Report (BGC 2012a). 2011 Geotechnical Investigation for Mine Site Infrastructure Foundation Report. Final Report (BGC 2012b). 2012 Geotechnical Investigation for Mine Site Infrastructure Factual Data Report (BGC 2012e) Geotechnical Design Ice-Rich Overburden Storage Area Berms (NELPCo 2013) Eagle Gold Project 2016 Heap Leach Facility Geotechnical Investigation, June 2017 (BGC 2017a)
2	VIT will establish a program to monitor permafrost conditions adjacent to cleared areas within the Project footprint once mine infrastructure is constructed. Downslope movement and soil moisture will be monitored. Monitoring frequency will be sufficient to assess the effects of freshet, large storm events, and other weather conditions that may affect terrain stability.	See Section 15 of the Environmental Monitoring and Adaptive Management Plan See Section 4 of the Water Management Plan See the Frozen Materials Management Plan
9	VIT will implement an Erosion and Sediment Control Plan for the footprint area during construction, operations and closure and reclamation (Environmental Management Plans – Appendix 30).	See Section 4 of the Water Management Plan See the Reclamation and Closure Plan
Water Quality and Aquatic Biota		
14	VIT will implement codified erosion prevention and sediment control practices and the Water Management Plan (Appendix 18) to prevent sediment release during construction (sediment control ponds).	See Section 4 of the Water Management Plan
16	VIT will construct and maintain diversion channels to keep non-contact water away from mine activities. These will be built with erosion protection measures and designed to convey large runoff volumes. Design criteria will be determined based on water license requirements.	See Sections 4 and 6 of the Water Management Plan
17	Sediment control ponds will be constructed and maintained to allow fine sediments to settle out. Permanent sediment control ponds will be sized for a 1:200 year 24-hour flood event and temporary sediment control ponds will be sized for a 1:100 year 24-hour flood event.	See Section 4 of the Water Management Plan

No.	Proponent Commitments	Where Addressed
Fish and Fish Habitat		
23	The following are commitments of particular importance to fish and fish habitat: a) During construction, inspection and monitoring of suspended sediments will be required within Project area watercourses to ensure sediment and erosion control measures have been implemented effectively and are functioning in accordance with regulatory requirements and commitments in the Erosion and Sediment Control Plan (Environmental Management Plans – Appendix 30). b) During operations and closure, monitoring will be conducted periodically to confirm that reclamation efforts and environmental protection measures, such as sediment and erosion control provisions, are properly maintained and functioning until no longer required. c) Once mitigation measures are no longer required, the VIT environmental manager will ensure that non-biodegradable materials are removed and disposed of in an appropriate manner. d) During operations and closure, water quality monitoring programs will comply with Metal Mining Effluent Regulations' requirements for effluent characterization and receiving environment conditions.	See Section 3.3 of this Plan; will be part of Construction Quality Assurance and Quality Control Plan See the Environmental Monitoring and Adaptive Management Plan See Sections 4 and 6 of the Water Management Plan
25	VIT will implement the following measures to control soil erosion and leaks from equipment into fish habitat: a) Minimize the extent of clearing, grubbing, and grading adjacent to watercourses to that required for safe vehicle access and construction activities b) Restrict vehicle and construction traffic in the vicinity of water courses to existing roads, and restrict crossing to existing bridges where possible, using appropriate temporary crossing methods where needed (e.g., temporary bridges) c) Flag environmentally sensitive areas before clearing and construction begins near watercourses d) Re-vegetate where soil stabilization and erosion control is required e) Protect stockpiles from erosion with tarps, sumps, or berms f) Stage the timing of activities for construction within 16 m of all watercourses and retain buffer zones until construction activities begin to limit time of bank and soil exposure g) Maintain 30 m riparian buffer between mine components (including temporary work spaces and stockpiles) and fish- bearing watercourses h) Implement a rigorous erosion and sediment control program including sediment and erosion control ponds sized to 1:100 year 24-hour flood event i) Monitor total suspended solids and turbidity levels from sediment control ponds prior to release j) Ensure industrial equipment operating near fish-bearing watercourses is in good working order and free of leaks.	See Section 3.3 of this Plan; will be part of Construction Quality Assurance and Quality Control Plan See the Environmental Monitoring and Adaptive Management Plan See Water Management Plan
Vegetation Resources		
31	VIT makes the following commitments to mitigate against invasive species: a) Vegetation communities adjacent to Project disturbance will be monitored throughout all Project phases to ensure that populations of invasive plant species are promptly identified as they become	See Section 3.3 of this Plan; will be part of Construction Quality Assurance and Quality Control Plan

No.	Proponent Commitments	Where Addressed
	established and that appropriate control measures are applied in a timely manner. b) Follow guidelines to prevent the introduction and spread of invasive plants as per the Invasive Plants Management Plan during all Project phases (Appendix 24 – Eagle Gold Conceptual Closure and Reclamation Plan). c) Minimize the extent of grubbing, soil stripping, and the removal of shrubs and herbaceous species, where possible, to reduce the area of bare ground potentially subject to invasive plant establishment. d) Mitigate against the establishment of invasive species and reduce erosion potential by re-establishing native vegetation on disturbed areas as soon as possible. e) Ensure that construction equipment is clean and free of soil and seeds before mobilizing to the Project site f) Use native species, to the greatest extent possible, during all Project phases, but most specifically during closure and reclamation phases to re-vegetate disturbed sites.	
32	VIT makes the following commitments to minimize potential effects of clearing on vegetation resources: a) Flag and stake known rare plant locations near the maximum disturbance boundary and instruct equipment operators to avoid these areas. Conduct regular monitoring of these sites during construction and operations. b) Reduce vegetation loss in areas around the footprint perimeter by adhering closely to construction plans, and avoiding off- site machine use. c) Clear the necessary trees and tall shrubs within the transmission line RoW during periods when the ground is frozen and snow-covered to minimize the disturbance to low shrubs, the moss layer, and topsoil. d) Minimize the extent of grubbing, stripping, and the removal of shrubs and herbaceous species where possible. e) When clearing is required, retain the humus layer and vegetation root mat, when possible. f) Re-vegetation of disturbed soils where appropriate to encourage slope stability and minimize soil degradation and erosion.	See Section 3.3 of this Plan; will be part of Construction Quality Assurance and Quality Control Plan See the Environmental Monitoring and Adaptive Management Plan See Section 4 of the Water Management Plan
33	VIT makes the following commitments to minimize potential effects on wetlands and riparian areas: a) Minimize disturbance in sensitive areas by implementing best management practices including the creation and maintenance of buffer zones around riparian and wetland ecosystems. b) Maintain existing drainage patterns to and from wetlands in areas outside of the disturbance footprint. c) When clearing is required, retain the humus layer and vegetation root mat to the extent practical, to reduce the potential for soil erosion and deposition in riparian and wetland ecosystems. d) Employ hand cutting of vegetation near access road and transmission line stream crossings to reduce disturbance to riparian areas during construction of the transmission line.	See Section 3.3 of this Plan; will be part of Construction Quality Assurance and Quality Control Plan See the Environmental Monitoring and Adaptive Management Plan See Section 4 of the Water Management Plan
Wildlife		
40	Implement a progressive Conceptual Closure and Reclamation Plan (Appendix 24). VIT will: a) re-vegetate reclamation areas with native species consistent with surrounding vegetation, except where regulatory agencies indicate that natural succession is preferable; and	See Section 7 of the Reclamation and Closure Plan

No.	Proponent Commitments	Where Addressed
	b) maximize use of direct placement techniques (minimizing stockpiling) to minimize the loss of biological activity in reclamation capping materials.	
Conceptual Closure and Reclamation Plan		
102	In developing the Conceptual Closure and Reclamation Plan, VIT will: a) Use Guidelines for Reclamation/Re-vegetation in Yukon as a guide for selecting appropriate candidate reclamation species to be assessed by seeding/planting trials. b) Take measures that will reduce the likelihood of plant infestations from occurring and actively manage infestations that may become established on mine operations areas. c) Address invasive plant establishment through the development and implementation of an Invasive Plant Management Program that will be conducted over the mine Project life.	See the Reclamation and Closure Plan
103	In the event that invasive plant populations do become established on the mine site or associated disturbances, VIT will utilize one or a combination of methods (pulling, mowing or cutting, burning, herbicide spraying, biological control) to control these infestations. VIT will liaise with Yukon Invasive Species Council (YISC), Environment Yukon (EY) and other proponents to keep informed of invasive plant species and management strategies in the region. VIT will focus its invasive plant management activities on species that have been categorized by YISC and EY as species of concern, species that are humans, animals, or ecosystems.	See the Reclamation and Closure Plan
105	During construction, an environmental monitor will be on site to monitor activities and to verify compliance with the provisions of all applicable permits, licenses and approvals. The environmental monitor will: a) Conduct monitoring programs as required under the respective permits, licenses, and approvals, and report the results of such programs, as required b) Ensure that soil salvage and replacement activities are completed appropriately to meet reclamation objectives c) Ensure that vegetative erosion control cover is established on soil stockpiles and on any other areas of disturbance, as appropriate d) Provide direction and recommend implementation measures aimed at avoiding or minimizing adverse environmental effects e) Implement erosion control measures such as installation of riprap, erosion control blankets, silt fences and filter fabrics.	See Section 3.3 of this Plan; will be part of Construction Quality Assurance and Quality Control Plan
106	As soon as reclamation areas become available, VIT will establish trials testing plant species suitable for reclamation in the Project footprint and trials testing vegetation establishment/growth on various topsoil depths and waste rock material. Information obtained from the trials/monitoring programs will be used to adjust reclamation activities or methods that will be best suited for reclaiming remaining mine disturbance areas.	See Section 10 of the Reclamation and Closure Plan
Environmental Management Plans		
110	VIT is committed to developing and implementing Environmental Management Plans (Appendix 30) with the following components: a) Erosion and Sediment Control Plan b) Fugitive Dust Control Plan c) Combustion Source Control Plan d) Vegetation Management Plan e) Wildlife Protection and Management Plan f) Environmental Monitoring Plan g) Schedule of Environmentally Sensitive Activity	See the following: Water Management Plan Dust Control Plan Wildlife Protection Plan Environmental Monitoring, Surveillance and Adaptive Management Plan Spill Response Plan

No.	Proponent Commitments	Where Addressed
	h) Heritage Resources Protection Plan i) Traffic and Access Management Plan j) Occupational Health and Safety Plan k) Cyanide Transportation Management Plan l) Spill Contingency Plan m) Noise Abatement Plan n) Waste Management Plan o) Water Management Plan p) Closure and Reclamation Plan.	Solid Waste and Hazardous Materials Management Plan Traffic Management Plan Cyanide Management Plan Heritage Resources Protection Plan Reclamation and Closure Plan

Table 1.2-3: Table of Concordance for Type A Water Use Licence QZ14-041 Relevant to this Plan

No.	Terms and Conditions	Where Addressed
Maintenance of Authorized Works		
24	All works associated with this licence shall be maintained in good repair such that they can be relied upon to meet their performance requirements. This requirement exists irrespective of any temporary or seasonal shutdown of activities at the site.	See Section 4.2, and the Operation, Maintenance and Surveillance Manual.
Heap Ore Testing		
31	The Licensee shall ensure that additional agglomeration test work is completed on sample ore representative of final crushing/processing output prior to loading the HLF.	Additional agglomeration test work has been completed and additional information will be provided as required by 151.
32	The Licensee shall ensure long-term column tests are undertaken to study the effects to stability and permeability of the ore placed in the heap leach facility. Particular consideration shall be given to the prediction of the potential migration of fines and the behaviour of saturated ore under design loads as may be experienced within the in-heap pond zone of the HLF.	An Ore Stability Test Plan, compliant with Decision Document Clause 86, will be provided prior to loading ore onto Phase 1 of the HLF as required by 152.
Use of Sprinklers within Heap Leach Facility		
33	The use of sprinklers to apply process or rinsing solution to the HLF shall not result in dispersion of cyanide to the surrounding environment.	The application of process or rinsing solution to the HLF will not result in dispersion of cyanide into the surrounding environment; see Appendix A HLF Detailed Design Report
Double Containment of Heap Fluid Conveyance Systems		
34	The Licensee shall ensure that process leach solution and rinse solution transfer pipelines are constructed with a secondary containment and collection system that ensures capture and containment of solutions in the event of leakage from or failure of the primary conveyance vessel (pipeline).	See the Cyanide Management Plan
Contingency Contact Water Storage Pond Location		
35	The Licensee shall ensure that an area north of the DGDC, and west (downgradient) of the Events Pond shall be reserved for an emergency event pond. The reserved area shall be capable of locating an emergency event pond with a minimum volume of 90,000 m3. All general arrangement drawings issued after the effective date of this Licence shall show this reserved area.	All general arrangement drawings show a reserved area for the location of an emergency event pond with a minimum volume of 90,000 m^3; see Appendix A HLF Detailed Design Report and the HLF Contingency Water Management Plan.

No.	Terms and Conditions	Where Addressed
Frozen Material Management		
36	The Licensee shall identify and excavate Ice-Rich Soils from beneath the footprint of the HLF.	See the Heap Leach Foundation Improvement Plan.
Phase 1 HLF Detailed Design		
60	The Licensee shall submit, at least 30 days prior to initiating construction of Phase I of the HLF, a final detailed design for Phase I of the HLF based upon the submitted HLF Detailed Design Report included in the Application (Exhibits 1.9.2.1.01 and 1.9.2.1.02) and compliant with any relevant requirements identified in this licence, including those in clauses 140 and 145 which require Review and Approval by the Board prior to finalization of the HLF design.	A final detailed design for Phase 1 of the HLF is provided in Appendix A.
Final Storage Capacity Criteria		
61	The final design of Phase I of the HLF and of the Events Pond shall consider the results of updated heap leach water balance and the heap leach contingency water management plan to determine the final design storage capacity of those facilities.	The final design of Phase 1 of the HLF considered an updated HLF water balance model and the HLF contingency water management plan to determine the final design storage capacity.
Spillway Design Criteria		
62	The spillways for both the HLF and the Events Pond shall be sufficient to pass the peak discharge predicted during passage of the Probable Maximum Flood through the HLF during the most critical phase HLF life cycle.	The spillways for both the HLF and Events pond are sufficient to pass the peak discharge of the PMF; see Appendix A HLF Detailed Design Report.
Foundation Preparation		
63	All Ice-Rich Soil shall be removed from the footprint of the HLF in accordance with the HLF foundation improvement plan (clause 148).	See the Heap Leach Foundation Improvement Plan
64	With the exception of the HLF embankment and the area of the Events Pond, all loose or unsuitable materials in the area of the HLF shall be removed as directed by a suitably qualified Professional Engineer.	See the Heap Leach Foundation Improvement Plan
65	At the location of the HLF embankment, all soils shall be excavated to Type 3 bedrock or better. Bedrock types are as defined on page 16 of Exhibit 1.3.9.	See the Heap Leach Foundation Improvement Plan
66	At the location of the Events Pond, loose surficial soils shall be removed to at least a depth of 3 m	Construction of the Events Pond will be completed as required by 66.
Phase 2 and Phase 3 of HLF Detailed Design		
67	The final designs of Phase 2 and Phase 3 of the HLF shall not be submitted until at least one full year of operations of the preceding phase has been completed. The final designs shall be submitted at least 30 days prior to any construction activities associated with these phases of the HLF.	Phase 2 and Phase 3 of the HLF are discussed briefly in Sections 1.1 and 3.2 of this Plan and final designs will be provided when and as required by 67 and 68.
68	The final design of Phase 2 and Phase 3 of the HLF shall explicitly consider the performance of any preceding phases of the heap. Particular consideration shall be given to the leakage performance of the HLF as indicated from monitoring of the LDRS underlying Phase I of the HLF and of the subdrain collection system from all preceding phases of the HLF.	Phase 2 and Phase 3 of the HLF are discussed briefly in Sections 1.1 and 3.2 of this Plan and final designs will be provided when and as required by 67 and 68.
Dublin Gulch Diversion Channel Design Criteria		
71	The DGDC shall be designed to pass the 500 year, time of concentration storm event without overtopping or an erosion (scour) failure from its upstream inlet to at least downstream of the confluence of the channel	Compliance with other requirements identified in QZ14-041 resulted in design

No.	Terms and Conditions	Where Addressed
	with the Events Pond spillway. Below the confluence with the Events Pond spillway, the channel shall be designed to at least pass the 100 year, time of concentration storm event without overtopping or erosion (scour) failure.	optimizations that negated the need for this diversion
72	In addition to the requirements of clause 71. the DGDC shall also be designed such that passage of the PMF event through the channel will not: a. Result in overtopping of the channel where such overtopping would spill flow from the channel into the heaped ore or onto the HLF embankment, its south abutment, or HLF spillway; and b. Erode or scour the channel such that flow from the channel will enter into the heaped ore or erode or otherwise damage the HLF. it abutments and the HLF spillway.	Compliance with other requirements identified in this license resulted in design optimizations that negated the need for this diversion. The Design Flood Passage Study required by 139 shows that Dublin Gulch can pass a PMF event without overtopping the natural confines of the valley and as such any scour would not affect the HLF and events pond.
Decision Document Compliance		
88 (b-d)	The final detailed designs for the water storage and conveyance structures shall be compliant with relevant Decision Document conditions. The Licensee shall ensure that: b) Temporary diversion or interceptor ditches are sized to account for infilling of sediments. This includes increasing the minimum depth from 300 mm where conditions warrant (e.g. ditches constructed with minimal to no grade) (DD term #49); c) Lined temporary and permanent diversion or interceptor ditches are lined in a manner that is stable (DD term #50); and d) Temporary and permanent diversion or interceptor ditches that convey water away from key mine site infrastructure (e.g. the pit. WRSAs. and event ponds) are sized to accommodate a 100-year 24-hour design storm event (DD term #51).	See Section 3.12 of this Plan and Appendix A HLF detailed Design Report.
Surface Water Hydrology and Water Quality Monitoring Program		
114 (b)	The Licensee shall update the Surface Water Hydrology and Water Quality Monitoring Programs to include volumetric flow monitoring of internal water transfers between Engineered Structures and of discharges to the environment from any Engineered Structures.	See Environmental Monitoring, Surveillance and Adaptive Management Plan.
115	The volumetric flow monitoring to be incorporated into the EMSAMP shall be sufficient to comply with the monitoring provisions of this licence and sufficient for the purposes of calibration of the Surface Water Balance Model and Heap Leach Water Balance Model.	See Environmental Monitoring, Surveillance and Adaptive Management Plan.
Groundwater Monitoring Program		
117 (a)	The Licensee shall update the Groundwater Monitoring Program to include, but not be limited to installation and monitoring of a minimum of two additional wells in the Dublin Gulch valley, one upgradient and one downgradient of the HLF.	See Environmental Monitoring, Surveillance and Adaptive Management Plan.
Meteorological Monitoring Program		
118 (a)	The Licensee shall update the Meteorological Monitoring Program to include, but not be limited to, monitoring of snowpack at the HLF.	See Environmental Monitoring, Surveillance and Adaptive Management Plan.
Infrastructure and Facilities Monitoring Program		
120 (d)	The Licensee shall update the Infrastructure and Facilities Monitoring Program to include, but not be limited to, a requirement to complete a Dam Safety Review for the heap leach facility no later than five years after construction of that facility.	See Environmental Monitoring, Surveillance and Adaptive Management Plan.

No.	Terms and Conditions	Where Addressed
Heap Inventory Monitoring Program		
126	The water inventory within both the saturated and unsaturated zones of the heap and on the surface of the HLF shall be monitored such that the volume of water stored in the heap can be determined on at least a monthly basis during operations and during any Temporary Closure periods.	See Operation, Maintenance and Surveillance Manual
127	Reporting of fluid volumes stored within HLF in both the heap and the Events Pond shall be included in monthly reports.	StrataGold Corporation (SGC) will comply with this condition when applicable.
128	By March 31st of each year, the Licensee shall submit to the Board a stochastic projection of the expected water volumes stored within the heap and Events Pond for the period of March 1 to August 31st of that year.	SGC will comply with this condition when applicable.
Cyanide Management Plan		
132	The Licensee shall submit to the Board for Review and Approval, an updated CMP which includes an annual independent third-party audit, consistent with the ICMC, of the cyanide management plan and its execution.	An update to the Cyanide Management Plan will be provided for review and approval prior to the use of cyanide on site as required by 132.
133	Storage and use of cyanide at the site must not occur until receipt of notice of approval of the updated CMP from the Board.	An update to the Cyanide Management Plan will be provided for review and approval prior to the use of cyanide on site as required by 132.
Design Flood Passage Study		
139	The Licensee shall complete and submit to the Board for Review and Approval a flood management study that will be the basis for the final design of the DGDC and the spillways for the HLF and the Events Pond. The flood management study shall include: a) Consideration of the passage of the peak discharge expected during the probable maximum flood event that develops concurrently in the HLF watershed and the contributing watersheds of the DGDC; b) Analyses showing design requirements for passage of the PMF through the HLF without damage to the HLF and its spillway; c) Analysis showing design requirements for passage of the PMF through the DGDC without damage to the HLF and its spillway; d) The basis for determination of the PMF including contributing rainfall, snowpack, antecedent events, and assumptions regarding the generation of runoff; and e) Consideration of a range of potential periods in the project life cycle when the PMF could occur to identify and show the most critical time for each individual conveyance structure which shall be the basis of the design requirements for the DGDC, HLF spillway, and Events Pond spillway.	Compliance with other requirements identified in the water use license resulted in design optimizations that negated the need for this diversion. The Design Flood Passage Study required by 139 shows that Dublin Gulch can pass a PMF event without overtopping the natural confines of the valley and as such any scour would not affect the HLF and events pond.
HLF Water Balance Update		
140	The Licensee shall submit to the Board for Review and Approval, an updated HLF water balance model that includes stochastic analyses of additional scenarios as follows: a) Explicit inclusion of potential climatic change on precipitation; b) Variation in the assumed sublimation of snow pack; c) Variation in the potential porosity of ore within the heap; d) Potential transfer of water from water storage ponds into the Events Pond for later use in heap irrigation; and	See the updated HLF water balance model

No.	Terms and Conditions	Where Addressed
	e) Any other factors that may be expected to impact the volume of water entering the heap and that can be stored in the heap and events pond.	
141	For each of the factors considered in the additional scenarios a rationale for the range of each factor (increased precipitation, sublimation variation, etc.) shall be provided.	See the updated HLF water balance model
142	The analyses completed shall consider the concurrent application of the factors in clause 140 to develop worse case expectations for the potential to release process water from the in-heap pond to the Events Pond and from the Events Pond to the environment.	See the updated HLF water balance model
143	The updated HLF water balance model shall also incorporate any modifications to the design of the HLF such as the spillway invert elevations for the HLF and the Events Pond.	See the updated HLF water balance model
144	The updated HLF model shall explicitly consider each phase of the HLF and a five year period of temporary closure occurring at each phase of the HLF.	See the updated HLF water balance model and the standalone memorandum considering a five-year period of temporary closure
HLF Contingency Water Management Plan		
145	The Licensee shall submit to the Board for Review and Approval, a HLF contingency water management plan to detail how management strategies would be implemented to address excess water within the HLF to avoid, if possible, a release of process water from the Events Pond.	See the HLF Contingency Water Management Plan
146	The HLF contingency water management plan shall be developed from considering model runs from the updated HLF water balance model that indicated the potential release of water from the events pond (if management strategies are not applied) and the modelled application of potential mitigation strategies to, if possible, avoid the release of process solutions from the Events Pond.	See the HLF Contingency Water Management Plan
147	The HLF contingency water management plan shall identify for each phase of the HLF the timing required for management strategies to be applied to avoid releases of process water from the Events Pond and shall identify any guiding criteria, such as snow pack accumulation, which should trigger activation or preparation of contingency water management activities, such as installation of additional irrigation lines.	See the HLF Contingency Water Management Plan
Heap Foundation Improvement Plan		
148	The Licensee shall develop and submit 30 days prior to Development Phase of the Project a Foundation improvement plan for the HLF. The foundation improvement plan shall include: a) A specific definition of what constitutes Ice-Rich Soils within the HLF by consideration of moisture content. ice content and distribution, soil type and structure, and required performance of thawed soils within the limits of the HLF; b) A plan to locate and remove Ice-Rich Soils from the footprint of the heap facility; and The means, where required. of improving and confirming the improvement of the heap foundation soils to achieve acceptable stiffness and liquefaction resistance.	See the Heap Leach Foundation Improvement Plan
149	Where the means of locating Ice-Rich Soils will result in disturbance of in-situ foundation soils a means of ensuring the disturbance is corrected or is not significant in terms of the performance of the foundation shall be identified.	See the Heap Leach Foundation Improvement Plan

No.	Terms and Conditions	Where Addressed
Heap Leach and Process Facilities Emergency Response Plan		
150	The Licensee shall submit 30 days prior to the Production Phase of the Project an updated Heap Leach and Process Facilities Emergency Response Plan. The updated plan shall: a) Be consistent with the final detailed design of the HLF and b) Be revised to include alert levels for the LDRSs that vary in accordance with the driving head level of the in heap pond and the Events Pond.	See Appendix D Heap Leach and Process Facilities Emergency Response Plan
Agglomeration Test Plan		
151	Prior to loading ore onto Phase 1 of the HLF, the Licensee shall submit to the Board an agglomeration test plan meeting the requirements of DD condition 85.	See Section 3.11.1 of this Plan. Additional agglomeration test work has been completed and a test plan will be provided as required by 151.
Ore Stability Test Plan		
152	Prior to loading ore onto Phase I of the HLF, the Licensee shall submit to the Board an Ore Stability test plan meeting the requirements of DD condition 86.	See Section 4.2 and 4.3 of this Plan An Ore Stability Test Plan will be provided as required by 152.
HLF Operations, Maintenance, and Surveillance Manual		
154	The Licensee shall submit to the Board for Review and Approval, an updated Operations, Maintenance and Surveillance Manual for the HLF and receive approval from the Board prior to loading ore in the HLF. The updated manual shall include sections on: a) Monitoring of fluid levels in the Events Pond and the fluid levels and water inventory (inclusive of surface snow cover and pore moisture) in the HLF and Events Pond; b) Protocols for allowing storage of water in the Events Pond and for increasing pumping rates for leach or rinsing fluids; c) monitoring of the quantity and quality of leakage detected in LDRSs for both the HLF and Events Pond; d) Protocols for comparing monitoring leakage rates into the LDRS to Alert Level I and Alert Level 2 rates (determined as in Exhibit 1.9.2.1.9) that vary with the depth of fluid stored in the in heap pond and the Events Pond; e) Incorporate actions to be completed if leakage rates exceed either Alert Level I or Alert Level 2 rates; f) Monitoring of the quantity and quality of flows within the heap facility subdrains; g) Monitoring of the evolution of the storage capacity of the in heap pond; h) Specific triggers for preparing for and implementing contingency water management strategies to address excess water in the HLF that could result in a potential release to the environment; i) Specific planning for use of sprinklers; and j) Identification of backup equipment and supplies (generators, switch gear, pumps, fuel caches, irrigation supplies, etc.) required for each phase of the Mine Plan for emergency management of the HLF.	See Operation, Maintenance and Surveillance Manual
155	To monitor the evolution of the storage capacity of the in-heap pond the Licensee shall develop protocols to estimate the storage volume within the in-heap pond (as may change over time) based on the rate of change to the in-heap pond level in response to the changing water balance within the HLF or by other means as may be feasible.	See Operation, Maintenance and Surveillance Manual

Table 1.2-4: Table of Concordance for Quartz Mining License QML-0011 Relevant to this Plan

No.	Terms and Conditions	Where Addressed
9.8	The Licensee must not place more than 92 million tonnes of ore on the heap leach facility during the term of this Licence.	See Section 2.4.1 of this Plan.
Plans to be submitted for approval as approved plans		
Sch B	Heap Leach and Process Facilities Construction and Operations Plan - A plan that describes the construction, operation and monitoring of the process facilities, and the organizational roles and responsibilities, facility description, operation, maintenance and surveillance measures and any contingency measures for the heap leach pad and related infrastructure.	See the following: Sections 1 through 4 of this Plan, Appendix A HLF Detailed Design Report Operation, Maintenance and Surveillance Manual HLF Contingency Water Management Plan.
<u>Heap Leach Process Facilities and Ancillary Infrastructure</u>		
Sch C Part 1 (4)	The Licensee is authorized to operate and maintain a heap leach and process facility consisting of equipment for crushing and conveying ore, ore stockpiles, cyanide leaching, carbon adsorption desorption and recovery, ore storage and transportation and ancillary infrastructure.	Sections 1 through 4 of this Plan
Sch C Part 1 (6)	The Licensee is authorized to construct, operate and maintain a valley fill heap leach including an embankment, in-heap pond, composite liner systems, solution recovery wells, solution collection, distribution and storage, a leak detection and recovery system and events ponds.	Sections 1 through 4 of this Plan
<u>Cyanide Management</u>		
Sch C Part 2 (1.3)	"Cyanide Management Plan, Version 2014-01" dated May 2014 and prepared by StrataGold Corporation. Subject to the following conditions: a) prior to transportation of cyanide to the mine site, an updated Cyanide Management Plan shall be submitted for review and approval, this update must include: i. an annual independent third-party audit (consistent with the International Cyanide Management Code) of the cyanide management plan and its execution; and ii. a copy of all Standard Operating Procedures referred to in the plan. b) cyanide transportation must be provided by a certified cyanide transporter compliant with the International Cyanide Code.	An update to the Cyanide Management Plan will be provided for review and approval prior to the use of cyanide on site as required by Schedule C, Part 2 (1.3).
<u>Heap Leach and Process Facilities Construction and Operations</u>		
Sch C Part 2 (1.6)	"Heap Leach and Process Facilities Plan, Version 2014-01" dated August 2014 and prepared by StrataGold Corporation. "Cyanide Destruction Column Studies Report" dated March 13, 2014 and prepared by Tetra Tech. Subject to the following conditions: a) the Licensee shall ensure that additional agglomeration test work is completed on sample ore representative of final crushing/processing output prior to loading the heap leach facility; b) the Licensee shall provide a detailed foundation improvement plan for the heap leach facility, 30 days prior to construction, including: i. removal of all ice rich material; ii. With the exception of the HLF embankment and the Events Pond, removal of all loose or unsuitable materials as directed by a suitably qualified engineer.	See the following: Sections 1 through 4 of this Plan; Additional agglomeration test work has been completed and a test plan will be provided as required by 151 of QZ14-041; Foundation Improvement Plan; HLF Emergency Response Plan.

No.	Terms and Conditions	Where Addressed
	iii. where the means of locating ice-rich soil results in disturbance of in-situ foundation soils, ensure disturbance is corrected or not significant in terms of foundation performance; iv. excavation of foundation to Type 3 bedrock or better at the location of the HLF embankment; v. installation of geotechnical equipment to monitor performance. c) the Licensee shall provide an update to the emergency response plan in the heap leach and process facilities plan, 30 days prior to operations, including alert levels for the leak detection and recovery system d) the Licensee shall provide an update to the Operations, Maintenance and Surveillance Manual for the heap leach facility prior to loading ore in the facility.	Operations Maintenance and Surveillance Manual
Sch C Part 2 (2.1, a, iii)	An update to include a Dam Safety Review for the heap leach facility no later than five years after construction;	See Environmental Monitoring, Surveillance and Adaptive Management Plan.

2 DESIGN BASIS AND CRITERIA

This section provides the design basis and criteria that guided the HLF design including project constraints, regulatory and guidance-based criteria and other criteria. These criteria define the effectiveness of the proposed design. Criteria are described for all components of the system, along with the rationale for the selection of the criteria, including how the criteria were developed in accordance with specific regulatory requirements and/or guidance documents. The rationale demonstrates how the proposed criteria meet regulatory requirements and/or guidance documents. Where applicable, detailed site-specific analyses in support of the establishment of certain criteria (e.g., water balance and stability analyses) are briefly summarized and referenced to more detailed descriptions. Design documentation that meets the proposed design criteria is also referenced.

2.1 PERMITTING CONSIDERATIONS

Permitting considerations for the HLF either remain consistent with those proposed during the regulatory approvals process or, in some cases, have been revised to meet the conditions imposed by the Type A Water Use Licence QZ14-041 and to address stakeholder input received during the regulatory approvals process.

The Heap Leach Facility design standards for the project include:

- The regulatory requirements of Yukon and Canada;
- The Yukon Water Board Licensing Guidelines (2009);
- The requirements specified in the Water Use Licence issued for the Project;
- Guidelines from the Canadian Dam Association (2013, 2014); and
- Permitting requirements of the State of Nevada. These are not regulatory requirements in the Yukon, but are considered as standards for best practice.

2.2 DESIGN REQUIREMENTS

There are currently no published territorial, federal or international standards for the design and construction of a heap leach facility. Guidelines from the State of Nevada, where there is a preponderance of heap leach facilities, provide minimum standards for heap leach facilities and have been adopted for the Project. North American standards for the design of embankment dams were used where applicable, specifically the Canadian Dam Association (CDA 2014) guidelines. Table 2.2-1 summarizes the main technical and permitting requirements for the State of Nevada for the key elements of the HLF design.

Table 2.2-1: Summary of Design Requirements for the State of Nevada

Heap Leach Feature	Description
Leach Pad	System must have containment capability equal to or greater than that of a composite liner consisting of a synthetic liner over one foot of compacted soil at a permeability of 1×10^{-6} cm/s or 1×10^{-5} cm/s if a leak detection system is used beneath portions of the liner with the greatest potential for leakage.
	Synthetic liners must be rated as having resistance to fluid passage equal to a permeability of less than or equal to 1×10^{-11} cm/s.

Solution Ponds	System must have a primary synthetic liner and a secondary liner that meet the above-described liner specifications. The synthetic liners must be separated by a fluid transmission layer which is capable of transmitting leaked fluids at a rate that will ensure that excessive head will not develop on the secondary liner.
Solution Management and Containment	Process components must be demonstrated to have the capacity to “withstand” the runoff from a 100-year, 24-hour precipitation event. In addition, facility fluid management systems must demonstrate the capability of remaining “fully functional and fully contain all process fluids including all accumulation resulting from a 25-year, 24-hour precipitation event. The foregoing standards are minimal and additional containment capacity may be required if surface water bodies or human populations are in close proximity to the facility, or if groundwater is shallow.
Foundations	Consider static / dynamic loads and differential movement or shifting
Construction QA/QC	Regulations require that each applicant develop and carry out a quality assurance and quality control program for liner construction. A summary of the QA/QC program must be submitted with as-built drawings after construction has been completed.
Neutralization/Detoxification of Spent Ore	Spent ore, whether it is to be left on pads or removed from a pad, must be rinsed until it can be demonstrated either the remaining solid material, when representatively sampled does not contain levels of contaminants that are likely to become mobile and degrade the waters of the state under the conditions that will exist at the site, or, the spent ore is stabilized in such a manner as to inhibit meteoric waters from migrating through the material and transporting contaminants that have the potential to degrade the waters of the state.

2.3 DESIGN BASIS

The Yukon Water Board Licensing Guidelines for Type A Quartz Mining Undertakings provide specific guidance for selected mine site earthworks facilities, as follows:

“*General: Type A quartz mining undertakings may vary significantly in their magnitude and in the potential environmental effects associated with them. The guidelines contained in this document assume the development of a mine with significant potential environmental impacts such as those resulting from acid rock drainage or the failure of a large tailings impoundment. Projects such as this are considered to fall into the Very High Consequence of Failure category described in the Canadian Dam Safety Guidelines (January 1999). In situations where this category is not appropriate for some reason, the Board is prepared to consider well developed and documented justification for the use of alternative consequences of failure criteria developed in accordance with the Canadian Dam Safety Guidelines*.”

Further, specific design guidance is included as follows:

- The design, construction, operation, maintenance and surveillance of dams and associated water management structures should be carried out in a manner which is consistent with the recommendations contained in the Canadian Dam Safety Guidelines (January 1999) for the *Very High* Consequence Category, unless compelling reasons consistent with the Canadian Dam Safety Guidelines for a lower consequence category are provided.
- Long-term dams and associated water management structures should be designed to withstand the Maximum Credible Earthquake (MCE) and pass the Probable Maximum Flood (PMF). Shorter term structures may be built to lesser standards but a compelling rationale for the selected criteria must be provided.
- Heaps should be designed to have a minimum factor of safety under static loading of 1.3 for short term cases (i.e. within the mine life) and 1.5 for long term cases (i.e. abandonment) as described in the

Investigation and Design of Mine Dumps (British Columbia Mine Dump Committee, 1991). The factor of safety for dams should be as recommended in the Canadian Dam Safety Guidelines (January 1999).

- Designs for dams and associated water management structures, rock dumps, and heaps should recognize the probable presence of permafrost and should include appropriate measures to manage permafrost and maximize the stability of the structures consistent with recommendations contained in the Canadian Dam Safety Guidelines (January 1999).

Although the 1999 and 2007 CDA are referenced are referenced by the regulatory guidance documents summarized above, the latest version of the CDA guidelines (2013), including the Application of Dam Safety Guidelines to Mining Dams Technical Bulletin, was used for the Project.

BGC (2017b) performed a dam breach analysis to provide input into evaluating the HLF embankment hazard classification, per Canadian Dam Association (2013) guidelines. The results confirm that the confining embankment can be classified as a *Significant* dam (i.e., there is no permanent population or infrastructure at risk in the inundation path, and restoration of fish and wildlife habitat is highly possible). Nevertheless, the Water Use License (WUL) for the Project imposes an *Extreme* dam classification (the most stringent possible) for hydrologic and storage criteria. Thus, the *Extreme* hydrologic and storage criteria have been used for the HLF design. The WUL does not include a requirement to impose more conservative geotechnical criteria beyond those specified in the CDA guidelines; nevertheless, geotechnical criteria applied here assume a *High* hazard dam classification. The dam classifications used here also consider the input from the Application of Dam Safety Guidelines to Mining Dams (CDA 2014), and have been vetted during consideration and consultation between owner and regulators.

2.4 DESIGN CRITERIA

The parameters and criteria presented in Sections 2.4.1 to 2.4.6 below form the basis of design for the HLF. Geotechnical design criteria (Section 2.4.3) were developed while considering the analyses and discussions in the following appendices to Appendix A: Seismic Peak Ground Accelerations for Design, Slope Stability Analyses, and Settlement Analysis. Geotechnical design criteria were developed by BGC while ore parameters were provided by StrataGold or other consultants working on the project.

2.4.1 Ore Quantities

Table 2.4-1: HLF Design Criteria - Ore Quantities

Ore	Quantity/Criteria
Heap ore capacity	Approximately 86Mt
Ore processing	Average of 10.8 Mt/a of crushed ore over a 275-day crushing and stacking season Fine ore: three-stage crushing to 6.5 mm (P_{80}) - primary crushing 365 days (29,500 tpd), secondary/tertiary 275 days per year (39,200 tpd)
Leach pad type	Permanent, multiple lift
Stacking Rate	Approximately 40,000-45,000 tpd
Stacking method	Conveyor-stacker
Stacked dry density of ore	Initial - 1.72 t/m^3

Ore	Quantity/Criteria
Stack / lift height	Nominal 10 m lifts
Overall slope angle of stacked ore	2.5:1 (H:V), 22 degrees
Ore Setback	5m from perimeter road 10m from dam (for lifts above the dam)

2.4.2 Leaching

Table 2.4-2: HLF Design Criteria - Leaching

Leaching	Quantity/Criteria
Leach schedule	365 days per year
Solution application method	Drip emitters (buried during cold weather)
Solution application rate	10 $L/hr/m^2$ (planned for operations: 7 $l/hr/m^2$)
Total leach cycle time	90-day primary leach (planned for operations: 45-day primary leach)
Solution application flow	2,070 m^3/hour (planned for operations: 1,500 m^3/hour)

2.4.3 Geotechnical Criteria

Table 2.4-3: HLF Design Criteria - Geotechnical

Geotechnical Stability	Quantity/Criteria
Design Basis Earthquake (DBE)	0.14g (1 in 475-year return period) 0.25g (1 in 2475-year return period)
Maximum Design Earthquake (MDE)	0.35g (Acceleration at the site estimated for the Maximum Credible Earthquake) Moment Magnitude 6.0
Minimum embankment Factor of Safety	Static Loading - 1.5 (impounding), 1.3 (non-impounding), Seismic Loading - 1.0 (use pseudo-static methods)
Permafrost	Ice-rich materials encountered in the embankment foundation will be removed; ice-rich material in the pad foundation, if thaw unstable, will be removed.

2.4.4 Hydrologic and Storage Criteria

Table 2.4-4: HLF Design Criteria - Hydrology and Storage

Confining Embankment	Quantity/Criteria
General	To provide stable confinement of ore and create an In-Heap Pond.
Overflow spillway	Sized to pass the PMF peak flow with 0.5 m of freeboard assuming In-Heap Pond storage is at capacity at the start of the event.

Event Pond	Quantity/Criteria
General	The purpose of the Events Pond (constructed downstream of the embankment) is to temporarily store excess inflows that cannot be stored in the In-Heap Pond. Any overflow into the Events Pond will be evacuated, and used as make-up water, as fresh ore is added to the HLF. During the initial heap operation, the Events Pond may also be used as temporary storage for make-up water. Otherwise, the Events Pond will be kept empty.
Overflow spillway (from HLF and In-Heap Pond)	Sized for routed PMF peak flow with 0.5 m of freeboard.
Storage Capacity	Sized to contain the runoff volume from the PMF event, assuming the In-Heap Pond is full.
Combined Ponds	**Quantity/Criteria**
Storage Capacity	Provide available emergency storage to contain a 72 hr drain-down combined with a 24-hr 100-yr rainfall event and assuming 0.5 m of freeboard.
Solution Recovery Wells	**Quantity/Criteria**
General	Solution is to be recovered from the heap through inclined well casings equipped with submersible pumps installed in the in-heap solution storage area along the upstream dam slope. Adequate access for installing and recovering pumps from well casings will be provided on the dam crest.

2.4.5 Liner Criteria

Table 2.4-5: HLF Design Criteria - Liner

Pad Liner System	Quantity/Criteria
Overliner Drain Fill (ODF)	Crushed clean rock to provide a free draining layer under the placed ore and to protect the lining system from damage by ore placement while not impacting the conveyance of solution to the recovery wells. ODF will consist of a minimum of 1.0 m thickness (within the In-Heap Pond, minimum of 0.6 m otherwise) of minus 38 mm clean durable rock with less than 20 percent passing the No. 4 ASTM sieve size, and less than 5 percent fines passing the No. 200 ASTM sieve size and minimum in place hydraulic conductivity of 2×10^{-4} m/s.
Geosynthetic (geomembrane) liner	Suitable liner material to provide required puncture resistance, elastic strain range and resistance to solution attack and chemical breakdown along with cold weather performance for the project’s climate conditions (refer to linear low-level polyethylene (LLDPE) project standard specifications).
Geosynthetic Clay Liner (GCL)	Geosynthetic clay liner below the geosynthetic liner to provide a composite liner to minimize leakage. Objective maximum permeability 1×10^{-5} cm/s or 1×10^{-6} cm/s in the absence of a leachate detection and removal system.
Solution collection and recovery system	A system to collect leachate and convey it to solution recovery

	wells. System to comprise ODF and a network of collection pipes to convey solution to In-Heap Pond area while limiting solution head on liner.
Leak detection and recovery system (LDRS)	A system within the In-Heap Pond and Events Pond to collect leakage through the composite liner and convey it to monitoring points. The system to comprise geonet or similar synthetic drainage product to collect and convey any leaked solution to a gravel filled sump and pumping system.
LDRS monitoring	Monitoring of the flow into the LDRS to ensure that allowable rates (determined by permitting authorities) are not exceeded.
Event Pond Liner System	**Quantity/Criteria**
Geosynthetic (geomembrane) liner	Suitable liner material to provide required puncture resistance, elastic strain range and resistance to solution attack and chemical breakdown along with cold weather performance for the project's climate conditions (refer to LLDPE project standard specifications).
Geosynthetic Clay Liner (GCL)	Geosynthetic clay liner below the geosynthetic liner to provide a composite liner to minimize leakage. Objective maximum permeability 1 x 10^{-5} cm/s or 1 x 10^{-6} cm/s in the absence of a leachate detection and removal system.
Solution collection and recovery system	System to comprise a network of collection pipes to convey solution back to the barren tank in the process plant including a network of collection pipes
Leak detection and recovery system (LDRS)	A system to collect leakage through the composite liner and convey it to monitoring points. The system to comprise geonet or similar synthetic drainage product to collect and convey any leaked solution to a gravel filled sump and pumping system.
LDRS monitoring	Monitoring of the flow into the LDRS to ensure that allowable rates are not exceeded.
Groundwater	**Quantity/Criteria**
General	A drainage system is required beneath the liner system to control groundwater pressures. The system is to collect and monitor groundwater in a controlled manner before discharge downslope of the embankment.

