KCB Consultants Ltd.

Resolution Copper Mining LLC

Resolution Copper Project

Skunk Camp TSF Seepage Assessment

Doc. # CCC. 03-81600-EX-REP-00034 – Rev. 0

UM09441A22.730

June 2020

June 26, 2020

Resolution Copper Mining LLC
P.O. Box 1944
Superior, Arizona
85273

Ms. Vicky Peacey
Senior Manager – Permitting and Approvals

Dear Ms. Peacey:

Resolution Copper Project
Skunk Camp TSF Seepage Assessment
Doc.# CCC.03-81600-EX-REP-00034 – Rev. 0

Please find enclose the Skunk Camp Tailings Storage Facility (TSF) Final Environmental Impact Statement (FEIS) seepage management plan and supporting assessment for input into the regional groundwater model, which was used to evaluate if the design could achieve compliance to water quality standards at the downstream points of compliance.

Yours truly,

KCB CONSULTANTS LTD.

Kate Patterson, P.E., P.Eng.
Project Manager

KP/LW:dl

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Resolution Copper Mining LLC

Resolution Copper Project

Skunk Camp TSF Seepage Assessment

Doc. # CCC. 03-81600-EX-REP-00034 – Rev. 0

EXECUTIVE SUMMARY

Background

Resolution Copper Mining LLC (RCM) is proposing to develop the Resolution Copper Project, an underground copper mine approximately two miles east of the town of Superior in the Pioneer Mining District, Pinal County, Arizona. Tonto National Forest (the Forest) issued the Draft Environmental Impact Statement (DEIS) for the proposed Resolution Copper Project and Land Exchange in August 2019 (Forest 2019). The DEIS identified the preferred Tailings Storage Facility (TSF) alternative as the Alternative 6 – Skunk Camp. The DEIS also listed mitigation measures, some to be completed prior to issuing the Final Environmental Impact Statement (FEIS).

RCM commissioned KCB Consultants Ltd. (KCBCL) to develop a seepage assessment and seepage management plan for the proposed TSF at the Skunk Camp site for the FEIS. The objective of this assessment is to provide the strategy and design for seepage management measures for the Skunk Camp TSF.

The goals for the Skunk Camp TSF are to have a stable facility and to limit the generation and potential release of poor water quality seepage. Management during operations of the potentially acid generating (PAG) pyrite tailings and their location within the facility post-closure is important to reducing the risk of acid rock drainage (ARD) and metals leaching (ML).

Seepage Model Development

KCBCL developed several one-dimensional (1D) models to estimate leakage from different tailings zones, as outlined in Table 1. Results of the 1D models were used as inputs to a three-dimensional (3D) Regional Groundwater Model developed by Montgomery & Associates (M&A 2020b). Results of the Regional Groundwater Model were used to inform development of a seepage management plan that achieves compliance.

Table 1 Tailings Zones and Models Developed for Seepage Assessment

Tailings Zone Number and Name	Tailings Zone Description	Representative Tailings	Model Developed to Support Leakage Estimate
1 – Cycloned Sand	▪ The Main Embankment is a cross-valley, centerline-raised, compacted cycloned sand dam that contains the scavenger tailings beach (Zone 2 and Zone 3). ▪ The pyrite cell embankments are downstream-raised, compacted cycloned sand dams that that contain pyrite tailings (Pyrite Cell 1 and Pyrite Cell 2) and the reclaim pond.	Cycloned Sand	▪ Operations: Cycloned Sand Embankment Leakage Estimate ▪ Long-term post-closure: Scavenger Tailings Closure Cover Model
2 – Near Dam Scavenger Beach	▪ Scavenger tailings will be deposited from the Main Embankment crest, slurry segregation will occur along the length of the beach as the tailings deposit. The zone closest to the embankment will be coarser, with the finer material depositing further away from the embankment.	Scavenger Total Tailings	▪ Operations and draindown: Scavenger Beach Seepage Model (includes consolidation)

Tailings Zone Number and Name	Tailings Zone Description	Representative Tailings	Model Developed to Support Leakage Estimate
	▪ For the purposes of this assessment, it was assumed that this zone is the area within 500 ft of the Main Embankment.		▪ Long-term post-closure: Scavenger Tailings Closure Cover Model
3 – Scavenger Beach	▪ The area of the scavenger beach that is not the Near Dam (Zone 2) is considered Zone 3. It is assumed that the finer material from the scavenger tailings deposited on the beach will settle further away from the embankment. ▪ In addition, the scavenger tailings deposited north of Pyrite Cell 2.	Scavenger Overflow	
4 – Pyrite Tailings	▪ Pyrite tailings deposited subaqueously in a low permeability lined cell from Mine Year 1 to 15 in Pyrite Cell 1 and Mine Year 16 to 41 in Pyrite Cell 2.	Pyrite Tailings	▪ Operations: Pyrite Cell Low Permeability Layer Leakage Model ▪ Long-term post-closure: Pyrite Tailings Closure Cover Model

Seepage Management Plan

A seepage management plan was developed that achieves water quality compliance at the point of compliances (POCs), supported by the Regional Groundwater Model.

The seepage management plan consists of the following:

- Operational Upstream Diversion Channels will divert non-contact water as much as practical to reduce water reporting to the TSF, thus this water would be unavailable for seepage into the foundation.
- Pyrite tailings will be deposited in two segregated, low permeability cells to reduce seepage flows from the reclaim pond during operations and limit seepage from the pyrite tailings draindown during post-closure.
- Cycloned sand embankments will be well-drained such that a phreatic surface will not develop in the embankments long-term (reducing head on the foundation). To limit infiltration, the cycloned sand embankments will be progressively reclaimed, where possible, throughout operations.
- The cycloned sand embankments will include a finger drain network that will extend into Zone 2 – Near Dam Scavenger Beach to capture seepage from tailings deposition and embankment construction.
- Tailings deposited in the scavenger beach (scavenger total tailings and scavenger overflow) will be thickened to a 60% solids content slurry (by mass) to maximize water recovery and deposited in thin lifts over a large area to maximize evaporation losses and minimize water available to infiltrate through the tailings and into the foundation. The scavenger beach will also be managed as dry as possible (i.e., no to minimal ponded water), with runoff or bleed water that collects in the low points pumped to the active pyrite cell.

- A lined seepage collection pond (SCP) downstream of the TSF for short-term management of seepage and construction water prior to returning to the active pyrite cell.
- A series of lined Contact Water Collection Ditches that convey captured seepage from the Main Embankment finger drains and convey to the SCP.
- Shallow alluvial pumpback wells downstream of the TSF to capture seepage that enters into the shallow foundation.
- A grout curtain and shallow pumpback well downstream of the SCP to capture stormwater flow in the alluvium or leakage from the SCP.

Discussion and Conclusions

Table 2 summarizes model sensitivities completed for each tailings zone and a discussion of the seepage management design resiliency of each tailings zone.

Table 2 Summary of Tailings Zone Model Sensitivities and Design Resiliency

Tailings Zone	Discussion on Model Sensitivities and Design Resiliency
Zone 1 – Cycloned Sand	▪ Cycloned sand tailings are not sensitive to changes in climate conditions during operations, as the inflow of water from hydraulic cell construction will be much greater than inflows from climate. As well, the material is relatively free draining and leakage is captured in underdrains. ▪ The leakage estimate for Zone 1 assumed that reclamation of the cycloned sand surface would begin after the end of embankment construction. This assumption added a level of conservatism to the leakage estimate, because, in practice, the cycloned sand embankments will be progressively reclaimed throughout operations to limit net infiltration (and therefore leakage into the foundation).
Zone 2 – Near Dam Scavenger Beach and Zone 3 – Scavenger Beach	▪ KCBCL developed several sensitivity scenarios for the Scavenger Beach Seepage Models to assess the expected range of leakage and capacity of tailings to attenuate water. The sensitivity scenarios included: ◆ climate (model extreme wet/dry events); and ◆ modeling consolidation. ▪ Results of the sensitivity scenarios indicate that leakage from the scavenger total and scavenger overflow tailings (scavenger beach) is not sensitive to extreme wet/dry precipitation years, and more sensitive to hydraulic conductivity. The hydraulic conductivity for the tailings has been selected based on laboratory testing and benchmarked from similar projects.
Zone 4 – Pyrite Tailings	▪ Results from the Pyrite Cell Low Permeability Layer Leakage Model indicate that the leakage is not sensitive to changes in climate conditions or a change in tailings depth. ▪ Leakage through the low permeability layer is most sensitive to changes in hydraulic conductivity of the low permeability layer. As such, KCBCL incorporated a level of conservatism in the selection of the low permeability layer hydraulic conductivity for input to the Regional Groundwater Model.

Based on the results of the characterization and assessments completed, the Skunk Camp TSF seepage management plan is expected to be effective at meeting water quality guidelines at the POCs. The seepage mitigation measure designs are resilient with available contingencies.

TABLE OF CONTENTS

EXECUTIVE SUMMARY i
1 INTRODUCTION 1
1.1 Assessment Approach 1
1.2 Report Structure 2
2 SITE CHARACTERIZATION AND CONCEPTUALIZATION 3
2.1 Location 3
2.2 Climate 5
2.3 Hydrogeological Setting 5
3 TAILINGS STORAGE FACILITY DESIGN 7
3.1 Tailings 7
3.2 Tailings Management Approach 7
3.3 Tailings Characterization and Zones for Seepage Modeling Assessments 11
3.4 Tailings Deposition Staging Plan and Rate of Rise 13
3.5 Seepage Management 15
3.5.1 Seepage Management Plan 15
3.5.2 Best Available Demonstrated Control Technology (BADCT) 16
3.6 TSF Closure and Reclamation Plan 17
3.7 Hydrogeological Properties of Foundation, Tailings and Engineering Controls 20
4 SEEPAGE MODEL RESULTS AND INTERPRETATION 22
4.1 Zone 1 – Cycloned Sand 22
4.1.1 Cycloned Sand Embankment Leakage Estimate During Construction 22
4.1.2 Scavenger Tailings Closure Cover Model 23
4.1.3 Implementation to Regional Groundwater Model 23
4.2 Zone 2 – Near Dam Scavenger Beach and Zone 3 – Scavenger Beach 25
4.2.1 Scavenger Beach Seepage Model 25
4.2.2 Scavenger Tailings Closure Cover Model 28
4.2.3 Implementation to Regional Groundwater Model 28
4.3 Zone 4 – Pyrite Tailings 33
4.3.1 Pyrite Cell Low Permeability Layer Leakage Model 33
4.3.2 Pyrite Tailings Closure Cover Model 33
4.3.3 Implementation to Regional Groundwater Model 34
5 DISCUSSION AND CONCLUSIONS 36
6 CLOSING 37
REFERENCES 38

TABLE OF CONTENTS
(continued)

List of Tables

Table 2.1 Average Precipitation, Evapotranspiration, and Temperature at Skunk Camp (KCBCL 2020) 5
Table 3.1 Tailings Zones for Seepage Modeling Assessments and Representative Tailings Types 11
Table 3.2 Strategies Reviewed to Meet Compliance 16
Table 3.3 Preliminary Reclamation Schedule and Seepage Management Plan (Adopted from KCBCL 2020) 17
Table 3.4 Foundation and Tailings Zones Hydraulic Conductivity Anisotropy Ratios 21
Table 3.5 Engineering Features Hydraulic Properties 21
Table 4.1 Model Predicted Net Infiltration for Zone 1 23
Table 4.2 Model Predicted Net Infiltration for Zone 2 and Zone 3 28
Table 5.1 Summary of Tailings Zone Model Sensitivities and Design Resiliency 36

List of Figures

Figure 1.1 TSF Seepage Assessment and Groundwater Modeling Approach 2
Figure 2.1 Skunk Camp TSF Location Plan 4
Figure 3.1 Skunk Camp TSF Overview 9
Figure 3.2 Skunk Camp TSF Section 10
Figure 3.3 Tailings Zones for Seepage Modeling Assessments 12
Figure 3.4 Skunk Camp TSF Closure Plan 19
Figure 3.5 Foundation Hydraulic Conductivity in Comparison to the Tailings Hydraulic Conductivity 20
Figure 4.1 Zone 1 – Cycloned Sand Leakage Results for Embankment Construction 22
Figure 4.2 Zone 1 – Cycloned Sand Implementation of Leakage Estimate to Regional Groundwater Model 24
Figure 4.3 Zone 2 and Zone 3 Scavenger Beach Seepage Model Column Locations 26
Figure 4.4 Rate of Rise for Model Locations Based on the Initial Mine Year of Deposition 27
Figure 4.5 Zone 2 – Near Dam Scavenger Beach Implementation of Leakage Estimate to Regional Groundwater Model (Operations) 29
Figure 4.6 Zone 2 – Near Dam Scavenger Beach Implementation of Leakage Estimate to Regional Groundwater Model (Draindown and Post-closure) 30
Figure 4.7 Zone 3 – Scavenger Beach Implementation of Leakage Estimate to Regional Groundwater Model (Operations) 31
Figure 4.8 Zone 3 – Scavenger Beach Implementation of Leakage Estimate to Regional Groundwater Model (Draindown and Post-closure) 32
Figure 4.9 Implementation of Zone 4 – Pyrite Tailings Leakage Results to Regional Groundwater Model 35

TABLE OF CONTENTS
(continued)

List of Appendices

Appendix I Tailings Hydraulic Properties

Appendix II Scavenger Beach Seepage Modeling

Appendix III Pyrite Cell Low Permeability Layer Leakage Estimate

Appendix IV Cycloned Sand Embankment Leakage Estimate

1 INTRODUCTION

Tonto National Forest (the Forest) issued a Draft Environmental Impact Statement (DEIS) for the proposed Resolution Copper Project and Land Exchange in August 2019 (Forest 2019). The DEIS identified the preferred tailings storage facility (TSF) alternative as the Alternative 6 – Skunk Camp. The seepage estimates included in the DEIS (KCB 2018, M&A 2018) were preliminary and based on limited understanding of site conditions. Significant site investigation, characterization and seepage modeling work has been completed to better understand the impacts for inclusion in the Final Environmental Impact Statement (FEIS).

Resolution Copper Mining LLC (RCM) commissioned KCB Consultants Ltd. (KCBCL) to develop a seepage management plan for the proposed Skunk Camp TSF for the FEIS. The objective of this report is to provide a summary of the Skunk Camp TSF seepage management strategy and plan, and the seepage mitigation measure designs. In addition, the report describes supporting assessment for the tailings inputs into the three-dimensional (3D) Regional Groundwater Model (M&A 2020b), which is used to evaluate if the design could achieve compliance to water quality standards at the downstream points of compliance (POCs).

1.1 Assessment Approach

Figure 1.1 summarizes the overall assessment approach used to assess the Skunk Camp TSF seepage management plan and its efficacy at meeting water quality guidelines at the POCs. As shown, the approach requires site characterization, tailings characterization, TSF design and a number of assessments that feed into the Regional Groundwater Model. Results of the Regional Groundwater Model were used to inform the seepage mitigation measures.

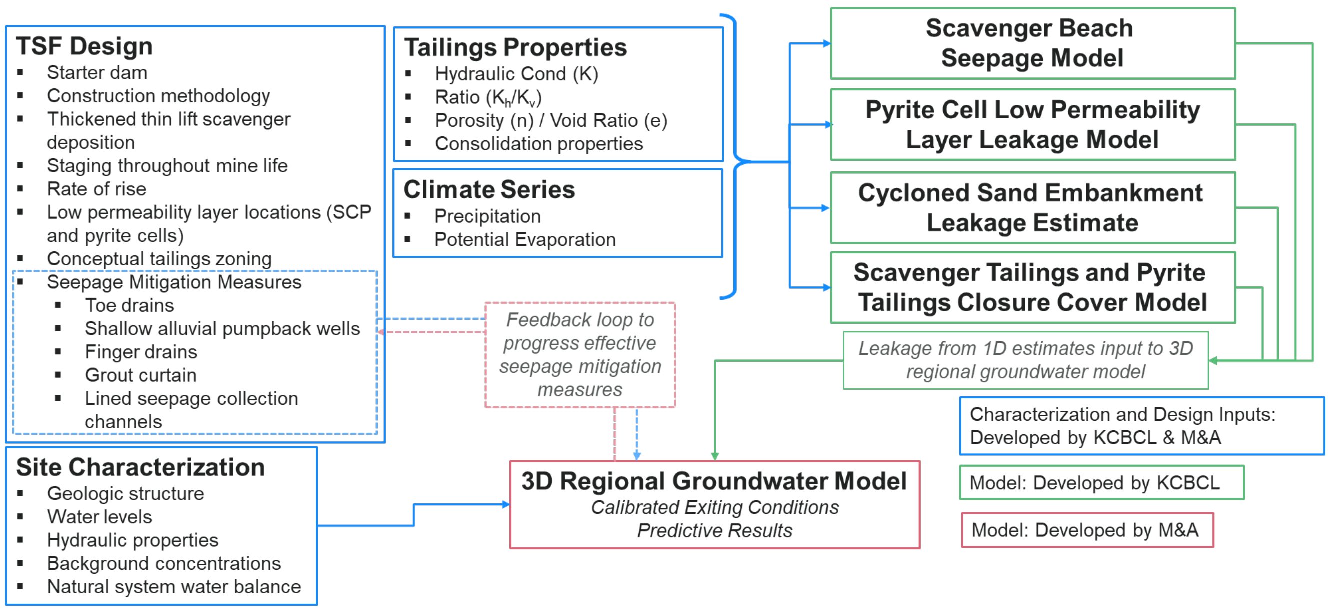
This report summarizes the KCBCL components shown in Figure 1.1. The following characterization and design inputs were developed by KCBCL and M&A to inform the Skunk Camp TSF seepage assessment:

- climate (Section 2.1, Appendix VI-A of KCBCL 2020);
- tailings properties (Section 3.3, Appendix I);
- site characterization (Section 2.3, KCBCL 2019, M&A 2019, M&A 2020c); and
- TSF design (Section 3).

KCBCL undertook the following modeling tasks to support the Skunk Camp TSF seepage assessment:

- One-dimensional (1D) Scavenger Beach Seepage Model (Appendix II);
- 1D Pyrite Cell Low Permeability Layer Leakage Model (Appendix III);
- Cycloned Sand Embankment Leakage Estimate (Appendix IV); and
- 1D Scavenger Tailings and Pyrite Tailings Closure Cover Model (Appendix IV of KCBCL 2020).

Figure 1.1 TSF Seepage Assessment and Groundwater Modeling Approach



1.2 Report Structure

The main text of this document is organized as follows:

- **Section 1 Introduction:** summarizes objectives, scope and organization of the report.
- **Section 2 Site Characterization and Conceptualization:** summarizes the site conditions pertinent to the seepage management plan design.
- **Section 3 Tailings Storage Facility Design:** summarizes the staging and deposition plan, tailings types and hydraulic properties, tailings zones developed for the seepage assessment, and the seepage management plan.
- **Section 4 Seepage Model Results and Interpretation:** summarizes KCBCL seepage assessments to support inputs to the Regional Groundwater Model.
- **Section 5 Discussion and Conclusions:** discusses the seepage management plan and TSF design resiliency.

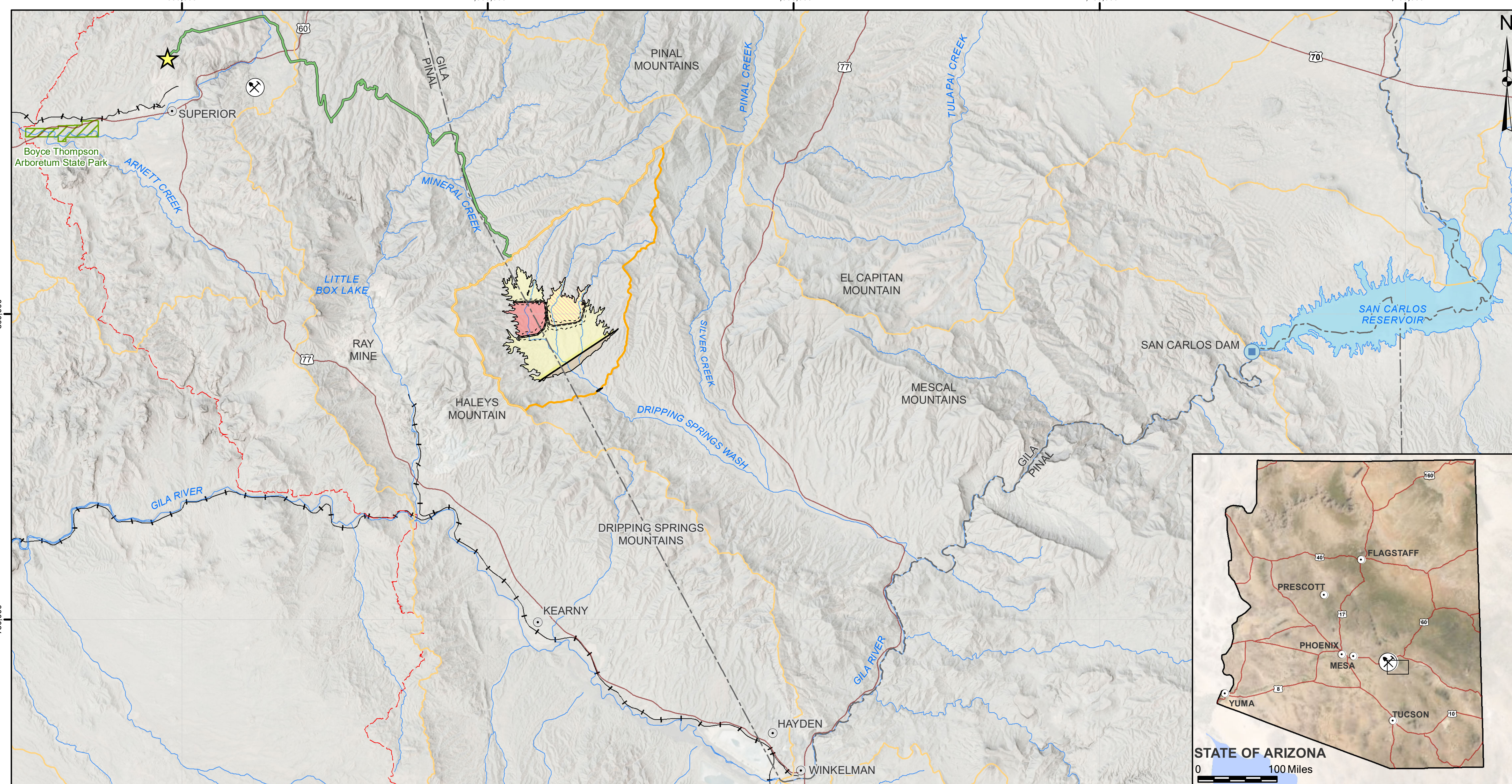
2 SITE CHARACTERIZATION AND CONCEPTUALIZATION

2.1 Location

The proposed Skunk Camp TSF site is located approximately one mile to the east of the Asarco Ray open pit mining complex, in the headwaters of the Dripping Spring Wash, see Figure 2.1. The Dripping Spring Wash Basin is approximately 378 square miles in area and is described by the Arizona Department of Water Resources (2009) as consisting of a mid-elevation mountain range and Arizona uplands Sonoran desert scrub.

The Dripping Spring Mountains define the western boundary of the site, while the Mescal Mountains and Pinal Mountains define the eastern boundary. The approximate base elevation of the proposed TSF is El. 3,160 ft and the peaks of adjacent mountains are: El. 4,566 ft at Haley Mountain (Dripping Spring Mountains), El. 6,568 ft at El Capitan Mountain (Pinal Mountains), and El. 7,848 ft at Pinal Peak (Pinal Mountains). The TSF site has elevations ranging from 3,215 feet above sea level (fasl) to 3,550 fasl.

Within the proposed TSF area, the drainages are ephemeral and infilled with sand and gravel alluvial deposits. When present, surface water flows in Dripping Spring Wash from northeast to southwest approximately 13 miles upstream of its confluence with the Gila River. The proposed site is located just southwest of the surface water divide between Dripping Spring Wash and Mineral Creek (Figure 2.1). Surface water south of the divide flows through the site, roughly southeast through Dripping Spring Wash Basin to the Gila River, while surface water north of the divide flows into the Mineral Creek basin, which flows into a tunnel bypass around the Asarco Open Pit and mining complex and eventually to the Gila River approximately 16 miles downstream of the confluence of Dripping Spring Wash and the Gila River.



LEGEND

- MAIN EMBANKMENT -CYCLONED SAND
- NEAR DAM SCAVENGER BEACH
- SCAVENGER BEACH
- PYRITE TAILINGS
- PYRITE TAILINGS UNDER SCAVENGER BEACH
- SEEPAGE COLLECTION DAM
- PROPOSED CONCENTRATOR SITE (WEST PLANTSITE)
- RESOLUTION OREBODY
- SKUNK CAMP TSF - WEST PLANT PIPELINE CORRIDOR AND TUNNEL
- MAJOR CATCHMENT BOUNDARY
- TSF CATCHMENT BOUNDARY
- WILDERNESS AREA AND STATE PARK
- SAN CARLOS DAM
- TOWN OR CITY
- COUNTY LINE
- HIGHWAY
- EXISTING RAILWAY
- ARIZONA NATIONAL SCENIC TRAIL (ARIZONA TRAIL)
- NATURAL WATERCOURSE

NOTES:
1. NAD83, ARIZONA STATE PLANE CENTRAL, COORDINATES IN FEET
2. IMAGERY PROVIDED BY ESRI/BING AERIAL IMAGERY
3. TERRAIN AND IMAGERY DATA SOURCE: ESRI

0 5 Mile

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PROJECT: RESOLUTION COPPER PROJECT SKUNK CAMP TSF SEEPAGE ASSESSMENT

TITLE: SKUNK CAMP TSF LOCATION PLAN

PROJECT No. UM09441A22

FIG No. 2.1

Z:\M\PHX\UM09441A22-RES-NW and Skunk Camp OOM\400 Drawings\GIS\02_Maps\Reports\SC_TSF_SeepageAssessment\SkunkCamp\SkunkCamp_LocationMap.mxd 2020-06-24 11:10:11 AM

2.2 Climate

Arizona experiences three types of precipitation events seasonally and very little precipitation occurring from April through June (AWA 2013). Typically, July and August are the wettest months and April to June are the driest. The three types of precipitation seasons are:

- Winter storms that occur during October through March. These are typically long duration, low intensity events that result in proportionally high infiltration rates and low runoff rates.
- Summer monsoonal storms that occur during June through September, also known as Local Storms. These are typically short duration, high intensity thunderstorms, and are common throughout the monsoon season and result in proportionally high levels of runoff as opposed to infiltration.
- Tropical storms that occur during August through October. These are rare events but produce the most extreme rainfalls in southern Arizona. They are the remnants of oceanic storms and typhoons and are typically moderate duration (~24 hours), high intensity events.

The TSF site is in a semi-arid climate. Table 2.1 summarizes the average estimated monthly precipitation and potential evapotranspiration for the site.

Table 2.1 Average Precipitation, Evapotranspiration, and Temperature at Skunk Camp (KCBCL 2020)

Climate Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Precipitation (in)	2.1	1.9	2.2	0.7	0.4	0.3	1.8	2.7	1.4	1.2	1.4	2.1	18.2
Potential Evapotranspiration (PET) (in)	3.0	3.6	5.4	7.0	9.0	9.3	8.7	7.8	6.5	5.1	3.6	3.0	72.1
Average Temperature (°F)	50	52	56	63	73	83	85	83	80	70	58	51	-

2.3 Hydrogeological Setting

The site is located within a broad alluvial valley that is flanked to the east and west by mountains. This valley is known as the Dripping Spring Wash and is bounded by the Dripping Spring Mountains to the west and the Pinal Mountains to the east (Figure 2.1). The Precambrian basement rocks primarily comprise granitic, volcanic and metamorphic crystalline units. The water yield from these units is likely to be controlled by the degree and continuity of fractures. This unit is overlain by Precambrian Siltstone, diabases sandstone and Quartzite and Paleozoic Limestone with varying water yields. Several perennial and ephemeral springs occur on the Dripping Spring Mountains along the contact between the Precambrian metamorphic units and the younger Precambrian units.

The primary aquifer in the study area occurs at the base of the Dripping Spring Wash with the primary producing aquifers located within the Tertiary sandstone and conglomerate units (commonly referred to as the Gila Formation). Laterally this aquifer is interpreted to extend across the broad valley bottom. The vertical extent of the aquifer is not defined across the entire lateral extent, however the thickness of the aquifer is confirmed to a depth of at least 980 ft from the ground surface at a single location, the same depth as the deepest hole drilled during the site investigation program to date. However, wells within the Dripping Spring Wash catchment have been observed to be up to 1,400 ft in depth, and still in the Gila Formation, based on records from the Arizona water well database (ADWR 2009). The median water well depth in the area according to the Arizona water well database is 250 ft.

The Tertiary sandstone and conglomerate encountered has a high degree of heterogeneity. The composition of this unit varies from fine to medium grained sandstone to coarse conglomerate that contains gravel and cobble sized clasts. Cementation varies from very weak to strong and is moderate to highly calcareous. Weak cementation typically occurs in the sandstone and strong cemented zones occur within the conglomerate.

The Tertiary sandstone and conglomerate is overlain by unconsolidated alluvial sediments that consist primarily of sand and gravel with varying proportions of silt and clay. This unit is not expected to provide a reliable groundwater source within the vicinity of the proposed TSF as the majority of this unit underlying the TSF is unsaturated.

Dripping Spring fault is a normal fault that extends parallel to and is within the Dripping Spring Wash. The fault has not been observed to have a surface expression in the Tertiary Conglomerate. However, in-situ permeability measurements completed in the vicinity of the fault zone indicate that there is a more fractured, higher permeability region around the fault location (M&A 2020c).

As part of the Skunk Camp TSF seepage assessment, M&A has completed site investigations to further develop an understanding of the hydrogeological setting at the site (M&A 2019, M&A 2020a, M&A 2020c). Results of the site investigation were used to inform the Regional Groundwater Model development (M&A 2020b).

Section 3.7 summarizes the range of foundation hydraulic conductivity measured in the field and the selected parameters for the Regional Groundwater Model.

3 TAILINGS STORAGE FACILITY DESIGN

3.1 Tailings

The Resolution Project's Mine Plan of Operations (MPO) production case includes generation of approximately 1.37 billion tons (Bton) of tailings with an average daily tailings production rate at peak production of 120,000 tons per day (tpd). Mineral processing will generate two physically, mineralogically, and geochemically discrete tailings streams known as "scavenger" tailings and "pyrite" tailings. Scavenger tailings are mostly be classified as Non-Potentially Acid Generating (NPAG) and account for approximately 84% of tailings produced by weight. A portion of the scavenger total tailings will be cycloned to produce cyclone underflow (cycloned sand) which will be used to construct the structural components of the embankment raises. The second product of the cycloning process is the finer fraction referred to as cyclone overflow. The pyrite tailings are classified as Potentially Acid Generating (PAG) and account for the remaining 16%. The pyrite tailings will be segregated and managed separate to scavenger tailings in the TSF.

3.2 Tailings Management Approach

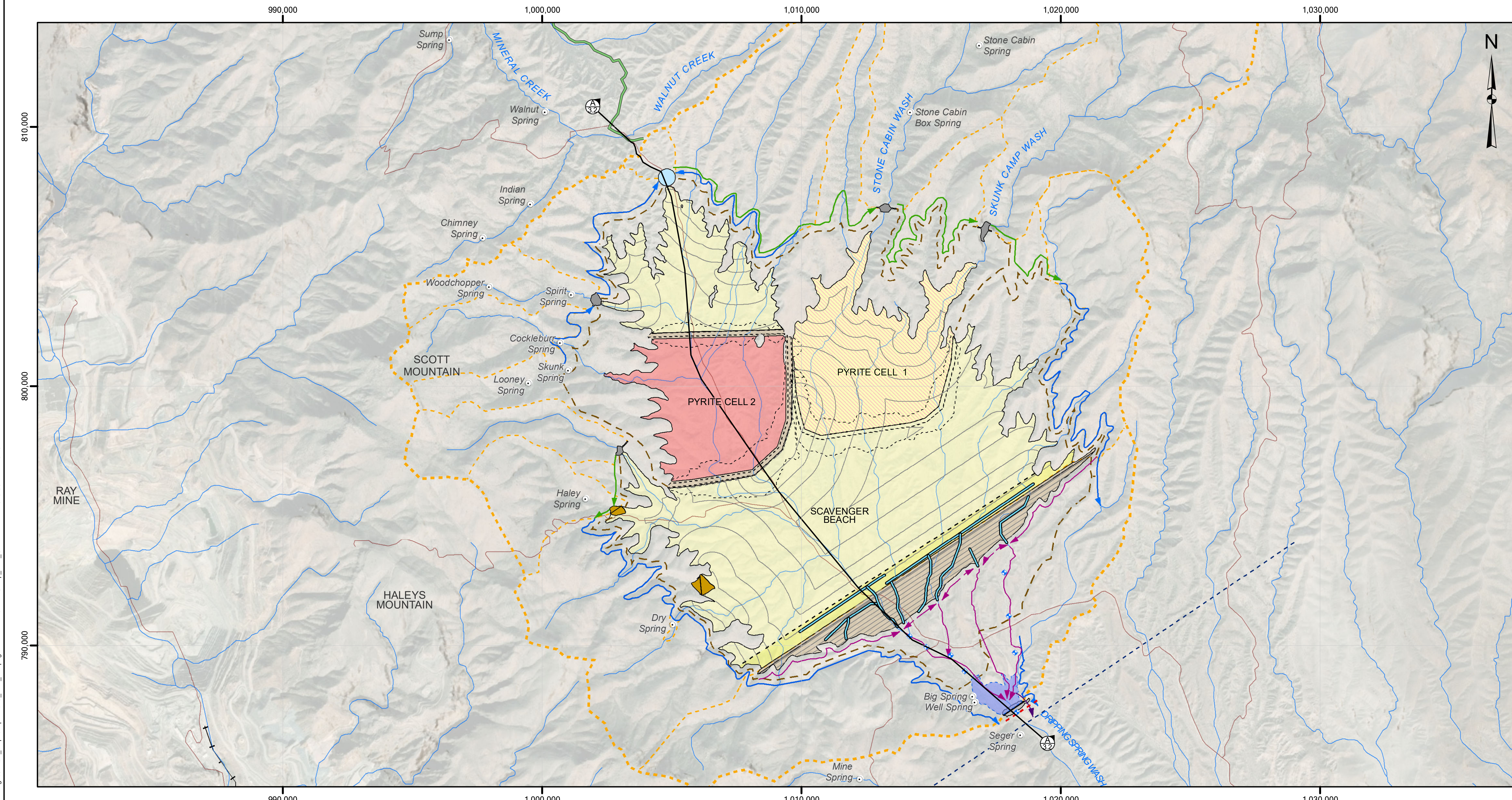
The proposed Skunk Camp TSF is presented as Alternative 6 in the DEIS, with the design details included in KCB (2018).

The TSF ultimate configuration and post-closure water management plan presented in KCB (2018) included a closure diversion channel to the north, ultimately diverting the entire TSF catchment towards Mineral Creek. To address DEIS comments, RCM has updated the closure objective to divert the TSF catchment to the south, towards Dripping Spring Wash, post-closure. To achieve this objective, an update to the tailings staging and deposition plan for the proposed Skunk Camp TSF was completed and used for the basis of the seepage assessments and seepage management plan (KCBCL 2020).

The proposed Skunk Camp TSF consists of two pyrite tailings storage cells upstream of the scavenger tailings beach and Main Embankment. The ultimate TSF configuration at the end of operations is shown on Figure 3.1 and Figure 3.2. Select key elements of the TSF design are summarized below (refer to KCB 2018 and KCBCL 2020 for more details).

The pyrite tailings will be deposited subaqueously in the low permeability cells contained by downstream-raised, compacted, cycloned sand embankments. Pyrite Cell 1 will receive tailings from startup to Mine Year 15 and will be subsequently covered with scavenger tailings starting in Mine Year 16. Pyrite Cell 2 cell construction will start prior to Mine Year 15 and will receive pyrite tailings from Mine Year 16 to Mine Year 41. The pyrite cells will also act as the supernatant or reclaim pond for reuse in processing. Runoff from the scavenger tailings beach will be collected in low areas and pumped into the active pyrite cell, such that no permanent pond will be maintained on the scavenger beach.

The pyrite cell dams and the Main Embankment will be constructed from compacted cycloned sand (coarser scavenger tailings produced from cycloning); the Main Embankment will be raised using the centerline method to an elevation of 3,565 feet above sea level (fasl) and the pyrite cell dams will be raised using the downstream method. Cyclone overflow (finer scavenger tailings produced during cycloning) and uncycloned scavenger tailings will be deposited upstream of the Main Embankment to form the tailings beach. Infiltration into the scavenger beach, and therefore potential seepage into the foundation, will be minimized by thickening prior to deposition in the TSF and adopting “thin-lift” deposition allowing time for water to evaporate. This approach will reduce ponding on the scavenger beach, reduce the potential mobility of the tailings, and reduce seepage into the foundation during operations and post-closure. The ultimate footprint will be approximately 4,000 acres in size with the ultimate height of the embankment crest reaching approximately 500 feet in height.



LEGEND

- MAIN EMBANKMENT -CYCLONED SAND
- NEAR DAM SCAVENGER BEACH
- SCAVENGER BEACH
- PYRITE TAILINGS
- PYRITE TAILINGS UNDER SCAVENGER BEACH
- PYRITE CELL EMBANKMENT FOOTPRINT
- CONTAINMENT DAM
- SKUNK CAMP TSF - WEST PLANT PIPELINE CORRIDOR AND TUNNEL
- PROPOSED ROAD
- SPRING
- TSF CATCHMENT BOUNDARY
- SUB-CATCHMENT BOUNDARY
- SECTION
- SURFACE WATER DIVERSION DAM DRAWDOWN PIPELINE
- OPERATIONAL UPSTREAM DIVERSION CHANNEL
- CONTACT WATER COLLECTION DITCH
- SCP EMERGENCY SPILLWAY
- FINGER DRAIN
- SHALLOW ALLUVIAL PUMPBACK WELL
- GROUT CURTAIN
- POINT OF COMPLIANCE LOCATION
- SURFACE WATER DIVERSION DAM
- SEEPAGE COLLECTION DAM
- SEEPAGE COLLECTION POND
- STORM RETENTION POND
- EXISTING ROAD
- EXISTING RAILWAY
- RIVER OR MAJOR DRAINAGE

NOTES:
1. NAD83, ARIZONA STATE PLANE CENTRAL
2. TERRAIN AND IMAGERY DATA SOURCE: ESRI
3. CONTAINMENT DAM REQUIRED FOR AVOIDANCE OF SPRINGS

NOT FOR CONSTRUCTION

0 1 Mile

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PROJECT: RESOLUTION COPPER PROJECT SKUNK CAMP TSF SEEPAGE ASSESSMENT

TITLE: SKUNK CAMP TSF OVERVIEW

PROJECT No.	FIG No.
UM09441A22	3.1

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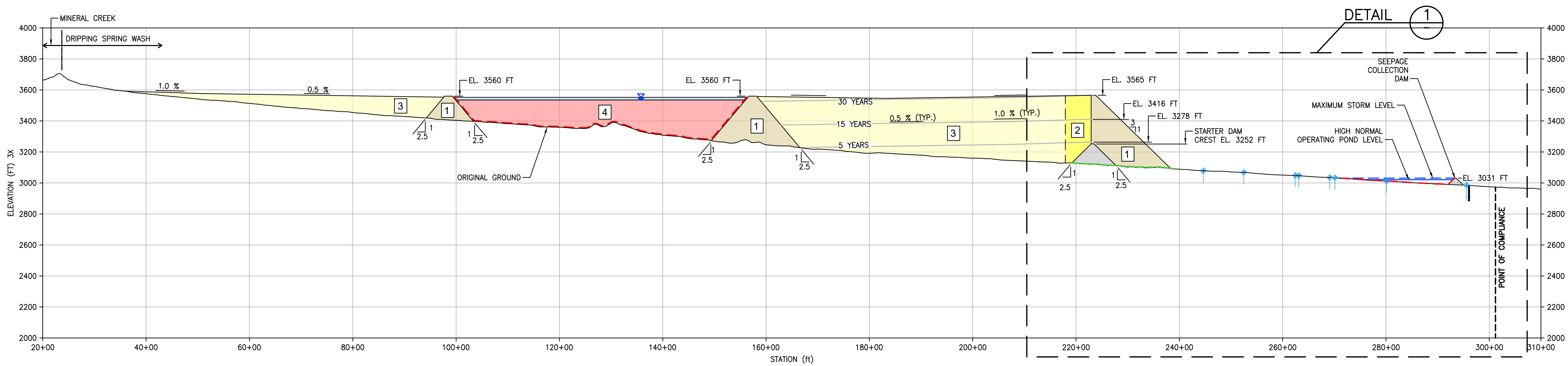
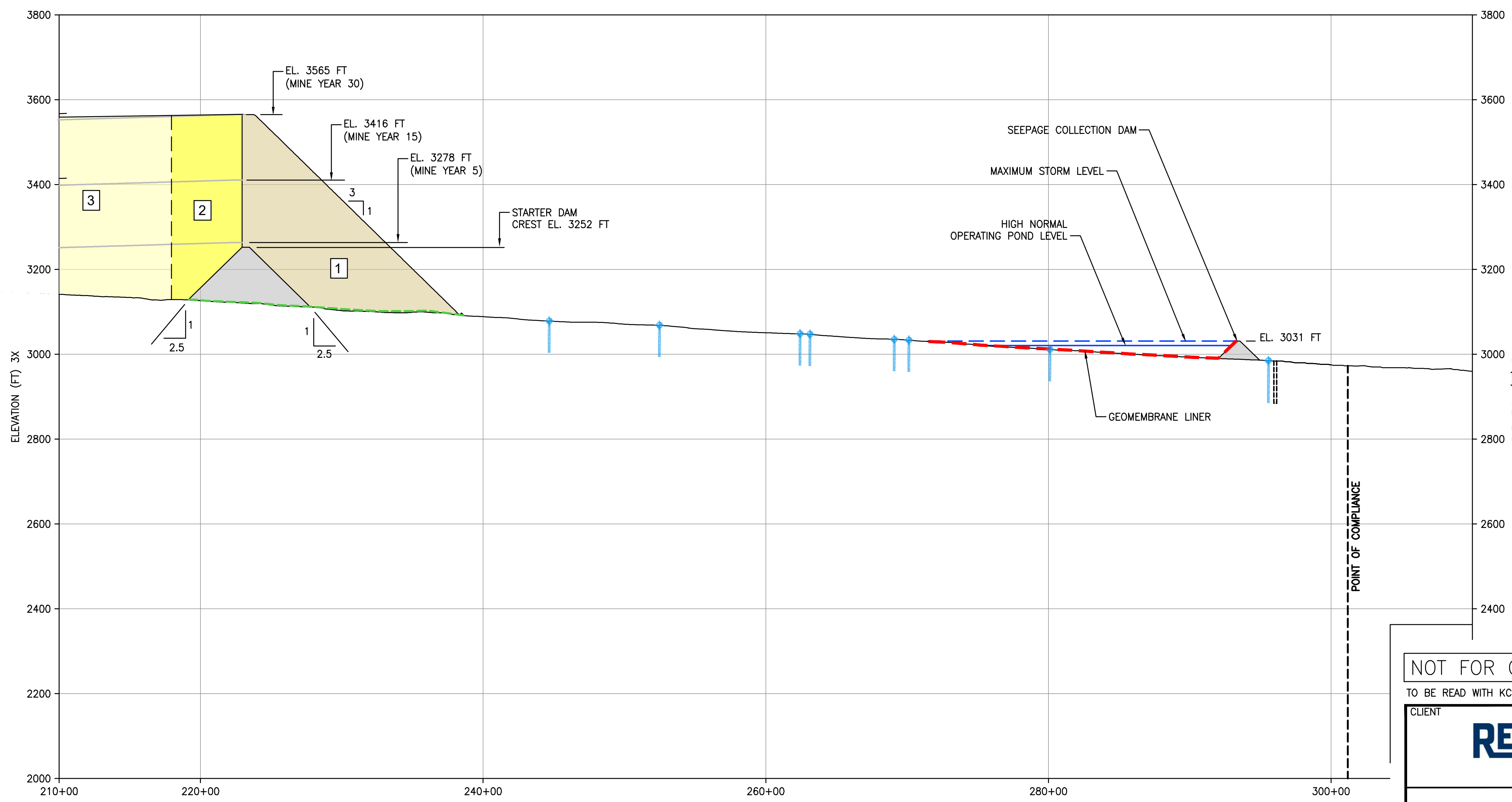


SECTION A (3.1) DRIPPING SPRING WASH PROFILE

SCALE A 3X VERTICAL EXAGGERATION



DETAIL 1

HORI. SCALE: B
VERT. 3X EXAGGERATION

NOTES

1. PROJECTION AND DATUM: ARIZONA STATE PLANE CENTRAL NAD 83 – INTERNATIONAL FEET.
2. TOPOGRAPHY BASED ON INTERMAP NEXTMAP DSM AND DTM ACQUIRED IN 2004.

LEGEND

PROPOSED TSF

- EARTHFILL DAM
- CYCLONED SAND EMBANKMENTS
- NEAR DAM SCAVENGER BEACH
- SCAVENGER BEACH
- PYRITE TAILINGS
- OPERATING POND
- LOW PERMEABILITY LAYER
- FINGER DRAIN
- POINT OF COMPLIANCE
- SHALLOW ALLUVIAL PUMPBACK WELL
- GROUT CURTAIN

TAILINGS ZONE

1. CYCLONED SAND
2. NEAR DAM SCAVENGER BEACH
3. SCAVENGER BEACH
4. PYRITE TAILINGS

SCALE A 1000 0 1000 FT
SCALE B 500 0 500 FT

NOT FOR CONSTRUCTION

TO BE READ WITH KCB CONSULTANTS LTD. REPORT DATED: JUNE 2020

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KCB Consultants Ltd.

PROJECT: RESOLUTION COPPER PROJECT SKUNK CAMP TSF SEEPAGE ASSESSMENT

TITLE: SKUNK CAMP TSF SECTION

SCALE	PROJECT No.	FIG. No.
AS SHOWN	UM09441A22	3.2

KCB-FIG-D-L

Date: 2020-06-24 Time: 11:58 AM
Drawing File: Z:\M\PHX\UM09441A22-RES-NW and Skunk Camp OOM\400 Drawings\CAD\Hydraulic Properties Memo\FIG 3.2 – Skunk Camp TSF Section A.dwg – FIG 3.2 (dhu)

3.3 Tailings Characterization and Zones for Seepage Modeling Assessments

There are four 'types' of tailings that were characterized for estimating seepage from the TSF:

- pyrite tailings;
- scavenger tailings;
  - scavenger total tailings (uncycloned scavenger tailings);
  - scavenger overflow (the fine fraction produced from hydrocycloning); and
  - scavenger cycloned sand (the fine fraction produced from hydrocycloning).