2.4.6 Process Plant Design Criteria

Table 2.4-6: HLF Design Criteria - Process Plant

Process Plant	Quantity/Criteria
Carbon adsorption	Two CIC trains, five columns per train (4t carbon per column)
Solution velocity to fluidized carbon bed	9.8 lpm/m^2
Barren solution heating	During winter months if needed
Fluid Discharge Loss	Zero
CIC gold recovery	98%

Process Plant	Quantity/Criteria
Metal Recovery	Pressure elution stripping followed by electrowinning

3 HEAP LEACH FACILITIES DESIGN AND CONSTRUCTION

3.1 FOUNDATION CONDITIONS

A detailed description of the HLF foundation conditions is provided in BGC (2012a, 2012b, and 2017a). These reports are appended to, and summarized in Appendix A. In general, the HLF site has moderate to high relief, with ground elevation varying from approximately 880 m asl to 1225 m asl. A surface geology map of the site was prepared by BGC and is presented as Drawing EGHLF-XD-01-03 in Appendix A.

3.1.1 Subsurface Conditions

Geologic conditions at the HLF site reflect the geotectonic forces that produced the Eagle Zone deposit. Folding, faulting and plutonic activities have resulted in relatively weak rock mass in places with relatively poor mechanical properties. Further, frost fracturing and discontinuous permafrost affect rock/soil characteristics in areas lower in elevation.

Overburden soils encountered on the sloping ground in the Ann Gulch valley typically consist of a veneer of organic soils overlying a blanket of colluvium, which overlies weathered bedrock.

Glacial till is generally only encountered on the lower flanks of the north-facing slopes of the Dublin Gulch valley, and do not occur within the HLF footprint. Where present, the till is often overlain by colluvium. Placer tailings (fill from reworked alluvium) cover most of the valley bottom of the Dublin Gulch valley, but not within the HLF footprint.

The bedrock encountered under the proposed HLF site is classified as metamorphosed sedimentary rock, with a variably deep weathering profile. The intact rock strength of the encountered rock types is highly variable, with strength ranging between R0 class (i.e. corresponding to < 1 MPa Unconfined Compressive Strength, UCS) and R4 (50-100 MPa UCS). The average intact strength is estimated to be approximately R2 (5-25 MPa) in the metasedimentary rock, depending upon the degree of weathering, but with significant variability across the site.

3.1.1.1 Overburden

Overburden soil conditions are distinctly different in the Dublin Gulch valley bottom from those encountered above the valley bottom in Ann Gulch in the area of the HLF. In the uplands above the valley bottom, the upper soil unit consists of a thin horizon of organic soil, rootlets, woody debris and plant matter ranging from 0.1 to 2.7 m thickness and averaging approximately 0.3 m. The organic cover above the valley bottom overlies colluvium; the colluvium ranges in thickness from 0.2 to 15.2 m, and averaging approximately 2.9 m. The colluvium consists of loose to compact angular gravel with occasional cobbles in a silt and sand matrix, derived from transported weathered metasedimentary bedrock. The colluvium may also include variable amounts of organics, which are often observed in distinct layers within the colluvium.

The placer tailings in the Dublin Gulch valley bottom have highly variable particle size distribution and density, and are generally saturated. The HLF facilities layout does not overlay the placer tailings deposits; however, these materials may be used for construction of required fills. The material is generally a well graded, silty sand and gravel, ranging to sand and gravel with some silt and occasional cobbles and boulders. There is little to no vegetative cover on the placer tailings.

Seismic refraction surveys were performed to evaluate the variability of the overburden depth (Appendix A2 of Appendix A). Generally, the seismic refraction survey results indicate that the thickness of the overburden transitions smoothly from very little at the top of the slopes increasing to the valley floor. This is the same trend with the depth of weathering.

3.1.1.2 Bedrock

Bedrock was observed in the uplands above Dublin Gulch immediately below colluvium at depths ranging between 0.0 and 16.8 m below existing grade (average depth to bedrock at 3.5 m where observed). The left abutment (looking downstream) of the proposed HLF confining embankment is characterized by colluvium up to 4 m in thickness over weathered bedrock (generally class R0 to R1). R1 class rock referred to as Type 3 rock in Appendix A, has a minimum intact UCS strength greater than 1 MPa and can be excavated with normal excavating equipment. The data in the right abutment area indicate colluvium thickness greater than 6 meters.

Bedrock at the mine site is subdivided into three broad categories – Type 1, Type 2 and Type 3 – on the basis of rock mass quality and inferred engineering behavior, with Type 1 being the highest quality, and Type 3 being the lowest quality with unconfined compressive strength of 1 to 5 MPa. Type 3 bedrock, the lowest quality rock mass considered to behave as rock (rather than as a soil), can be recognized on the basis of evident preserved fabric of the parent rock within the highly weathered rockmass, and the requirement for moderate effort to excavate with heavy excavators. Types 1 and 2 bedrock are of generally better rockmass quality. The transition from Type 3 to Type 2 can be inferred where it becomes necessary to rip the rock. Type 1 bedrock will require the use of hydraulic hammers and/or drilling and blasting to excavate.

Observed bedrock consisted of highly to completely weathered metasedimentary rock (i.e.Type 3 rock) or moderately to highly weathered rock (i.e. Type 2 rock). The metasediments in general are observed as strongly foliated yellowish brown to dark grey phyllites interbedded with quartzites. The quartzites are variably gritty, micaceous, and massive. Phyllitic metasediments are composed of muscovite-sericite and chlorite.

The rock mass quality and characteristics have been inferred from observations in boreholes within the heap leach pad footprint. Rock Mass Rating values of 20 to 30 were determined from the observed rock core to about 10 m depth, then increased to about 45 to 50 at most locations.

The seismic refraction surveys (Appendix A2 of Appendix A) confirmed a depth to highly weathered bedrock ranging from 1 to 5 m along the hillside in the area of the Events Pond. The depth to moderately weathered bedrock ranged from 10 to 20 m in this area.

Seismic refraction results indicate highly weathered bedrock ranging from 0 to 4 m in the proposed HLF confining embankment left abutment. The depth to moderately weathered bedrock ranged from 20 to 25 m in this area.

3.1.1.3 Groundwater

Based on water level data collected from 2010/2011 to 2017 from six groundwater monitoring wells in the Ann Gulch basin, depths to groundwater in the lower valley range from 3 to 8 m bgs, and in the upper valley range from 8 to 19 m bgs. In the lower valley this sometimes coincides to immediately above the colluvium-weathered bedrock contact. In the upper valley the water level is generally within the bedrock. It is anticipated that these levels will vary seasonally. A standpipe piezometer installed at borehole BH-BGC16-091 in the area of the HLF confining embankment indicated a water level of 10 m and 5 m below top of pipe measured in September 2016 and June 2017, respectively.

3.1.1.4 Permafrost

Frozen ground as discontinuous permafrost was encountered within the footprint of the HLF in 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. Frozen ground was typically encountered within colluvial gravels and gravels and sands with depths varying between 0.6 m to 2.8 m, and occasionally included excess ice with limited thickness. Section 5.2.1 of Appendix A (which is also described in the HLF Foundation Improvement Plan) presents requirements for identifying and removing ice-rich materials.

3.2 SITE PREPARATION

3.2.1 Construction Staging

The HLF is a valley fill design that incorporates an earthfill/rockfill confining embankment (dam) designed with a double-lined upstream dam face, that will provide physical stability to the heap and stacked ore and containment of process solution in the In-Heap Pond. The In-Heap Pond provides for the storage and management of cyanide process solutions within the heap, eliminating the need for downstream pregnant and barren process solution ponds or tanks.

The heap leach pad will nominally be built in three phases over the life of mine (Figure 3.2-1). The ore will be stacked in 10 m thick lifts. The Phase 1 pad (Figure 3.2-2) will be constructed in pre-production to accommodate around three years of ore production or approximately 29 Mt of ore. The construction of the Phase 2 pad (Figure 3.2-3) will start before Year 3 of operations The Phase 2 heap will consist of approximately 29 Mt of ore and will be stacked above the Phase 1 heap and the Phase 2 pad. The Phase 2 heap stacking will begin in Year 4 and conclude during Year 6 of operation.

The Phase 3 pad (Figure 3.2-4) will begin construction in Year 5. The Phase 3 heap stacking will start during Year 6 of operation and conclude in Year 9 after covering the Phase 3 pad. The Phase 3 heap amount will be approximately 29 Mt. The heap ore quantities amounts are based on an estimated average stacked ore heap dry density of 1.72 tonnes/m^3.

3.2.2 HLF Foundation Preparation

Foundation preparation includes removing or relocating any existing structures, removing vegetation and loose or unsuitable materials including ice rich soils, grading, and installation of subsurface drainage pipelines to prepare a suitable foundation for construction of the HLF.

Several conditions could affect the performance of the HLF foundation; however, when properly identified the conditions can be mitigated. For preparation of the HLF foundation subgrade, all organic soils will be removed, exposing the underlying colluvium. Removal of loose native colluvium and weathered bedrock will be required to provide a suitable subgrade for the placement of the liner and the ore in areas beyond the HLF embankment. The Heap Leach Facility Foundation Improvement Plan (SGC 2017) provides a review of the characteristics and the estimated spatial extent of the ground ice under the HLF, highlights the characteristics of the ground ice encountered during site investigations, and includes a definition and discussion of ice-rich soils. The HLF Foundation Improvement Plan discusses how ice-rich soil can be identified during construction and reviews ground ice removal measures. Removal of ice-rich materials and replacement (as necessary) with compacted fill shall be performed to the satisfaction of the Engineer. The general approach for excavation and identification and removal of topsoil, unsuitable materials and ice-rich materials is provided below:

- **Identify and Remove Topsoil and Loose or Unsuitable Materials:** The natural ground surface will be cleared, grubbed and stripped of all organic and unsuitable materials generally 3m outside of the limits of the HLF. Clearing and grubbing will include the removal of vegetation and roots. Stripping includes the removal of topsoil, defined as soil of any gradation or degree of plasticity that contains significant quantities of visually identifiable organics (e.g., vegetable matter, sod, roots, or humus) as determined by the Engineer. The thickness of organics (in most cases equal to the depth of the topsoil) to be removed will vary across the site and will be determined by the Engineer based on the character and thickness of material encountered. Clearing, grubbing and stripping will generally be conducted as a single operation.
- **Excavation to Type 3 Bedrock:** In the area of the HLF embankment, excavation to Type 3 or better bedrock will be completed. Identification of Type 3 bedrock will be identified by suitable qualified construction personnel under the supervision of the Engineer.
- **Identify and Remove Ice-Rich Soils:** Ice-rich soils in permafrost, when thawed and generating excess pore pressures, can result in soil instabilities and therefore; it is critical to identify and remove any ice-rich soils in the foundation of the HLF prior to liner construction and stacking. On the other hand, if the frozen ground does not contain excess ice (no ice-rich soils) and is thaw stable, there is negligible impact on the stability of the ground upon thaw. A detailed description of the methods for addressing ice-rich soils and for the overall HLF foundation preparation is summarized in Section 5.2 of the design report (Appendix A), and also found in the HLF Foundation Improvement Plan (SGC 2017).

Table 3.2-1 presents a summary of the material and construction requirements for foundation preparation and underdrains.

Table 3.2-1: HLF Material and Construction Requirements

Component	Material and Construction Requirements
Structures	Remove any existing structures Plug any boreholes or piezometers in top 30 m depth with concrete grout or bentonite.
Vegetation	Strip vegetation to minimum 3 m beyond the HLF construction limits and place in temporary topsoil stockpiles for final reclamation. Locate stockpiles as shown on drawings or at the direction of the Owner.
Organic Surface Soils	Strip organic soil cover to minimum 3 m beyond the HLF construction limits and place in temporary topsoil stockpiles for final reclamation. Locate stockpiles as shown on drawings or at the direction of the Owner.
Foundation Improvement	Remove loose and unsuitable materials to Type 3 or better bedrock at the dam abutments. Remove ice-rich materials.
Underdrains	Construct underdrain system as shown on the drawings. Perform grading as necessary in drainage bottoms to allow equipment access and to accommodate the required underdrain size. Install underdrains with geotextile, ADS N-12 (or equal) PE pipe and gravel materials as specified.

Component	Material and Construction Requirements
Site Grading	Remove loose or unsuitable materials within the dam and limits as directed by the Engineer. Engineer to inspect exposed rock in dam foundation to determine suitability. Stripped rock subgrade surfaces and rock outcrops in at-grade areas to be cleared of loose rock fragments greater than 150 mm in size and wetted in preparation for Site Grading Fill placement. Foundation preparation to consist of placing and compacting fill material in varying thicknesses to suit field conditions to support the liner system. Site Grading Fill material shall include inorganic soils with a maximum 150-mm particle size and a minimum of 70 percent passing the 19-mm sieve size. Place fill in maximum 0.3 m loose lifts and compact each lift to a minimum 95 percent of the maximum dry density (ASTM D-698) within ±2 percent of the optimum moisture content. Compacted Rockfill will have a maximum of 70 percent particles passing the 19-mm sieve (and therefore does not meet the specification of Site Grading Fill), and have a maximum rock particle size of no more than two thirds the loose lift thickness. The rockfill shall generally have 300-mm maximum rock particle size and oversized rocks larger than 300 mm shall be removed to the exterior fill slopes. Rocks larger than 300 mm may be incorporated in thicker fill lifts provided the rocks do not protrude from the lift surfaces after compaction, and the required compaction of the lifts is proven achievable by a test fill.
Subgrade	After clearing, grubbing, stripping, and excavating, the exposed subgrade surface shall be inspected and evaluated by the Engineer for the presence of loose or soft areas or unsuitable material prior to fill placement or geomembrane installation. Subgrade evaluation methods will depend on the location and the materials that will be placed over the subgrade and on the prevailing field conditions. Evaluation methods may include proof-rolling with a loaded dump truck or similar pneumatic-tired equipment to ensure that the surface is firm and smooth. Probing with a metal rod may also be performed. Soil subgrade surface receiving site grading fill or geomembrane shall be scarified to a minimum depth of 150mm, moisture conditioned if necessary to within plus or minus two (±2) percent of the optimum moisture content as determined by the Standard Proctor test (ASTM D-698), and recompacted to a minimum of 95 percent of the maximum dry density (ASTM D-698). Soil subgrade surface receiving geosynthetics, including geosynthetic clay liner, shall be prepared such that it is smooth and free of protruding rocks, vegetation, or any other materials, or objects deemed unsuitable by the Engineer. The subgrade should be rolled with a smooth-drum compactor to remove any wheel ruts, tracks, or other abrupt grade changes greater than 25 mm (1 inch) in depth. All protrusions extending more than 12 mm from the subgrade surface shall be removed.

3.2.3 Foundation Drainage

An underdrain system will be constructed to collect and drain subsurface water from beneath the HLF and limit upward pressure on the HLF liner. The underdrains will convey subsurface water to collector pipes that will discharge to an outlet monitoring vault (Figure 3.2-5). More detail on the underdrain system is found in Section 3.9.3.

3.2.4 HLF Confining Embankment

The embankment dam is designed as an earth fill/rock fill structure with a geomembrane lined upstream dam face and appropriate filter and transition zones to provide a suitable surface for geomembrane installation and to ensure containment integrity with filter compatible materials.

The embankment section includes an 8 m crest width for road and pipeline access and 2.5H:1V upstream and downstream slopes. Approximately 60 m of the embankment crest adjacent to the inclined solution well casings will be widened to 11 m to accommodate the PLS riser pipe system and allow for maintenance access in this area.

Drawings EGHLF-XD-04-01 through EGHLF-XD-04-03 in Appendix A present construction details for the embankment. Drawings EGHLF-XD-08-01 through EGHLF-XD-08-03 present construction details for the In-Heap Pond.

The planned fill placement for the HLF structures includes the use of conventional earth moving equipment, water wagons, roller compactors for earth fills, and vibratory compactors for rock fills. Suitable fill materials will be produced from required excavations for the HLF structures, borrow areas and open pit pre-stripping and is generally expected to be colluvium and weathered rock. Fill will be placed in horizontal lifts with a maximum thickness of 300 mm and compaction to 95% of standard Proctor density. Moisture conditioning will be performed as needed in the embankment fills for compaction.

Dozers will spread the fill in controlled lifts for compaction by the loaded trucks or by large vibratory steel drum compactor rollers. The lift thickness and compaction effort will be determined by the Engineer in test fills at the embankment site during start-up of embankment construction and as required during construction or when material differing from the initial test materials is encountered.

3.2.5 Liner System

The liner system provides a boundary to contain ore and process fluids. A single composite liner system will be constructed within the HLF limits (double composite liner within the In-Heap Pond and on the upstream face of the dam embankment). In conjunction with the geomembrane, a GCL will be used in the entire HLF impoundment, and an additional low permeability soil zone at the dam upstream face.

The selected composite liner system consists of a primary geomembrane liner barrier in direct contact with a low permeability bentonite GCL barrier for containment. The liner system design includes 1 m of overliner drain fill (ODF) in the In-Heap Pond (and a minimum of 0.6 m otherwise) above the liner to protect the liner during ore placement and limit hydraulic heads on the geomembrane liner surface during operations.

The lining system for the HLF In-Heap Pond is comprised of the following:

- a minimum 1m thick layer of overliner material with imbedded drainage piping;
- a 2.0-mm (80-mil) double-side textured LLDPE primary liner;
- a geonet that is part of the LDRS and located between the primary and secondary liners;
- a 1.5-mm (60-mil) double-side textured LLDPE secondary liner;
- a GCL below the secondary LLDPE liner;

- liner bedding fill; and
- a prepared subgrade.

The lining system for the HLF Phase 1 pad (up-gradient of the In-Heap Pond) is comprised of the following:

- a minimum 0.6 m thick layer of overliner material with imbedded drainage piping;
- a 2.0mm (80-mil) double-side textured LLDPE liner;
- a GCL below the LLDPE liner;
- liner bedding fill; and
- a prepared subgrade.

The Events Pond will include a double-lined facility with LDRS having the following components:

- a 2.0mm (80-mil) high-density, single-side textured polyethylene (HDPE) primary liner;
- a geonet that is part of the LDRS and located between the primary and secondary liners;
- a 1.5mm (60-mil) double-side textured LLDPE secondary liner;
- a GCL below the secondary LLDPE bottom liner;
- liner bedding fill; and
- a prepared subgrade.

3.2.6 Overliner Drain Fill

Overliner Drain Fill (ODF) material will be produced from crushing and/or screening operations from screening of sand and gravel aggregate from borrow sources or low-grade ore from the pit. Crushed cobbles and boulders screened from the placer fill deposit in the Dublin Gulch valley and/or crushed competent rock from site excavations are the primary anticipated source for ODF material during initial construction, and then will be sourced from low-grade ore once in operations. The ODF shall consist of free-draining granular material with 38-mm maximum particle size and a maximum of 5 percent fines passing the No. 200 ASTM sieve size (0.075-mm). The material shall be free of organic matter and soft, friable particles in quantities objectionable to the Engineer. The minimum in place hydraulic conductivity of the ODF will be $2x10^{-4}$ m/s. Table 3.2-2 summarizes the specifications and criteria for drain pipework and overliner drain fill for the overliner system.

The ODF material shall be placed in such a manner as to reduce segregation and to construct the zones in accordance with the details, lines and grades as shown on the Drawings, or as specified by the Engineer. Methods shall be developed on site for placing the material in a manner that will protect the geomembranes and drain pipework from damage and keep compaction of the material to a minimum. Any drain fill material that has received too much compaction shall be scarified to a loose condition without damage to the underlying geomembrane and pipework.

The ODF above the geomembrane shall be placed in a single 0.6 m minimum lift thickness by suitable dozer and truck equipment, as approved by the Engineer. A thicker layer, a minimum of twice the pipe diameter, shall be placed above the larger diameter primary collection drain pipes as detailed on the Drawings. A 1.0 m thick layer shall be placed over all double-lined areas. No moisture conditioning or compaction is required. Haul truck speeds, braking, and turning during ODF placement shall be strictly controlled to prevent damage to the underlying geomembrane and pipework. The cover fill thickness shall also be increased in concentrated traffic areas or across collection pipes, as required, to prevent damage to the geomembrane and pipework. Haul traffic on the cover fill surface shall be spread out as much as practical to prevent over-compaction of the cover fill in localized areas.

Table 3.2-2: Overliner System

Component	Specifications and Criteria
Drain Pipework	Perforated corrugated PE primary collection pipes to be ADS N-12 dual wall smooth interior, or approved equivalent. 450, 250 and 100 mm diameter perforated corrugated polyethylene (PE) collection pipes.
Overliner Drain Fill	The ODF shall consist of free-draining granular material with 38-mm maximum particle size and a maximum of 5 percent fines passing the No. 200 ASTM sieve size (0.075-mm) with minimum in place hydraulic conductivity of $2x10^{-4}$ m/s.

3.3 CONSTRUCTION QUALITY ASSURANCE / QUALITY CONTROL

The preparatory and construction works outlined in Section 3.2 of this report describes construction staging, foundation preparation and drainage for the HLF pad and embankment, overliner and liner systems. The HLF Technical Specifications, provided as Appendix J in Appendix A, describe technical specifications applicable to development of the lined pad, confining embankment, In-Heap Pond, and Events Pond and the Quality Assurance/Quality Control Testing for each component. The Technical Specifications also provide a detailed accounting of the entire construction work scope that includes: site preparation, fill placement, geosynthetic installation and pipework installation.

Specific features of the Technical Specifications include, but are not limited to the following:

- Mobilization/demobilization of all equipment and material required for the work;
- Installation of temporary interceptor collection ditches and diversions for surface water control;
- Clearing, grubbing and stripping in required areas;
- Excavation in required areas;
- Development of borrow areas within and outside of the HLF limits;
- Construction of access roads for HLF construction;
- Foundation preparation for site grading fill and liner placement;
- Fill placement and compaction;
- Installation of geosynthetic materials for liner, drainage and leak detection systems;
- Installation of solution collection pipework;
- Placement of overliner drain fill; and

- Furnishing and installing materials and constructing items appurtenant and incidental to the above.

3.4 STABILITY AND SETTLEMENT ANALYSES

3.4.1 Slope Stability

Slope stability analyses (Appendix G of Appendix A) were conducted on three cross sections to assess the slope stability of the proposed design for the HLF: one cross section through the maximum height section of each embankment and ore heap; one through a steep section of the HLF which does not intersect the embankment and incorporates the plant site cut slope; and the third through the Events Pond. The locations of these sections are illustrated in Figure G1 of Appendix G to the HLF Design Report (Appendix A).

The HLF dam has been classified as *Significant* hazard according to Canadian Dam Association dam safety guidelines (CDA 2013 and 2014). The dam break analysis is presented in Appendix B. However, for conservatism the HLF embankment design criteria for seismicity is considered as a *High* hazard. CDA design recommendations for *High* hazard dams include consideration of the Earthquake Design Ground Motion (EDGM) produced by an earthquake with an annual exceedance probability of 1 in 2,475 and factors of safety as summarized in Table 2.4-3.

The HLF was evaluated for both static and pseudo-static (earthquake) conditions using a Design Basis Earthquake (DBE) for operational conditions and a Maximum Design Earthquake (MDE) for long-term post-closure conditions. The engineering design criteria provide for an operational minimum static factor of safety of 1.3 for the ore heap (non-impounding areas) and 1.5 for the confining embankment. The minimum factor of safety for pseudo-static conditions is 1.0. The slope stability analyses confirm that the target factors of safety suggested by CDA (2014) are achieved for the HLF design.

3.4.1.1 Phreatic Conditions

Leach Ore Pile

The granular ore heap will be wetted by controlled leaching with a gravity drain system above the pad liner draining to an internal sump. Therefore, the heap will remain in an unsaturated state except within a portion of the In-Heap Pond, where the embankment provides physical confinement. For design purposes, a maximum head of 1.0 m on the pad liner was used in areas outside the In-Heap Pond and the water level in the In-Heap Pond was conservatively assumed to be at the spillway invert. Vibrating wire piezometers will be installed in the In-Heap Pond to monitor and confirm the low phreatic conditions during operations. More details on instrumentation can be found in Section 4.5 of Appendix A.

Embankment and Event Pond

The HLF embankment upstream face will be lined with a double geomembrane composite liner system designed to limit seepage with leak detection. The slope stability modeling used a failure surface in the foundation materials, with no phreatic surface in the embankment.

Foundation

Based on water level data collected since 2010/2011 from six groundwater monitoring wells in the Ann Gulch basin, depths to groundwater in the lower valley range from 3 to 8 m bgs, and in the upper valley range from 8 to 19 m bgs. A liner underdrain will be used to prevent upward hydraulic pressure on the liner. The combination of the liner underdrain and elimination of infiltration due to placement of the liner system is expected to result in a lower groundwater level during operations and into post-operations. For the slope-stability analysis, groundwater was modeled 1 m below the liner, for conservatism.

The liner system will be perforated during closure to provide drainage, therefore the post-closure pseudo-static analyses used a single groundwater surface 1 m below the punctured liner.

3.4.1.2 Stability Analysis

Stability analyses were conducted using the Slope/W component of GeoStudio 2016 (v. 8.16) by Geo-Slope International, Ltd. Slope/W was used to conduct limit equilibrium analyses using the Morgenstern-Price method, which satisfies both moment and force equilibrium. The Slope/W program incorporates a search routine to locate the failure surfaces with the lowest factor of safety within user-defined search limits. Trial failure surfaces were defined with “entry and exit” and “block specified” slip surface types, which allow the search routine to evaluate two different failure shapes. In the entry and exit option, the user defines a range of possible slip surface entry and exit locations within which the most critical (lowest factor of safety) circular failure surface may be identified. With the block specified option, the user defines nodes through which straight lines of the failure surface must pass; this option allows the user to focus the analysis on long, thin areas or layers of low strength (such as a liner interface) which a slip surface could preferentially pass through, contributing to a low factor of safety. A fully-defined slip surface was used to specifically evaluate failure surfaces along the liner. Additional details and material properties used in the analyses are provided in Appendix G of the HLF Design Report (Appendix A).

Stability Analysis Results

The results of the slope stability analyses are shown in Table 3.4-1, and are included as Attachment G1 to Appendix G of the HLF Design Report (Appendix A). Acceptable factors of safety are demonstrated for both the ore pile and the HLF confining embankment.

Table 3.4-1: Stability Results for the HLF

Stability Analysis Description	Factor of Safety		
	Circular	Block	Fully Specified
Section A			
Static	1.9	1.6	2.1
Pseudo-static	1.3	1.1	1.5
Pseudo-static Post-operation	1.2	1.0	1.5
Post-earthquake	1.9	1.4	1.1
Section B			
Static	2.0	2.1	2.0
Pseudo-static	1.5	1.4	1.5
Pseudo-static Post-operation	1.3	1.3	1.2

Post-earthquake	2.0	1.9	1.6
Section C			
Static	1.6	1.8	-
Pseudo-static	1.2	1.3	-

3.4.1.3 Dynamic Deformation

A dynamic deformation analysis was completed for the cross section through the maximum height of the embankment and ore pile to evaluate the potential impact of deformation of the confining embankment during the design earthquake event. The deformations were estimated using the method developed by Bray and Travasarou (2007), which is based on the results of a series of finite element studies calibrated to actual measured movements in dams and other structures constructed with geomembrane liner systems.

The deformation results calculated by the method proposed by Bray and Travasarou (2007) are presented in Appendix G of Appendix A and Table 3.4-2.

Table 3.4-2: Dynamic Deformation Results: Estimate Vertical Displacement against Probability of Exceedance

Probability of Exceedance (%)	Embankment Displacement (cm)	Heap Displacement (cm)
84	<1	3.4
50	<1	6.8
16	<1	13.2

The deformations reported above were deemed to be reasonable and the risk of loss of containment due to earthquake-induced deformation considered to be low.

3.4.2 Settlement Assessment

A two-dimensional settlement analyses was performed to assess strains on the HLF liner system and pipework systems under expected loading conditions (Appendix H in Appendix A). The construction of the HLF will apply loads to the foundation soils which would result in total and differential settlements. These settlements may impact the performance of the proposed liner system and collection pipe network at the base of the HLF pad. In addition, the settlements may impact the stability of the confining embankment and the performance of other facilities directly associated with the embankment such as the conveyor system and the In-Heap Pond. A finite element stress-deformation modelling program (Sigma/W) was used to estimate the strain on the liner system and drainage pipes due to expected loading conditions. The assessment was conducted using data collected from geotechnical site investigations and site information obtained from various BGC reports.

The maximum allowable strain on the composite liner system is 8%, which represents the recommended value for the textured LLDPE geomembrane (Peggs, 2005). While the GCL yield strain is estimated to be more than 50%, in practice the maximum allowable strain would be less than 10% to limit the thinning of bentonite which could affect the performance of the GCL (LaGatta, 1997). The results of the differential settlement analyses presented herein predicted a maximum value of 2%, which indicates a factor of safety of about 5 for the GCL and 4 for the geomembrane.

HDPE pipe can withstand an axial strain approaching 10% without permanent damage (Chevron, 2016). For conservatism and to account for pipe joint separation, a maximum allowable strain of 5% was used for the proposed HDPE solution collection pipes. The analyses indicate a factor of safety of 2.5 for the HDPE drainage pipework.

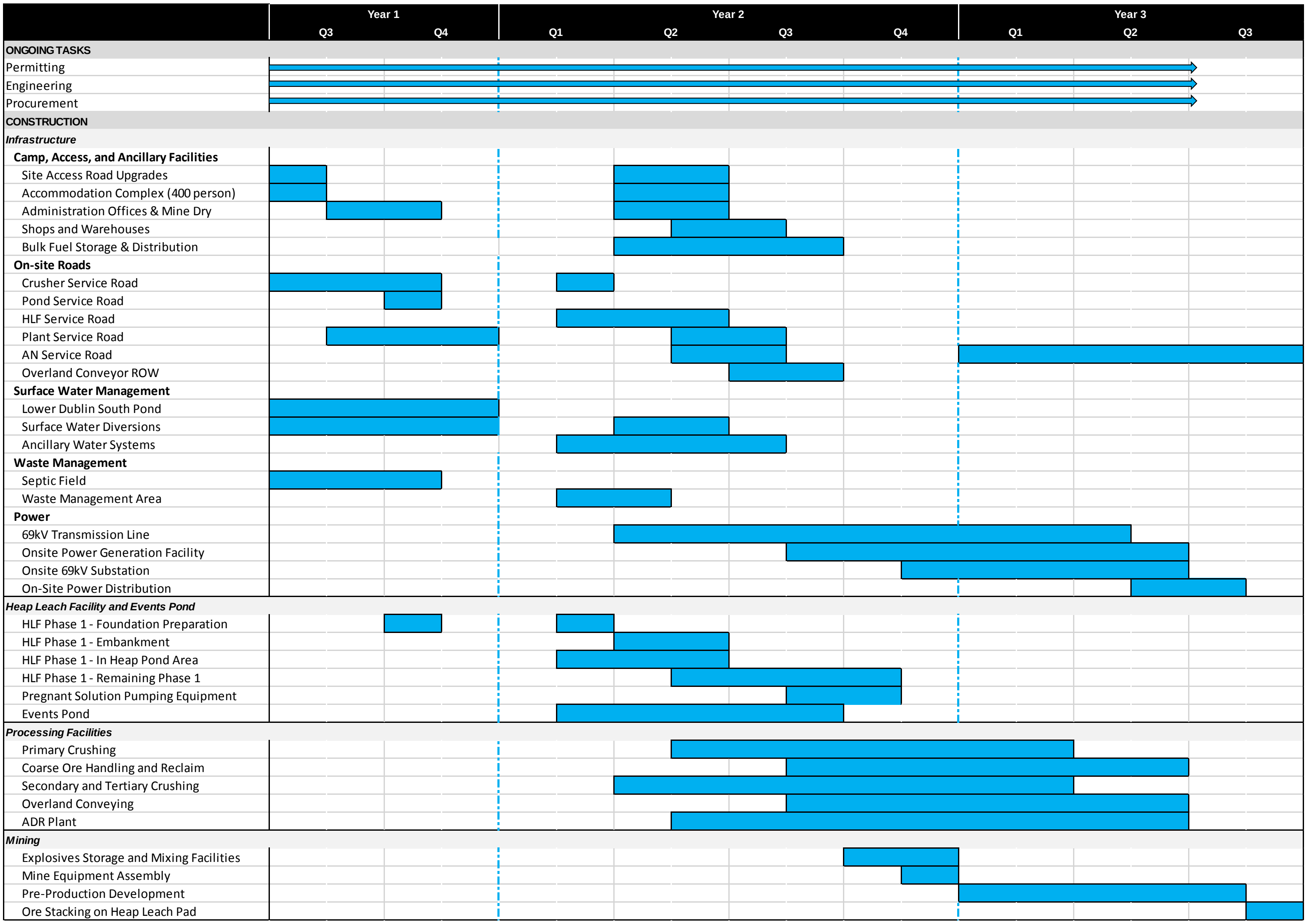
Appendix H of the HLF Design Report (Appendix A) presents the settlement calculations.

3.5 CONSTRUCTION SCHEDULE

3.5.1 Overview

A construction schedule is provided in Table 3.5-1. This construction schedule is illustrative and dependent upon receipt of continuing regulatory approvals, project financing, contractor availability and seasonal limitations.

Table 3.5-1: Construction Schedule



3.5.2 Rough Earthworks

In 2017, preparation of the ground for construction of Phase 1 of the HLF began with clearing and grubbing of the embankment site to allow for foundation preparation of the confining embankment and the In-Heap Pond area. Once cleared and grubbed, topsoil was stripped and stockpiled for later use in the reclamation and closure phase of the Project. During these activities, any material identified to be suitable for use in construction was segregated and stockpiled.

Following topsoil stripping, the area was assessed for any instances of permafrost with the intent to remove any such material and replace it with suitable fill.

Clearing, grubbing and grading of the HLF foundation preparation began Q3 2017 with a target completion date of Q2 2018. Additional rough earthworks for Phase 1 of the HLF, following the procedures described above, will continue throughout 2018, with a winter hiatus into Q1 2019 due to cold weather, to prepare the Events Pond and the up-gradient Phase 1 HLF interceptor ditch.

3.5.3 Foundation Preparation

Foundation preparation for the HLF embankment commenced in in Q3 2017 and, for the embankment and Phase 1 area of the HLF, will continue until Q2 2018. The HLF foundation preparation activities are discussed in Section 3.2.2 and the Heap Leach Facility Foundation Improvement Plan.

3.5.4 Water Management Features

3.5.4.1 Sediment Control Ponds and Runoff Interception Ditches

Sediment control ponds, sediment/exfiltration basins, runoff interception ditches, and other sediment and erosion control structures will be constructed on an ongoing basis during the development of the HLF. The construction sequencing, inspection, and maintenance of these structures are discussed in the Operations Water Management Plan.

3.5.4.2 Events Pond

Upon completion of rough earthworks for the Events Pond, subgrade will be leveled out and consolidated to provide a sound structure to build upon. This work is currently assumed to take place in Q2 and Q3 2018. The placement of structural fill and the installation of the liner system, including leak detection and recovery systems, are then assumed to be completed in Q3 2018.

3.5.5 HLF Pad Liner

The first construction stage of the HLF liner system will commence upon completion of rough earthworks and begins with the installation of the underdrain system. Installation of the underdrain system will commence in Q2 2018 with completion anticipated in early Q3 2018. Placement of the different Phase 1 geosynthetic liner systems, as described in Section 3.8, will then commence with target completion in late Q3 2018.

Construction activities on the HLF pad liner systems that require the use of heavy equipment will not occur during the coldest months of the year to ensure the liner systems are not damaged. In Q4 2018 solution collection valves, flanges, couplings, etc. will be installed.

In mid to late 2018, ODF placement will begin in stages to align with the construction of different areas of the liner system.

3.5.6 Confining Embankment

Construction of the confining embankment will commence in Q2 2018 and will continue for approximately 4 months. The placement of the embankment fill is not a seasonally constrained activity but may be halted for brief periods on the recommendation of onsite geotechnical engineers during periods of heavy snow which could impact the compaction of the fill material.

3.6 HEAP LEACH PAD AND CONFINING EMBANKMENT

3.6.1 General

The design incorporates a double-side textured 80-mil LLDPE liner. A GCL will be used in lieu of a 300mm thick layer of compacted low-permeability material. GCL will be placed underneath the geomembrane and will provide equal or greater protection than 300mm material having a saturated hydraulic conductivity of no greater than $1x10^{-6}$ cm/s.

The HLF is designed to contain a network of pipes throughout the limits of the facility and will collect and convey PLS and any meteoric water that infiltrates into the heap.

In summary, the proposed Heap Leach Pad will consist of two liner systems (see EGHLF-XD-02-06 in Appendix A):

- In-Heap Pond Liner System.
- Up-gradient Heap Leach Pad Liner System.

Section 3.8 presents the liner system details. A minimum one meter (1 m) thick layer of overliner material will be placed over the LLDPE geomembrane in the In-Heap Pond area. The ODF will be placed in bulk onto the liner using suitable haulage equipment or conveyors and spread by dozers in a uniform layer.

Solution collection pipes will be placed within the ODF to convey PLS to the In-Heap Pond which is defined by the confining embankment.

The HLF embankment confines and provides stability to the HLF ore pile. It also creates an In-Heap Pond configuration that provides storage of pregnant solution within the ore pore spaces of the ore. The embankment location, geometry, and height determine the ore storage capacity and solution storage capacity of the HLF.

3.6.2 Confining Embankment Design Requirements

The HLF will provide heap stability and containment of process solutions in the In-Heap Pond. The embankment dam is designed as an earthfill/rockfill structure with a geomembrane lined upstream dam face and appropriate fill to ensure containment integrity. Appendix J of the HLF Design Report (Appendix A) presents the fill specifications for the HLF confining embankment.

The Embankment height was determined in conjunction with the In-Heap Pond storage capacity. The embankment height depends on the required In-Heap Pond storage capacity, which was informed by the results of the water balance modeling conducted for the HLF (The Mines Group, 2017), while considering various scenarios outlined in the HLF Contingency Water Management Plan (SGC 2017). To determine the confining embankment height, a stage-storage curved based on the embankment design and HLF grading was developed. The actual net capacity (storage volume within the open pore space) of the In-Heap Pond was determined using the volume of each layer of pond and the associated bulk density. The In-Heap Pond consists of 16 mm, 12 mm, and 6.5 material with a bulk density of 1.68 tonne/m^3, 1.71 tonne/m^3, and 1.72 tonne/m^3 respectively. By using these densities and volumes, the In-Heap Pond volume was calculated to be 120,100 m^3. This was done using the Specific Gravity of 2.65 to calculate the porosities for each layer which was found to be 36.6%, 35.9%, and 35.1% for the 16 mm, 12 mm, and 6.5 mm respectively. The porosities were then used to find the storage volume of the In-Heap Pond listed above. The bulk densities used are based on the findings summarized in Appendix C.

The embankment section includes an 8 m crest width at elevation 939.5 m asl for road and pipeline access and 2.5H:1V upstream and downstream slopes. The fill types include compacted rockfill and earthfill material taken from selective excavations for placement in the central and downstream section of the embankment. More competent durable rock for production of required drain rock will be quarried and crushed from required site excavations, and filter materials will be produced from screening of placer fill materials in the Dublin Gulch valley bottom.

3.7 SOLUTION STORAGE FACILITIES

The HLF can be classified as a *Significant* dam based on the CDA guidelines (2013, 2014), however, the use of the Probable Maximum Flood (PMF) event, and an *Extreme* dam classification, as the design basis was prescribed by the Yukon Water Board and is one of the Terms and Conditions of SGC's current permit. The capacities for the In-Heap Pond, the In-Heap Pond Spillway and Events Pond described below have been designed to accommodate the passage of the PMF through the HLF without damage to the HLF and its spillway in accordance with the WUL, and additionally, for containment of total runoff from the HLF up to and including the PMF event.

The HLF and associated solution storage facility designs have been informed by the Design Flood Passage Study (BGC 2017c), the Heap Leach Water Balance Model (Mines Group 2017) and the HLF Contingency Water Management Plan (SGC 2017).

The PMF runoff was calculated using a 24-hour Probable Maximum Precipitation (PMP) event of 256 mm (Knight Piésold 2013) contributing over the catchment areas for Phases 1, 2 and 3 of the HLF. The solution storage facilities will have an approximate combined storage capacity of 420,000 m^3 (Table 3.7-1). Note that the PMF (258,800 m^3) is wholly contained in the Events Pond (capacity of 299,900 m^3) assuming the In-Heap Pond is full.

Table 3.7-1: Heap Leach Facility Solution Storage Capacity

Volume (m^3)	By Phase 3
Design Volume	
In-Heap Pond	120,100
Events Pond	299,900
Total	420,000
Calculated Events Volume	
HLF PMF Runoff	258,800
In Heap 72-hr draindown	149,400
Total	407,800
Surplus HLF Storage Capacity	**11,800**

3.7.1 In-Heap Pond Spillway

The In-Heap Pond spillway was designed in accordance with the license conditions mandated by the Yukon Water Board in SGC's current permit and uses the PMF event as a design basis. Flow from the spillway is routed to the Events Pond. For sizing the spillway, the analysis (Appendix B of Appendix A) assumed that Phase 1 of the pad is constructed, Phases 2 and 3 are being cleared and grubbed for construction, and the pad is loaded with ore to the elevation of the spillway invert. The analysis also conservatively assumed that no infiltration would occur into the loaded ore and the In-Heap Pond was assumed to be full at the onset of the PMF. Therefore, no attenuation of the incoming peak flow was assumed due to storage within the In-Heap Pond. The HLF interceptor collection ditches (sized for the 100-year, 24-hour event) were assumed to have overtopped resulting in the entire upstream watershed contributing to the peak flow.

The peak flow from the PMF at the outlet of the In-Heap Pond is estimated to be 12.2 m^3/s based on hydrologic modeling in the analysis. This is the design flow for the spillway. The summary of hydrologic modeling can be found in Appendix B of the HLF Design Report (Appendix A).

The spillway will route runoff exceeding the storage capacity of the In-Heap Pond into the Events Pond. The spillway will only convey runoff during exceptionally large precipitation events. The outlet for the In-Heap Pond, and correspondingly the inlet structure for the spillway channel is comprised of two side-by-side 1.5 m x 1.5 m concrete box culverts which will convey the design flow without overtopping. The spillway channel will have a trapezoidal cross section with a bottom width of 3.5 m and side slopes angled at 2.5H:1V. The channel invert gradient will vary between 2% and 14% and will traverse cross-slope to minimize gradient and limit cut and fill. The spillway channel will follow a 20-m radius bend prior to discharging into the Events Pond. The outlet of the spillway channel will consist of a trapezoidal drivable swale with a bottom width of 3.5 m and side slopes angled at 25% (4H:1V). Superelevation of the water surface in the bend immediately upstream of the Events Pond was also evaluated against the available freeboard.

The U.S. Army Corps of Engineers Hydrologic Engineering Center's HEC-RAS model, version 4.1 (HEC, 2010b) was used to model flows up to the design flow event and estimate hydraulic parameters used in the design of the spillway channel.

The spillway will have an invert of 938 m asl at the upstream end. This configuration allows a 1.0 m of freeboard from the maximum anticipated water surface elevation to the crest of the Embankment. The In-Heap Pond Spillway design details are discussed further in Appendix B of the HLF Design Report (Appendix A).

Drawings EGHLF-XD-07-04 in Appendix A present details of the In-Heap Pond Spillway design.

3.7.2 Events Pond

The final Events Pond capacity was informed through an iterative process using stochastic water balance modeling (The Mines Group, 2017) and while considering various scenarios described in the HLF Contingency Water Management Plan. Thus, a final capacity of the Events Pond of approximately 299,900 m^3 to the spillway invert at elevation 894.5 m has been provided in the final design. The volume provided in the final design above the modelled PMF volume also considers that a certain volume of water could be stored in the Events Pond when the PMF occurs.

There is a total capacity of approximately 340,000 m^3 to the crest of elevation of 895.5 m of the Events Pond.

The peak discharge from the PMF through the Events Pond spillway after hydrologic routing assumed 3.8 m^3/s. The spillway on the Events Pond will have a bottom width of 3 m and a depth of 0.8 m. The Events Pond design details are discussed further in the HLF Design Report (Appendix A). See Drawings EGHLF-XD-07-01 through EGHLF-XD-07-06 in Appendix A for the Events Pond design details.

3.8 LINER SYSTEMS

3.8.1 Liner System Design

3.8.1.1 General

The liner for the leach pad and event ponds will consist of a composite geomembrane and underlying low-permeability bedding material, which is the state-of-practice liner system for heap leach facilities. The primary purpose of the composite liner system is to prevent the loss of HLF process solutions for both environmental and economic reasons.

A GCL will be used in lieu of a 300 mm thick layer of compacted low-permeability material.

Differential settlement on the liner system due to variable loading conditions was considered in the liner design and is discussed in Section 3.4.2.

A layer of ODF comprised of gravel material will be placed over the LLDPE geomembrane to promote drainage. The ODF will consist of a minimum 1.0 m thick layer of crushed material over the In-Heap Pond area and 0.6 m - over the remainder of the HLP. A network of perforated piping will be embedded in the layer to help convey the solution within the layer. Drainage collected in the overliner collection system will report to the sump within the In-Heap Pond. The primary functions of the ODF are to minimize hydraulic heads on the liner system to, reduce the risk of leakage, protect the synthetic liner from damage during ore placement, and maximize the return of the gold containing pregnant solution for processing. Piezometers will be installed within the liner cover fill to monitor the hydraulic head on the liner system during pad operation.

The In-Heap Pond will have a double-geomembrane liner installed over a GCL liner together with a leak detection system. The leak detection system will be installed between the two geomembranes to monitor and recover any leaks through the top geomembrane.

The Events Pond also will incorporate a double-geomembrane liner installed over a GCL liner together with a leak detection and recovery system. This will allow it to temporarily contain excess solutions for short durations until the excess solution is evacuated and used as make-up water for fresh ore. Details of the pad and pond liner systems are shown on Drawing EGHLF-XD-02-06 in Appendix A.

3.8.1.2 Liner Subgrade

Subgrade surfaces below the GCL will be rolled with a smooth-drum compactor to remove any wheel ruts, tracks or other abrupt grade changes greater that 25 mm in depth. All protrusions extending more than 12 mm from the subgrade surface will be removed. The prepared subgrade will be smooth and free of any vegetation, sharp-edged rocks, stones, sticks, construction debris, and other foreign matter that could contact and potentially damage the GCL. All work to prepare the subgrade for GCL placement, including any areas subject to invasive evaluation methods and their subsequent repair, shall be completed to the satisfaction of the engineer of record.

3.8.1.3 Geomembrane Selection

The critical aspects of geomembrane selection for the Project include accommodation for puncture resistance, elongation capacity (elasticity), expected foundation consolidation in fill areas under the ore heap, adequate interface shear strength between the pad geomembrane and the underlying soil liner or GCL and overlying cover fill for heap stability, and satisfactory performance under exposure to climatic conditions (temperature expansion and contraction, wind forces, and sunlight ultraviolet (UV) effects).

The geomembrane types typically used for HLFs are LLDPE, HDPE, and polyvinyl chloride (PVC). The more flexible LLDPE and PVC geomembranes are best for buried applications subjected to high loads such as the leach pad. HDPE geomembrane is best for exposed applications such as ponds and ditches. LLDPE geomembranes were selected for the leach pad including the In-Heap Pond geomembrane, and HDPE geomembranes were selected for the Events Pond for the following reasons:

- LLDPE geomembrane has significantly better elongation performance, puncture resistance, interface friction strength, and stress cracking resistance compared to HDPE geomembrane;
- LLDPE geomembrane remains flexible at temperatures well below freezing to about -25°C with a low temperature brittleness of -70°C according to ASTM D-746;
- HDPE geomembrane has better chemical and UV resistance; and
- LLDPE geomembrane can be readily seamed to HDPE geomembrane.

A 2.0-mm (80-mil) LLDPE top geomembrane was selected for the leach pad, based on performance requirements, past design, construction experience and load testing. The geomembrane will be double-side textured above the GCL to enhance heap stability and construction safety. The Events Pond top geomembrane will be 2.0-mm (80-mil) single-side textured HDPE with the textured side up for traction.

A geocomposite (drainage net) will be installed between the In-Heap Pond and Events Pond geomembrane systems and will tie to a leak detection sump and pipe system for collecting and removing any leaks through the top geomembrane. The geocomposite consists of a geonet heat-laminated on both sides with nonwoven geotextile. The geonet is a net-like polymeric material formed from intersecting ribs integrally joined at the junctions and is used to facilitate drainage between the geomembranes.

3.8.1.4 Liner System Testing

A large-scale puncture test was performed on the 1.5mm (60-mil) and 2.0mm (80-mil) double-side textured LLDPE geomembrane underlain by a GCL and subgrade soil liner and overlain by granular fill with various maximum particle sizes. The soil subgrade and cover fill materials were of representative samples obtained from the project site. A normal stress of 4,413 kPa (640 psi), which represents 150% of maximum ore load, was applied for 48 hours and the geomembrane inspected for damage. No punctures were observed visually or detected by a vacuum box test with a negative pressure of 62 kPa (9 psi). The geomembrane puncture test results are included in Appendix A4 of the HLF Design Report (Appendix A). Liner puncture tests for the following drain cover materials:

- minus 25mm (1-inch)
- minus 38mm (1.5-inch)
- minus 50mm (2-inch)

All tests passed for both 1.5mm and 2.0mm LLDPE geomembrane with no significant damage to liner under max static loading. Therefore, 1.5mm LLDPE with a drain cover material containing particles up to 50mm could be considered acceptable for operational use. However, 2.0mm LLDPE with maximum 38mm drain cover particle size was conservatively selected for design for better operational reliability of the liner system and to mitigate against potential geomembrane damage considering construction loading that may occur during placement of the drain gravel over the geomembrane.

A large-scale direct shear test was performed on the interface between the textured LLDPE geomembrane and the underlying GCL and soil subgrade and overlying cover fill materials from the site. The test was performed to obtain interface shear strength parameters for use in the heap stability analyses. The results of the test are provided in Appendix A4 of the HLF Design Report (Appendix A) along with results of the stability analyses (Section 3.4).

3.8.2 Overliner Drain Fill

Solution will be collected in the high permeability overliner material at the base of the heap pad, with perforated collection pipes placed within the overliner to increase solution removal rates. The ODF will be placed over the entire In-Heap Pond and leach pad area including the upstream face of the confining embankment. The ODF will be produced from the crushing of relatively clean durable rock material. Some screening may be required to produce a free draining, non-plastic, ODF material with a minus 38 mm maximum rock size and a maximum of 5 percent fines passing the No. 200 ASTM sieve size (0.075-mm). The design criteria specify an ODF permeability and maximum ore heap load to ensure both reasonable spacing of the drain pipes and fully drained heap conditions. The ODF will have an operation permeability of $2x10^{-4}$ m/s or higher.

The ODF will consist of a 1 m thick layer of crushed material in the In-Heap Pond area. Otherwise, the minimum ODF thickness in the leach pad area will be 0.6 m. A thicker layer, a minimum of twice the pipe diameter, shall be placed above the larger diameter primary collection drain pipes. A network of perforated piping will be embedded in the layer to help convey the solution within the layer. Drainage collected in the overliner will report to the In-Heap Pond.

The primary functions of the ODF are as follows:

- minimize the head on the geomembrane liner system to reduce the risk of process solution leakage,
- protect the synthetic liner from damage during ore placement,
- maximize the return of the gold containing pregnant solution for processing.

The piping network embedded in the ODF will consist of a series of dual wall corrugated, smooth interior, slotted collection pipes. The piping network will provide rapid transport of process solution to the In-Heap Pond and maintain a minimal head on the liner. Drawings EGHLF-XD-06-01through EGHLF-XD-06-03 in Appendix A and Figure 3.2-5 illustrate the layout of the solution collection pipework in the ODF material.

3.9 SOLUTION AND LEAKAGE COLLECTION SYSTEMS

3.9.1 Solution Collection System

3.9.1.1 Solution Pipe Network

Solution will be collected in the high permeability overliner material at the base of the heap pad, with perforated collection pipes placed within the overliner to increase solution removal rates. The heap leach pad will contain a piping network distributed throughout the pad and will accommodate the volumes from a 100-year, 24-hour storm in addition to 150% of the flow generated from the applied leaching solution. The drain pipes are located within the free-draining overliner material placed above the pad liner and will collect and convey the stormwater and PLS to the In-Heap Pond.

The drain pipes will consist of 100-mm, 250-mm and 450-mm diameter corrugated dual-wall, perforated ADS N-12 pipes. A series of 100-mm primary collector pipes will be spaced at 25 m on center and arranged in a "herringbone" pattern to convey flows for collection in 450-mm header pipes. Where slope lengths dictate, secondary 250-mm collector pipes will be required to convey flows from the 100-mm pipes to the 450-mm header pipes (Figure 3.2-2).

To maximize the efficiency of the ore's drainage and to minimize the potential for leakage through the pads' liner system, the hydraulic head above the liner was designed to be less than a maximum height of 0.6 m resulting in a minimum secondary pipe spacing ranging from 12 m to 17 m depending on the slope of the leach pad.

The effects of the maximum load on the pipes were analyzed to verify acceptable deflections are not exceeded to ensure integrity of the pipes under operational conditions.

Appendices C and D of the HLF Design Report (Appendix A) present the pipe spacing and flow design calculations, and the pipe deflection analysis, respectively.

3.9.1.2 Solution Collection Sump and Riser

The collection pipe network in the overliner drain fill will direct solution to the sump at the toe of the embankment for pumping through inclined riser pipes to the process plant. The HLF will be graded towards the collection sump at the upstream toe of the embankment.

The base of the sump will be constructed approximately 4.5 m below the elevation of the surrounding liner. The liner system and LDRS will extend under the sump. Solution will be pumped from the sump through up to five available inclined risers to the process plant.

The inclined arrangement will consist of five thick-walled, steel pipes, with a nominal outside diameter of 900 mm to allow for raising and lowering of a submersible pump. Three or four pumps will have the capacity to meet the solution application throughflow. The remaining one or two riser pipes will be installed as a back-up, to maintain access to the sump in the event that the any riser pipes become blocked. The base of the risers will rest on a gravel layer, additional layers of geotextile and geomembrane, and will be located within the overliner material, not on the liner, to provide a buffer zone above the liner system to resist the riser pipes from pushing down into the liner.

The riser pipes will be surrounded with a zone of ODF, which will act as a protective cushioning layer. A zone of ODF will be placed around the base of each riser and at least 5m above the PLS header pipes and drain loop for frost protection and cushion material, and to promote flow of solution toward the riser. Beyond the zone of coarse gravel, the regular crushed ore will be placed.

Drawings EGHLF-XD-05-02 through EGHLF-XD-05-05 of the HLF Design Report (Appendix A) present the sump design details.

3.9.2 Leak Detection and Recovery Systems

3.9.2.1 General

A Leak Detection and Recovery System (LDRS) will be constructed within the In-Heap Pond and the Events Pond and will consist of a monitoring sump equipped with an automatic, fluid-level activated pump located between the primary and secondary liners. The pump will be sized to sufficiently remove fluids to minimize head on the secondary liner.

The ponds will contain a sump for collection of any potential leaks in the primary liner via the geonet material located between the two geomembranes to allow fluid to the sump. More detailed information regarding the LDRS is presented in Appendix F of the HLF Design Report (Appendix A).

Drawings EGHLFXD- 05-01 through EGHLF-XD-05-06 of Appendix A present the LDRS sump and pipework design details for the In-Heap Pond. Drawings EGHLF-XD-07-01 through EGHLF-XD-07-04 of Appendix A present the LDRS sump and pipework design details for the Event Pond.

3.9.2.2 Action Leakage Rates

As presented in Appendix F of the HLF Design Report (Appendix A), a liner leakage analysis was completed to determine required sizes of the LDRS components such as the geomembrane and the sumps, and to determine leakage flow Alert Levels for each pond.

Alert Levels were determined using industry-standard methodology and assuming good Quality Control and Quality Assurance during installation of the geomembrane and subsequent construction of the solution piping and overliner drain fill.

The Alert Levels for the In-Heap Pond, specific to the pond water elevation, are shown in Table 3.9-1.

Table 3.9-1: In-Heap Pond Alert Levels

In-Heap Pond Elevation (masl)	Alert Level 1 (L/day)	Alert Level 2 (L/day)	In-Heap Pond Elevation (masl)	Alert Level 1 (L/day)	Alert Level 2 (L/day)
913	160	3,300	927	18,000	370,000
914	810	16,000	928	21,000	420,000
915	1,300	26,000	929	24,000	490,000
916	1,900	39,000	930	28,000	550,000
917	2,600	53,000	931	32,000	640,000
918	3,500	69,000	932	36,000	720,000
919	4,400	89,000	933	41,000	820,000
920	5,600	110,000	934	47,000	940,000
921	6,800	140,000	935	53,000	1,100,000
922	8,200	160,000	936	61,000	1,200,000
923	9,700	190,000	937	69,000	1,400,000
924	11,000	230,000	938	77,000	1,500,000
925	13,000	270,000		83,000	1,700,000

In-Heap Pond Elevation (masl)	Alert Level 1 (L/day)	Alert Level 2 (L/day)		In-Heap Pond Elevation (masl)	Alert Level 1 (L/day)	Alert Level 2 (L/day)
926	16,000	310,000		939 Embankment crest		

The Alert Levels for the Events Pond specific to the pond water elevation are shown in Table 3.9-2.

Table 3.9-2: Event Pond Alert Levels

Event Pond Elevation (masl)	Alert Level 1 (L/day)	Alert Level 2 (L/day)		Event Pond Elevation (masl)	Alert Level 1 (L/day)	Alert Level 2 (L/day)
883	4,700	150,000		890	31,000	970,000
884	7,800	250,000		891	35,000	1,100,000
885	11,000	350,000		892	40,000	1,300,000
886	14,000	460,000		893	45,000	1,400,000
887	18,000	580,000		894	51,000	1,600,000
888	22,000	700,000		895	57,000	1,800,000
889	26,000	830,000		895.5 spillway invert	60,000	1,900,000

If during normal operations it is found that the amount of fluid pumped back to the pond from the LDRS exceeds the AL1, the operator should take action as described in the Heap Leach and Process Facilities Emergency Response Plan (Appendix D) to determine the cause. This action may include physical inspection, mechanical leak detection, electric leak location, or other methods to determine what is causing the Alert Level 1 exceedance to maintain the liner integrity such that the Alert Level 2 is not exceeded.

If during normal operations it is found that the amount of fluid pumped back to the pond from the LDRS exceeds Alert Level 2, the operator should follow the Heap Leach and Process Facilities Emergency Response Plan (Appendix D).

3.9.3 Underdrain System

The HLF underdrain system provides for the collection and drainage of subsurface water beneath the lined facility to limit upward pressure on HLF liner. The underdrain will be constructed with geofabric wrapped around granular drain rock backfill materials and 100 mm perforated pipes placed at regular intervals (approximately 75m spacing) beneath all phases of the HLF, with additional drains to be installed during construction as field conditions dictate. The drains will convey unaffected subsurface water to collector pipes that will discharge to an outlet monitoring vault. The vault is configured to allow for sampling of seepage flows for water quantity and quality, and is equipped with a pump system to return flows to the HLF for use as make up water or allow flows to outfall to

Dublin Gulch if discharge criteria are met. Details of the proposed underdrain system are shown in Figure 3.2-5 and Drawings EGHLF-XD-03-03 through EGHLF-XD-03-04 of Appendix A.

In addition to providing control for groundwater seepage, the underdrain system also provides leak monitoring capability for the upper HLF (above the in-heap pond area). The transverse primary underdrains will provide interception of potential leakage through the liner, and the underdrain header collection pipes will be placed below the PLS header pipe corridor where flows will be concentrated during leaching operations, thereby providing leak monitoring of critical areas most likely to have fluid present on the liner system during much of the operational life of the facility.

The proposed liner system is designed to limit any leakage through the geomembrane by use of a low permeability GCL. It is highly unlikely that substantial leakage through the geomembrane and GCL components of the liner due to the composite nature of the liner system. Under normal conditions, low hydraulic head levels will be present over the liner system in the upper HLF area resulting in low leakage rates. The lower HLF area will include a double lined facility with a leak detection and recovery system. In these areas, the underdrain system will provide a secondary detection capability.

In the unlikely event unplanned measurable leakage occurs from the liner system, the unplanned discharge would be identified during regular inspections at the outlet monitoring vault. Separate non-perforated collection pipes for each phase of the HLF allow the outflows from each area to be monitored independently. This allows for more focused mitigation actions in the case of water quality exceedance from the underdrain monitoring system. The vault is also equipped with a pump system to return any leakage identified to the ADR/HLF.

3.9.4 Closure Drain System

During closure of the HLF, cyanide in the spent ore will be destructed and the heap will be rinsed. Once acceptable water quality is verified, the liner system below the In-Heap Pond will be punctured by drilling to allow complete drainage of water through a pre-installed outlet system. The closure inlet sump and drain pipes are sized to convey the wettest month precipitation to minimize solution accumulation within the spent ore. The closure drain inlet system will consist of a LLDPE lined gravel sump with perforated N-12 pipe drain loop directing flow to PE outlet pipes. The closure sump will be placed directly below the leak detection sump to ensure that residual flows from the leak detection system are directed to the closure outfall.

The liner system will be punctured by drilling through two 250 mm pre-installed open casing pipes extending to the PLS sump. A drill string will be lowered through each casing allowing drilling through the PLS and LDRS sump liners. A series of pre-installed steel plates will guide the drill and stop the drilling head at the appropriate depth within the closure sump. Once the drill string is retrieved, fluid will drain through the punctured liner into the closure sump where it will enter the closure outlet pipe and drain under pressure to the outlet vault.

The closure drainpipes will be directed to the underdrain system outlet vault, and will use similar controls to allow for water quality and quantity monitoring. The underdrain pump return system will remain in place to allow return of flows to the HLF if needed. The closure outlet system is presented in Drawings EGHLF-XD-03-05, EGHLF-XD-05-05, and EGHLF-XD-05-06 of Appendix A.

3.10 SOLUTION CONVEYANCE AND PUMPING SYSTEMS

3.10.1 General

Barren solution containing cyanide will be applied to the ore stacked on the HLF to extract the gold. After passing through the ore, this solution will be collected by the solution recovery system.

A series of barren solution pumps located at the Adsorption Desorption Recovery (ADR) facility (Figure 3.10-1) will pump solution to the Heap Leach Pad. Pressure piping will be dual contained at all times. A series of pipe headers will distribute the solution to secondary and tertiary headers, and ultimately to drip emitters placed on or under the surface of the ore during sub-zero conditions. Fresh sodium cyanide solution will be added as needed to the barren solution tank at the ADR facility. The primary supply line will be located within the pad and a safe distance from the service roads and conveyors.

The PLS recovery pumps are located in the In-Heap Pond sump as described above in Section 3.9.1. Up to five vertical turbine pumps will be used to advance the PLS to the ADR plant at a design rate of 2,070 m^3/h. The PLS recovery pump system is presented in Drawings EGHLF-XD-05-01 through EGHLF-XD-05-04 of Appendix A.

The process pumping system includes pumps, pipelines, valves, and associated controls to move solution between the ADR plant and the HLF.

The process pumping and solution delivery systems include the following provisions for year-round operation:

- ability to heat barren solutions
- buried emitters (ripped in by dozer) to a depth of at least 1 m
- heat traced and insulated barren solution tank
- heat traced and insulated (or buried) pipelines as needed
- backup power supply to pumps via emergency generators
- provision for pipeline drain down upon shutdown.

3.10.2 Cold Weather Considerations

A review and comparison of heap leaching operations in cold climates indicates year-round leaching operations at the Eagle Gold site is feasible. Design provisions are incorporated to add and maintain heat in the process solutions applied to the heap.

Since ore particle size, ambient temperatures, delivered ore moisture, and snowfall may play a role in the ability to stack in winter, the Project has adopted the following mitigation measures:

- selected an in-valley heap configuration to create a heat sink
- selected a south-facing valley
- use of the In-Heap Pond for PLS storage
- sizing of the fine ore crushing operation to allow increased production rate during warmer months
- incorporation of a temporary ore stockpile to accommodate 90 days of ore storage.

- sizing of the starter HLP to accommodate more than one year of ore production to allow advanced stacking for at least the first winter season
- 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 (buried for cold weather operations)
- heat-tracing and insulating the barren tank
- heat-tracing and insulating (or burying) pipelines, and
- generators for backup power supply to pumps and emergency process equipment.

3.11 ORE PROCESSING AND PAD DEVELOPMENT

3.11.1 Ore Crushing and Delivery

Ore will be mined and delivered to the primary crusher at a rate of 29,500 t/d (10.76 Mt/a). The remaining crusher units, conveyor and portable stacking system are designed to crush and place ore at a rate of 39,200 t/d. The locations of the crushing system are shown on Figure 3.11-1. The HLF will operate year-round. During most of the year (275 d/a) ore will be crushed, and stacked using a conveyor stacking system. Primary crushed ore will be stockpiled on the temporary ore stockpile during the coldest 90 d each winter. Leaching of ore on the heap leach pad occurs on a year round basis.

Ore will first be delivered by haul truck to the primary crusher, located north of the open pit. During regular operations (275 d/a), the crushed ore will then be transported by covered conveyor from the primary crusher to the coarse ore transfer station. Ore will then be transported to the secondary and tertiary crushers. The crushed ore will be transported by covered conveyor to the HLF for stacking. Column leach test results indicated that crushing to a P80 size of 6.5 mm will lead to an overall average gold recovery ranging from 68 to 79% (Table 3.11-1). Sodium cyanide requirements were estimated to average 0.35 kg/t at a 6.5 mm crush size. Lime requirements were estimated to average 1.00-2.00 kg/t.

Table 3.11-1: Summary of Gold Recovery by Ore Type

Material Type	Gold Recovery (%)
Weathered Granodiorite	79
Fresh to Weakly Altered Granodiorite	73
Seretic, Chloritic, Carbonate Altered Granodiorite	68
Weathered Metasediments	73
Unaltered Metasediments	68

Source: KCA 2016

A series of compacted permeability tests were conducted to determine heap permeability under various pressures. The tests simulated loads at various heap heights between 0 and 150 m. All of the conventionally crushed samples demonstrated good stability and low slump without cement agglomeration (KCA 2012 and 2016). As part of standard quality assurance testing and final design development, additional test work to evaluate the need for agglomeration has been undertaken on representative ore during initial crushing and processing output runs.

3.11.2 Heap Leach Pad Stacking

The heap leach stacking plan was designed in coordination with the mining plan to efficiently schedule ore stacking and leaching over the LOM. Ore will be stacked on the HLF in lifts in accordance with stacking equipment capacity. The tonnage on each lift was calculated based on the tonnes per day of crushed ore, conveyed to the HLF and the lift volumes. The HLF will undergo year-round leaching with the stacking of ore occurring 275 days per annum (d/a).

The In-Heap Pond area will be the first area filled with ore. As stacking operations advance, ore will be stacked on top of the HLF in 10 m lifts. Ramps will be established to allow conveyor access to the top of the heap for construction of additional lifts. Table 3.11-2 and Drawing EGHLF-XD-02-02 in Appendix A summarize the currently proposed stacking plan (Table 3.11-3).

Table 3.11-2: Pad Stacking Plan

Lift No.	Top Elevation (m)	Incremental Area (m^2)	Cumulative Area (m^2)	Incremental Volume (m^3)	Cumulative Volume (m^3)	Incremental ore to heap leach pad (kt)	Cumulative ore to heap leach pad (kt)	Mine Year	Stacking Time	
									Days	Months
High Perm Area	930	15,203		105,978	105,978	182,281	182,281	1	31	1
Intermediate Liner	935	19,028		94,215	200,193	162,050	344,331	1	151	5
Lift 1	945	37,461	44,036	352,585	552,778	606,446	950,778	1	121	4
Lift 2	955	56,355	72,737	527,280	1,080,057	906,921	1,857,699	1	61	2
Lift 3	965	73,349	100,737	703,007	1,783,065	1,209,173	3,066,871	1	31	1
Lift 4	975	91,511	130,652	883,043	2,666,108	1,518,834	4,585,705	1	40	1
Lift 5	985	111,622	163,585	1,082,465	3,748,572	1,861,839	6,447,544	1	52	2
Lift 6	995	106,272	194,712	1,032,185	4,780,758	1,775,359	8,222,903	1	152	5
Lift 7	1005	128,216	230,906	1,237,173	6,017,930	2,127,937	10,350,840	1	49	2
Lift 8	1015	152,848	270,478	1,483,222	7,501,152	2,551,141	12,901,982	2	61	2
Lift 9	1025	177,810	311,271	1,732,139	9,233,292	2,979,280	15,881,261	2	73	2
Lift 10	1035	204,613	356,109	1,986,762	11,220,054	3,417,231	19,298,492	2	80	3
Lift 11	1045	246,443	415,612	2,401,771	13,621,825	4,131,046	23,429,538	3	182	6
Lift 12	1055	271,727	462,823	2,693,334	16,315,159	4,632,535	28,062,073	3	112	4
Lift 13	1065	295,223	516,469	2,924,889	19,240,048	5,030,810	33,092,883	3	212	7
Lift 14	1075	287,057	548,973	2,910,041	22,150,089	5,005,270	38,098,153	4	144	5
Lift 15	1085	273,792	575,840	2,799,906	24,949,994	4,815,838	42,913,990	4	212	7
Lift 16	1095	256,740	599,048	2,635,826	27,585,821	4,533,622	47,447,612	5	132	4
Lift 17	1105	254,855	637,813	2,570,242	30,156,063	4,420,816	51,868,428	5	204	7
Lift 18	1115	231,360	659,094	2,368,550	32,524,613	4,073,907	55,942,335	6	122	4
Lift 19	1125	217,805	686,213	2,234,868	34,759,481	3,843,973	59,786,308	6	111	4
Lift 20	1135	209,884	720,273	2,141,794	36,901,275	3,683,886	63,470,194	7	193	6
Lift 21	1145	200,901	753,384	2,052,494	38,953,769	3,530,289	67,000,483	7	101	3
Lift 22	1155	185,806	780,343	1,916,122	40,869,891	3,295,729	70,296,212	7	101	3
Lift 23	1165	169,419	802,802	1,761,583	42,631,473	3,029,922	73,326,134	7	163	5
Lift 24	1175	152,228	824,376	1,580,209	44,211,682	2,717,959	76,044,093	8	92	3
Lift 25	1185	138,995	846,817	1,445,750	45,657,432	2,486,689	78,530,783	8	70	2

Lift No.	Top Elevation (m)	Incremental Area (m²)	Cumulative Area (m²)	Incremental Volume (m³)	Cumulative Volume (m³)	Incremental ore to heap leach pad (kt)	Cumulative ore to heap leach pad (kt)	Mine Year	Stacking Time	
									Days	Months
Lift 26	1195	122,227	866,815	1,286,434	46,943,866	2,212,667	80,743,449	8	142	5
Lift 27	1205	110,385	889,400	1,141,348	48,085,214	1,963,119	82,706,569	8	61	2
Lift 28	1215	101,743	916,068	1,047,118	49,132,332	1,801,042	84,507,611	9	49	2
Lift 29	1225	72,419	923,804	825,233	49,957,565	1,419,401	85,927,012	9	52	2

Table 3.11-3: Leaching Plan

Lift No.	Elevation (m)	Mine Year	Primary Leach (days from start of stacking)	Days Leached	Secondary Leach (days from start of stacking)
High Perm Area	930	1	212.00	19	231
Intermediate Liner	935	1	212.00	19	231
Lift 1	945	1	273.00	19	292
Lift 2	955	1	304.00	9	313
Lift 3	965	1	344.00	19	363
Lift 4	975	1	396.00	39	435
Lift 5	985	1	548.00	19	567
Lift 6	995	1	597.00	30	627
Lift 7	1005	1	658.00	40	698
Lift 8	1015	2	731.00	42	773
Lift 9	1025	2	811.00	45	856
Lift 10	1035	2	993.00	45	1038
Lift 11	1045	3	1105.00	45	1150
Lift 12	1055	3	1317.00	45	1362
Lift 13	1065	3	1461.00	45	1506
Lift 14	1075	4	1673.00	45	1718
Lift 15	1085	4	1805.00	45	1850
Lift 16	1095	5	2009.00	45	2054
Lift 17	1105	5	2131.00	45	2176
Lift 18	1115	6	2242.00	45	2287
Lift 19	1125	6	2435.00	45	2480
Lift 20	1135	7	2536.00	40	2576
Lift 21	1145	7	2637.00	45	2682
Lift 22	1155	7	2800.00	30	2830
Lift 23	1165	7	2892.00	19	2911
Lift 24	1175	8	2962.00	30	2992
Lift 25	1185	8	3104.00	30	3134
Lift 26	1195	8	3165.00	19	3184
Lift 27	1205	8	3214.00	12	3226

Lift No.	Elevation (m)	Mine Year	Primary Leach (days from start of stacking)	Days Leached	Secondary Leach (days from start of stacking)
Lift 28	1215	9	3266.00	30	3296
Lift 29	1225	9	3306.00	30	3296

Following the primary leaching cycle some residual leachable gold remains in the ore and will be recovered during secondary leaching. Further a proportion of the remaining leachable gold is recovered when heap leach is rinsed at closure. Each leach cell will have a primary leach time of 45 days. Remaining gold will be recovered through secondary leaching from the solution applied to the cells above. A solution application rate of 10 $l/h/m^2$ was used for design however operational application rates are estimated at 7 l/h/m2., A leachable cell area was calculated based on cell tonnage, a 10 m lift height and a 1.72 t/m^3 bulk density.

3.12 SURFACE WATER MANAGEMENT

In general, designs for surface water management facilities and infrastructure (e.g., temporary diversions, permanent diversions, interceptor ditches, sediment control ponds/basins, spillways) including layout, sizing, material and construction specifications, and erosion control are provided in the Water Management Plan. The following describes additional water management design considerations specifically associated with the HLF.

Temporary interceptor runoff collection ditches will be constructed for each phase of the HLF to collect and divert stormwater flows from entering the HLF. The ditches will be constructed and in operation before construction of each pad phase. The temporary ditches represent the limits of each phase of the HLF as the pad liner will tie into the access road adjacent to the channels. Once the HLF is ready for the next phase the temporary ditches will be filled and regraded for placement of the liner for the next phase.

The temporary interceptor ditches are sized for the 100-year, 24-hour event, and will be armored with riprap. See Drawings EGHLF-XD-03-01 and EGHLF-XD-03-02 of Appendix A for the layout of the ditches and phase transition details.

A narrow bench (approximately 10 m wide) will be constructed up-gradient from the HLF confining embankment crest for stormwater collection and conveyance of flows to the In-Heap Pond spillway which has an invert elevation of 938 m. In the event of an emergency or other unforeseen circumstance in which pumping of solution ceases, or in the event of excessive surface runoff from the HLF, discharge of excess water or solution will be directed in a controlled manner via the lined spillway to the Events Pond. Solution levels within the In-Heap Pond are expected to be kept low during normal operations. However, during emergency situations, the In-Heap Pond spillway will prevent overtopping of the embankment, and will maintain containment of the solution. The In-Heap Pond spillway is designed to safely convey the flow from the PMF event. The Events Pond also includes an outlet spillway. Drawings EGHLF-XD-08-01 through EGHLF-XD-08-03 of Appendix A present the spillway designs.

3.13 METAL RECOVERY AND PROCESSING FACILITIES

The proposed ADR plant will contain the following systems for adsorbing gold from cyanide solutions from the HLF:

- two carbon-in-column (C-I-C) trains operating in parallel (sized for 2,108 m^3/h design flow of PLS) with five carbon adsorption columns, cascade type;
- carbon capacity of 8 t for the elution column

- a carbon transfer system including a transfer pump, valves and associated piping
- process solution pumps to provide barren solution transfer from the pump boxes to the barren solution tank, and carbon transfer solution
- a barren leach solution heating circuit to provide supplemental heat to the barren solution during the winter months.

Each of the trains will be equipped with:

- a vibrating safety discharge carbon screen with 200 mesh (74 µm) openings
- a feed box
- samplers for pregnant and barren solutions.

Solution will be pumped from the In-Heap Pond to each of the two solution feed boxes ahead of each train. The solution feed box will discharge the PLS flow to the first column in each adsorption train. The PLS will flow by gravity from column to column. Within each column, the PLS will flow upwards, suspending activated carbon particles in a fluidized bed; gold will be adsorbed onto the carbon particles. Gold loaded carbon in each tank will be advanced to the next column by pumping a mixture of water and carbon counter-current to the pregnant solution flow. This action will advance the carbon so as to have the freshest carbon exposure to the weakest tenor of PLS thereby maximizing gold recoveries and minimizing residual gold values in the barren solution.

For operational flexibility, the circuit design includes the ability to bypass any column at any time. The barren solution leaving the final column will discharge over an inclined vibratory carbon safety screen with 200 mesh (74 µm) openings to remove any carbon which may have been carried over into the barren solution. The barren solution will then flow by gravity to the barren solution tank.

Cyanide and pH concentration of the barren leach solution will be adjusted in the barren solution tank and be pumped back to the HLF. During winter operations the barren solution will have the ability to be heated.

3.13.1 Leach Solution Heating

During periods of extremely low temperatures, barren solution from the barren solution tank can be re-circulated through the cold side of four operating shell-and-tube heat exchangers. The heated solution will be re-circulated from the heat exchangers back to the hot water heater in a closed loop. The heated solution returned to the barren solution tank will raise the temperature of the barren solution flowing to the HLF.

3.13.2 Acid Washing

Loaded carbon will be pumped from the C-I-C trains to either the acid wash tank, or to the elution/desorption column, depending on operational requirements. Under normal operating conditions, the loaded carbon will first be acid treated, then neutralized with caustic solution, followed by the subsequent elution stage. The acid wash is designed to manage scaling on the carbon, thereby maintaining its ability to adsorb gold.

A 3% (w/w) hydrochloric acid solution will be re-circulated through the bed of carbon in the acid wash tank. This acid washing treatment will remove scale build-up and other inorganic contaminants that will inhibit gold adsorption onto the carbon. After the wash solution discharging from the acid wash vessel has stabilized at a pH value of 1.0 to 2.0, the spent acid wash solution, which is only slightly acidic, will be pumped back to the acid mixing tank. After acid washing, the carbon will be neutralized by pumping alkaline barren solution through the carbon bed.

Caustic solution will be added to the wash solution to ensure complete acid neutralization. Periodically, the acid solution will be pumped into the barren solution tank to help reduce the build-up of contaminants in the circuit.

3.13.3 Elution/Desorption

After the acid washing step, the loaded carbon will be pumped to the elution column. The elution/stripping of gold from the loaded carbon will be accomplished with a hot caustic and cyanide solution. After reaching the elution/stripping temperature, the solution will flow upward through the elution column. The elution column/strip vessel will be designed to treat an 8 t batch of loaded carbon. The gold-bearing solution will exit the elution vessel, and then flow through cool-down heat exchangers and then onwards by gravity to the electrowinning circuit.

3.13.4 Electrowinning

The gold will be electro-plated onto stainless steel cathodes. Barren electrolyte solution exiting the electrolytic cells will flow by gravity back to the electrowinning solution discharge tank, then to the barren/strip solution tank for making up to strength with caustic and cyanide (if needed) and return to the elution/stripping vessel. At regular intervals concentrate will be washed from the cathodes, dewatered by filter, dried, fluxed, and smelted into dore bars.

When the elution/stripping cycle has been completed, the eluted/stripped carbon will be transferred to either the thermal regeneration circuit or to the carbon storage tank. From the carbon storage tank, the carbon will be secured with carbon fines removed and the coarser fraction pumped back to the adsorption circuit.

3.13.5 Cyanide and Caustic Solution

The sodium cyanide will be prepared to a concentration of 20 to 25% (w/w) strength and then transferred to the cyanide mix storage tank. This concentrated cyanide solution will be metered into the barren solution tank, to the carbon columns, and to the strip solution tank, as required.

Sodium hydroxide, or caustic solution, will be used in the system for acid neutralization and for preparing the fresh elution solution. The sodium hydroxide will be prepared to 10% solution strength. Caustic will be added to the system via a metering pump and a flow meter.

3.13.6 Cathodes and Smelting

Gold laden stainless steel cathodes will be removed after elution/stripping and electrowinning. The cathodes will be washed internally in the cathode wash box using a high-pressure spray using raw water. The resulting gold sludge will be separated from the wash solution by a plate and frame filter press. The sludge will be periodically collected from the press and dried in the drying oven.

Smelting will take place in a crucible furnace. The filtered precipitate will be mixed with fluxes, typically a combination of borax, niter and possibly silica sand. A cascading mould system will be included. Off gases from the melting furnace will be extracted with a fan and then discharged into a bag house to remove particulate matter. The bars of doré will be stored in a safe. Refining slags will be recycled first to re-melt and then sent to the HLF.

3.13.7 Carbon Handling Circuit

The carbon handling circuit will include all the components necessary to move, store, add, and remove carbon in the ADR system. Carbon will be transferred between the various unit operations in the ADR plant by a screw type pump (high clearance low degradation) and by pressurization in the elution column. Carbon transfer in the adsorption circuit will be by air operated valves and a high clearance pump. The valves will be operated locally or remotely from the programmable logic controller in the control room. Carbon regeneration will be conducted in a diesel fired rotary kiln. A carbon conditioning circuit will also be included in the circuit which will prepare the fresh carbon for use in the adsorption process and remove undersize carbon from the carbon circuit.

3.13.8 Metal Recovery

Based on the stacking and leaching plan presented in Section 3.11, the resulting metal recovery over the life of mine is shown in Table 3.13-1.

Table 3.13-1: Heap Leach Metal Recovery

Year	1	2	3	4	5	6	7	8	9	Total
Throughput (Mt)	3	10	11	10	11	10	11	10	11	86
Ore Grade (g/t)	0.83	0.75	0.78	0.81	0.78	0.77	0.66	0.62	0.60	0.73
Contained (koz)	92	234	270	279	271	267	230	215	208	2,067
Actual Recovery (%)	15.2	68.8	70.7	77.4	74.5	71.5	80.4	76.3	78.8	72.0
Recovered (koz)	14	161	191	216	202	191	185	164	164	1,488

NOTE: Overall expected recovery = 73.2%

3.14 BORROW SOURCES

The borrow development for the HLF structures includes excavation of fill borrow materials from within the HLF and ADR footprints, and from other areas within the mine site. Fill materials will be processed from required onsite excavations or screened/crushed alluvial and placer fill materials as discussed in the Project Technical Specifications (see Appendix J of Appendix A).

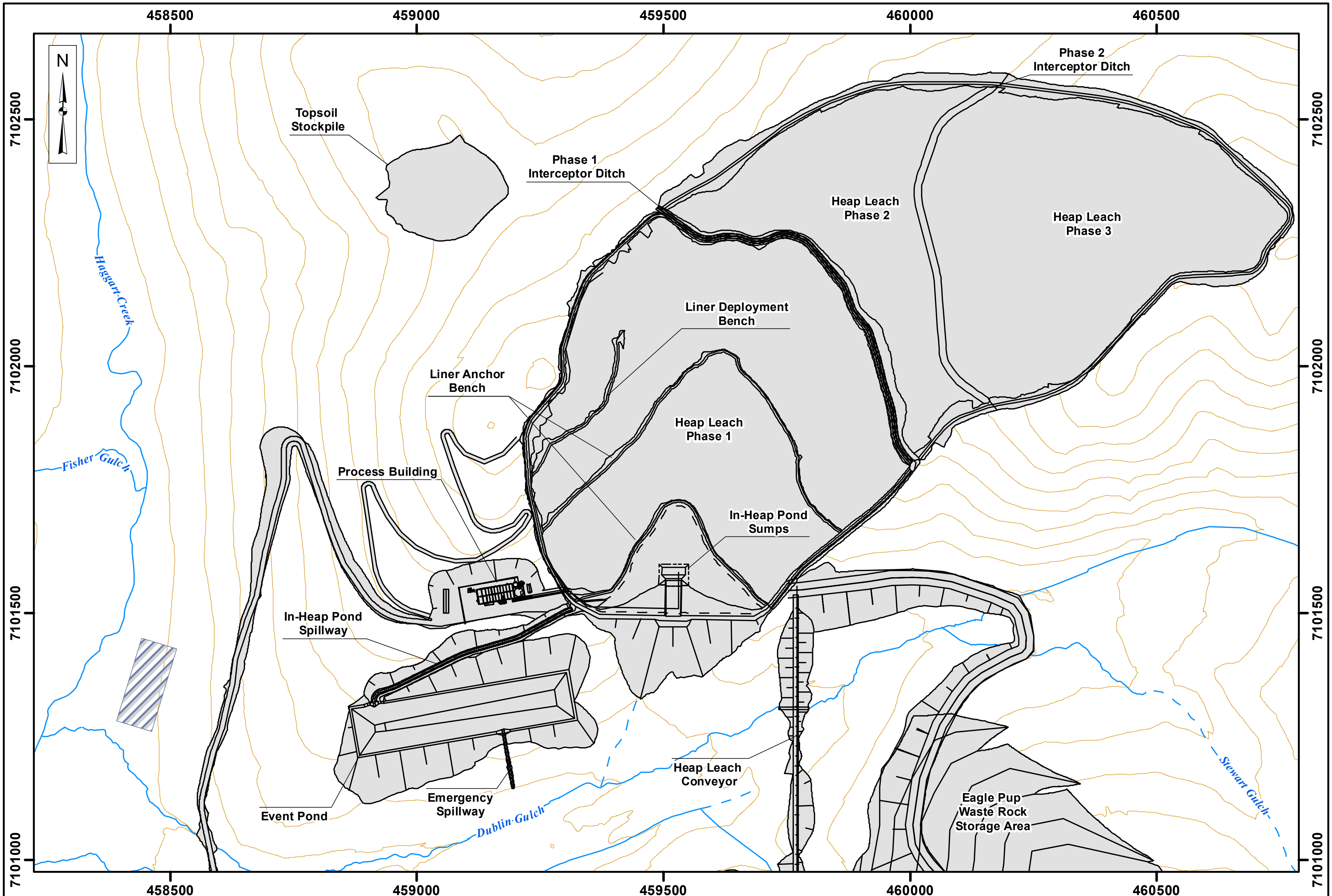
The required excavations within the footprint of the HLF include stripping of surficial soils on the abutments to a competent weathered rock or bedrock foundation, as per the HLF Foundation Improvement Plan. The required excavations for perimeter roads and benches around the HLF will generally be a cut and fill balance, as determined during construction. The suitable borrow materials from required stripping excavations are planned to be used directly in shallow compacted fills, or placed in temporary stockpiles for moisture conditioning or processing for filter materials.

For specific geotechnical details (e.g., testing, quantities, material specifications) on borrow materials proposed for construction, including borrow sources and borrow requirements, see Section 3.2.4 of the Mine Development, Operations and Material Management Plan. For geochemical characteristics of borrow materials see the Environmental Monitoring, Surveillance and Adaptive Management Plan.

3.15 ACCESS MANAGEMENT

Site access in general will be controlled via a guard station on the single access road leading into the site. Only authorized site personnel are authorized access to the heap leach and processing facilities and associated infrastructure. All other people must be accompanied by site personnel. Additionally, signage will be posted at regular intervals to notify people of the facilities and restrictions on access and/or potential hazards.