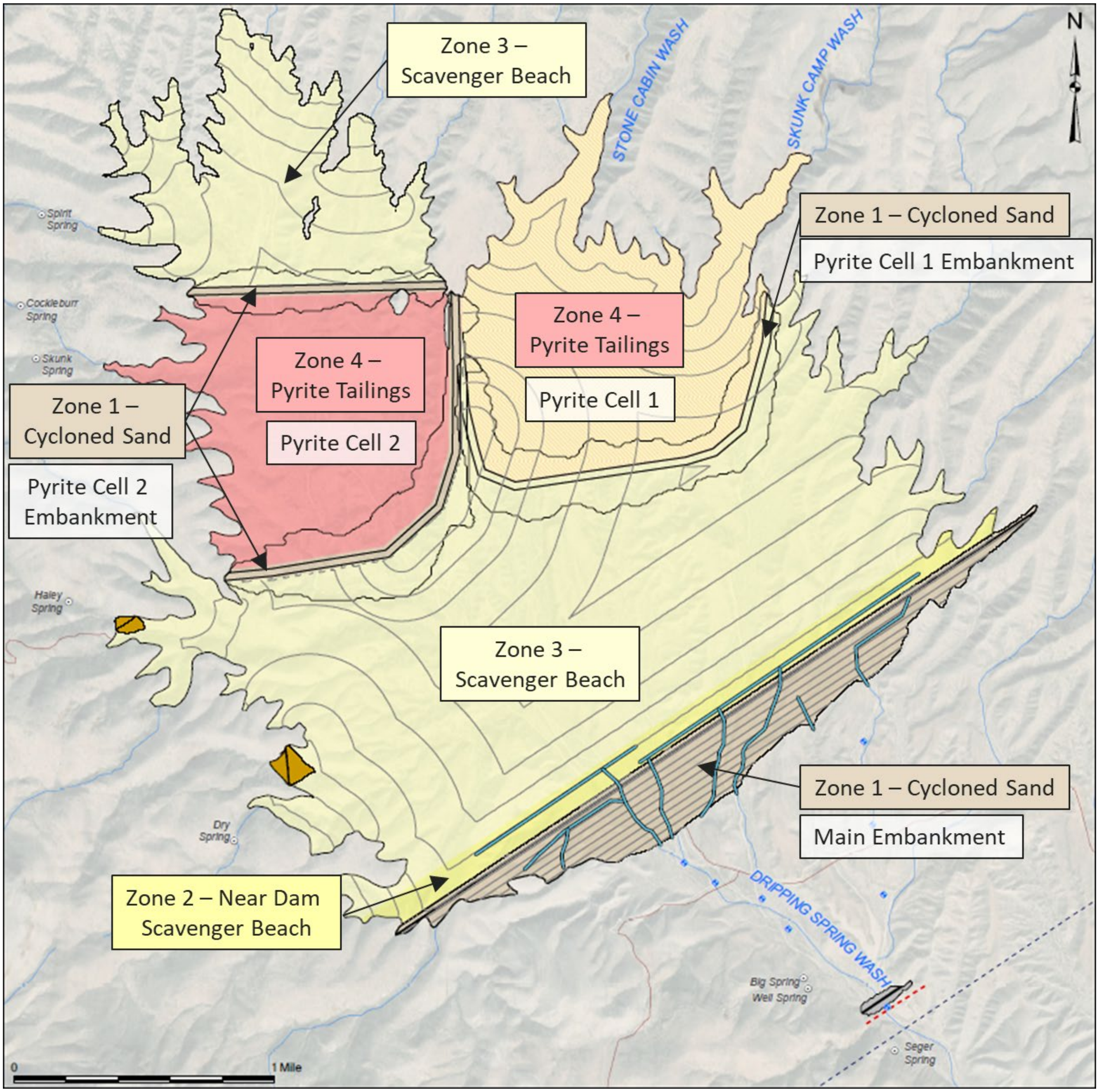
Laboratory testing and experience with other facilities was used to characterize the hydraulic tailings properties each tailings, see Figure 3.5 and Appendix I for details.

For the purposes of the seepage assessments, the Skunk Camp TSF was separated into different tailings 'zones'. Each 'zone' was assigned one of the four tailings 'types' to be representative of the tailings properties that are expected in that 'zone'. A summary of these zones is provided in Table 3.1 and Figure 3.3.

Table 3.1 Tailings Zones for Seepage Modeling Assessments and Representative Tailings Types

Tailings Zone No.	Tailings Zone Name	Tailings Zone Description	Representative Tailings (see Appendix I for properties)
1	Cycloned Sand	▪ The Main Embankment is a cross-valley, centerline-raised, compacted cycloned sand dam that contains the scavenger tailings beach (Zone 2 and Zone 3). ▪ The pyrite cell embankments are downstream-raised, compacted cycloned sand dams that that contain pyrite tailings (Pyrite Cell 1 and Pyrite Cell 2) and the reclaim pond.	Cycloned Sand
2	Near Dam Scavenger Beach	▪ Scavenger tailings will be deposited from the Main Embankment crest, slurry segregation will occur along the length of the beach as the tailings deposit. The zone closest to the embankment will be coarser, with the finer material depositing further away from the embankment. ▪ For the purposes of this assessment, it was assumed that this zone is the area within 500 ft of the Main Embankment.	Scavenger Total Tailings
3	Scavenger Beach	▪ The area of the scavenger beach that is not the Near Dam (Zone 2) is considered Zone 3. It is assumed that the finer material from the scavenger tailings deposited on the beach will settle further away from the embankment. ▪ In addition, the scavenger tailings deposited north of Pyrite Cell 2.	Scavenger Overflow
4	Pyrite Tailings	▪ Pyrite tailings deposited subaqueously in a low permeability lined cell from Mine Year 1 to 15 in Pyrite Cell 1 and Mine Year 16 to 41 in Pyrite Cell 2.	Pyrite Tailings

Figure 3.3 Tailings Zones for Seepage Modeling Assessments



3.4 Tailings Deposition Staging Plan and Rate of Rise

The TSF tailings deposition strategy is characterized by four stages:

- Stage I: Mine Years 0 to 2 (1% of total tailings volume deposited);
- Stage II: Mine Years 3 to 15 (32% of total tailings volume deposited);
- Stage III: Mine Years 16 to 30 (54% of total tailings volume deposited); and
- Stage IV: Mine Years 31 to 41 (13% of total tailings volume deposited).

Refer to Appendix II of the Skunk Camp TSF Reclamation Plan (KCBCL 2020) for staging plan details (see Figure 3.1 and Figure 3.2 for a plan and profile view of the ultimate TSF, respectively, and Figure 4.2 for plan view of the TSF at key mine years). Results of the staging (e.g., rate of rise and location of tailings deposition) were used to inform the inputs to the Scavenger Beach Seepage Models (Appendix II). The staging results were also used to inform the Cycloned Sand Embankment Leakage Estimate (Appendix IV).

Construction of the Main Embankment and Pyrite Cell 1 starter dams will be completed prior to the start of operations.

During Stage I (Mine Years 0 to 2), pyrite tailings will be deposited from a pyrite deposition barge into Pyrite Cell 1, which will be maintained with a minimum water cover for the pyrite tailings and to float the pyrite deposition system and reclaim barge. Scavenger tailings will be deposited from the crest of the Main Embankment and slurry bleed water[1] that collects on the scavenger beach tailings surface will be collected in low points and pumped to Pyrite Cell 1. Cycloning of scavenger tailings will be ongoing to produce cycloned sand for construction of the Main Embankment and Pyrite Cell 1 Embankment.

During Stage II (Mine Years 3 to 15), the following will be continued from Stage I:

- subaqueous deposition of pyrite tailings in Pyrite Cell 1;
- scavenger tailings spigotted from the Main Embankment;
- slurry bleed water and runoff collected on the scavenger tailings surface pumped to Pyrite Cell 1; and
- cyclone scavenger tailings to produce cycloned sand for the Main Embankment and Pyrite Cell 1 Embankment construction.

In addition to the ongoing work, the starter embankment for Pyrite Cell 2 will be established in Mine Year 5 (constructed of cycloned sand) and water will begin to be impound to establish the minimum water cover for the pyrite tailings and to float the pyrite deposition system and reclaim barge. Pyrite tailings deposition to Pyrite Cell 1 will stop in Mine Year 15.

[1] Tailings slurry is a fluid, when deposited saturated tailings solids will settle to an initial settled density resulting in the expulsion of free water at the tailings surface, referred to as “bleed water”.

Stage III is from Mine Years 16 to 30. At the start of Stage III, pyrite tailings will begin deposition to Pyrite Cell 2. Scavenger tailings will be deposited in Pyrite Cell 1 to cover the pyrite tailings and displace the pond. Scavenger tailings deposition will continue within the Main Embankment, eventually inundating Pyrite Cell 1. Slurry bleed water collected on the low points of the scavenger tailings surface will be pumped to Pyrite Cell 2. Cycloned sand will continue to be produced for ongoing construction of the Main Embankment and the Pyrite Cell 2 Embankment.

Stage IV (Mine Years 31 to 41) continues to see pyrite tailings deposition to Pyrite Cell 2. Scavenger tailings will continue to be deposited within the main impoundment, as well as north of Pyrite Cell 2 to form the ultimate tailings surface that slopes to the south-east. The scavenger tailings deposition is subdivided into Stages IV-a to IV-d:

a. Year 31: scavenger tailings deposition from northeast extents of TSF footprint;
b. Year 32: scavenger tailings deposition from southwest extents of TSF footprint;
c. Years 33-35: scavenger tailings deposition from north extents of TSF footprint (north of Pyrite Cell 2); and
d. Years 36-41: scavenger tailings deposition from southwest extents of TSF footprint;

Towards the end of Stage IV, scavenger tailings will be deposited within Pyrite Cell 2 to cover the pyrite tailings and promote drainage towards the TSF low point to the south-east, where the Closure Diversion Channel will be constructed.

The rates of rises used for the Scavenger Beach Seepage Models for Zone 2 – Near Dam Scavenger Beach (scavenger total tailings) and Zone 3 – Scavenger Beach (scavenger overflow) are based on the staging plan and presented in Appendix II.

3.5 Seepage Management

3.5.1 Seepage Management Plan

A seepage management plan was developed that achieves water quality compliance at the POCs supported by the Regional Groundwater Model. The seepage management plan presented herein has not been optimized, rather, it is intended to demonstrate that compliance is expected to be achievable for the Skunk Camp TSF. Future designs and studies will optimize the plan to reduce impacts to groundwater and uncertainties around the seepage mitigation measure effectiveness.

The seepage management plan is presented on Figure 3.1 and Figure 3.2 and consists of the following:

- Operational Upstream Diversion Channels will divert non-contact water as much as practical to reduce water reporting to the TSF, thus this water would be unavailable for seepage into the foundation.
- Pyrite tailings will be deposited in two segregated, low permeability cells to reduce seepage flows from the reclaim pond during operations and limit seepage from the pyrite tailings draindown during post-closure.
- Cycloned sand embankments will be well-drained such that a phreatic surface will not develop in the sand long-term (reducing head on the foundation). To limit infiltration, the cycloned sand embankments will be progressively reclaimed, where possible, throughout operations.
- The cycloned sand embankments will include a network of finger drains system that will extend into Zone 2 – Near Dam Scavenger Beach to capture seepage from tailings deposition and embankment construction.
- Tailings deposited in the scavenger beach (scavenger total tailings and scavenger overflow) will be thickened to a 60% solids content slurry (by mass) to maximize water recovery and deposited in thin lifts over a large area to maximize evaporation losses and minimize water available to infiltrate through the tailings and into the foundation. The scavenger beach will also be managed as dry as possible (i.e., no to minimal ponded water), with runoff or bleed water that collects in the low points pumped to the active pyrite cell.
- A lined seepage collection pond (SCP) downstream of the TSF for short-term management of seepage and construction water prior to returning to the active pyrite cell.
- A series of lined Contact Water Collection Ditches that convey captured seepage from the Main Embankment finger drains and convey to the SCP.
- Shallow alluvial pumpback wells downstream of the TSF to capture seepage that enters into the shallow foundation.
- A grout curtain and shallow pumpback well downstream of the SCP to capture stormwater flow in the alluvium or leakage from the SCP.

3.5.2 Best Available Demonstrated Control Technology (BADCT)

The Skunk Camp TSF seepage management plan will incorporate several approaches that comply with Best Available Demonstrated Control Technology (BADCT) to achieve compliance at POCs. Table 3.2 summarizes the strategies reviewed and implemented.

Table 3.2 Strategies Reviewed to Meet Compliance

Seepage Control Measures	Cycloned Sand Embankments (Zone 1)	Scavenger Beach (Zone 2 and 3)	Pyrite Cells (Zone 4)	Downstream of TSF
Discharge control systems to achieve BADCT for base metal TSFs (ADEQ 2005)				
Interception of storm run-off and groundwater flow in shallow aquifers to minimize water inflow	✓	✓	✓	✓
Natural geologic features functioning as liners	n/a	n/a	n/a	✓
Localized lining with geosynthetic materials and/or clay	-	-	✓	✓
Slime Sealing beneath tailings pond (Vick 1983). If properly done, this can produce an effective vertical hydraulic conductivity of 1×10^{-7} cm/s or less	n/a	✓	✓	n/a
Interception of subdrainage beneath the impoundment to minimize hydraulic head and promote dewatering after closure	✓	✓	n/a	n/a
Leachate collection systems consisting of granular finger or blanket drains and corrugated perforated HDPE pipes can be used to supplement natural subdrainage (Brawner 1986)	✓	✓	n/a	n/a
Lining beneath main underdrains is sometimes done to further minimize seepage	*	*	n/a	n/a
Centerline embankment construction to obtain non-liquefiable stability zone	✓	n/a	✓[1]	-
Drains and reclaim water pump-back systems to lower or eliminate the phreatic surface in the embankment (or impoundment)	✓	✓	n/a	✓
High strength, free draining rockfill zones in the embankment	✓	n/a	n/a	✓
Runoff water collection via channels and dikes or berms from embankment surface	✓	n/a	n/a	✓
Other seepage control measures				
Tailings thickening	✓	✓	n/a	n/a
Engineered hydraulic barriers downstream of embankment and above natural regional ground water table – grout curtains and/or pump-back wells in shallow alluvium	n/a	n/a	n/a	✓

Legend:
✓ Incorporated to design
* Evaluated but not effective at improving seepage capture
\- Not evaluated
n/a Not applicable

Note:
1. Downstream-raised embankments fulfill the intent of this item

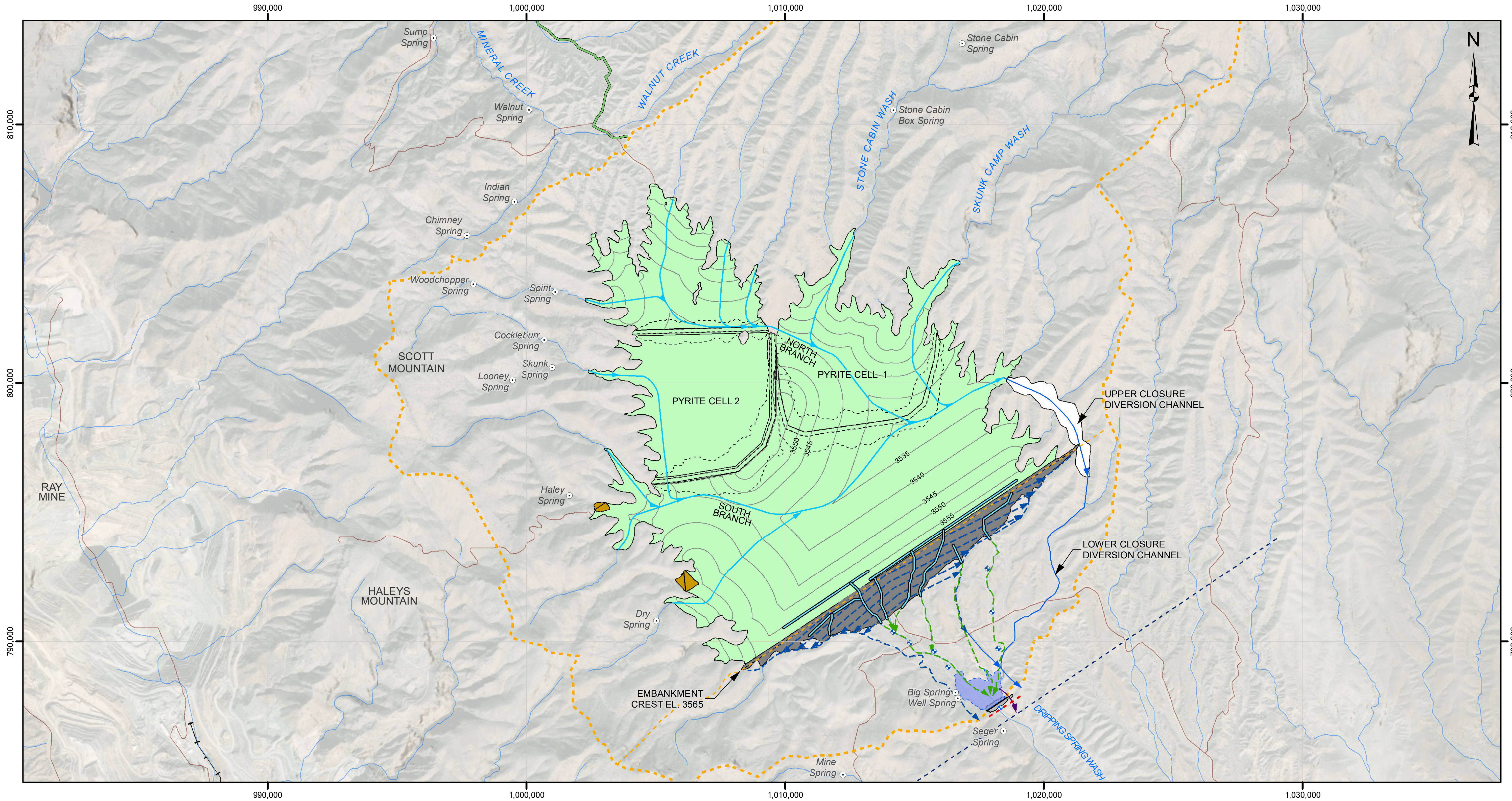
3.6 TSF Closure and Reclamation Plan

KCBCL developed a closure strategy and reclamation plan for the Skunk Camp TSF (KCBCL 2020). The long-term closure goals for the Skunk Camp TSF are to have a well-drained, stable facility and to limit the generation and potential release of poor water quality seepage to the downstream environment. The TSF closure plan is shown on Figure 3.4, the closure stages is summarized in Table 3.3 with the associated seepage management considerations.

Table 3.3 Preliminary Reclamation Schedule and Seepage Management Plan (Adopted from KCBCL 2020)

Stage	Mine Year	Key Activities
Life of Mine Progressive Reclamation	1 to 41	▪ Progressive reclamation (e.g., tailings deposition to achieve ultimate configuration, Main Embankment surface reclamation). ▪ Excavate Closure Diversion Channel to Dripping Spring Wash (the channel will not connect the TSF surface to Dripping Spring Wash until TSF surface is reclaimed after the Closure Transition Period). ▪ Lined Contact Water Collection Ditches convey seepage from finger drains and contact surface water from Main Embankment to the SCP. ▪ Shallow alluvial pumpback wells to collect TSF seepage and return to SCP. ▪ SCP water is pumped back to the operating pyrite cell. ▪ Ongoing field data collection to refine closure plan.
End of Operations	41	▪ Cessation of tailings deposition within the TSF. ▪ Cessation of shallow alluvial pumpback well operations upstream of the SCP. ▪ Continued operation of the shallow pumpback well downstream of the SCP (upstream of the grout curtain) to capture stormwater or seepage from the SCP.
Closure Transition Period	42 to 51 (approximately 10 years after the end of operations)	▪ Closure of Pyrite Cell 2 (resulting in no ponded water on the TSF surface). ▪ Surface shaping to closure design configuration. ▪ Place closure cover and vegetate. ▪ Construct Closure Embankment Bench and Toe Ditches on the Main Embankment. ▪ Connect TSF surface to Drippings Spring Wash via Closure Diversion Channel. ▪ Decommission Operational Upstream Diversion Channels and Contact Water Collection Ditches. ▪ Install Finger Drain Collection Pipes, to convey TSF impoundment draindown from finger drains to the SCP. ▪ During this period, the SCP does not have capacity to manage inflow with evaporation solely and will need active management (water treatment, additional evaporation ponds, spray evaporators, etc.). ▪ Continued operation of the shallow pumpback well downstream of the SCP (upstream of the grout curtain) to capture stormwater or seepage from the SCP. ▪ Monitoring closure performance criteria, in preparation for the Closure Active Care Phase. ▪ Monitoring/surveillance for dam safety, to meet long-term performance criteria, e.g., non-flowable scavenger tailings.

Stage	Mine Year	Key Activities
Closure – Active Care	51 to 120 (approximately 10 years to 80 years after the end of operations)	▪ Finger Drain Collection Pipes convey TSF impoundment draindown from finger drains to the SCP. ▪ Continue active management of the SCP (water treatment, additional evaporation ponds, spray evaporators, etc.). ▪ Continued operation of the shallow pumpback well downstream of the SCP (upstream of the grout curtain) to capture stormwater or seepage from the SCP. ▪ Monitoring closure performance criteria, in preparation for Closure Passive Care Phase. ▪ Monitoring/surveillance for dam safety, to meet long-term performance criteria – non-flowable scavenger tailings.
Closure – Passive Care Phase 1	120 to ~290 (approximately 80 years to 250 years after the end of operations)	▪ Finger Drain Collection Pipes convey TSF impoundment draindown finger drains to the SCP. ▪ SCP has capacity to manage inflow passively with evaporation. ▪ Continued operation of the shallow pumpback well downstream of the SCP (upstream of the grout curtain) to capture stormwater or seepage from the SCP. Dam safety and water quality compliance surveillance and monitoring frequency is decreased.
Closure – Passive Care Phase 2	Post ~290 (approximately 250 years after the end of operations)	▪ Seepage from finger drains ceases and with water quality standards are met at the POC. ▪ Decommission Finger Drain Collection Pipes, SCP, grout curtain and shallow pumpback well. ▪ Dam safety and water quality compliance surveillance and monitoring frequency is further decreased.



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LEGEND

- RECLAIMED EMBANKMENT
- RECLAIMED TAILINGS SURFACE
- PYRITE CELL EMBANKMENT FOOTPRINT
- CONTAINMENT DAM
- SKUNK CAMP TSF - WEST PLANT PIPELINE CORRIDOR AND TUNNEL
- SPRING
- TSF CATCHMENT BOUNDARY
- SUB-CATCHMENT BOUNDARY
- TAILINGS SURFACE CHANNELS
- CLOSURE EMBANKMENT BENCH AND TOE DITCHES
- FINGER DRAIN COLLECTION PIPE
- CLOSURE DIVERSION CHANNEL
- SCP EMERGENCY SPILLWAY
- CLOSURE SURFACE DIVERSION CHANNEL EXCAVATION
- FINGER DRAIN
- SHALLOW ALLUVIAL PUMPBACK WELL
- DECOMISSIONED PUMPBACK WELL
- GROUT CURTAIN
- POINT OF COMPLIANCE LOCATION
- SEEPAGE COLLECTION DAM
- SEEPAGE COLLECTION POND
- EXISTING ROAD
- EXISTING RAILWAY
- RIVER OR MAJOR DRAINAGE

NOTES:
1. NAD83, ARIZONA STATE PLANE CENTRAL
2. TERRAIN AND IMAGERY DATA SOURCE: ESRI
3. CONTAINMENT DAM REQUIRED FOR AVOIDANCE OF SPRINGS
4. CONTOURS NOT SHOWN ON PYRITE CELL 2, HOWEVER, THE TAILINGS WOULD BE GRADED TO DRAIN TOWARDS THE SOUTH

NOT FOR CONSTRUCTION

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0 1 Mile

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TITLE: SKUNK CAMP TSF CLOSURE PLAN

PROJECT No. UM09441A22

FIG No. 3.4

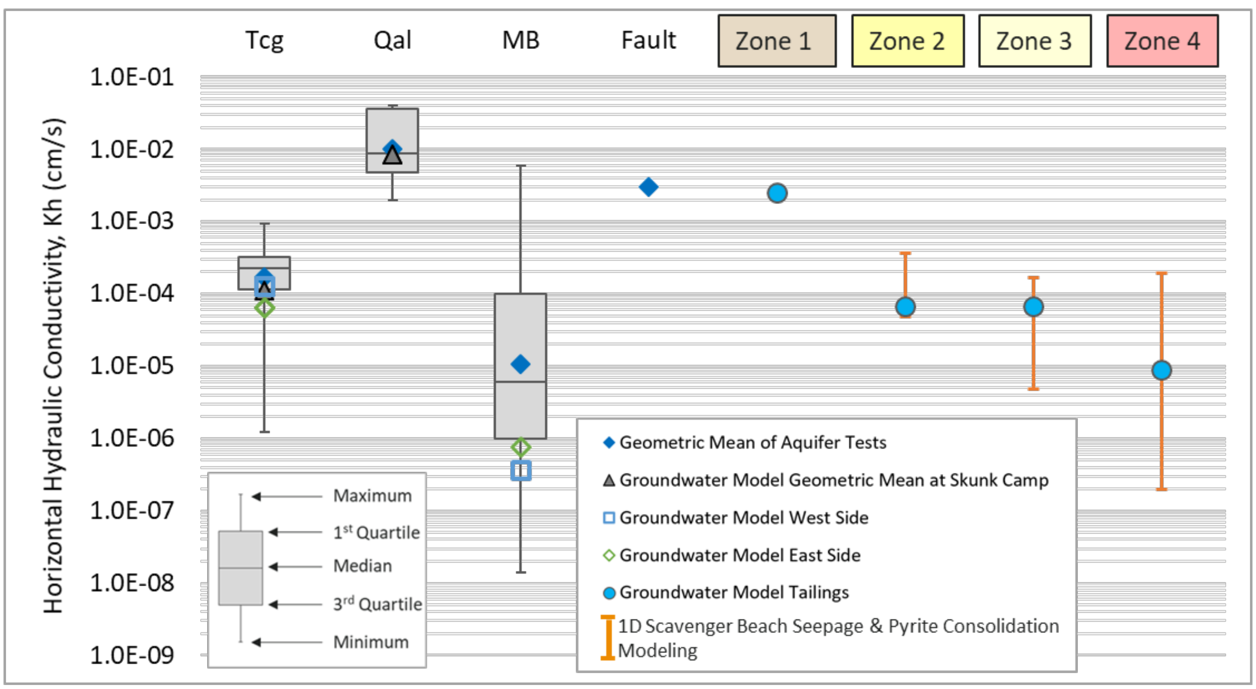
3.7 Hydrogeological Properties of Foundation, Tailings and Engineering Controls

The main foundation units pertinent to seepage modeling are Tertiary conglomerate (Gila Conglomerate), Quaternary alluvium, the 'Mountain Block' (MB) and the more fractured, higher permeability zone along the Dripping Spring Wash. The TSF footprint is founded on the conglomerate, alluvium and more fractured zone (not on the MB). The in-situ measured hydraulic conductivities, in comparison to the tailings zones, are presented on Figure 3.5.

Foundation properties for the 1D Scavenger Beach Seepage Models for the Gila Conglomerate and alluvium have been modeled as a free draining surfaces. This assumes that the alluvium and weathered Gila Conglomerate has the permeability and storage capacity to accommodate infiltration from the TSF without groundwater mounding from the foundation into the TSF (refer to Appendix I for tailings hydraulic properties and Appendix II for details on the 1DScavenger Beach Seepage Modeling). The adopted weathered Gila Conglomerate hydraulic properties, which has higher vertical hydraulic conductivity than the tailings, is considered appropriate as it represents the majority of the TSF footprint (see Figure 3.5 and Table 3.4).

The 3D Regional Groundwater Model (M&A 2020b) will incorporate foundation properties of the Gila Conglomerate and alluvium consistent with recent site investigation, and the model will allow for any potential mounding effects.

Figure 3.5 Foundation Hydraulic Conductivity in Comparison to the Tailings Hydraulic Conductivity



Notes:
1. See Section 3.3 and Figure 3.3 for explanation of tailings zones.
2. This figure shows horizontal hydraulic conductivity (Kh), refer to Table 3.4 for anisotropy ratios.
3. Tcg = Tertiary Conglomerate (commonly referred to as Gila Conglomerate)
4. Qal = Alluvium
5. MB = Mountain Block
6. Fault Zone = more fractured Tertiary Conglomerate (Gila Conglomerate)

Table 3.4 Foundation and Tailings Zones Hydraulic Conductivity Anisotropy Ratios

Foundation Material or Tailings Zone	Regional Groundwater Model Anisotropy Ratio within the TSF footprint (K_h/K_v)	Source
Tcg (Tertiary Conglomerate)	10[1]	M&A 2020a
Qal (Alluvium)	5.6[1]	
Zone 1 – Cycloned Sand	5	Appendix I
Zone 2 – Near Dam Scavenger Beach	10	
Zone 3 – Scavenger Beach	10	
Zone 4 – Pyrite Tailings	5	

Note:

1. Values obtained from model calibration within expected bounds.

Engineering features included in the seepage management plan include finger drains, a grout curtain and low permeability layers for pyrite cells. These engineering features were incorporated into the Regional Groundwater Model (M&A 2020b), with their hydraulic properties summarized in Table 3.5.

Table 3.5 Engineering Features Hydraulic Properties

Material	Vertical Saturated Hydraulic Conductivity (K_v) (cm/s)	Anisotropy Ratio (K_h/K_v)	Source
Finger Drains (Borrow Material)	$1x10^{-2}$	1	Preliminary assumption for modeling – to be confirmed through further site investigation and design.
Grout Curtain	$1x10^{-6}$	1	
Low Permeability Layer for pyrite cells	$1x10^{-10}$	1	Appendix III

Note:

1. The grout curtain design is to be further evaluated in detailed design stages. If required, a cut-off trench through the alluvium could be constructed.

4 SEEPAGE MODEL RESULTS AND INTERPRETATION

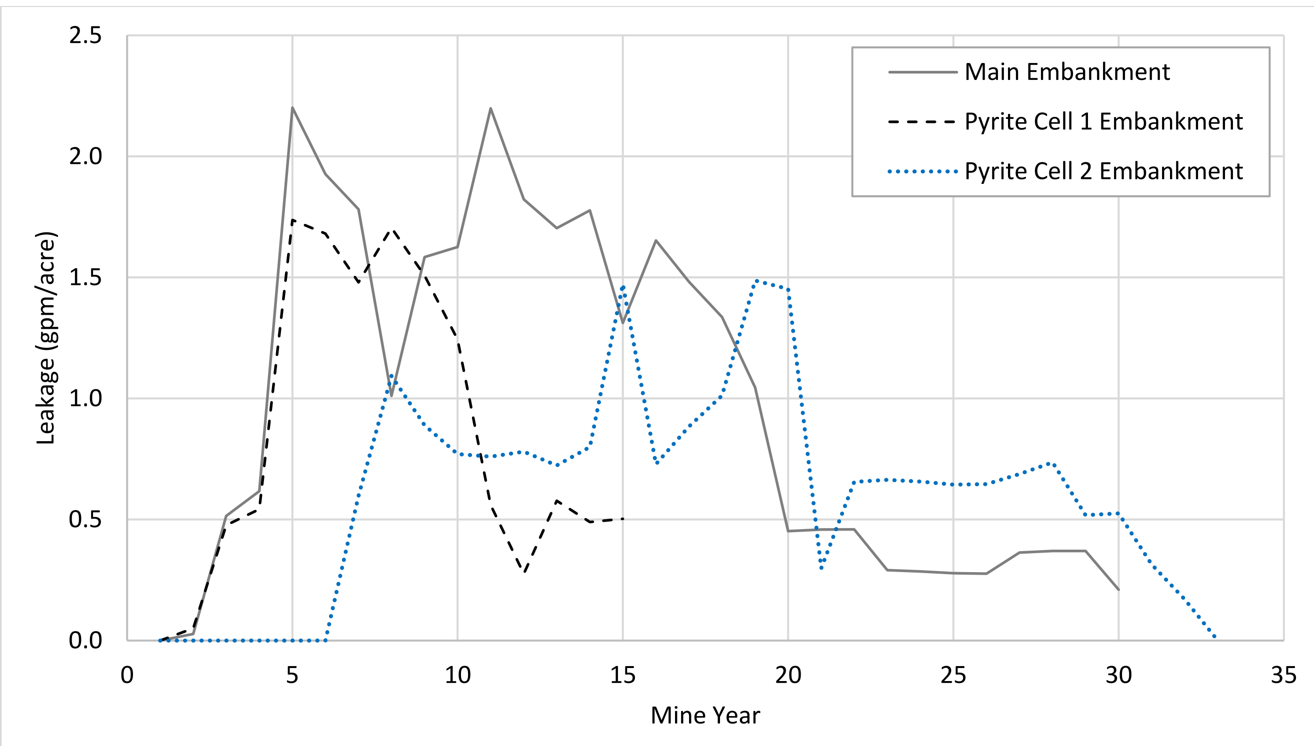
4.1 Zone 1 – Cycloned Sand

4.1.1 Cycloned Sand Embankment Leakage Estimate During Construction

A water balance approach was used to estimate infiltration through the cycloned sand embankments of the Skunk Camp TSF (i.e., Zone 1 – Cycloned Sand) that would be available as leakage into the foundation or collection into the underdrainage systems.

The water balance was developed for the three cycloned sand embankments (Main Embankment, Pyrite Cell 1 Embankment, and Pyrite Cell 2 Embankment) and included inflows and outflows from embankment construction and climate. Refer to Appendix IV for more details on the water balance development. Results of the conceptual water balance (i.e., leakage from Zone 1 – Cycloned Sand) are shown in Figure 4.1 for the period of embankment construction.

Figure 4.1 Zone 1 – Cycloned Sand Leakage Results for Embankment Construction



Notes: 1. Construction of the Pyrite Cell 1 Embankment ceases in Mine Year 15. The cycloned sand remains exposed to the atmosphere until Mine Year 28, at which point the embankment is covered with scavenger tailings.
2. Construction of the Main Embankment ceases in Mine Year 30. For the purposes of the seepage assessment, KCBCL assumed that the exposed cycloned sand will be reclaimed immediately following the end of construction.
3. Construction of the Pyrite Cell 2 Embankment ceases in Mine Year 33. For the purposes of the seepage assessment, KCBCL assumed that the exposed cycloned sand will be reclaimed immediately following the end of construction.

4.1.2 Scavenger Tailings Closure Cover Model

KCBCL developed soil-atmosphere models using Hydrus-1D (Šimůnek et al. 2009) to predict flux components of the near-surface water balance (i.e., infiltration into the tailings past the extinction depth) for scavenger tailings which includes:

- Zone 1 – Cycloned Sand;
- Zone 2 – Near Dam Scavenger Beach; and
- Zone 3 – Scavenger Beach.

The Scavenger Tailings Closure Cover Model simulates evaporation, plant transpiration, runoff, infiltration, vapor flow and moisture redistribution within the tailings and cover materials. The objective of the scavenger beach and cycloned sand closure cover is to limit net infiltration into the underlying tailings and embankment. KCBCL used the model results to compare net infiltration from different closure cover options, evaluate their relative performance, and select an appropriate closure cover design. Appendix IV of the Skunk Camp TSF Reclamation Plan (KCBCL 2020) describes the modeling approach, inputs and results. KCBCL also modeled the uncovered cycloned sand tailings to quantify the benefits of the closure cover.

Table 4.1 summarizes the predicted net infiltration rates based on a 3 ft “soil-like” Gila Conglomerate cover, refer to the Skunk Camp TSF Reclamation Plan for details on the selection of the cover material (KCBCL 2020). KCBCL assumed that the long-term post-closure net infiltration through the closure cover and to the underlying tailings is equivalent to the long-term post-closure leakage (i.e., the tailings would reach a steady-state seepage system) for the purposes of this assessment.

Table 4.1 Model Predicted Net Infiltration for Zone 1

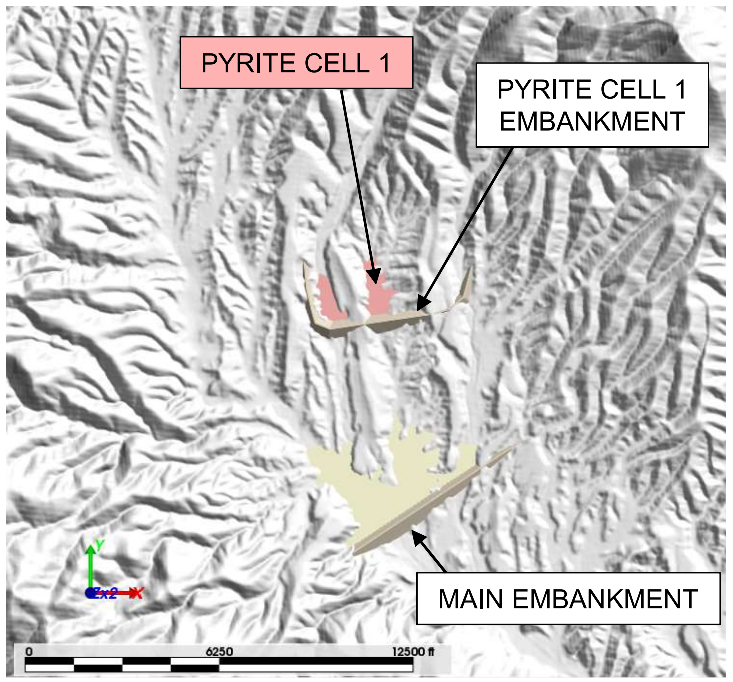
Tailings Zone	Net Infiltration over 56 Year Dataset (% of Average Annual Precipitation)	Selected Net Infiltration for Leakage Estimate (% of Average Annual Precipitation)
Zone 1 – Cycloned Sand	▪ ~30% uncovered ▪ ~3% with 3 ft vegetated soil-like Gila Conglomerate cover	▪ 30% uncovered ▪ 3% with 3 ft vegetated soil-like Gila Conglomerate cover

4.1.3 Implementation to Regional Groundwater Model

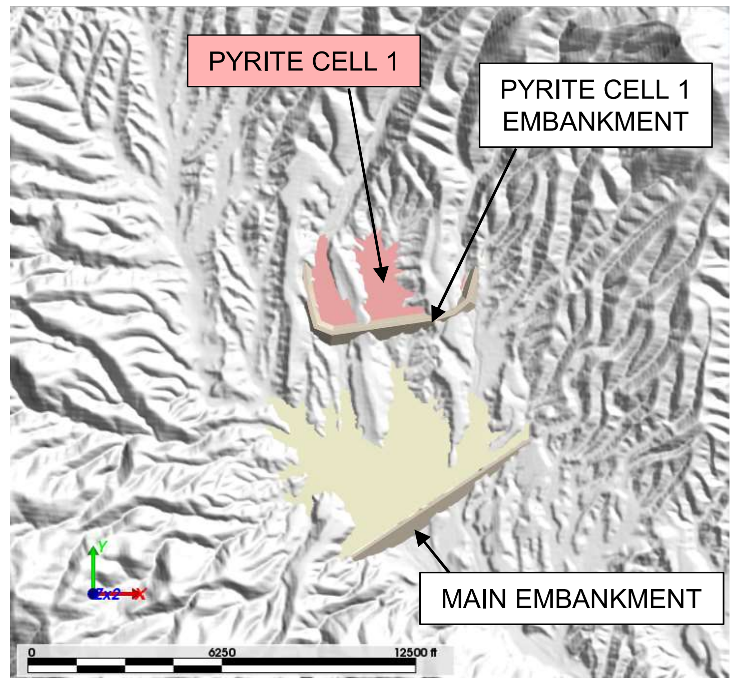
For the purposes of the seepage assessment, KCBCL assumed that the closure cover will be placed on the Main Embankment and Pyrite Cell 2 Embankment immediately following the end of embankment construction. This assumption adds a level of conservatism to the leakage estimate, because, in practice, the cycloned sand embankments will be progressively reclaimed throughout operations to limit net infiltration (and therefore leakage).

For implementation to the Regional Groundwater Model, the 1D leakage rates from the water balance estimate (during construction) and Closure Cover Model (post-construction and closure) were applied across the exposed cycloned sand planar two-dimensional (2D) areas of the embankments, see Figure 4.2.

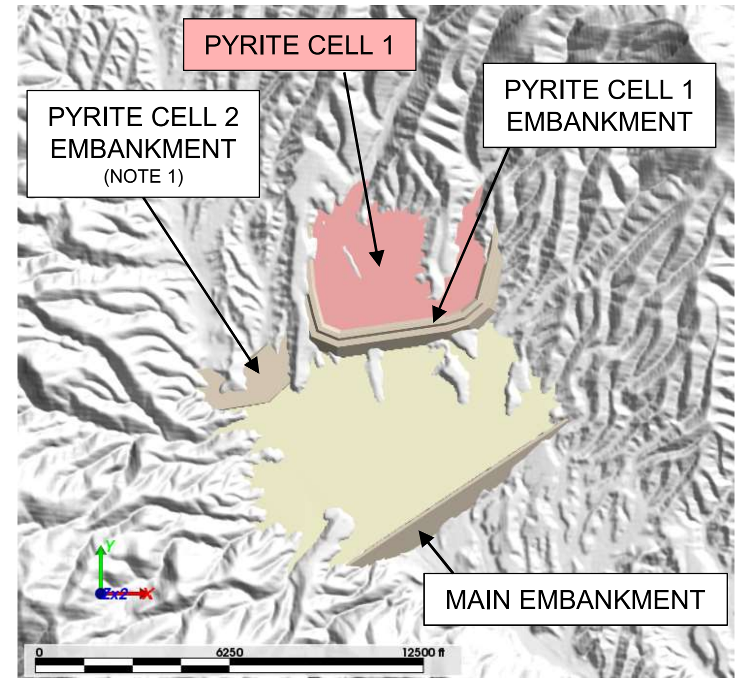
MINE YEAR 2 (END OF STAGE I)



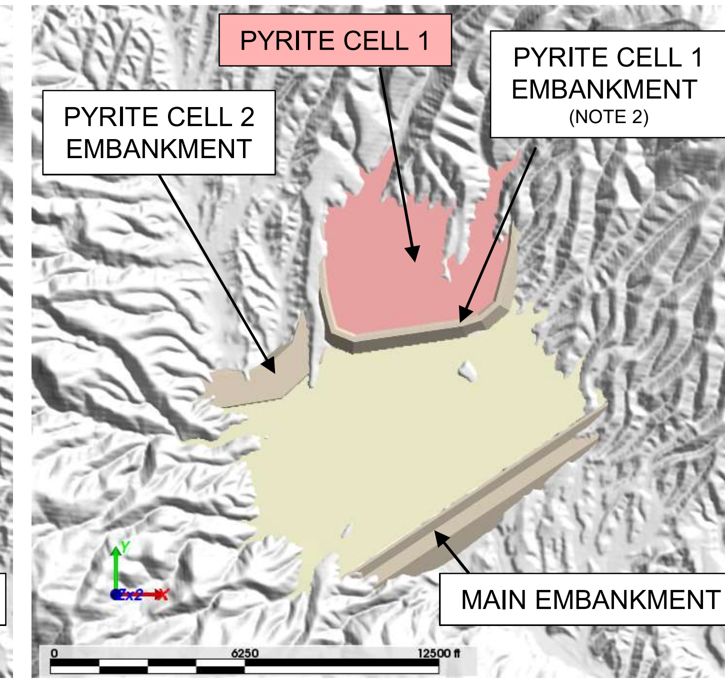
MINE YEAR 5 (STAGE II)



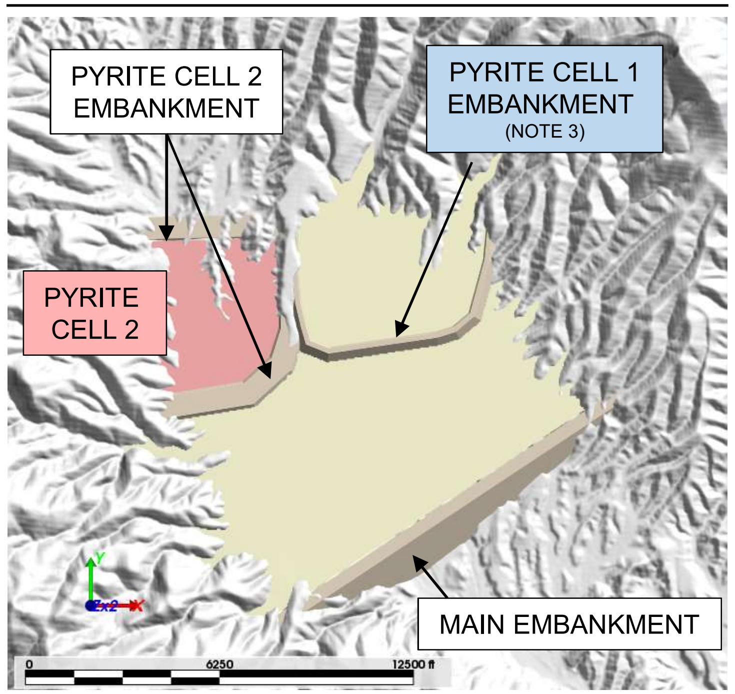
MINE YEAR 10 (STAGE II)



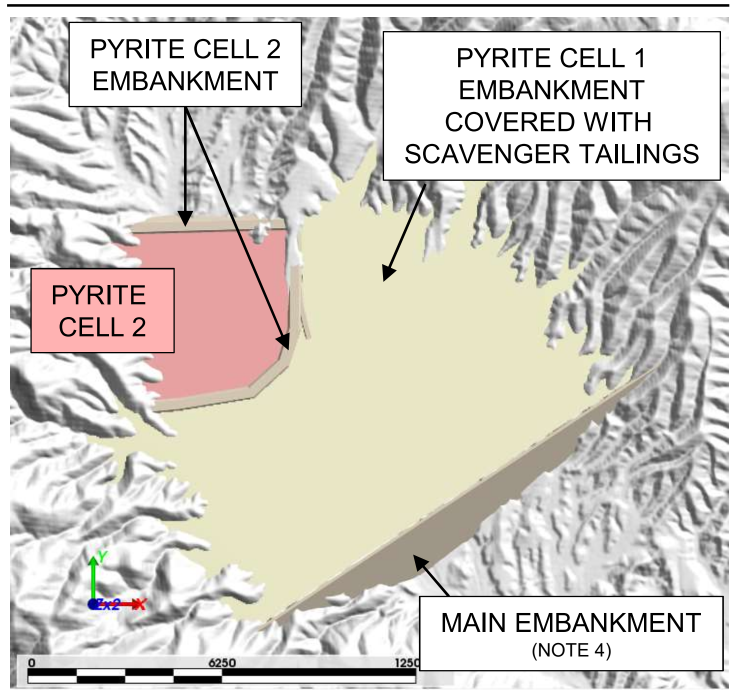
MINE YEAR 15 (END OF STAGE II)



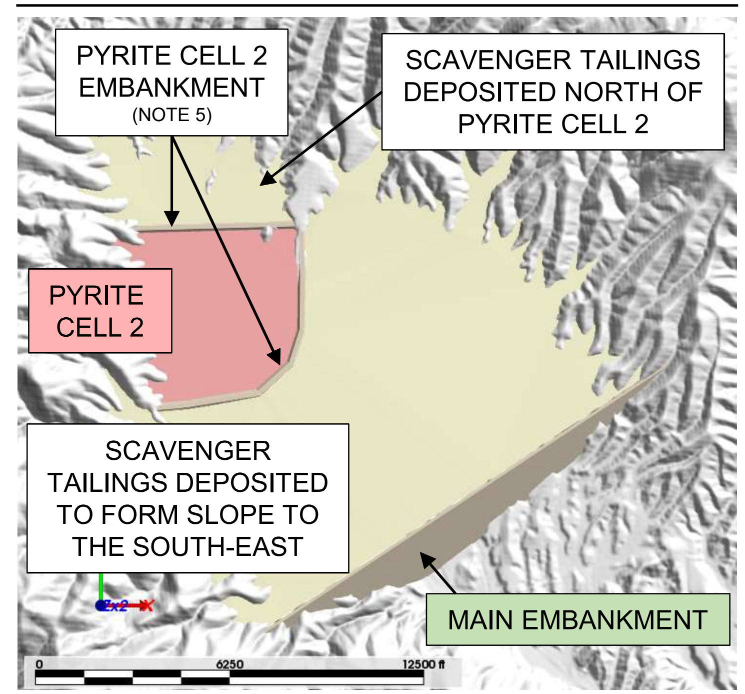
MINE YEAR 20 (STAGE III)



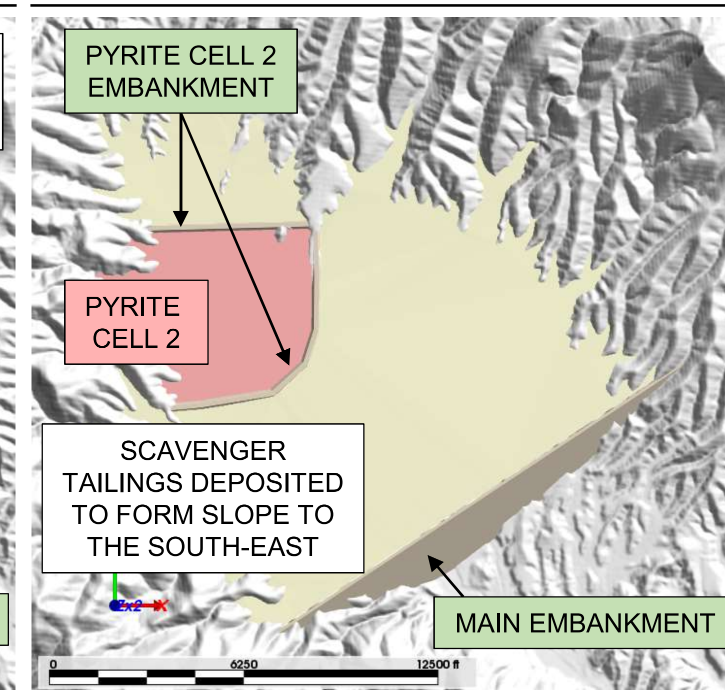
MINE YEAR 30 (END OF STAGE III)



MINE YEAR 35 (STAGE IV)



MINE YEAR 41 (END OF STAGE IV)



LEGEND

- PYRITE TAILINGS
- SCAVENGER BEACH
- CYCLONED SAND
- ACTIVE PYRITE CELL
- EMBANKMENT WITH ONGOING CONSTRUCTION: IMPLEMENT WATER BALANCE LEAKAGE RESULTS
- EMBANKMENT WITHOUT ONGOING CONSTRUCTION: IMPLEMENT EXPOSED CYCLONED SAND MODEL RESULTS (30% AVERAGE ANNUAL PRECIPITATION, TABLE 4.1 OF MAIN REPORT)
- EMBANKMENT WITH CLOSURE COVER: IMPLEMENT CLOSURE COVER MODEL RESULTS (3% AVERAGE ANNUAL PRECIPITATION, TABLE 4.1 OF MAIN REPORT)

NOTES

1. CONSTRUCTION OF PYRITE CELL 2 EMBANKMENT BEGINS IN MINE YEAR 6.
2. CONSTRUCTION OF PYRITE CELL 1 EMBANKMENT STOPS IN MINE YEAR 15.
3. PYRITE CELL 1 EMBANKMENT REMAINS EXPOSED UNTIL MINE YEAR 28, AT WHICH TIME IT IS COVERED BY SCAVENGER TAILINGS.
4. CONSTRUCTION OF MAIN EMBANKMENT STOPS IN MINE YEAR 30.
5. CONSTRUCTION OF PYRITE CELL 2 EMBANKMENT STOPS IN MINE YEAR 33.