Wildlife access management is further described in various plans including the Wildlife Protection Plan and the Traffic Management Plan. In general, all aspects of the heap leach and process facilities will either be contained within a building (e.g., ADR Plant, crusher buildings, etc.), buried (e.g., emitter pipes for solution application on the HLF) or fenced off (e.g., Events Pond) thereby regulating access from wildlife. Additional measures such as noise cannons or floating bird balls will be considered as necessary.



Legend:

Facility	Perennial
In-Heap Pond	Ephemeral
Sump	Intermittent
Contour (25m)	Reserved Area

StrataGold Corporation

0 75 150 300
Metres

Projection: NAD 83 UTM Zone 8N

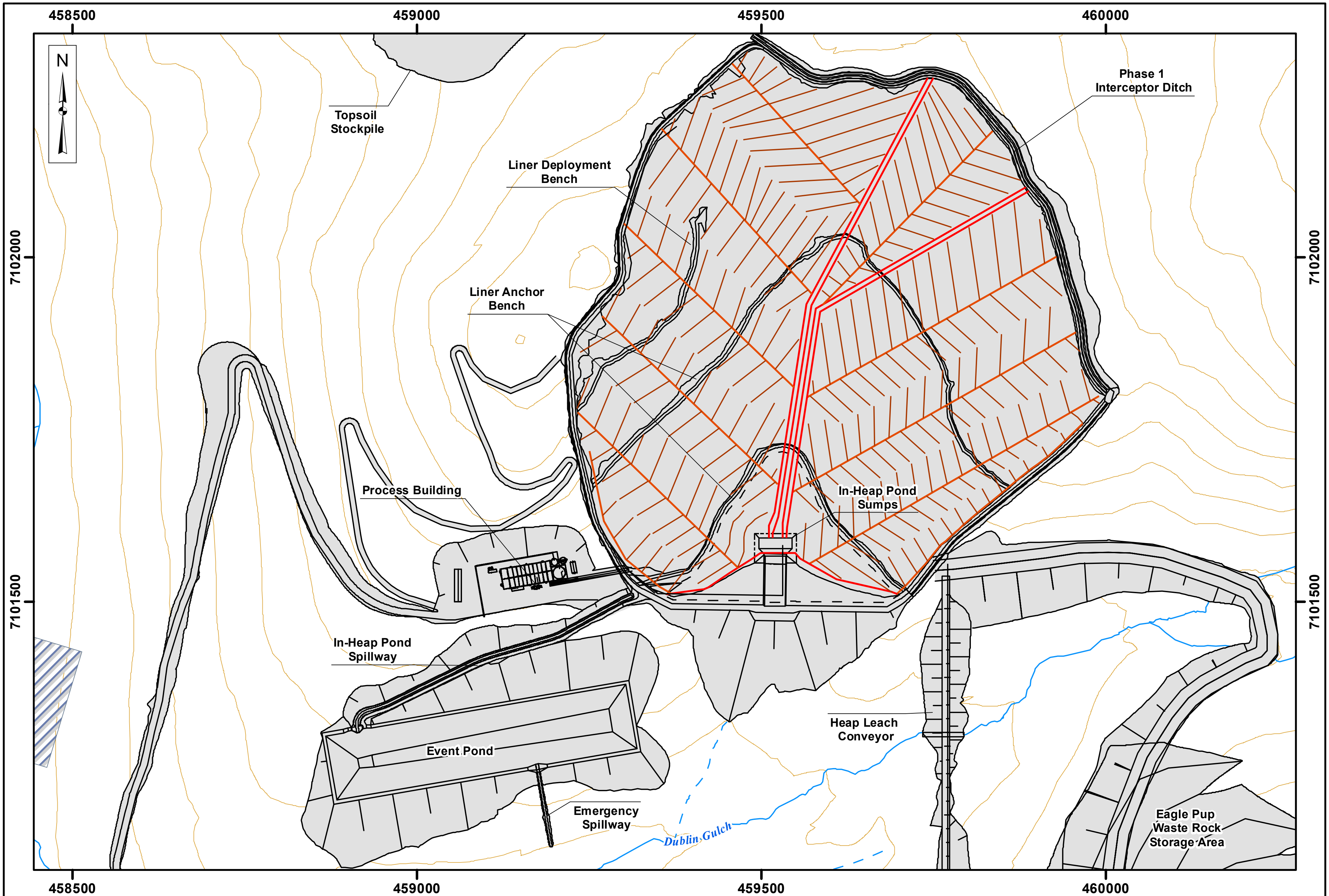
Drawn By: HC

Date: 2017/11/15

Figure: 3.2-1

EAGLE GOLD PROJECT
YUKON TERRITORY

Heap Leach Facility Phases



Legend:

Facility	PLS Drain Pipe 100 mm	Perennial	Contour (25m)
In-Heap Pond	PLS Header Pipe 250 mm	Ephemeral	Reserved Area
Sump	PLS Header Pipe 450 mm	Intermittent	

StrataGold Corporation

0 50 100 200
Metres

Projection: NAD 83 UTM Zone 8N

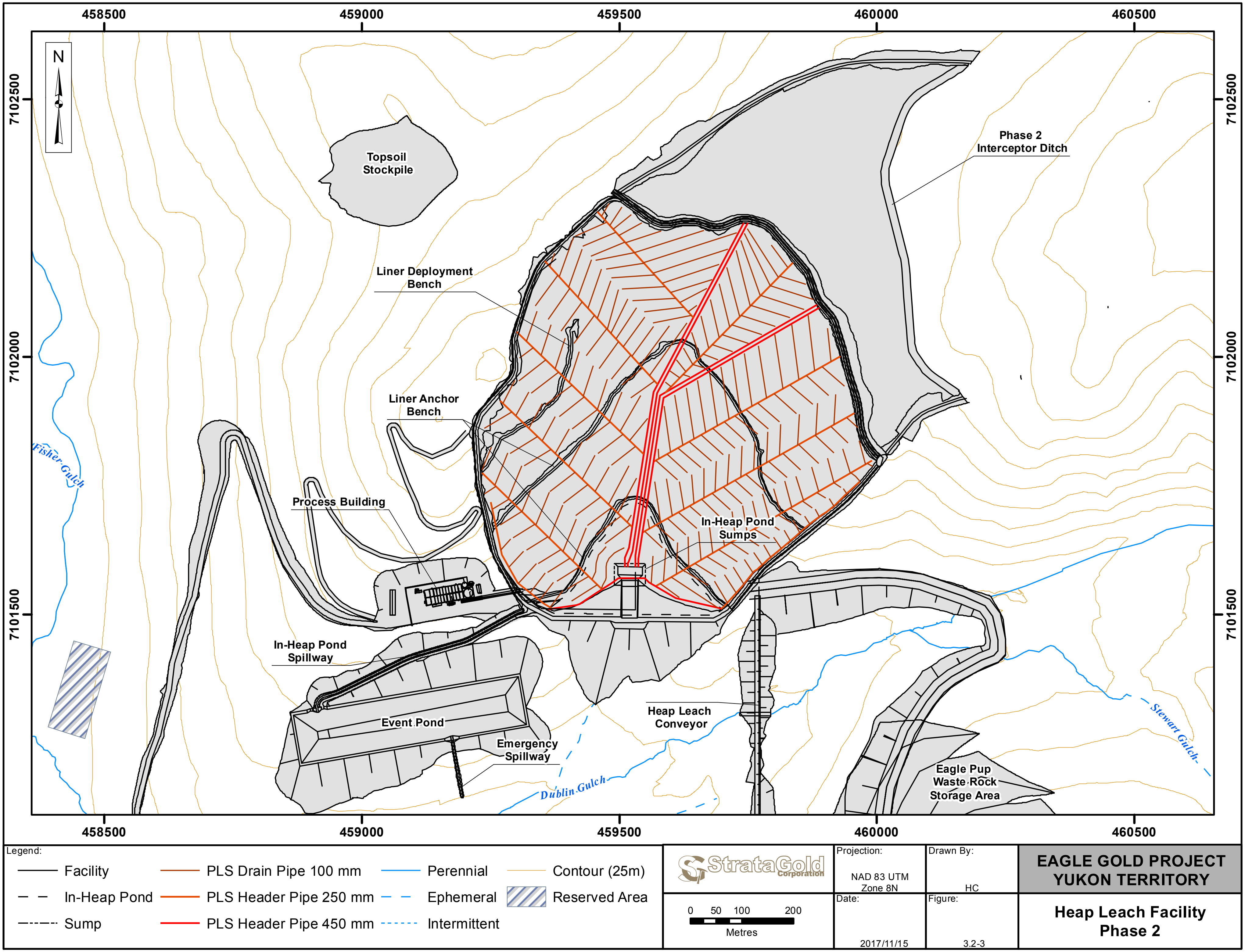
Drawn By: HC

Date: 2017/11/15

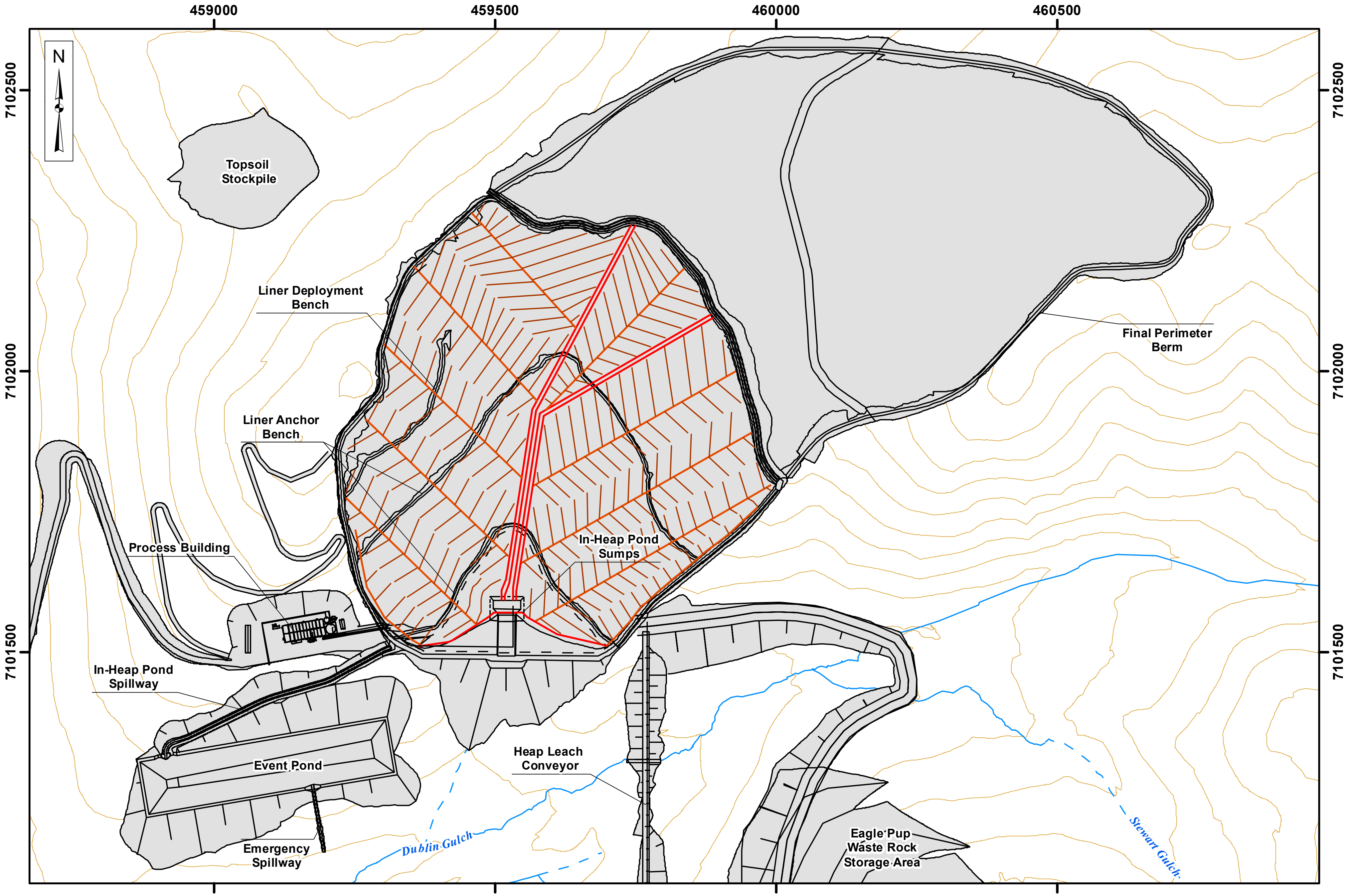
Figure: 3.2-2

EAGLE GOLD PROJECT
YUKON TERRITORY

Heap Leach Facility Phase 1



458500
459000
459500
460000
460500
7102500
7102000
7101500
N
Topsoil Stockpile
Phase 2 Interceptor Ditch
Liner Deployment Bench
Liner Anchor Bench
Process Building
In-Heap Pond Sumps
In-Heap Pond Spillway
Event Pond
Emergency Spillway
Heap Leach Conveyor
Eagle Pup Waste Rock Storage Area
Fisher Gulch
Dublin Gulch
Stewart Gulch
Legend:
Facility
In-Heap Pond
Sump
PLS Drain Pipe 100 mm
PLS Header Pipe 250 mm
PLS Header Pipe 450 mm
Perennial
Ephemeral
Intermittent
Contour (25m)
Reserved Area
StrataGold Corporation
0 50 100 200
Metres
Projection:
NAD 83 UTM Zone 8N
Drawn By:
HC
Date:
2017/11/15
Figure:
3.2-3
EAGLE GOLD PROJECT
YUKON TERRITORY
Heap Leach Facility Phase 2



Legend:

Facility	PLS Drain Pipe 100 mm	Perennial	Contour (25m)
In-Heap Pond	PLS Header Pipe 250 mm	Ephemeral	
Sump	PLS Header Pipe 450 mm	Intermittent	

StrataGold Corporation

0 50 100 200
Metres

Projection: NAD 83 UTM Zone 8N

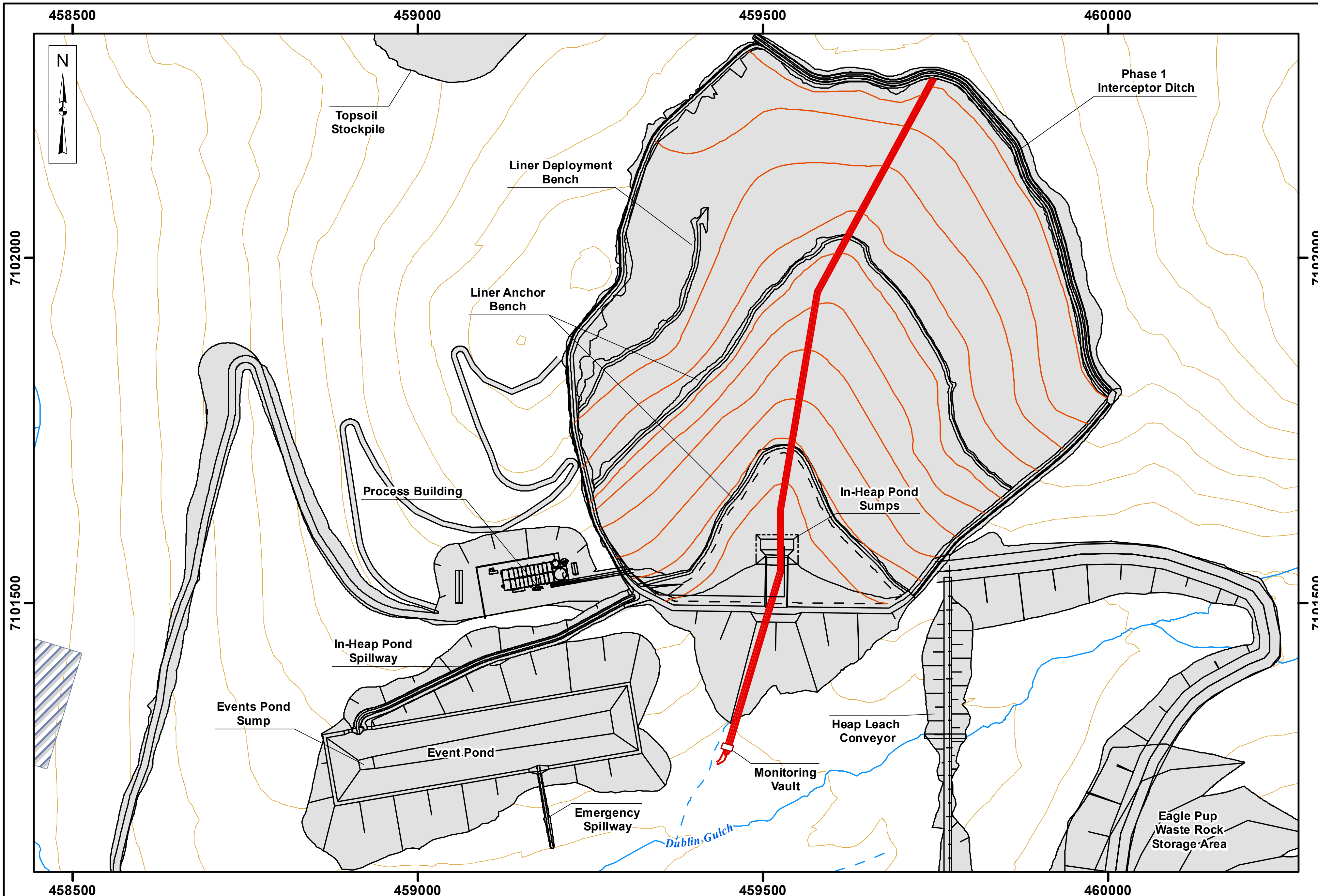
Drawn By: HC

Date: 2017/11/15

Figure: 3.2-4

EAGLE GOLD PROJECT
YUKON TERRITORY

Heap Leach Facility Phase 3



Legend:

Facility	Underdrain Header Pipe	Perennial	Contour (25m)
In-Heap Pond	Underdrain Lateral Pipe	Ephemeral	Reserved Area
Sump	Monitoring Vault	Intermittent	

StrataGold Corporation

0 50 100 200 Metres

Projection: NAD 83 UTM Zone 8N

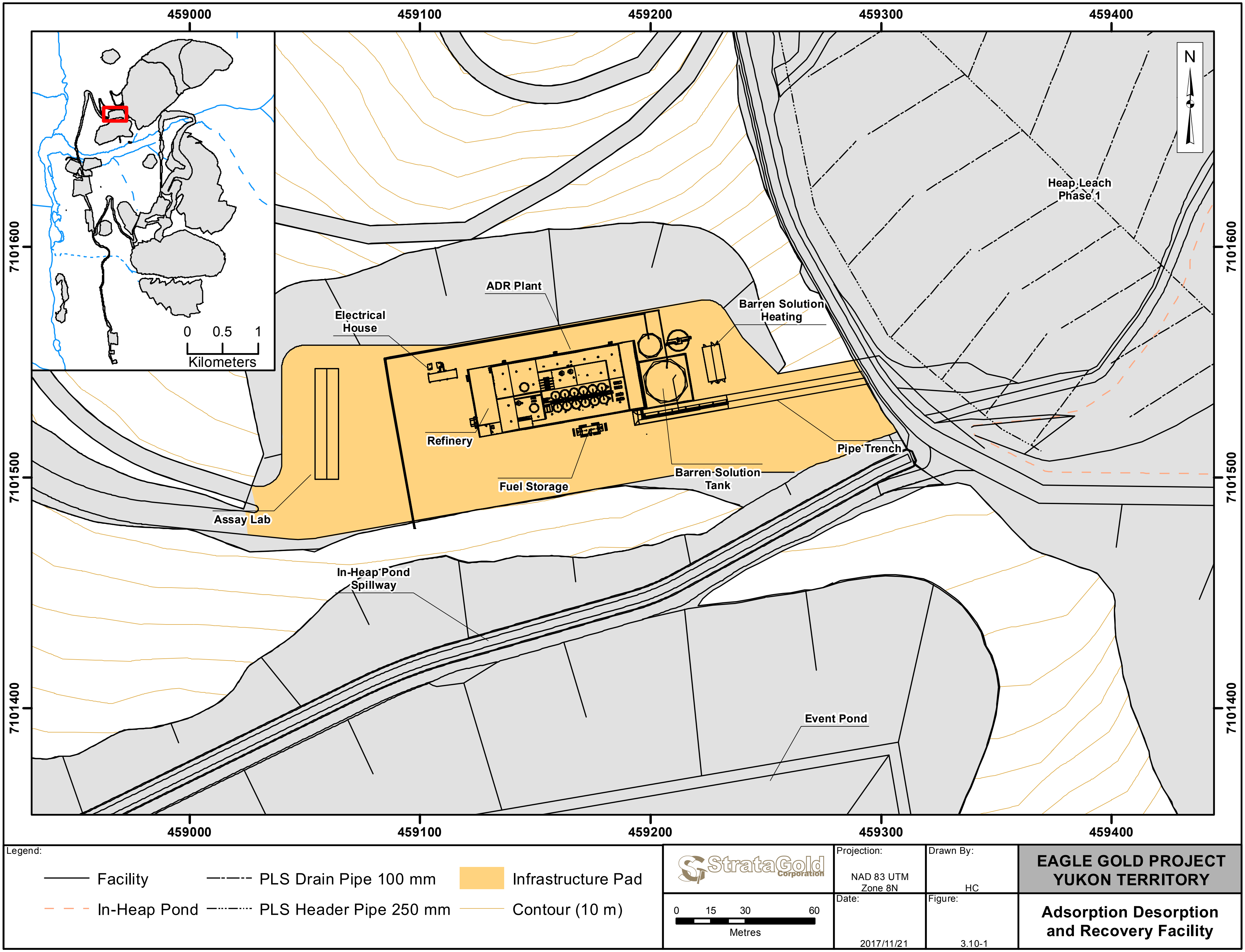
Drawn By: HC

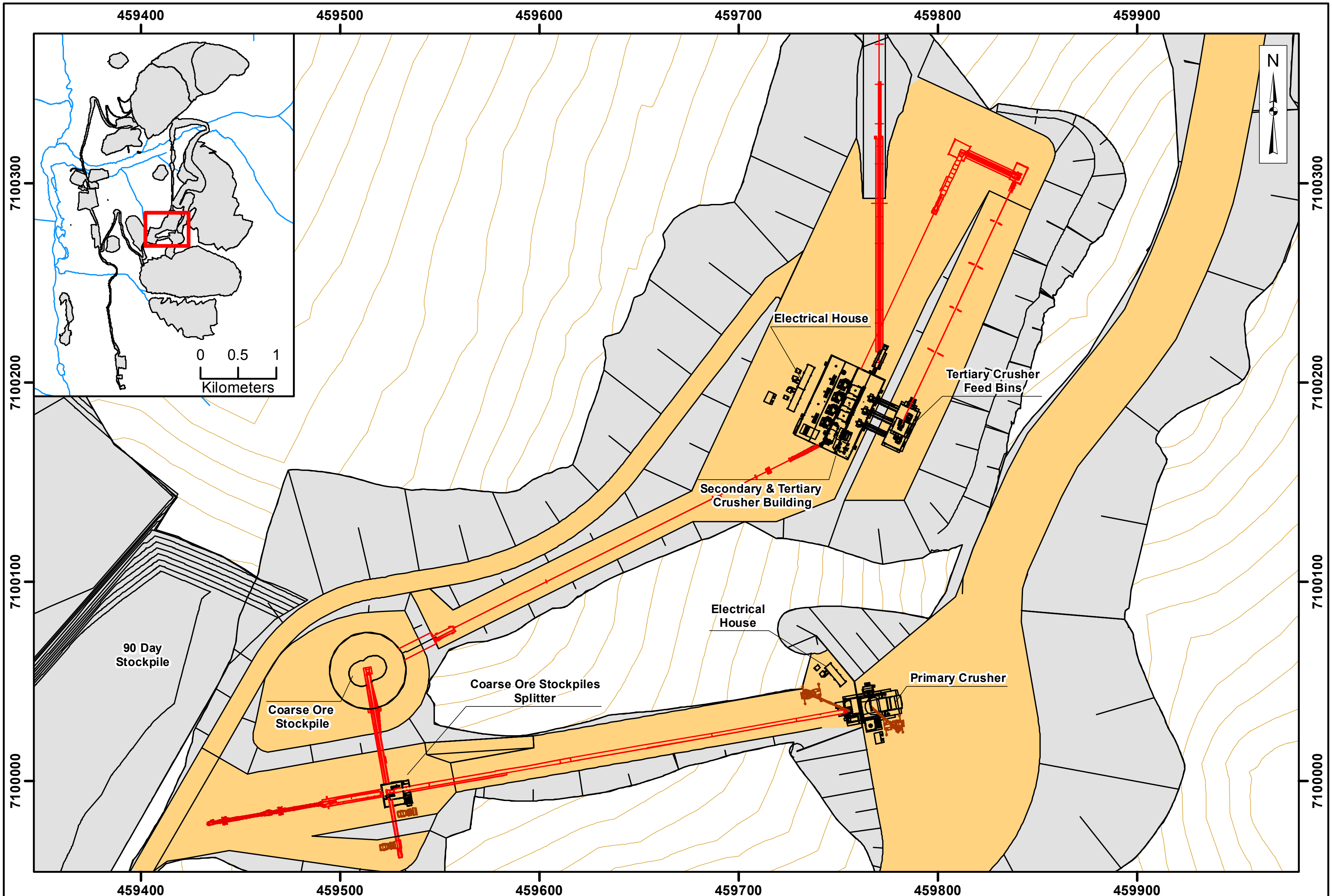
Date: 2017/11/15

Figure: 3.2-5

EAGLE GOLD PROJECT
YUKON TERRITORY

Heap Leach Facility Phase 1 Underdrains


459000
459100
459200
459300
459400
7101600
7101500
7101400
0
0.5
1
Kilometers
N
Heap Leach Phase 1
ADR Plant
Electrical House
Barren Solution Heating
Refinery
Pipe Trench
Barren Solution Tank
Fuel Storage
Assay Lab
In-Heap Pond Spillway
Event Pond
Legend:
Facility
In-Heap Pond
PLS Drain Pipe 100 mm
PLS Header Pipe 250 mm
Infrastructure Pad
Contour (10 m)
StrataGold Corporation
0 15 30 60
Metres
Projection:
NAD 83 UTM Zone 8N
Drawn By:
HC
Date:
2017/11/21
Figure:
3.10-1
EAGLE GOLD PROJECT
YUKON TERRITORY
Adsorption Desorption and Recovery Facility



Legend:

Facility — Mobile Equipment — Watercourse

Conveyor — Contour (10 m) — Infrastructure Pad

StrataGold Corporation

Projection: NAD 83 UTM Zone 8N

Drawn By: HC

0 20 40 80 Metres

Date: 2017/11/21

Figure: 3.11-1

EAGLE GOLD PROJECT YUKON TERRITORY

Crushing Plant

4 HEAP LEACH FACILITIES OPERATION

As with all heap leap projects, solution management is a critical component to understand and quantify because during operation, rinsing and detoxification phases, most HLFs typically contain volumes of process solution that exceed the total storage capacity of the ponds (i.e., Events Pond and In-Heap Pond) and other on-site facilities (e.g., barren tank in the ADR). Robust solution management plans have been developed based on HLF water balance modeling (The Mines Group, 2017) and the HLF Contingency Water Management Plan. These plans maximize the potential for avoiding loss of control of the water balance that could arise from climatic events, power failures or the failure of other site infrastructure.

The results of the HLF WBM describes how storage and water treatment facilities will be utilized during the seven phases of the project as defined below in Table 4.1-1.

Table 4.1-1: Operational and Closure Conditions for the HLF

Project Phase	Approximate Project Years	Duration (yrs)	Project Conditions
0	-2 and -1		Site development including construction of Phase 1 of HLF
1	1 to 3	3.0	Stacking from start-up through completion of Phase 1 of HLF Contact water controlled through water management strategies Begin construction of Phase 2 of HLF
2	3 to 5	2.6	Northward expansion of the HLF footprint Stacking through to completion of Phase 2 of HLF Begin construction of Phase 3 of HLF
3	6 to 9	3.4	Northeastward expansion of the HLF footprint Stacking through to completion of Phase 3 of HLF
4	9 and 10	2.0	Termination of mining and ore production Continued irrigation of the ore stack for gold production Managed pumpback of heap solution draindown
5	10 and 11	1.3	Termination of gold production Beginning of rinsing and cyanide destruction Managed pumpback of heap solution draindown – no discharge to treatment Closure of LDSP Decommission ADR Begin building cover on HLF
6	12 to 18	7.0	Controlled draindown of heap (draindown solution split into two flows: managed pumpback to HLF and proportion sent to treatment) Change from active treatment to passive treatment when criteria are met Complete building cover on HLF
7	19 to >50	15.0	Uncontrolled draindown of heap – until seepage rate meets meteoric input HLF passive treatment systems (PTS) in place Decommission MWTP and CN Destruct Facility Post-closure monitoring – all project facilities closed except that which is needed to support monitoring programs and PTS maintenance, as needed

4.1.1 Heap Leach Facility Water Balance

An operational water balance model was developed for the HLF with the primary objectives of evaluating heap leach pad performance in terms of predicting: 1) makeup water demands, and 2) the potential for maintaining an adequate level of desired available solution storage. Two (2) different types of water balance models were used: a deterministic model (using a chain of single valued input parameters to produce a series of single valued results) and a stochastic model (probability based). In the stochastic model the single valued input parameters were replaced with probability distributions derived from the computed statistics of the observations (in this case the monthly mean and variance or its square root, the standard deviation). A Monte Carlo procedure was then used to propagate the uncertainty through the model by sampling all of the input parameter distributions and compiling output distributions for specific results of interest.

4.1.1.1 Operational Solution Storage Considerations

In general, solution storage capacity is comprised of the In-Heap Pond and the Events Pond. The desired available storage volume is defined as the total pond capacity (420,000 m^3) minus the volume of water in storage within the pond system at any given point in time that is available to contain a combination of unplanned events. In this case, the events considered are an unplanned draindown event and an extreme rainfall event, while still maintaining freeboard in the Events Pond, as follows:

- A 72 hour draindown event (i.e., due to a power loss-pumps stop operating, pump malfunction, or pump maintenance), assuming a pumping rate of 1,500 m^3/hr, is equal to 108,000 m^3, plus
- A 24 hour 100-yr rainfall runoff event, which varies according to Phase of heap development, and
- Freeboard – best management practices for heap leach facilities call for 0.5 m of freeboard below the spillway invert of the Events Pond.

Table 4.1-2 summarizes the calculated desired available storage volume for each phase of the HLF. As the heap grows in size, the 24-hr 100-yr storm event increases in runoff volume, so that the desired available storage volume also increases.

Table 4.1-2: Desired Available Storage

Phase	72-hr draindown (m^3)	0.5 m freeboard (m^3)	24-hr 100-yr rainfall runoff (m^3)	Desired Available Storage (m^3)
Phase 1	108,000	19,600	25,200	152,800
Phase 2	108,000	19,600	37,600	165,200
Phase 3	108,000	19,600	54,300	181,900

4.1.1.2 Deterministic Model

A 68-year site synthetic weather record was developed by Lorax (2017a) using site-specific climate data from the Project (i.e., Potato Hills and Camp stations) and regional climate data (i.e., from Mayo, Dawson, Keno Hill, Elsa and Klondike stations) for the purposes of deterministic modeling. From this record a 12 year subset was chosen to represent the expected precipitation history at the Project site during the mine life (operations and initial closure). The 12 year record included a three-year dry period and a three-year wet period. As a check on the expected performance of the HLF during normal operations, two (2) additional meteoric records were extracted from the full site synthetic weather record (The Mines Group, 2017).

Results from the deterministic modeling show that operating volumes in the ponds remain low during normal operations due to the dominance of ore wetting in system losses. Once ore stacking ceases (e.g., at closure) and the ore wetting loss component is no longer available, the system continues to recruit meteoric water such that some solution management is required (e.g., increasing dynamic storage) to minimize seasonal accumulation of water.

Assuming no mitigation to address the incoming meteoric water, pond levels peak during Phase 4 after termination of mining/ore production and during continued irrigation for gold production. The pond levels during normal operations maintain an adequate amount of available storage throughout the life of mine. Makeup water demand declines over the operating life of the facility. The percentage of time that the makeup water demand is zero increases with later phases as the lined footprint increases and more captured meteoric water is available.

During Phases 1 and 2, the modeled minimum available storage is always substantially greater than the minimum needed to contain the combination of events (Table 4.1-3), while during Phase 3 a temporary shortfall in available storage could occur but will be mitigated by a slight increase (<6%) in dynamic storage (i.e., temporarily increasing irrigation area to consume the surplus water).

Most of the time, the In-Heap Pond will be operated so that water levels are within a few meters of the bottom of the pond such that nearly all of the storage will be available. This is reflected by the relatively high average available storage volumes in Table 4.1-3.

Table 4.1-3: Deterministic Model Results: Minimum Available and Average Available Storage

Phase	Desired Available Storage (m^3)	Average Available Storage (m^3)	Minimum Available Storage (m^3)
Phase 1	152,800	407,500	380,400
Phase 2	165,200	402,800	315,300
Phase 3	181,900	355,700	152,100 *

* Note: The temporary shortfall in available storage in Phase 3 can be removed in less than 30 days with a pumping rate increase of less than 6%.

During certain meteoric events (i.e., snowmelt, rainfall), an increased rate of infiltration will cause the In-Heap Pond water levels to temporarily increase, which would in effect decrease the make-up water demand. In a short period of time new ore will consume this water and water levels in the pond will return back down to the operating level. However, prior to returning to normal operating levels the pond(s) will contain a higher proportion of solution such that there will be less available storage. The model tracks the volume of available storage through time and identifies when pond levels encroach on the desired available storage.

4.1.1.3 Stochastic Model

A stochastic model was also used to examine extreme or upset conditions and to quantify the risk of experiencing those upset conditions. The stochastic model produces results that are probability distributions, which show the entire range of possible values for each parameter of interest. Stochastic models use a Monte Carlo sampling procedure to sample input distributions and generate output distributions. In this case, Latin Hypercube sampling algorithm and 5000 iterations (samples) were used to assure thorough resolution of the extreme limits of the distribution.

Based on the stochastic model, makeup water demand during HLF Phase 1, which includes start-up and the charging of the system with water will typically range from about 60,000 m3 to 85,000 m3 per month during the warmer months and about 55,000 m3 to 75,000 m3 during the cooler months. The exception is the spring freshet period, typically occurring in the month of May, where the influx of water from snowmelt substantially reduces the outside makeup water demand. The reduction in makeup water demand steadily increases with each phase due to the associated increase in the lined footprint of the HLF. Phase 2 makeup water demand falls into a range of 30,000 m^3 to 50,000 m^3 during the warmer months and 30,000 m3 to 40,000 m3 during the colder months. Phase 3 makeup water demand falls into a range of 10,000 m3 to 40,000 m3 during the warmer months and 25,000 m3 to 35,000 m3 during the colder months. Outside makeup water demand is zero during Phase 4 and Phase 5, as no new ore is added to the system.

The other matter of interest in stochastic modeling involves the volume of water stored within the pond system and the ability to maintain an adequate level of storage capacity to address unplanned events. The stochastic results show there is essentially no risk of encroaching on the required minimum desired storage volume during Phase 1, Phase 2, or Phase 3 (normal operations). There is a small risk of encroachment (0.2%) during the freshet month (May) in Phase 3. Phase 1 through Phase 3 are similar in that the strong ore wetting demand keep ponds relatively empty and facilitate a quick recovery even from strong freshet inflows. During Phase 4 ore stacking ends and there is no more water demand. The annual influx of water associated with each freshet begins to accumulate in the system. The primary water management strategy to address excess water will be to temporarily increase dynamic storage until new ore uses up the surplus.

On average the month of May maintains an available storage volume of about 274,000 m^3 and the most common value (the mode) is on the order of 300,000 m^3, well above the desired minimum storage volume that will account for the 100-year 24-hour rain event plus 72 hours of solution draindown while retaining a freeboard of 0.5 m in the Events Pond (combined events total 181,890 m^3 – Table 4.1-2). However, there are circumstances that could occur which would encroach upon the minimum desired storage volume and those circumstances would occur about 2.7% of the time without any mitigation (e.g., increasing the volume in dynamic storage).

4.1.2 Drain Down

Once all gold production has ceased and the proposed rinsing of the HLF is finished, the post closure heap will be allowed to dewater and drain. The draindown process is an unsaturated flow process that is controlled by the soil water retention characteristics of the ore. The rate of flow during draindown is a function of the unsaturated hydraulic conductivity which is in turn a function of the moisture content of the ore. As the ore drains, the moisture content decreases with the effective unsaturated hydraulic conductivity. This eventually leads to an exponentially declining flow rate curve.

There are two distinct areas of the HLF that will behave differently during the draindown period. The first area is the column of ore below the area under leach which will have an elevated moisture content relative to the adjacent unirrigated ore. The elevated moisture allows the leach column to drain at a faster rate than the unirrigated ore. At some point in time the moisture content of the leach column will essentially equal the moisture content of the unirrigated ore and there will be no measurable difference in the draindown rate anywhere across the heap.

It is not practical, nor advantageous to simply turn off the pumps and allow the heap to freely drain as a very large volume of water would report quickly to the ponds, filling and overtopping them. Therefore, it is assumed that pumping of process solution will continue at a declining rate until such time as the water content in the active leach column approaches the water content in the unirrigated ore or the potential draindown volume remaining would not fill the ponds but would be captured in the pond system and still provide sufficient capacity to maintain the desired available storage volume. At that point the pumps would be turned off and the heap permitted to continue to drain until it reached meta-stable equilibrium with the level of meteoric water that continues to enter the pad year after year.

The rate at which the water is pumped to treatment will control the time required for the leach column to reach the moisture content of the unirrigated ore and also the time required to reach equilibrium with the meteoric precipitation regime. Although less of an effect, the placement of a cover material on the surface of the HLF will also effect the rate of drainage and time to equilibrate by creating clean surface runoff that can be diverted off of the covered pad and then released to the environment.

Figure 4.1-1 through Figure 4.1-3 show draindown model results (flow rate, water content change, and water stored in ponds) that assumes about 10 L/s of water flow to a treatment plant both before and after the leach the leach column water content equals the water content of the unirrigated ore.

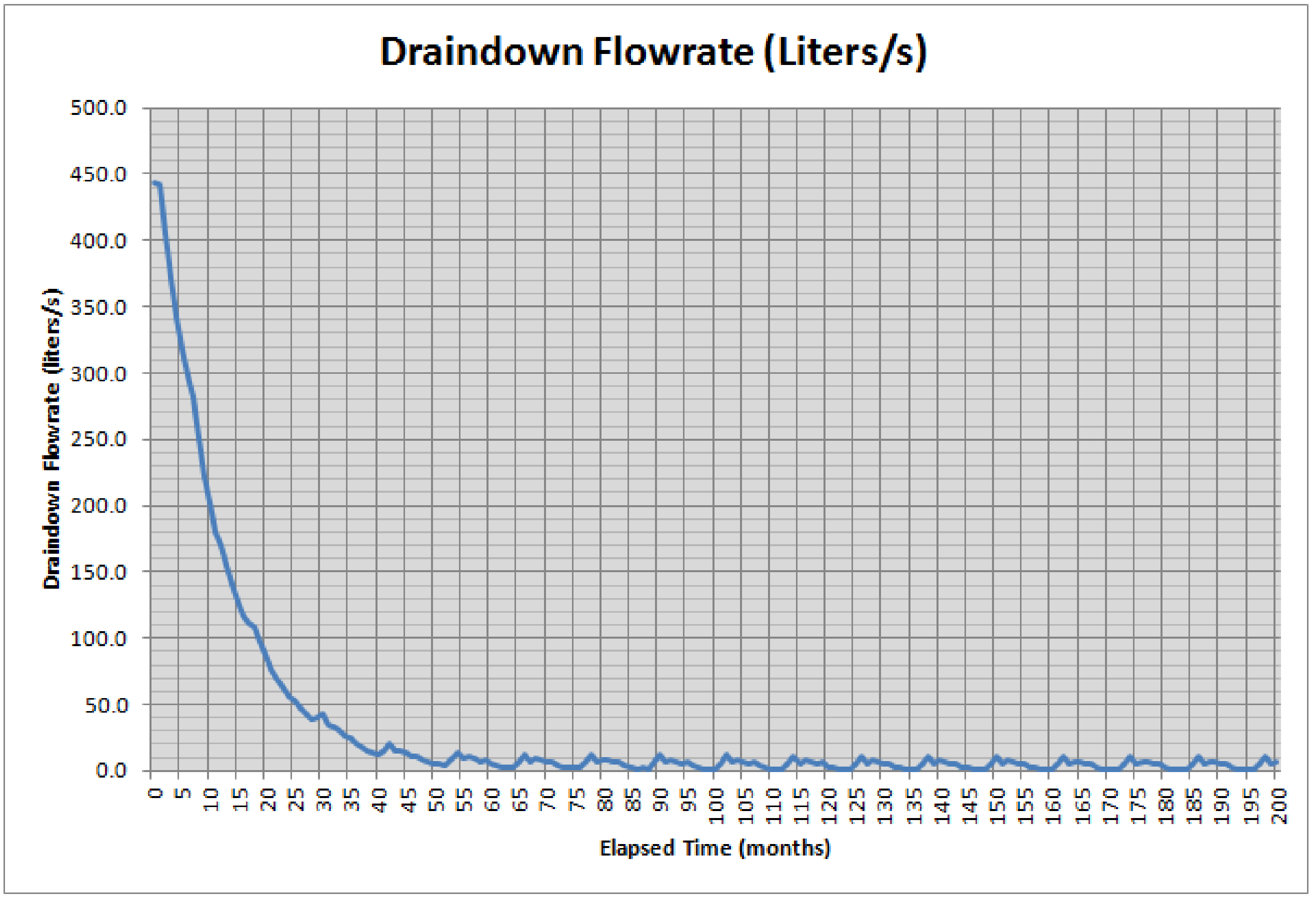


Figure 4.1-1: Draindown Flow Rate Over Time

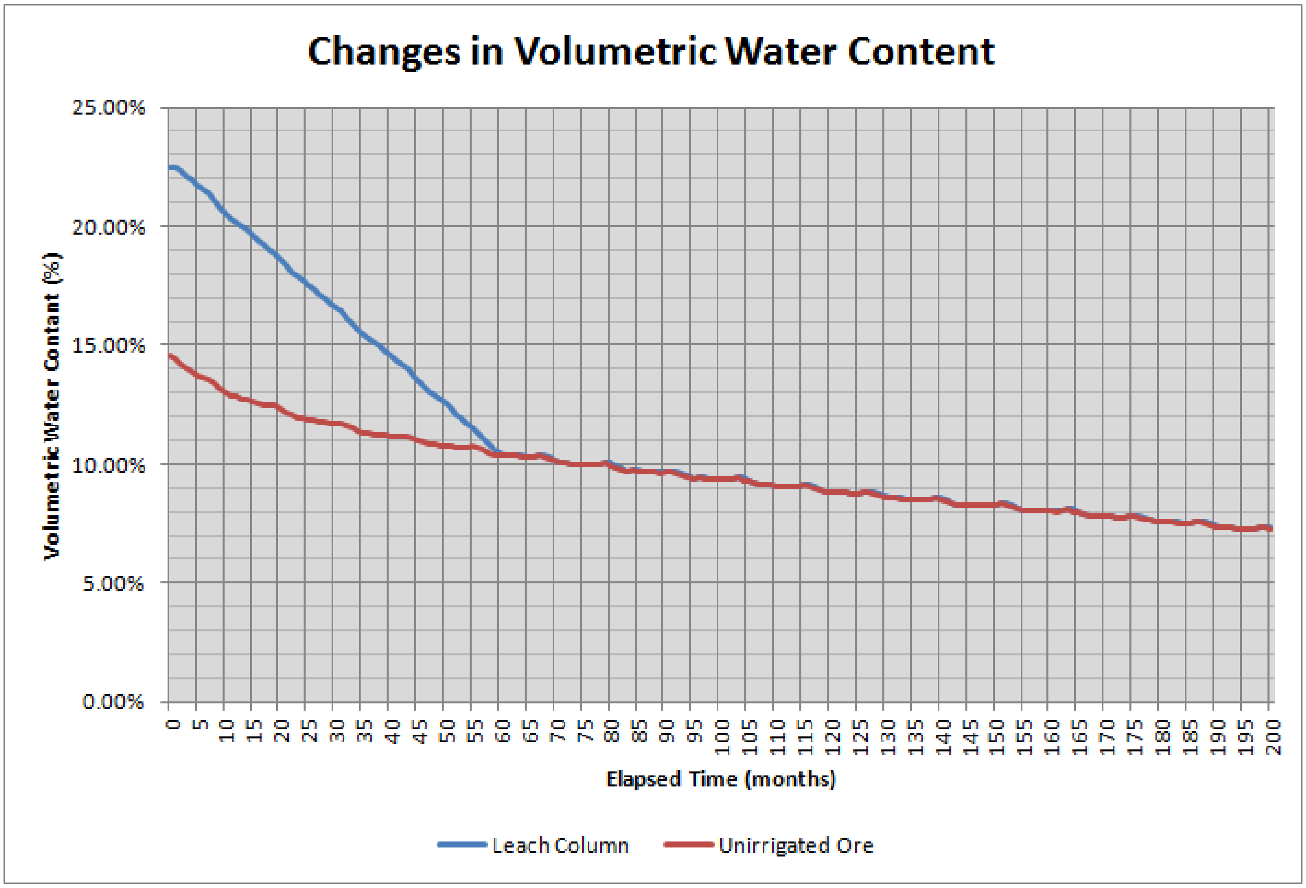


Figure 4.1-2: Changes in Volumetric Water Content Over Time

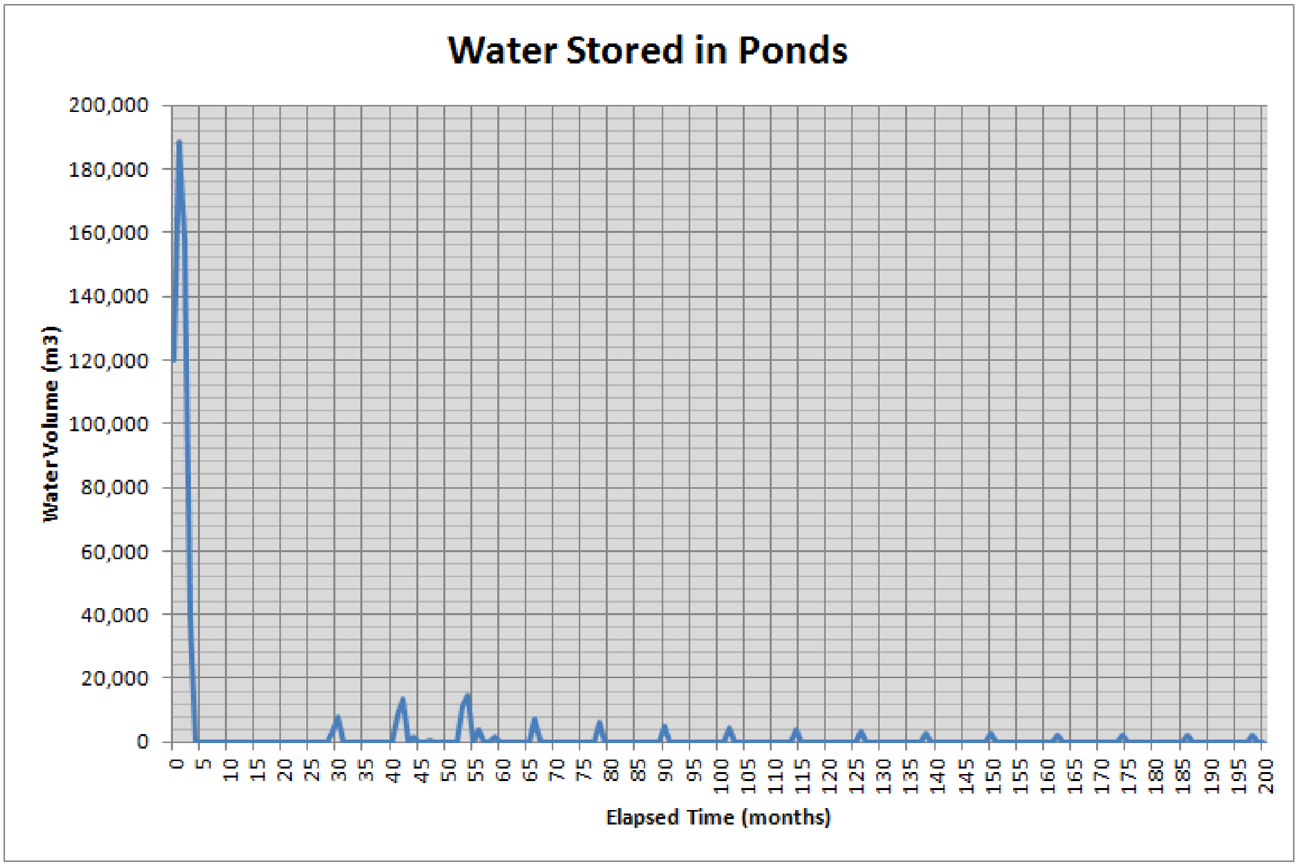
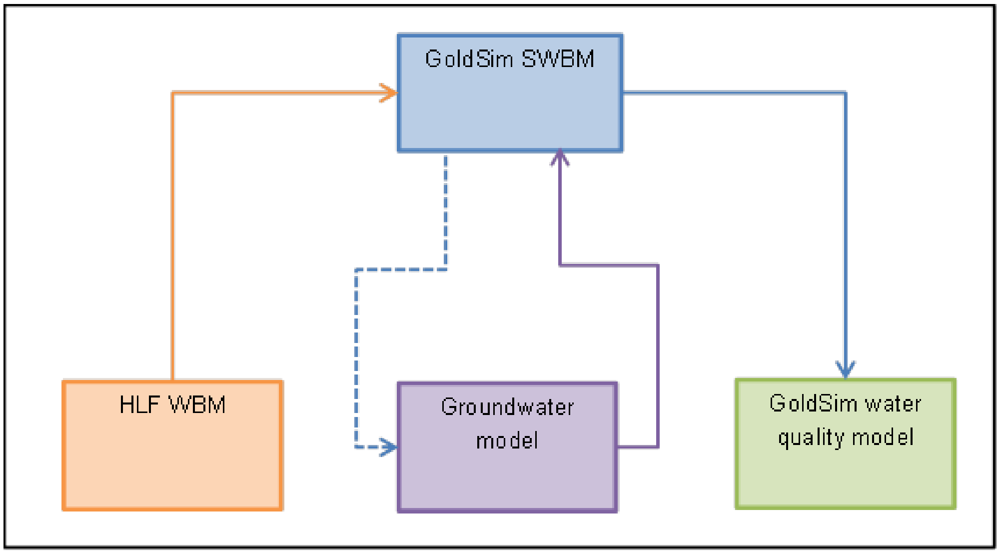


Figure 4.1-3: Estimate of Water Volume Stored in Ponds Over Time

4.1.3 Integration with Site Water Balance Model

A site water balance model (SWBM) was created in support of the Eagle Gold Project. The SWBM simulates the supply and demand for water on a month-by-month basis, from the initiation of mine operations through mine closure and post-closure. The SWBM was created using GoldSim, a dynamic probabilistic simulation model used extensively for mine site water management applications. GoldSim permits inputs to be entered as probability distributions (rather than discrete values), performs Monte Carlo simulations, tracks outputs from those simulations, and provides a graphic interface to facilitate the review and identification of interactions between components.

The SWBM created in GoldSim integrates logic and assumptions from the HLF WBM (The Mines Group 2017) and incorporates the groundwater baseflow and recharge rates estimated by the groundwater model as well as provides inputs to the water quality model. Figure 4.1-4 illustrates the integration of the SWBM with the HLF water balance, groundwater model and water quality model.



NOTES:
1. - - - - - -> TRANSFER OF BASELINE DATA
2. ———> TRANSER OF OPERATIONAL DATA (PREDICTED OR MODELLED)

Figure 4.1-4: Water Balance Model Integration Schematic

The framework and logic of the operational HLF WBM (which includes the closure draindown model) was integrated into the GoldSim SWBM.

The SWBM results indicate that the system is able to supply enough water to meet the process water requirements for the HLF and other water requirements throughout operations, under all runoff scenarios.

Following the rinsing and cyanide destruction in the heap, the heap draindown phase commences when draindown water will be discharged to the environment and is assumed to require active treatment until passive treatment systems are in place. The heap draindown process has two parts, with the duration of each part a function of the moisture contents of both the ore under active leach and the unirrigated portions of the heap. The first part of draindown will be actively managed in which draindown water is bled from the system and pumped to active treatment until passive systems are in place, at a variable rate. At this time, the remaining draindown water is being recycled back to the heap pad surface through the irrigation system. The recycle rate to the heap will decrease since the ore under leach, given its higher moisture content, will drain at a faster rate than the unirrigated ore portions of the heap until a similar moisture content in both is reached.

Once all the heap ore is assumed to be at the same moisture content the second part of draindown commences. During this phase all the ore in the heap drains at the same rate and the draindown water will be allowed to drain freely to the In-Heap Pond, which will be converted to a passive treatment system, with no recycled pumpback. The accumulated water in the In-Heap Pond/passive treatment system will receive an assumed annualized average rate of 10 l/s (or less, depending on what is remaining in the In-Heap Pond) until the heap ore reaches a stable equilibrium with incoming infiltration, after which it will continue to drain to the environment on a seasonal basis in perpetuity.

4.1.4 Emergency Management

As noted above in Section 4.1.1.3, based on the stochastic modeling, there is very little risk of encroaching on the desired minimum emergency storage volume during normal operations in Phase 1, Phase 2, or Phase 3, but circumstances could occur which would encroach upon the minimum desired emergency storage volume if no mitigation measures (e.g., pumping to treatment, increase the volume in dynamic storage, etc.) were taken.

The probabilities of the single events (e.g., 100 year rainfall or power outage) should not be compared to the stochastic probabilities. Storm pond design criteria are based on a single 24 hour event and assumes that there is not sufficient time to respond to or mitigate the event, such that the only available option is to detain the entire event in a pond. Risk characterized by the stochastic model represents a random combination of multiple events over an extended period of time, which would include the single 24 hour events. Most of the time events will not appear without warning, but will be seen developing over time allowing the effects of these event sequences to be mitigated either before they encroach upon the minimum desired emergency storage or shortly after a shortfall becomes evident. This is particularly true of the climate at the Project site where the greatest risk is associated with the spring snowmelt or freshet event. The snowpack responsible for this event will be seen developing over a period of at least four or five months and will be measured and monitored over the period from October through April so that the subsequent snowmelt event in May will be predicted with a high degree of certainty and prepared for well ahead of time.

Of interest is not simply the probability of experiencing a shortfall in emergency storage, but also the ability to manage the risk and recover from the shortfall in a reasonable amount of time (typically within 30 days). There are multiple ways of managing the risk of encroaching on the minimum desired emergency storage volume. For small shortfalls increasing the rate of solution pumped to treatment can eliminate the shortfall. For large shortfalls an increase in the application pumping rate and associated area under leach can empty ponds very quickly by putting more water into dynamic storage (i.e., into previously identified water management zones on unirrigated portions of the heap). Another potential method of mitigation would involve reduction of the snowpack. Given that the winter configuration will bury drip emitters below the surface and that no ore will be placed during the coldest period each winter, it would be possible to safely remove a portion of a very large snowpack without risk of contacting cyanide solution. Alternatively, snowpiling is an effective measure to delay the melting process. Additional details on contingency water management are provided in the Contingency Water Management Plan (SGC 2017)

The stochastic model was designed to evaluate mitigation options for correcting a shortfall in emergency storage. When a shortfall is triggered the model computes the treatment rate required to eliminate the shortfall over a 30 day period, and also computes the required increase in pumping rate/area under leach as a percentage of the base pumping rate/area under leach required to eliminate the shortfall over a 30 day period. The Water Balance Modeling for the Eagle Gold Mine Proposed Heap Leach Pad Facility (The Mines Group, 2017) summarizes the results of the stochastic modeling for available emergency storage volume by month over all five Phases and provides:

- the probability of experiencing a shortfall in the minimum required emergency storage volume,
- the maximum pumping rate increase required to recover the shortfall in 30 days,
- the maximum treatment rate required to recover the shortfall in 30 days,
- the probability of an uncontrolled discharge from the pond system (if no mitigation is applied), and

- the estimated volume that could be released (if no mitigation is applied).

The stochastic model results for the HLF provided in The Water Balance Modeling for the Eagle Gold Mine Proposed Heap Leach Pad Facility (The Mines Group, 2017) are incorporated into a site-wide stochastic water balance model (GoldSim Model) that considers the capacities of other facilities which can reduce exceedance probabilities further.

4.2 OPERATIONS, MAINTENANCE AND SURVEILLANCE PLAN

A preliminary Operation, Maintenance and Surveillance (OMS) Manual has been prepared for the HLF and will be updated prior to HLF operations. Since the HLF design incorporates a dam, the OMS Manual was prepared in accordance with the procedures outlined in the Mining Association of Canada's (MAC) current guidance document Developing an Operation, Maintenance and Surveillance Manual for Tailings and Water Management Facilities (MAC, 2011). This OMS Manual provides a framework for actions and a basis for measuring performance and demonstrating due diligence for the HLF operations. Key items and activities covered in the OMS Manual include the following:

- Roles and responsibilities of personnel assigned to OMS activities for the HLF;
- Description of the HLF including site conditions, key components, regulatory requirements, and design criteria;
- Facility operations including ore stacking, leaching, in-heap solution management, solution processing, environmental protection, and documentation and reporting;
- Facility maintenance including routine and event-driven maintenance, and documentation and reporting;
- Facility surveillance including routine, event-driven and annual comprehensive inspections and documentation and reporting; and,
- Emergency preparedness and response planning.

As required by the regulatory approvals granted for the Project, the OMS Manual will be updated and submitted for approval prior to leaching operations commencing.

4.3 ADAPTIVE MANAGEMENT AND EMERGENCY MANAGEMENT

A Heap Leach Facility Emergency Response Plan (HLF EMP) (Appendix D) was developed to ensure that an adequate level of emergency preparedness and response will be available in the event of an emergency scenario involving the HLF or associated structures. Adaptive Management for the HLF is considered by the HLF ERP, as well as in the Contingency Water Management Plan (SGC 2017).

The Plan is supplemental to the Eagle Gold Project Emergency Response Plan.

This plan was developed based on the following guidelines:

- Dam Safety Guidelines (2013);
- International Cyanide Management (2012);
- Type A and B Quartz Mining Undertakings - Information Package for Applicants (2012); and
- Plan Requirement Guidance for Quartz Mining Projects (2013).

The HLF EMP includes a heap leach and process facilities overview, defines organizational and responsibility roles and communication protocols for responding to, coordinating and following up from an emergency event, and provides a summary of emergency detection and classification levels for each of the HLF facilities. To effectively and proactively manage the HLF, the HLF EMP provides the basis for understanding HLF processes and the associated uncertainties, risks and consequences related to the management of each process/facility. This includes identification of various emergency scenarios as well as the effective identification of preventative measures and responses. A Failure Modes Effects Analysis (FMEA) (Appendix E) was conducted to provide a balanced evaluation of the risks associated with various components of the HLF system.

The following emergency scenarios were considered in the FMEA for the heap leach and process facilities:

- HLF embankment failure (hydraulic, structural or seepage)
- In-Heap Pond solution escape
- Events Pond failure
- Liner system failure
- Solution collection system failure
- Ore heap slope failure
- Closure Drain System failure
- Hydrogen cyanide release from ADR plant
- Hydrogen cyanide release during transportation

5 HEAP LEACH FACILITIES SHUTDOWN

5.1 TEMPORARY SHUTDOWN

Reclamation and closure of the HLF is addressed in the Reclamation and Closure Plan, which includes general cyanide destruction, heap rinsing and drain down of the HLF. This section addresses measures to be taken during temporary shut-down of HLF, which assumes that all solution management systems will be operational, and that solution will continue to be recycled through the HLF and ADR circuit, and that the total moisture content of the HLF will remain static (with the minor addition from meteoric input). If shut-down conditions persist, then solution management will enter the closure phase, including the destruction of cyanide, followed by rinsing and draindown as described above in Section 4.1.2, and as detailed in the Reclamation and Closure Plan.

Temporary shut-down conditions are considered in the design of the HLF and ADR. Specific design attributes include:

- redundancy in power sources (back-up generators),
- additional risers from which to pump PLS,
- excess solution storage capacity in the HLF ponds (In-Heap Pond and Events Pond) that exceeds design criteria
- insulated lines,
- sump designed for closure,
- ability to continue to recirculate process solution on to the heap surface (HLF total moisture content is relatively low and the HLF process is a closed circuit),
- the use of raincoats to minimize meteoric input,
- back-up active water treatment capacity for cyanide destruction.

Further, the Environmental Monitoring, Surveillance and Adaptive Management Plan includes extensive geotechnical and water quality monitoring sites associated with the HLF to continually assess the performance of the embankment, liners, and solution circuit integrity, and the potential affects on groundwater.

5.2 PERMANENT SHUTDOWN (CLOSURE)

5.2.1 Closure Objectives and Criteria

Closure objectives for the HLF include:

- conducting drain-down and cyanide destruction activities in a controlled manner to achieve and maintain chemical stability of heap effluent;
- performing grading and cover placement in a manner that will achieve long-term physical stability including minimizing erosion, subsidence or slope failure;
- incorporating design criteria and attributes so that the HLF is able to withstand severe climatic and seismic events;

- achieving long-term chemical stability such that runoff and seepage quality meet water quality criteria; and,
- implementing appropriate contingency measures as required.

5.2.2 Closure Measures

The HLF will be one of the last facilities to be reclaimed as the cyanide destruction and rinsing processes will take approximately two years, following the cessation of active mining and placement of ore. The construction of a store-and-release cover system will commence once cyanide concentration meets the objectives for routing solution flow to the mine water treatment plant or the passive water treatment system constructed down gradient of the facility. There are essentially four stages in the closure process:

- residual leaching,
- cyanide destruction and rinsing,
- draindown, and,
- passive water treatment.

5.2.2.1 Residual Leaching

After the last ore materials are placed, transition to a residual leaching period will commence. During this phase, diffusion of the cyanide solutions into the heap materials continues and recovery of gold from the heap drainage continues until it is decided that it is economically beneficial to transition to a detoxification and rinsing phase. The exact duration of this residual leaching phase cannot be determined in advance (which will be a cost-benefit trade off of commodity prices, operational and overhead costs, and other site-specific factors), but for purposes of cost estimation, a duration of one year is assumed. During this residual leaching phase, the crushing and stacking equipment is decommissioned, and the primary activities are movement of pipes and leaching equipment around the heap to maintain optimal leach phasing.

5.2.2.2 Cyanide Destruction and Rinsing

As the economic recovery of precious metals from the heap is reaching the transition point where the net economic benefits of gold recovery diminishes, the heap operations will transition to a cyanide destruction and rinsing stage. This stage refers to the destruction of cyanide within the solution, such that it is no longer acutely toxic from the toxicity of cyanide, and the term “rinsing” refers to the continued application of solutions that are low in cyanide concentration to the heap to flush out areas with higher concentrations. During this time there may continue to be recovery of gold-bearing solutions.

This phase will appear similar to the residual leaching phase, in that the primary activities will be movement of pipes and leaching equipment around the heap as necessary to continue to deliver rinse water to the heap. However, the rinse water added to the top of the heap will no longer have cyanide present in it. Instead, biochemical treatment of the heap solutions will decrease the active cyanide from solution. This will be achieved by adding sugar solutions (sugar solution with reducing sugars, typically molasses or corn syrup are the most cost effective) to the barren solution exiting the gold recovery circuit, where any residual free or reactive cyanide forms and biochemically reacts with the sugar molecule, forming cyanohydrin. The rate of sugar solution added to the barren solution is designed to both react residual cyanide in the barren solution, as well as cyanide in the pores of the heap. Thus, the treatment is achieved both in the barren tank prior to circulation up to the heap, as well as within the heap, which is termed in situ treatment.

This process is similar to what was done at the Brewery Creek Heap to detoxify the solution inventory to close the heap, and also was successfully pilot tested for the Eagle heap materials (Tetra Tech 2014). This experience and experience elsewhere forms the basis for the application approach and dosing rate for the biochemical treatment reagents. Additional detail on the in-situ cyanide destruction process is included in the Reclamation and Closure Plan.

When the cyanide concentrations have decreased in the In-Heap Pond such that the heap outflow to the ADR is consistently below the required free cyanide concentrations, the treatment strategy will shift to a strategy that will stabilize and further improve the water quality from within the heap for water quality constituents beyond cyanide, including nitrogen species (ammonia, nitrate, nitrite, and thiocyanate) and metals and trace metalloids (e.g., copper, zinc, antimony, arsenic, selenium).

This subsequent phase of in situ treatment will provide a further treatment within the In-Heap Pond, as well as decreasing metals concentration to sufficient levels to either directly discharge, or at least provide water that is of sufficiently good quality to only require polishing in a passive treatment system (described below). As soon as the cyanide concentrations have decreased to less than the required free cyanide concentrations, heap draindown will begin.

5.2.2.3 Draindown

The heap drain-down and transition period (during which there will still be additional gold recovery) will be planned and managed to fully integrate with the site water management plan. The overall solution inventory will be decreased by processing water through the MWTP and/or the heap PTS for discharge. Depending on the flow rates achieved through the MWTP, the PTS, and the effectiveness of the cover system that is being built on the heap, the actively managed draindown period is assumed to take 10 years (assuming a treatment rate of 4 l/s). The time period for active management can be increased or decreased by adjusting the treatment rate. The actual treatment rate will be determined based on multiple years of heap operation and monitoring data. During this time the following activities will occur:

The transition to heap draindown will occur with the perforation of the sump and activation of the closure sump. The transition from cyanide destruction to draindown will include the following steps:

- Discharge of water from the closure sump to the MWTP at a controlled rate consistent with the capacity of the MWTP to treat and discharge the water.
- Discharge of some water from the closure sump to a passive treatment system to be built in the Events Pond location.
- When either
    - the heap is sufficiently drained and is discharging below WUL QZ14-041 discharge criteria, or
    - the passive treatment wetland system is treating all of the remaining flow at the design capacity and achieving discharge criteria,
    - then the MWTP can be turned off and decommissioned in accordance with license terms.

During the draindown period, the solutions that are recirculated back up into the heap will have organic carbon amended into them. This draindown in situ treatment period will switch from a sugar-based solution to an alcohol-based solution, with the purpose of creating sulfate reducing conditions within the saturated zone of the heap. This will allow for the heap drainage to continue to improve ultimately to achieve water quality consistent with that observed in alcohol fed bioreactors. In these conditions, reduction in metal concentrations is also commonly observed as result of the reducing conditions established during microbial metabolic processes, because many metals are less soluble in a reduced state (chromium, copper, selenium, uranium, for instance). Other metals that preferentially sorb to iron or manganese oxides in a more neutral pH range created during the cyanide destruction process will generally decrease, including trace metals such as arsenic and antimony. Metals that form insoluble sulfides will also become substantially treated. It is expected that at the end of the recirculation and draindown period that the heap solutions can either be directly discharged in accordance with the site discharge criteria, or that the PTS will be able to polish it using primarily aerobic processes, as described below.

5.2.2.4 Passive Water Treatment

Several passive treatment technologies have been evaluated for potential application for late closure and post-closure water treatment technologies. Preliminary studies and planning initially suggested that Constructed Wetland Treatment Systems (CWTS) would best fulfill the site-specific objectives for passive treatment at the Project site; however, a hybrid PTS comprised of a biochemical reactor (BCR), permeable reactive barrier (PRB), or zero valent iron (ZVI), followed by a CWTS may be optimal. The refined PTS design is described here.

Based on predicted water qualities and quantities, there are slight variations in the proposed PTSs for the HLF and waste rock storage area (WRSA) water sources. Using the predicted closure water quality, all CWTSs were sized according to plausible removal rate coefficients (RRC). The RRC is a way of expressing the rate of water treatment, based on treatability of the compound and hydraulic retention time. Although it is recognized that the treatment rate of a range of element concentrations varies in a CWTS, the influent and outflow concentrations predicted for this system are in a range that allow a first order RRC to be loosely applied, recognizing that this will be refined through the reclamation research program for the PTS. As described in the Reclamation and Closure Plan, the RRCs were developed based on CWTSs or pilot-scale PTSs with similar arsenic concentrations as those predicted for the Project with and without iron

The proposed passive water treatment systems were designed to meet discharge criteria as required by Water Use Licence QZ14-041. Based on water quality and site-specific considerations, the HLF PTS has been conceptualized as a four-step treatment train.

1. The liner under the HLF to the sump will be perforated through the access piping built into the heap and sump during construction, allowing seepage to flow under pressure from the sump to the PTS. A valving system within the headworks of the piping can then be used to control the drainage rate to the PTS, or alternatively recycle some portion of the heap drainage by pump back onto the heap surface and eventually via percolation to the HLF In-Heap Pond, which will be dosed with an organic material (such as ethanol or molasses). This recirculation of heap drainage into the base of In-Heap Pond zone will support the operation of the anaerobic bioreactor within the In-Heap Pond. Ultimately for the HLF, the bioreactor will be responsible for carrying out cyanide destruction and the CWTS will be responsible for meeting closure water quality objectives.
2. The seepage will leave the anaerobic bioreactor through a rip-rap lined cascade to re-aerate and precipitate elements as oxides. A preference will be given to rip-rap rock that contains iron or manganese

oxides to help facilitate the formation of Fe/Mn surface coatings on the rip-rap that will enhance removal of As/Sb/Se.

3. The seepage will enter the Events Pond, which will now be repurposed into a series of CWTS cells. The CWTS will bring water that has been largely treated by the bioreactor down to concentrations acceptable for discharge. The CWTS is designed to mineralize and sequester elements into the sediments in a benign manner through sorption, coupled biogeochemical reactions and accretion.
4. The treated water will exit the CWTS into a retention basin that will provide a mixing point for the water exiting all parallel replicate systems in the CWTS, and serve as a monitoring point for water prior to entering receiving water bodies.

More detail on the conceptual design of the HLF PTS is found in the Reclamation and Closure Plan.

5.2.3 Covers

The currently planned end land-use for the reclaimed HLF and WRSA at the Project site is natural habitat (wilderness). Key design objectives for the HLF / WRSA closure cover systems include long-term geotechnical and geomorphic stability, as well as providing a medium for sustainable growth of native plants. Another key function of the HLF / WRSA closure cover systems is to reduce long-term net percolation rates to the greatest extent possible using locally available materials for cover system construction. Passive treatment systems will be designed and implemented to handle resultant environmental loadings from the HLF and WRSA post-closure seepage.

The proposed covers are store and release covers, which reduce infiltration into the underlying material by storing precipitation (similar to a sponge) in the rooting zone of the cover material and then releasing some of the water back to the atmosphere through evapotranspiration from vegetation. The cover comprises a thick layer of material placed in a loose state and re-vegetated with selected local species that have high moisture uptake characteristics. A similar store and release cover system was constructed at a similar open pit-heap leach gold mine project (Brewery Creek, YT) that was closed and reclaimed. The currently proposed closure HLF cover system design, referred to as the 'Base Case', is a 0.2 m thick layer of topsoil underlain by a 0.3 m thick layer of placer tailings / colluvium.

The current design is supported by 43 long-term simulations (run in The Hydrologic Evaluation of Landfill Performance (HELP) 3.90 D Model (2011)) to determine the sensitivity of the Base Case due to variations in materials, climate, and/or vegetation. The simulations were also completed to determine what, if any, improvements could be made to the Base Case cover system design. All the scenarios were initially completed without vegetation present so that changes in performance could be directly correlated to changes in materials or climate. Vegetation was then included to further evaluate select scenarios. The results of these simulations are found in the Reclamation and Closure Plan.

Based on the modelling of the Base Case a profile schematic of the cover that would be placed over the HLF is shown below as Figure 5.2-1. This conceptual design schematic shows the profile of the cover for the flat areas on the plateaus and benches, as well as the profile for the inter-bench slopes.

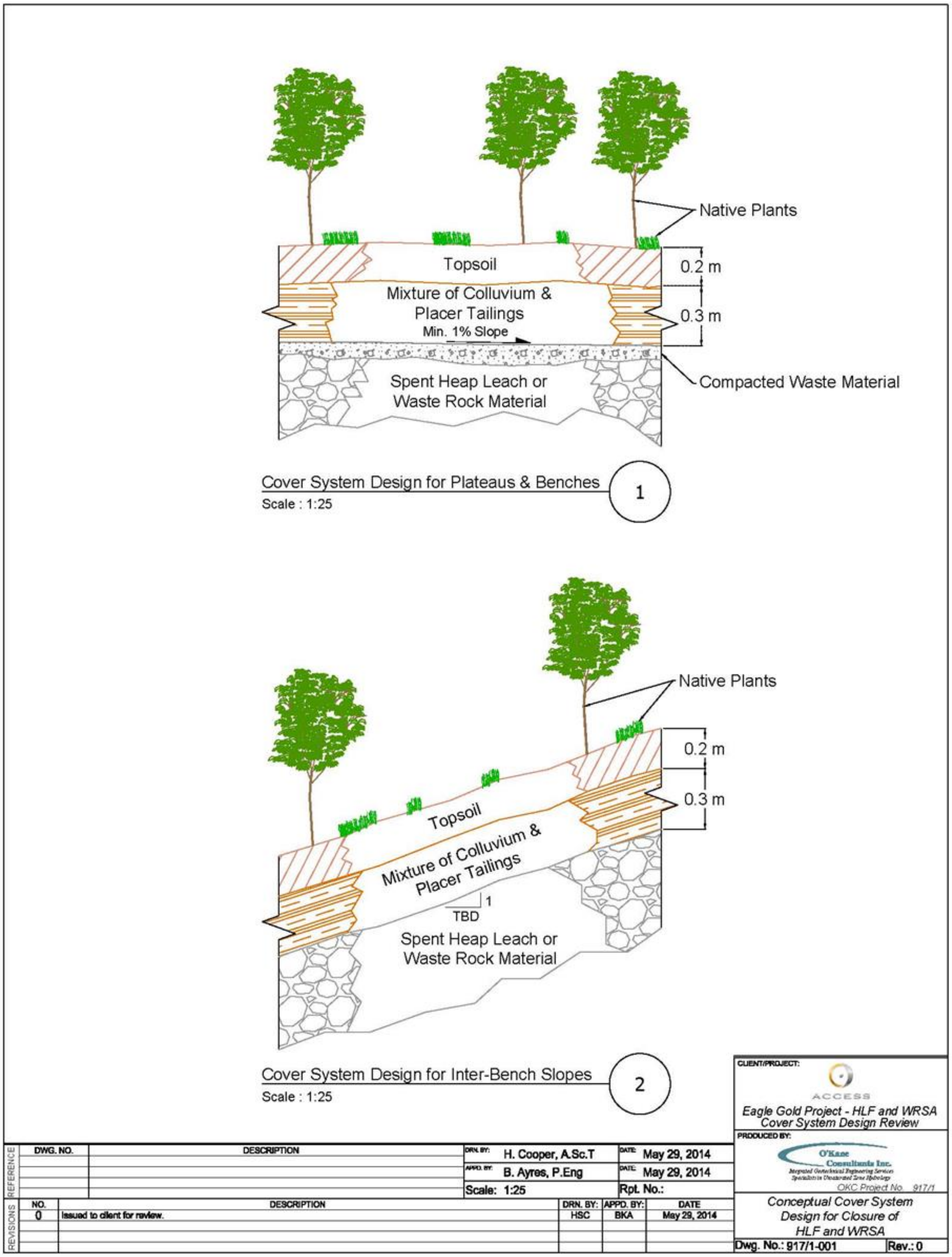


Figure 5.2-1: Conceptual HLF and WRSA Cover Design

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APPENDIX A

Heap Leach Facility Detailed Design - Eagle Gold Project

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APPENDIX B

In-Heap Pond and Events Pond Dam Breach Inundation Modelling

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Project Memorandum

To:	**StrataGold**	**Doc. No.:**	
Attention:	**Mark Ayranto**	**cc:**	**Troy Meyer**
From:	**Shielan Liu**	**Date:**	**December 11, 2017**
Subject:	**Eagle Gold In-Heap Pond and Events Pond Dam Breach Inundation Modelling - Final**		
Project No.:	**0792018**		

1.0 INTRODUCTION

This memorandum presents the assumptions, methods and results of the dam breach inundation modelling completed for the proposed In-Heap Pond and Event Pond of the Heap Leach Facility (HLF) at StrataGold Corporation's (SGC) Eagle Gold Project located in Yukon Territory, Canada. SGC is a directly held, wholly owned subsidiary of Victoria Gold Corp.

The objective of this dam breach inundation analysis is to estimate potential magnitude hypothetical dam breach events, given the proposed embankment heights and storage volumes, and provide and conservative estimate of downstream effects, which ultimately provides input into evaluating the validity of the embankment hazard classification, per Canadian Dam Association (CDA) guidelines. The key outputs from this project include hypothetical maximum inundation areas, maximum flow depths, flood attenuation and final debris flow deposition depth along the inundation path.

While this study does not suggest any attempt to quantify the probability of these embankment breaches, it is fully recognized that by standard practice, the input assumptions assume the most conservative approach conceivable. This study addresses only the potential inundation extent in the event of a hypothetical breach of the embankments and does not attempt to quantify the consequences to facilities, calculate economic losses, address potential loss of life within the inundation area, or suggest potential risk management strategies.

2.0 SITE CONDITIONS

The HLF area is located within the Ann Gulch drainage basin a small tributary of Dublin Gulch, which drains into Haggart Creek. The LiDAR survey data shows that the Ann Gulch drainage basin is relatively steep with a mean 15-degree to maximum 54-degree gradient.

Drawing 01 shows the general site arrangement plan. The proposed HLF embankment lies across the lower portion of the Ann Gulch basin near the confluence with Dublin Gulch. The In-Heap Pond is defined as the storage area directly upstream of the confining embankment. The In-Heap Pond is designed to store the crushed ore, pregnant solution and water from snowmelt and rainfall in the pore spaces of the crushed ore. The target P80 grain size of the crushed ore is 6.5 millimeters (mm) in diameter. The In-Heap Pond is sized to provide containment storage for the 100-year, 24-hour event plus 24 hours of heap drain-down.

The proposed Events Pond is located immediately west and downgradient of the HLF embankment. Under the normal operational condition, the Events Pond will remain empty. The Events Pond serves as an overflow containment area that provides additional storage in case the In-Heap Pond capacity is exceeded. The Events Pond is sized to hold the volume of approximately 155,000m^3 from a 24-hour PMF event (BGC 2017, Appendix B), plus an additional allowance of approximately145,000m^3 at Emergency spillway invert while assuming the In-Heap Pond is full. The runoff from the In-Heap Pond will be routed to the Events Pond via the engineered spillway channel (BGC 2017, Appendix B).

Table 2-1 summarizes the proposed embankment geometries for the In-Heap Pond and Events Pond. The dam height from crest to the pond bottom is 28.5m for the HLF embankment, and15.5m for the Events Pond embankment.

Table 2-1. Proposed embankment geometry data.

Embankment	Crest Elevation (m)	Crest Width (m)	Spillway Invert Elevation (m)	Pond Bottom Elevation (m)	Side slope
In-Heap Pond	939.5	10	938.0	911.0	2.5H:1V
Events Pond	895.5	5	894.5	880.0	2.5H:1V

The heap embankment will be lined with a double geomembrane composite liner system with leak detection, designed to limit seepage to the environment. The selected soil properties of the compacted embankment fill used for slope stability analysis and the dam breach analysis are listed in Table 2-2.

Table 2-2. Design soil properties of embankment fill.

Unit Weight	(kN/m^3)	21.5
Cohesion	(kPa)	0
Internal Friction Angle Φ’	(°)	38

Figure 2-1 illustrates the gross total storage-elevation curve for the In-Heap Pond (brown line) and the Events Pond (blue line). See also Appendix E in the HLF design report (BGC 2017).

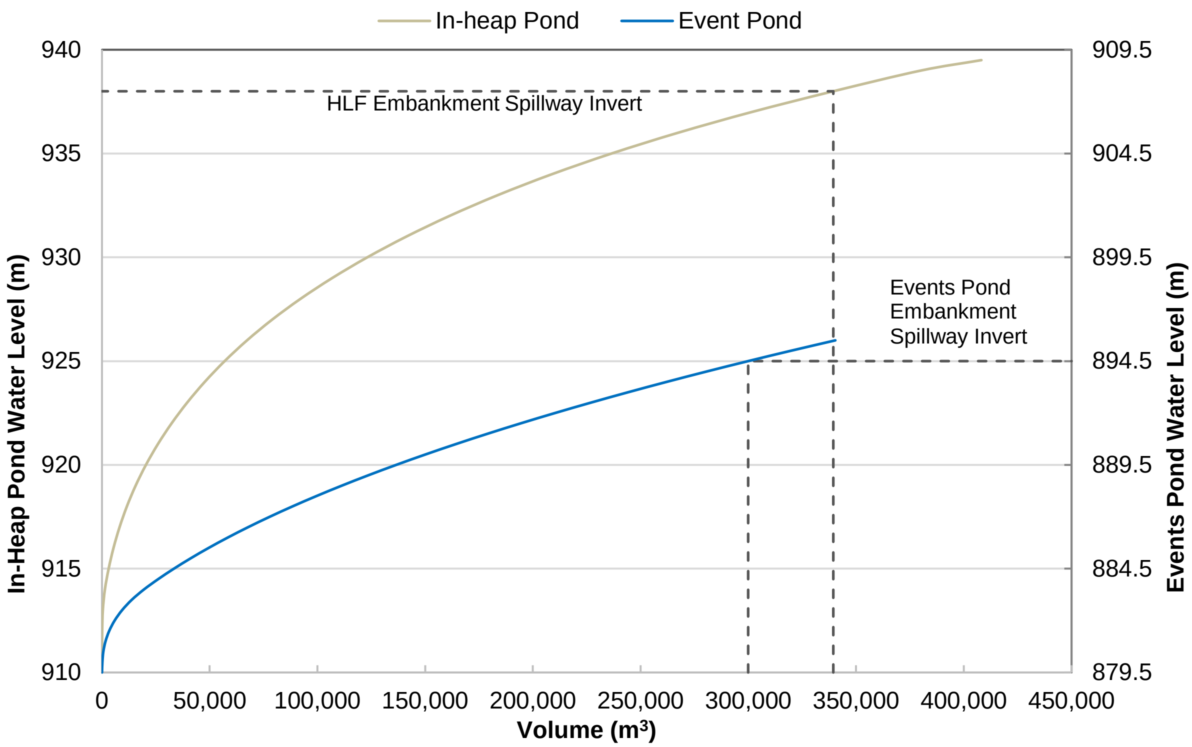

Figure 2-1. The gross total storage-elevation curve for In-Heap and Events Ponds.

Because the original ground slope in the In-Heap Pond is steeper than 15 degrees in average, the combination of the stored crushed ore, pregnant solution and water from snowmelt and rainfall could be potentially released to the downstream as debris flow in a HLF embankment breach event. Thus, the total volume that would be released in a HLF embankment breach includes the volume of fluid in the pore spaced plus an allowance for the solids contained in a debris flow. The volumes of the released solids and water for each of breach scenarios are calculated in Section 5.

Dublin Gulch and Haggart Creek are perennial streams (Knight Piesold 2012). Several of the tributaries to these creeks/gulches become dry at sections along the water course where flow is subsurface. Several tributaries have little to no groundwater storage and flow is in response to snowmelt or heavy rains (Tetra Tech 2013). The design storm event, the peak flow of the Probable Maximum Flood (PMF) at the outlet of In-Heap Pond, was estimated to be approximately 12.2m^3/s (BGC 2017, Appendix B).

A series of control ponds, access road crossing the Dublin Gulch, a water treatment plant and a camp site are designed to be located at approximately 500m downstream of the upstream edge of the Events Pond, near the confluence of Dublin Gulch and Haggart Creek. There is no residential area development along Haggart Creek.

3.0 MODEL SCENARIOS AND ASSUMPTIONS

In accordance with the CDA guidelines (CDA 2007, revised 2013), two dam breach scenarios are considered and are detailed below.

Flood-Induced Dam Failures

Flood-induced dam failures, also referred to as “Rainy-day” failures, occur during large flood inflow conditions when the pond water level rises high enough to cause dam overtopping. Typically, overtopping failure would be considered as the worst scenario. Given one of the objectives of dam breach inundation study was to estimate the potential impact of dam failure events under the extreme conditions, the spillways were conservatively assumed not functioning properly during a “Rainy-day” event for this study. The overtopping failure was assumed to be triggered by the combination of a Probable Maximum Flood (PMF) event and water mismanagement. The water levels for the overtopping failure was assumed to be same as the crest elevations. In addition, to assume the most conservative situation, the In-Heap and Events Pond embankments were assumed to fail simultaneously during a “Rainy-day” event.

Sunny-Day Failures

Sunny-day failures are assumed to occur when the pond is at its normal operating level and may include dam slope failure due to static or earthquake loading, or piping-induced (internal erosion) dam failure. The earthquake triggered piping failure was assumed for the “Sunny-day” event. The water levels were assumed at the spillway inverts for the In-Heap Pond during an “Sunny-day” event while the Events Pond was assumed as empty.

Based on the considerations and assumptions described above the scenarios modelled in this study are summarized in Table 3-1.

Table 3-1. Summary of modelling scenarios.

Scenario ID	Failure Condition	Embankment	Water level	Base Flow
1	Rainy-day Overtopping	In-Heap Pond	939.5	PMF
		Events Pond	895.5	
2	Sunny-day Piping	In-Heap Pond	938.0	-

4.0 MODELLING PACKAGES

4.1. BREACH Model

A dam breach module BREACH that was originally developed by National Weather Service (NWS) of the United States was used to calculate the flow discharge rate based on the mass balance of the inflow and outflow from the pond during the breach process. The required inputs include dam geometry data, such as the crest elevation, dam toe elevation, crest width, the upstream and downstream side slopes, and the general soil properties of the dam fill material, the initial piping locations, the surface area and water level relation. The output breach outflow hydrographs were routed to the downstream for the inundation modelling.

4.2. FLO-2D Model

The numerical model FLO-2D (FLO-2D Software Inc. 2016) was used to simulate the dam breach scenarios. FLO-2D is approved by the U.S. Federal Emergency Management Agency for this type of study, and has been used in practice for more than 20 years. The FLO-2D inundation simulation module is a depth-averaged volume conservation based flood routing model that was developed specifically for the analysis of muddy flows travelling over complex three-dimensional terrain, making it well suited for the mixture of solids and water runout analysis. For flows with volumetric sediment concentrations greater than 20%, FLO-2D assumes that the flow resistance of the slurry is governed by a non-Newtonian quadratic rheological model. For flows with volumetric sediment concentrations less than 20%, the influence of the solids component on the rheology of the breaching fluid is considered negligible and the material is expected to flow like water. In this case, FLO-2D reverts to a conventional clear water flood routing model, in which the breaching fluid is treated as clear water and flow resistance is governed simply by surface roughness along the path.

Key assumptions and input parameters to FLO-2D flood and debris flow inundation module include, topographic data, inflow hydrographs that reflect the released volumes and peak flows from the embankment breach, and flow resistance parameters as detailed in Section 5.0. The outputs include maximum inundation area, maximum flow depth, final flow depth and flow arrival time to locations of interest, which are presented and discussed in Section 6.0.

5.0 MODELLING ASSUMPTIONS AND INPUT DATA

5.1. Released Volumes

Dam breaches from the HLF embankment are assumed to involve release of both crushed ore and free water. The free water is assumed to drain entirely from the impoundment, 10%-100% of the impounded solids could be released (e.g., Rico et al. 2008). The debris flow generally deposits in the channel gradient range from 3° to 10° (Pierson 1980; Ikeya 1981; Mizuyama 1981). As discussed in Section 2, because of the steep terrain at the HLF location (>15°), the stored crushed ore and water was assumed to drain entirely as debris flow from the In-Heap Pond. BGC considered this was a more reasonable assumption than the Tetra Tech's assumptions in 2013 that only the water in the voids between the crushed ore could be released (Tetra Tech 2013).