STAGE		MINE YEAR
I		0 TO 2
II		3 TO 15
III		16 TO 30
IV	a	31
	b	32
	c	33 TO 35
	d	36 TO 41

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SKUNK CAMP TSF SEEPAGE ASSESSMENT

TITLE: SKUNK CAMP TSF STAGING PLAN AND IMPLEMENTATION OF LEAKAGE ESTIMATE TO REGIONAL GROUNDWATER MODEL FOR ZONE 1

PROJECT No. UM09441A22

FIG No. 4.2

4.2 Zone 2 – Near Dam Scavenger Beach and Zone 3 – Scavenger Beach

4.2.1 Scavenger Beach Seepage Model

To estimate leakage from Zone 2 – Near Dam Scavenger Beach and Zone 3 – Scavenger Beach, several 1D Scavenger Beach Seepage Models were developed. A Scavenger Beach Seepage Model is a vertical tailings column representing the sloping tailings surface, built-up through placement of consecutive thin lifts of thickened tailings, at a certain point in the TSF. The model was developed in TOUGH2 for operations and draindown[2] and considered the following:

- a typical climate year (with a sensitivity completed on an extreme climate sequence);
- material properties of the tailings (see Appendix I);
- bleed water/runoff that flows down-gradient of the tailings surface as a result of slurry deposition;
- tailings beach rate of rise;
- boundary conditions[3]; and
- tailings consolidation processes (including consolidation of the initial tailings deposition and the effects of consolidation under self-weight).

Appendix II provides further details on the Scavenger Beach Seepage Model development to represent seepage from Zone 2 – Near Dam Scavenger Beach and Zone 3 – Scavenger Beach, including sensitivity cases developed.

Modeling locations within the TSF were selected in Zone 2 – Near Dam Scavenger Beach and Zone 3 – Scavenger Beach to represent tailings placed throughout the mine life, see Figure 4.3 and Figure 4.4. In Zone 3 – Scavenger Beach, four models were developed for tailings beach with ultimate depths of 50 ft, 150 ft, 250 ft, and 350 ft to provide a series of representative points for the scavenger tailings deposited in the beach throughout the life of mine. A single modeling point was selected within Zone 2 – Near Dam Scavenger Beach, represented by the scavenger total tailings. Zone 2 – Near Dam Scavenger Beach is significantly smaller than Zone 3 – Scavenger Beach, its contribution to leakage is much smaller, therefore, it was deemed unnecessary to create multiple seepage models for Zone 2.

Results of the Scavenger Beach Seepage Models developed for Zone 2 – Near Dam Scavenger Beach (scavenger total tailings) and Zone 3 – Scavenger Beach (scavenger overflow) are further described and results presented in Appendix II.

[2] Long-term post-closure seepage rates were developed separately for Zone 2 and Zone 3, see Section 4.1.2.
[3] As noted in Section 3.7, the Scavenger Beach Seepage Model considers the foundation conditions as free draining. Foundation properties, which will allow for mounding effects in the TSF, will be incorporated to the Regional Groundwater Model.

Figure 4.3 Zone 2 and Zone 3 Scavenger Beach Seepage Model Column Locations

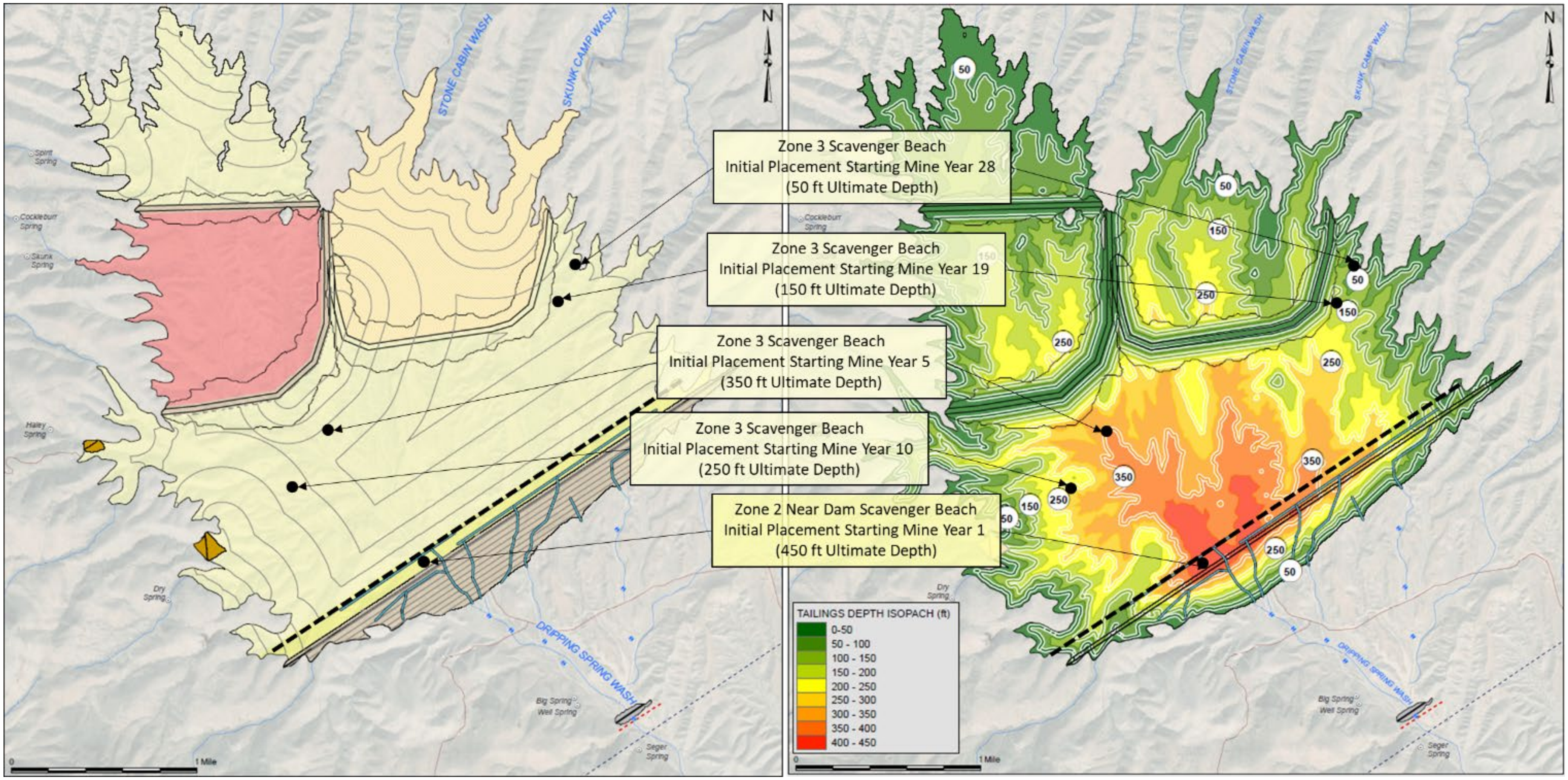
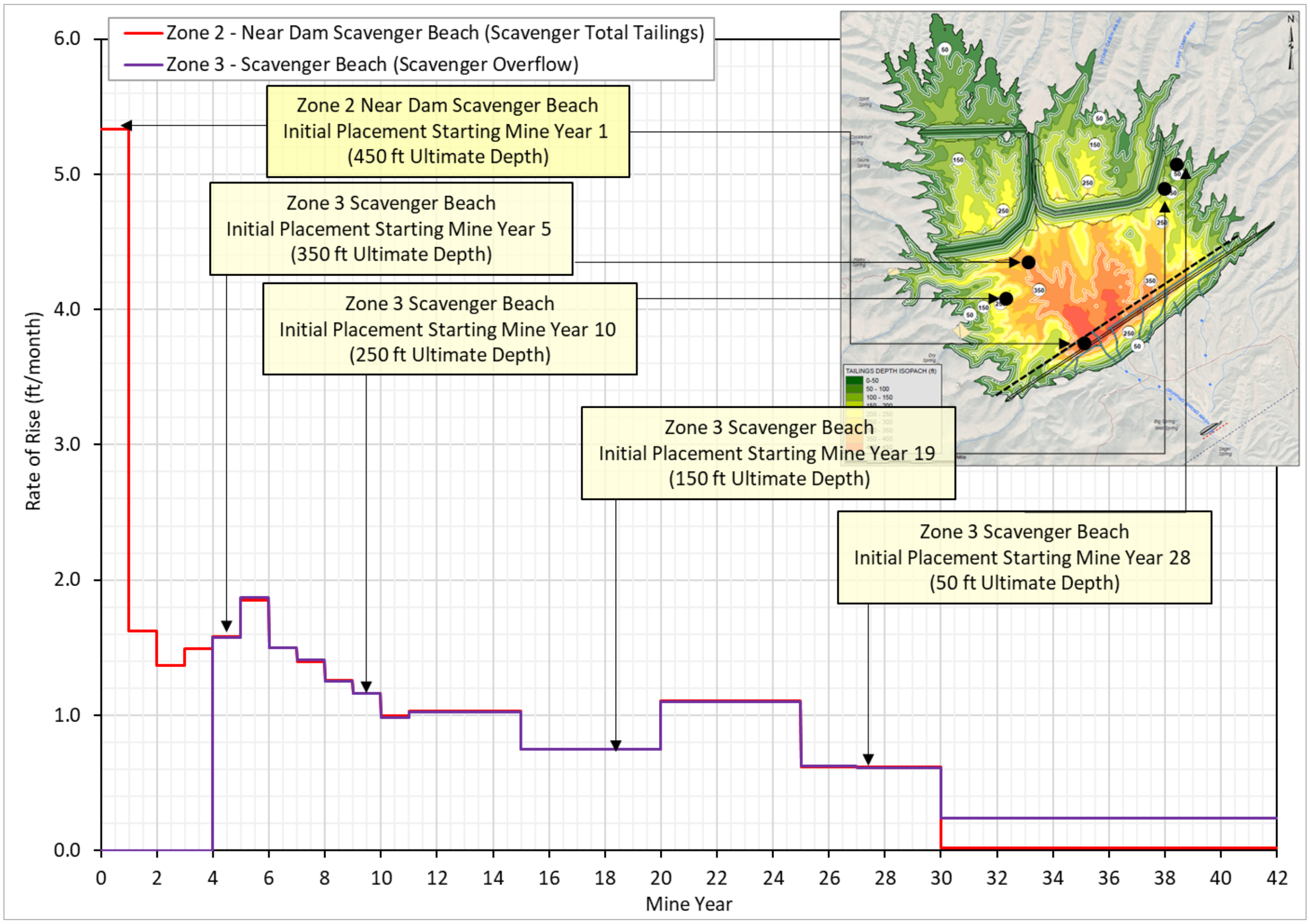


Figure 4.4 Rate of Rise for Model Locations Based on the Initial Mine Year of Deposition



4.2.2 Scavenger Tailings Closure Cover Model

Table 4.2 summarizes the long-term post-closure leakage rates from Zone 2 – Near Dam Scavenger Beach and Zone 3 – Scavenger Beach. Refer to Section 4.1.2 and Appendix IV of the Skunk Camp TSF Reclamation Plan (KCBCL 2020) for more details on closure cover model development. KCBCL assumed that the long-term post-closure net infiltration through the closure cover and to the underlying tailings is equivalent to the long-term post-closure leakage (i.e., the tailings would reach a steady-state seepage system).

Table 4.2 Model Predicted Net Infiltration for Zone 2 and Zone 3

Tailings Zone	Net Infiltration over 56 Year Dataset (% of Average Annual Precipitation)	Selected Net Infiltration for Leakage Estimate (% of Average Annual Precipitation)
Zone 2 – Near Dam Scavenger Beach	▪ < 1% with 2 ft vegetated Soil-Like Gila Conglomerate cover ▪ <3% with 2 ft non-vegetated Soil-Like Gila Conglomerate cover	▪ 2% with 2 ft vegetated Soil-Like Gila Conglomerate cover[1]
Zone 3 – Scavenger Beach	▪ < 1% with 2 ft vegetated Soil-Like Gila Conglomerate cover	▪ 1% with 2 ft vegetated Soil-Like Gila Conglomerate cover

Note:

1. Selected 2% of average annual precipitation to represent leakage under partially vegetated conditions.

4.2.3 Implementation to Regional Groundwater Model

Figure 4.5 to Figure4.8 summarizes how the 1D leakage estimates were incorporated to the 3D Regional Groundwater Model for Zone 2 – Near Dam Scavenger Beach and Zone 3 – Scavenger Beach during operations, draindown, and long-term post-closure.

FIGURE 4.5a: LEAKAGE RESULTS REPRESENTATIVE OF TAILINGS PLACED MINE YEAR 1 TO 5 (NOTE 2,4)

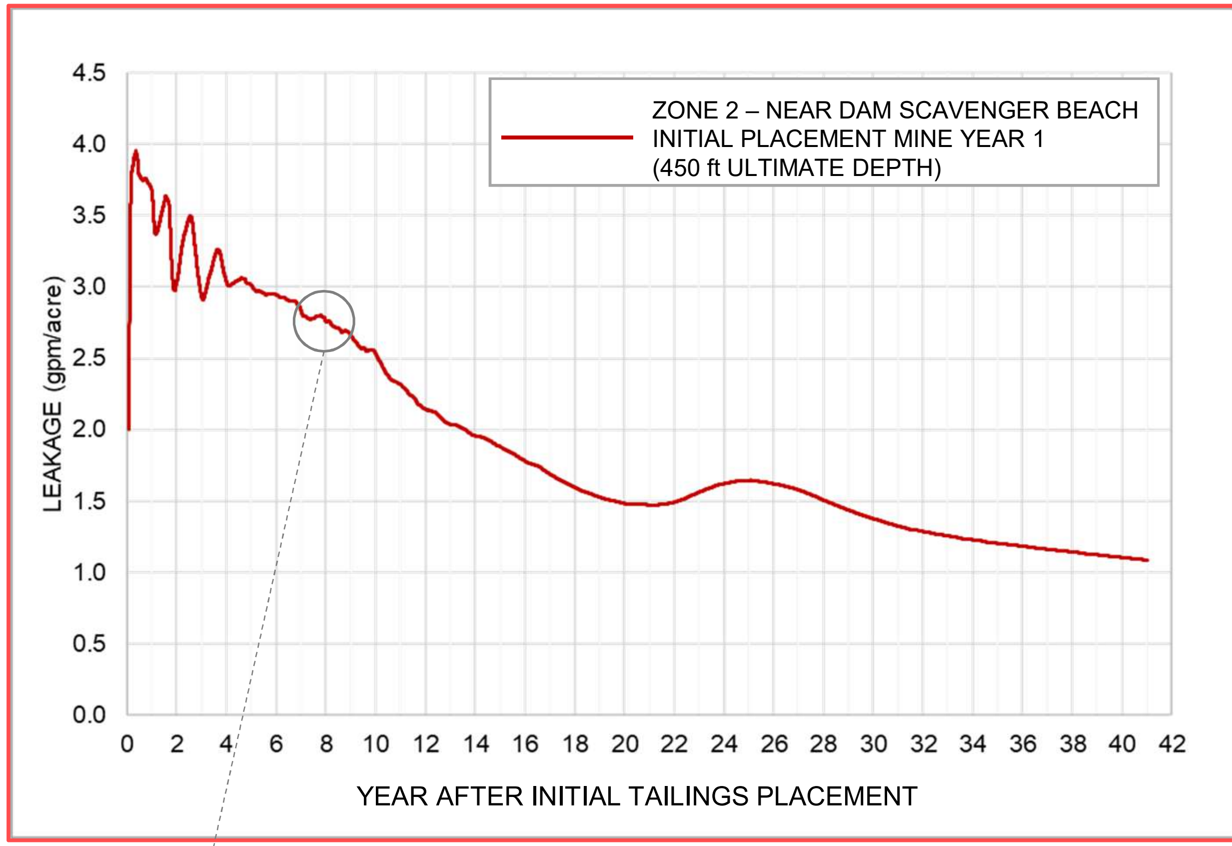
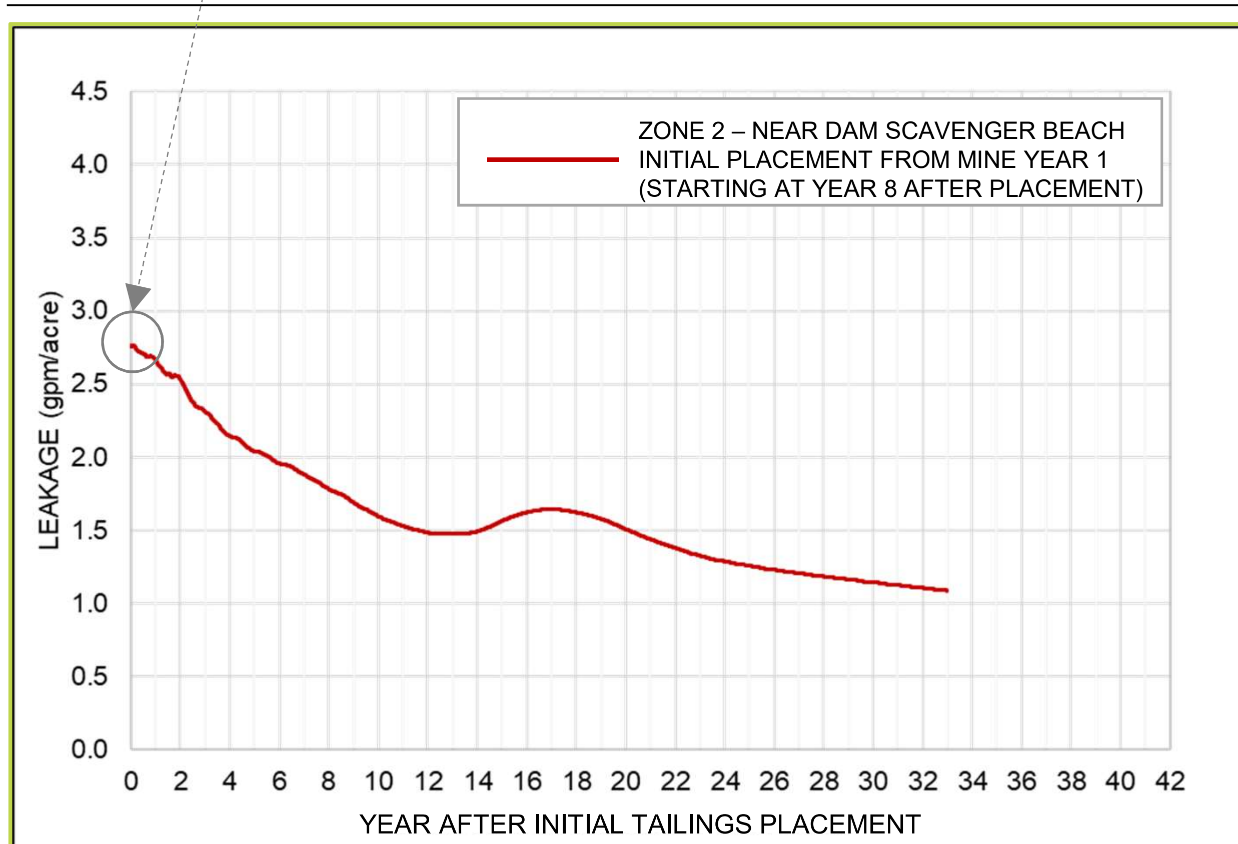
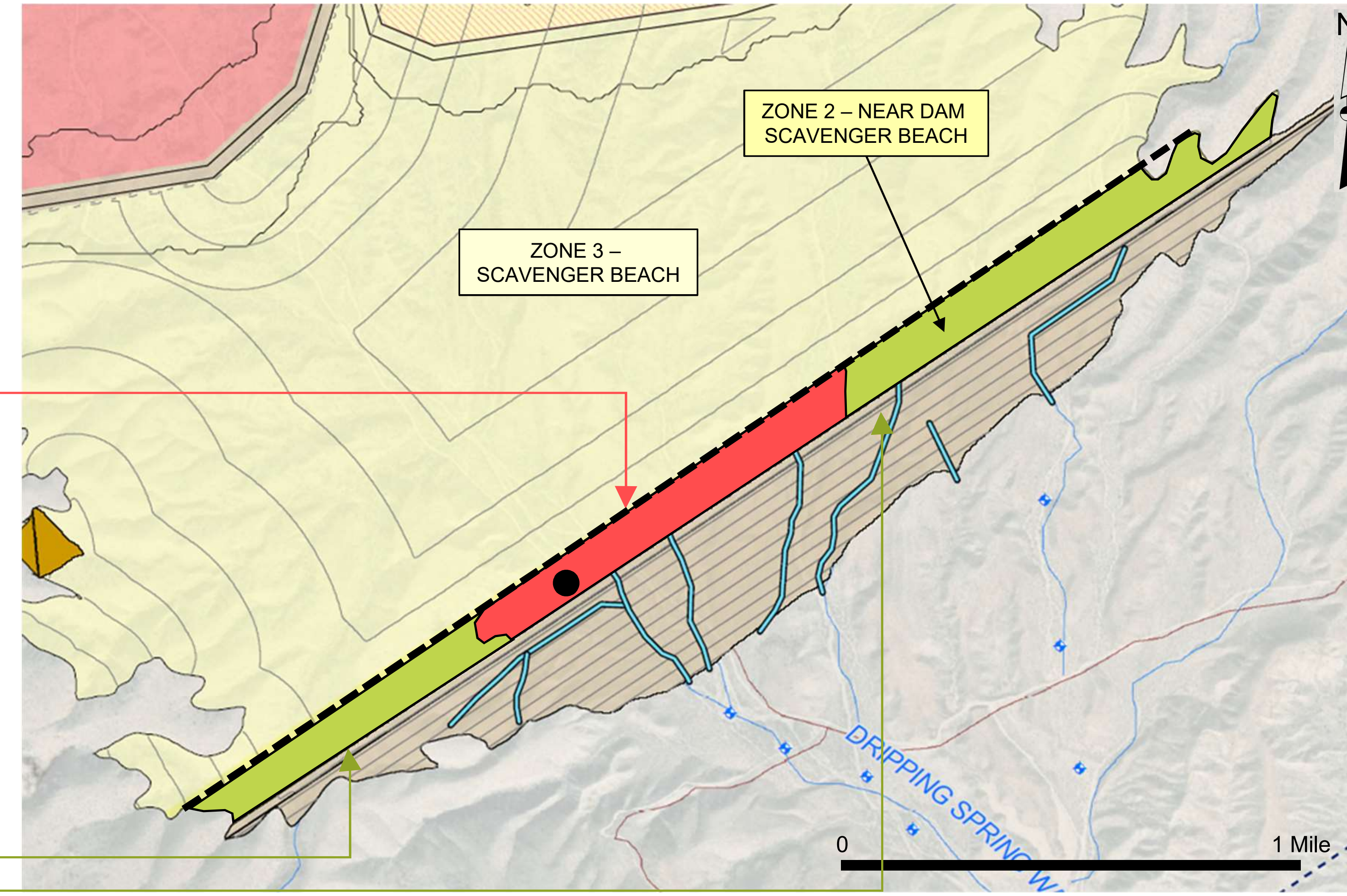


FIGURE 4.5b: LEAKAGE RESULTS REPRESENTATIVE OF TAILINGS PLACED MINE YEAR 6 TO 41 (NOTE 3,4)





NOTES

1. A SINGLE 1D SCAVENGER BEACH SEEPAGE MODEL POINT WAS SELECTED IN ZONE 2 – NEAR DAM SCAVENGER BEACH
2. FIGURE 4.5a SHOWS THE LEAKAGE RESULTS FOR THE SELECTED 1D SCAVENGER BEACH SEEPAGE MODEL POINT. KCBCL ASSUMED THAT THESE LEAKAGE RESULTS WERE REPRESENTATIVE OF TAILINGS WITH AN INITIAL PLACEMENT DURING MINE YEAR 1 TO MINE YEAR 5 (i.e., TAILINGS WITH A HIGH INITIAL RATE OF RISE AND ULTIMATE TAILINGS DEPTH GREATER THAN 350 ft).
3. FIGURE 4.5b SHOWS THE LEAKAGE RESULTS FOR THE SELECTED 1D SCAVENGER BEACH SEEPAGE MODELING POINT STARTING AT "YEAR 8" OF FIGURE 1. THESE LEAKAGE RESULTS WERE ASSUMED TO BE REPRESENTATIVE OF TAILINGS WITH AN INITIAL PLACEMENT DURING MINE YEAR 6 TO MINE YEAR 41 (i.e., TAILINGS WITH A LOWER INITIAL RATE OF RISE AND ULTIMATE TAILINGS DEPTH LESS THAN 350 ft).
4. LEAKAGE RESULTS WERE APPLIED TO THE INCREMENTAL AREA OF TAILINGS PLACED EACH MINE YEAR BASED ON THE TAILINGS STAGING PLAN, SEE SECTION 3.4 OF THE MAIN REPORT.
5. FOR A MORE DETAILED LEGEND, REFER TO FIGURE 3.1 OF THE MAIN TEXT.

LEGEND (NOTE 5)

- ZONE 2 AND ZONE 3 BOUNDARY LINE
- ZONE 3 – SCAVENGER BEACH
- ZONE 2 – NEAR DAM SCAVENGER BEACH >350 ft DEPTH
- ZONE 2 – NEAR DAM SCAVENGER BEACH <350 ft DEPTH
- SHALLOW ALLUVIAL PUMPBACK WELL
- FINGER DRAIN
- SCAVENGER BEACH SEEPAGE MODEL LOCATION (NOTE 1)

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TITLE: ZONE 2 – NEAR DAM SCAVENGER BEACH IMPLEMENTATION OF LEAKAGE ESTIMATE TO REGIONAL GROUNDWATER MODEL (OPERATIONS)

PROJECT No. UM09441A22

FIG No. 4.5

FIGURE 4.6a: LEAKAGE RESULTS FOR TAILINGS DRAINDOWN (NOTE 2,3)

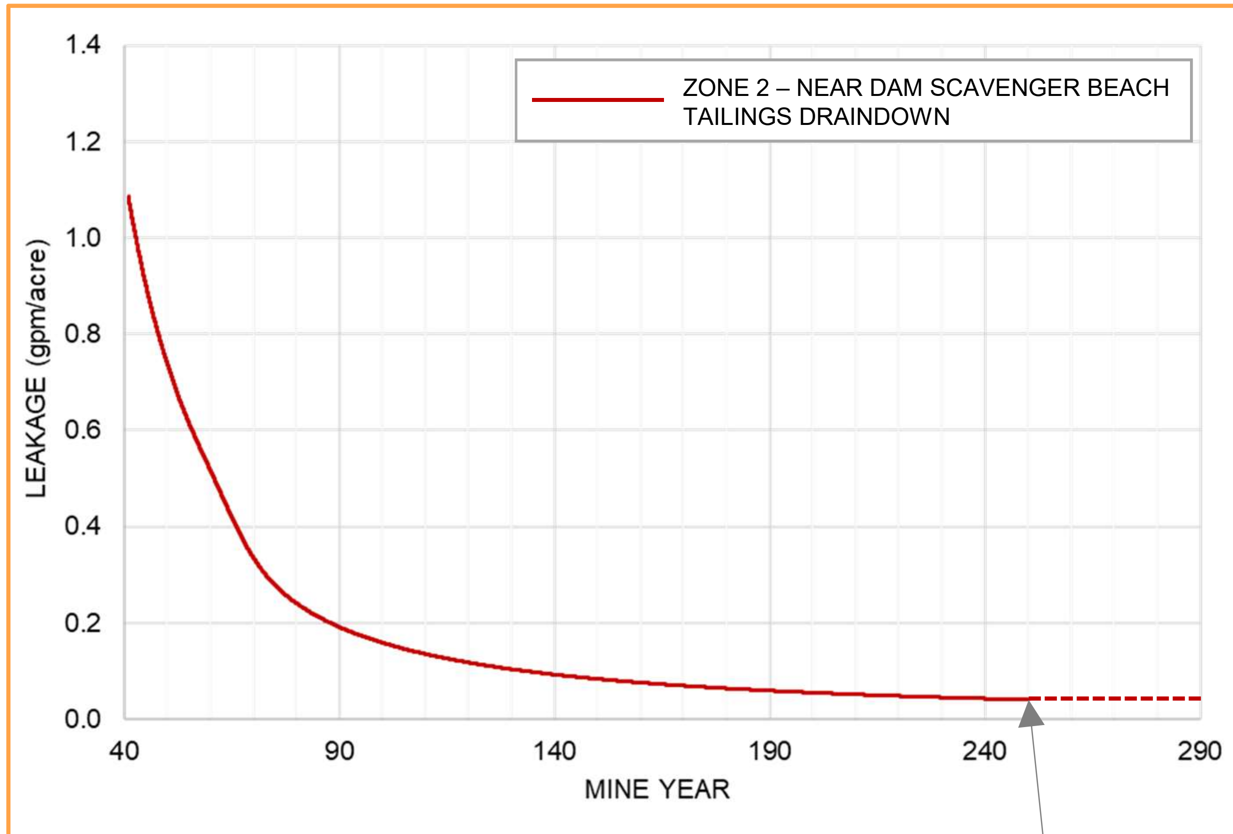
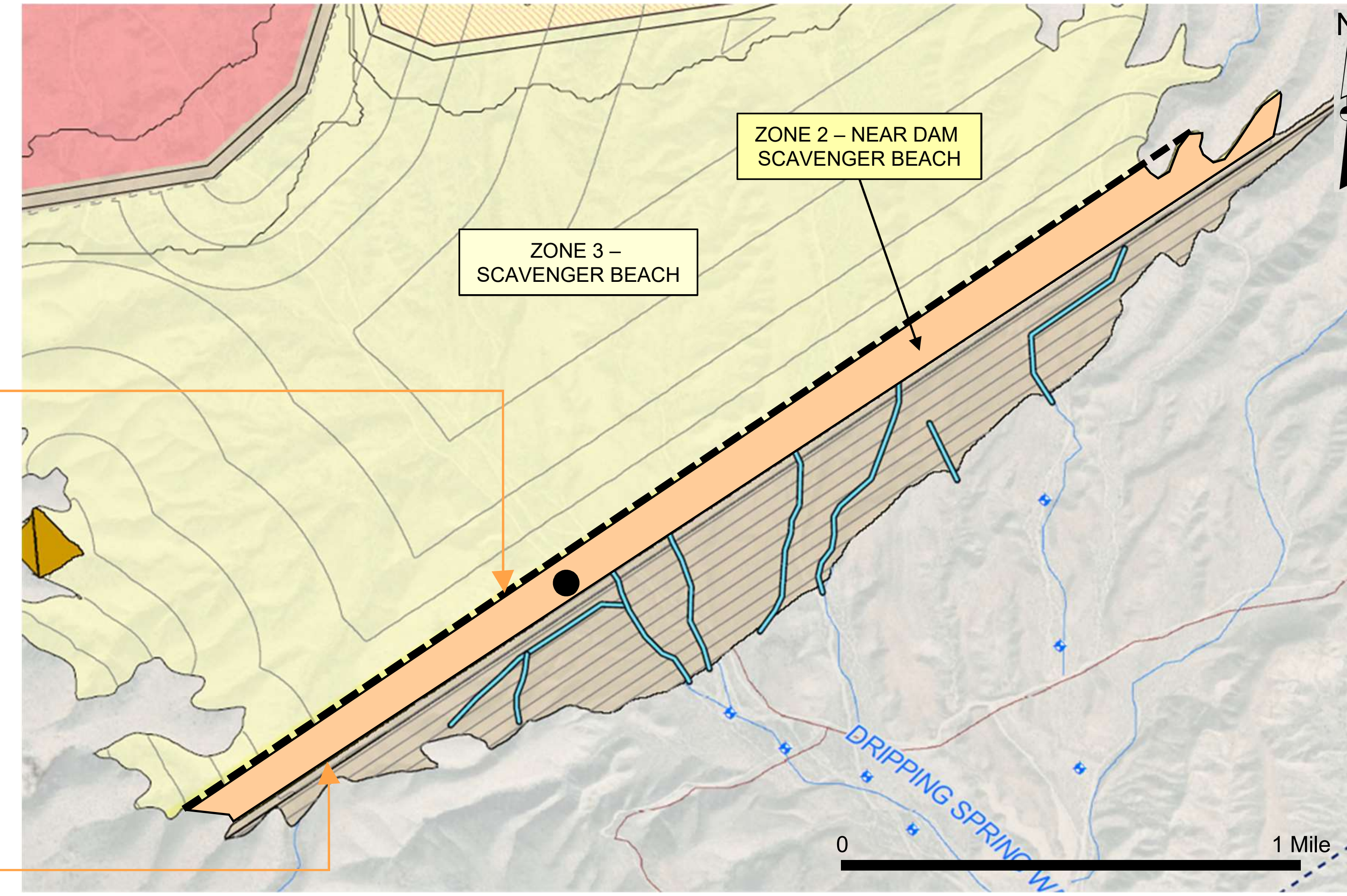


TABLE 4.5a: LONG-TERM POST-CLOSURE LEAKAGE ESTIMATE (NOTE 4)

PARAMETER	VALUE
ESTIMATED LONG-TERM POST CLOSURE (i.e., AFTER MINE YEAR 250) LEAKAGE FLUX BASED ON CLOSURE COVER MODELING	2% OF AVERAGE ANNUAL PRECIPITATION
	0.02 gpm/acre



NOTES

1. A SINGLE 1D SCAVENGER BEACH SEEPAGE MODEL POINT WAS SELECTED IN ZONE 2 – NEAR DAM SCAVENGER BEACH
2. FIGURE 4.6a SHOWS THE LEAKAGE RESULTS FOR THE SELECTED 1D SCAVENGER BEACH SEEPAGE MODEL POINT DURING TSF DRAINDOWN. KCBCL ASSUMED THAT THESE LEAKAGE RESULTS WERE REPRESENTATIVE OF ALL TAILINGS PLACED IN ZONE 2 – NEAR DAM SCAVENGER BEACH.
3. TAILINGS IN ZONE 2 – NEAR DAM SCAVENGER BEACH (SCAVENGER TOTAL TAILINGS) ARE EXPECTED TO DRAINDOWN OVER APPROXIMATELY 200 YEARS AND REACH LONG-TERM POST-CLOSURE LEAKAGE AT APPROXIMATELY MINE YEAR 250.
4. TABLE 4.6a SUMMARIZES THE LONG-TERM POST-CLOSURE LEAKAGE RATE TO BE APPLIED ACROSS THE RECLAIMED SURFACE AREA OF ZONE 2 – NEAR DAM SCAVENGER BEACH.
5. FOR A MORE DETAILED LEGEND, REFER TO FIGURE 3.1 OF THE MAIN TEXT.

LEGEND (NOTE 5)

- ZONE 2 AND ZONE 3 BOUNDARY LINE
- ZONE 3 – SCAVENGER BEACH
- ZONE 2 – NEAR DAM SCAVENGER BEACH
- SHALLOW ALLUVIAL PUMPBACK WELL
- FINGER DRAIN
- SCAVENGER BEACH SEEPAGE MODEL LOCATION (NOTE 1)

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PROJECT No.	FIG No.
UM09441A22	4.6

FIGURE 4.7a: LEAKAGE RESULTS REPRESENTATIVE OF INITIAL TAILINGS PLACED MINE YEAR 1 TO 7 (NOTE 2)

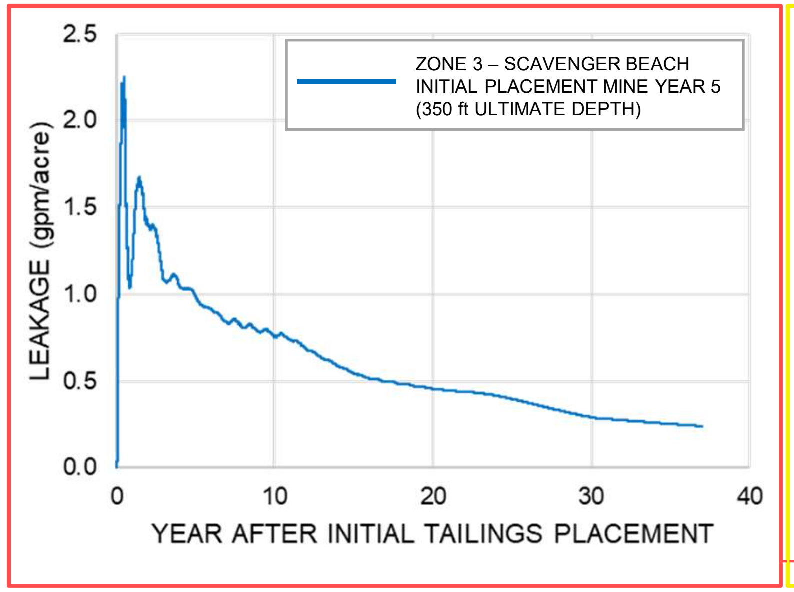


FIGURE 4.7b: LEAKAGE RESULTS REPRESENTATIVE OF INTIAL TAILINGS PLACED MINE YEAR 8 TO 14 (NOTE 3)

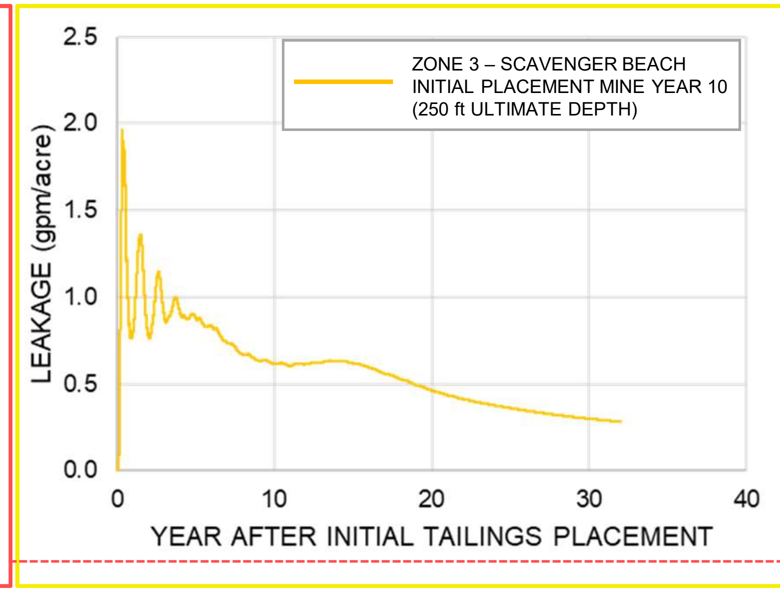


FIGURE 4.7c: LEAKAGE RESULTS REPRESENTATIVE OF INITIAL TAILINGS PLACED MINE YEAR 15 TO 23 (NOTE 4)

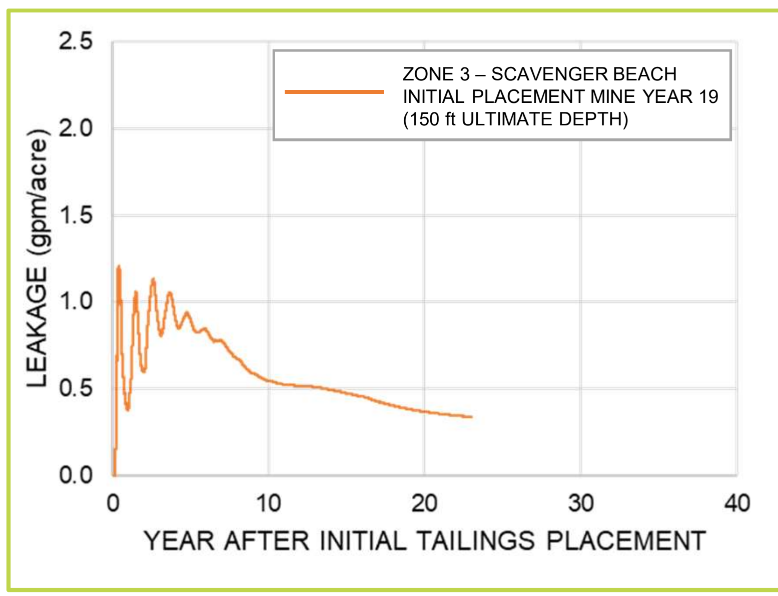
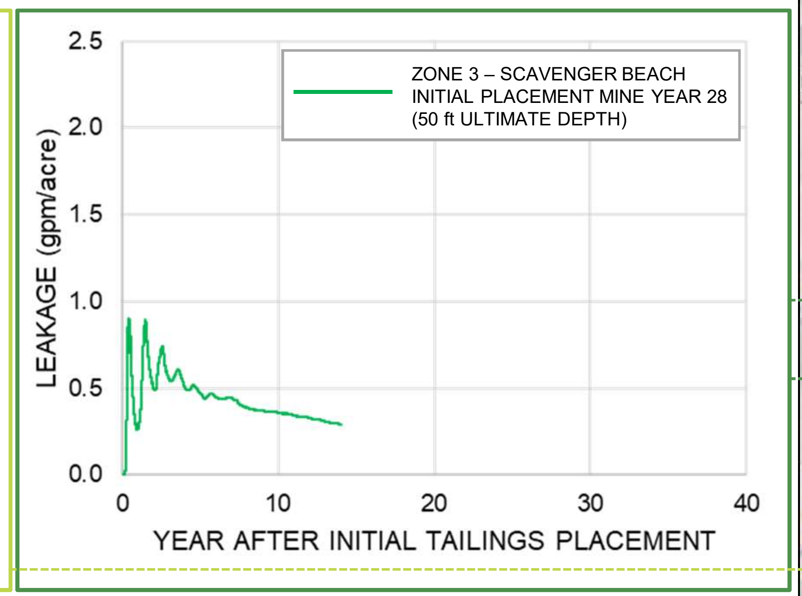
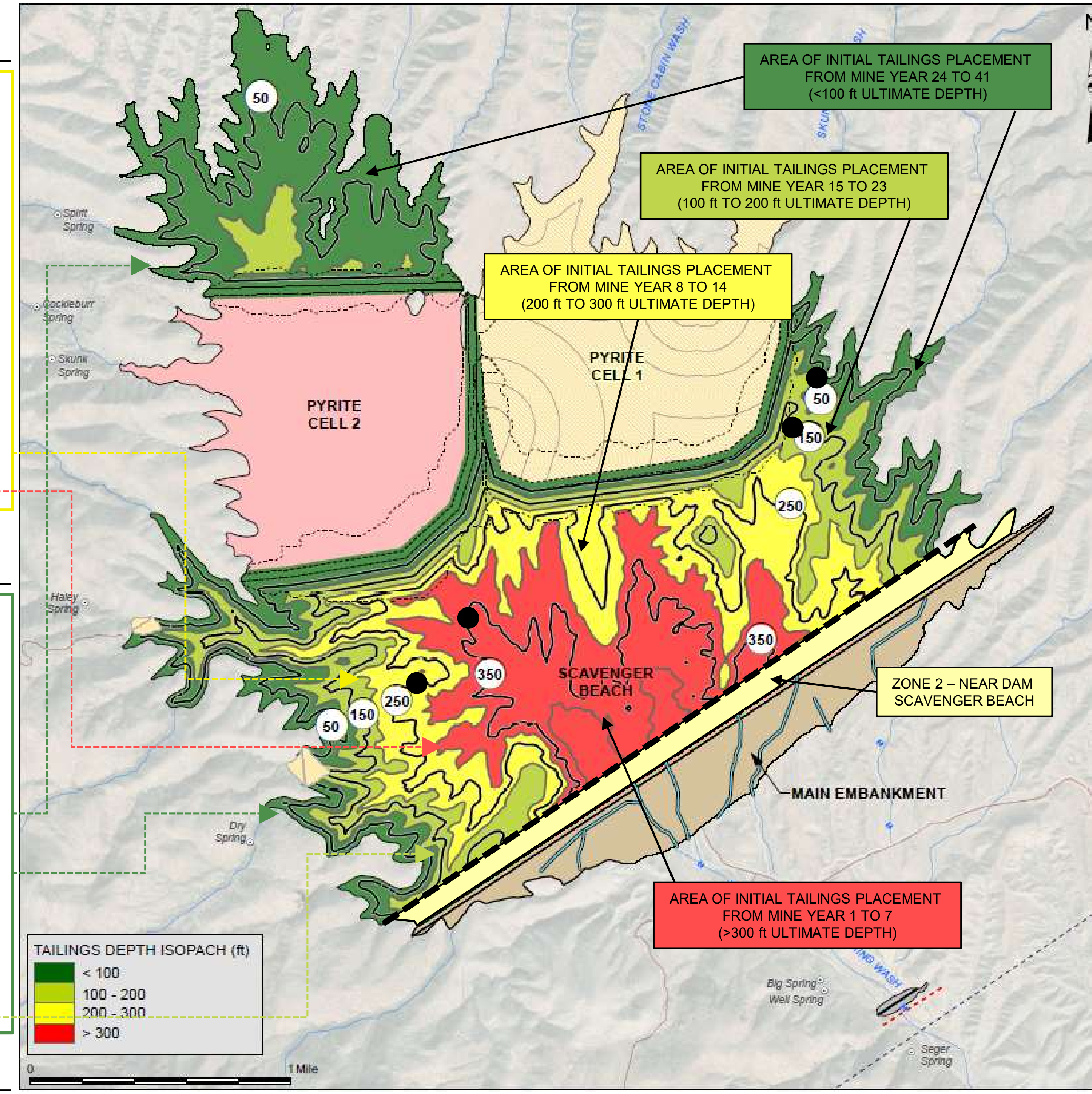


FIGURE 4.7d: LEAKAGE RESULTS REPRESENTATIVE OF INITIAL TAILINGS PLACED MINE YEAR 24 TO 41 (NOTE 5)





NOTES

1. FOUR 1D SCAVENGER BEACH SEEPAGE MODEL POINTS WERE SELECTED IN ZONE 3 – SCAVENGER BEACH
2. FIGURE 4.7a SHOWS THE LEAKAGE RESULTS FOR THE SCAVENGER BEACH SEEPAGE MODEL REPRESENTING INITIAL TAILINGS PLACEMENT IN MINE YEAR 5 (350 ft ULTIMATE DEPTH). KCBCL ASSUMED THAT THESE LEAKAGE RESULTS WERE REPRESENTATIVE OF TAILINGS WITH AN INITIAL PLACEMENT FROM MINE YEAR 1 TO 7 (i.e., TAILINGS WITH AN ULTIMATE DEPTH GREATER THAN 300 ft).
3. FIGURE 4.7b SHOWS THE LEAKAGE RESULTS FOR THE SCAVENGER BEACH SEEPAGE MODEL REPRESENTING INITIAL TAILINGS PLACEMENT IN MINE YEAR 10 (250 ft ULTIMATE DEPTH). KCBCL ASSUMED THAT THESE LEAKAGE RESULTS WERE REPRESENTATIVE OF TAILINGS WITH AN INITIAL PLACEMENT FROM MINE YEAR 8 TO 14 (i.e., TAILINGS WITH AN ULTIMATE DEPTH BETWEEN 200 ft AND 300 ft).
4. FIGURE 4.7c SHOWS THE LEAKAGE RESULTS FOR THE SCAVENGER BEACH SEEPAGE MODEL REPRESENTING INITIAL TAILINGS PLACEMENT IN MINE YEAR 19 (150 ft ULTIMATE DEPTH). KCBCL ASSUMED THAT THESE LEAKAGE RESULTS WERE REPRESENTATIVE OF TAILINGS WITH AN INITIAL PLACEMENT FROM MINE YEAR 15 TO 23 (i.e., TAILINGS WITH AN ULTIMATE DEPTH BETWEEN 100 ft AND 200 ft).
5. FIGURE 4.7d SHOWS THE LEAKAGE RESULTS FOR THE SCAVENGER BEACH SEEPAGE MODEL REPRESENTING INITIAL TAILINGS PLACEMENT IN MINE YEAR 28 (50 ft ULTIMATE DEPTH). KCBCL ASSUMED THAT THESE LEAKAGE RESULTS WERE REPRESENTATIVE OF TAILINGS WITH AN INITIAL PLACEMENT FROM MINE YEAR 24 TO 41 (i.e., TAILINGS WITH AN ULTIMATE DEPTH LESS THAN 100 ft).
6. FOR A MORE DETAILED LEGEND, REFER TO FIGURE 3.1 OF THE MAIN TEXT.