The solid volumetric concentration varies from 52.2% to 65.9% from initial to loaded condition in the In-Heap Pond (BGC 2017, Appendix E). The higher solid volumetric concentration indicates a lower mobility. The average solid volumetric concentration between the initial and loaded condition 59.0% level was used for released volume calculation. Assumed the crushed ore was saturated and the volume above the spillway invert was pure water, the total released solids excluding the water contents in the crushed ore and water including the water contents in the crushed ore in the In-Heap Pond for the Scenarios listed in Section 3 are summarized in Table 5-1. The water in the Events Pond was assumed released entirely.

Table 5-1. Summary of breach volumes.

Scenario ID	Failure Condition	Embankment	Total Released Volume (m³)	Total Released Solid Volume (m³)
1	Rainy-day Overtopping	In-Heap Pond	408,200	200,246
		Events Pond	340,400	-
2	Sunny-day Piping failure	In-Heap Pond	339,400	200,246

5.2. Peak Flow Estimate

The peak flow is a key parameter that affects the flow depth and propagation velocity along the flood route. The physical based breach model such as BREACH does not do a good job in simulating sediment erosion processes even though the physical geometry and soil properties of the dam are well described. To estimate the reasonable range of breach peak flows, several empirical relations between the peak flow, the dam height and storage volume were used for the peak flow estimate.

Rico et al. (2008) applied Costa's empirical equations (1988) for constructed and landslide dams respectively to estimate the upper bound and lower bound dam breach peak flows for tailings dams. While the In-Heap Pond has a mixture of fairly uniformly sized crushed ore and water, and likely has rheological responses different than tailings dams, Costa's equations for tailings dams were considered the best available, and used for this study.

- Costa (1988) for Constructed dam (upper bound): $Q_{max} = 325\ (HV * 10^{-6})^{0.42}$
- Costa (1988) for Landslide Dam, (lower bound): $Q_{max} = 181\ (HV * 10^{-6})^{0.43}$.

For the Event Pond, the empirical relations for the constructed water dam were used for comparison:

- Froehlich (1995): $Q_{max} = 0.607 * \ (H)^{1.24}(\mathrm{V})^{0.295}$
- Costa and Schuster (1988) for Earth and Rockfill dams: $Q_{max} = 0.0184 * \ (9800 * HV)^{0.42}$.

Where Q_{max} is the peak flow (m^3/s), H is the water level above the pond bottom (m), and, V is the total released volume (m^3).

The estimated peak flows from the equations above are summarized in Table 5-2.

Table 5-2. Summary of peak flows estimate.

Scenario ID	Embankment	Total Volume (m³)	Water Drop (m)	Costa 1988 Constructed Dam (m³/s)	Costa 1988 Landslide Dam (m³/s)	Froehlich (1995) (m³/s)	Costa and Schuster Earth and Rockfill (m³/s)
1	In-Heap Pond	408,200	28.5	900	520		
	Events Pond	340,400	15.5	660		810	590
2	In-Heap Pond	339,400	27.0	820	470		

5.3. Breach Hydrographs

Given the storage characteristics, the breach peak flows from the In-Heap Pond were adjusted to near the upper bound for the Rainy-day overtopping scenario, and to near the lower bound for the “Sunny-day” piping failure scenario. The breach peak flows from the Events Pond were adjusted to the average values in BREACH models.

The “Rainy-day” breach hydrographs are presented in Figure 5-1 and “Sunny-day” breach hydrographs are presented in Figure 5-2. The solid curves represent the total discharge for each scenario. The areas below the hydrographs match the total breach runout volumes shown in Table 5-1. The dashed curves represent the solids, i.e., sediment discharges for each scenario. The areas below the dashed curves match the released tailings solids volumes shown in Table 5-1. Erosion and entrainment of dam material and loose surficial material downstream of the dam was assumed to contribute a relatively small volume of additional solids to the breach flows.

The breach locations for both ponds were chosen to be at the downstream dam toes with the shortest distance to the upstream dam toes. The distance between two breach locations is approximately 400 meters.

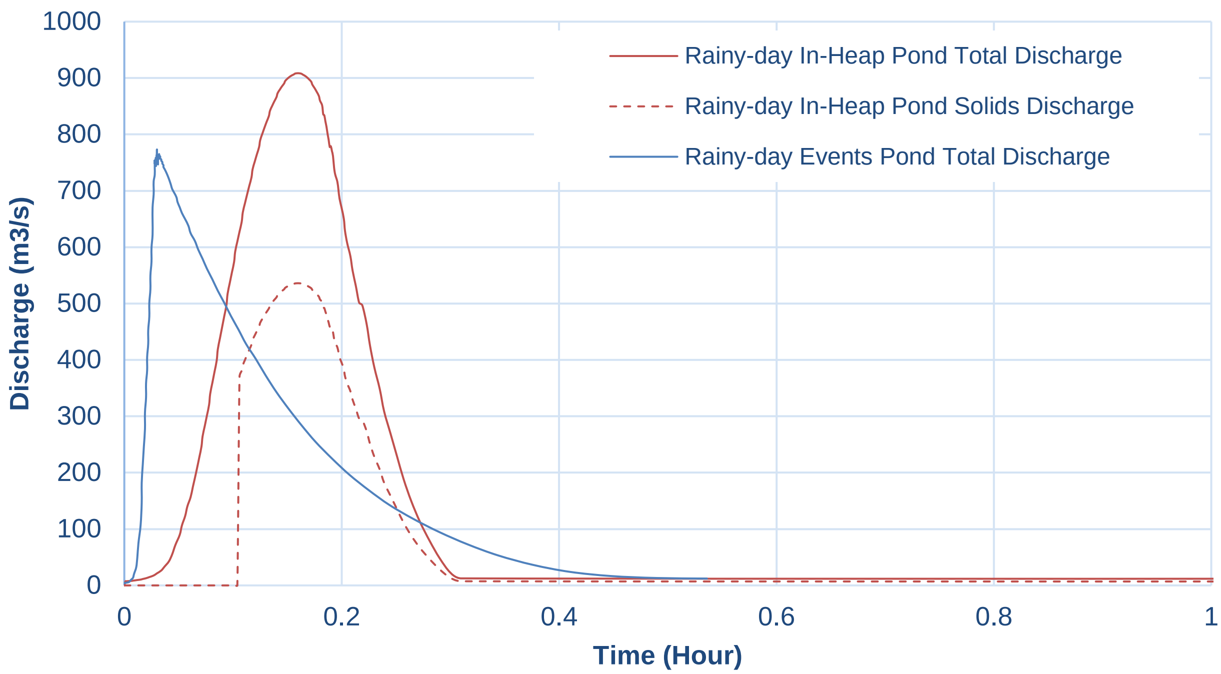

Figure 5-1. Breach outflow hydrographs for “Rainy-day” overtopping failure scenario.

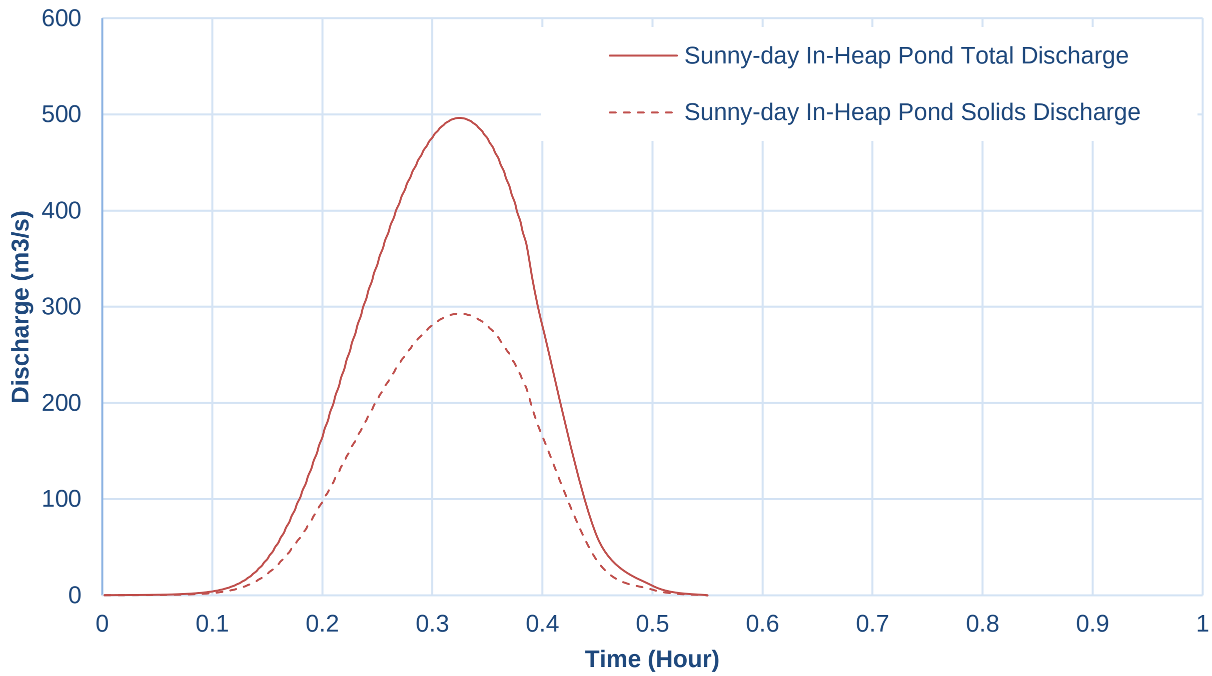

Figure 5-2. Breach outflow hydrographs for "Sunny-day" piping failure scenario.

5.4. Topography and Model Domain

The LiDAR data set provided by All North dated May 10th, 2016 was used for inundation study. The LiDAR data coverage encompasses an approximately 3 km long reach along Dublin Gulch to the confluence with Haggart Creek, an approximately 5.6 km long reach along Haggart Creek, shown as the shaded relief layer on the Drawing 01. The design In-Heap Pond and Events Pond are also merged to LiDAR data for the modelling purpose. The river length from the dam toe of HLF embankment to the downstream boundary of the LiDAR data is approximately 4.8 km. The original resolution of 1 m LiDAR data was resampled to a 5 m x 5 m raster and input to FLO-2D for this study. Given no land development along Haggart Creek, the model domain was set to the LiDAR data coverage area. The model domain boundary is shown as the green line on the Drawing 01.

5.5. Crushed Ore Rheological Parameters

To model the released debris flow, FLO-2D requires the input of several empirical coefficients associated with rheological parameters of the mixture of crushed ore and water, including the yield stress and dynamic viscosity of the slurry. The empirical relationships between yield stress τ_y , dynamic viscosity η and volumetric sediment concentration c_v are defined by the empirical coefficients α_i and β_i, as shown below:

$$\tau_y = \alpha_1 e^{\beta_1 c_v}$$

$$\eta = \alpha_2 e^{\beta_2 c_v}$$

Table 5-3 shows the α_i and β_i values been input to the models. These values are chosen from the FLO-2D manual (2016) for the material with relative high yield stress and dynamic viscosity at sediment concentration >50%.

Table 5-3. Yield stress and viscosity parameters applied for crushed ore.

Resistance Component	Estimated Parameter	
	A	B
Yield Stress (Pa)	0.047	21.1
Dynamic Viscosity (Pa.s)	0.128	12.0

5.6. Resistance Parameters

FLO-2D requires estimates of the Manning's *n* coefficient, which characterizes the surface roughness along the flood path downstream of the dam. Given the overall site conditions that a lower flow resistance in the active channel (primarily made of sand and gravel) and a greater flow resistance in the overbanks due to the presence of shrubs and small trees, a uniform Manning's *n* number of 0.06 was assigned to the grid cells in FLO-2D. This value was selected from tables presented in Chow (1959).

5.7. Duration of Simulation

The duration of the simulations was determined by the time required for the peak flow to pass through the model domain and exit the outflow boundary. The duration of the simulation was set to 5 hours for each scenario.

6.0 RESULTS AND DISCUSSIONS

The FLO-2D modelling results, including maximum flow depths, inundation areas, flood peak flow attenuation and front and peak arrival time for each scenario are presented and discussed below.

6.1. Maximum Flow Depths and Inundation Areas

Using the most conservative assumptions as inputs to the model, modelled inundation areas and maximum flow depths along the river channels and flood plains are illustrated in Drawings 01 and 03 for the "Rainy-day" and "Sunny-day" scenarios respectively. The modelling results suggest that:

- The breach flow from the In-Heap Pond will not flow into the Events Pond from the chosen breach location. The sensitivity analysis run with the breach location moved to the western toe of the embankment showed that the breach flow from the In-Heap Pond are not likely to flow into the Events Pond.
- The breach released flow is mostly constrained in the creek channels along the Dublin Gulch and Haggart Creek valleys in a "Rainy-day" event.
- The travel distance of the released debris flow from the In-Heap Pond is about 2km downstream in a "Sunny day" event.

- The floods peak wave could be greater than 5 m in the channels for both of scenarios. In average, the peak flood waves along the flood path are less than 5m.
- For both scenarios, the Control Pond, the access road crossing the Dublin Gulch to the water treatment plant could be impacted by 2 to 5 meters deep flood. A small portion of the Camp Area could potentially be impacted.

Given the relative minor impact area for both of “Rainy-day” and “Sunny-day” scenarios, the comparison of the inundation area increments between a dam breach event and the condition without base flow only was not evaluated.

6.2. Flow Attenuation and Peak Arrival

The flood attenuation was evaluated with the hydrographs at two cross sections downstream, labeled on the Drawing 01 and 03. Cross section A is located near the confluence of the Dublin Gulch and Haggart Creek, approximately 1km downstream of the HLF embankment breach location. Cross section B is located near the model domain boundary, approximately 4.8 km downstream of the HLF embankment breach location. Figure 6-1 illustrates the hydrographs for the “Rainy-day” overtopping scenarios at two cross sections. Figure 6-2 shows the hydrograph for the “Sunny-day” piping failure at Cross Section A.

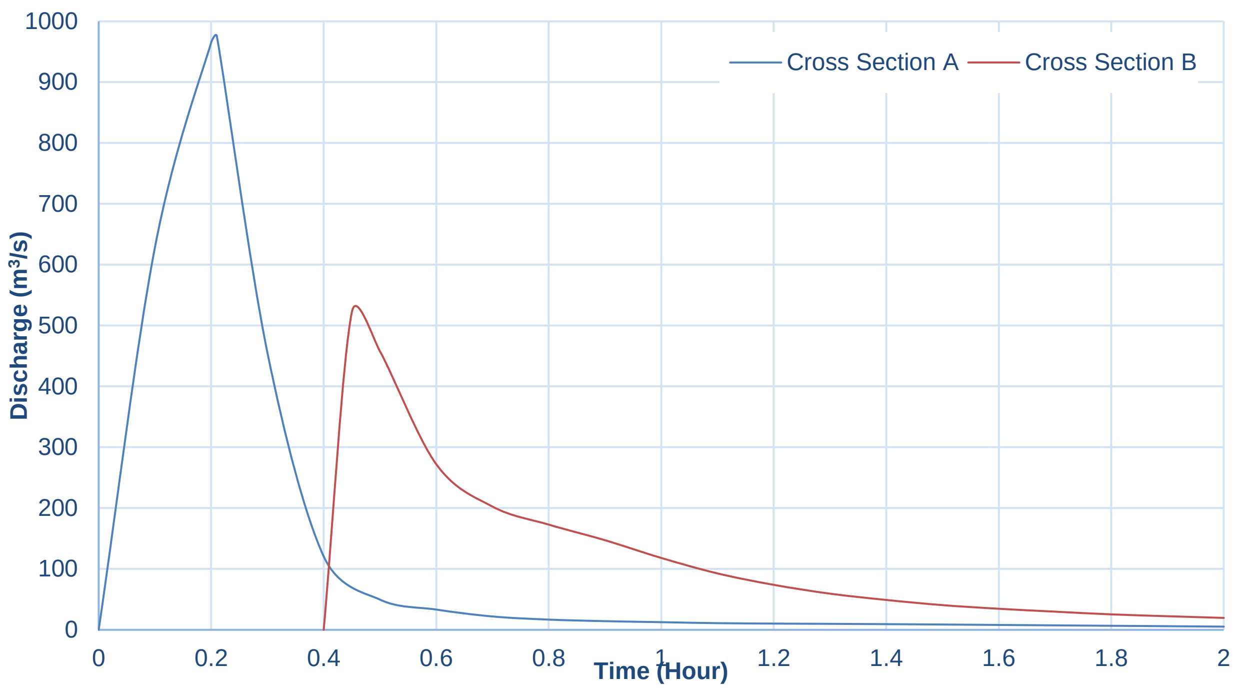

Figure 6-1. “Rainy-day” overtopping failure caused debris flow/flood hydrographs at Cross Sections A and B.

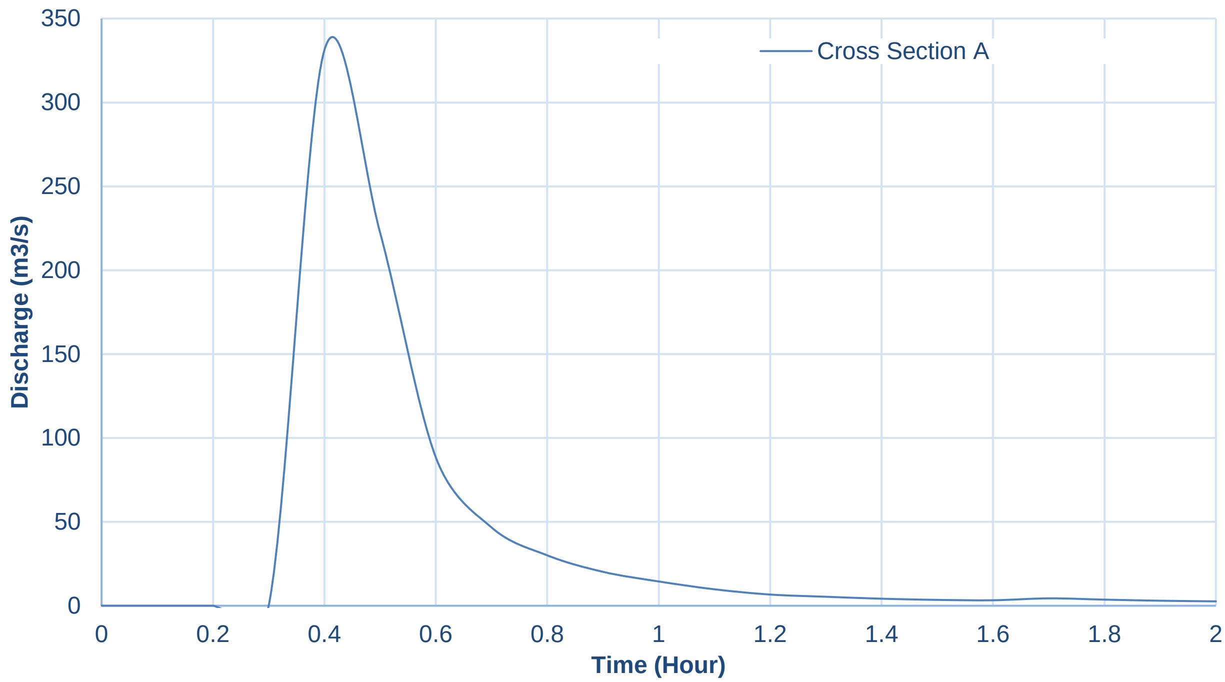

Figure 6-2. "Sunny-day" piping failure caused debris flow/flood hydrographs at Cross Section A.

The start time on the X-axis for each figure is the time when the breach initiates, shown in Figure 6-1 and Figure 6-2.

For "Rainy-day" scenario, it only takes about 0.2 hours for the peak flow to pass the Cross Section A, about 0.4 hours to pass the Cross Section B. The average front velocity is approximately 8-11m/s. The relatively high velocities are largely due to the high channel gradients in the area. The peak flow at the model domain boundary decreases to approximately 520m^3/s for "Rainy-day" scenario, indicating that the flow with the released pregnant solution from the In-Heap Pond could be potentially carried to further downstream.

For "Sunny-day" scenario, it takes about 0.45 hours for the peak flow to pass the Cross-Section A. The flow will stop at the upstream of the Cross Section B. Therefore, no hydrograph at Cross Section B is presented in Figure 6-2.

6.3. Final Debris Flow Deposition

The breach released debris flows from the In-Heap Pond almost stop after 5 hours. The final debris flow deposition maps for the "Rainy-day" and "Sunny-day" are shown in the Drawings 02 and 04 respectively.

For the "Rainy-day" scenario, because the released debris flow from In-Heap pond will mix with the flow released from Events Ponds, small portion of crushed ore will be scattered in the creeks while the big portion of the crushed ore will be carried to the further downstream.

For the "Sunny-day" scenario, because of the high volumetric sediment concentration in the released debris flow, most of the crushed ore will deposit at the confluence of the Dublin Gulch and Haggart Creek with the maximum deposition depth about 5 meters.

7.0 UNCERTAINTIES AND LIMITATIONS

There are numerous uncertainties inherent to dam breach modelling and routing of extreme floods or debris flows caused by a dam breach. Thus, conservative assumptions were assumed. Sources of uncertainty include, but are not limited to, the following:

- There are uncertainties in the estimation of the released heap volume. The potential variation in the released heap volume estimate was discussed in Section 5.1.
- There is uncertainty in the breach modelling peak flows. As discussed in Section 5.2, they were estimated using empirical equations due to the difficulty in measuring and predicting these values.
- There is no dam breach data available for the calibration for the rheological parameters at the site. The comparison of the "Rainy-day" and "Sunny-day" scenarios provides a hint on the importance of these parameters. The sediment concentration of slurry flow in "Rainy-day" scenarios show less viscous rheological parameters than for the "Sunny-day" scenarios, translating in different peak arrival time and deposition maps
- The resistance term represented by the Manning's n for the river and floodplain was not calibrated with the streamflow data with hydrographs in the region. The Manning's n would have impact to flow depth, flow velocity and inundation areas. However, compared to the uncertainties mentioned above, the Manning's n has a relative minor impact in the modelling results.
- There are uncertainties on the breach initial time estimate. The assumptions on the instant release from the breach result in the conservative peak arrival time.
- There are uncertainties on predicting the final deposition of the crushed ore. The outputted deposition maps only illustrate the potential but not accurate deposition locations because of the uncertainties associated with the input data and the limitations associated with the debris flow deposition processes simulation in FLO-2D model.
- There are limitations inherent to the modelling package. The flood wave propagation involves complex and dynamic physical processes, which are not all captured by the inundation modelling. These complexities include sediment transport processes, including deposition and erosion, the rheological behavior of the debris flow and the roll wave propagation process.

Due to the uncertainties and limitations involved in the dam breach and inundation modelling discussed above, conservative assumptions were applied to provide conservative hypothetical inundation scenarios.

8.0 CONCLUSIONS

A dam breach and inundation study was completed for the proposed HLF Embankment and Events Pond Embankment. For both "Rainy-day" and "Sunny-day" scenarios, the Control Pond, and the access road crossing Dublin Gulch could potentially be inundated by the debris flow with the depth of 2-5m by the hypothetical events. Small portions of the Camp Area could also be affected. For the “Rainy-day” scenario, small portion of the crushed ore will be scattered in the creeks, big portion of the crushed ore will be carried further downstream of Haggart Creek. For the “Sunny-day” scenario, the crushed ore will potentially deposit at the confluence of Dublin Gulch and Haggart Creek with the maximum deposition depth about 5 meters.

The modelling is based on hypothetical modes of failure under very extreme conditions, and are intended only to provide input for hazard classification of the facilities. This analysis does not attempt to quantify the consequences to facilities, calculate economic losses, address life loss potential to people within the inundation area or suggest potential risk management strategies. These analyses also do not indicate the accurate downstream distribution of released crushed ore and pregnant solution following a hypothetical dam breach.

9.0 CLOSURE

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Yours sincerely,

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SL/TM/MH/rm/mm

Attachments: Drawing 01-04

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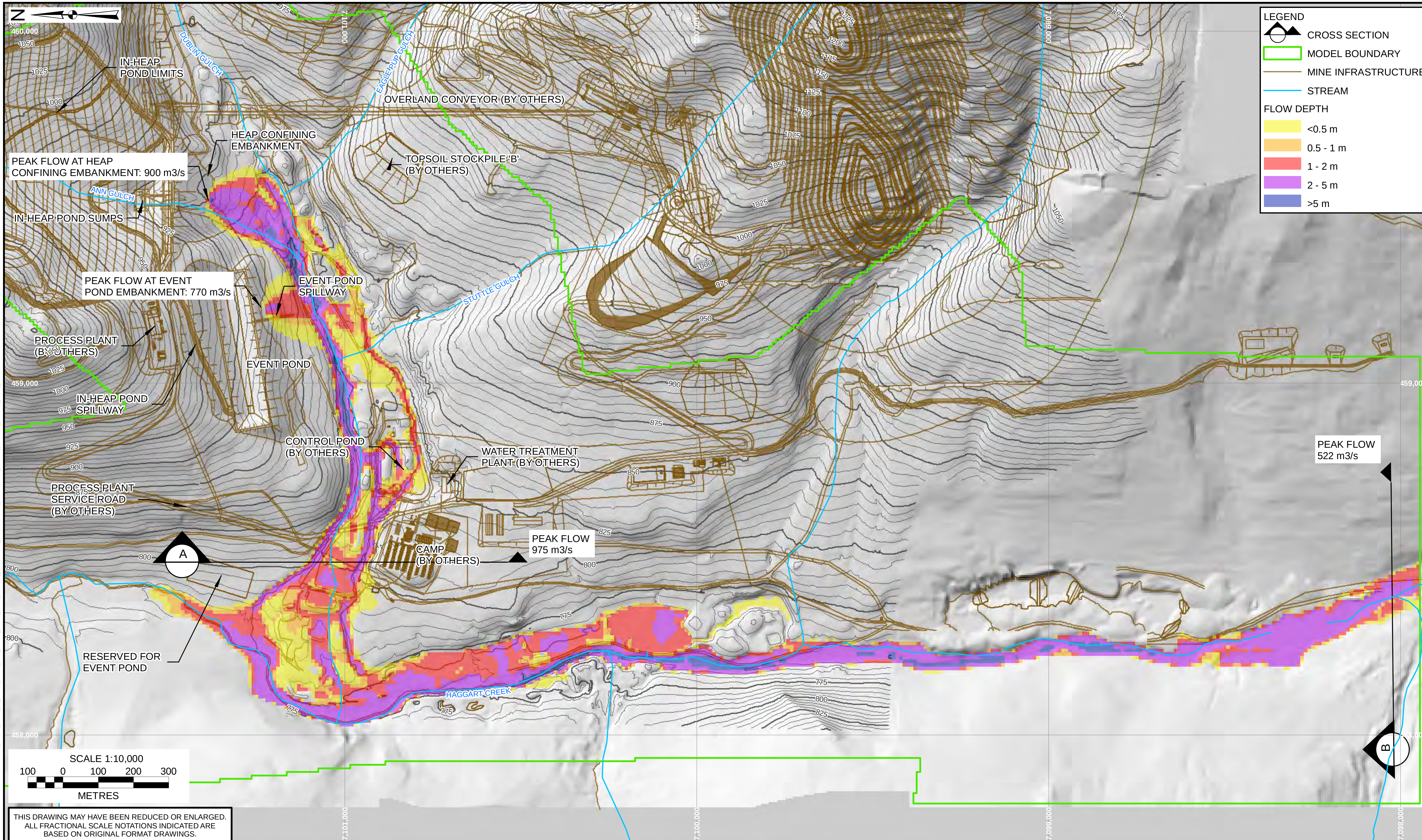
DRAWINGS



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TITLE: MAXIMUM FLOW DEPTH - RAINY DAY SCENARIO

PROJECT No.: 0792-018

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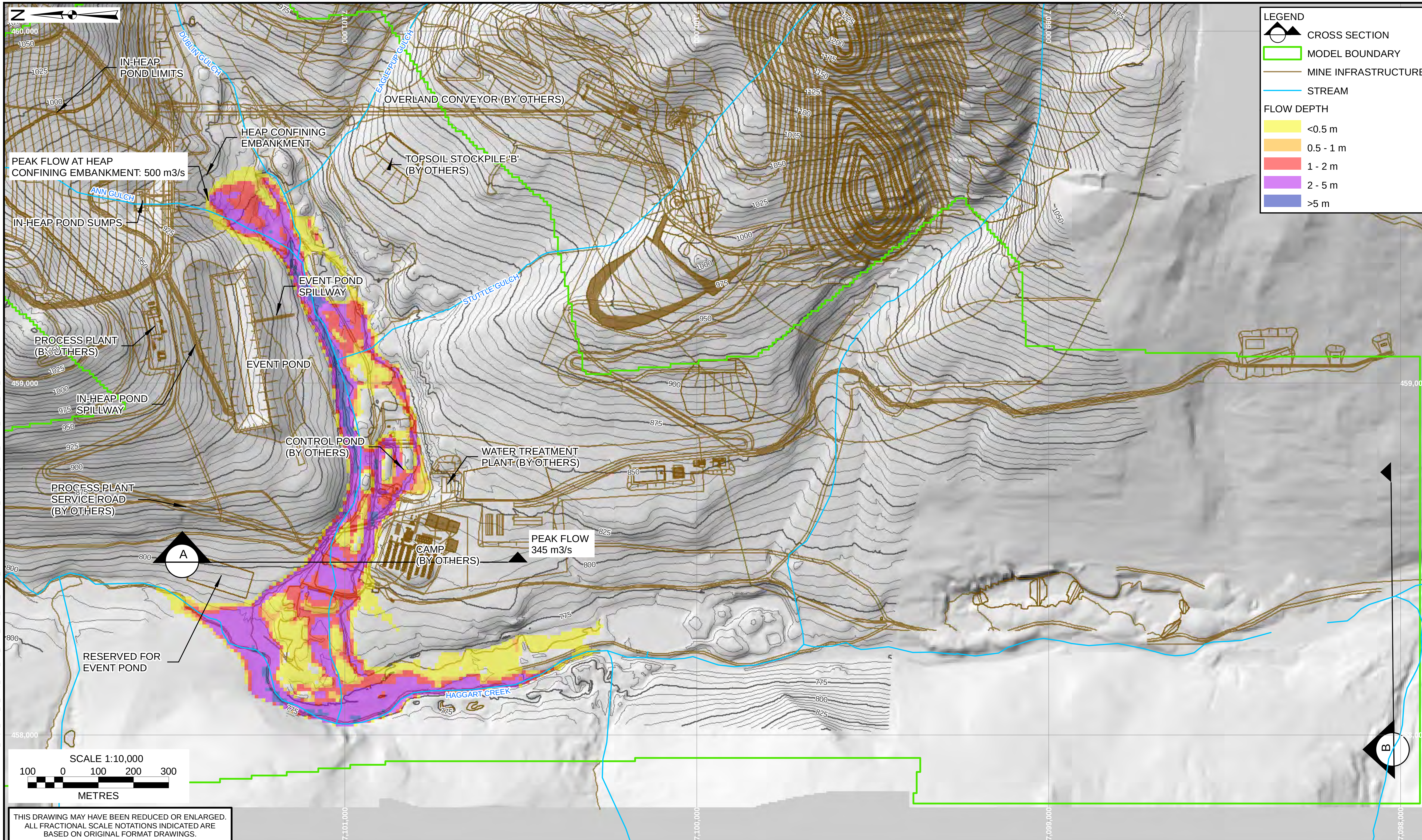

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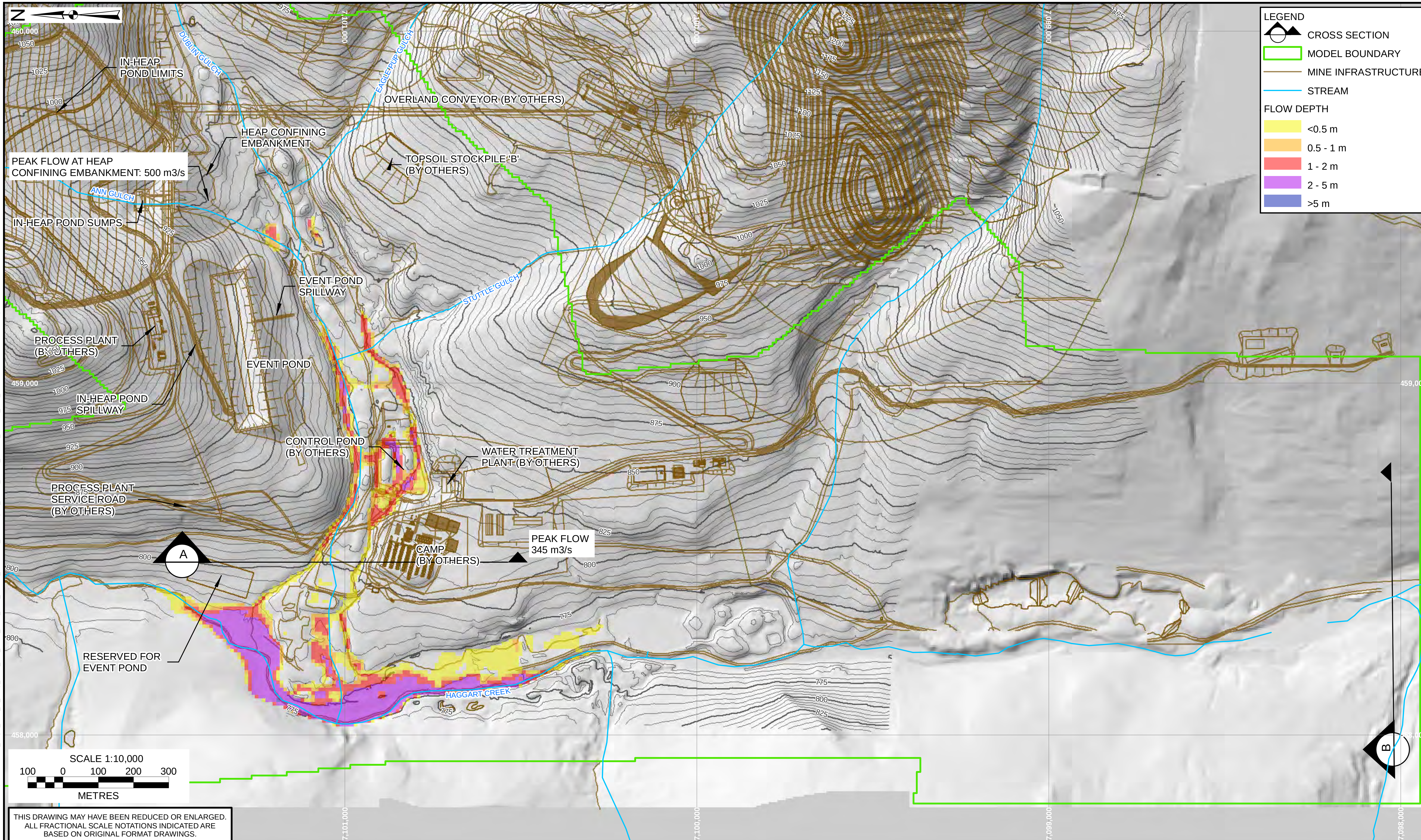

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BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: STRADAGOLD

PROJECT: EAGLE GOLD IN-HEAP POND AND EVENTS POND DAM BREACH INUNDATION MODELLING

TITLE: FINAL FLOW DEPTH - SUNNY DAY SCENARIO

PROJECT No.: 0792-018

DWG No: 04

X:\Projects\0792 Victoria Gold\018\GIS\Production\Report\20171016_Eagle_Gold_In_Heap_Pond_and_Event_Pond_Dam_Breach_Inundation_Modelling\04_FINAL_FLOW_DEPTH_SUNNY_DAY_SCENARIO.mxd Date: Friday, December 01, 2017 Time: 5:15 PM

APPENDIX C

Heap Leach Facility Operational Changes Memorandum

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Technical Memorandum

109001

December 13, 2017

To: Victoria Gold Corporation From: Forte Dynamics, Inc.

Victoria Gold Corporation
Heap Leach Facility Operational Changes

1. Introduction

Forte Dynamics has performed various analyses and review of the Eagle Gold Heap Leach Facility. As part of this review, various parameters of the heap leach facility have been altered according to additional test work and analyses performed by Victoria Gold Corporation (VGC) and Forte Dynamics. These parameters include the in-heap storage volume, the ore bulk density, and the total barren solution flow rate delivered to the pad. As VGC continues with the final design of the heap leach pad and associated processing facilities, various initial assumptions have changed based on final heap configuration and design, along with other operational parameters. The changes in configuration coupled with additional test work conducted in the recent months have manifested themselves in changes to the operational parameters described above. This memorandum details the changes to the heap leach facility design and the additional testing done and summarizes the analysis conducted related to these items. It also describes the impact on the changed in-heap storage volume, ore bulk density, and the barren solution flow rate. These changes are consistent with the current permit levels and do not increase or modify the existing permit.

2. Heap Leach Facility Final Design Changes

As VGC has moved forward with final design of the Eagle Gold heap leach pad, the following designs have changed and can be seen in previously submitted documentation:

- Pad Configuration: 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 which led to a reduction in the total volume of the heap along with reducing the top leaching area available.
- Application Rate: Detailed analysis based on lab testing and summarized in previously submitted documents resulted in the application rate being reduced from 10 L/hr/m2 to 7 L/hr/m2, affecting the leaching area and the barren solution flow rate.
- In-Heap Pond Design: Final design of the in-heap pond and sump to meet pumping requirements for flow intake affected the material sizing within the pond and the PSD of material at various elevations to meet a defined filter criteria. This includes a 16mm, 12 mm, and 6.5 mm portion of the in-heap pond.

3. Parameter Changes

3.1 Bulk Density

VGC conducted additional testing for the ore material for recovery and hydrodynamic characterization. As part of this testing, various PSD sizes were analyzed to determine the optimal crush size along with the drainage criteria for various sections of the pad. For the 6.5 mm crush size 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/m3.

In addition to the changed bulk density, the ultimate configuration was changed for ore stability for the life of the pad. Forte then developed the stacking plan using an average ore placement of approximately 39,000 tonnes per day to load the pad to the ultimate configuration. Table 3-1 shows the volume associated with each lift and the associated tonnage at 1.72 tonne/m3 for the life of the pad. At the adjusted bulk density, the total tonnage to the pad is approximately 86 million tonnes. This change in pad capacity is an increase from the previous expected tonnage capacity of 77 million tonnes. Therefore, with the current mine plan, the life of the pad is extended into year nine of pit production. This is directly related to the changed bulk density found from the additional test work conducted on the ore.

Table 3-1: Loading Through Life of Pad

Lift	Volume (m3)	Cumulative Volume (m3)	Tonnes	Cumulative Tonnes	Top Elevation (m)
High Permeability Area	106,000	106,000	182,000	182,000	930
Intermediate Lift	94,200	200,000	162,000	344,000	935
Lift 1	353,000	553,000	606,000	951,000	945
Lift 2	527,000	1,080,000	907,000	1,860,000	955
Lift 3	703,000	1,780,000	1,210,000	3,070,000	965
Lift 4	883,000	2,670,000	1,520,000	4,590,000	975
Lift 5	1,080,000	3,750,000	1,860,000	6,450,000	985
Lift 6	1,030,000	4,780,000	1,780,000	8,220,000	995
Lift 7	1,240,000	6,020,000	2,130,000	10,400,000	1,005
Lift 8	1,480,000	7,500,000	2,550,000	12,900,000	1,015
Lift 9	1,730,000	9,230,000	2,980,000	15,900,000	1,025
Lift 10	1,990,000	11,200,000	3,420,000	19,300,000	1,035
Lift 11	2,400,000	13,600,000	4,130,000	23,400,000	1,045
Lift 12	2,690,000	16,300,000	4,630,000	28,100,000	1,055
Lift 13	2,920,000	19,200,000	5,030,000	33,100,000	1,065
Lift 14	2,910,000	22,200,000	5,010,000	38,100,000	1,075
Lift 15	2,800,000	24,900,000	4,820,000	42,900,000	1,085
Lift 16	2,640,000	27,600,000	4,530,000	47,400,000	1,095
Lift 17	2,570,000	30,200,000	4,420,000	51,900,000	1,105
Lift 18	2,370,000	32,500,000	4,070,000	55,900,000	1,115
Lift 19	2,230,000	34,800,000	3,840,000	59,800,000	1,125
Lift 20	2,140,000	36,900,000	3,680,000	63,500,000	1,135
Lift 21	2,050,000	39,000,000	3,530,000	67,000,000	1,145
Lift 22	1,920,000	40,900,000	3,300,000	70,300,000	1,155
Lift 23	1,760,000	42,600,000	3,030,000	73,300,000	1,165
Lift 24	1,580,000	44,200,000	2,720,000	76,000,000	1,175
Lift 25	1,450,000	45,700,000	2,490,000	78,500,000	1,185
Lift 26	1,290,000	46,900,000	2,210,000	80,700,000	1,195
Lift 27	1,140,000	48,100,000	1,960,000	82,700,000	1,205
Lift 28	1,050,000	49,100,000	1,800,000	84,500,000	1,215
Lift 29	825,000	50,000,000	1,420,000	85,900,000	1,225

3.2 In-Heap Pond Volume

As part of the final design for the in-heap pond, VGC has altered the sump design parameters. This includes using 16 mm ore in the bottom portion of the pond with a 12 mm filter layer above this, followed by 6.5 mm for the remainder of the in-heap pond. The additional test work detailed in Section 3.1 above included testing for the 16 mm, 12 mm, and 6.5 mm material. Table 3-2 details the test work for the various sizes and was taken from the Hydraulic Conductivity Testing Review Memorandum previously submitted by Forte Dynamics.

Table 3-2: Bulk Density Testing

Bulk Density (Tonne/m3)*			
Ore Size Tested	Top 20	Bottom 20	Average (T20&B20)
P_{80} 16 mm	1.67	1.68	1.68
P_{80} 16 mm (No 200 mesh)	1.64	1.63	1.63
P_{80} 12 mm	1.71	1.71	1.71
P_{80} 12 mm (No 200 mesh)	1.65	1.67	1.66
P_{80} 6.5 mm	1.68	1.74	
	1.71	1.74	
	1.71	1.75	
Average	1.70	1.74	**1.72**
P_{80} 6.5 mm (No Bruno)	1.73	1.69	
	1.76	1.67	
	1.73	1.67	
Average	1.74	1.67	**1.71**

* Bulk density at final compacted height

For the calculation of the in-heap volume a bulk density of 1.68 tonne/m3, 1.71 tonne/m3, and 1.72 tonne/m3 was used for the 16 mm, 12 mm, and 6.5 mm ore, respectively. In addition, the volume of each layer of material was found from the final in-heap design drawings. These volumes were used to find the total volume of the in-heap pond of 120,100 m3.

3.3 Barren Solution Flow Rate

Based on the changed ultimate configuration and the adjusted solution application rate detailed in the Hydraulic Conductivity Testing Review Memorandum, the optimal barren solution flow rate was analyzed by Forte Dynamics. A recovery forecasting model was used to run various flow rates to the pad to determine the optimal barren solution flow rate. Based on the changed configuration of the pad coupled with the adjusted application flow rate, the optimal barren solution flow rate was found to be 1500 m3/hr. In addition to the changed flow rate, the analysis indicated that a more optimal recovery could be achieved with a reduced leach cycle of 45 days from the original 90 days in the feasibility study. Table 3-3 shows the flowrate at 7 L/hr/m2 associated with the available top area for any given lift. This table gives an estimate for the optimal rate based purely on area and application rate which coincides closely with an optimal maximum barren solution rate of 1500 m3/hr.