LEGEND (NOTE 6)

- ZONE 2 AND ZONE 3 BOUNDARY LINE
- ZONE 2 – NEAR DAM SCAVENGER BEACH
- SHALLOW ALLUVIAL PUMPBACK WELL
- FINGER DRAIN
- SCAVENGER BEACH SEEPAGE MODEL LOCATION (NOTE 1)

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PROJECT No.	FIG No.
UM09441A22	4.7

FIGURE 4.8a: LEAKAGE RESULTS REPRESENTATIVE OF INITIAL TAILINGS PLACED MINE YEAR 1 TO 7 (NOTE 2)

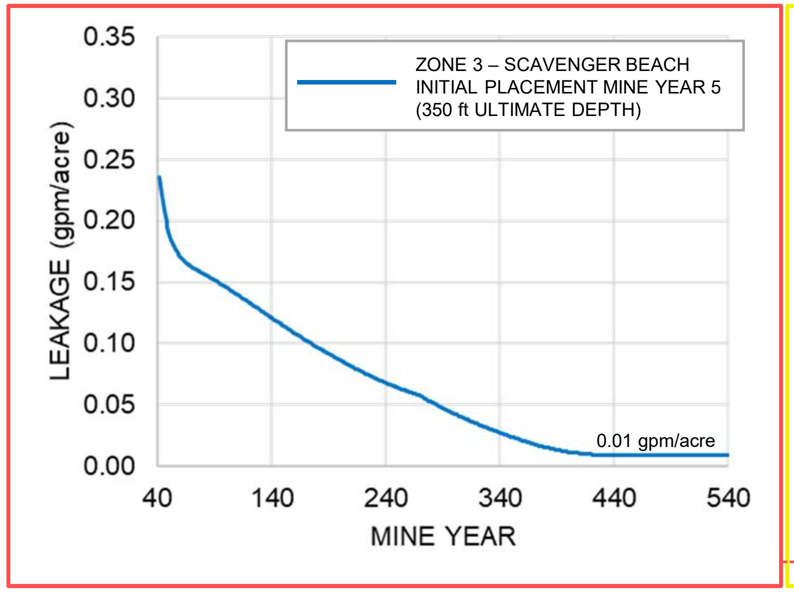


FIGURE 4.8b: LEAKAGE RESULTS REPRESENTATIVE OF INTIAL TAILINGS PLACED MINE YEAR 8 TO 14

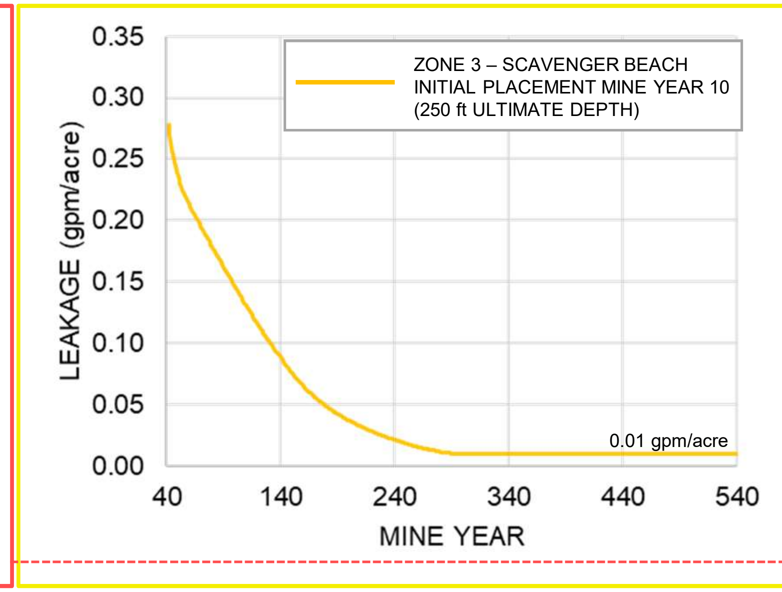


FIGURE 4.8c: LEAKAGE RESULTS REPRESENTATIVE OF INITIAL TAILINGS PLACED MINE YEAR 15 TO 23

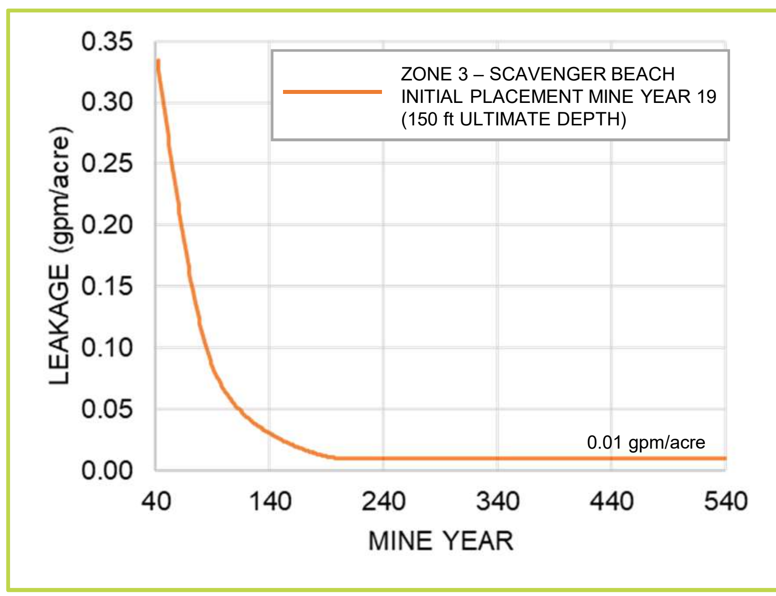
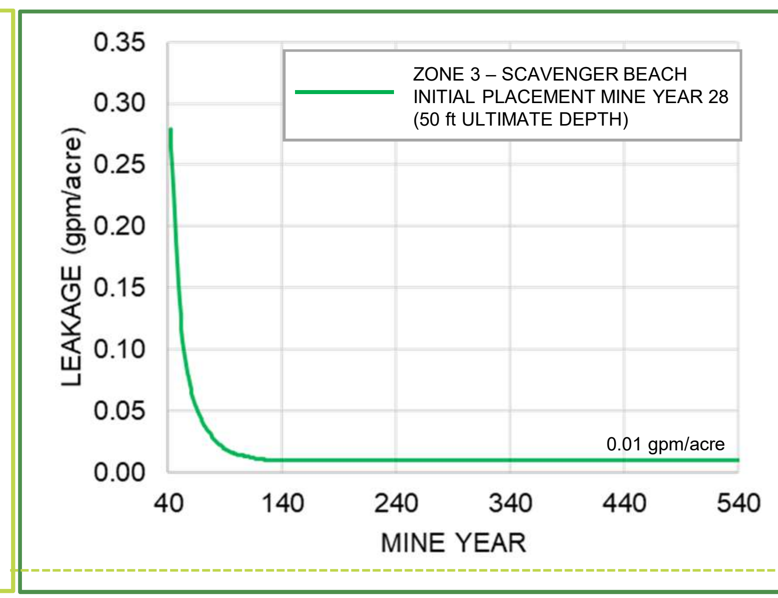
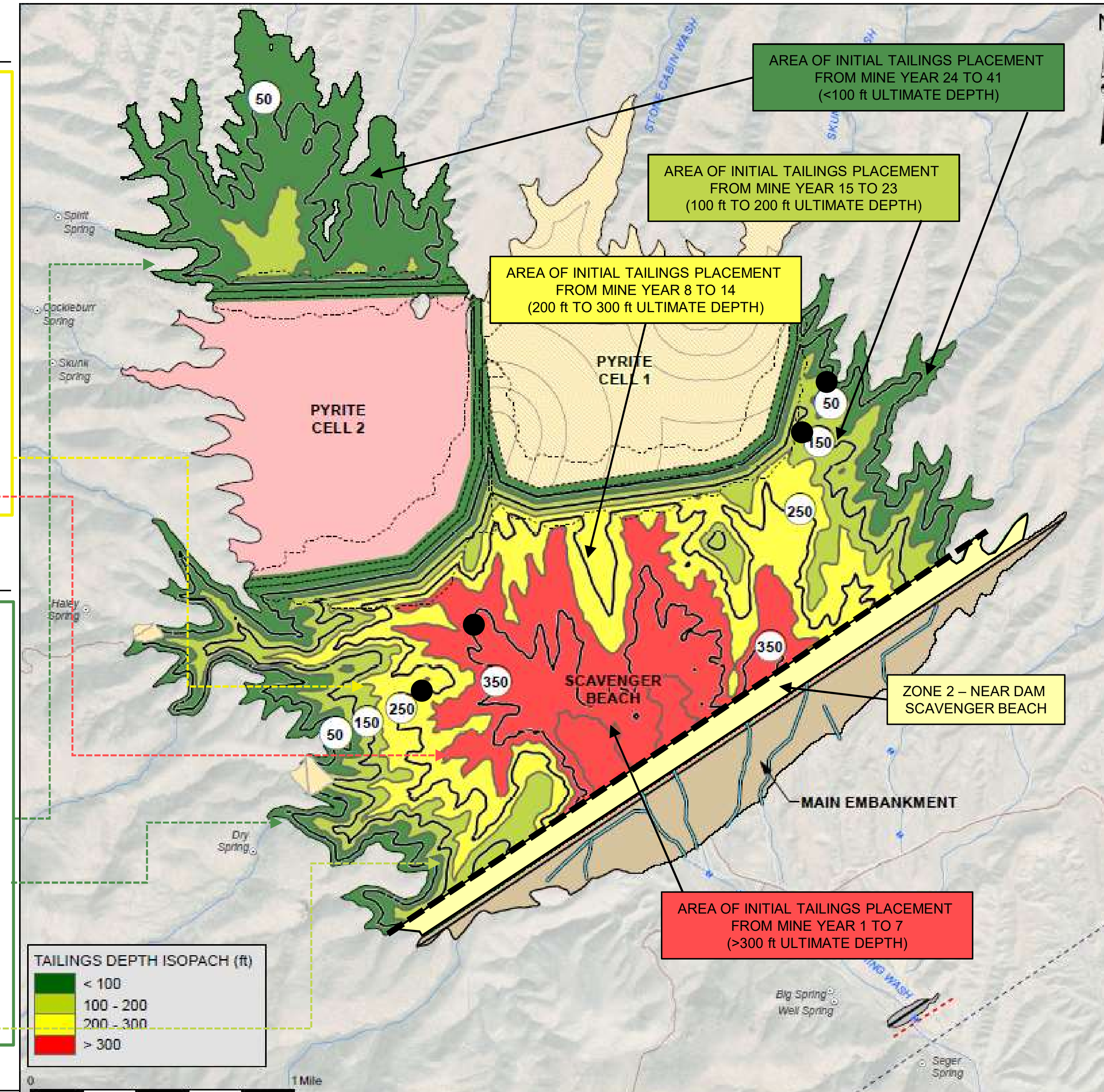


FIGURE 4.8d: LEAKAGE RESULTS REPRESENTATIVE OF INITIAL TAILINGS PLACED MINE YEAR 24 TO 41





NOTES

1. FOUR 1D SCAVENGER BEACH SEEPAGE MODEL POINTS WERE SELECTED IN ZONE 3 – SCAVENGER BEACH
2. FIGURES 4.8a TO 4.8d SHOW THE LEAKAGE RESULTS FOR THE FOUR 1D SCAVENGER BEACH SEEPAGE MODELING POINTS IN ZONE 3 DURING DRAINDOWN AND INTO THE LONG-TERM POST-CLOSURE RATE.
3. TABLE 4.8a SUMMARIZES THE LONG-TERM POST-CLOSURE LEAKAGE RATE TO BE APPLIED ACROSS THE RECLAIMED SURFACE OF ZONE 3 – SCAVENGER BEACH WHEN THE SYSTEM REACHES A STEADY STATE OF INFLOWS AND OUTFLOWS.
4. FOR A MORE DETAILED LEGEND, REFER TO FIGURE 3.1 OF THE MAIN TEXT.

TABLE 4.8a: LONG-TERM POST-CLOSURE LEAKAGE ESTIMATE (NOTE 3)

PARAMETER	VALUE
ESTIMATED LONG-TERM POST CLOSURE LEAKAGE FLUX BASED ON CLOSURE COVER MODELING	1% OF AVERAGE ANNUAL PRECIPITATION
	0.01 gpm/acre

LEGEND (NOTE 4)

- ZONE 2 AND ZONE 3 BOUNDARY LINE
- ZONE 2 – NEAR DAM SCAVENGER BEACH
- SHALLOW ALLUVIAL PUMPBACK WELL
- FINGER DRAIN
- SCAVENGER BEACH SEEPAGE MODEL LOCATION (NOTE 1)

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PROJECT No. UM09441A22

FIG No. 4.8

4.3 Zone 4 – Pyrite Tailings

4.3.1 Pyrite Cell Low Permeability Layer Leakage Model

KCBCL developed a model to estimate the seepage rate through the low permeability layer at the base of the pyrite cells and develop an Equivalent Porous Medium (EPM) hydraulic conductivity and thickness to be used for more complex numerical seepage modeling (e.g., Regional Groundwater Model). For the purposes of this assessment, the low permeability layer consists of tailings deposited on a geomembrane liner. Seepage predictions from this assessment are at the lower bound of the expected range of low permeability layers that could be used in design.

KCBCL used two steady-state axisymmetric SEEP/W models (GEOSLOPE 2012) to evaluate the low permeability layer hydraulic conductivity and seepage rate. Appendix III provides details on the model set-up, inputs and results.

Key observations from the Pyrite Cell Low Permeability Layer Leakage Model include:

- when the low permeability layer underlies the pyrite tailings, the EPM hydraulic conductivity is calculated to range from $1x10^{-12}$ to $3x10^{-11}$ cm/s and the vertical unit flux ranges from $6x10^{-4}$ to $1x10^{-2}$ gpm/acre;
- when the pond is directly on the low permeability layer[4], the EPM hydraulic conductivity is calculated to range from $1x10^{-6}$ to $1x10^{-8}$ cm/s and the vertical unit flux ranges from 2.5 to 250 gpm/acre; and
- tailings depth does not significantly affect the low permeability layer EPM hydraulic conductivity.

Based on the results of this assessment, a hydraulic conductivity of $1x10^{-10}$ cm/s was conservatively selected for input to the Regional Groundwater Model, which is roughly equivalent to 0.01% of average annual precipitation.

4.3.2 Pyrite Tailings Closure Cover Model

KCBCL developed a 1D unsaturated/saturated seepage model for the pyrite cell with TOUGH2 to assess the relative performance of different closure cover options and select an appropriate closure cover. The model predicts an overall water balance for the pyrite cell that includes evaporation, surface infiltration, water table elevation, material saturation, seepage and storage components. The model domain includes the pyrite cell low permeability layer (assuming some degradation of the low permeability layer) and 25 ft of pyrite tailings. Appendix IV of the Skunk Camp TSF Reclamation Plan (KCBCL 2020) describes the model inputs and results.

The pyrite tailings will be covered with at least 10 ft of scavenger tailings prior to placing the closure cover. The TOUGH2 models indicate the critical control for seepage is the low permeability layer at

[4] The pond will be directly on the low permeability layer for a limited time during pyrite cell start-up. As such, this scenario does not provide representative hydraulic conductivity values and was not used to estimate leakage through the low permeability layer.

the base of the pyrite cells, not solely the cover material. The cover material properties have a negligible effect on seepage rates. The predicted seepage is less than 2% of average annual precipitation. This is likely conservative for the following reasons:

- the low permeability layer models (Appendix III) suggest the equivalent hydraulic conductivity of a liner below the pyrite tailings could be two orders of magnitude lower that modeled in TOUGH2;
- the hydraulic conductivity of the pyrite tailings would likely be lower than that considered in the TOUGH2 models due to higher effective stresses and consolidation; and
- the TOUGH2 models do not account for vapor flow and plant transpiration, which would likely reduce net infiltration into the pyrite tailings.

KCBCL selected 2% of average annual precipitation to represent the long-term post-closure leakage from the lower permeability layer underlying the Zone 4 – Pyrite Tailings to represent a long-term condition in which a geomembrane liner has degraded.

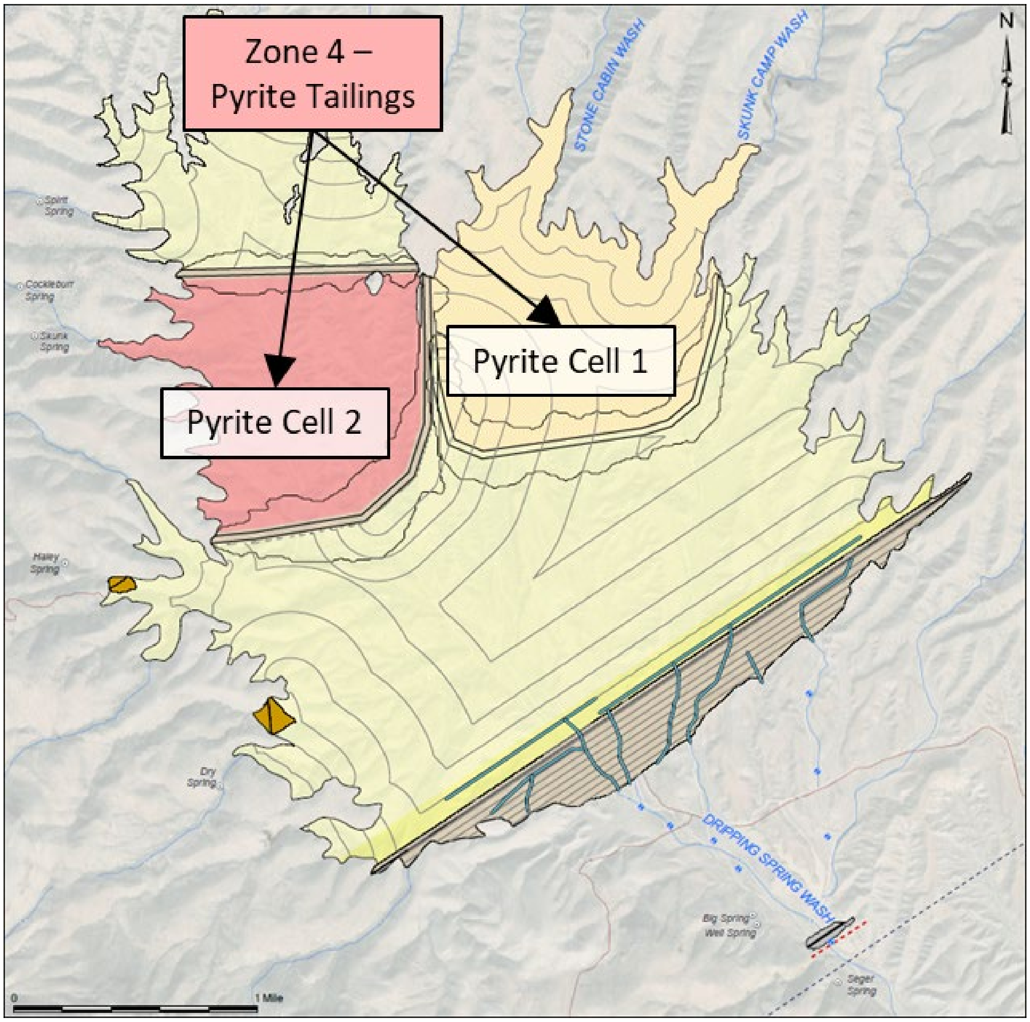
4.3.3 Implementation to Regional Groundwater Model

During operations (Mine Year 1 to 41), the Regional Groundwater Model calculates leakage through the low permeability liner from the pyrite cells to the subsurface based on the hydraulic conductivity of the liner (selected as $1x10^{-10}$ cm/s, see Section 4.3.1), a layer thickness of 3 ft, and head gradient between the pyrite cells and the subsurface layers below based on TSF staging. The leakage is represented as the seepage passing from the pyrite cells to the subsurface with the low permeability acting as a barrier or restrictive layer.

For 50 years post-closure (Mine Year 42 to 91), KCBCL calculated that the low permeability layer annual leakage rate would be 0.05% of average annual precipitation, based on results of the Pyrite Cell Low Permeability Layer Leakage Model. For the following 100 years (Mine Year 92 to 191), KCBCL assumed that the low permeability layer would linearly degrade to a maximum leakage of 2% of average annual precipitation (see Section 4.3.2). Leakage from Zone 4 – Pyrite Tailings is calculated to remain at 2% of average annual precipitation beyond Mine Year 191.

For implementation to the Regional Groundwater Model, the post-closure 1D leakage rates through the low permeability layer (Zone 4 – Pyrite Tailings) were applied across the two pyrite cell surface areas for (Figure 4.9).

Figure 4.9 Implementation of Zone 4 – Pyrite Tailings Leakage Results to Regional Groundwater Model



5 DISCUSSION AND CONCLUSIONS

As summarized in Figure 1.1, the Skunk Camp TSF site characterization, tailings characterization and seepage and groundwater modeling assessments were used to develop the seepage management plan.

Table 5.1 summarizes model sensitivities completed for each tailings zone and a discussion of the design resiliency of each tailings zone.

Table 5.1 Summary of Tailings Zone Model Sensitivities and Design Resiliency

Tailings Zone	Discussion on Model Sensitivities and Design Resiliency
Zone 1 – Cycloned Sand	▪ Cycloned sand tailings are not sensitive to changes in climate conditions during operations, as the inflow of water from hydraulic cell construction will be much greater than inflows from climate, see Appendix IV. As well, the material is relatively free draining and leakage is captured in underdrains. ▪ The leakage estimate for Zone 1 assumed that reclamation of the cycloned sand surface would begin after the end of embankment construction. This assumption added a level of conservatism to the leakage estimate, because, in practice, the cycloned sand embankments will be progressively reclaimed throughout operations to limit net infiltration (and therefore leakage into the foundation).
Zone 2 – Near Dam Scavenger Beach and Zone 3 – Scavenger Beach	▪ KCBCL developed several sensitivity scenarios for the Scavenger Beach Seepage Models to assess the expected range of leakage and capacity of tailings to attenuate water, see Appendix II. The sensitivity scenarios included: ◆ climate (model extreme wet/dry events); and ◆ modeling consolidation. ▪ Results of the sensitivity scenarios indicate that leakage from the scavenger total and scavenger overflow tailings (scavenger beach) is not sensitive to extreme wet/dry precipitation years, and more sensitive to hydraulic conductivity. The hydraulic conductivity for the tailings has been selected based on laboratory testing and benchmarked from similar projects.
Zone 4 – Pyrite Tailings	▪ Results of the Pyrite Cell Low Permeability Layer Leakage Model indicate that the leakage is not sensitive to changes in climate conditions or a change in tailings depth, see Appendix III. ▪ Leakage through the low permeability layer is most sensitive to a change in hydraulic conductivity of the low permeability layer. As such, KCBCL incorporated a level of conservatism in the selection of the low permeability layer hydraulic conductivity for input to the Regional Groundwater Model.

Based on the results of the characterization and assessments completed, the Skunk Camp TSF seepage management plan is expected to be effective at meeting water quality guidelines at the POCs. The seepage mitigation measure designs are resilient with available contingencies.

6 CLOSING

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KCB CONSULTANTS LTD.

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APPENDIX I

Tailings Hydraulic Properties

Appendix I
Tailings Hydraulic Properties

I-1 INTRODUCTION

This document summarizes the tailings hydraulic properties used in the seepage models supporting the Resolution Copper Final Environmental Impact Statement (FEIS). The seepage models include the:

- KCB Consultants Ltd. (KCBCL) Closure Cover Model (KCB 2020, Appendix IV);
- KCBCL Scavenger Beach Seepage-Consolidation Model (Appendix II);
- KCBCL Large Strain Consolidation Model (KCBCL 2020, Appendix V);
- KCBCL Pyrite Cell Low Permeability Layer Leakage Model (Appendix III); and
- Montgomery and Associates (M&A) Regional Groundwater Model (M&A 2020).

Table I-2summarizes the seepage model objectives and tailings hydraulic property inputs.

The Skunk Camp tailings storage facility (TSF) was conceptualized as having four discrete tailings zones for the purposes of the EIS seepage models, as shown on Figure I-1and described on Table I-1. The Near Dam Scavenger Beach tailings (Zone 2) are expected to be coarser and more permeable than the Scavenger Beach tailings (Zone 3) due to their proximity to the tailings discharge points. As such, laboratory tests on scavenger total tailings were assumed representative of the Near Dam Scavenger Beach, and tests on scavenger overflow tailings were assumed representative of the Scavenger Beach.

Figure I-1 Tailings Zone Conceptualization for Seepage Modeling

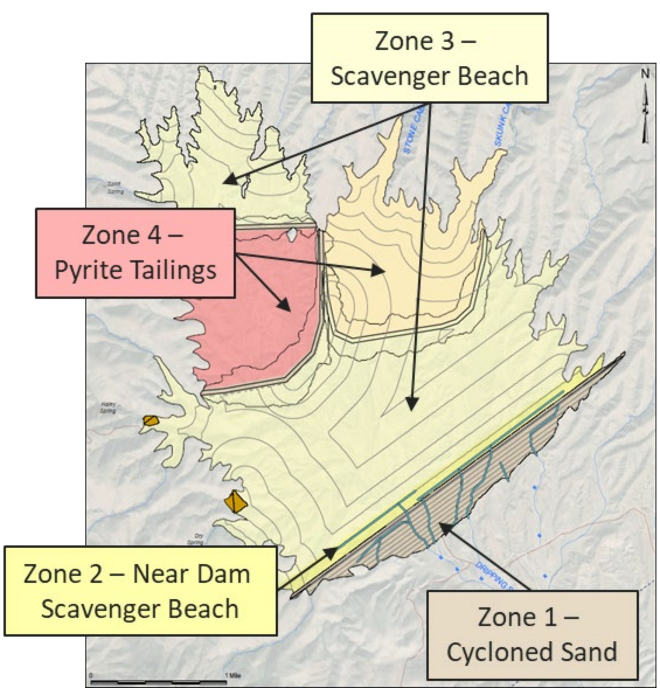


Table I-1 Tailings Zone Conceptualization for Seepage Modeling

Tailings Zone No.	Tailings Zone Name	Tailings Zone Description	Representative Tailings
1	Cycloned Sand	▪ Cross-valley cycloned sand embankment that contains tailings deposited in the Near Dam and Far Beach zones. ▪ Cycloned sand embankment that contains pyrite tailings deposited in Pyrite Cell 1. ▪ Cycloned sand embankment that contains pyrite tailings deposited in Pyrite Cell 2 and scavenger tailings deposited in the North Beach zone.	Cycloned Sand
2	Near Dam Scavenger Beach	▪ Scavenger tailings deposited within 500 ft of the Main Embankment.	Scavenger Total Tailings
3	Scavenger Beach	▪ Scavenger tailings deposited further than 500 ft upstream of the Main Embankment, south of the Pyrite Cells. ▪ Scavenger tailings deposited north of Pyrite Cell 2.	Scavenger Overflow
4	Pyrite Tailings	▪ Pyrite tailings deposited sub aqueously in a low-permeability lined cell #1 from Mine Year 1 to 15. ▪ Pyrite tailings deposited sub aqueously in a low-permeability lined cell #2 from Mine Year 16 to 41.	Pyrite Tailings

KCBCL defined hydraulic parameters for each TSF zone included in the seepage models. The parameters were selected based on:

- Tailings laboratory testing data (Section I-2); and
- Model objective and effective stress domain.

Section I-3 summarizes the tailings hydraulic parameters as well as the supporting rationale and data.

Table I-2 Seepage Model Summary

Model	Software & Dimensions	Model Objective	Tailings Parameters	Parameter Assumptions	Model Reference
Closure Cover Model	Hydrus 1D & TOUGH2 1D	▪ Estimate infiltration into scavenger beach tailings and cycloned sand past extinction depth during closure, after closure cover is placed. ▪ Estimate seepage into foundation from pyrite cell during closure, after closure cover is placed.	▪ Vertical Saturated Hydraulic Conductivity ▪ Porosity ▪ Soil-Water Characteristic Curves	▪ Scavenger beach and cycloned sand properties reflect in situ conditions at low effective stresses. ▪ Cycloned sand properties reflect 98% standard proctor density.	KCBCL 2020, Appendix IV
Scavenger Beach Seepage-Consolidation Model	TOUGH2 1D	▪ Estimate consolidation of scavenger beach tailings during operations. ▪ Estimate seepage from scavenger beach tailings into foundation during operations and closure.	▪ Initial (settled) void ratio ▪ Specific Gravity ▪ Consolidation Functions (porosity – effective stress, vertical saturated hydraulic conductivity – effective stress) ▪ Soil-Water Characteristic Curves	▪ Tailings properties are a function of consolidation (and thus effective stress).	Appendix II
Large Strain Consolidation Model	FS Consol 1D	▪ Estimate consolidation of scavenger beach and pyrite tailings during operations and closure.	▪ Initial (settled) solids content ▪ Specific Gravity ▪ Consolidation Functions (porosity – effective stress, vertical saturated hydraulic conductivity – effective stress)	▪ Tailings properties are a function of consolidation (and thus effective stress).	KCBCL 2020, Appendix V
Pyrite Cell Low Permeability Layer	Seep/W 2D (axisymmetric)	▪ Estimate Effective Porous Medium hydraulic conductivity of 3 ft thick low permeability layer. ▪ Estimate seepage through low permeability layer during operations.	▪ Vertical Saturated Hydraulic Conductivity ▪ Hydraulic Conductivity Anisotropy Ratio	▪ Hydraulic conductivity reflects lower, mid and upper bound values from oedometer consolidation test (Section I-3.3).	Appendix III
Regional Groundwater Model	3D MODFLOW USG	▪ Estimate TSF seepage flow through foundation and assess compliance.	▪ Vertical Saturated Hydraulic Conductivity ▪ Hydraulic Conductivity Anisotropy Ratio ▪ Porosity	▪ Scavenger beach properties based on results of scavenger beach seepage-consolidation model. ▪ Cycloned sand properties reflect 98% standard proctor density. ▪ Pyrite tailings properties reflect average effective stress conditions in Pyrite Cells.	M&A 2020

I-2 HYDRAULIC LABORATORY TESTING

KCBCL compiled tailings laboratory test data from the following laboratory testing programs:

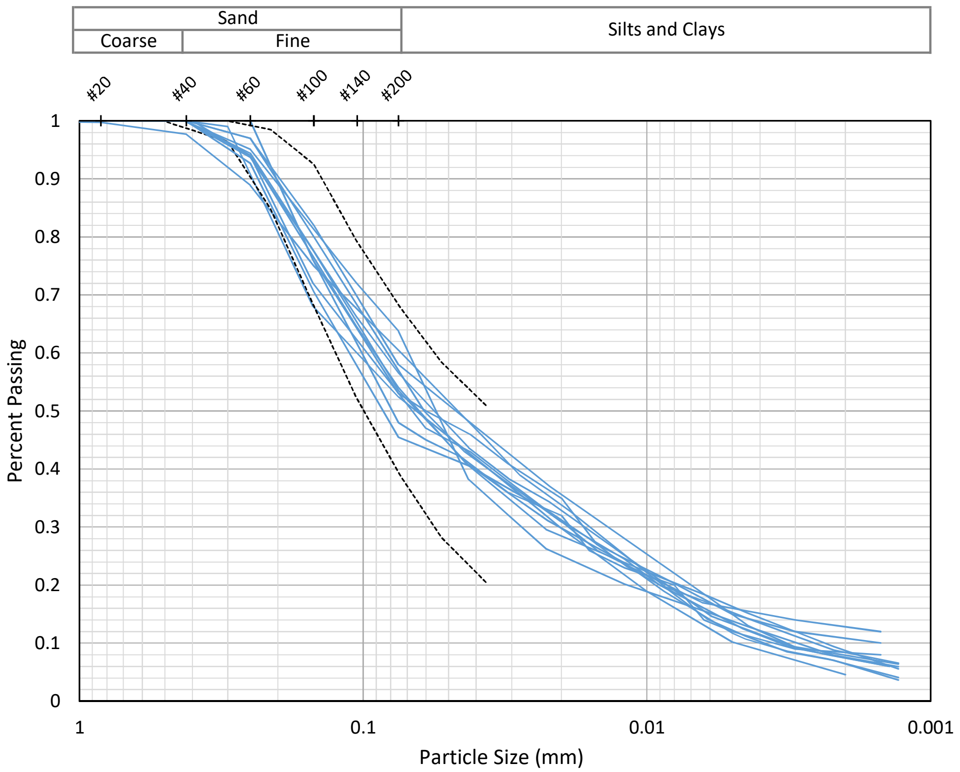
- 2007, 2009 and 2010 programs (KCB 2011): large-strain consolidation tests on scavenger total and cleaner tailings. Cleaner tailings are the sulfidic, potentially acid generating tailings stream from tailings characterization programs prior to 2018.
- 2015 program (KCB 2016, Appendix I): moisture retention and rigid wall permeameter tests on cleaner, scavenger total, scavenger slimes and scavenger beach tailings. Scavenger slimes are scavenger total tailings regraded to represent fine tailings deposited near the reclaim pond (94% fines content). Scavenger beach tailings are scavenger total tailings regraded to represent coarse tailings deposited near the spigots (25% fines content).
- 2018 program (KCB 2018): standard Proctor, settling, consolidation, flexible wall permeameter (triaxial permeability), rigid wall permeameter and moisture retention tests on scavenger total, scavenger overflow, scavenger beach composite, cycloned sand and pyrite tailings. The beach composite is a sample produced by placing alternating layers of scavenger overflow (70%) and total tailings (30%) to model an interlayered beach deposit.
- 2019 program (KCBCL 2020, Appendix I): moisture retention and rigid wall permeameter tests on pyrite tailings.
- 2020 program (Appendix I-A): seepage induced consolidation tests on scavenger total and scavenger overflow tailings.

Table I-3 summarizes the available laboratory test data. The test results are presented on Figure I-2, Figure I-3, Figure I-4 and Figure I-5.

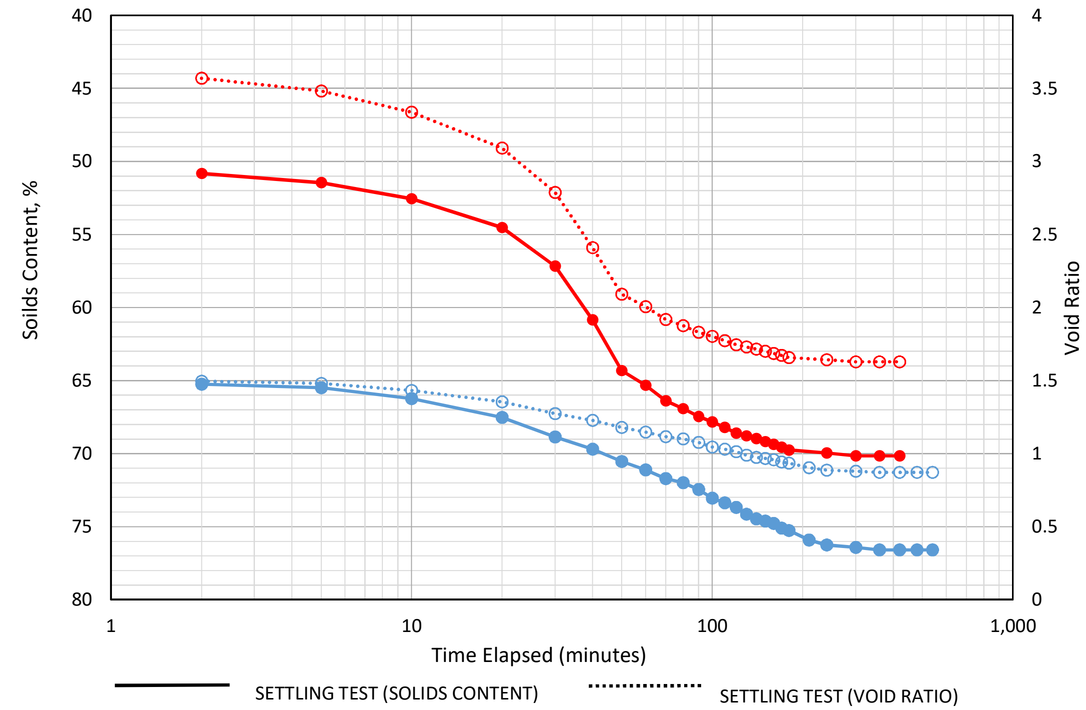
Table I-3 Tailings Laboratory Test Summary

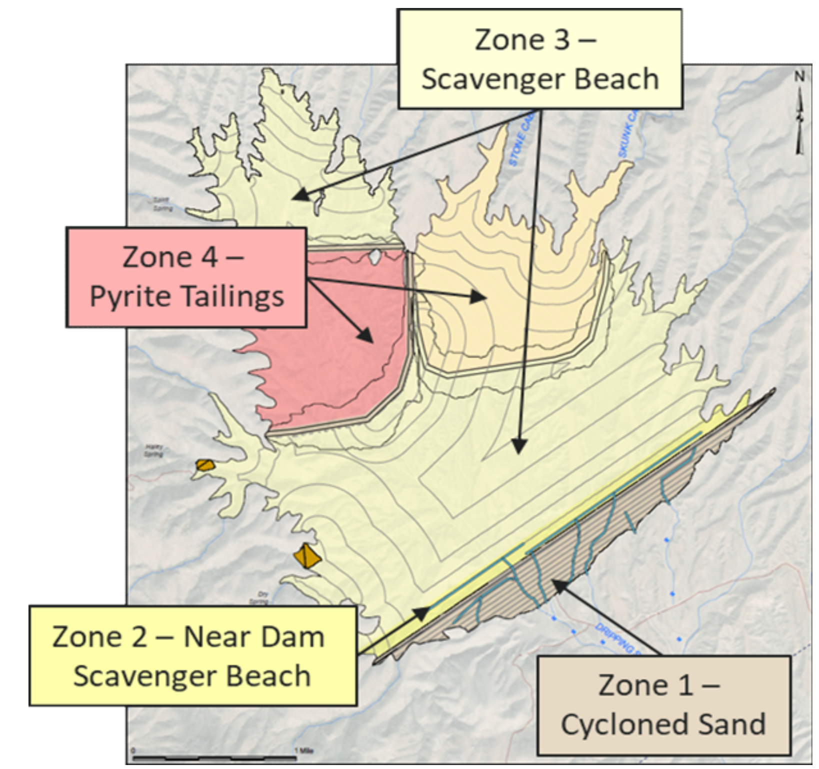
Material	Index (Figure I-2)		Consolidation (Figure I-3)				Flexible Wall Permeameter (Figure I-4)	Rigid Wall Permeameter & Moisture Retention (Figure I-4and Figure I-5)
	Standard Proctor	Slurry Settling	Seepage-Induced	Oedometer	Rowe Cell	Large Strain		
Cycloned Sand	2018: 1 test Optimum Moisture Content: 13% Maximum Dry Density: 101.5 pcf	-	-	2018: 3 tests	-	no tests	2018: 1 test	2018: 1 test
Scavenger Total Tailings	2018: 3 tests	2018: 1 test	2020: 1 test	2018: 4 tests	-	2007: 1 test 2009: 1 test 2010: 4 tests	2018: 3 tests	2015: 1 test 2018: 2 tests
Scavenger Overflow	-	-	2020: 1 test	2018: 3 tests	-	-	2018: 2 tests	2018: 2 tests
Pyrite Tailings	-	2018: 1 test	-	2018: 1 test	2018: 1 test	-	2018: 1 test	2019: 1 moisture retention test, 2 rigid wall permeameter tests