Table 3-3: Flow Rate with Surface Area

Lift	Top Surface Area	Flowrate at 7 L/hr/m2
High Permeability Area	15,200	106
Intermediate Lift	19,000	133
Lift 1	37,500	262
Lift 2	56,400	394
Lift 3	73,300	513
Lift 4	91,500	641
Lift 5	112,000	781
Lift 6	106,000	744
Lift 7	128,000	898
Lift 8	153,000	1,070
Lift 9	178,000	1,240
Lift 10	205,000	1,430
Lift 11	246,000	1,730
Lift 12	272,000	1,900
Lift 13	295,000	2,070
Lift 14	287,000	2,010
Lift 15	274,000	1,920
Lift 16	257,000	1,800
Lift 17	255,000	1,780
Lift 18	231,000	1,620
Lift 19	218,000	1,520
Lift 20	210,000	1,470
Lift 21	201,000	1,410
Lift 22	186,000	1,300
Lift 23	169,000	1,190
Lift 24	152,000	1,070
Lift 25	139,000	970
Lift 26	122,000	860
Lift 27	110,000	770
Lift 28	102,000	710
Lift 29	72,400	507

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APPENDIX D

Heap Leach and Process Facilities Emergency Response Plan

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EAGLE GOLD PROJECT

HEAP LEACH AND PROCESS FACILITIES EMERGENCY RESPONSE PLAN

Version 2017-01

NOVEMBER 2017

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DOCUMENT CONTROL

Submission History

Version Number	Version Date	Document Description and Revisions Made
2014-01	June 2014	Original submission drafted in June 2014 and submitted as an Appendix to the Heap Leach and Process Facilities Plan submitted August 2014 to the Department of Energy, Mines and Resources in support of an application for a Quartz Mining Licence and to the Yukon Water Board in support of an application for a Type A Water Use License for the full Construction, Operation and Closure of the Project.
2017-01	Nov 2017	Revisions made to reflect the current site general arrangement and submitted to the Department of Energy, Mines and Resources and the Yukon Water Board in advance of Heap Leach Facility construction.

Version 2017-01 of the Heap Leach and Process Facilities Emergency Response Plan (the Plan) for the Eagle Project has been revised in November 2017 to update Version 2014-01 submitted in June 2014. The table below is intended to identify modifications to the Plan and provide the rationale for such modifications

Version 2017-01 Revisions

Section	Revision/Rationale
1.0 Introduction	▪ Updated text to better describe the Project.
3.0 Heap Leach and Process facilities Overview	▪ Revised Section 3.1 (Heap Leach Embankment and In-Heap solution pond), Section 3.2 (Events Pond), 3.4 (Overliner Drain Fill), and 3.5 (Solution Collection System), for consistency with the final detailed design of the HLF in accordance with WUL clause 150(a) and for readability.
Table 5.2-1 Emergency Level Determination	▪ Revised Liner and LDRS alert levels. Such that alert levels vary in accordance with the driving head level of the In-Heap Pond and the Events Pond in accordance with WUL clause 150(b), WUL 154 (d) and QML Schedule C, Section 1.6(c)i. ▪ Removed reference to the Dublin Gulch Diversion Channel for consistency with the current project general arrangement.
5.3.2 Tier 2 Communication Protocol	▪ Updated contact information
6.0 Emergency Scenario Causes, Preventative Measures and Response	▪ Revised Section 6.0 for consistency with refined Failure Modes Effects Assessment ▪ Revised to incorporate actions to be completed if leakage rates exceed either Alert Level I or Alert Level 2 rates in accordance with WUL clause WUL 154 (e).
Figure 8.1-1 Inundation Map and Evacuation Route	▪ Revised figure for consistency with the current project general arrangement and updated inundation mapping.

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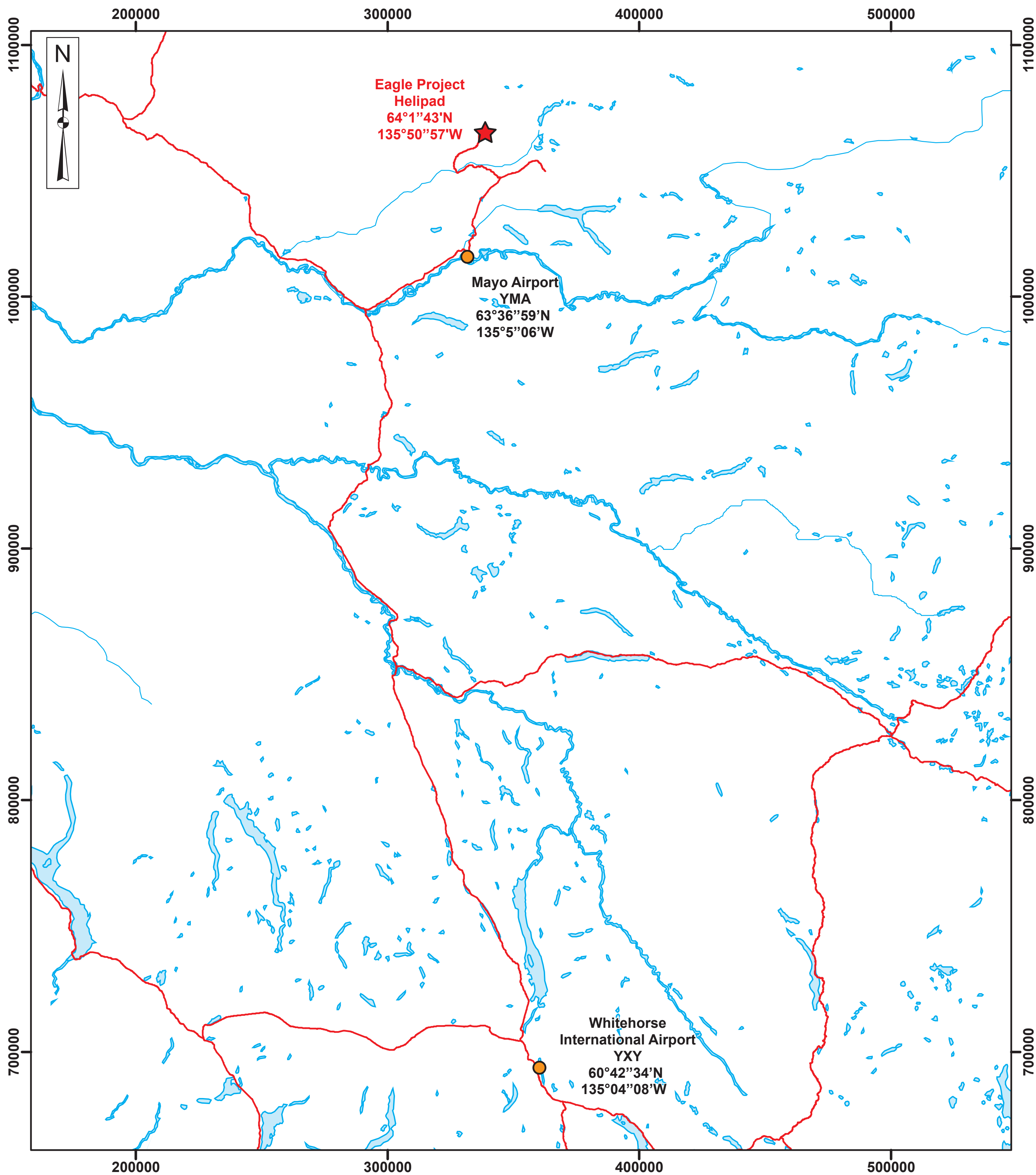
1 INTRODUCTION

StrataGold Corporation (SGC), a directly held wholly owned subsidiary of Victoria Gold Corp. has proposed to construct, operate, close and reclaim a gold mine in central Yukon. The Eagle Gold Project (‘the’ Project) is located 85 km from Mayo, Yukon using existing highway and access roads as shown on Figure 1.1-1.

The Project will involve open pit mining and gold extraction using a three-stage crushing process, heap leaching, and a carbon adsorption, desorption, and recovery system over the mine life.



Legend:

- ★ Eagle Gold Project
- Watercourse
- ● Town / Village
- Waterbody
- Major Roadway

StrataGold Corporation

0 12.5 25 50
Kilometres
Scale = As Shown

EAGLE GOLD PROJECT
YUKON TERRITORY

Project Location

Projection:	Drawn By:	Date:	Figure:
Yukon Albers	SS	2014/05/23	1-1

2 HEAP LEACH AND PROCESS FACILITIES EMERGENCY RESPONSE PLAN PURPOSE

The purpose of this Heap Leach Facility Emergency Response Plan (the Plan) is to ensure that an adequate level of emergency preparedness and response is available in the event of an emergency scenario involving the Heap Leach Facility (HLF) or associated structures. The Plan is supplemental to the Eagle Gold Project Emergency Response Plan.

This plan was developed based on the following guidelines:

- Guidelines from the Canadian Dam Association (2013) including the Application of Dam Safety Guidelines to Mining Dams (CDA 2014);
- International Cyanide Management Code (2012);
- Type A and B Quartz Mining Undertakings - Information Package for Applicants (2012); and,
- Plan Requirement Guidance for Quartz Mining Projects (2013).

3 HEAP LEACH AND PROCESS FACILITIES OVERVIEW

The Heap Leach Facility (HLF) is a valley fill design which incorporates an earthfill/rockfill embankment that will provide stability to the base of the heap and the stacked ore. The embankment also creates an In-Heap Pond leaching configuration that provides storage of pregnant solution within the pore spaces of the ore.

The major design components for the HLF include the following: the embankment and the In-Heap Pond; a composite liner system; solution recovery wells; associated piping network for solution collection and distribution; a leak detection and recovery system (LDRS); and a downstream Events Pond to contain excess solution that results from extreme precipitation or emergency events.

3.1 HEAP LEACH EMBANKMENT AND IN-HEAP SOLUTION POND

The embankment is designed as an earthfill/rockfill structure with a geo-membrane lined upstream face to ensure containment integrity. The final embankment crest will be at 939.5 masl and includes an 8 m crest width for road and pipeline access, and 2.5H:1V upstream and downstream slopes.

The In-Heap Pond will store process solution within the pore space of the ore, directly up gradient of the confining embankment. In the event the design capacity is exceeded, the spillway in the In-Heap Pond will enable a controlled discharge of water to the Events Pond.

3.2 EVENTS POND

The Events Pond is sized to provide storage for the Probable Maximum Flood (PMF) storm event from the ultimate HLF (all phases). The PMF event rainfall depth was estimated to be 256 mm which is assumed to contribute entirely over the ultimate HLF pad footprint.

3.3 LINER SYSTEM

The liner for the HLF and the Events Pond will consist of a composite geomembrane and underlying low-permeability bedding material. The primary purpose of the composite liner system is to prevent the loss of process leach solution (PLS) for both environmental and economic reasons.

3.4 OVERLINER DRAIN FILL

The overliner drain fill (ODF) is a layer of crushed material placed over the entire In-Heap Pond and heap leach pad area including the upstream face of the confining embankment. The ODF minimizes the hydraulic head on the liner system to reduce the risk of PLS leakage and protects the liner system from damage during ore placement.

3.5 SOLUTION COLLECTION SYSTEM

Solution will be collected in the high permeability ODF at the base of the heap leach pad, with perforated collection pipes placed within the ODF to increase solution removal rates. The collection pipe network will direct the solution to the sump at the toe of the embankment for pumping through inclined riser pipes to the process plant.

The base of the sump will be constructed below the elevation of the surrounding liner and the liner system and LDRS will extend under the sump. Solution will be pumped from the sump through inclined risers to the process plant. The inclined arrangement will consist of thick-walled, steel pipes to allow for raising and lowering of a submersible pump. Pumps will have the capacity to meet the solution application throughflow. Back-up riser pipes will be installed to maintain access to the sump in the event that any of the riser pipes become blocked.

3.6 LEAK DETECTION AND RECOVERY SYSTEM

A LDRS will be constructed within the In-Heap Pond and the Events Pond and will consist of a monitoring sump equipped with an automatic, fluid-level activated pump located between the top and bottom liners. The pump will be sized to sufficiently remove fluids to minimize head on the bottom liner and will also be connected to a flow meter to provide the volumes recovered over specific time intervals.

3.7 UNDERDRAIN SYSTEM

The HLF underdrain system provides for the collection and drainage of subsurface water beneath the lined facility to limit upward pressure on the facility liner. The underdrain will be constructed with geofabric wrapped around granular drain rock backfill materials and 100 mm perforated pipes placed at regular intervals (approximately 75 m spacing). The drains will convey unaffected subsurface water to collector pipes that will discharge to an outlet monitoring vault. The vault is equipped with a pump system to return flows to the HLF for use as make up water or allow flows to outfall to receiving waters if discharge criteria are met.

3.8 SOLUTION CONVEYANCE AND PUMPING SYSTEMS

Barren solution containing cyanide will be applied to the ore stacked on the HLF to extract the gold. After passing through the ore, this solution will be collected by the solution collection system.

A series of barren solution pumps located at the Adsorption Desorption Recovery (ADR) facility will pump solution to the Heap Leach Pad. A series of pipe headers will distribute the solution to secondary and tertiary headers, and ultimately drip emitters placed under the surface of the ore.

The process pumping system includes pumps, pipelines, valves, and associated controls to move solution between the ADR plant and the HLF.

3.9 METAL RECOVERY AND PROCESSING FACILITY

Gold will be recovered from the PLS by activated carbon adsorption and pressurized cyanide/caustic desorption, followed by electrowinning onto stainless steel cathodes, and then subsequent on-site smelting to gold doré. This process is referred to as the adsorption, desorption and recovery process. The gold-barren leach solution that remains after passing the PLS through the carbon columns will be replenished with reagents for cyanide and pH control and re-circulated back to the HLF as barren solution.

Sodium cyanide briquettes will be added to the system via 1 tonne super sacks. The sodium cyanide will be mixed and then transferred to the cyanide mix storage tank. This concentrated cyanide solution will be metered into the barren solution tank, to the carbon columns, and to the strip solution tank, as required. Sodium hydroxide, or caustic solution, will be used in the system for acid neutralization and for preparing the fresh barren solution.

4 ORGANIZATION AND RESPONSIBILITY

4.1 EMERGENCY RESPONSE

Clearly defined roles and responsibilities are vital for effective and timely response to an emergency situation. The key roles for emergency response related to the Project are described below and depicted in Figure 4.1-1.

Discoverer

The Discoverer is any individual witnessing an emergency on the Project site and is responsible for initiating a Code 1 emergency response. The Discoverer will call out on their current radio channel “Code 1, Code 1, Code 1” and clearly state the nature and location of the emergency. The Discoverer will then change their radio to Channel 1 (Emergency Channel) and repeat “Code 1, Code 1, Code 1” and the nature and location of the emergency. The Discoverer will remain on Channel 1 and await response from the Emergency Responder.

Emergency Responder

The Emergency Responder will respond to the Discoverer on Channel 1 to request confirmation of the nature and location of the emergency. Once the emergency details have been confirmed, the Emergency Responder will provide instructions to the Discoverer on the appropriate immediate response the Discoverer should undertake.

The Emergency Responder will then contact Security who will be responsible for initiating a page for the Emergency Response Team (ERT).

Security

Security is responsible for paging the ERT at the request of the Emergency Responder. If no reply to the initial Code 1 call from the Discoverer is heard from the Emergency Responder, Security will assume the role of Emergency Responder to ensure a timely response.

Emergency Response Team

The ERT will mobilize to the scene and the first, or most senior ERT member, will conduct an initial assessment and assume command of the scene. The ERT team member who assumes control of the scene will not relinquish control of the scene until the arrival of the Emergency Response Coordinator (ERC).

Emergency Response Coordinator

The ERC will mobilize to the scene and, after being briefed on any developments, will assume control of the scene and direct the response of all personnel at the scene. After the ERC has provided direction for the response effort, which may include radioing for additional assistance from First Aid Attendants, he/she will appoint an appropriate ERT member to act as Team Captain and to assume control of the scene. The ERC will then report to the Incident Control Center (ICC) to brief the Incident Commander (IC).

First Aid Attendants

Any First Aid Attendants on the Project site that are not part of the ERT will immediately cease all activity upon hearing the Code 1 and ensure they are in a location where they can clearly hear any radio broadcasts for further assistance. If further assistance is required, they will mobilize to the scene or any other location as directed by the ERC.

If a First Aid Attendant is in the immediate area of the emergency they are to report to the scene and assist with the efforts of the Discoverer or identify themselves to the ERT as a First Aid Attendant and await further instructions.

Incident Commander

The Incident Commander will immediately report to the ICC when a Code 1 response has been initiated. The IC will be responsible for communicating the nature and extent of any emergency to SGC senior management.

Prior to the arrival of related Governmental Agencies, only the IC has the authority to order the evacuation of personnel from the Project site or the authority to give the “All Clear” order, indicating that it is safe to re-enter an area or building following an evacuation.

SGC Senior Management

SGC Senior Management will be responsible for communication with relevant Yukon Government agencies based on information provided by the IC.

All Other Site Personnel

All site personnel that are not directly involved in emergency response efforts will cease work, unless the cessation of their work could result in an emergency situation, and will observe radio silence until an “All Clear” has been given.

Incident Command Center

Each incident in which a Code 1 response has been raised will require the activation of the Incident Control Center. The ICC will be able to receive and send critical communications (telephone, VHF radio and fax) and will be operated continuously throughout the incident. The ICC is located in the Administrative Office Boardroom on site and chaired by the Incident Commander. A secondary location will be established in the SGC Vancouver office.

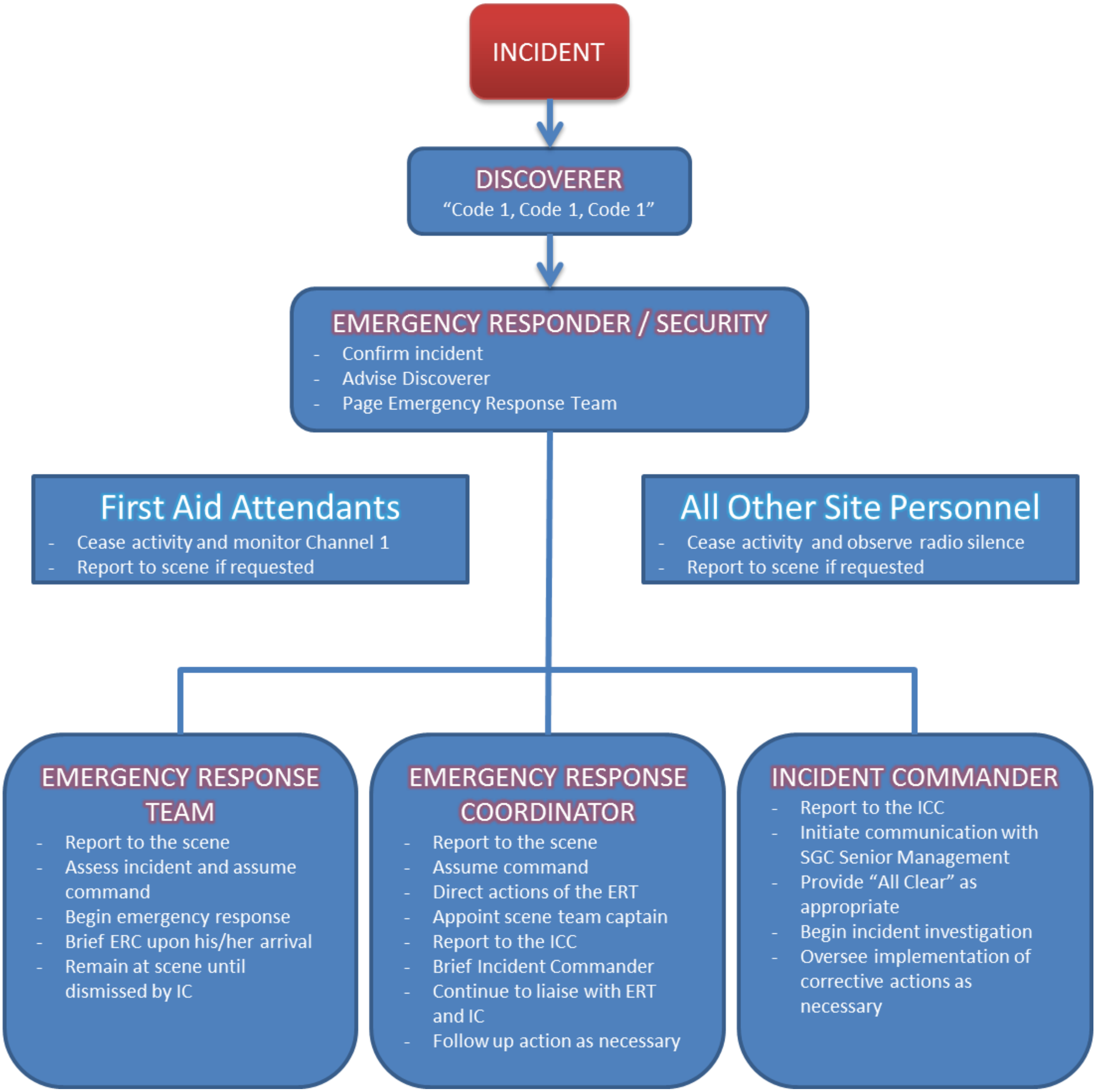


Figure 4.1-1: Emergency Response Organizational Chart

4.2 DELEGATION OF RESPONSIBILITIES

The Project is intended to be a continuous operation with work activities being undertaken 24 hours a day for 365 days a year. Continuous operations require a planned and documented delegation of responsibilities to ensure the integrity of emergency response. The Mine Manager is ultimately responsible for ensuring that all key positions related to emergency response are staffed by competent personnel. The delegates for each of the emergency response positions will be posted in conspicuous locations around the Project site including, but no limited to, the administration building, the dining room, arctic corridors leading to the bunk rooms, the ICC, and at the SGC Vancouver office.

The currently approved delegates for emergency response are provided in Table 4.2-1.

Table 4.2-1: Emergency Response Designates

Emergency Response Position	Project Phase	Primary Personnel	Designate	Minimum Skills/Qualifications
Emergency Responder	Pre-Construction	First Aid Attendant	First Aid Attendant	Occupational First Aid Level 3 WHMIS
	Construction and Operations	ICC & First Aid dedicated First Aid Attendant	ICC & First Aid dedicated First Aid Attendant cross shift	Occupational First Aid Level 3 WHMIS
	Closure	First Aid Attendant	First Aid Attendant	Occupational First Aid Level 3 WHMIS
Security	Pre-Construction	Camp Coordinator	Site Operations	N/A
	Construction and Operations	Security Team Leader	Security Officer	N/A
	Closure	Camp Coordinator	Site Operations	N/A
Emergency Response Team	Pre-Construction	Various	Various	Occupational First Aid Level 1 WHMIS
	Construction and Operations	Various	Various	Occupational First Aid Level 1 Surface Mine Rescue WHMIS Industrial Fire Brigade Spill Response Hazardous Materials Handling
	Closure	Various	Various	Occupational First Aid Level 1 WHMIS Spill Response Hazardous Materials Handling
Emergency Response Coordinator	Pre-Construction	Various	Various	Occupational First Aid Level 3 WHMIS Industrial Fire Brigade

Emergency Response Position	Project Phase	Primary Personnel	Designate	Minimum Skills/Qualifications
	Construction and Operations	Health, Safety and Compliance Manager	Safety Coordinator	Occupational First Aid Level 3 Surface Mine Rescue WHMIS Industrial Fire Brigade Spill Response Hazardous Materials Handling
	Closure	Various	Various	Occupational First Aid Level 3 WHMIS Industrial Fire Brigade
Incident Commander	Pre-Construction	Site Manager	Camp Coordinator	WHMIS
	Construction and Operations	Mine Manager	Health, Safety and Compliance Manager	Surface Mine Rescue WHMIS Industrial Fire Brigade Spill Response Hazardous Materials Handling
	Closure	Site Manager	Camp Coordinator	WHMIS Spill Response Hazardous Materials Handling

5 EMERGENCY DETECTION AND CLASSIFICATION

5.1 EMERGENCY DETECTION

As described in operational and environmental management plans developed for the Project, a range of monitoring and inspections will be conducted to ensure that Project features operate as intended. Unusual conditions or emergency events may be detected by the planned monitoring and inspection but may also be detected by:

- Observation by SGC personnel or contractors during the ordinary course of operations
- Observation by government personal (local, territorial, federal), visitors, or the public
- Evaluation of instrumentation data
- Earthquakes felt or reported in the vicinity of the Project
- Advanced warning of conditions that may cause an unusual event or emergency (e.g. severe weather warnings, forest fires, etc.)

Unusual conditions or emergency events are situations that are different from the normal or expected conditions of the heap leach and process facilities. These unusual conditions may indicate problems needing further monitoring, inspection, or corrective measures or may indicate an emergency condition requiring emergency response. Table 5.1-1 provides a description of the emergency levels which may be detected on the Project.

Table 5.1-1: Emergency Levels

Emergency Level		Description
1	Non-failure	Abnormal situation which has not threatened the operation, or structural integrity, of a system.
2	Potential failure developing	Abnormal situation which may eventually lead to a system failure but there is no immediate threat
3	Imminent or actual failure	Extremely urgent situation where a system failure is occurring or its failure is imminent

5.2 EMERGENCY CLASSIFICATION

The design, construction, and operation of the heap leach and process facilities are all intended to mitigate the possibility of an emergency event developing; however, the potential for an emergency event does exist. Table 5.2-1 provides some of the unusual conditions and emergency events that have been planned for and also provides the anticipated emergency level. This information is provided as a general guide only and the professional opinion of qualified personnel should always be strongly considered.

Table 5.2-1: Emergency Level Determination

Project Facility or Event	Unusual Condition	Emergency Level
HLF Spillway	Process solution is spilling to Events Pond	1
	Process solution is spilling to Events Pond which is at 80% of total capacity	2
	Process solution is spilling to Events Pond which is at full capacity	3
Embankment	New cracks in the embankment less than 0.5 cm wide without seepage	1
	New cracks in the embankment greater than 0.5 cm wide without seepage	2
	Cracks in the embankment with seepage	3
	Visual movement/slippage of the embankment slope	2
	Sudden or rapidly proceeding slides of the embankment slopes	3
	Process solution is overtopping embankment crest	3
Events Pond	Events Pond is full to 80% of total capacity	2
	Fluid level has encroached freeboard and rising flow over the Events Pond spillway is imminent or occurring	3
	New cracks in the pond slopes less than 0.5 cm wide without seepage	1
	New cracks in the pond slopes greater than 0.5 cm wide without seepage	2
	Cracks in the pond slopes with seepage	3
	Visual movement/slippage of the pond slopes	2
	Sudden or rapidly proceeding slides of the pond slopes	3
Ore heap	Visual movement/slippage of the ore heap (shallow slope failure)	2
	Sudden or rapidly proceeding slides of the ore heap (deep slope failure)	3
Liner and LDRS	In Heap Pond Alert Level 1 (refer to Table 6.4-1, below)	1
	In Heap Pond Alert Level 2 (refer to Table 6.4-1, below)	2
	Events Pond Alert Level 1 (refer to Table 6.4-2, below)	1
	Events Pond Alert Level 2 (refer to Table 6.4-2, below)	2
Earthquake	Measurable earthquake felt or reported on or within 100 km of the Project	1
	Earthquake resulting in visible damage to the HLF or appurtenances	2
	Earthquake resulting in uncontrolled release of PLS from the HLF	3
Security Threat	Verified threat that, if carried out, could result in damage to the HLF or appurtenances	2
	Detonated bomb or act of sabotage/vandalism that has resulted in damaged to the HLF or appurtenances	3

5.3 COMMUNICATION WITH STAKEHOLDERS

SGC's response and communication procedures for heap leach and process facility scenarios are based on a three-tiered system linked to the emergency levels. Broadly, the three tiers for response and communication are shown in Table 5.1-1.

The tiered communication and emergency level system has been developed so that SGC Senior Management and site personnel are able to notify appropriate communities, government agencies, and other stakeholders of an emergency. Proper communication of an event involving heap leach and process facilities is intended to reduce the likelihood of a panicked response which may exacerbate the emergency.

5.3.1 Tier 1 Communication Protocol

If a scenario is deemed to be a "Non-Failure" situation then the primary communication responsibility is to report the situation to an immediate supervisor and/or the Manager of Health, Safety and Compliance. The goal of the communication is to ensure that all relevant personnel are aware of the situation so corrective measures can be taken as necessary. Any site personnel made aware of a Tier 1 emergency level event are to limit communication to internal SGC personnel and any decision to communicate the situation to government agencies, the media, or local communities is at the discretion of SGC Senior Management.

5.3.2 Tier 2 Communication Protocol

If a scenario is deemed a "Potential failure developing" situation, the communication level is expanded outside of SGC. The responsibility for this communication is the Mine Manager and/or the Manager of Health, Safety and Compliance once they have been made aware of the situation. The goal of the communication is to ensure that the relevant government agencies are aware of the situation and are advised that SGC is taking appropriate action to correct the situation and assistance is likely not immediately required.

The organizations to be contacted will vary based on the type of emergency developing, however the Yukon Workers' Compensation Health and Safety Board should be notified (867-667-5450) and at the discretion of the Mine Manager and/or the Manager of Health, Safety and Compliance the following agencies may also be notified:

- Yukon Emergency Medical Service (EMS) 867-667-3333
- Mayo RCMP 867-996-5555
- Mayo Fire and Ambulance 867-996-2222
- Yukon Spill Report Centre 867-667-7244
- Yukon Water Board 867-456-3980
- Transport Canada CANUTEC 24-hour service 613-996-6666
- Yukon Government - Energy, Mines and Resources CS&I Mayo 867-996-2568
- Yukon Government - Energy, Mines and Resources CS&I Whitehorse 867-456-3882

5.3.3 Tier 3 Communication Protocol

If an “Imminent or actual failure” situation is developing at the Project site, the communication is expanded outside of SGC and includes local stakeholders. This extremely urgent situation may require assistance and has the potential to affect communities.

SGC Senior Management will have responsibility for communicating a Tier 3 emergency; however, if the Mine Manager cannot immediately contact them, the Mine Manager is to assume communication responsibility until SGC Senior Management can assume control.

The organizations to be contacted will vary based on the type of emergency developing, however the Yukon Workers’ Compensation Health and Safety Board must be notified (867-667-5450) and following agencies may also be notified so that they can provide assistance with the response or with the notification of affected communities:

- Yukon Emergency Medical Service (EMS) 867-667-3333
- Mayo RCMP 867-996-5555
- Mayo Fire and Ambulance 867-996-2222
- 24 HOURS Yukon Spill Report Centre 867-667-7244
- Yukon Water Board 867-456-3980
- Transport Canada CANUTEC 24-hour service 613-996-6666
- Yukon Government - Energy, Mines and Resources CS&I Mayo 867-996-2568
- Yukon Government - Energy, Mines and Resources CS&I Whitehorse 867-456-3882

6 EMERGENCY SCENARIO CAUSES, PREVENTATIVE MEASURES AND RESPONSE

To effectively and proactively manage the HLF, there is a need to have a broad understanding of all of the associated uncertainties, risks and consequences. It is important that focusing on one risk component, such as a slope failure, doesn't lead to other components being overlooked. The Failure Modes and Effects Analysis (FMEA) methodology allows a balanced evaluation of the risks associated with various components of a system. A FMEA for the HLF was undertaken to support detailed design and to inform development and operational planning for the Project.

The HLF FMEA identified a range of failure modes over the major HLF components which, during construction and operations, are mitigated by standard engineering and design practices. However, planning for emergency response in the unlikely event that these failure modes are experienced is a key proactive management tool.

In addition to the failure modes identified by the FMEA, additional consideration must be given to activities associated with the operation of the HLF which would not have implications for the structural and functional integrity of the HLF but could result in an emergency. The additional risks which need to be considered to ensure the safe operation of the HLF primarily involve the safe handling and use of cyanide.

The following emergency scenarios have been considered for the heap leach and process facilities:

1. HLF embankment failure (hydraulic, structural or seepage)
2. In-Heap Pond solution escape
3. Events Pond failure
4. Liner system failure
5. Solution collection system failure
6. Ore heap slope failure
7. Closure Drain System failure
8. Hydrogen cyanide release from ADR plant
9. Hydrogen cyanide release during transportation

6.1 HEAP LEACH FACILITY EMBANKMENT FAILURE

Incident	**HLF Embankment Failure**

Potential Causes	• Hydraulic (overtopping of dam crest or erosion of embankment toe):
	  ○ Overtopping of dam crest during runoff event due to spillway plugging
	  ○ Embankment toe erosion due to misdirected spillway outlet discharge
	• Structural (foundation or slope failure):
	  ○ Poor quality control during foundation preparation and embankment fill placement
	  ○ Extraordinary seismic event exceeding projected maximum event
	• Seepage
	  ○ Internal erosion / progressive piping of fines through embankment

Preventative Measures	• Maintain heap water balance operational criteria and follow procedures identified in the HLF Contingency Water Management Plan for solution management • Follow procedures identified in OMS Manual including regular site inspections by mine personnel and dam safety inspections and reviews by engineer • Implement high level of construction quality control and assurance with regular inspections by the engineer • Push snowpack into large piles to decrease rate of snowmelt • Preventative maintenance • Event driven maintenance
Detection Method	• Regular inspection of spillway and outfall by site personnel and engineer • Regular inspection of dam face and toe area by site personnel and engineer • Construction quality control and assurance program • Regular inspection by engineer during construction • Compliance with Canadian Dam Association Technical Bulletin for Seismic Hazard Considerations for Dam Safety • Dam instrumentation • Seepage monitoring

Site Response	• Initiate “Code 1” as per “Initial Response - Code 1 Procedure”
	• Administer first aid as required
	• Evacuate down gradient work areas
	• Immediate notification of SGC Senior Management so communication protocol can be enacted
	• Immediate lowering of PLS volumes to safe levels by any or all of the following methods:
	  ○ Pumping to Events Pond
	  ○ Increasing area under leach (i.e. returning PLS into circulation)
	  ○ Excavation of additional down gradient emergency management pond
	  ○ Pumping to MWTP for treatment and release
	  ○ Pumping to water management ponds (e.g. Lower Dublin South Pond) if appropriate
	  ○ Activating spare vertical turbine pump

Incident	**HLF Embankment Failure**
	• Buttress embankment with structural fill such as waste rock • Inspect and clear the HLF spillway as necessary • Restore freeboard by placing sandbags if necessary • Contain any spill of PLS to the greatest extent possible
Emergency Level	Tier 3
Potential Effects	• Major damage to multiple pad components • Damage to liner system and loss of product - solution leakage • Damage to collection piping system • Uncontrolled release of ore and solution
Follow Up	• Incident/accident investigation • Inspection by geotechnical engineer • Cease pad loading and new solution application until repair and geotechnical inspection complete • Environmental remediation if PLS is released

6.2 IN HEAP POND SOLUTION ESCAPE

Incident	In Heap Pond Solution Escape
Potential Causes	• Poor quality control during foundation preparation and embankment fill placement • Damage to liner system after construction during ore placement • Failure of electrical or pump system leading to solution buildup in excess of storage capacity • Extraordinary combination of upset events occurring simultaneously resulting in loss of storage in In-Heap Pond

Preventative Measures	• Implement high level of construction quality control and assurance with regular inspections by the engineer
	• Follow procedures identified in OMS Manual including:
	  o stacking plan and ore placement procedures
	  o dam safety inspections and reviews by engineer
	  o monitoring of solution levels
	• Maintain heap water balance operational criteria and follow procedures identified in the HLF Contingency Water Management Plan for solution management
	• Regular inspection of back up electrical and pumping equipment to ensure operability in case of emergency
	• Site electrical system will include switch gear to allow power to be sourced from YEC grid or on site back up diesel generation
	• Design includes operational and backup PLS pumps

Detection Method	• Construction quality control and assurance program
	• Regular inspection by engineer during construction and operation
	• In-Heap Pond Leak Detection and Recovery System (LDRS)
	• In-Heap Pond and flow instrumentation:
	  o Level meter in pond
	  o Flow meters within solution recovery system

Site Response	• Initiate “Code 1” as per “Initial Response - Code 1 Procedure” • Administer first aid as required • Immediate notification of SGC Senior Management so communication protocol can be enacted • Immediate lowering of PLS volumes in Events Pond by pumping of PLS to MWTP for treatment and release • Excavation of additional down gradient emergency management pond • Restore freeboard by placing sandbags if necessary • Inspect and repair any damaged liner and solution collection components • Contain any spill of PLS to the greatest extent possible
Emergency Level	Tier 3
Potential Effects	• Uncontrolled release of solution to environment
Follow Up	• Incident/accident investigation • Inspection by engineer of impacted components

Incident	In Heap Pond Solution Escape
	• Cease pad loading and new solution application until repair and inspection complete • Increased monitoring frequency until effectiveness of response assured • Environmental remediation if PLS is released

6.3 EVENTS POND FAILURE

Incident	Events Pond Failure
Potential Causes	• Poor quality control during foundation preparation and embankment fill placement • Damage to liner system after construction during operations (ice damage, wildlife damage, equipment damage, etc.) • Failure of electrical or pump system leading to solution buildup in excess of storage capacity • Extraordinary combination of upset events occurring simultaneously resulting in loss of storage capacity in Events Pond
Preventative Measures	• Implement high level of construction quality control and assurance with regular inspections by the engineer • Follow procedures identified in OMS Manual including: o stacking plan and ore placement procedures o dam safety inspections and reviews by engineer o monitoring of water levels • Maintain heap water balance operational criteria and follow procedures identified in the HLF Contingency Water Management Plan for solution management • Regular inspection of back up electrical and pumping equipment to ensure operability in case of emergency • Site electrical system will include switch gear to allow power to be sourced from YEC grid or on site back up diesel generation • Design includes both operational and backup PLS pumps
Detection Method	• Construction quality control and assurance program • Regular inspection by engineer during construction and operation • Events Pond Leak Detection and Recovery System (LDRS) • Visual inspections • Water levels in In-Heap Pond and Events Pond • Snowpack levels on heap
Site Response	• Initiate “Code 1” as per “Initial Response - Code 1 Procedure” • Administer first aid as required • Immediate notification of SGC Senior Management so communication protocol can be enacted • Immediate lowering of PLS volumes in Events Pond by any or all of the following methods: • Increasing area under leach (i.e., returning PLS into circulation) • Pump PLS to MWTP for treatment and release • Excavation of additional down gradient emergency management pond • Restore freeboard by placing sandbags if necessary • Buttress embankment with structural fill such as waste rock • Inspect and repair any damaged liner and solution collection components • Remove or repair liner system in Events Pond

Incident	Events Pond Failure
	• Contain any spill of PLS to the greatest extent possible
Emergency Level	Tier 3
Potential Effects	• Damage to liner system and loss of product - solution leakage • Uncontrolled release of solution to environment
Follow Up	• Incident/accident investigation • Inspection by geotechnical engineer • Environmental remediation if PLS is released

6.4 LINER SYSTEM FAILURE

Incident	Liner System Failure
Potential Causes	• Poor fabrication quality • Damage to system components during construction • Damage to system components after construction during ore placement • Differential settlement caused by improper foundation preparation
Preventative Measures	• Follow technical specifications including compliance testing of geosynthetics during procurement • Follow technical specifications including construction of a test fill program to establish proper construction procedures to limit damage • Follow procedures identified in OMS Manual including stacking plan and ore placement procedures • Implement high level of construction quality control and assurance with regular inspections by the engineer
Detection Method	• Quality control during manufacturing • Compliance testing during procurement • Construction quality control and assurance program • Visual inspection • In-Heap Pond LDRS system • Monitoring vault flows (quantity and quality) • Regular inspection by engineer during construction
Site Response	Leakage rate at alert level 1 based on In-Heap Pond elevation • Isolate leak if possible • Restrict leaching operations in affected area of liner failure in HLF • Contain any spill of PLS to the greatest extent possible • Increase monitoring frequency of underdrain vault for possible PLS solution leakage through secondary liner and GCL. If PLS solution identified, temporarily cease solution application in affected area, drill and case borehole and pump bentonite or similar material to affected area for failure in HLF Leakage rate between alert level 1 and alert level 2 based on In-Heap Pond elevation • Isolate leak if possible • Restrict leaching operations in affected area of liner failure in HLF • Increase monitoring frequency of underdrain vault for possible PLS solution leakage through secondary liner and GCL. If PLS solution identified, temporarily cease solution application in affected area, drill and case borehole and pump bentonite or similar material to affected area for failure in HLF • Install interlift liner where practical • Contain any spill of PLS to the greatest extent possible Leakage rate above alert level 2 based on In-Heap Pond elevation • Isolate leak if possible • Restrict leaching operations in affected area of liner failure in HLF • Increase monitoring frequency of underdrain vault for possible PLS solution leakage through secondary liner and GCL. If PLS solution identified,

Incident	Liner System Failure
	temporarily cease solution application in affected area, drill and case borehole and pump bentonite or similar material to affected area for failure in HLF • Install interlift liner where practical • Unload ore and repair any damaged liner for failure in HLF • Contain any spill of PLS to the greatest extent possible Event Pond liner leakage <60,000L • Isolate leak if possible • Electrical leak detection and repair of damaged location Event Pond liner leakage >60,000L • Isolate leak if possible • Electrical leak detection and repair of damaged location • Remove and replace liner system in Events Pond
Emergency Level	Pond alert levels are specific to the pond water elevation (see Tables 6.4-1 and 6.4-2): • In-Heap Pond alert level 1 - Tier 1 • In-Heap Pond alert level 2 - Tier 2 • Events Pond alert level 1 - Tier 1 • Events Pond alert level 2 - Tier 2
Potential Effects	• Loss of product - solution leakage • Uncontrolled release of solution to environment
Follow Up	• Incident/accident investigation • Increased monitoring frequency until effectiveness of response assured • Environmental remediation if PLS is released

Table 6.4-1: In-Heap Pond Alert Levels

In-Heap Pond Elevation (masl)	Alert Level 1 (L/day)	Alert Level 2 (L/day)
913	160	3,300
914	810	16,000
915	1,300	26,000
916	1,900	39,000
917	2,600	53,000
918	3,500	69,000
919	4,400	89,000
920	5,600	110,000
921	6,800	140,000
922	8,200	160,000
923	9,700	190,000

924	11,000	230,000
925	13,000	270,000
926	16,000	310,000
927	18,000	370,000
928	21,000	420,000
929	24,000	490,000
930	28,000	550,000
931	32,000	640,000
932	36,000	720,000
933	41,000	820,000
934	47,000	940,000
935	53,000	1,100,000
936	61,000	1,200,000
937	69,000	1,400,000
938	77,000	1,500,000
939 (embankment crest)	83,000	1,700,000

Table 6.4-2: Events Pond Primary Liner Leakage Results and Alert Levels

Event Elevation (masl)	Alert Level 1 (L/day)	Alert Level 2 (L/day)
883	4,700	150,000
884	7,800	250,000
885	11,000	350,000
886	14,000	460,000
887	18,000	580,000
888	22,000	700,000
889	26,000	830,000
890	31,000	970,000
891	35,000	1,100,000
892	40,000	1,300,000
893	45,000	1,400,000
894	51,000	1,600,000
895 (spillway invert 894.5)	57,000	1,800,000
895.5 (crest)	60,000	1,900,000

6.5 SOLUTION COLLECTION SYSTEM FAILURE

Incident	**Solution Collection System Failure**
Potential Causes	• Poor quality control during installation • Damage to system during ODF placement • Damage to system during ore placement
Preventative Measures	• Follow technical specifications including compliance testing of geosynthetics during procurement • Follow technical specifications including construction of a test fill program to establish proper construction procedures to limit damage • Follow procedures identified in OMS Manual including stacking plan and ore placement procedures
Detection Methods	• Construction quality control and assurance program • In-Heap Pond LDRS system • Monitoring vault flows (quantity and quality) • Visual inspection • HLF pad piezometer installed in overliner
Site Response	• Unload ore and repair or replace where practical • Install interlift liner and collection piping system where practical
Emergency Level	Tier 2
Potential Effects	• Elevated hydraulic head in ore pile • Loss of ability to control water balance
Follow Up	• Incident/accident investigation • Increased monitoring frequency until effectiveness of response assured

6.6 ORE HEAP SLOPE FAILURE

Incident	Ore Heap Slope Failure
Potential Causes	• Improper ore placement methods causing ore pile slope failure • Elevated phreatic level or erosion causing ore pile slope failure

Preventative Measures	• Maintain operational controls for solution management
	• Follow procedures identified in OMS Manual including:
	  o Visual inspections of ore pile for erosion
	  o stacking plan and ore placement procedures
	  o monitoring of ore pile phreatic levels

Detection Method	• In-Heap Pond LDRS • Monitoring vault flows (quantity and quality) • Visual inspection • HLF pad piezometer installed in overliner

Site Response	• Initiate “Code 1” as per “Initial Response - Code 1 Procedure”
	• Administer first aid as required
	• Immediate notification of SGC Senior Management so communication protocol can be enacted
	• Immediate lowering of PLS volumes to HLF Operating Volume by any or all of the following methods:
	  • Pumping to Events Pond
	  • Increasing area under leach (i.e. returning PLS into circulation)
	  • Pumping to water management ponds (e.g. Lower Dublin South Pond) if appropriate
	• Restrict PLS application in affected area
	• Unload affected ore pile area and inspect and repair any damaged HLF liner and solution collection components
	• Install interlift liner if unloading of ore pile impractical
	• Buttress ore pile
	• Contain any spill of PLS to the greatest extent possible

Emergency Level	Deep Slope Failure - Tier 3 Shallow Slope Failure - Tier 2
Potential Effects	• Major damage to multiple pad components • Damage to liner system and loss of product - solution leakage • Damage to collection piping system • Uncontrolled release of ore and solution
Follow Up	• Incident/accident investigation • Inspection by geotechnical engineer • Environmental remediation if PLS is released • Cease pad loading until repair complete

6.7 CLOSURE DRAIN SYSTEM FAILURE

Incident	Closure Drain System Failure
Potential Causes	• Clogging of sump materials • Damage during or after construction
Preventative Measures	• Develop contingency plan for alternative method of draining heap, such as drilling through ore pile into underdrains • Implement high level of construction quality control and assurance with regular inspections by the engineer
Detection Method	• Flows at monitoring vault • Visual inspection
Site Response	• Drill through ore pile into underdrains • Pump PLS to MWTP for treatment • Drill and case horizontal wells at base of embankment for passive drainage at closure
Emergency Level	Tier 2
Potential Effects	• Failure to drain heap
Follow Up	• Incident/accident investigation • Increased monitoring frequency until effectiveness of response assured

6.8 RELEASE OF HCN GAS WITHIN THE ADR PLANT

Incident	Release of HCN Gas within the ADR Plant
Potential Causes	• Accidental release of dry sodium cyanide which is then exposed to acids, acid salts, water, moisture or carbon dioxide • Rupture or failure of tanks, pipelines, fittings or valves containing sodium cyanide solution • Temporary loss of process pH control systems
Preventative Measures	• Preventative maintenance • Event driven maintenance • Hazard identification and response training for relevant ADR Plant Personnel • Installation and regular testing of fixed HCN detectors and portable HCN monitors • High level of construction quality assurance
Detection Method	• Routine facility inspection • Event driven inspection • Activation of fixed HCN detectors or portable HCN monitors

Site Response	• Initiate “Code 1” as per “Initial Response - Code 1 Procedure”
	• Evacuate area
	  • Small spills in reactive conditions - 60 m in all directions, 200 m downwind
	  • Large spills in reactive conditions - 390 m in all directions, 1.3 km downwind
	• Administer first aid as required
	• ERT or other trained and equipped personnel stop release, contain spill, and neutralize if possible
	• Immediate notification of SGC Senior Management so communication protocol can be enacted
	• Construct emergency catchment areas if secondary containment breached

Emergency Level	Tier 1 - 3
Potential Effects	• Fatality
Follow Up	• Incident/accident investigation • Pump spilled solutions back in the cyanidation process • Environmental remediation if PLS is released

6.9 RELEASE OF HCN GAS DURING TRANSPORTATION

Incident	Release of HCN Gas during Transportation
Potential Causes	• Vehicle accident resulting in the release of dry sodium cyanide which is then exposed to acids, acid salts, water, moisture or carbon dioxide
Preventative Measures	• Strictly enforced speed limits for cyanide transport vehicles • Pilot vehicles for cyanide transport vehicles on access road during inclement weather • Appropriate spill response equipment mandatory for all cyanide transport vehicles • Use of International Cyanide Management Code certified transporters • Establish cooperative arrangements with emergency responders in communities along the transportation route • Periodic emergency response drills
Detection Method	• Observation of event

Site Response	• Initiate “Code 1” as per “Initial Response - Code 1 Procedure”
	• Evacuate area
	  • Small spills in reactive conditions - 60 m in all directions, 200 m downwind
	  • Large spills in reactive conditions - 390 m in all directions, 1.3 km downwind
	• Administer first aid as required
	• ERT or other trained and equipped personnel stop release, contain spill, and neutralize if possible
	• Immediate notification of SGC Senior Management so communication protocol can be enacted

Emergency Level	Tier 3
Potential Effects	• Fatality
Follow Up	• Incident/accident investigation • Environmental remediation

7 HYDROGEN CYANIDE INFORMATION

Hydrogen cyanide gas is an extremely toxic, flammable compound which can be produced by the decomposition of sodium cyanide when exposed to acids, acid salts, water, moisture and carbon dioxide. HCN gas is colorless with a faint odor of bitter almonds and can be smelled in the concentration range of 1 - 5 parts per million (ppm). Exposure to HCN gas concentrations greater than 50 ppm for 30 minutes can result in cyanide poisoning and any exposed individual must obtain immediate medical treatment.