Scavenger Total Tailings (Zone 2) Gradations

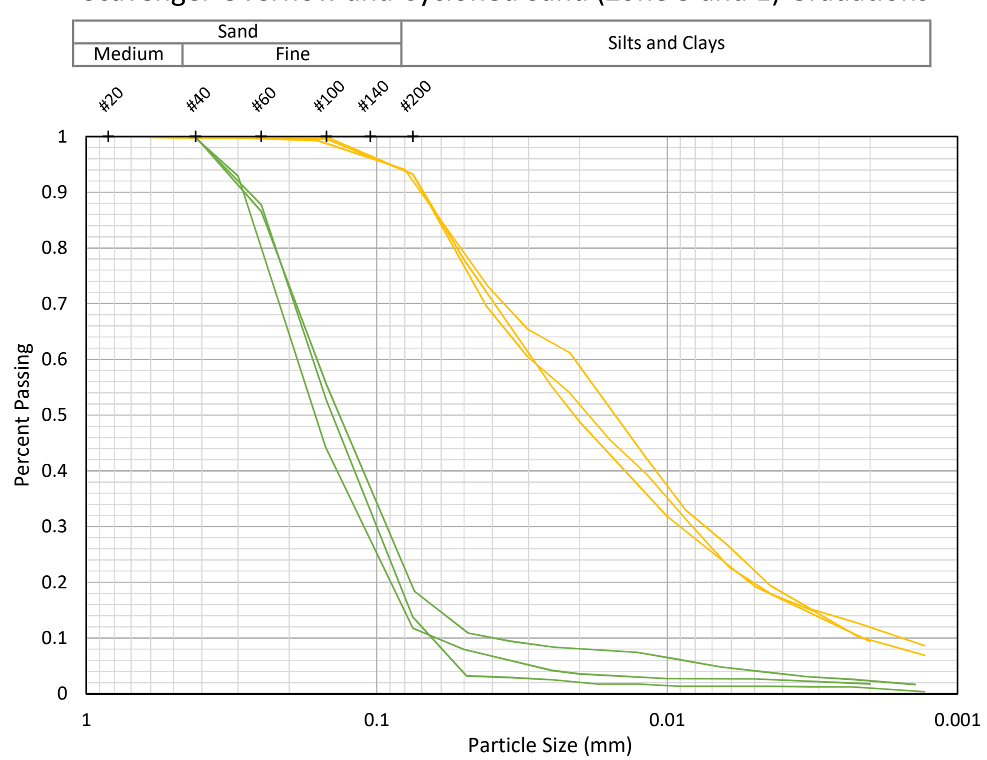


Standpipe Settling Tests

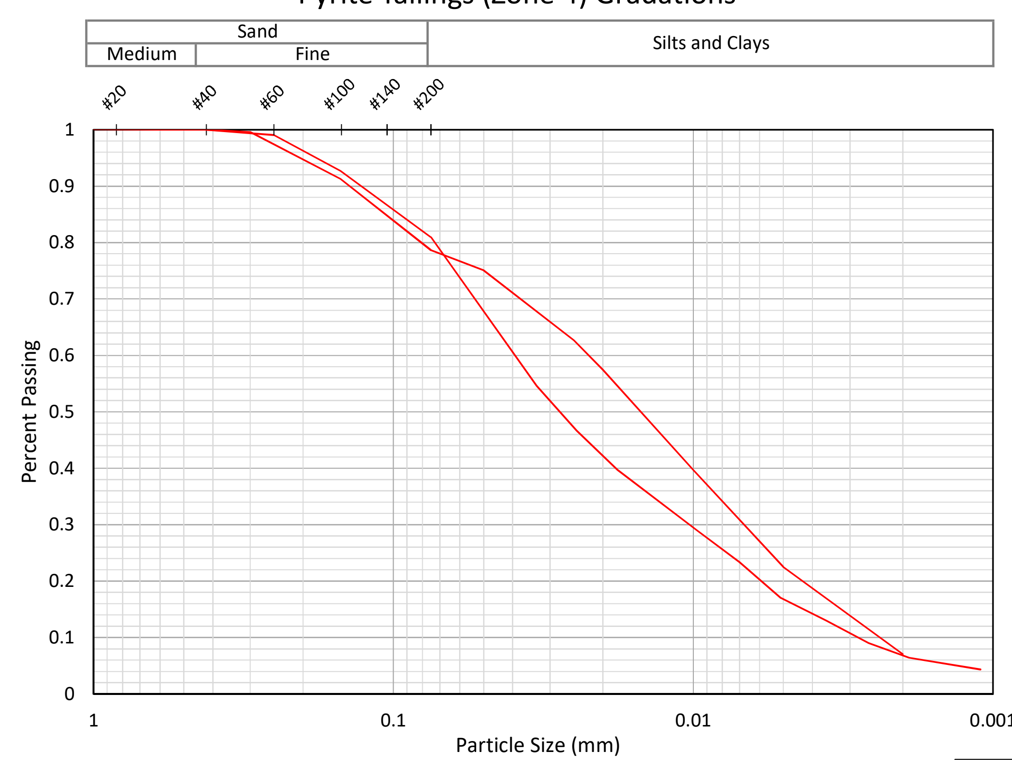




Scavenger Overflow and Cycloned Sand (Zone 3 and 1) Gradations



Pyrite Tailings (Zone 4) Gradations



LEGEND

CYCLONED SAND (ZONE 1)
SCAVENGER TOTAL TAILINGS (ZONE 2)
SCAVENGER TOTAL MILL RANGE (ZONE 2)
SCAVENGER OVERFLOW (ZONE 3)
PYRITE TAILINGS (ZONE 4)

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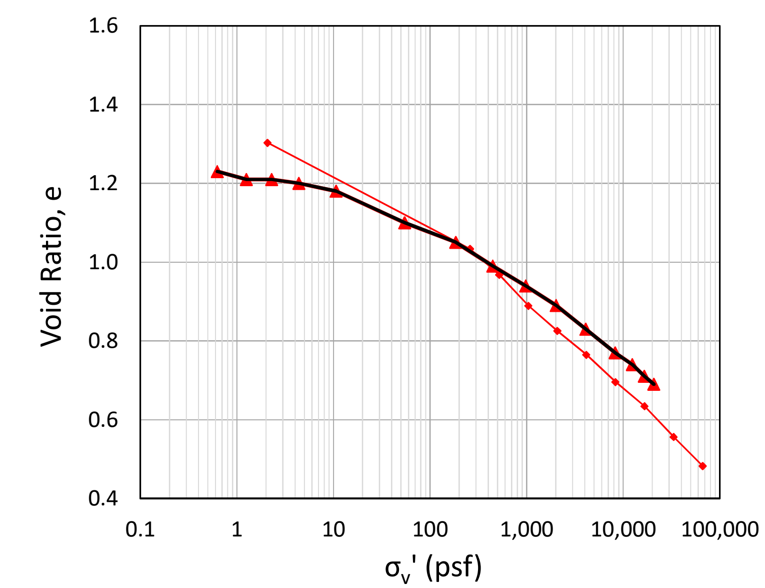
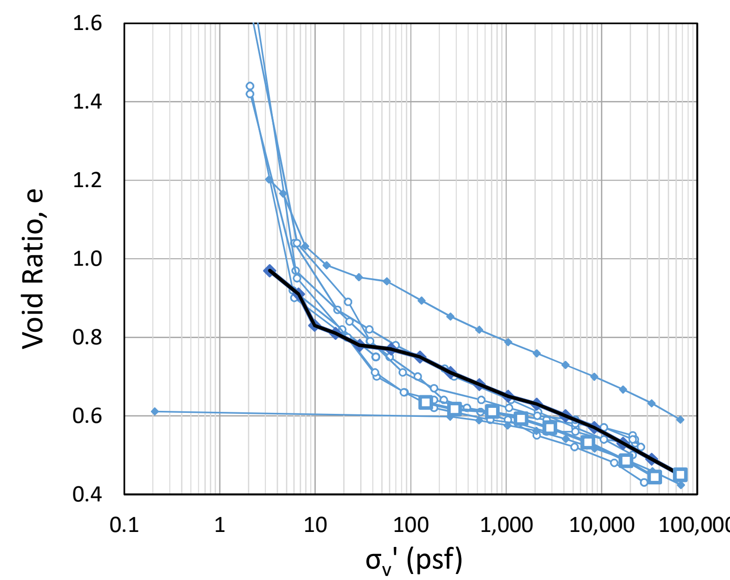
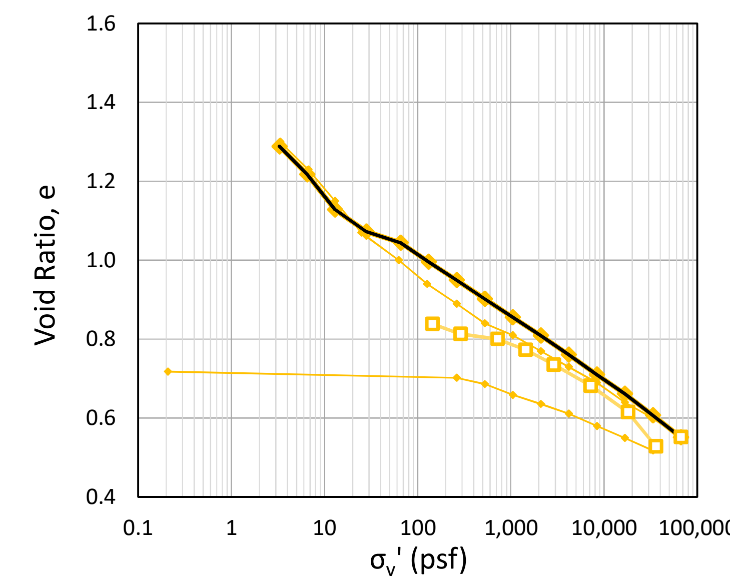
SKUNK CAMP TSF SEEPAGE ASSESSMENT

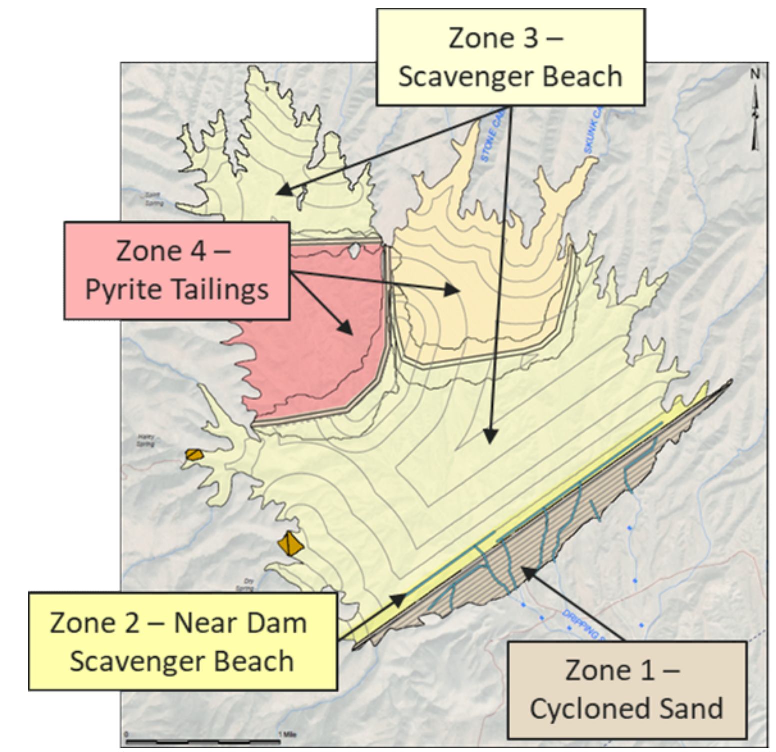
TITLE
GRADATION AND SETTLING TEST SUMMARY

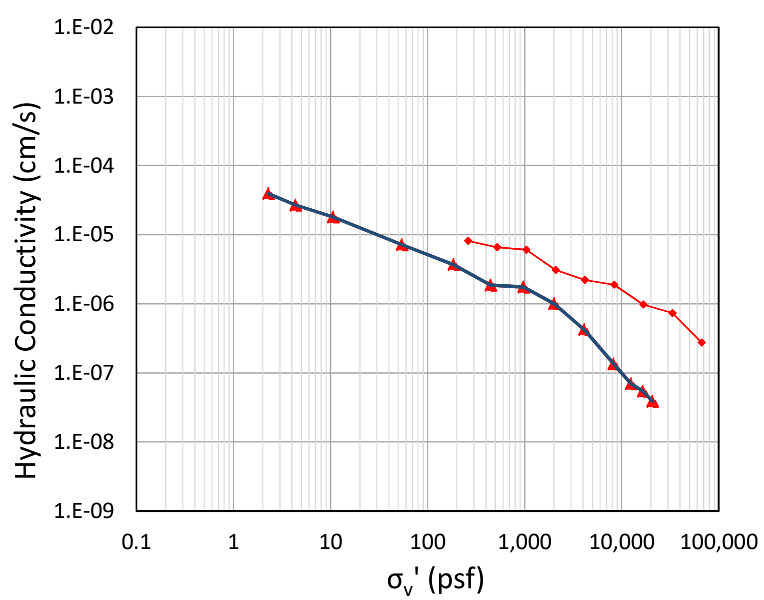
PROJECT No. UM09441A22
No. I-2

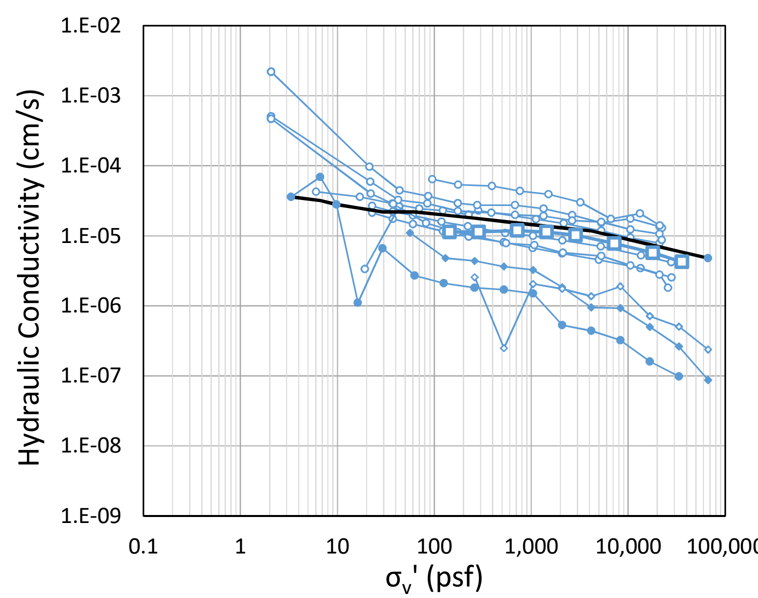


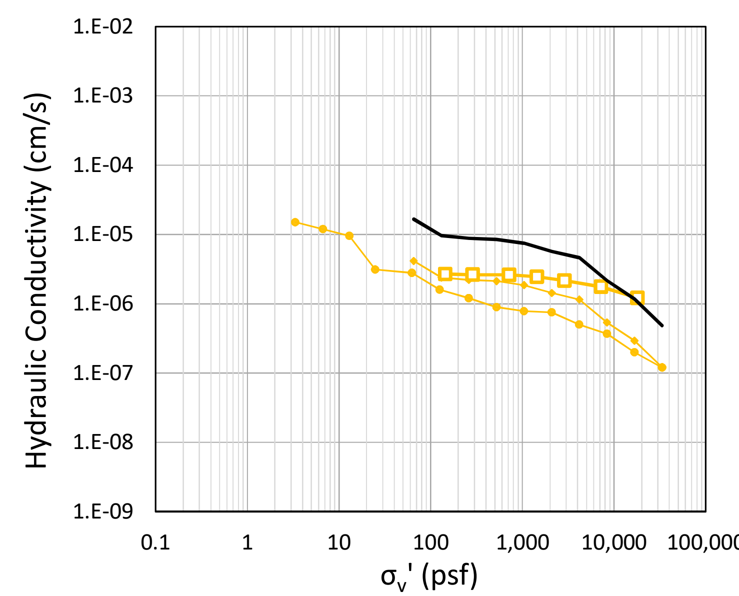












LEGEND

- LARGE-STRAIN CONSOLIDATION
- ROWE CELL
- OEDOMETER
- SEEPAGE INDUCED CONSOLIDATION TEST

- SCAVENGER TOTAL TAILINGS (ZONE 2) LABORATORY TESTS
- SCAVENGER OVERFLOW (ZONE 3) LABORATORY TESTS
- PYRITE TAILINGS (ZONE 4) LABORATORY TESTS
- KCBCL SCAVENGER BEACH SEEPAGE-CONSOLIDATION (APPENDIX II) & PYRITE CELL CONSOLIDATION (KCBCL 2020, APPENDIX V) MODEL PARAMETERS

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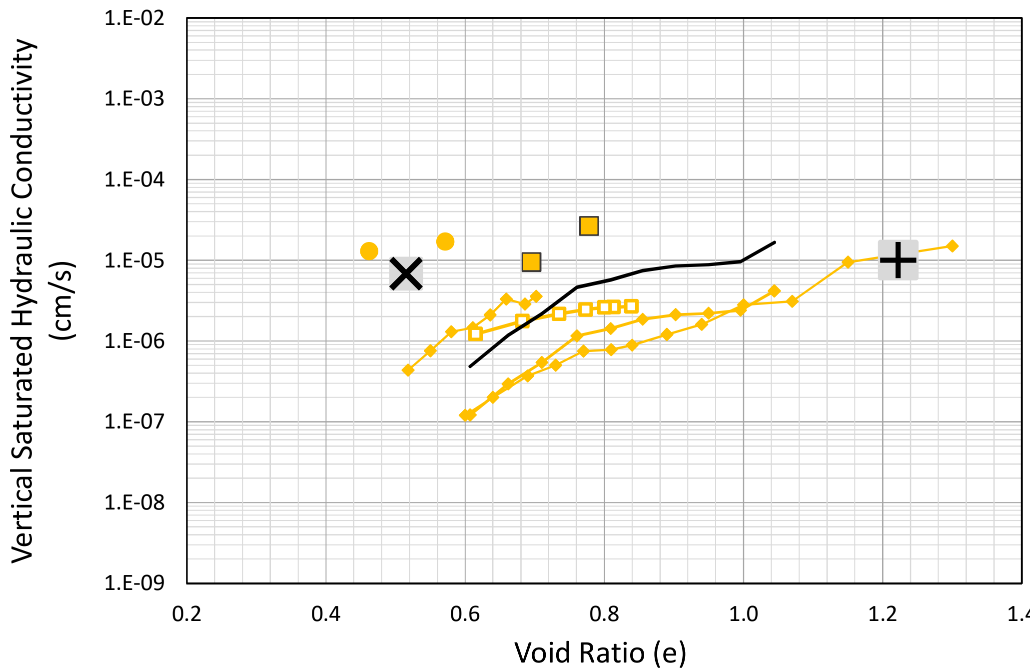
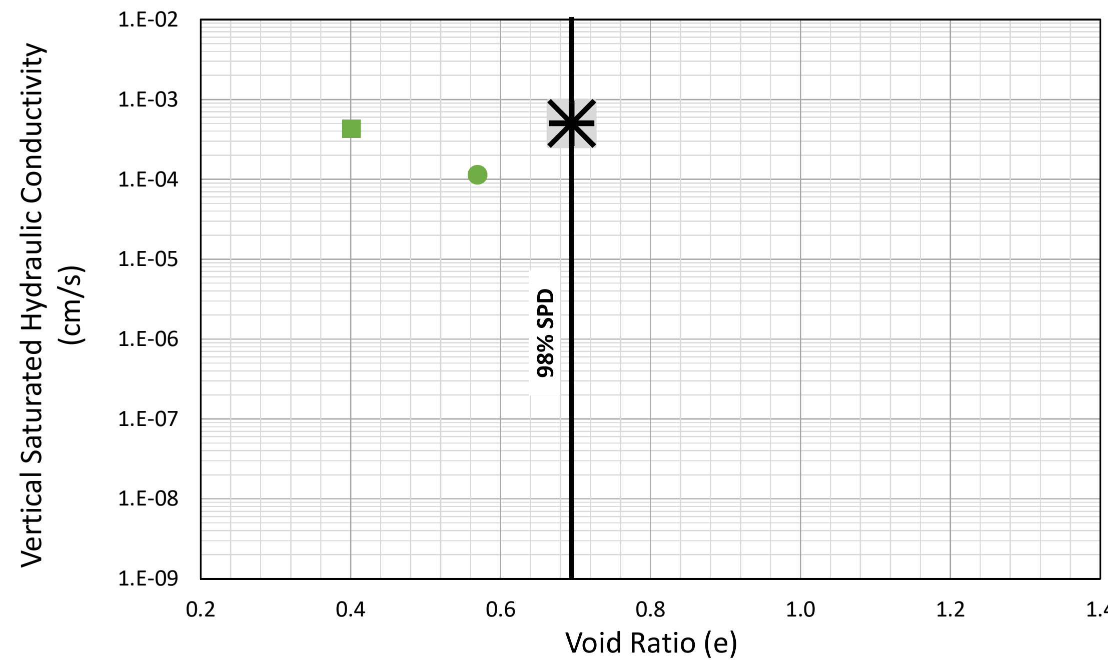
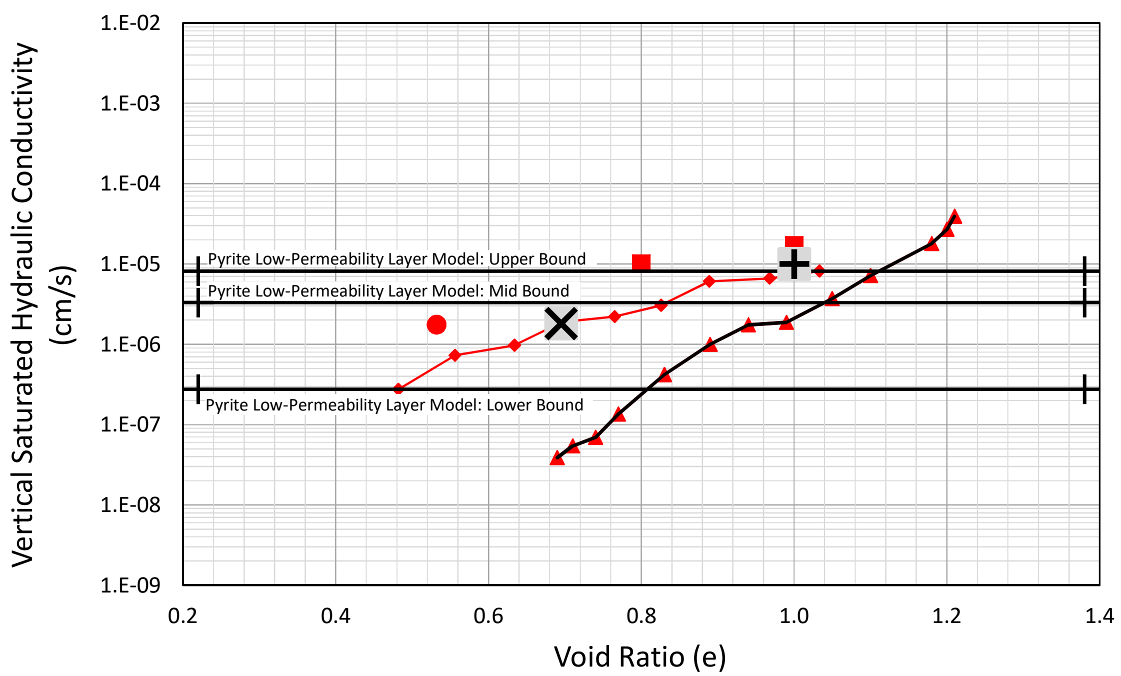


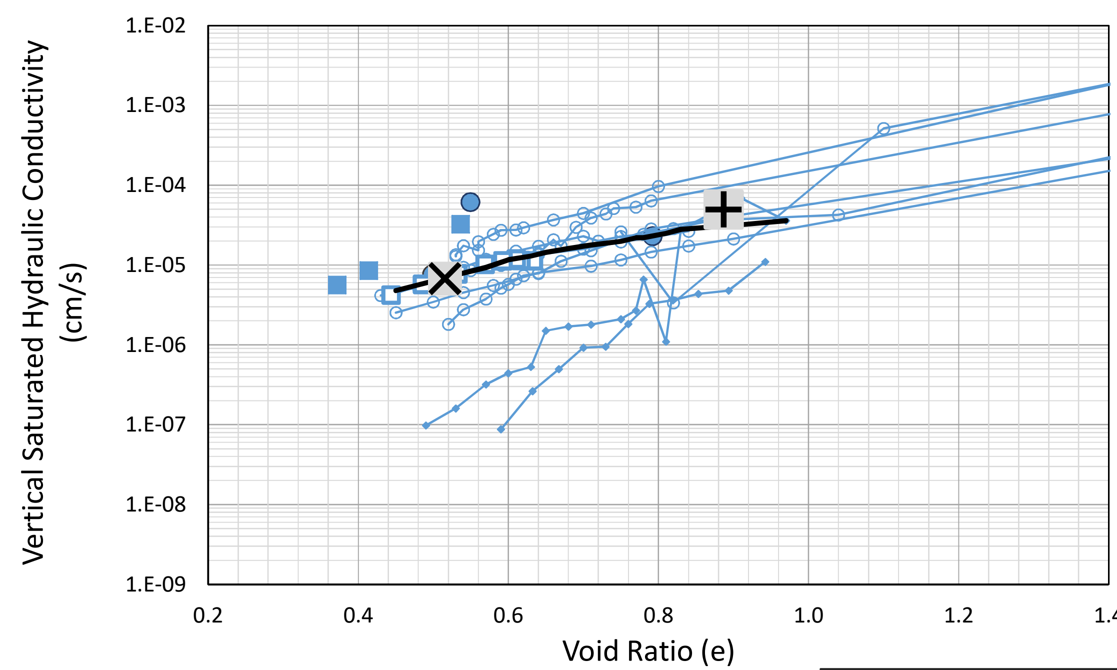


LEGEND

TAILINGS LABORATORY TEST RESULTS

- CYCLONED SAND (ZONE 1) LABORATORY TEST
- SCAVENGER TOTAL TAILINGS (ZONE 2) LABORATORY TEST
- SCAVENGER OVERFLOW (ZONE 3) LABORATORY TEST
- PYRITE TAILINGS (ZONE 4) LABORATORY TEST
- LARGE-STRAIN CONSOLIDATION
- OEDOMETER
- ROWE CELL
- SEEPAGE INDUCED CONSOLIDATION TEST
- RIGID WALL PERMEAMETER
- FLEXIBLE WALL PERMEAMETER





SEEPAGE MODEL PARAMETERS

- M&A 3D REGIONAL GROUNDWATER MODEL Kv (M&A 2020)
- KCBCL SCAVENGER BEACH SEEPAGE-CONSOLIDATION (APPENDIX II) & PYRITE CELL CONSOLIDATION Kv (KCBCL 2020, APPENDIX V)
- KCBCL CLOSURE COVER MODEL Kv (KCBCL 2020, APPENDIX IV)
- KCBCL PYRITE CELL LOW PERMEABILITY LAYER LEAKAGE MODEL Kv (APPENDIX III)

Notes

1. M&A Regional Groundwater Model parameters are the average void ratio and hydraulic conductivity from the Near Dam Scavenger Beach (Zone 2) profile of the KCBCL Scavenger Beach Seepage-Consolidation Model (Appendix II) at the end of operations.

2. KCBCL Closure Cover Model parameters reflect in-situ conditions at shallow depths (low effective stresses).

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SKUNK CAMP TSF SEEPAGE ASSESSMENT

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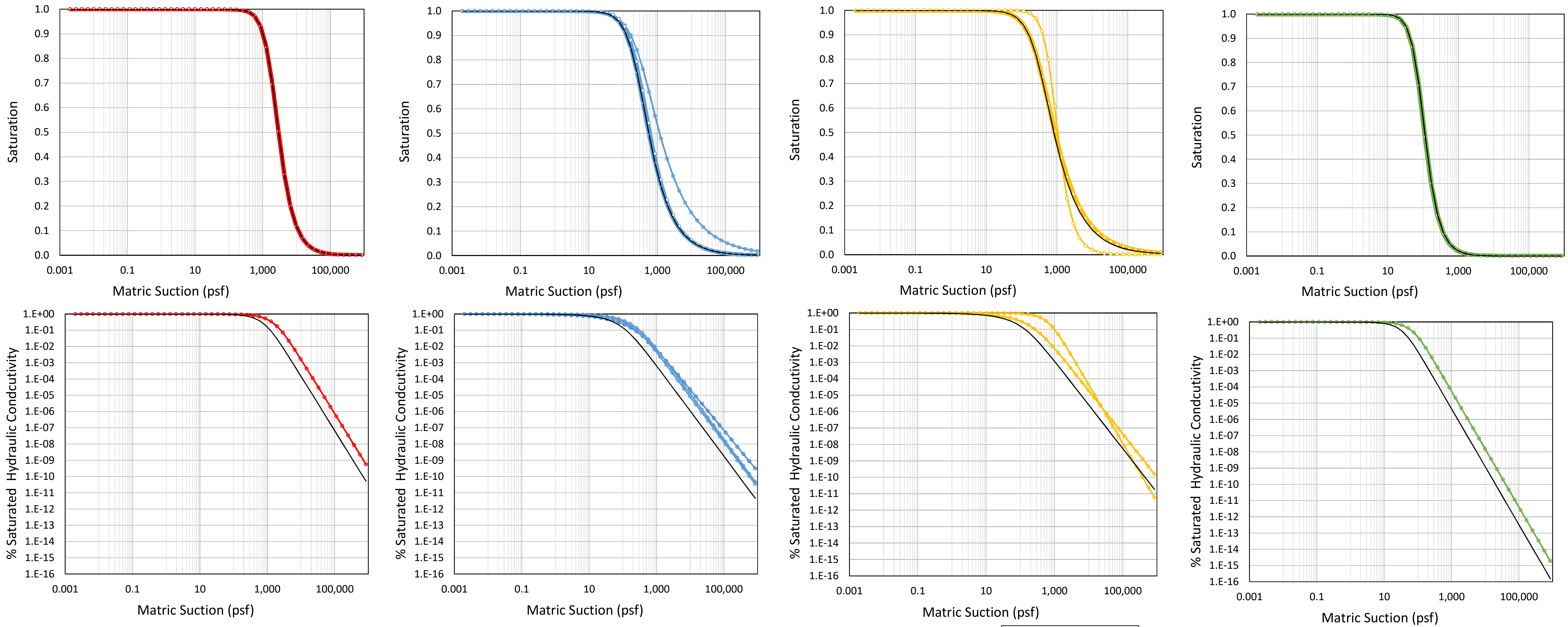
HYDRAULIC CONDUCTIVITY TO VOID RATIO FUNCTION

PROJECT No. UM09441A22

No. I-4



LEGEND

- CYCLONED SAND (ZONE 1)
- SCAVENGER TOTAL TAILINGS (ZONE 2)
- SCAVENGER OVERFLOW (ZONE 3)
- PYRITE TAILINGS (ZONE 4)
- TEMPE CELL TEST
- KCBCL SCAVENGER BEACH SEEPAGE-CONSOLIDATION MODEL (APPENDIX II) AND COVER MODEL INPUT PARAMETERS (KCBCL 2020, APPENDIX IV)

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PROJECT

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SKUNK CAMP TSF SEEPAGE ASSESSMENT

TITLE

NORMALIZED SOIL WATER CHARACTERISTIC CURVES AND HYDRAULIC CONDUCTIVITY FUNCTIONS

PROJECT No. UM09441A22

No. I-5

I-3 TAILINGS PARAMETERS FOR SEEPAGE MODELS

Table I-4 summarizes the tailings hydraulic parameters for the five seepage models. The following sections outline the rationale and data supporting the hydraulic parameters.

Table I-4 Tailings Hydraulic Parameters Summary

<table>
<tr><th rowspan="2">Tailings Zone</th><th rowspan="2">Seepage Model</th><th rowspan="2">In situ Porosity (n) [1]</th><th rowspan="2">Vertical Saturated Hydraulic Conductivity (K_v) (cm/s)</th><th rowspan="2">Anisotropy Ratio (K_h/K_v)</th><th rowspan="2">Initial Settled Porosity (n) [2]</th><th rowspan="2">Specific Gravity</th><th colspan="3">Van Genuchten Parameters</th></tr>
<tr><th>Residual Saturation</th><th>Alpha (1/cm)</th><th>N</th></tr>
<tr><td rowspan="2">Zone 1: Cycloned Sand</td><td>Closure Cover</td><td rowspan="2">0.41</td><td rowspan="2">$5x10^{-4}$</td><td>N/A</td><td>N/A</td><td>N/A</td><td>0.015</td><td>0.024</td><td>2.568</td></tr>
<tr><td>Regional Groundwater</td><td>5</td><td>N/A</td><td>N/A</td><td colspan="3">N/A</td></tr>
<tr><td rowspan="4">Zone 2: Near Dam Scavenger Beach (Scavenger Total Tailings)</td><td>Closure Cover</td><td>0.47</td><td>$5x10^{-5}$</td><td>N/A</td><td>N/A</td><td>N/A</td><td rowspan="2">0.013</td><td rowspan="2">0.0077</td><td rowspan="2">1.783</td></tr>
<tr><td>Scavenger Beach Seepage-Consolidation</td><td rowspan="2">0.31 – 0.44</td><td rowspan="2">$5x10^{-6}$ – $4x10^{-5}$</td><td>N/A</td><td rowspan="2">0.44</td><td rowspan="2">2.80</td></tr>
<tr><td>Large Strain Consolidation</td><td>N/A</td><td colspan="3">N/A</td></tr>
<tr><td>Regional Groundwater</td><td>0.34</td><td>$7x10^{-6}$</td><td>10</td><td>N/A</td><td>N/A</td><td colspan="3">N/A</td></tr>
<tr><td rowspan="4">Zone 3: Scavenger Beach (Scavenger Overflow)</td><td>Closure Cover</td><td>0.55</td><td>$1x10^{-5}$</td><td>N/A</td><td>N/A</td><td>N/A</td><td rowspan="2">0.0040</td><td rowspan="2">0.0062</td><td rowspan="2">1.673</td></tr>
<tr><td>Scavenger Beach Seepage-Consolidation</td><td rowspan="2">0.36 – 0.52</td><td rowspan="2">$5x10^{-7}$ – $2x10^{-5}$</td><td>N/A</td><td rowspan="2">0.52</td><td rowspan="2">2.80</td></tr>
<tr><td>Large Strain Consolidation</td><td>N/A</td><td colspan="3">N/A</td></tr>
<tr><td>Regional Groundwater</td><td>0.34</td><td>$7x10^{-6}$</td><td>10</td><td>N/A</td><td>N/A</td><td colspan="3">N/A</td></tr>
<tr><td rowspan="4">Zone 4: Pyrite Tailings</td><td>Closure Cover</td><td>0.50</td><td>$1x10^{-5}$</td><td>N/A</td><td>N/A</td><td>N/A</td><td>0.0020</td><td>0.0010</td><td>2.347</td></tr>
<tr><td>Large Strain Consolidation</td><td>0.41 – 0.59</td><td>$4x10^{-8}$ – $4x10^{-5}$</td><td>N/A</td><td>0.59</td><td>3.58</td><td colspan="3">N/A</td></tr>
<tr><td>Pyrite Cell Low Permeability Layer</td><td>N/A</td><td>$3x10^{-7}$ – $3x10^{-6}$</td><td rowspan="2">5</td><td>N/A</td><td>N/A</td><td colspan="3">N/A</td></tr>
<tr><td>Regional Groundwater</td><td>0.41</td><td>$2x10^{-6}$</td><td>N/A</td><td>N/A</td><td colspan="3">N/A</td></tr>
</table>

Notes:

1. In situ porosity over each model's time domain. Porosity and void ratio were assumed constant over life of mine and post-closure for the Closure Cover and Regional Groundwater models. Porosity varies over life of mine and is constant post-closure for the Scavenger Beach Seepage-Consolidation model to account for consolidation. Porosity varies over life of mine and post-closure for the Large-Strain Consolidation model.
2. Initial condition for porosity in the Scavenger Beach Seepage-Consolidation and Large-Strain Consolidation models.

I-3.1 Closure Cover Model Parameters

Table I-5summarizes the hydraulic parameters for the closure cover model. The objectives of the closure cover model are to:

- Estimate infiltration into the scavenger tailings (Zones 1 (Cycloned Sand), 2 (Near Dam Scavenger Beach) and 3 (Scavenger Beach)) during closure, after the closure cover is placed.
- Estimate seepage into the foundation from the pyrite tailings during closure, after the closure cover is placed.

Appendix IV of the Skunk Camp Reclamation Plan (KCBCL 2020) describes the modeling approach, inputs and results. KCBCL specified hydraulic parameters for the scavenger tailings models (Zones 1, 2 and 3) that are representative of in situ conditions at shallow depths (less than 10 ft) based on the results of the KCB 2018 tailings testing program (KCB 2018). Parameters for the pyrite tailings (Zone 4) also reflect relatively low effective stresses (100 psf to 1000 psf) to provide conservatively high estimates for hydraulic conductivity and seepage rates. Hydraulic properties were selected as follows:

- Porosity or Void Ratio – see Figure I-4:
  - Cycloned Sand (Zone 1): 98% of maximum standard Proctor density (KCB 2018).
  - Near Dam Scavenger Beach (Zone 2): per KCB 2018 standpipe settling test on scavenger total tailings.
  - Scavenger Beach (Zone 3): per KCB 2018 oedometer test on scavenger overflow tailings at low effective stresses (10 psf to 100 psf).
  - Pyrite Tailings (Zone 4): per KCB 2018 oedometer test on pyrite tailings at effective stresses of 100 psf to 1000 psf.
- Vertical Saturated Hydraulic Conductivity – see Figure I-4:
  - Cycloned Sand (Zone 1): per GeoSystems Analysis 2018 flexible wall permeameter test (KCB 2018).
  - Near Dam Scavenger Beach (Zone 2): per KCB 2018 oedometer test on scavenger total tailings at low effective stresses (10 psf to 100 psf).
  - Scavenger Beach (Zone 3): per KCB 2018 oedometer test on scavenger overflow tailings at low effective stresses.
  - Pyrite Tailings (Zone 4): per KCB 2018 oedometer test on pyrite tailings at effective stresses of 100 psf to 1000 psf.
- Van Genuchten Unsaturated Flow Parameters (residual water content, alpha and N) – see Figure I-5:
  - All tailings: per Geo Systems Analysis 2018 and 2019 moisture retention test (KCB 2018, KCBCL 2020 Appendix I). The residual water content is the residual saturation measured by the moisture retention tests multiplied by the porosities summarized on Table I-5.

Table I-5 Closure Cover Modeling Parameters

Tailings Zone	Porosity	Vertical Saturated Hydraulic Conductivity	Van Genuchten Parameters		
			Residual Water Content	Alpha	N
	cm^3/cm^3	cm/s	cm^3/cm^3	1/cm	n/a
Zone 1: Cycloned Sand	0.41	$5x10^{-4}$	0.006	0.024	2.568
Zone 2: Near Dam Scavenger Beach	0.47	$5x10^{-5}$	0.006	0.0077	1.783
Zone 3: Scavenger Beach	0.55	$1x10^{-5}$	0.002	0.0062	1.673
Zone 4: Pyrite Tailings	0.50	$1x10^{-5}$	0.001	0.001	2.347

I-3.2 Scavenger Beach Seepage-Consolidation Model and Large Strain Consolidation Model Parameters

Table I-6 summarizes the hydraulic parameters for the Scavenger Beach Seepage-Consolidation model. The model evaluates consolidation during operations and one-dimensional seepage during operations and closure in the scavenger beach (Zones 2 and 3), as described in Appendix II.

Table I-7 summarizes the hydraulic parameters for the large-strain consolidation model from the Skunk Camp TSF Reclamation Plan (KCBCL 2020, Appendix V). The large-strain model evaluates consolidation of the scavenger beach tailings (Zones 2 and 3) and pyrite tailings (Zone 4) during operations and closure.

KCBCL selected hydraulic parameters for the consolidation models that reflect tailings properties at deposition as well as at the range of stresses expected within the TSF over the life of mine. The parameters were selected as follows:

- Initial Settled Porosity or Void Ratio (porosity or void ratio shortly after deposition, after the tailings have separated from the bleed water):
  - Near Dam Scavenger Beach (Zone 2): per KCB 2018 oedometer test on scavenger total tailings at low effective stresses (10 psf to 100 psf).
  - Scavenger Beach (Zone 3): per KCB 2018 oedometer test on scavenger overflow tailings at low effective stresses (10 psf to 100 psf).
  - Pyrite Tailings (Zone 4): per KCB 2018 standpipe settling test on pyrite tailings.
- Specific Gravity:
  - All tailings: from index testing (KCB 2018).
- Porosity or Void Ratio vs. Effective Stress functions – see Figure I-3:
  - Near Dam Scavenger Beach (Zone 2): per KCB 2018 oedometer test on scavenger total tailings.

- Scavenger Beach (Zone 3): per KCB 2018 oedometer test on scavenger overflow tailings.
- Pyrite Tailings (Zone 4): per KCB 2018 Rowe cell test on pyrite tailings. KCBCL specified the pyrite tailings consolidation functions with the Rowe Cell test instead of the oedometer test because the Rowe cell test measured hydraulic conductivity over a wider range of effective stresses. This was required to evaluate consolidation at shallow depths.

- Vertical Saturated Hydraulic Conductivity vs. Effective Stress functions – see Figure I-3:
  - Near Dam Scavenger Beach (Zone 2): per KCB 2018 oedometer test on scavenger total tailings.
  - Scavenger Beach (Zone 3): per KCB 2018 oedometer test on scavenger overflow tailings. KCBCL adjusted the hydraulic conductivity to void ratio curves from the oedometer test to reflect the higher hydraulic conductivities measured by the 2018 flexible and rigid wall permeameter tests, as shown on Figure I-4.
  - Pyrite Tailings (Zone 4): per KCB 2018 Rowe cell test on pyrite tailings.
- Van Genuchten Unsaturated Flow Parameters (residual saturation, alpha and n) – see Figure I-5:
  - All tailings: KCBCL normalized the soil water characteristic curves from the GeoSystems Analysis 2018 moisture retention tests (KCB 2018) for use in the Scavenger Beach Seepage-Consolidation model.

Table I-6 Scavenger Beach Seepage-Consolidation Model Parameters

Material	Initial Settled Porosity [1]	Specific Gravity	Porosity [2]	Vertical Saturated Hydraulic Conductivity	Van Genuchten Parameters		
					Residual Saturation	Alpha	N
	cm^3/cm^3	-	cm^3/cm^3	cm/s	cm^3/cm^3	1/cm	N/A
Zone 2: Near Dam Scavenger Beach	0.44	2.80	0.31 – 0.44	$5x10^{-6} – 4x10^{-5}$	0.013	0.0077	1.783
Zone 3: Scavenger Beach	0.52	2.80	0.36 – 0.52	$5x10^{-7} – 2x10^{-5}$	0.0040	0.0062	1.673

Notes:
1. Initial condition for porosity.
2. Porosity varies over life of mine to account for consolidation.

Table I-7 Large Strain Consolidation Model Parameters

Material	Initial Settled Porosity [1]	Specific Gravity	Porosity [2]	Vertical Saturated Hydraulic Conductivity
	cm^3/cm^3	-	cm^3/cm^3	cm/s
Zone 2: Near Dam Scavenger Beach	0.44	2.80	0.31 – 0.44	$5x10^{-6} – 4x10^{-5}$
Zone 3: Scavenger Beach	0.52	2.80	0.36 – 0.52	$5x10^{-7} – 2x10^{-5}$
Zone 4: Pyrite Tailings	0.59	3.58	0.41 – 0.59	$4x10^{-8} – 4x10^{-5}$

Notes:
1. Initial condition for porosity.
2. Porosity varies over life of mine and post-closure to account for consolidation.

I-3.3 Pyrite Cell Low Permeability Layer Model Parameters

Table I-8 summarizes the hydraulic parameters for the Pyrite Cell Low Permeability Layer model. The parameters were specified as follows:

- Hydraulic Conductivity: per KCB 2018 oedometer test on pyrite tailings. KCBCL specified the range of pyrite tailings hydraulic conductivities based on the results of the oedometer test because it measured higher conductivities that the Rowe cell test. The oedometer results were considered more conservative for the purpose of the low permeability layer model.
- Anisotropy Ratio: KCBCL specified an anisotropy ratio of 5 for the pyrite tailings to reflect sub-aqueous deposition. Subaqueous deposition could result in an anisotropy ratio from 1 to 10, depending on the conditions during deposition (flow rate, solids content, height of water, deposition topography), a kh/kv was chosen to be a mid-point, the model results are not expected to be sensitive to this value.

Table I-8 Pyrite Cell Low Permeability Layer Model Parameters

Material	Vertical Saturated Hydraulic Conductivity cm/s	Anisotropy Ratio (K_h/K_v) -
Zone 4: Pyrite Tailings	$3x10^{-7} – 3x10^{-6}$	5

I-3.4 Three-Dimensional Regional Groundwater Model Parameters

Table I-9 summarizes the tailings hydraulic parameters for the regional groundwater model. The parameters were specified as follows:

- Porosity or void ratio – see Figure I-4:
  - Cycloned Sand (Zone 1): 98% of maximum standard proctor density (KCB 2018).
  - Near Dam Scavenger Beach (Zone 2) and Scavenger Beach (Zone 3): average porosity expected within the scavenger beach based on the results of the Scavenger Beach Seepage-Consolidation Model (Appendix II).
  - Pyrite Tailings (Zone 4): average porosity or void ratio expected within the pyrite cells based on the 2018 KCB oedometer test on pyrite tailings (Figure I-3).
- Vertical Saturated Hydraulic Conductivity – see Figure I-4:
  - Cycloned Sand (Zone 1): per GeoSystems Analysis 2018 flexible wall permeameter test (KCB 2018).
  - Near Dam Scavenger Beach (Zone 2) and Scavenger Beach (Zone 3): average vertical hydraulic conductivity expected within the scavenger beach based on the results of the Scavenger Beach Seepage-Consolidation Model (Appendix II).

    - Pyrite Tailings (Zone 4): average vertical hydraulic conductivity expected within the pyrite cells based on the 2018 KCB oedometer test on pyrite tailings (Figure I-3).

- Anisotropy Ratio:
    - Cycloned Sand (Zone 1): based on construction method. Hydraulic cell construction could result in an anisotropy ratio from 1 to 10, depending on slimes segregation. The anisotropy ratio was chosen to be a mid-point, the model results are not expected to be sensitive to this value.
    - Near Dam Scavenger Beach (Zone 2) and Scavenger Beach (Zone 3): based on the composition of the scavenger beach. The scavenger beach will likely consist of interbedded layers of scavenger total tailings and lower-permeability scavenger overflow. This will likely result in greater anisotropy than the cycloned sand and pyrite tailings.
    - Pyrite Tailings (Zone 4): based on deposition method (subaqueous). Subaqueous deposition could result in an anisotropy ratio from 1 to 10, depending on the conditions during deposition (flow rate, solids content, height of water, deposition topography), an anisotropy ratio was chosen to be a mid-point, the model results are not expected to be sensitive to this value.

Table I-9 Regional Groundwater Model Parameters

<table>
<tr><th>Material</th><th>Porosity
cm³/cm³</th><th>Vertical Saturated Hydraulic Conductivity
cm/s</th><th>Anisotropy Ratio (K_h/K_v)
-</th></tr>
<tr><td>Zone 1: Cycloned Sand</td><td>0.41</td><td>$5x10^{-4}$</td><td>5</td></tr>
<tr><td>Zone 2: Near Dam Scavenger Beach</td><td rowspan="2">0.34</td><td rowspan="2">$7x10^{-6}$</td><td rowspan="2">10</td></tr>
<tr><td>Zone 3: Scavenger Beach</td></tr>
<tr><td>Zone 4: Pyrite Tailings</td><td>0.41</td><td>$2x10^{-6}$</td><td>5</td></tr>
</table>

Attachments: Appendix I-A – Consolidation Tests

REFERENCES

Klohn Crippen Berger Ltd. (KCB). 2011. Resolution Project: 2010 Geotechnical Testing of Tailings Samples. January 12.

Klohn Crippen Berger (KCB). 2016. Resolution Copper Project: Near West Tailings Storage Facility Closure Cover Study. March.

Klohn Crippen Berger. (KCB). 2018. Tailings Storage Facility DEIS Designs: Tailings Geotechnical Characterization. Doc. # CCC.03-26000-EX-REP-00001. June.

KCB Consultants Ltd. (KCBCL). 2020. Resolution Copper Project: Skunk Camp TSF Reclamation Plan. Doc. # CCC.03-81600-EX-REP-00023 – Rev. 0. June 10.

Montgomery & Associates. (M&A). 2020. Numerical Groundwater Flow Model in Support of the Proposed Skunk Camp Tailings Storage Facility. July.

APPENDIX I-A

Consolidation Tests

	Initial	Final	
Length =	5.636	4.078	cm
Diameter =	7.100	7.100	cm
Wet Mass =	498.24	351.46	g
Area =	39.59	39.59	cm^2
Volume =	223.14	161.46	cm^3
Moisture Content =	66.3%	17.7%	
Specific Gravity =	2.75	2.75	(ASTM D854)
Dry Mass of Solids =	299.60	298.61	g
Density =	2.23	2.18	g/cm^3
Dry Density =	1.34	1.85	g/cm^3
Unit Weight =	139.4	135.9	lb/ft^3
Dry Unit Weight =	83.8	115.5	lb/ft^3
Solids Content =	60.1%	85.0%	

Note: Approximately 83 grams of supernatant water removed from test specimen after allowing for settlement overnight and before assembling test device.

Piston Pressure:	6.0 psi	421.8 g/cm^2
Sample Pressure:	5.0 psi	351.5 g/cm^2
Consolidation pressure:	**1.0 psi**	70.3 g/cm^2
Before Consolidation		
Initial Sample Height:	5.636	cm
Initial Dry Unit Weight:	1.34	g/cm^3
Initial Void Ratio:	1.05	
After Consolidation		
Final Sample Height:	4.480	cm
Final Dry Unit Weight:	1.68	g/cm^3
Final Void Ratio:	0.63	
Calculations		
Coefficient of Compressibility, a_v	5.90E-03	cm^2/g
Coefficient of Volume Compressibility, m_v	2.88E-03	cm^2/g
Compression Index, C_c	-	

Δ Time (sec)	Permeability k (cm/sec)	Coefficient of Consolidation, c_v (cm^2/sec)
4.61	2.0E-05	7.05E-03
9.72	1.6E-05	5.58E-03
13.17	1.5E-05	5.11E-03
16.35	1.5E-05	5.04E-03
20.69	1.4E-05	4.86E-03
25.98	1.4E-05	4.73E-03
32.82	1.3E-05	4.64E-03
43.76	1.3E-05	4.46E-03
56.42	1.2E-05	4.17E-03
12.00	1.1E-05	3.84E-03
21.02	1.1E-05	3.78E-03
Average (of final 3 values)	1.13E-05	3.93E-03

Piston Pressure:	7.0 psi	492.2 g/cm^2
Sample Pressure:	5.0 psi	351.5 g/cm^2
Consolidation Pressure:	**2.0 psi**	140.6 g/cm^2
Before Consolidation		
Initial Sample Height:	4.480	cm
Initial Dry Unit Weight:	1.68	g/cm^3
Initial Void Ratio:	0.63	
After Consolidation		
Final Sample Height:	4.434	cm
Final Dry Unit Weight:	1.70	g/cm^3
Final Void Ratio:	0.62	
Calculations		
Coefficient of Compressibility, a_v	2.39E-04	cm^2/g
Coefficient of Volume Compressibility, m_v	1.46E-04	cm^2/g
Compression Index, C_c	0.06	

Δ Time (sec)	Permeability k (cm/sec)	Coefficient of Consolidation, c_v (cm^2/sec)
6.18	1.5E-05	1.03E-01
11.28	1.4E-05	9.38E-02
14.49	1.3E-05	9.06E-02
18.18	1.3E-05	8.85E-02
22.46	1.3E-05	8.73E-02
27.78	1.3E-05	8.63E-02
34.73	1.2E-05	8.56E-02
45.14	1.2E-05	8.44E-02
56.89	1.2E-05	8.07E-02
68.47	1.1E-05	7.87E-02
79.87	1.1E-05	7.48E-02
Average (of final 3 values)	1.14E-05	7.81E-02

Piston Pressure:	10.0 psi	703.1 g/cm^2
Sample Pressure:	5.0 psi	351.5 g/cm^2
Consolidation Pressure:	**5.0 psi**	351.5 g/cm^2
Before Consolidation		
Initial Sample Height:	4.434	cm
Initial Dry Unit Weight:	1.70	g/cm^3
Initial Void Ratio:	0.62	
After Consolidation		
Final Sample Height:	4.417	cm
Final Dry Unit Weight:	1.71	g/cm^3
Final Void Ratio:	0.61	
Calculations		
Coefficient of Compressibility, a_v	2.94E-05	cm^2/g
Coefficient of Volume Compressibility, m_v	1.82E-05	cm^2/g
Compression Index, C_c	0.02	

Δ Time (sec)	Permeability k (cm/sec)	Coefficient of Consolidation, c_v (cm^2/sec)
6.53	1.4E-05	7.77E-01
11.86	1.3E-05	7.14E-01
15.13	1.3E-05	6.94E-01
18.84	1.2E-05	6.83E-01
23.14	1.2E-05	6.79E-01
28.58	1.2E-05	6.72E-01
35.47	1.2E-05	6.71E-01
44.96	1.2E-05	6.78E-01
55.46	1.2E-05	6.62E-01
65.86	1.2E-05	6.55E-01
74.98	1.2E-05	6.37E-01
Average (of final 3 values)	1.18E-05	6.52E-01

Piston Pressure:	15.0 psi	1,054.6 g/cm^2
Sample Pressure:	5.0 psi	351.5 g/cm^2
Consolidation Pressure:	**10.0 psi**	703.1 g/cm^2
Before Consolidation		
Initial Sample Height:	4.417	cm
Initial Dry Unit Weight:	1.71	g/cm^3
Initial Void Ratio:	0.61	
After Consolidation		
Final Sample Height:	4.368	cm
Final Dry Unit Weight:	1.73	g/cm^3
Final Void Ratio:	0.59	
Calculations		
Coefficient of Compressibility, a_v	5.08E-05	cm^2/g
Coefficient of Volume Compressibility, m_v	3.16E-05	cm^2/g
Compression Index, C_c	0.06	

Δ Time (sec)	Permeability k (cm/sec)	Coefficient of Consolidation, c_v (cm^2/sec)
7.51	1.2E-05	3.85E-01
13.20	1.2E-05	3.65E-01
16.63	1.1E-05	3.60E-01
20.23	1.1E-05	3.63E-01
24.90	1.1E-05	3.59E-01
30.61	1.1E-05	3.57E-01
37.66	1.1E-05	3.60E-01
48.13	1.1E-05	3.61E-01
Average (of final 3 values)	1.13E-05	3.59E-01

Piston Pressure:	25.0 psi	1,757.7 g/cm^2
Sample Pressure:	5.0 psi	351.5 g/cm^2
Consolidation Pressure:	**20.0 psi**	1,406.2 g/cm^2
Before Consolidation		
Initial Sample Height:	4.368	cm
Initial Dry Unit Weight:	1.73	g/cm^3
Initial Void Ratio:	0.59	
After Consolidation		
Final Sample Height:	4.304	cm
Final Dry Unit Weight:	1.75	g/cm^3
Final Void Ratio:	0.57	
Calculations		
Coefficient of Compressibility, a_v	3.32E-05	cm^2/g
Coefficient of Volume Compressibility, m_v	2.08E-05	cm^2/g
Compression Index, C_c	0.08	

Δ Time (sec)	Permeability k (cm/sec)	Coefficient of Consolidation, c_v (cm^2/sec)
8.23	1.1E-05	5.24E-01
14.27	1.1E-05	5.04E-01
18.03	1.0E-05	4.95E-01
22.25	1.0E-05	4.92E-01
27.23	1.0E-05	4.90E-01
33.46	1.0E-05	4.88E-01
41.26	1.0E-05	4.90E-01
52.79	1.0E-05	4.91E-01
Average (of final 3 values)	1.02E-05	4.90E-01

Golder Associates Inc.
Denver, Colorado

Title: SLURRY CONSOLIDATION TEST
SAMPLE DATA AND CALCULATIONS

Project Name: RCML/TSF Corridor PFS-A Study/AZ

Project Number:	Reviewed:	Date:	Sample ID:	Figure:
1810598801.9000.9100	MB	17-Mar-2020	Scavenger	1A

	Initial	Final	
Length =	5.636	4.078	cm
Diameter =	7.100	7.100	cm
Wet Mass =	498.24	351.46	g
Area =	39.59	39.59	cm^2
Volume =	223.14	161.46	cm^3
Moisture Content =	66.3%	17.7%	
Specific Gravity =	2.75	2.75	(ASTM D854)
Dry Mass of Solids =	299.60	298.61	g
Density =	2.23	2.18	g/cm^3
Dry Density =	1.34	1.85	g/cm^3
Unit Weight =	139.4	135.9	lb/ft^3
Dry Unit Weight =	83.8	115.5	lb/ft^3
Solids Content =	60.1%	85.0%	

Piston Pressure:	55.0 psi	3,866.9 g/cm^2	Piston Pressure:	130.0 psi	9,140.0 g/cm^2	Piston Pressure:	255.0 psi	17,928.5 g/cm^2
Sample Pressure:	5.0 psi	351.5 g/cm^2	Sample Pressure:	5.0 psi	351.5 g/cm^2	Sample Pressure:	5.0 psi	351.5 g/cm^2
Consolidation pressure:	**50.0 psi**	3,515.4 g/cm^2	Consolidation pressure:	**125.0 psi**	8,788.5 g/cm^2	Consolidation pressure:	**250.0 psi**	17,576.9 g/cm^2
Before Consolidation			**Before Consolidation**			**Before Consolidation**		
Initial Sample Height:	4.304	cm	Initial Sample Height:	4.203	cm	Initial Sample Height:	4.074	cm
Initial Dry Unit Weight:	1.75	g/cm^3	Initial Dry Unit Weight:	1.79	g/cm^3	Initial Dry Unit Weight:	1.85	g/cm^3
Initial Void Ratio:	0.57		Initial Void Ratio:	0.53		Initial Void Ratio:	0.49	
After Consolidation			**After Consolidation**			**After Consolidation**		
Final Sample Height:	4.203	cm	Final Sample Height:	4.074	cm	Final Sample Height:	3.960	cm
Final Dry Unit Weight:	1.79	g/cm^3	Final Dry Unit Weight:	1.85	g/cm^3	Final Dry Unit Weight:	1.90	g/cm^3
Final Void Ratio:	0.53		Final Void Ratio:	0.49		Final Void Ratio:	0.44	
Calculations			**Calculations**			**Calculations**		
Coefficient of Compressibility, a_v	1.75E-05	cm^2/g	Coefficient of Compressibility, a_v	8.92E-06	cm^2/g	Coefficient of Compressibility, a_v	4.73E-06	cm^2/g
Coefficient of Volume Compressibility, m_v	1.11E-05	cm^2/g	Coefficient of Volume Compressibility, m_v	5.82E-06	cm^2/g	Coefficient of Volume Compressibility, m_v	3.18E-06	cm^2/g
Compression Index, C_c	0.09		Compression Index, C_c	0.12		Compression Index, C_c	0.14	

Δ Time (sec)	Permeability k (cm/sec)	Coefficient of Consolidation, c_v (cm^2/sec)	Δ Time (sec)	Permeability k (cm/sec)	Coefficient of Consolidation, c_v (cm^2/sec)	Δ Time (sec)	Permeability k (cm/sec)	Coefficient of Consolidation, c_v (cm^2/sec)
10.82	8.1E-06	7.29E-01	14.14	6.0E-06	1.03E+00	18.82	4.4E-06	7.55E-01
18.70	7.8E-06	7.04E-01	24.76	5.7E-06	9.85E-01	32.34	4.3E-06	7.33E-01
23.46	7.7E-06	6.96E-01	30.81	5.7E-06	9.82E-01	40.26	4.3E-06	7.31E-01
28.95	7.7E-06	6.91E-01	38.37	5.6E-06	9.67E-01	49.76	4.2E-06	7.25E-01
34.73	7.8E-06	7.03E-01	46.48	5.7E-06	9.73E-01	60.74	4.2E-06	7.24E-01
42.90	7.7E-06	6.96E-01	56.99	5.6E-06	9.70E-01	74.12	4.2E-06	7.25E-01
52.70	7.8E-06	7.02E-01	70.03	5.7E-06	9.78E-01	91.93	4.2E-06	7.25E-01
68.42	7.7E-06	6.93E-01	89.30	5.7E-06	9.84E-01	117.05	4.2E-06	7.29E-01
			107.48	5.7E-06	9.85E-01			
Average (of final 3 values)	7.75E-06	6.97E-01	Average (of final 3 values)	5.72E-06	9.82E-01	Average (of final 3 values)	4.23E-06	7.26E-01

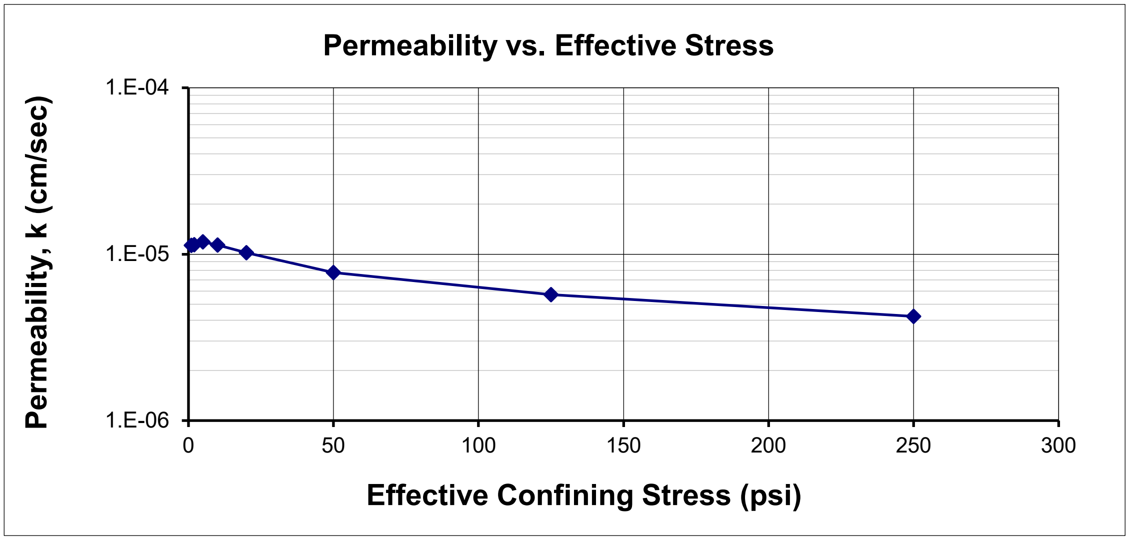
Golder Associates Inc.
Denver, Colorado

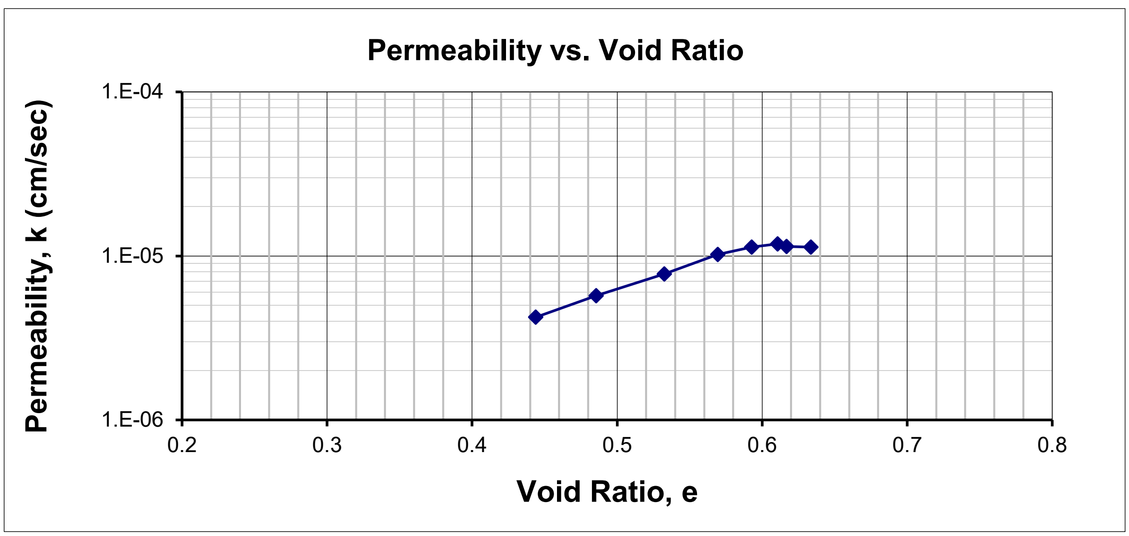
Title:

SLURRY CONSOLIDATION TEST
SAMPLE DATA AND CALCULATIONS

Project Name: RCML/TSF Corridor PFS-A Study/AZ

Project Number:	Reviewed:	Date:	Sample ID:	Figure:
1810598801.9000.9100	MB	17-Mar-2020	Scavenger	1B





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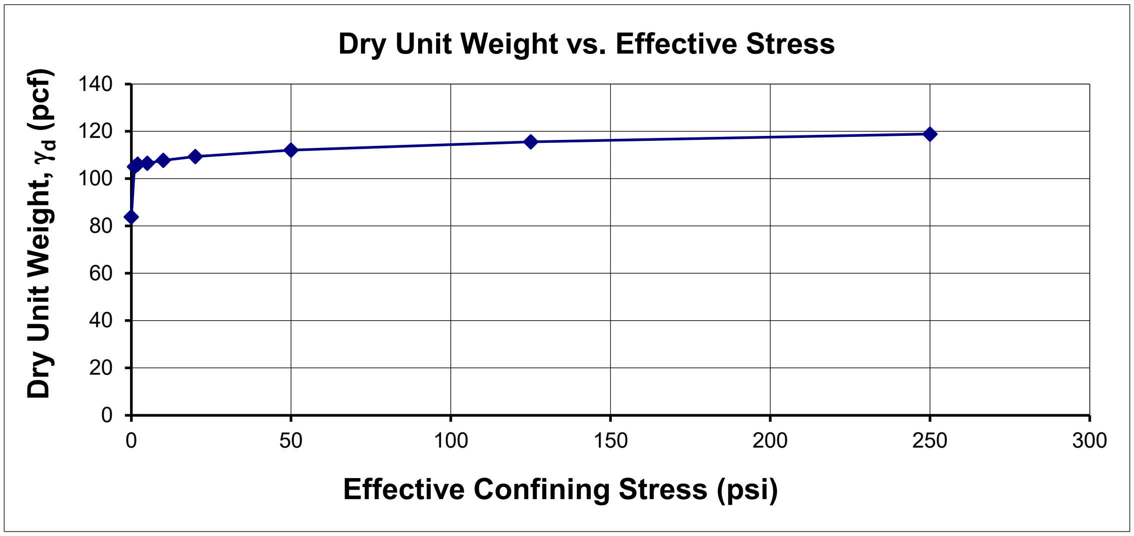
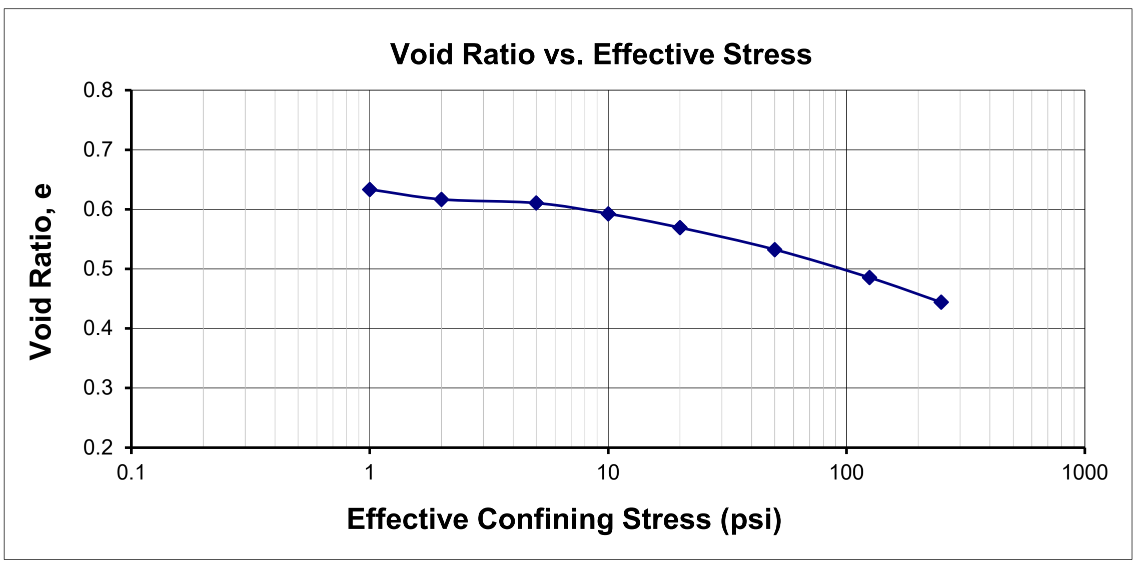
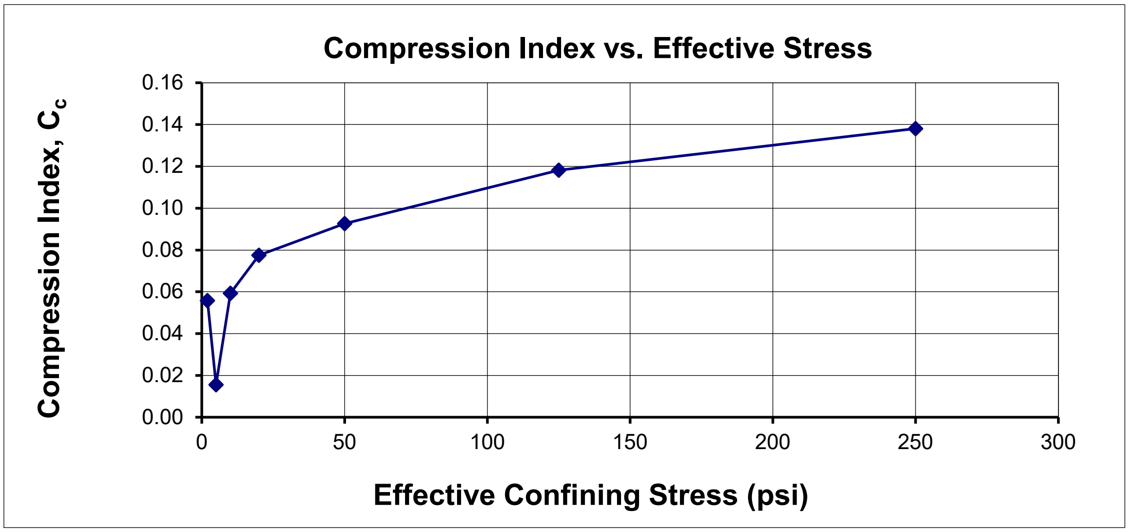
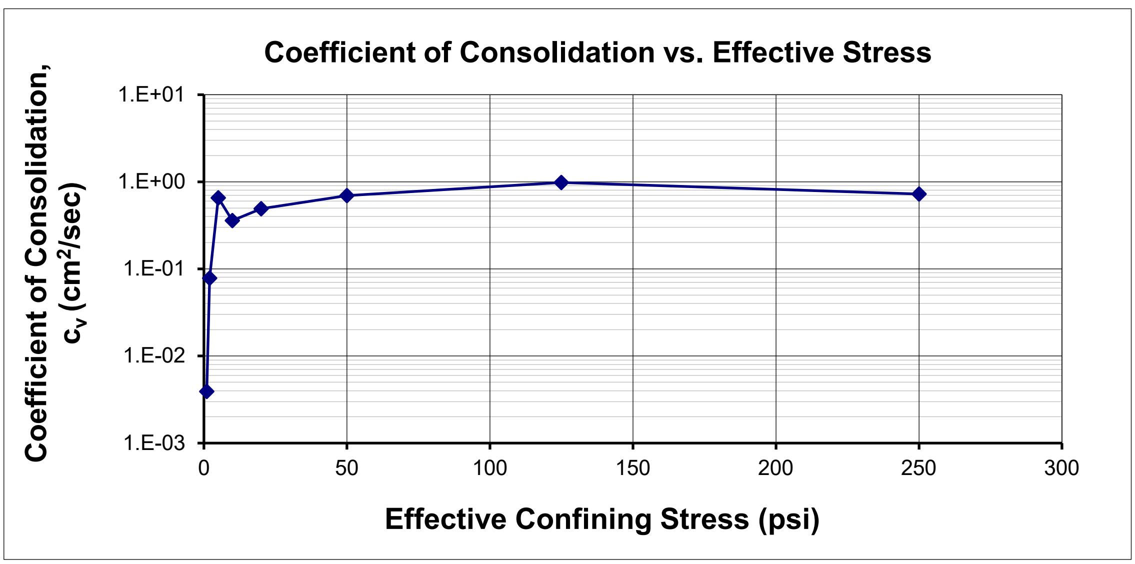
Project Name: RCML/TSF Corridor PFS-A Study/AZ				
Project Number: 1810598801.9000.9100	**Reviewed:** MB	**Date:** 17-Mar-2020	**Sample ID:** Scavenger	**Figure:** 2





Golder Associates Inc. **Denver, Colorado**		**Title:** **SLURRY CONSOLIDATION TEST RESULTS** **DENSITY DATA**		
Project Name: RCML/TSF Corridor PFS-A Study/AZ				
Project Number: 1810598801.9000.9100	**Reviewed:** MB	**Date:** 17-Mar-2020	**Sample ID:** Scavenger	**Figure:** 3





Golder Associates Inc. **Denver, Colorado**		**Title:** **SLURRY CONSOLIDATION TEST RESULTS** **COMPRESSION DATA**		
Project Name: RCML/TSF Corridor PFS-A Study/AZ				
Project Number: 1810598801.9000.9100	**Reviewed:** MB	**Date:** 17-Mar-2020	**Sample ID:** Scavenger	**Figure:** 4

	Initial	Final	
Length =	5.476	3.341	cm
Diameter =	7.100	7.100	cm
Wet Mass =	378.67	276.76	g
Area =	39.59	39.59	cm^2
Volume =	216.81	132.28	cm^3
Moisture Content =	66.6%	21.6%	
Specific Gravity =	2.77	2.77	(ASTM D854)
Dry Mass of Solids =	227.29	227.60	g
Density =	1.75	2.09	g/cm^3
Dry Density =	1.05	1.72	g/cm^3
Unit Weight =	109.0	130.6	lb/ft^3
Dry Unit Weight =	65.4	107.4	lb/ft^3
Solids Content =	60.0%	82.2%	

Note: Approximately 15.1 grams of supernatant water removed from test specimen after allowing for settlement overnight and before assembling test device.

Piston Pressure:	6.0 psi	421.8 g/cm^2
Sample Pressure:	5.0 psi	351.5 g/cm^2
Consolidation pressure:	**1.0 psi**	70.3 g/cm^2
Before Consolidation		
Initial Sample Height:	5.476	cm
Initial Dry Unit Weight:	1.05	g/cm^3
Initial Void Ratio:	1.64	
After Consolidation		
Final Sample Height:	3.816	cm
Final Dry Unit Weight:	1.51	g/cm^3
Final Void Ratio:	0.84	
Calculations		
Coefficient of Compressibility, a_v	1.14E-02	cm^2/g
Coefficient of Volume Compressibility, m_v	4.32E-03	cm^2/g
Compression Index, C_c	-	

Δ Time (sec)	Permeability k (cm/sec)	Coefficient of Consolidation, c_v (cm^2/sec)
15.23	8.6E-06	2.00E-03
26.15	6.2E-06	1.44E-03
39.56	5.1E-06	1.17E-03
55.38	4.4E-06	1.02E-03
75.41	3.9E-06	9.11E-04
100.82	3.6E-06	8.42E-04
138.05	3.4E-06	7.84E-04
166.88	3.1E-06	7.27E-04
206.83	2.9E-06	6.72E-04
236.96	2.7E-06	6.35E-04
295.02	2.4E-06	5.60E-04
Average (of final 3 values)	2.69E-06	6.22E-04

Piston Pressure:	7.0 psi	492.2 g/cm^2
Sample Pressure:	5.0 psi	351.5 g/cm^2
Consolidation Pressure:	**2.0 psi**	140.6 g/cm^2
Before Consolidation		
Initial Sample Height:	3.816	cm
Initial Dry Unit Weight:	1.51	g/cm^3
Initial Void Ratio:	0.84	
After Consolidation		
Final Sample Height:	3.763	cm
Final Dry Unit Weight:	1.53	g/cm^3
Final Void Ratio:	0.81	
Calculations		
Coefficient of Compressibility, a_v	3.63E-04	cm^2/g
Coefficient of Volume Compressibility, m_v	1.98E-04	cm^2/g
Compression Index, C_c	0.08	

Δ Time (sec)	Permeability k (cm/sec)	Coefficient of Consolidation, c_v (cm^2/sec)
25.98	5.0E-06	2.53E-02
36.31	4.4E-06	2.25E-02
48.73	4.0E-06	2.05E-02
64.12	3.7E-06	1.90E-02
82.31	3.6E-06	1.80E-02
105.43	3.4E-06	1.74E-02
142.06	3.2E-06	1.64E-02
167.40	3.1E-06	1.57E-02
201.74	2.9E-06	1.49E-02
227.85	2.8E-06	1.43E-02
269.71	2.6E-06	1.32E-02
324.73	2.4E-06	1.23E-02
Average (of final 3 values)	2.62E-06	1.33E-02

Piston Pressure:	10.0 psi	703.1 g/cm^2
Sample Pressure:	5.0 psi	351.5 g/cm^2
Consolidation Pressure:	**5.0 psi**	351.5 g/cm^2
Before Consolidation		
Initial Sample Height:	3.763	cm
Initial Dry Unit Weight:	1.53	g/cm^3
Initial Void Ratio:	0.81	
After Consolidation		
Final Sample Height:	3.736	cm
Final Dry Unit Weight:	1.54	g/cm^3
Final Void Ratio:	0.80	
Calculations		
Coefficient of Compressibility, a_v	6.17E-05	cm^2/g
Coefficient of Volume Compressibility, m_v	3.40E-05	cm^2/g
Compression Index, C_c	0.03	

Δ Time (sec)	Permeability k (cm/sec)	Coefficient of Consolidation, c_v (cm^2/sec)
28.88	4.5E-06	1.31E-01
39.16	4.1E-06	1.20E-01
51.49	3.8E-06	1.12E-01
67.06	3.6E-06	1.05E-01
85.30	3.4E-06	1.00E-01
109.67	3.3E-06	9.64E-02
143.51	3.2E-06	9.39E-02
167.14	3.1E-06	9.04E-02
201.09	2.9E-06	8.60E-02
229.21	2.8E-06	8.17E-02
263.53	2.7E-06	7.80E-02
326.84	2.4E-06	7.06E-02
Average (of final 3 values)	2.61E-06	7.68E-02

Piston Pressure:	15.0 psi	1,054.6 g/cm^2
Sample Pressure:	5.0 psi	351.5 g/cm^2
Consolidation Pressure:	**10.0 psi**	703.1 g/cm^2
Before Consolidation		
Initial Sample Height:	3.736	cm
Initial Dry Unit Weight:	1.54	g/cm^3
Initial Void Ratio:	0.80	
After Consolidation		
Final Sample Height:	3.680	cm
Final Dry Unit Weight:	1.56	g/cm^3
Final Void Ratio:	0.77	
Calculations		
Coefficient of Compressibility, a_v	7.68E-05	cm^2/g
Coefficient of Volume Compressibility, m_v	4.26E-05	cm^2/g
Compression Index, C_c	0.09	

Δ Time (sec)	Permeability k (cm/sec)	Coefficient of Consolidation, c_v (cm^2/sec)
36.07	3.5E-06	8.26E-02
47.76	3.3E-06	7.73E-02
61.01	3.2E-06	7.41E-02
76.74	3.1E-06	7.18E-02
95.86	3.0E-06	7.01E-02
122.20	2.9E-06	6.80E-02
158.92	2.8E-06	6.66E-02
187.35	2.7E-06	6.34E-02
226.93	2.6E-06	5.99E-02
254.46	2.5E-06	5.78E-02
295.81	2.3E-06	5.46E-02
Average (of final 3 values)	2.45E-06	5.74E-02

Piston Pressure:	25.0 psi	1,757.7 g/cm^2
Sample Pressure:	5.0 psi	351.5 g/cm^2
Consolidation Pressure:	**20.0 psi**	1,406.2 g/cm^2
Before Consolidation		
Initial Sample Height:	3.680	cm
Initial Dry Unit Weight:	1.56	g/cm^3
Initial Void Ratio:	0.77	
After Consolidation		
Final Sample Height:	3.601	cm
Final Dry Unit Weight:	1.60	g/cm^3
Final Void Ratio:	0.74	
Calculations		
Coefficient of Compressibility, a_v	5.41E-05	cm^2/g
Coefficient of Volume Compressibility, m_v	3.05E-05	cm^2/g
Compression Index, C_c	0.13	

Δ Time (sec)	Permeability k (cm/sec)	Coefficient of Consolidation, c_v (cm^2/sec)
40.81	3.0E-06	9.97E-02
53.52	2.9E-06	9.43E-02
68.68	2.7E-06	9.00E-02
83.16	2.8E-06	9.05E-02
107.82	2.6E-06	8.52E-02
136.57	2.5E-06	8.31E-02
178.69	2.5E-06	8.09E-02
209.90	2.4E-06	7.73E-02
250.02	2.3E-06	7.43E-02
285.78	2.1E-06	7.04E-02
325.11	2.1E-06	6.79E-02
Average (of final 3 values)	2.16E-06	7.08E-02

Golder Associates Inc.
Denver, Colorado

Job Short Title: RCML/TSF Corridor PFS-A Study/AZ

Title: SLURRY CONSOLIDATION TEST
SAMPLE DATA AND CALCULATIONS

Sample No.	Reviewed:	Date:	Job Number:	Figure:
Overflow	MB	3/26/2020	1810598801.9000.9100	1A

	Initial	Final	
Length =	5.476	3.341	cm
Diameter =	7.100	7.100	cm
Wet Mass =	378.67	276.76	g
Area =	39.59	39.59	cm^2
Volume =	216.81	132.28	cm^3
Moisture Content =	66.6%	21.6%	
Specific Gravity =	2.77	2.77	(ASTM D854)
Dry Mass of Solids =	227.29	227.60	g
Density =	1.75	2.09	g/cm^3
Dry Density =	1.05	1.72	g/cm^3
Unit Weight =	109.0	130.6	lb/ft^3
Dry Unit Weight =	65.4	107.4	lb/ft^3
Solids Content =	60.0%	82.2%	

Piston Pressure:	55.0 psi	3,866.9 g/cm^2
Sample Pressure:	5.0 psi	351.5 g/cm^2
Consolidation pressure:	**50.0 psi**	3,515.4 g/cm^2
Before Consolidation		
Initial Sample Height:	3.601	cm
Initial Dry Unit Weight:	1.60	g/cm^3
Initial Void Ratio:	0.74	
After Consolidation		
Final Sample Height:	3.491	cm
Final Dry Unit Weight:	1.65	g/cm^3
Final Void Ratio:	0.68	
Calculations		
Coefficient of Compressibility, a_v	2.51E-05	cm^2/g
Coefficient of Volume Compressibility, m_v	1.45E-05	cm^2/g
Compression Index, C_c	0.13	

Δ Time (sec)	Permeability k (cm/sec)	Coefficient of Consolidation, c_v (cm^2/sec)
49.33	2.4E-06	0.168650998
65.49	2.3E-06	1.58E-01
83.24	2.2E-06	1.52E-01
104.99	2.1E-06	1.47E-01
130.90	2.1E-06	1.43E-01
165.24	2.0E-06	1.40E-01
217.36	2.0E-06	1.36E-01
246.05	2.0E-06	1.35E-01
300.11	1.8E-06	1.26E-01
331.90	1.8E-06	1.24E-01
394.58	1.7E-06	1.14E-01
Average (of final 3 values)	1.76E-06	1.22E-01

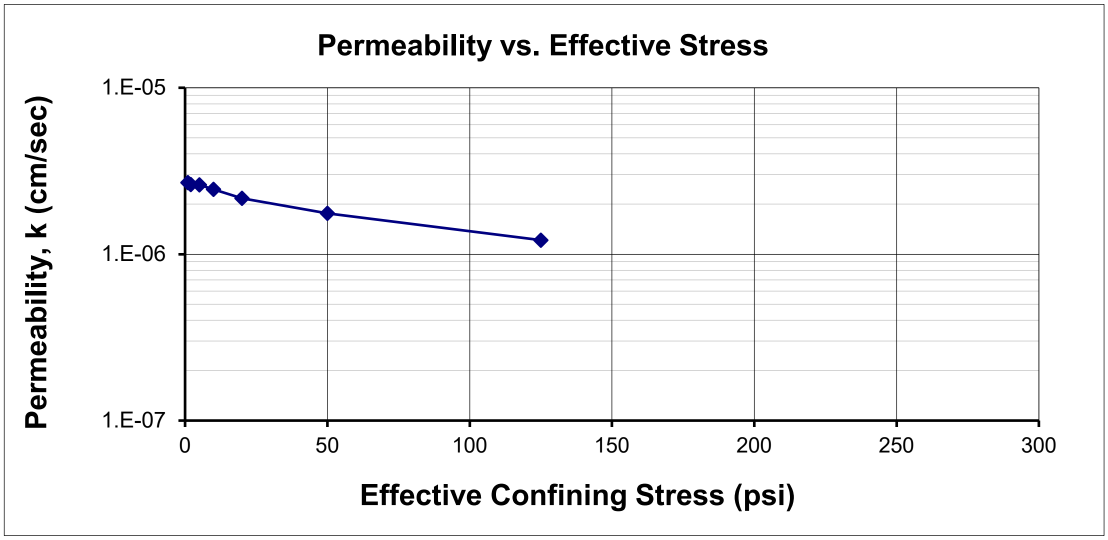
Piston Pressure:	130.0 psi	9,140.0 g/cm^2
Sample Pressure:	5.0 psi	351.5 g/cm^2
Consolidation pressure:	**125.0 psi**	8,788.5 g/cm^2
Before Consolidation		
Initial Sample Height:	3.491	cm
Initial Dry Unit Weight:	1.65	g/cm^3
Initial Void Ratio:	0.68	
After Consolidation		
Final Sample Height:	3.352	cm
Final Dry Unit Weight:	1.71	g/cm^3
Final Void Ratio:	0.62	
Calculations		
Coefficient of Compressibility, a_v	1.27E-05	cm^2/g
Coefficient of Volume Compressibility, m_v	7.55E-06	cm^2/g
Compression Index, C_c	0.17	

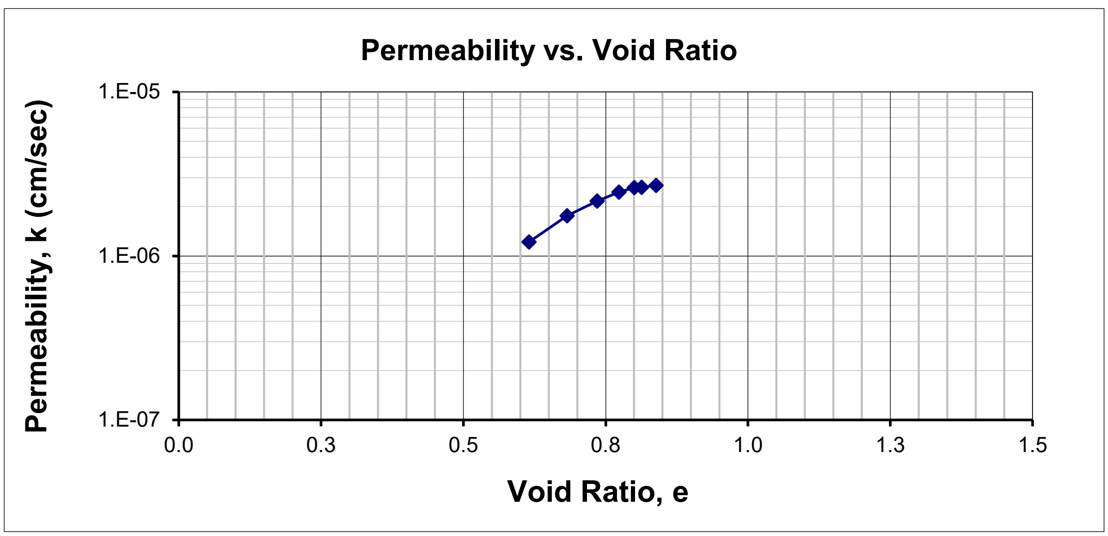
Δ Time (sec)	Permeability k (cm/sec)	Coefficient of Consolidation, c_v (cm^2/sec)
67.77	1.7E-06	0.226079575
88.99	1.6E-06	0.213517641
113.93	1.5E-06	0.204192764
142.30	1.5E-06	0.199086545
177.43	1.5E-06	0.194865391
223.43	1.4E-06	0.191194607
292.39	1.4E-06	0.186210664
336.71	1.4E-06	0.18139297
397.33	1.3E-06	0.175902916
458.08	1.2E-06	0.165224654
511.14	1.2E-06	0.162535683
602.89	1.2E-06	0.15475434
Average (of final 3 values)	1.21E-06	1.61E-01

Piston Pressure:	255.0 psi	17,928.5 g/cm^2
Sample Pressure:	5.0 psi	351.5 g/cm^2
Consolidation pressure:	**250.0 psi**	17,576.9 g/cm^2
Before Consolidation		
Initial Sample Height:	3.352	cm
Initial Dry Unit Weight:	1.71	g/cm^3
Initial Void Ratio:	0.62	
After Consolidation		
Final Sample Height:	3.171	cm
Final Dry Unit Weight:	1.81	g/cm^3
Final Void Ratio:	0.53	
Calculations		
Coefficient of Compressibility, a_v	9.92E-06	cm^2/g
Coefficient of Volume Compressibility, m_v	6.14E-06	cm^2/g
Compression Index, C_c	0.29	

Note: Permeabilty readings were not acheivable due to commuunication between the cell chamber and the sample chamber. Without permeability readings, the coefficient of consolidation could not be calculated.