In a release situation, the immediate release area and a downwind isolation zone must be established. Vapor generation will be very rapid and vapors can travel a considerable distance. All ignition sources must be removed as vapors are easily ignitable at ambient temperature conditions.

7.1.1 First Aid for Inhalation of Hydrogen Cyanide Gas

The application of prompt and effective first aid is crucial to maximize the chances of survival following cyanide poisoning. In all cases of exposures to cyanides, emergency transport to the nearest medical facility should be arranged.

The following first aid steps may prove useful.

Step 1 - Remove the patient from cyanide exposure.

The first priority is to try and remove the patient, if possible, from further exposures to cyanides and into a source of fresh air. Rescuers must be properly trained in emergency procedures and wear appropriate PPE.

Even if the patient recovers quickly after being removed from exposure to cyanide, administer 100 percent oxygen and arrange transfer to a medical facility.

Step 2 - Support airway, breathing and circulation

Speed is critical in treating a patient with cyanide poisoning.

- Check the patient’s airway. Remove blockages or restrictions as necessary.
- Check the patient’s breathing.

If the patient is breathing, place in the recovery position and administer 100 percent oxygen. If the patient is unconscious, insert an oral airway if available and if trained in its use. If the patient is not breathing, begin resuscitation using a resuscitation bag or mask connected to an oxygen source or 100 percent oxygen via a non-rebreathing facemask.

Mouth-to-mouth resuscitation should be avoided due to the risk of contamination of the rescuer.

Check for a pulse. If no pulse is present, start external cardiac massage (also known as hands-only CPR)

Step 3 - Decontamination

Contaminated clothing should be carefully removed and placed in a sealed bag for decontamination or disposal. The patient should then be washed down with copious fresh water; however, decontamination should not delay first aide.

Step 4 - Transfer of patient to medical care

If not already arranged, immediately organize urgent ambulance treatment to the nearest medical facility. During transfer, the patient should be accompanied by someone trained in CPR and a cyanide antidote kit should also be taken.

7.1.2 Signs and Symptoms of Hydrogen Cyanide Gas Exposure

Effects occur extremely rapidly following exposure to hydrogen cyanide. After inhalation exposure, symptoms begin within seconds to minutes; death may occur within minutes. The time of onset of effects depends on the concentration and duration of exposure.

Early symptoms of cyanide poisoning include light headedness, giddiness, rapid breathing, nausea, vomiting (emesis), feeling of neck constriction and suffocation, confusion, restlessness, and anxiety. Accumulation of fluid in the lungs (pulmonary edema) may complicate severe intoxications. Rapid breathing is soon followed by respiratory depression/respiratory arrest (cessation of breathing).

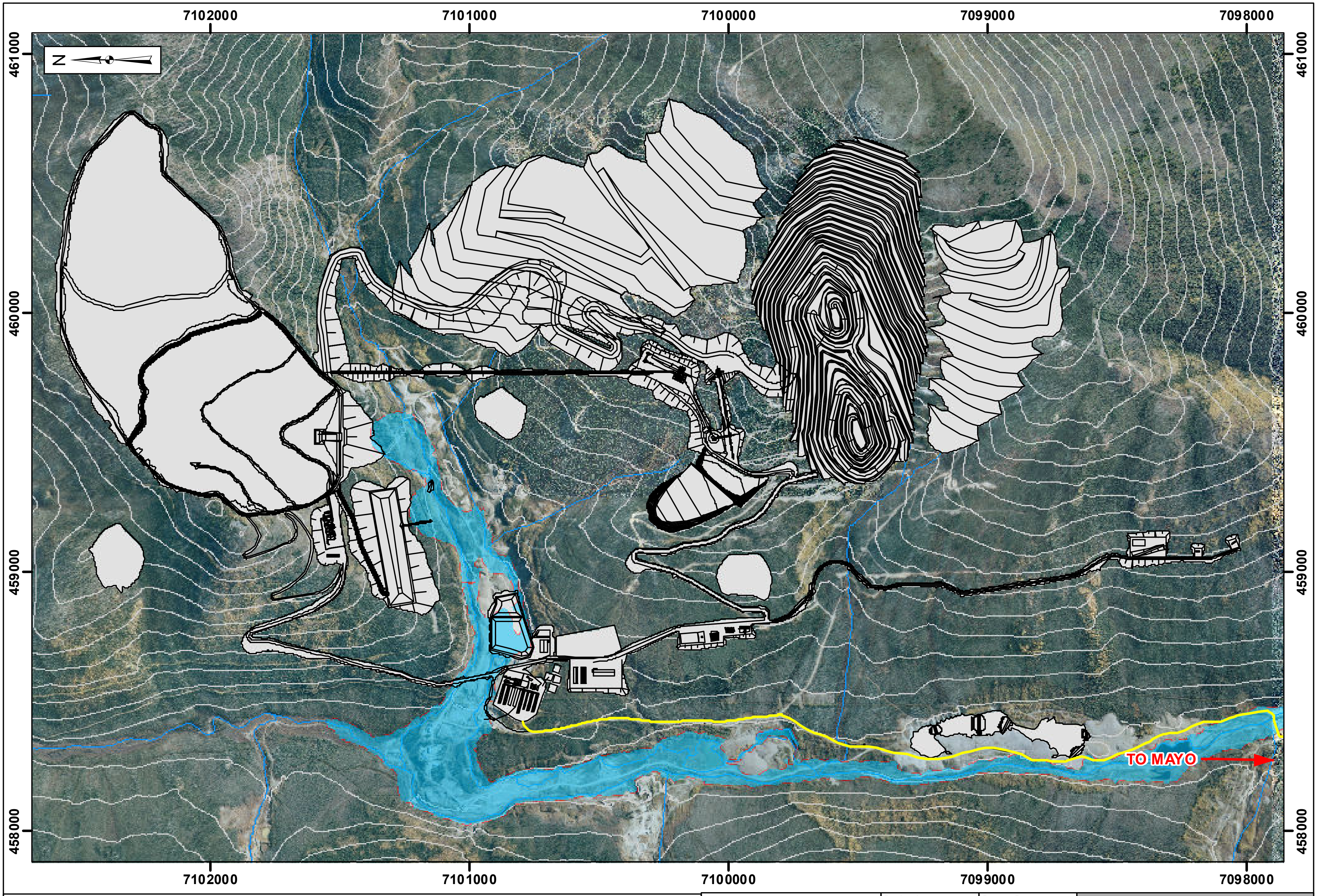
Severe cyanide poisonings progress to stupor, coma, muscle spasms (in which head, neck, and spine are arched backwards), convulsions (seizures), fixed and dilated pupils, and death. The central nervous system (CNS) is the most sensitive target organ of cyanide poisoning. Cardiovascular effects require higher cyanide doses than those necessary for CNS effects. In serious poisonings, the skin is cold, clammy, and diaphoretic. Blue discoloration of the skin may be a late finding. Severe signs of oxygen deprivation in the absence of blue discoloration of the skin suggest cyanide poisoning.

8 EVACUATION

The emergency scenarios considered for the heap leach and process facilities will under most circumstances require only temporary evacuation from an affected work area. Only in an extreme circumstance should a full site evacuation be undertaken. A full evacuation can only be authorized by the Mine Manager. The muster location and evacuation route for the Project is provided in Figure 8.1-1.

Based on the anticipated emergency scenarios for the heap leach and process facilities only a major failure of the embankment due to an extraordinary seismic event during periods of extreme cold weather present a situation in which a full evacuation should be considered.

As part of the FMEA and design of the Project an inundation map was developed which predicts the locations which would be flooded by PLS during a catastrophic failure of the embankment. Figure 8.1-1 illustrates the anticipated inundation areas for a catastrophic failure of the HLF embankment.



Legend:

- Evacuation Route
- Facility
- Inundation Area
- Watercourse
- Contour (25m)

StrataGold Corporation

0 125 250 500
Metres

Projection:	Drawn By:	EAGLE GOLD PROJECT YUKON TERRITORY
NAD 83 UTM Zone 8N	HC	
Date: 2017/11/09	Figure: 8.1-1	Inundation Map and Evacuation Route

APPENDIX E

Heap Leach Facility Failure Modes Effects Analysis

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BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Project Memorandum

To:	**StrataGold Corp.**	**Doc. No.:**	
Attention:	**Mark Ayranto**	**cc:**	
From:	**Troy Meyer, P.Eng.**	**Date:**	**August 30, 2017**
Subject:	**FMEA - Eagle Gold Heap Leach Facility**		
Project No.:	**0792018**		

1.0 INTRODUCTION

StrataGold Corporation (SGC) plans to process gold-bearing ore on in a heap leach facility (HLF) using standard cyanide heap leach technology. The HLF includes a lined pad, confining embankment, foundation underdrain system, In-Heap Pond for storage and recovery of pregnant leach solution (PLS), Events Pond, spillways, and stormwater interceptor ditches.

The Phase 1 HLF design is presented in a document prepared by BGC titled "Eagle Gold Project Heap Leach Facility Detailed Design" and dated September 2017. Technical Specifications and an Operation, Maintenance and Surveillance (OMS) Manual have been prepared to support the construction and operation of the HLF.

Effective and proactive management of the HLF requires a broad understanding of the associated uncertainties, risks, and potential consequences related to construction, operation and closure of the HLF. It is important that focusing on one component and hypothetical failure mode, such as the confining embankment slope failure, doesn't lead to other components being overlooked. The Failure Mode and Effects Analysis (FMEA) methodology balances the evaluation of risks associated with various components of a system. Haimes (2004) describes an FMEA as a reliability-based method that is "widely used for reliability analysis of systems, subsystems, and individual component of systems". It constitutes an enabling mechanism with which to identify the multiple paths of system failures. Indeed, a requisite for an effective risk assessment process is to identify all conceivable failure modes of a system."

SGC and BGC prepared and updated this FMEA for the HLF with input from a team of cross-disciplinary experts. The team represented a range of disciplines and experiences related to various aspects of the HLF design and operations. Relevant issues considered during the environmental assessment and subsequent regulatory approval stages for the Project, involving Yukon Government, the Yukon Water Board and the First Nation of Na-cho Nyak Dun, were considered in this updated FMEA.

1.1. Objectives

The FMEA was conducted as part SGC's approach to risk management planning for the HLF because:

- Failure of critical components of the HLF represents a material risk to SGC, in that it could affect the Project's ability to leach ore and collect the pregnant leach solution; and
- Risk management planning is a key component to ensure ongoing compliance with regulatory approvals.

The objective of the FMEA was therefore to take a proactive approach to risk mitigation by clearly understanding a broad range of “key risks” for the HLF, and using a balanced evaluation of those risks as a basis for prioritizing and focusing risk mitigation measures.

1.2. Project Description

The Project is planned as an open pit operation with a HLF and an adsorption-desorption-recovery (ADR) processing plant. The Project is in the center of the Yukon Territory about 350 kilometers north of the capital, Whitehorse, and approximately 45 kilometers north of Mayo, a small village on the Stewart River. The Project site is located within the lower Dublin Gulch/Eagle Creek watershed.

The HLF will accommodate approximately 77 Mt of crushed ore from the Eagle Zone open pit at full build-out, and has an approximate capacity of 25 Mt in the Phase 1 pad. Ore excavated from the pit will be crushed at the crusher complex to be located north of the open pit, and transported via an approximately 1.2 km long conveyor to the eastern perimeter of the HLF ultimate limit. The crushed ore will be transported to the leach pad and stacked using mobile conveyors and a radial stacker, where a dilute cyanide solution will be applied to the ore heap via drip emitters and leached through the heap. The leachate solution will drain by gravity to an internal process pond (the In-Heap Pond) located at the base of the HLF confining embankment. The PLS will be pumped from the In-Heap Pond to the ADR plant for processing to extract gold.

1.3. Facility Description

1.3.1. General

The proposed HLF is located entirely within the Ann Gulch catchment, a small ephemeral tributary to Dublin Gulch. The HLF will be constructed in phases with each phase accommodating approximately 25 Mt of ore. Phase 1 of the HLF will be constructed and operate in Year 1 of the mine plan. The base of the HLF confining embankment is located upstream of the confluence of Ann Gulch and Dublin Gulch at an elevation of 880 masl, and at full height in Phase 3 the HLF extends up Ann Gulch to an elevation of approximately 1225 masl at the top of the planned ore stack. All components of the HLF have been located such that the passage of a Probable Maximum Flood (PMF) through the Dublin Gulch valley will not encroach on the HLF.

The HLF comprises several elements: a confining embankment to provide stability to the base of the HLF, a lined storage area for the ore to be leached, pumping wells for the extraction of solution, a lined Events Pond to contain excess solution in extreme events, upstream surface water interceptor ditches, and leak detection and recovery systems (LDRS) and associated monitoring points to ensure the containment of solution.

1.3.2. Confining Embankment

The HLF is a valley fill design that incorporates an embankment that will provide stability to the base of the heap and the stacked ore. The embankment will also provide for the storage and management of cyanide process solution within the heap, which eliminates the need for external pregnant process solution ponds. The confining embankment is designed to provide safe storage for the required ore tonnage, and creates an In-Heap Pond area for temporarily storing fluids and pumping of PLS to the ADR plant. The In-Heap Pond and embankment are sized to provide storage for 24 hours of operational solution flow.

1.3.3. Events Pond

The external Events Pond is double-lined and is sized to provide containment storage for the PMF event with some additional capacity for seasonal accumulation of water. The Events Pond will be constructed to temporarily store excess process solution that may occur during upset conditions. The solution contained in the pond will be recycled back into the heap leach circuit. The pond will incorporate a LDRS beneath the upper liner system.

In the unlikely event that storage volume within the Events Pond is at maximum capacity, the solution will be treated through the cyanide detoxification plant and the water treatment plant prior to discharge or managed in accordance with the HLF Contingency Water Management Plan.

1.3.4. Underdrain System

The HLF underdrain system provides for the collection and drainage of subsurface water beneath the lined facility to limit upward pressure on the HLF liner. The underdrain includes foundation trenches lined with geofabric and filled with granular drain rock backfill materials and 100 mm perforated pipes placed at regular intervals (approximately 75m spacing) beneath all phases of the HLF. Additional drains are to be installed during construction as field conditions dictate. The drains will convey subsurface water to collector pipes that will discharge to an outlet monitoring vault. The vault is configured to allow for sampling of seepage flows for water quantity and quality, and will be equipped with a pump system to return flows to the HLF for use as make up water or allow flows to outfall if discharge criteria are met. In the unlikely event that unplanned measurable leakage occurs from the liner system, the discharge would be identified during regular water quality monitoring of flows at the outlet monitoring vault. Separate non-perforated collection pipes for each phase of the HLF allow the outflows from each area to be monitored independently. This allows for more focused mitigation actions in the case of water quality exceedance from the underdrain monitoring system.

1.3.5. Liner System

The liner for the HLF In-Heap Pond and Events Pond consists of a double composite liner system and the liner for the HLF pad area consists of a single composite liner system. These incorporate an underlying low-permeability bedding material, which is the state-of-practice liner system for heap leach facilities. A geosynthetic clay liner (GCL) will be used in lieu of a 300 mm thick layer of compacted low-permeability soil.

The lining system for the In-Heap Pond area is comprised of the following:

- A minimum 1 m thick layer of overliner material with imbedded perforated drainage piping
- A 2.0 mm (80-mil) double-side textured linear low-level polyethylene (LLDPE) primary liner
- A geonet (geocomposite) that is part of the LDRS and located between the primary and secondary liners
- A 1.5 mm (60-mil) double-side textured LLDPE secondary liner
- A GCL; and
- Prepared subgrade beneath the GCL.

The lining system for the HLF pad (up-gradient of the In-Heap Pond) is comprised of the following:

- A 0.6 m thick layer of overliner material with imbedded perforated drainage piping
- A 2.0 mm (80-mil) LLDPE liner
- A GCL; and
- Prepared subgrade beneath the GCL.

The Events Pond will be a double-lined facility with LDRS having the following components:

- A 2.0 mm (80-mil) high-density, polyethylene primary liner
- A geonet that is part of the LDRS and located between the primary and secondary liners
- A 1.5 mm (60-mil) textured LLDPE secondary liner
- A GCL; and
- Prepared subgrade beneath the GCL.

A LDRS will be constructed within the In-Heap Pond and Events Pond and will consist of a monitoring sump equipped with an automatic, fluid-level activated pump located between the primary and secondary liners. The pump will be sized to sufficiently remove fluids to minimize head on the secondary liner.

1.3.6. Solution Collection System

Solution will be collected in the high permeability overliner material at the base of the heap pad, with perforated collection pipes placed within the overliner to increase solution removal rates. A drain cover fill layer (termed Overliner Drain Fill or ODF within the construction documents) will be placed over the entire leach pad area including the upstream face of the confining embankment. Competent durable rock for production of ODF gravel shall be produced from crushing and/or screening operations of ore and/or mine waste and/or from screening of sand and gravel aggregate from borrow sources. The design criteria specify an ODF permeability and maximum ore heap load to ensure both reasonable spacing of the drain pipes and fully drained heap conditions.

The heap leach pad is designed to contain a network of pipes that will be distributed throughout the limits of the facility and will collect and convey PLS in addition to stormwater. Solution collection pipes will be placed within the ODF to convey PLS and storm flows to the In-Heap Pond which is confined by the embankment.

The collection pipe network in the ODF will direct the solution to the sump at the toe of the embankment for pumping through inclined riser pipes. Solution will be pumped from the sump through three of five available inclined risers to the process plant. The inclined wells will extend from the base of the In-Heap Pond to the embankment crest. Three pumps will have the capacity to meet the solution application throughflow. The remaining two riser pipes will be installed as a back-up, in order to maintain access to the sump in the event that any riser pipes become blocked.

1.3.7. Stormwater Controls

Temporary runoff interceptor ditches will be constructed around each phase of the heap leach pads to collect and divert stormwater runoff away from the heap pad. The ditches are sized for the 100-year, 24-hour event, armored with riprap and will be constructed and in operation before construction of each pad phase. Once the heap leach pads are ready for the next phase the temporary interceptor ditch will be filled and regraded for placement of the liner for the next phase.

1.3.8. Instrumentation

Operational monitoring requirements for the HLF will include instrumentation for measuring phreatic levels and pore pressures within the foundation and embankment, fluid levels within the heap and sumps, and movement of the embankment. Monitoring will be used to verify the facility components are performing as expected and to provide early warning of problematic conditions. Observations on the performance of the initial stages may provide useful information for optimizing subsequent stages of development.

1.3.9. Closure System

During closure of the HLF, the cyanide in the spent ore will be destructed and the heap will be rinsed. Once acceptable water quality is verified, the liner system below the In-Heap Pond will be punctured by drilling to allow complete drainage of water through a pre-installed outlet system. The closure sump and drain pipes are sized to convey the wettest month precipitation to minimize solution accumulation within the spent ore. The closure drain system will consist of a LLDPE lined gravel sump with perforated pipe drain loop directing flow to polyethylene outlet pipes. The closure sump will be placed directly below the leak detection sump to direct residual flows from the leak detection system to the closure outfall.

2.0 FMEA METHODOLOGY AND APPROACH

2.1. FMEA Boundaries

The FMEA was conducted in the context of a well-defined system. The spatial, functional and temporal boundaries of the FMEA were discussed with participants and the following guidelines were adopted.

1. The FMEA is bounded spatially to incorporate the HLF itself and the other directly connected site components as follows:
    - Confining Embankment and Spillway;
    - In-Heap Pond;
    - Events Pond;
    - HLF Liner System
        - Underdrains
        - Geomembrane
        - Geonet
        - ODF
    - Solution Collection System;
    - Ore Heap; and
    - Closure Drain System.
2. The FMEA includes site components and functions that directly affect (or could affect) the construction, operation or closure of the HLF:
    - Ore preparation;
    - Ore delivery and placement;
    - Ore leaching;
    - Solution pumping systems;
    - Electrical systems;
    - Management system; and
    - Work force.
3. The temporal scope of the FMEA was not limited, but three phases were defined:
    - Construction - the period during initial construction of the key HLF components;

- Operations – the period during which ore is actively placed and leached;
- Closure – the period during which the ore is no longer placed and treated but solution may continue to be collected and processed.

2.2. Participants and Preparation

An FMEA for the HLF was initially completed over a period from April 2013 to June 2013 and was re-evaluated between June 2017 to August 2017 based on optimizations to the facility and inputs received during the regulatory processes for the Project. The 2017 participants were:

- Troy Meyer, P.Eng (BGC Engineer);
- Mike Henderson, P.Eng (BGC Reviewer);
- Roy Mayfield, P.Eng (BGC Reviewer);
- Mark Ayranto (SGC Reviewer);
- Tony George, P. Eng (SGC Reviewer);
- Hugh Coyle (SGC Reviewer); and
- Stephen Wilbur (SGC Reviewer).

In preparation for the FMEA process, a general template for the FMEA was compiled and distributed. Participants prepared the following:

- A list of various components that constitute the HLF and associated processes/procedures;
- A list of documents related to the HLF design, construction, operation, and closure ; and
- An initial list of “failure modes”.

2.3. Approach

Troy Meyer, P.Eng prepared a FMEA template that included the list of components and an initial list of failure modes, and provided the participants with an overview of the background material and FMEA methodology.

The first step was to decide on the criteria to be used for likelihood, consequence severity and risk. Previous criteria were used from similar FMEA exercises and provided a basis that was familiar to most participants. The FMEA approaches presented in Haimes (2004) and Robertson and Shaw (2002) were used as general guidelines.

A key for the FMEA template is provided in Figure 1. Participants agreed to adopt the definitions of occurrence frequency ratings shown in Figure 2, and the consequence-severity definitions shown in Figure 3., Consequence-severity is defined using the following categories:

- Health and Safety;
- Economic and Social Loss;

- Environmental and Cultural Loss;
- Regulatory Impacts and Censure; and
- Public Concern and Image.

An additional rating category that captures confidence in the detection of a possible event is shown in Figure 4.

Participants were then asked to assess specific hypothetical failure modes and their potential effects, by providing estimates of the likelihood of failure, criticality of potential consequences and confidence of the evaluation.

A Risk Priority Number (RPN) was then calculated as follows:

RPN = SEV x OFR x DET

Where:

SEV = Severity Rating (1 to 10, where 1 is ‘negligible’ and 10 is ‘extreme’)

OFR = Occurrence Frequency Rating (1 to 10, where 1 is ‘not likely’ and 10 is ‘expected’)

DET = Detection Rating (1 to 10, where 1 is ‘high confidence’ and 10 is ‘low confidence’)

The resulting RPN can range between 1 and 1000, with higher risk priority assigned to larger values. As the HLF risks were assessed, it became clear that some of the consequence types would be the dominant risks, while others were likely in a “Low Risk” category. This was primarily due to low severity ratings or low likelihood ratings.

3.0 FMEA RESULTS

The outcome of the discussions and evaluations is summarized in the FMEA Risk Register, presented in Figure 5. Various failure modes over the major HLF components were listed and discussed.

The four highest RPN scores are summarized in the following table.

Component	Potential Failure Mode	Severity (SEV)	Occurrence Frequency Rating (OFR)	Detection Rating (DET)	Risk Priority Number(RPN)
Confining Embankment	Structural failure – foundation or slope failure	7 (High)	1 (Not Likely)	10 (Low Confidence)	70
Confining Embankment	Hydraulic failure - overtopping or toe erosion	7 (High)	2 (Not Likely)	4 (Medium Confidence)	56

HLF Liner System	Damage during ore placement	6 (Moderate)	3 (Low Likelihood)	3 (Medium High Confidence)	54
Ore Heap	Elevated phreatic level or erosion	6 (Moderate)	4 (Low Likelihood)	2 (High Confidence)	48

The potential consequences of these hypothetical events were considered moderate to high primarily due to the remote Project location and size, as there is low potential for multiple loss of life and the feasibility of restoration or compensation in-kind for environmental loss is moderate. The FMEA conducted for the HLF generally concluded that the primary driver for the RPN was severity. The severity ratings concluded by the participants were largely due to regulatory impacts and censure, and public concern and image. These areas are considered critical for the operation of the Project.

While the structural failure of the HLF confining embankment due to an extraordinary seismic event received the highest RPN, the design criteria applied to the Project based on the seismic hazard analysis is in accordance with Canadian Dam Association guidelines. Hydraulic failure (overtopping due to spillway plugging or toe erosion due to misdirected spillway discharge) of the confining embankment could result in uncontrolled release of ore and process fluids and downstream impacts to the environment. A liner system failure would potentially result in contamination of the groundwater. Failure of the ore pile slopes would likely damage the liner system.

It should be noted that seepage failure of the confining embankment is considered to have a high consequence however the RPN is relatively low (28) compared to a structural or hydraulic failure mode. This is due to the very high confidence in the ability to control construction quality and to detect precursors to such an event via dedicated monitoring systems installed in and around the embankment.

4.0 REFERENCES

Haimes, Y.Y. (2004) Risk Modeling, Assessment, and Management, 2nd Edition, John Wiley and Sons, 837 pp.

Robertson and Shaw (2002) Mine Closure, Infomine E-Book, http://www.infomine.com/library/publications/docs/e-book%2002%20mine%20closure.pdf

5.0 CLOSURE

BGC Engineering Inc. (BGC) prepared this document for the Eagle Gold Project. The information contained herein reflects the judgment of BGC staff in light of the information available to BGC at the time of document preparation. Any use which a third party makes of this document or any reliance on decisions to be based on it is the responsibility of such third parties. BGC accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this document.

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Yours sincerely,

BGC ENGINEERING INC.
per:

Troy Meyer, P.Eng.
Principal Geotechnical Engineer

Reviewed by:

Mike Henderson, P.Eng.

Attachment(s): Figures 1 through 5

FIGURE 1 - DESIGN FMEA KEY

Item and Function	Potential Failure Mode	Potential Effects of Failure	SEV	Potential Cause(s) of Failure	OFR	Detection Method & Quality Controls	DET	RPN	Recommended Actions
List Part Name, Number and Function	List the possible modes of failure	List the consequences of failure on part function and on the next higher assembly		List those such as: inadequate design, improper materials, etc.		List these measures available to detect failures before they reach the customer			List them for each of the failure modes identified as being significant by the RPN

SEV = Severity rating (1 to 10)
OFR = Occurrence Frequency Rating (1 to 10)
DET = Detection Rating (1 to 10)
RPN = SEV*OFR*DET = Risk Priority Number (1 to 1000)

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FIGURE 2 - OCCURANCE FREQUENCY RATING

Eagle Gold Heap Leach Facility

Occurance Frequency Rating (OFR)	Likelihood Class	Description
1-2	Not Likely	Extremely unlikely to occur during the lifetime of facility
3-4	Low	Not expected to occur during the lifetime of facility
5-6	Moderate	Expected to occur once during the lifetime of facility
7-8	High	Expected to occur several times during the lifetime of facility
9-10	Expected	Expected to occur more than once a year

FIGURE 3 - SEVERITY RATING

Consequences Severity	Severity Rating	Health and Safety	Economic and Social Loss	Environmental and Cultural Loss	Regulatory Impacts and Censure	Public Concern and Image
Extreme	9-10	Large potential for multiple loss of life involving residents and working, travelling and/or recreating public. Development within inundation area (the area that could be flooded if the dam fails) typically includes communities, extensive commercial and work areas, main highways, railways, and locations of concentrated recreational activity. Estimated fatalities could exceed 100.	Very high economic losses affecting infrastructure, public and commercial facilities in and beyond inundation area. Typically includes destruction of or extensive damage to large residential areas, concentrated commercial land uses, highways, railways, power lines, pipelines and other utilities. Estimated direct and indirect (interruption of service) costs could exceed $100 million.	Loss or significant deterioration of nationally or provincially important fisheries habitat (including water quality), wildlife habitat, rare and/or endangered species, unique landscapes or sites of cultural significance. Feasibility and/or practicality of restoration and/or compensation is low.	Unable to meet regulatory obligations; shut down or severe restriction of operations	Local, international and NGO outcry and demonstrations, results in large stock devaluation; severe restrictions of 'license to practice'; large compensatory payments etc.
High	7-8	Some potential for multiple loss of life involving residents, and working, travelling and or recreating public. Development within inundation area typically includes highways and railways, commercial and work areas, locations of concentrated recreational activity and scattered residences. Estimated fatalities less than 100.	Substantial economic losses affecting infrastructure, public and commercial facilities in and beyond inundation area. Typically includes destruction of or extensive damage to concentrated commercial land uses. highways, railways, power lines, pipelines and other utilities. Scattered residences may be destroyed or severely damaged. Estimated direct and indirect (interruption of service) costs could exceed $1 million.	Loss or significant deterioration of nationally or provincially important fisheries habitat (including water quality), wildlife habitat, rare and/or endangered species, unique landscapes or sites of cultural significance. Feasibility and practicality of restoration and/or compensation is high.	Regularly (more than once per year) or severely fail regulatory obligations or expectations - large increasing fines and loss of regulatory trust	Local, international or NGO activism resulting in political and financial impacts on company's 'license to do business' and in major procedure or practice changes
Moderate	5-6	Low potential for multiple loss of life. Inundation area is typically undeveloped except for minor roads, temporarily inhabited or non-residential farms and rural activities. There must be a reliable element of natural warning if larger development exists.	Low economic losses to limited infrastructure, public and commercial activities. Estimated direct and indirect(interruption of service) costs could exceed $100,000.	Loss or significant deterioration of regionally important fisheries habitat (including water quality), wildlife habitat, rare and endangered species, unique landscapes or sites of cultural significance. Feasibility and practicality of restoration and/or compensation is high. Includes situations where recovery would occur with time without restoration.	Occasionally (less than one per year) or moderately fail regulatory obligations or expectations - fined or censured	Occasional local, international and NGO attention requiring minor procedure changes and additional public relations and communications
Low	3-4	Minimal potential for any loss of life. The inundation area is typically undeveloped	Minimal economic losses typically limited to owners property and do not exceed $100,000. Virtually no potential for future development of other land uses within the foreseeable future.	No significant loss or deterioration of fisheries habitat, wildlife habitat, rare or endangered species, unique landscapes or sites of cultural significance.	Seldom or marginally exceed regulatory obligations or expectations. Some loss of regulatory tolerance, increasing reporting.	Infrequent local, international and NGO attention addressed by normal public relations and communications
Negligible	1-2	No Concern	No measurable impact		Do not exceed regulatory obligations or expectations	No local, international, or NGO attention

FIGURE 4 - DETECTION RATING

Eagle Gold Heap Leach Facility

Class	Detection Rating (DET)	Description
Low	Range from 1 to 10 Lowest = 10 Highest = 1	Do not have confidence in ability to detect
Medium		Have some confidence in ability to detect
High		Have high level of confidence in ability to detect

FIGURE 5 - FMEA RISK REGISTER

EAGLE GOLD HEAP LEACH FACILITY										
Component	*Function*	*Potential Failure Mode*	*Potential Effects of Failure*	*SEV*	*Potential Cause(s) of Failure*	*OFR*	*Detection Method and Quality Controls*	*DET*	*RPN*	*Recommended Actions*
Confining Embankment	Confines ore and solution within the heap leach facility	Structural Failure - foundation or slope failure	Major damage to multiple pad components Damage to liner system and loss of product - solution leakage Damage to collection piping system Uncontrolled release of ore and solution	7	Poor quality control during foundation preparation and embankment fill placement	2	Construction quality control and assurance program Regular inspection by engineer during construction	2	**28**	Implement high level of construction quality control and assurance with regular inspections by the engineer
				7	Extraordinary seismic event exceeding projected maximum event	1	Compliance with Canadian Dam Association Technical Bulleting for Seismic Hazard Considerations for Dam Safety	10	**70**	Implement high level of construction quality control and assurance with regular inspections by the engineer Maintain operational heap water balance model and comply with operational criteria for solution volumes to limit potential volume of solution release Buttress embankment with structural fill, such as waste rock, to stabilize the structure
		Seepage Failure - internal erosion (piping)	Major damage to multiple pad components Damage to liner system and loss of product - solution leakage Damage to collection piping system Uncontrolled release of solution	7	Progressive piping (fines erosion) through embankment	2	Dam instrumentation - piezometers Seepage monitoring	2	**28**	Follow procedures identified in OMS Manual including regular site inspections by mine personnel and dam safety inspections and reviews by engineer Buttress embankment with structural fill, such as waste rock, to stabilize the structure
		Hydraulic Failures: - Overtopping - Toe Erosion	Major damage to multiple pad components Damage to liner system and loss of product - solution leakage Damage to collection piping system Uncontrolled release of ore and solution	7	Overtopping of dam crest during runoff event due to spillway plugging Embankment toe erosion due to misdirected spillway outlet discharge	2	Regular inspection of spillway and outfall by site personnel and engineer Regular inspection of dam face and toe area by site personnel and engineer	4	**56**	Maintain heap water balance operational criteria and follow procedures identified in the HLF Contingency Water Management Plan for solution management Follow procedures identified in OMS Manual including regular site inspections by mine personnel and dam safety inspections and reviews by engineer
In-Heap Pond	Provides operational storage of solutions Frost protection for solution in the In-Heap Pond	Solution escape from containment system	Uncontrolled release of solution to environment	4	Poor quality control during foundation preparation, fill placement, liner and overliner installation	2	Construction quality control and assurance program Regular inspection by engineer during construction	3	**24**	Implement high level of construction quality control and assurance with regular inspections by the engineer
				6	Damage to liner system after construction during ore placement	3	In-Heap Pond Leak Detection and Recovery System (LDRS)	2	**36**	Follow procedures identified in OMS Manual including stacking plan and ore placement procedures
				2	Failure of electrical system leading to solution buildup in excess of storage capacity Failure of pump system leading to solution buildup in excess of storage capacity	4	In-Heap Pond and flow instrumentation: - Level meter in pond - Flow meters within solution recovery system	1	**8**	Maintain heap water balance operational criteria and follow procedures identified in the HLF Contingency Water Management Plan for solution management Follow procedures identified in OMS Manual including dam safety inspections and reviews by engineer Regular inspection of back up electrical and pumping equipment to ensure operability in case of emergency Site electrical system will include switch gear to allow power to be sourced from YEC grid or on site back up diesel generation Design includes 5 PLS pumps - 3 operational and 2 backup
				2	Extraordinary combination of upset events occurring simultaneously resulting in loss of storage in InHeap Pond	3	In-Heap Pond and flow instrumentation: - level meter in pond - flow meters within solution recovery system Snowpack levels on heap	2	**12**	Follow procedures identified in OMS Manual including monitoring ofsolution levels Maintain heap water balance operational criteria and follow procedures identified in the HLF Contingency Water Management Plan for solution management
Events Pond	Provides operational and contingency storage of solutions	Solution escape from containment system Foundation or slope failure	Damage to liner system and loss of product - solution leakage Uncontrolled release of solution to environment	4	Poor quality control during foundation preparation, fill placement, liner installation	2	Construction quality control and assurance program Regular inspection by engineer during construction	3	**24**	Implement high level of construction quality control and assurance with regular inspections by the engineer
				6	Damage to liner system after construction during operations (ice damage, wildlife damage, equipment damage, etc.).	3	Events Pond Leak Detection and Recovery System (LDRS) Visual inspections	2	**36**	Follow procedures identified in OMS Manual including regular inspection of pond by site personnel
				6	Failure of electrical system leading to solution buildup in excess of storage capacity Failure of pump system leading to solution buildup in excess of storage capacity	4	Water levels in In-Heap Pond and Events Pond	1	**24**	Maintain heap water balance operational criteria and follow procedures identified in the HLF Contingency Water Management Plan for solution management Follow procedures identified in OMS Manual including dam safety inspections and reviews by engineer Regular inspection of back up electrical and pumping equipment to ensure operability in case of emergency Site electrical system will include switch gear to allow power to be sourced from YEC grid or on site back up diesel generation Design includes 5 PLS pumps - 3 operational and 2 backup
				2	Extraordinary combination of upset events occurring simultaneously resulting in loss of storage in Events Pond	3	Water levels in In-Heap Pond and Events Pond Snowpack levels on heap	2	**12**	Follow procedures identified in OMS Manual including monitoring ofsolution levels Maintain heap water balance operational criteria and follow procedures identified in the HLF Contingency Water Management Plan for solution management
				6	Poor fabrication quality	3	Quality control during manufacturing Compliance testing during procurement	2	**36**	Follow technical specifications including compliance testing of geosynthetics during procurement

EAGLE GOLD HEAP LEACH FACILITY										
Component	***Function***	***Potential Failure Mode***	***Potential Effects of Failure***	***SEV***	***Potential Cause(s) of Failure***	***OFR***	***Detection Method and Quality Controls***	***DET***	***RPN***	***Recommended Actions***
HLF Liner System - Underdrains - Geomembrane - Geonet - Overliner Drain Fill (ODF)	Groundwater Protection Containment and recovery of metal values	Liner seam defects Puncture or tear Material flaws Clogging of pipes, geonet or ODF Crushing of pipes or geonet	Loss of product - solution leakage Uncontrolled release of solution to environment	5	Damage to system components during construction	3	Construction quality control and assurance program Visual inspection	2	**30**	Follow technical specifications including construction of a test fill program to establish proper construction procedures to limit damage
				6	Damage to system components after construction during ore placement	3	In-Heap Pond LDRS system Monitoring vault flows (quantity and quality) Visual inspection	3	**54**	Follow procedures identified in OMS Manual including stacking plan and ore placement procedures
				5	Differential settlement caused by improper foundation preparation	2	Construction quality control and assurance program Regular inspection by engineer during construction	3	**30**	Implement high level of construction quality control and assurance with regular inspections by the engineer
Solution Collection System	Collects process solution and conveys to process plant	Clogging of perforated pipes or pump intakes Crushing of pipes Damage to system during construction or ore loading	Elevated hydraulic head in ore pile Loss of ability to control water balance	5	Poor quality control during installation	3	Construction quality control and assurance program	3	**45**	Follow technical specifications including compliance testing of geosynthetics during procurement
				5	Damage to system during ODF placement	3	Construction quality control and assurance program In-Heap Pond LDRS system Monitoring vault flows (quantity and quality) Visual inspection	2	**30**	Follow technical specifications including construction of a test fill program to establish proper construction procedures to limit damage
				2	Damage to system during ore placement	3	HLF pad piezometer installed in overliner Construction quality control and assurance during overliner placement	2	**12**	Follow procedures identified in OMS Manual including stacking plan and ore placement procedures
Ore Heap	Process system for extracting metals Metal inventory till full recovery realized	Ore pile slope failure	Major damage to multiple pad components Damage to liner system and loss of product - solution leakage Damage to collection piping system Uncontrolled release of ore and solution	6	Improper ore placement methods causing ore pile slope failure	2	In-Heap Pond LDRS system Monitoring vault flows (quantity and quality) Visual inspection	2	**24**	Follow procedures identified in OMS Manual including visual inspections of ore pile for erosion, stacking plan and ore placement procedures
				6	Elevated phreatic level or erosion causing ore pile slope failure	4	HLF pad piezometer installed in overliner Visual inspection	2	**48**	Maintain operational controls for solution management Follow procedures identified in OMS Manual including monitoring of ore pile phreatic levels, visual inspections of ore pile for erosion
Closure Drain System	Allows for drainage of fluid in a controlled manner through closure period and into post-closure	Clogging of sump materials Damage of system components	Failure to drain heap	2	Clogging of sump materials	2	Flows at monitoring vault	2	**8**	Develop contingency plan for alternative method of draining heap, such as drilling through ore pile into underdrains
				2	Damage during or after construction	3	Visual inspection	4	**24**	Implement high level of construction quality control and assurance with regular inspections by the engineer