Golder Associates Inc. **Denver, Colorado**	**Title:** **SLURRY CONSOLIDATION TEST** **SAMPLE DATA AND CALCULATIONS**			
Job Short Title: RCML/TSF Corridor PFS-A Study/AZ				
Sample No. Overflow	**Reviewed:** MB	**Date:** 3/26/2020	**Job Number:** 1810598801.9000.9100	**Figure:** 1B



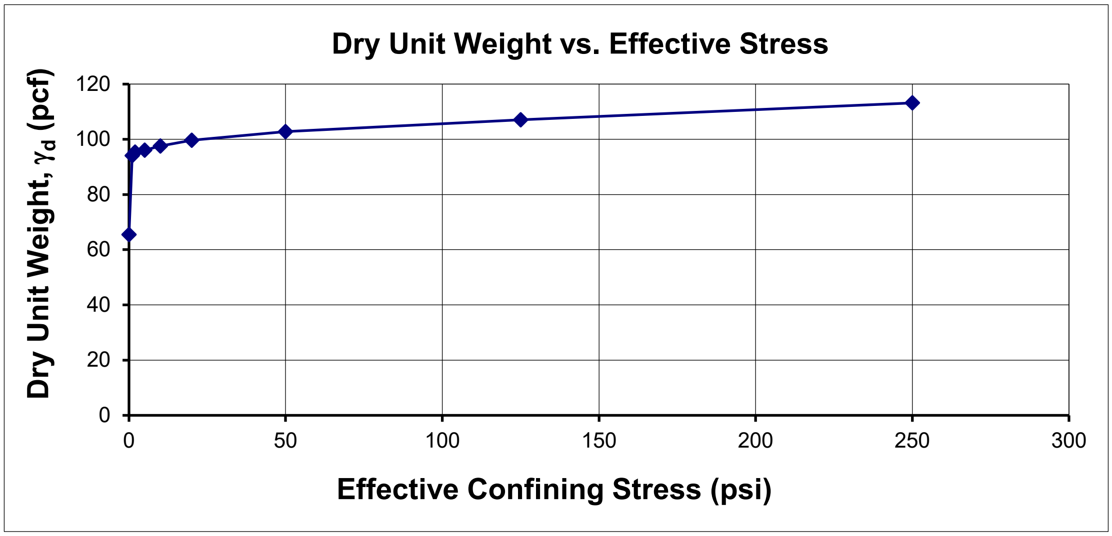


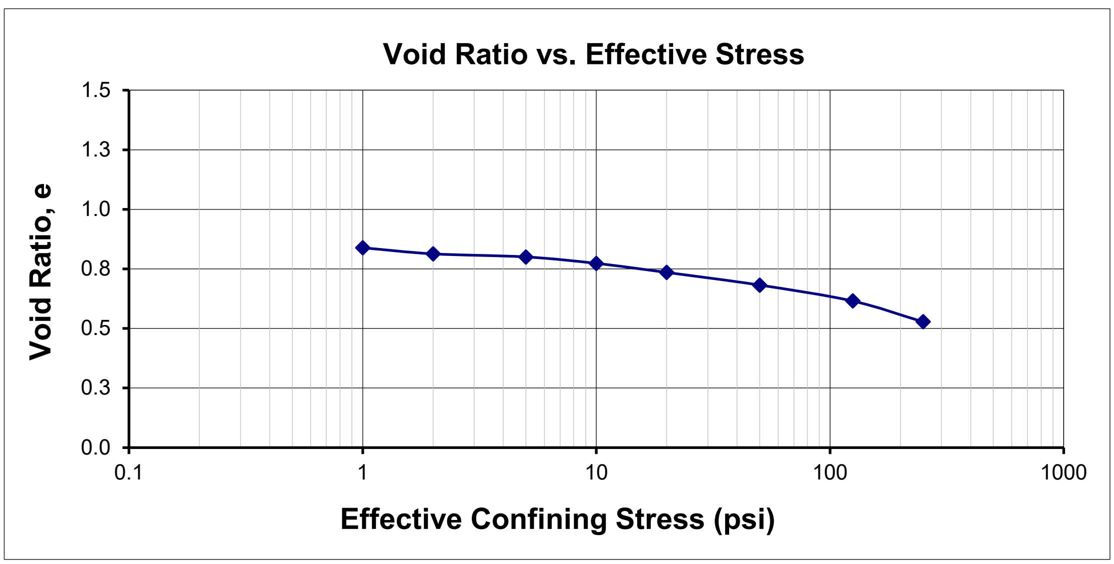
Golder Associates Inc.
Denver, Colorado

Job Short Title: RCML/TSF Corridor PFS-A Study/AZ

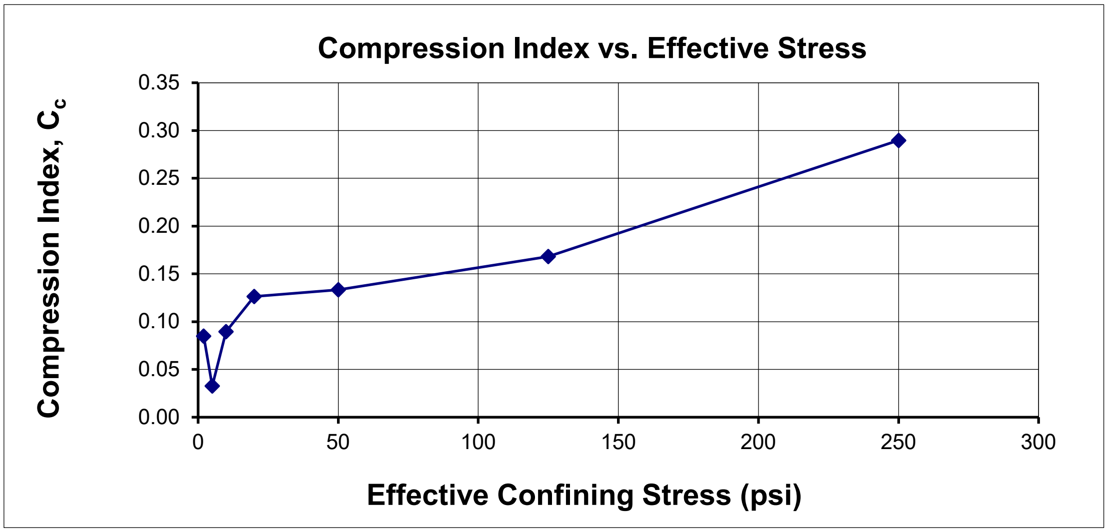
Title:
SLURRY CONSOLIDATION TEST RESULTS
PERMEABILITY DATA

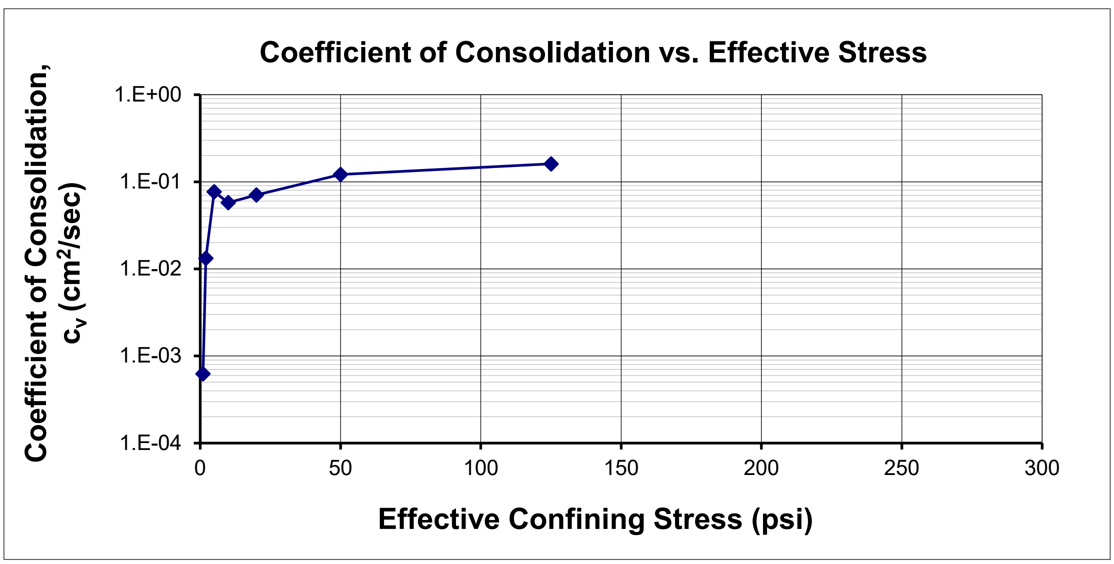
Sample No.	Reviewed:	Date:	Job Number:	Figure:
Overflow	MB	3/26/2020	310598801.9000.910	2





Golder Associates Inc. **Denver, Colorado**		**Title:** **SLURRY CONSOLIDATION TEST RESULTS** **DENSITY DATA**		
Job Short Title: RCML/TSF Corridor PFS-A Study/AZ				
Sample No. Overflow	**Reviewed:** MB	**Date:** 3/26/2020	**Job Number:** 310598801.9000.910	**Figure:** 3





Golder Associates Inc. Denver, Colorado	Title:
Job Short Title: RCML/TSF Corridor PFS-A Study/AZ	SLURRY CONSOLIDATION TEST RESULTS COMPRESSION DATA

Sample No.	Reviewed:	Date:	Job Number:	Figure:
Overflow	MB	3/26/2020	310598801.9000.910	4

APPENDIX II

Scavenger Beach Seepage Modeling

Appendix II
Scavenger Beach Seepage Modeling

Table of Contents

II-1 INTRODUCTION 1

II-2 CONCEPTUAL MODEL AND MODELING APPROACH 2
- II-2.1 Conceptual Model 2
- II-2.2 Modeling Approach 3
- II-2.3 1D Model Locations 6

II-3 MODEL SET-UP, ASSUMPTIONS AND INPUTS 8
- II-3.1 Model Domain and Timestep 8
- II-3.2 Boundary Conditions 8
- II-3.3 Climate 9
- II-3.4 Materials Properties 10
- II-3.5 Bleed Water 10
- II-3.6 Tailings Rates of Rise 11
- II-3.7 Consolidation 12

II-4 RESULTS 13
- II-4.1 Zone 2 – Near Dam Scavenger Beach (Scavenger Total Tailings) – Base Case 13
- II-4.2 Zone 3 – Scavenger Beach (Scavenger Overflow Tailings) – Base Case 17
- II-4.3 Sensitivity Analyses 20

II-5 CONSOLIDATION MODEL COMPARISON 24

List of Tables

Table II-1 Modeling Approach Stages 4
Table II-2 Water Year 1987 Climate Inputs 9
Table II-3 Initial Settled Tailings Materials Properties 10
Table II-4 Calculated Tailings Bleed Water Volumes 11

List of Figures

Figure II-1 Tailings Zone for Seepage Modeling 1
Figure II-2 1D Column Conceptual Model Schematic 3
Figure II-3 Stage 1 – Slurry Deposition and Climatic Boundary 5
Figure II-4 Stage 2 – Consolidation and Unsaturated Flow 5
Figure II-5 Zone 2 and Zone 3 Scavenger Beach Seepage Model 1D Column Locations 7
Figure II-6 SCSDS Daily Precipitation and Potential Evapotranspiration 9

Table of Contents
(continued)

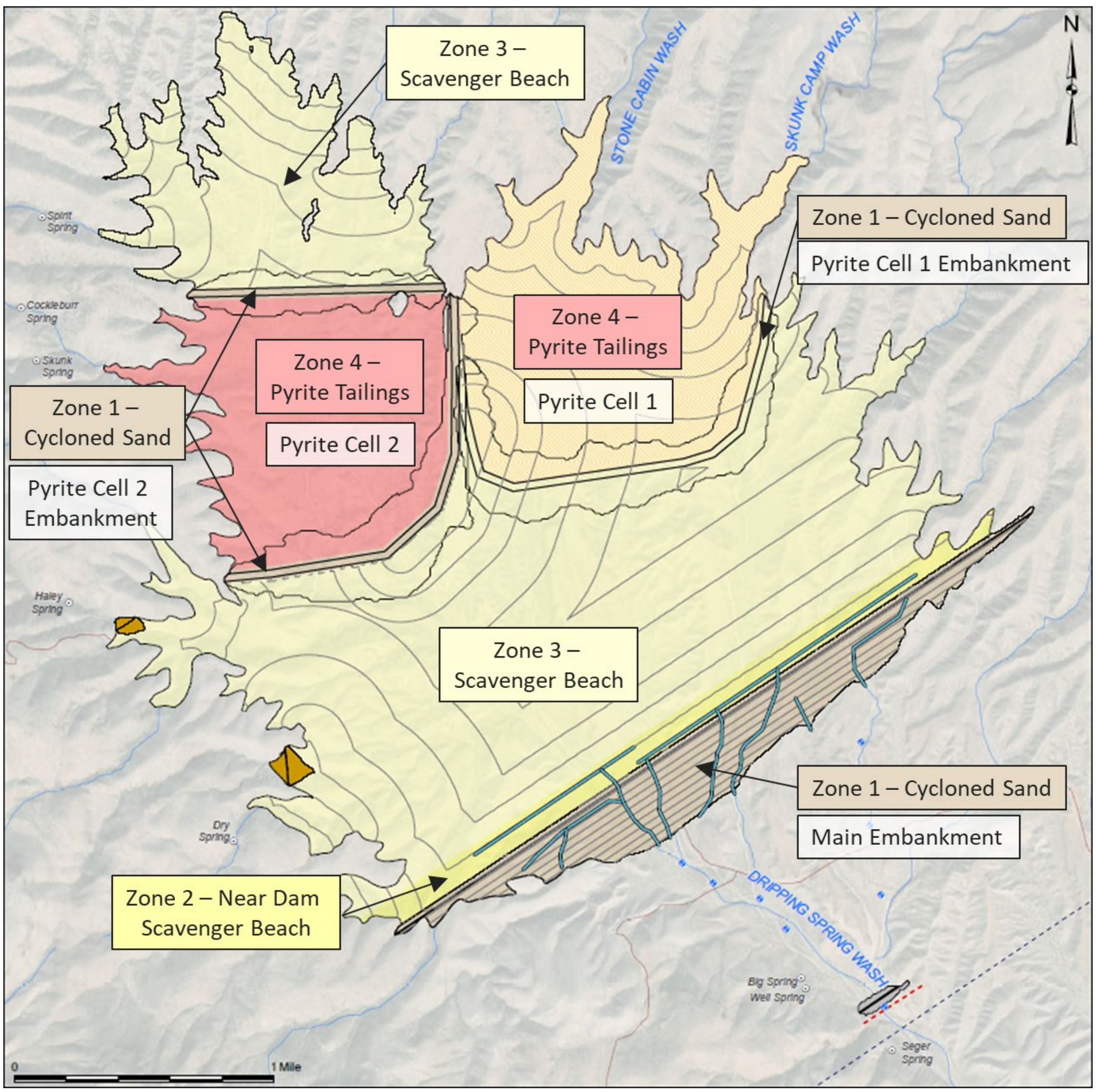
Figure II-7 Scavenger Beach Rate of Rise 12
Figure II-8 Zone 2 – Near Dam Scavenger Beach (Scavenger Total Tailings) Results for the Operational Mine Life (41 years) 15
Figure II-9 Zone 2 – Near Dam Scavenger Beach (Scavenger Total Tailings) Results for Post-Closure 16
Figure II-10 Zone 3 – Scavenger Beach (Scavenger Overflow Tailings) Results for the Operational Mine Life (41 years) 18
Figure II-11 Zone 3 – Scavenger Beach (Scavenger Overflow Tailings) Results for Post-Closure 19
Figure II-12 Zone 2 – Near Dam Scavenger Beach (Scavenger Total Tailings) Sensitivity Scenarios Basal Leakage Flux – Operations (41 years) 21
Figure II-13 Zone 3 – Scavenger Beach (Scavenger Overflow Tailings) Sensitivity Scenarios Basal Leakage Flux – Operations (41 years) 22
Figure II-14 Zone 2 – Near Dam Scavenger Beach (Scavenger Total Tailings) Climate Sensitivity Basal Leakage Flux – Operations (41 years) 23
Figure II-15 Zone 3 – Scavenger Beach (Scavenger Overflow Tailings) Climate Sensitivity Basal Leakage Flux – Operations (41 years) 24
Figure II-16 Zone 2 – Near Dam Scavenger Beach (Scavenger Total Tailings) Consolidation Model Comparison 25
Figure II-17 Zone 3 – Scavenger Beach (Scavenger Overflow Tailings) Consolidation Model Comparison 25

II-1 INTRODUCTION

KCB Consultants Ltd. (KCBCL) completed one-dimensional (1D) combined seepage and consolidation modeling of several representative tailings profiles in the scavenger beach to help estimate seepage rates into the foundation during TSF operations and post-closure. The seepage estimate simulated by the 1D modelling represents the vertical flow through the tailings profile. These seepage estimates are used as input fluxes into the regional three-dimensional (3D) groundwater model (by others) to allow for the assessment of changes in groundwater conditions of the underlying foundation as a result of the TSF development and draindown.

The appendix summarizes the approach, inputs, assumptions and results of the scavenger beach (Zone 2 and Zone 3, see Figure II-1 and Section 3.3 of the main report) 1D combined seepage and consolidation modeling.

Figure II-1 Tailings Zone for Seepage Modeling



II-2 CONCEPTUAL MODEL AND MODELING APPROACH

II-2.1 Conceptual Model

The conceptual representation of the tailings profile and associated fluxes and physical characteristics is presented in Figure II-2. The concept considers a vertical tailings column built-up through placement of consecutive thin lifts of deposited thickened tailings. For the purposes of this assessment the tailings column is assumed to have homogenous tailings properties (i.e., consolidation properties, saturated vertical hydraulic conductivity at a specified porosity); in reality, tailings deposited on the beach will segregate and have heterogeneous properties. The first lift would be placed directly on the ground surface, overlying either weathered bedrock (Gila Conglomerate) or Quaternary alluvium (both modeled as a free-draining boundary, see Section II-3.1). Subsequent tailings lifts would be placed directly on the previous lift according to the simplified rates of rise estimated from the tailings deposition plan (Figure II-7).

Tailings are placed at 100% saturation and thus water inputs into the system include water placed with the tailings and infiltration from precipitation. Excess water can pond on the surface, arising from “free water” or runoff released from slurry settlement and/or precipitation. The free water runoff is removed from the model as it flows down-gradient on the tailings surface and collects in a low point where it will be pumped to the active pyrite cell (see Section 3 for more details on the TSF design and operation).

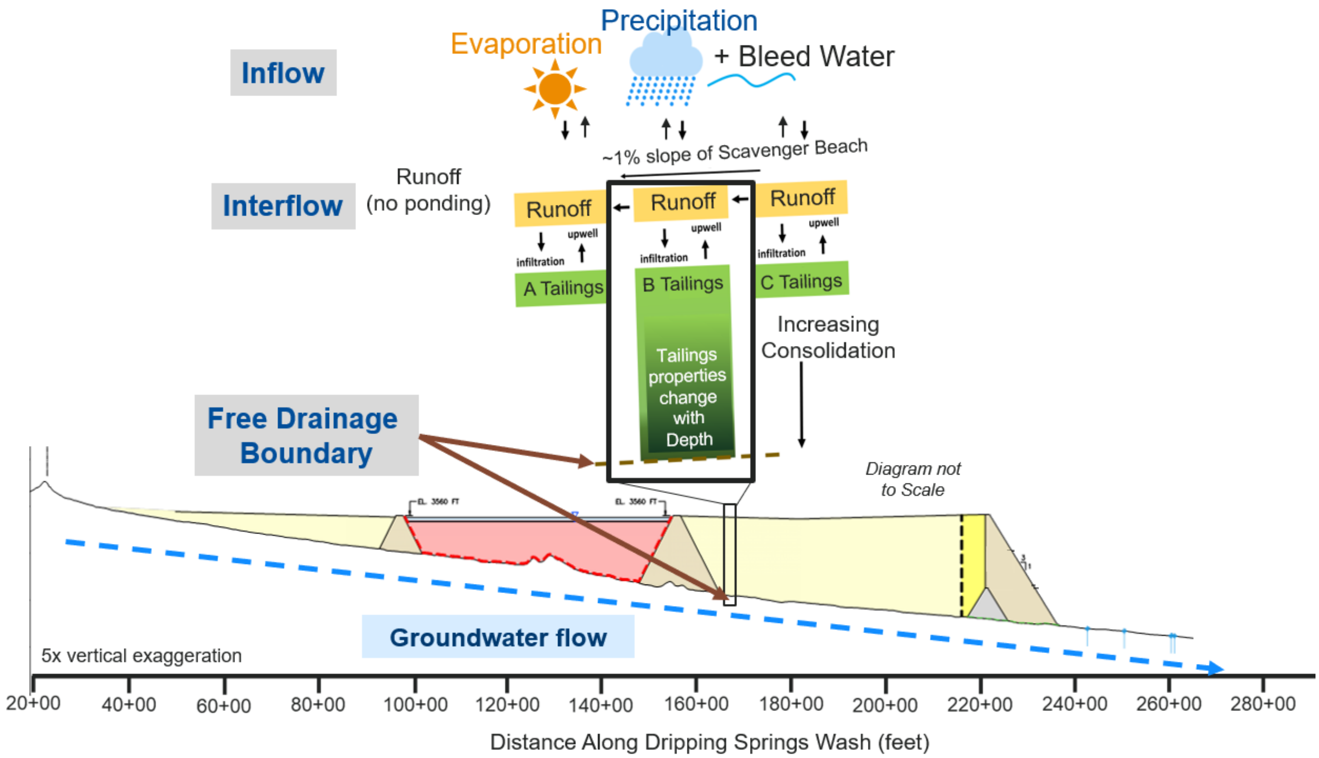
Climatic conditions (magnitude and intensity of precipitation and evaporation) influence the amount of infiltration into the tailings from deposition and precipitation[1].

Seepage from the base of the tailings column is dependent on vertical migration of water through the column under the influence of gravity and subject to upward suction pressures (from evaporative forces and partial saturation conditions) developed within the system.

Tailings consolidation processes were also considered in the 1D modeling, which includes the process of initial tailings deposition (the initial settlement of tailings following slurry discharge resulting in “bleed water”), as well as the effects of consolidation under self-weight. Conceptually, the process of the initial tailings deposition comprises the placement of saturated tailings on the foundation surface or a previous tailings surface, which results in tailings settling and the expulsion of water due to the slurry becoming a solid (for the purposes of this assessment, this water is referred to as “bleed water”). The process of consolidation under self-weight is captured in the model based on a tailings weight load trigger, above which a change in the hydraulic parameters (hydraulic conductivity and porosity) of the underlying tailings occurs (e.g., decrease in pore volume, increase in pore pressure). The increased pore pressure results in flow pattern change and pore pressure redistribution. As a result of this process, the pore volume reduction leads to two-phase (water and air) compression and water saturation change. The pore volume reduction also results in hydraulic conductivity reduction in the compressed tailings.

[1] The climate conditions at the Skunk Camp site will result in the surface of the tailings beach desiccating, crusting, and cracking. This will result in the surface at each tailings lift having a lower void ratio in the crust layer than what is below.

Figure II-2 1D Column Conceptual Model Schematic



II-2.2 Modeling Approach

To enable simulation of the variably saturated and unsaturated system, the climatic interactions, and the consolidation of the tailings, the TOUGH2 modeling platform was selected. TOUGH2 is an industry-adopted modeling platform for multi-phase flow (air and water) that integrates climate and surface water conditions with the groundwater model (e.g., surface runoff, evaporation, infiltration).

Modeling is broadly completed in two stages: 1) initial tailings slurry deposition and climatic surface and 2) consolidation and unsaturated flow. The stages are described in Table II-3 and shown in Figure II-3 and Figure II-4.

Table II-1 Modeling Approach Stages

Stage	Title	Approach	Description
1	Initial tailings slurry deposition and climatic surface	Calculation based on slurry solids content, estimate of initial settled density from laboratory testing and climatic boundary	Based on the tailings deposition plan, a rate of rise of the tailings in the TSF has been defined (Section II-3.6). This rate of rise forms the basis of the changing tailings profile and characteristics in the 1D model simulation (i.e., thickness, hydraulic properties). The monthly tailings rise was modeled in accordance with the tailings deposition schedule, with the rate of rise corresponding to the thickness of each rise (i.e., higher rise rate results in the larger thickness in the model). Each tailings rise is incorporated into the modeled profile as a saturated layer, therefore, the higher the rate of rise, the larger the thickness of tailings and the higher the amount of bleed water contributing to potential infiltration into the tailings profile. A climate boundary was applied at the surface to incorporate precipitation and evaporation effects. See Section II-3.3, II-3.4, II-3.5, and II-3.6 for further details.
2	Consolidation and unsaturated flow	TOUGH2 1D tailings column that incorporate TSF rate of rise, unsaturation flow, consolidation due to increase in effective stress	Consolidation properties based on laboratory testing were used to estimate the tailings hydraulic properties based on effective stress. The methodology to estimate the hydraulic properties from consolidation is consistent with Gibson et al. (1967). See Section II-3.4, and II-3.1 for further details.

Figure II-3 Stage 1 – Slurry Deposition and Climatic Boundary

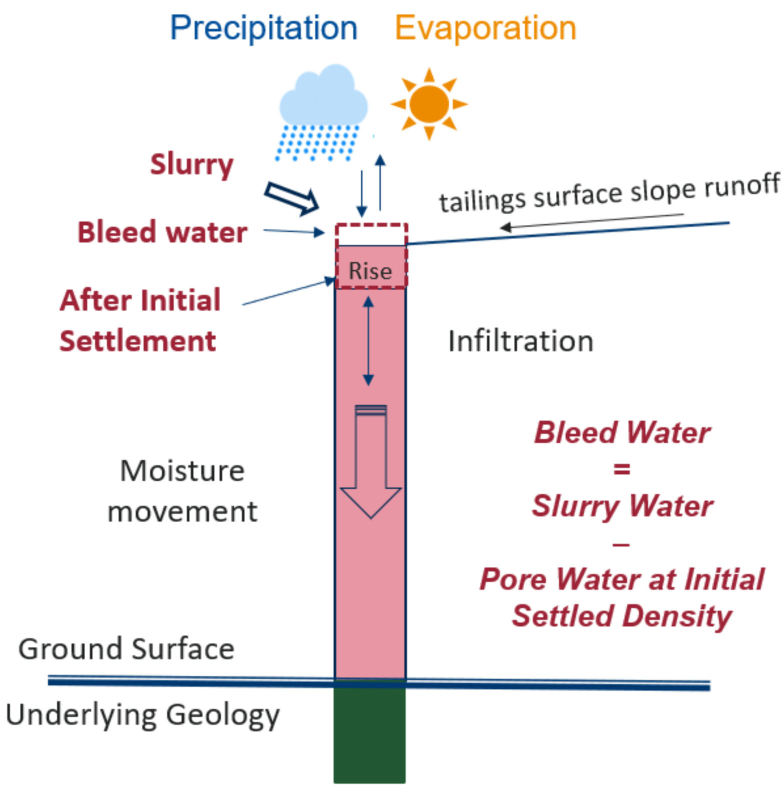
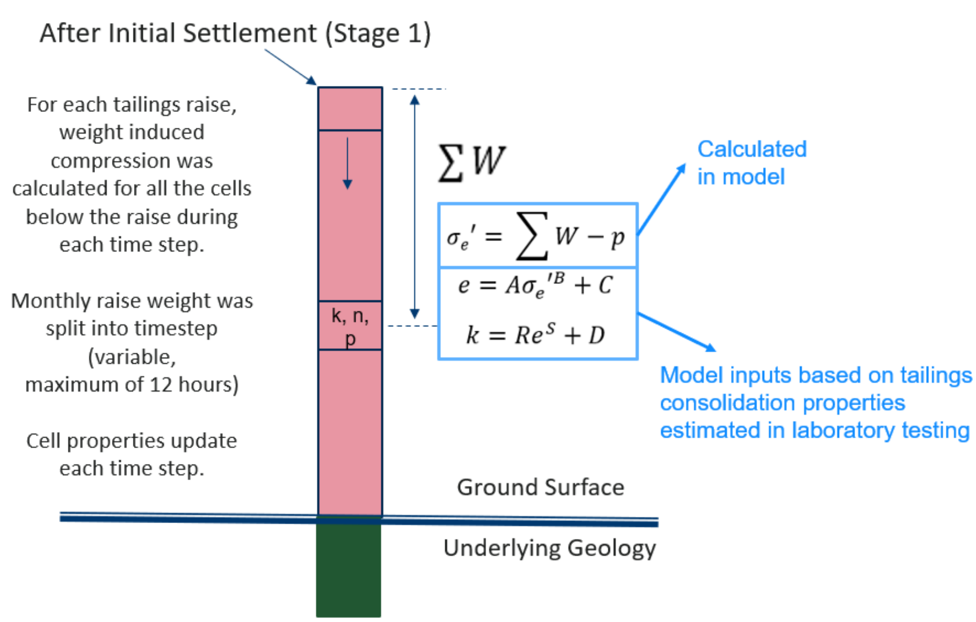


Figure II-4 Stage 2 – Consolidation and Unsaturated Flow



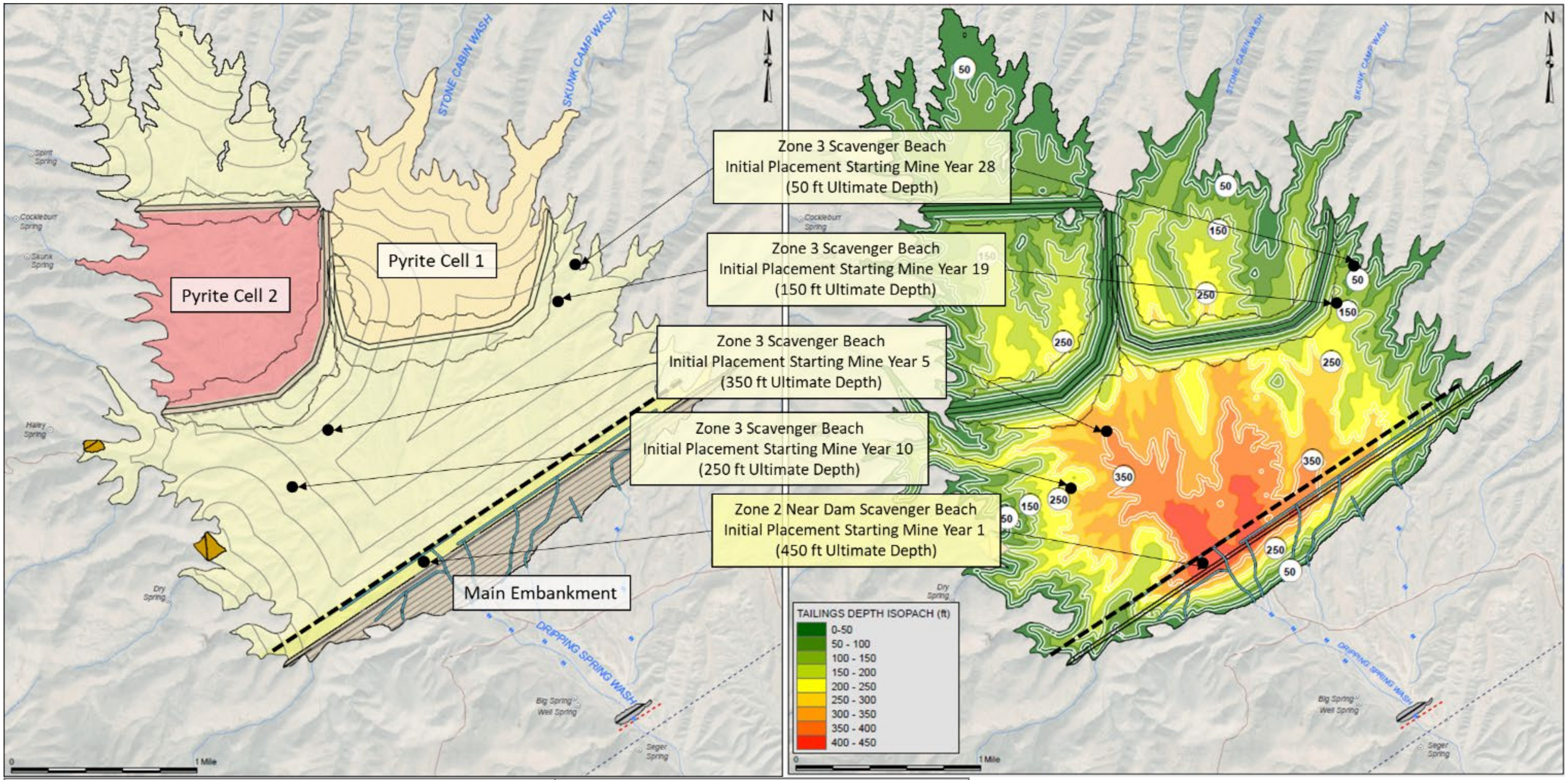
II-2.3 1D Model Locations

Seepage into the foundation from a tailings beach depends on many factors (e.g., foundation hydraulic conductivity, climate, solids content of deposited slurry, tailings hydraulic and consolidation properties, rate of rise of the tailings beach, pond management on the tailings surface). To address the influence of rate of rise on seepage into the foundation five locations (1 location for Zone 2 and 4 locations for Zone 3) within the scavenger beach were chosen for the 1D modeling, see Figure II-5.

Tailings slurry will be deposited onto the beach from the embankment crest, as the slurry settles segregation will occur resulting in coarse material remaining closer to the embankment. The tailings properties assumed to be representative for Zone 2 (Near Dam Scavenger Beach) is the scavenger total tailings (total scavenger, whole scavenger or uncycloned scavenger) to account for a mixture of coarse tailings segregated from whole scavenger tailings and overflow tailings.

Due to cycloning of the scavenger tailings a large portion of the tailings deposited in the beach will be cyclone overflow. The total scavenger tailings deposited on the beach will segregate and the finer tailings will deposit further along the beach. The tailings properties assumed to be representative for Zone 3 (Scavenger Beach) is the scavenger overflow tailings.

Figure II-5 Zone 2 and Zone 3 Scavenger Beach Seepage Model 1D Column Locations



Initial Mine Year of Placement to Achieve Ultimate Depth	Ultimate Tailings Depth (ft)
5	350
10	250
19	150
28	50

Notes:

1. Contours on the left hand figure represent the tailings surface at the end of operations (Mine Year 41).
2. Contours on the right hand figure represent the tailings depth at the end of operations (Mine Year 41).

II-3 MODEL SET-UP, ASSUMPTIONS AND INPUTS

II-3.1 Model Domain and Timestep

The 1D vertical column is comprised of cells with different thicknesses. The number of cells and thickness of the cell is based monthly raises with the proposed TSF rate of rise (Section II-3.6). For the first 30 years of TSF operation each model cell represented a single month raise in the tailings surface (i.e., 12 months x 30 years equates to 360 cells). Due to the decrease in the rate of rise for the final 11 years of TSF operation (see Section II-3.6), the final 11 years of TSF operation is represented by four cells.

The model is completed on a variable timestep to satisfy the convergence criteria with a maximum time step of 12 hours. Slurry deposition, climate and consolidation processes are calculated on each timestep.

II-3.2 Boundary Conditions

The boundary conditions applied to the model are summarized as follows:

- **Bottom of column:**

  A free draining foundation condition is assumed beneath the proposed TSF (at the base of the 1D model). This condition is assumed for both the alluvium and the Gila Conglomerate and, in general, represents a foundation with relatively higher hydraulic conductivity than the overlying tailings, such that infiltration from the tailings to the foundation does not "mound up" in the foundation and limit infiltration from the tailings. See Section 3.3 of the main report for comparison of the foundation and tailings hydraulic conductivities. Furthermore, the free draining foundation condition can also represent the presence of an "underdrain" beneath the tailings. It is expected that the infiltration rates into the foundation would decrease if mounding above the base of the tailings were to occur.

- **Top of column:**

  A boundary layer is added on the top of tailings, where potential evaporation, runoff and infiltration interact (see Figure II-2). Bleed water (see Figure II-3 and Section II-3.5) is combined with precipitation (see Section II-3.3) as potential surface water inflow at this boundary layer. Potential evaporation (see Section II-3.3) is also applied at this layer. Actual evaporation depends on availability of water in the boundary layer; if there is a moisture deficit, the moisture in tailings column below may up well (i.e., have an upward gradient).

  The calculation of water infiltration, or losses, at the tailings surface into the tailings below the boundary layer is a function/balance of the conditions at the surface, along with the saturation profile within the tailings profile, which governs the capacity of the tailings profile to allow infiltration. In addition to the boundary conditions contributing to the saturation of the tailings profile, the changing hydraulic parameters and pore pressures as a result of tailings consolidation under self-weight, also contributes to saturation. This process is discussed further in Section II-3.7.

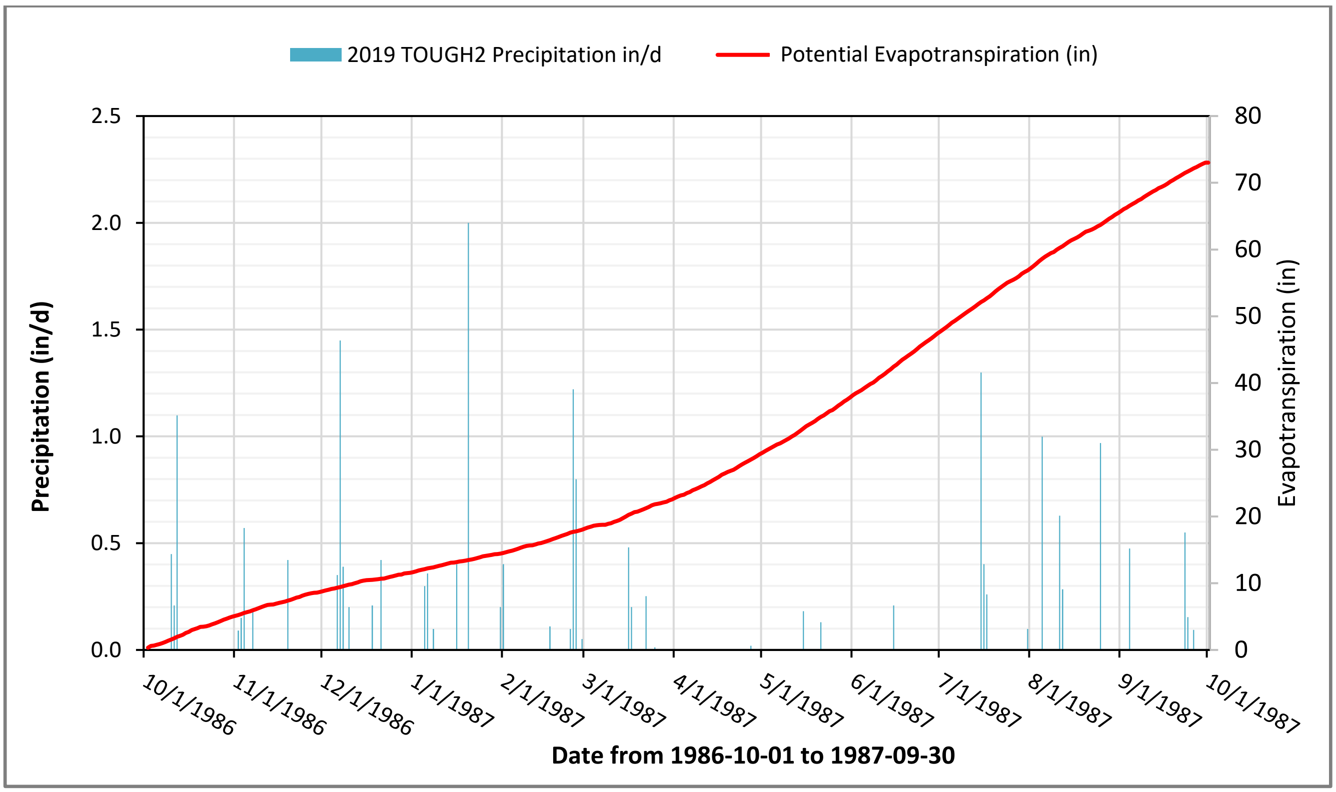
II-3.3 Climate

The semi-arid climate zone of the Skunk Camp site has low annual precipitation (~18 inches) and high annual potential evapotranspiration (PET) (~72 inches) The Skunk Camp Synthetic Data Set (SCSDS) was created for the closure cover modeling, the climate analysis is presented in Appendix IV-A (KCBCL 2020). The Scavenger Beach Seepage Model uses daily precipitation and potential evapotranspiration from the SCSDS for the period October 1, 1986 to September 30, 1987 (water year) chosen to be a "typical" year, with the annual data set repeated for each consecutive year during the model simulations. Table II-1 and Figure II-6 summarizes the precipitation and evapotranspiration from water year 1987 used for the 1D seepage modeling. Note, the 1987 water year has slightly higher precipitation and slightly lower potential evaporation in comparison to the average Skunk Camp climate.

Table II-2 Water Year 1987 Climate Inputs

Climate Parameter	1986			1987									Total
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Precipitation (in)	1.8	1.4	3.0	3.4	2.7	0.9	0.0	0.3	0.2	2.1	2.9	1.3	19.9
Potential Evaporation (PE) (in)	4.8	3.3	2.8	3.0	3.2	5.2	6.9	8.6	9.2	9.0	7.8	6.4	70.3

Figure II-6 SCSDS Daily Precipitation and Potential Evapotranspiration



The climate data set from October 1, 1993 to September 30, 2002 was used for a sensitivity analysis on climate. The 10-year data set was repeated for the duration of the model simulations. This climate period was selected for the sensitivity simulations because the period included:

- a wet year (1993), with an annual water year precipitation of 32.6 in and an average recurrence interval (ARI) of about +50;
- two dry years (2000 and 2002), each with an annual water year precipitation of 5.4 in and an ARI of about -140.

Based on the closure cover modeling (KCBCL 2020) the resulting average infiltration rate from precipitation over this period is 6% to 8%, which is in comparison to 4% infiltration for the base case precipitation scenario (1986 to 1987).

II-3.4 Materials Properties

As discussed in Section II-2.3 it is assumed that scavenger total tailings is representative of Zone 2 (Near Dam Scavenger Beach) and scavenger overflow tailings are representative of Zone 3 (Scavenger Beach). The hydraulic properties of the tailings are described by zone in Appendix I. The initial settled material properties (assumed for Stage 1 - Figure II-3 and the start of Stage 2 - Figure II-4) are given in Table II-3.

Table II-3 Initial Settled Tailings Materials Properties

Zone (see Section II-2.3)	Representative Tailings Type	Initial Settled Porosity (n)	Initial Settled Void Ratio (e)	Initial Settled Placed Saturation (%)	Initial Settled Vertical Hydraulic Conductivity k_v (cm/s)
2	Scavenger Total Tailings	0.437	0.775	100	2×10^{-5}
3	Scavenger Overflow Tailings	0.517	1.072	100	1×10^{-5}

Foundation properties have been assumed to be based on weathered Gila Conglomerate and modeled as equivalent porous medium. The Gila Conglomerate and the Alluvium is considered as a free draining surface, therefore material properties are not required for the foundation.

II-3.5 Bleed Water

Tailings slurry is a fluid, when deposited saturated tailings solids will settle to an initial settled density resulting in the expulsion of free water at the tailings surface, referred to as “bleed water”. Settling of tailings after deposition is not an instantaneous process, the process has been simplified as described in Section II-2.2. As the slurry settles on the surface of the beach the tailings are deposited at 100% saturation at an initial settled density and “bleed water” is released from the slurry, both the pore water at the initial settled density and the bleed water is available to infiltrate into the tailings column depending on the vertical gradient.

Porosity values for the tailings were selected to represent materials after initial slurry settlement has occurred, therefore implying instantaneous removal of water due to initial slurry settling. To account for this process, the bleed water that is released from the tailings between initial deposition and the initial settled density (i.e. the porosity values used in the model) was calculated to enable the "ponded" bleed water to contribute to the model as a surface runoff contribution to the upper-most tailings lift (see Figure II-2). Water introduced to the model via this surface runoff contribution will be removed by runoff or evaporation, if the underlying tailings profile does not have capacity for the ponded water to infiltrate.

The solids content at deposition (60% solids content by mass) and the initial settled tailings material properties (Table II-3) were used to calculate the bleed water available for infiltration, Table II-4.

Table II-4 Calculated Tailings Bleed Water Volumes

Zone (see Section II-2.3)	Representative Tailings Type	Slurry Solids Content by Weight (%)	Tailings Slurry Equivalent Void Ratio[1]	Initial Settled Void Ratio (e)[2]	Bleed water inflow per unit depth (ft/ft)[3]
2	Scavenger Total Tailings	60%	1.87	0.775	0.615
3	Scavenger Overflow Tailings	60%	1.87	1.072	0.384

Notes:
1. Based on the design target for the tailings deposition slurry of 60% solids content by mass.
2. Based on laboratory testing (settling tests and consolidation testing), see Appendix I for additional details.
3. Calculated as the difference between the slurry water and initial settled pore water at 100% saturation. Rate of rise would be used to calculate what is added to the modeled tailings surface for each timestep. Bleed water is calculated as:

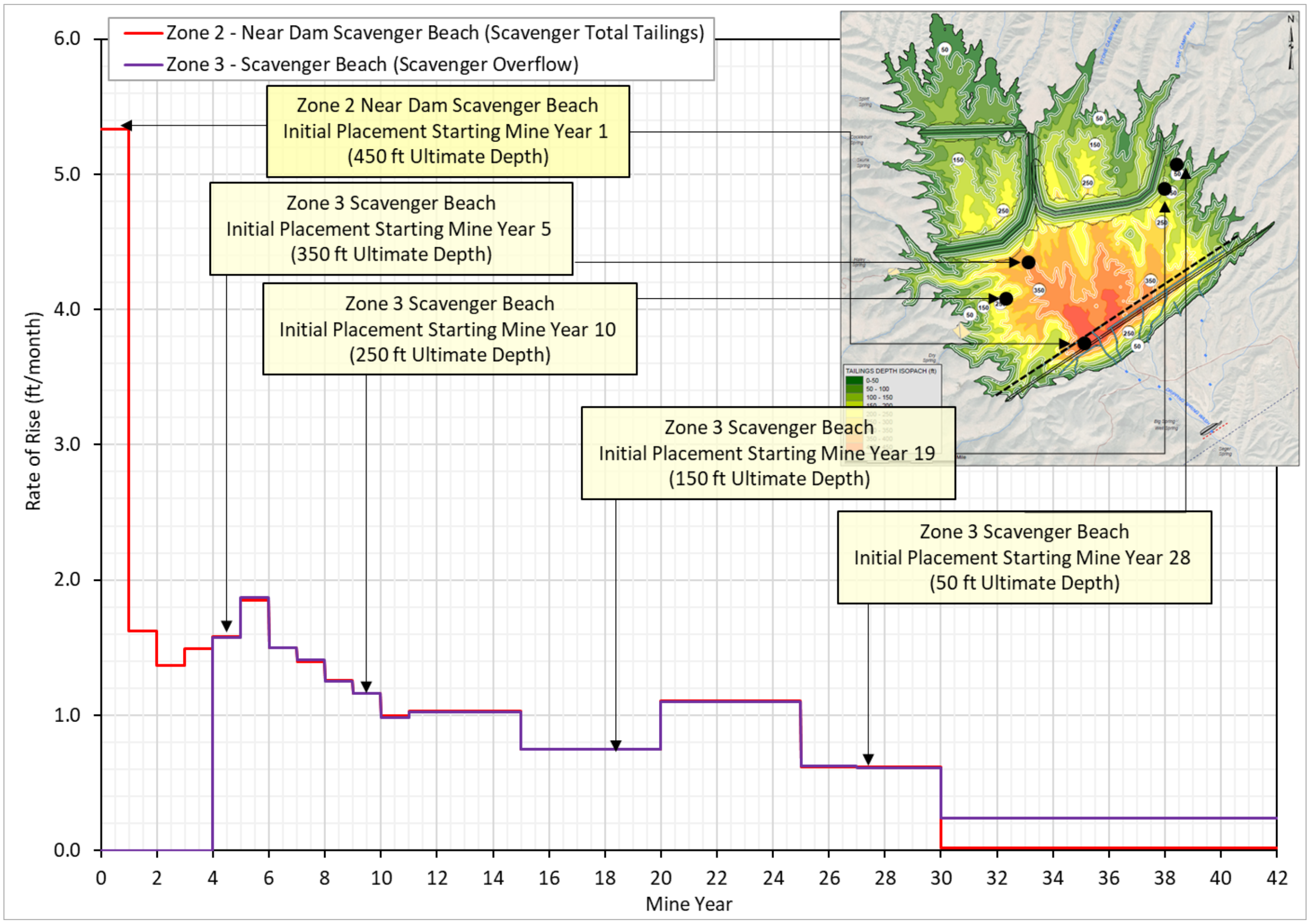
$$q_b = \frac{e_{slurry} - e_{rise}}{1 + e_{rise}}$$

Where q_b is bleed water produced by forming unit height saturated rise from slurry at per unit square area, e_{slurry} is slurry void ratio and e_{rise} is formed rise void ratio.

II-3.6 Tailings Rates of Rise

Operation of the TSF is proposed to occur over 41 years. The rate of rise of the TSF is predicted to vary over the duration of TSF operation based on the tailings deposition plan (KCBCL 2019b). The scavenger beach rate of rise used for the modeling is presented in Figure II-7.

Figure II-7 Scavenger Beach Rate of Rise



II-3.7 Consolidation

Upon deposition of a layer of tailings, the vertical stress in the underlying deposit increases due to the weight of the freshly deposited layer. The increase in vertical stress (equal to the total unit weight of the freshly deposited layer multiplied by the height of the layer) is partially borne by the pore water fluid at the instant of loading. The pore fluid pressure dissipates due to the flow of pore fluids to adjacent lower pressure cells. Pore pressure dissipation increases the effective stress in the tailings and causes the tailings to compress or “consolidate” (i.e., decrease in void space or void ratio). TOUGH2 conducts the coupling between porous medium deformation (consolidation) and the flow of fluids in the medium. Based on the large strain consolidation equations by Gibson et al. (1967), as tailings is deposited, the effective stress on the underlying tailings increases and induces void ratio reduction; moreover, the reduced void ratio leads to the reduction of hydraulic conductivity. The equations of effective stress with void ratio and void ratio with hydraulic conductivity can be described as the following empirical formulas.

$$\sigma_e{}' = \sum W - p$$

$$e = A\sigma_e{}'^B + C$$

$$k = Re^S + D$$

where $\sigma_e{}'$ is vertical effective stress, *e* is void ratio, *k* is hydraulic conductivity, p is the pore pressure. *A, B, C,* and *D* are empirical constants estimated for the different tailings types (for the purposes of this assessment these were determined from properties measured in laboratory slurry consolidation, oedometer and Rowe cell tests, see Appendix I for further details).

The TOUGH2 model does not change the model domain (i.e., cell thickness). To account for consolidation TOUGH2 varies void ratio (porosity) but maintains mass balance to account for changes in tailings properties. Firstly, the effective stress is calculated for each cell based on the mass of tailings and water above in the column and the estimated pore pressure. Based on this, the void ratio (and subsequently porosity) and saturated vertical hydraulic conductivity for each cell is calculated based on the above equations. The pore pressures generated from the decreased void ratio dissipates by Darcy's law. Although the volume of the cell is constant in the model, the mass of the cell decreases as the tailings consolidate (i.e., water is expelled from the tailings voids). All calculations are based on mass (e.g., saturation), thus the constant cell size volume is not expected to have a significant impact on the overall results.

II-4 RESULTS

Model results are provided in the following sections for the five 1D column locations (1 location for Zone 2 and 4 locations for Zone 3) within the scavenger beach (see Figure II-5 for locations).

Variations to the modeling inputs (hydraulic conductivity, consolidation and climate) were completed to assess variations in the resulting flux into the foundation.

II-4.1 Zone 2 – Near Dam Scavenger Beach (Scavenger Total Tailings) – Base Case

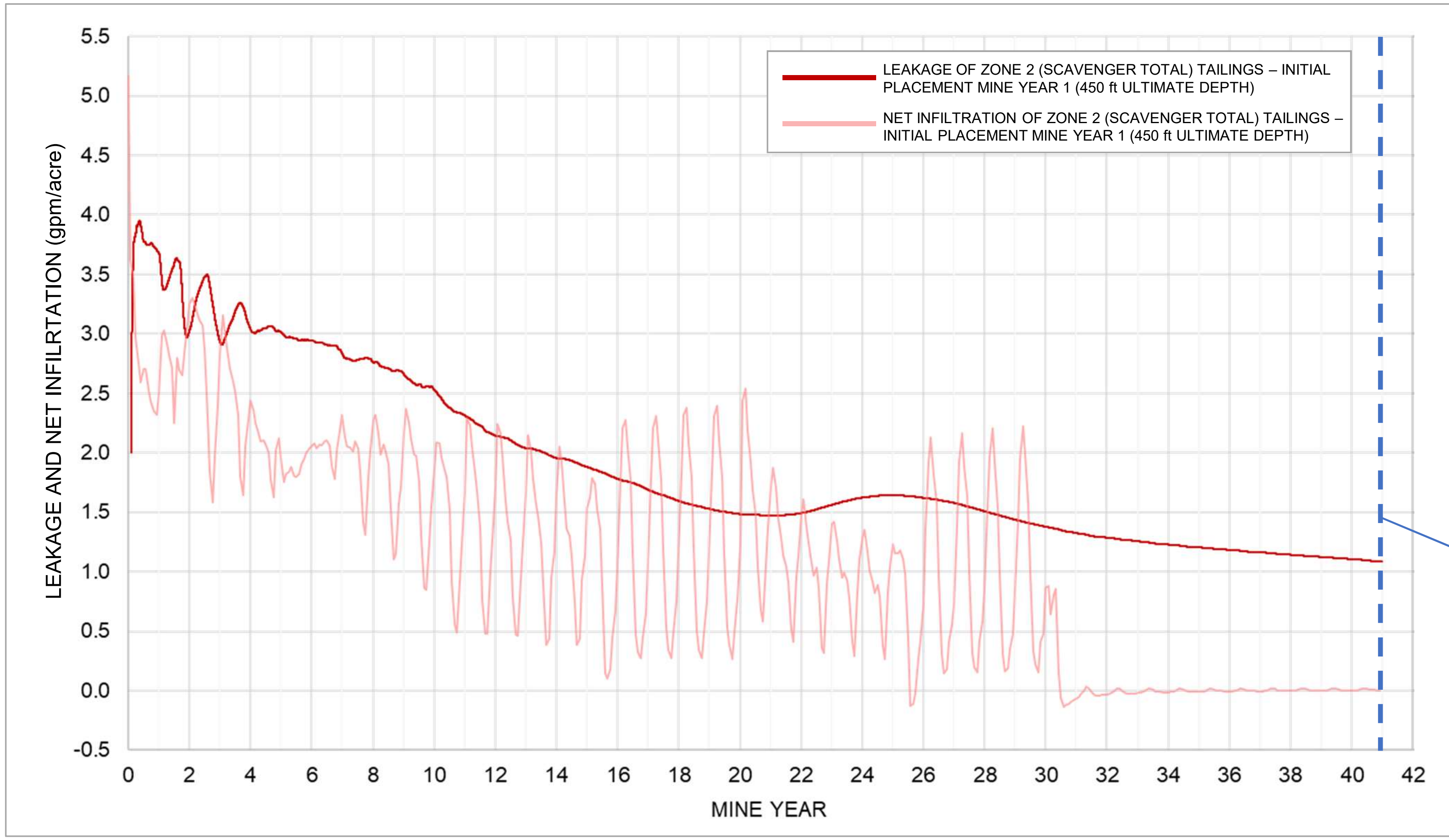
The Zone 2 – Near Dam Scavenger Beach (scavenger total tailings) column is located in the deepest portion of the scavenger beach, see Figure II-5. Based on the model assumptions and inputs (including climate conditions, material properties, surface water contributions, tailings surface rate of rise and consolidation effects) given in Section II-3, the predicted infiltration into the tailings column, basal leakage into the foundation (or underdrainage system) and tailings column saturation profiles for the mine life and post-closure are presented in Figure II-8 and Figure II-9, respectively.

The Zone 2 – Near Dam Scavenger Beach (scavenger total tailings) column has a maximum flux rate into the foundation of approximately 4 gpm/acre, which is mainly due to the high rate of rise during the early operation years at the column location. Flux into the foundation decreases over the life of the mine due to the tailings consolidating resulting in lower hydraulic conductivity close to the foundation and the lower rate of rise.

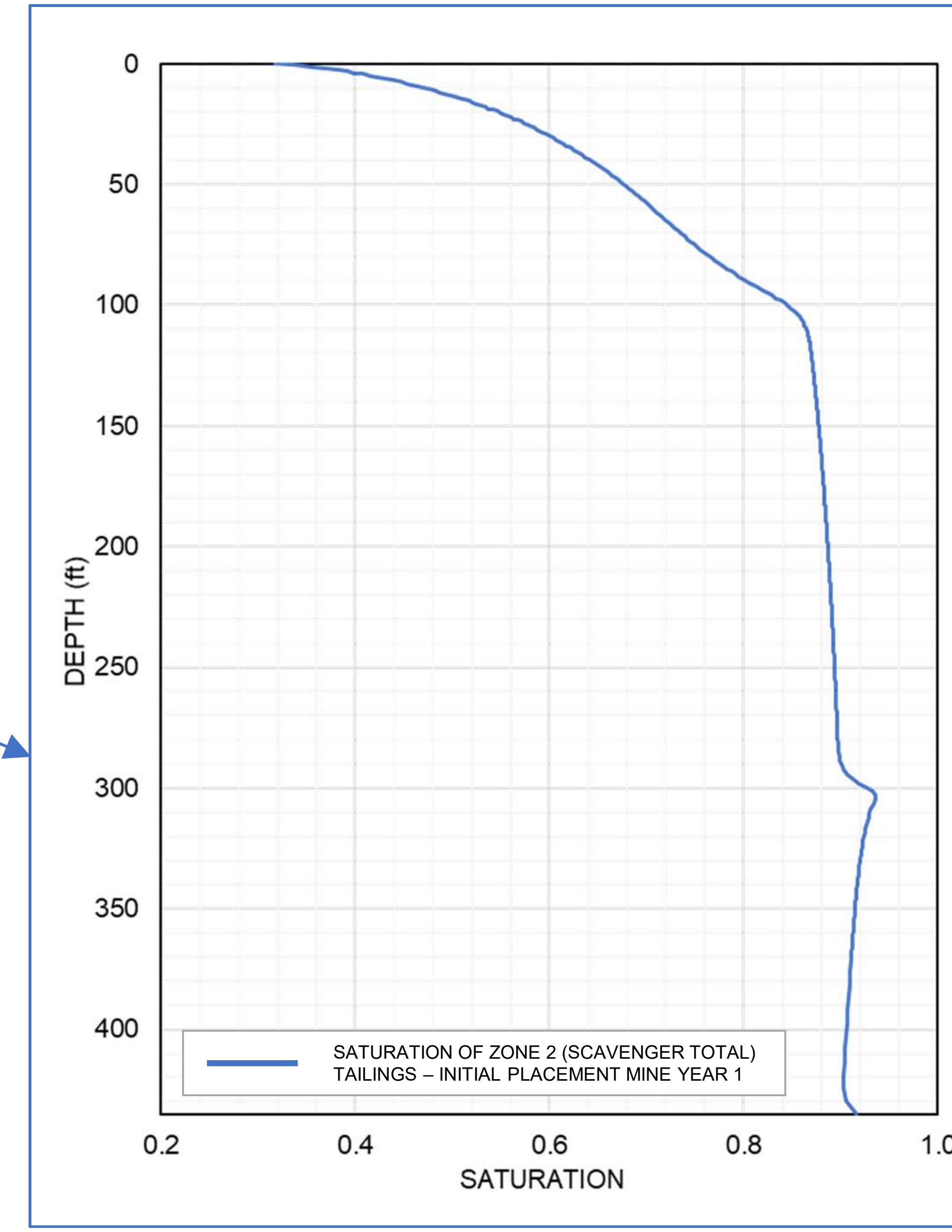
The saturation profile for the column at the end of mine life show saturation gradually increases with depth from ~30% saturation at from the tailings surface to ~86% saturation at approximately 100 ft below the surface. Between 100 ft depth and the base of the tailings profile the saturation increases to ~92%. The top 100 ft of tailings are lower saturation because based on the tailings staging plan (KCBCL 2020 and Figure II-7) deposition at this location ceases at Mine Year 30. A pulse in saturation is observed at 300 ft (94%), which is due to the migration of seepage down the tailings profile over time for a high rate of rise, as these results represents the saturation at a snapshot in time (i.e., Year 41).

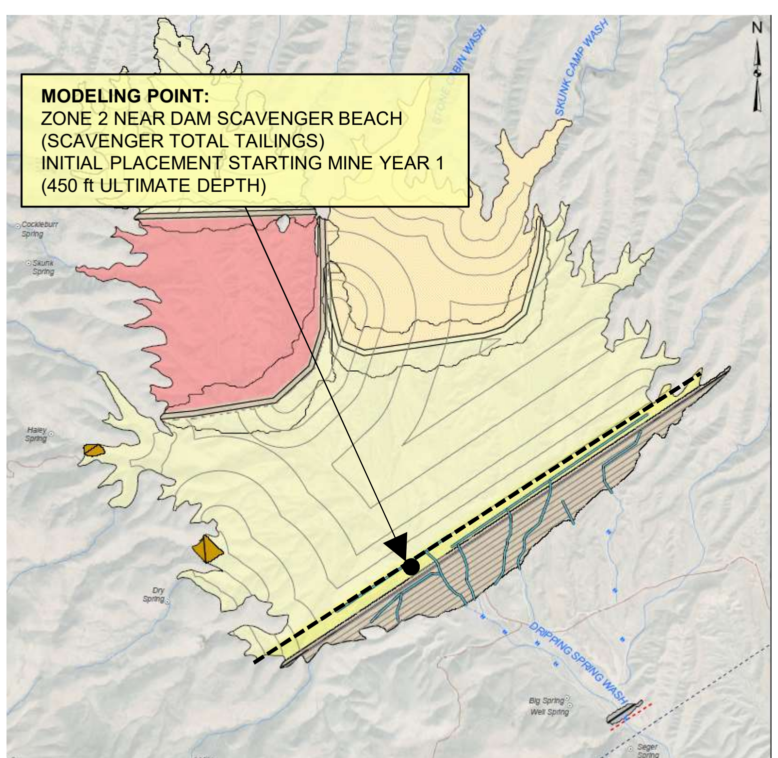
Flux rate into the foundation and saturation of the tailings column both decrease post-closure, as shown in Figure II-9. Post-closure basal leakage flux decreases from 1.1 gpm/acre to less than 0.2 gpm/acre within the first 50 years following the cessation of operations. Between 50 years and 500 years following the end of operation, the basal leakage flux gradually decreases to less than 0.05 gpm/acre. Following the cessation of the TSF operation, water within the tailings profile drains down over time. After 100 years following the cessation of operations the majority of the tailings profile is less than 60% saturated, while the upper 170 ft of tailings is less than 50% saturated.

ZONE 2 TAILINGS – LEAKAGE AND NET INFILTRATION RESULTS FOR OPERATIONS



ZONE 2 TAILINGS - SATURATION PROFILE AT MINE YEAR 41





NOTE: SEE FIGURE 3.1 OF THE MAIN TEXT FOR LEGEND

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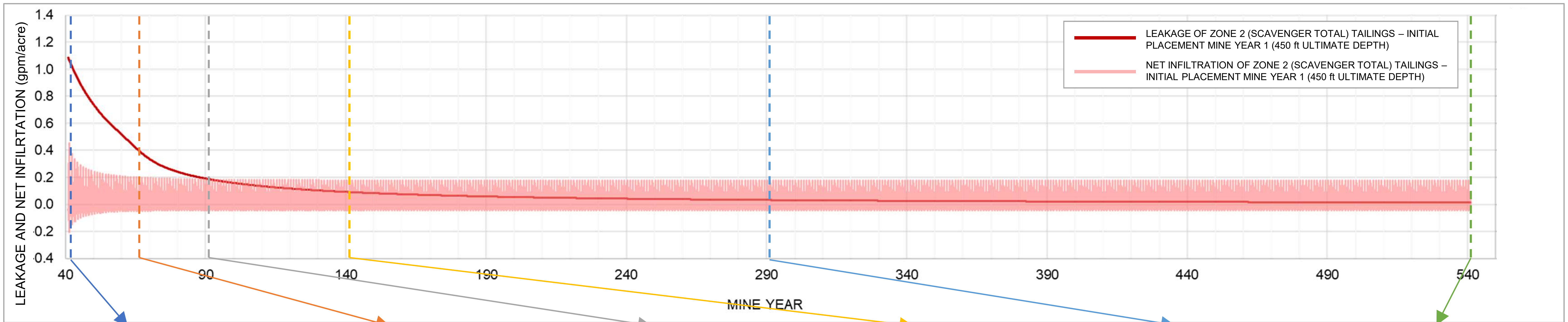
SKUNK CAMP TSF SEEPAGE ASSESSMENT

TITLE: ZONE 2 - NEAR DAM SCAVENGER BEACH (SCAVENGER TOTAL TAILINGS) LEAKAGE RESULTS FOR OPERATIONS

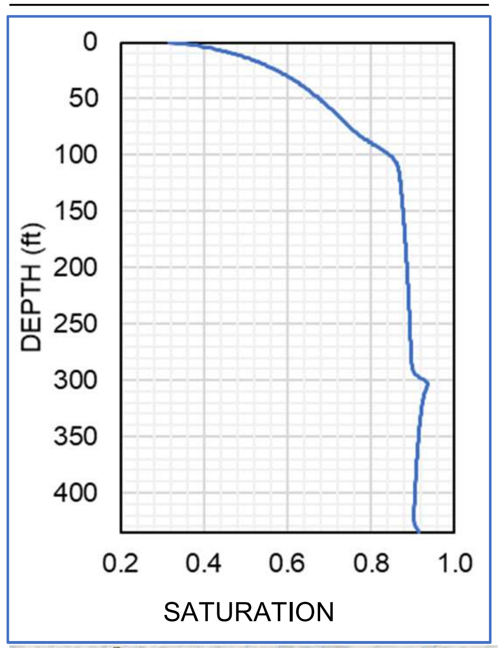
PROJECT No. UM09441A22

FIG No. II-8

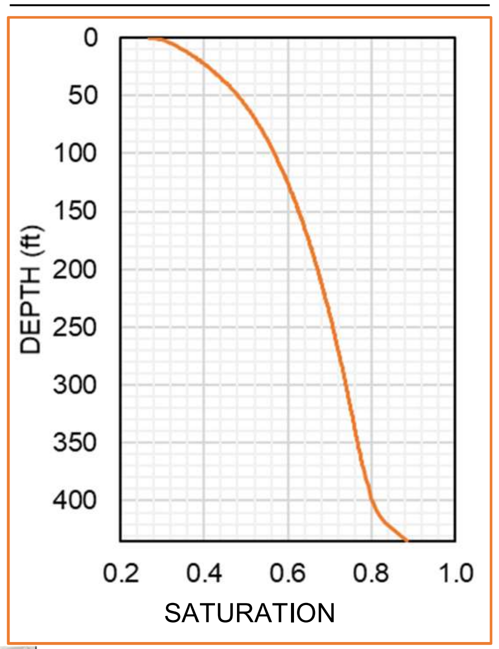
ZONE 2 TAILINGS – LEAKAGE AND NET INFILTRATION RESULTS FOR CLOSURE



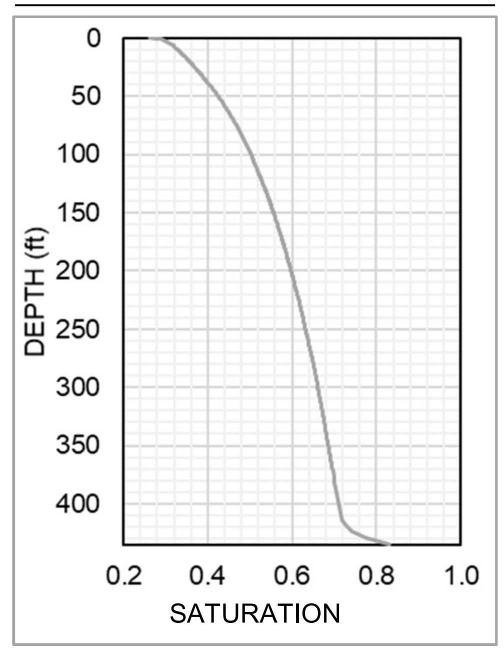
SATURATION PROFILE AT MINE YEAR 41



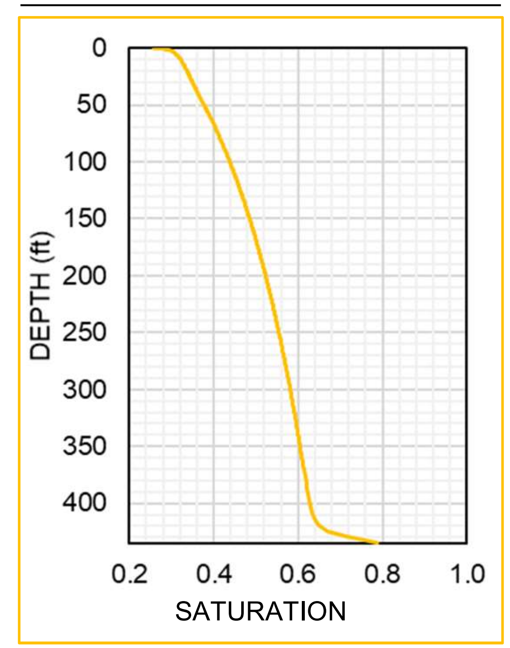
SATURATION PROFILE AT MINE YEAR 66



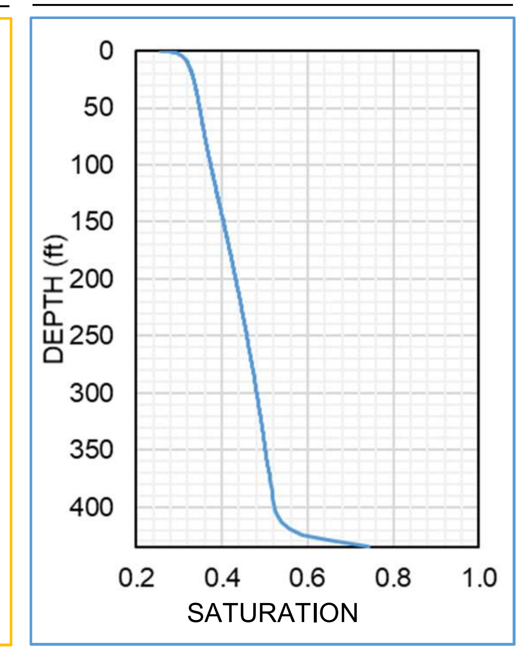
SATURATION PROFILE AT MINE YEAR 91



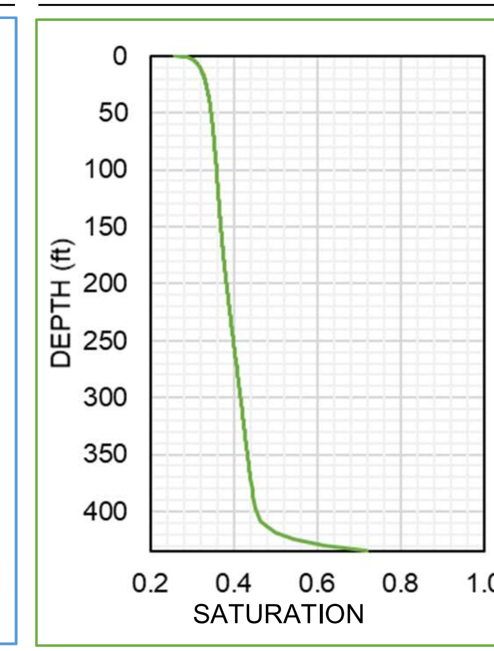
SATURATION PROFILE AT MINE YEAR 141

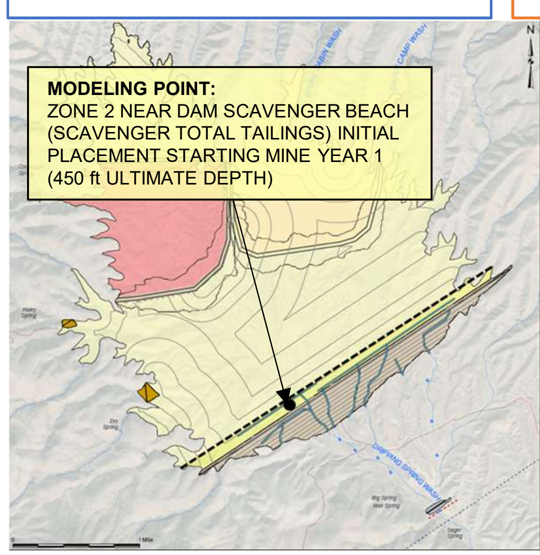


SATURATION PROFILE AT MINE YEAR 291

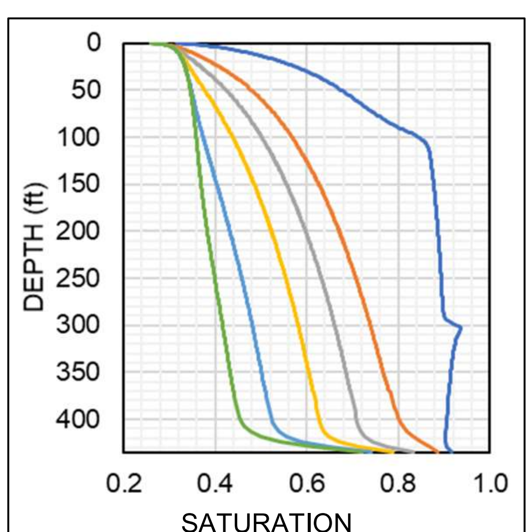


SATURATION PROFILE AT MINE YEAR 541





NOTE: SEE FIGURE 3.1 OF THE MAIN TEXT FOR LEGEND



SATURATION OF ZONE 2 (SCAVENGER TOTAL) TAILINGS INITIAL PLACEMENT MINE YEAR 1 (450 ft ULTIMATE DEPTH) AT:

- MINE YEAR 41
- MINE YEAR 66
- MINE YEAR 91
- MINE YEAR 141
- MINE YEAR 291
- MINE YEAR 541

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SKUNK CAMP TSF SEEPAGE ASSESSMENT

TITLE: ZONE 2 - NEAR DAM SCAVENGER BEACH (SCAVENGER TOTAL TAILINGS) LEAKAGE RESULTS FOR POST-CLOSURE

PROJECT No. UM09441A22

FIG No. II-9

II-4.2 Zone 3 – Scavenger Beach (Scavenger Overflow Tailings) – Base Case

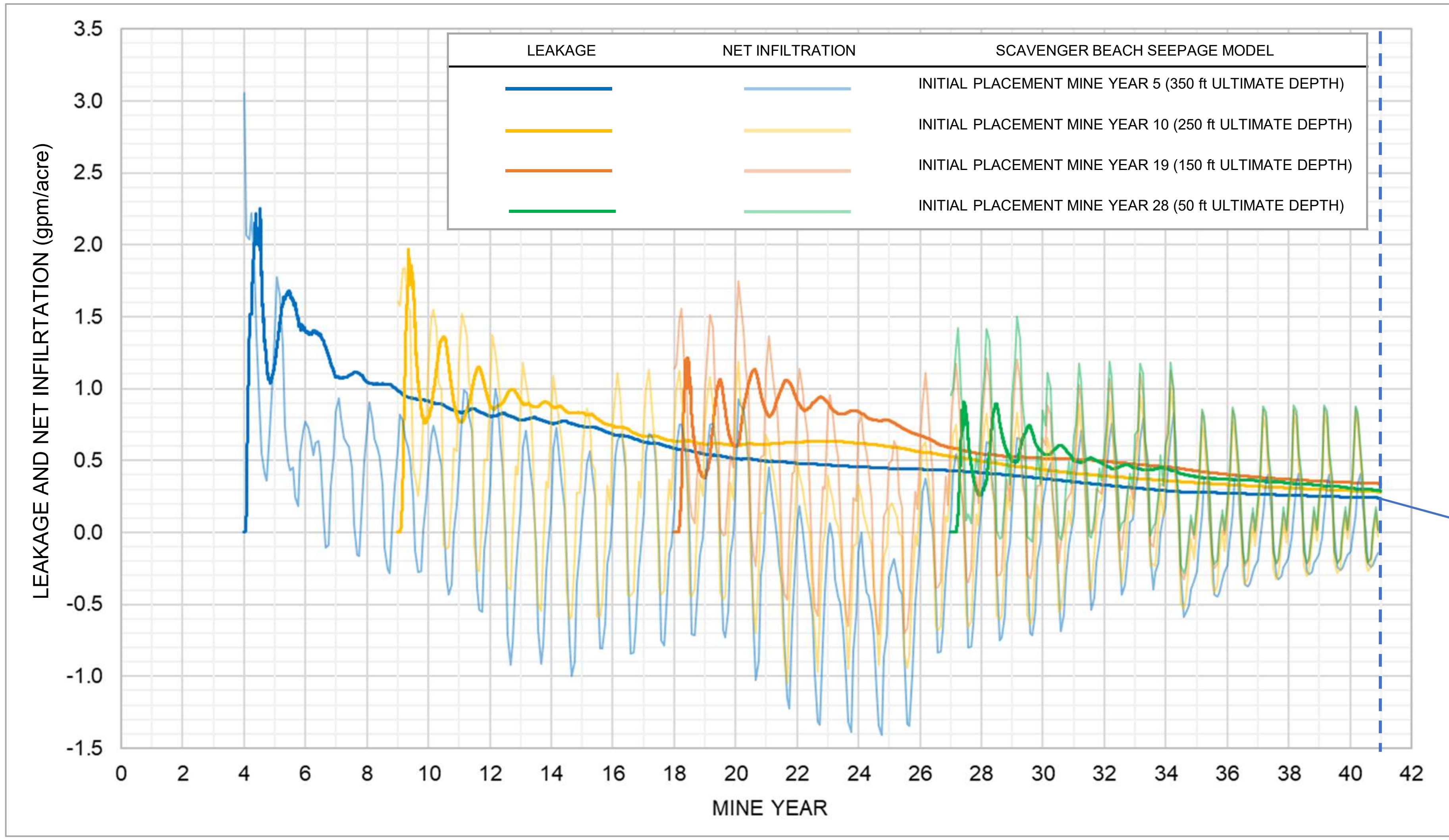
The Zone 3 – Scavenger Beach (scavenger overflow tailings) columns are located further into the scavenger beach, see Figure II-5. Based on the model assumptions and inputs (including climate conditions, material properties, surface water contributions, tailings surface rate of rise and consolidation effects) given in Section II-3, the predicted infiltration into the tailings column, basal leakage into the foundation and tailings column saturation profiles for the mine life and post-closure are presented in Figure II-10 and Figure II-11, respectively.

The Zone 3 – Scavenger Beach (scavenger overflow tailings) columns have a maximum flux rate into the foundation ranging from approximately 2.2 gpm/acre to 1 gpm/acre, which are correlated to the rate of rise at the column location after initial deposition. Flux into the foundation decreases over the life of the mine to approximately 0.2 gpm/acre to 0.4 gpm/acre at the end of operations.

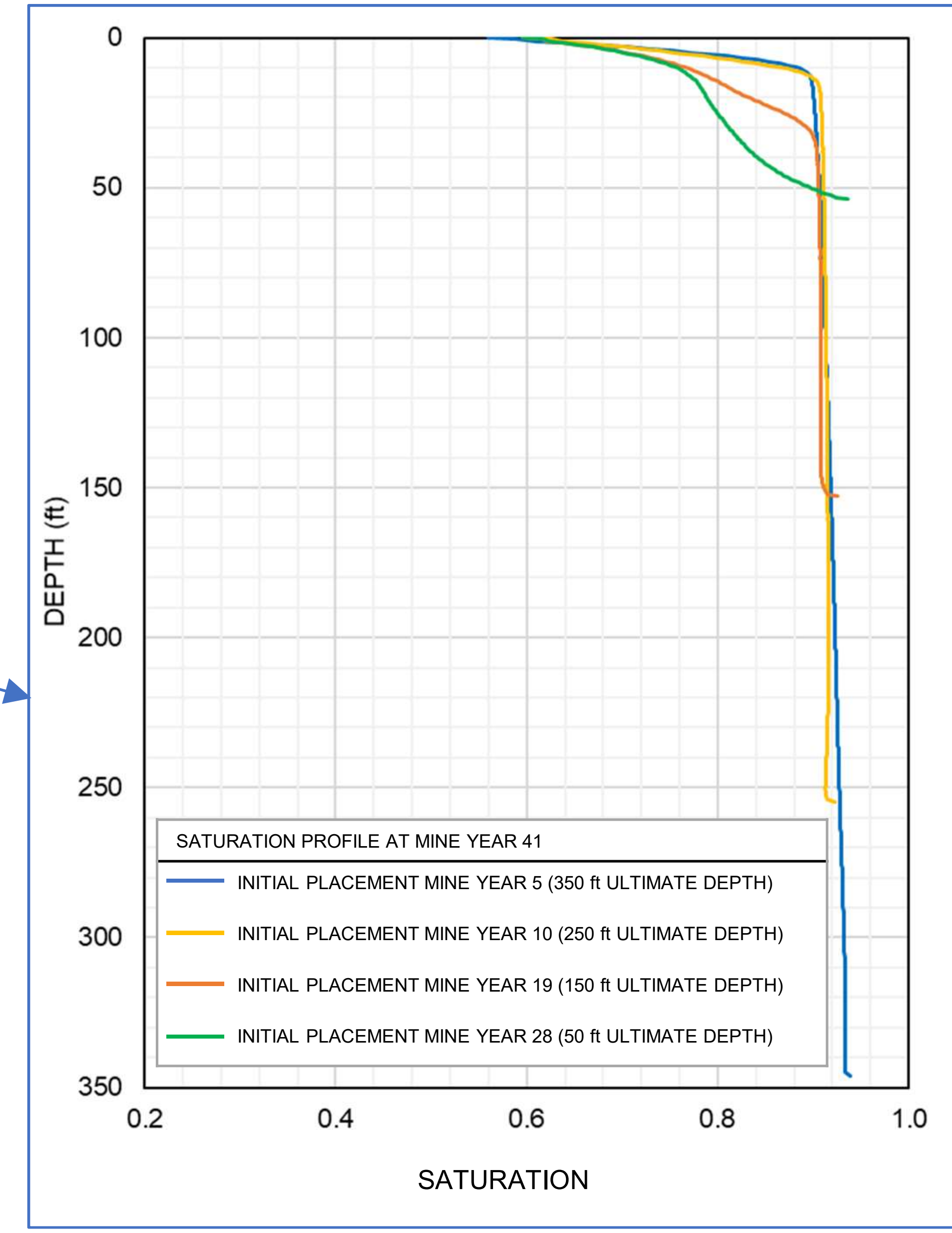
The saturation profiles for the columns at the cessation of operations show that the majority of the tailings column is over 90% saturation, with the exception of the upper 20 ft of the profile where the tailings decrease in saturation.

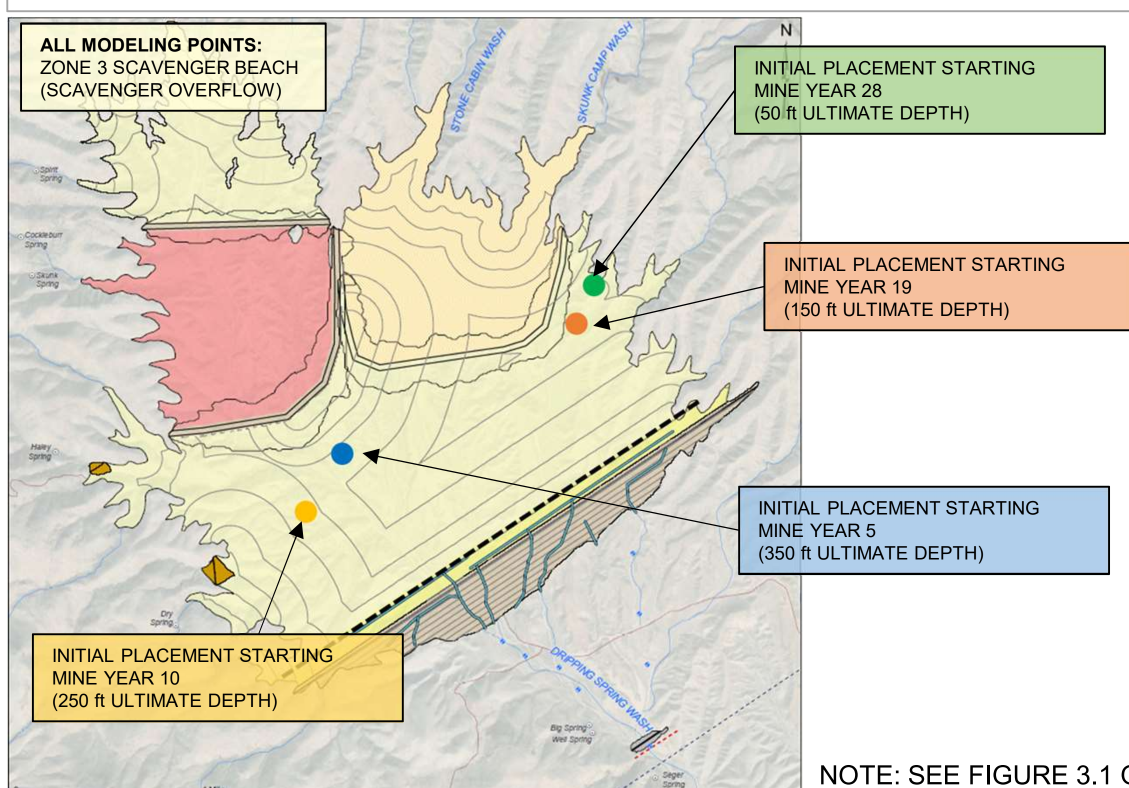
Flux rate into the foundation and saturation of the tailings column both decrease post-closure, as shown in Figure II-10. Post-closure basal leakage flux decreases from 0.2 gpm/acre to 0.4 gpm/acre at the end of operations to less than 0.05 gpm/acre within the 40 years to 300 years, depending on the final height of the tailings column. Following the cessation of the TSF operation water within the tailings profile drains down over time but at a slower rate in comparison to Zone 2 – Near Dam Scavenger Beach.

ZONE 3 TAILINGS – LEAKAGE AND NET INFILTRATION RESULTS FOR OPERATIONS



ZONE 3 TAILINGS - SATURATION PROFILE AT MINE YEAR 41





NOTE: SEE FIGURE 3.1 OF THE MAIN TEXT FOR LEGEND

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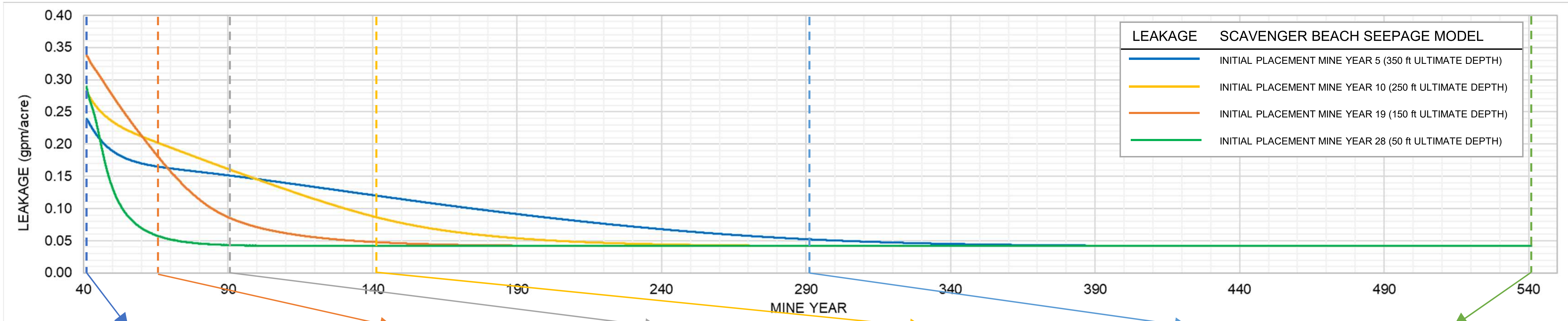
SKUNK CAMP TSF SEEPAGE ASSESSMENT

TITLE: ZONE 3 - SCAVENGER BEACH
(SCAVENGER OVERFLOW)
LEAKAGE RESULTS FOR OPERATIONS

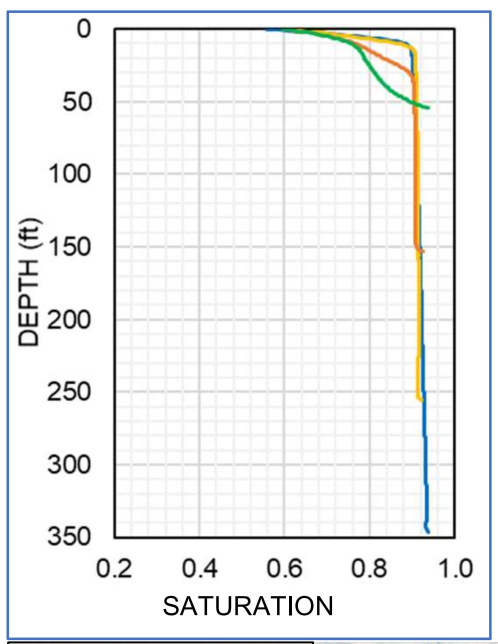
PROJECT No. UM09441A22

FIG No. II-10

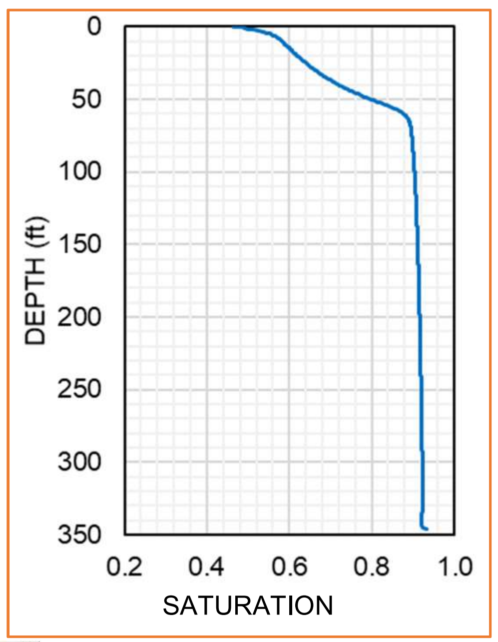
ZONE 3 TAILINGS – LEAKAGE AND NET INFILTRATION RESULTS FOR CLOSURE



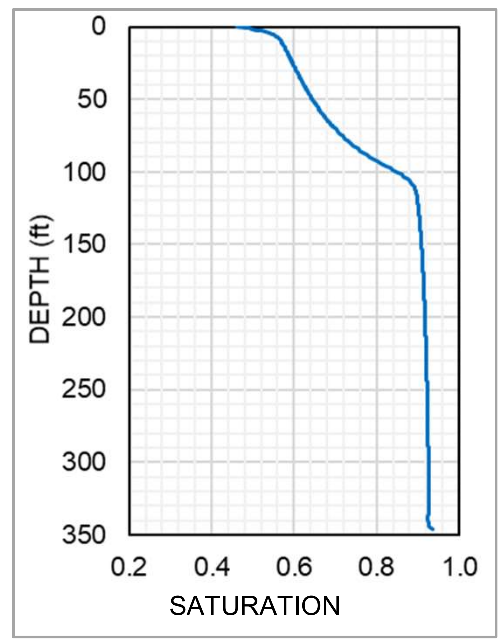
SATURATION PROFILE AT MINE YEAR 41



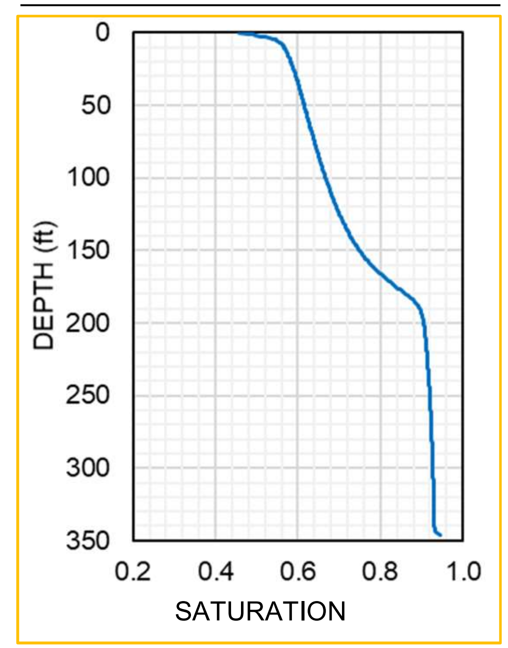
SATURATION PROFILE AT MINE YEAR 66



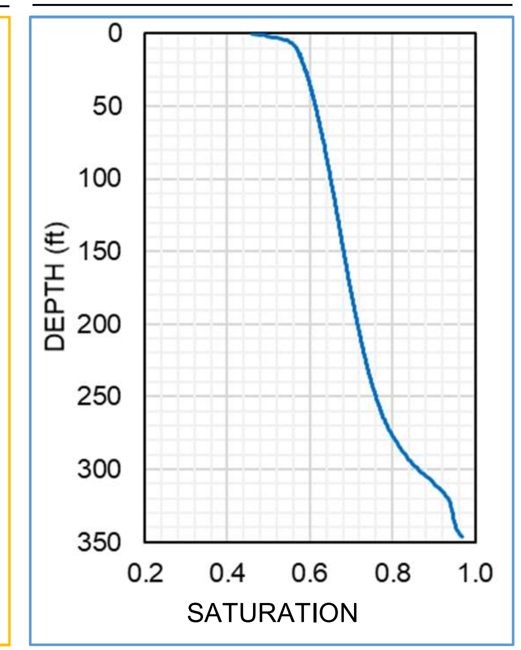
SATURATION PROFILE AT MINE YEAR 91



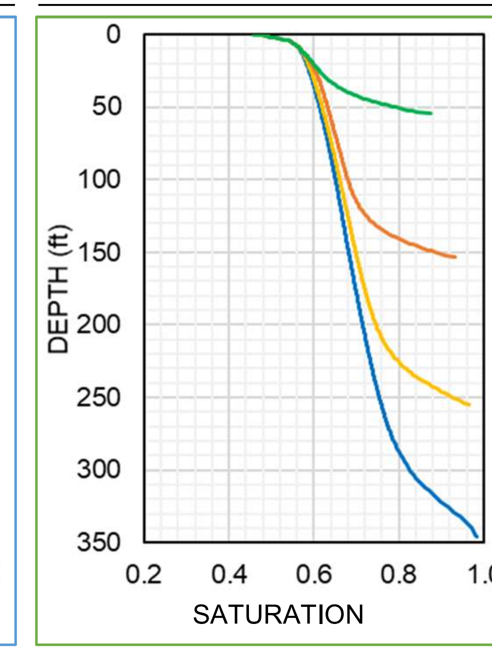
SATURATION PROFILE AT MINE YEAR 141

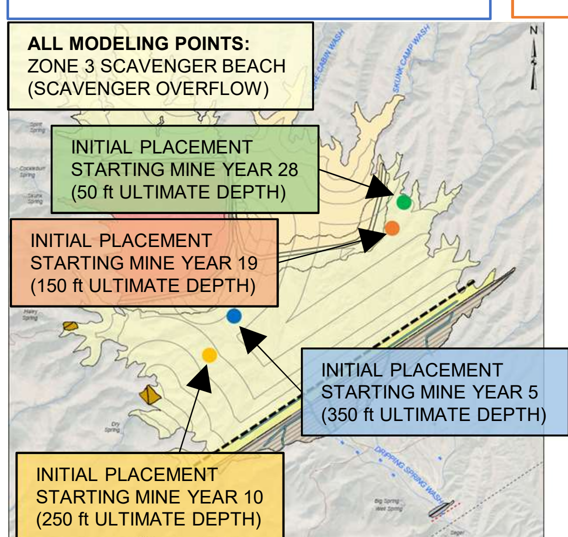


SATURATION PROFILE AT MINE YEAR 291

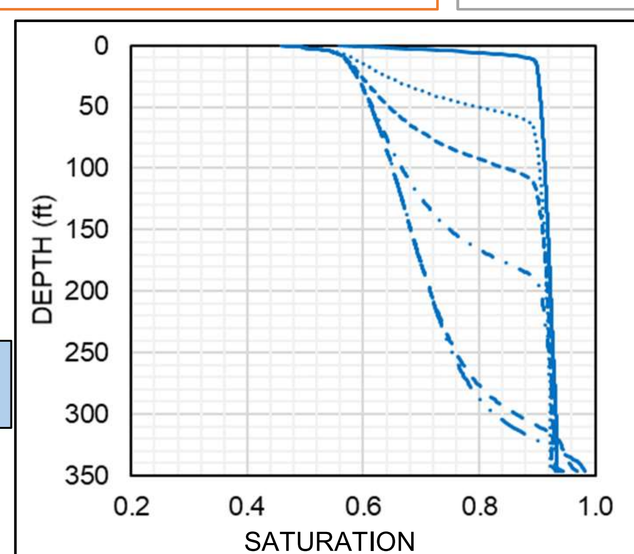


SATURATION PROFILE AT MINE YEAR 541





NOTE: SEE FIGURE 3.1 OF THE MAIN TEXT FOR LEGEND



NOTES

1. SATURATION PROFILES FOR THE 250 ft, 150ft, AND 50 ft ULTIMATE DEPTH SCAVENGER BEACH SEEPAGE MODELS WERE ONLY DEVELOPED FOR MINE YEAR 41 AND 541. SATURATION PROFILES FOR THE 350 ft ULTIMATE DEPTH SCAVENGER BEACH SEEPAGE MODEL WERE DEVELOPED FOR KEY MINE YEARS.
2. NET INFILRATION FOR ZONE 3 RANGED FROM ABOUT -0.5 gpm/acre TO 0.75 gpm/acre DURING THE DRAINDOWN AND POST-CLOSURE PERIOD. AS SUCH, NET INFILTRATION WAS NOT PLOTTED WITH LEAKAGE FOR DRAINDOWN AND POST-CLOSURE TO BETTER SHOW THE LEAKAGE RESULTS.

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	TITLE: ZONE 3 - SCAVENGER BEACH (SCAVENGER OVERFLOW) LEAKAGE RESULTS FOR POST-CLOSURE
PROJECT No. UM09441A22	FIG No. II-11

II-4.3 Sensitivity Analyses

II-4.3.1 General

Sensitivities were completed on select modeling inputs (hydraulic conductivity, consolidation, and climate) to assess variations in the resulting flux into the foundation. Section II-4.3.2 presents sensitivities on hydraulic conductivity and the application of consolidation and Section II-4.3.3 presents the sensitivity on climate.

II-4.3.2 Hydraulic Conductivity and Consolidation

Two sensitivity scenarios were completed for the life of mine to assess the effects and assumptions of consolidation:

- Base Case - consolidation applied as described in Section II-3.7 and results presented in Section II-4.1 and Section II-4.2.
- Sensitivity Scenario 1 – Incorporate changes in void ratio and porosity based on effective stress, but do not incorporate changes to the initial vertical saturated hydraulic conductivity (Kv_{sat} = 2 x 10^{-5} cm/s) throughout the column.
- Sensitivity Scenario 2 – Do not incorporate changes from consolation processes (void ratio, porosity, saturated hydraulic conductivity. Use initial porosity [n = 0.44] and initial vertical saturated hydraulic conductivity [Kv_{sat} = 2 x 10^{-5} cm/s] throughout the column.

Sensitivity on hydraulic conductivity and consolidation results for basal leakage for the Zone 2 column (scavenger total tailings, initial placement during Mine Year 1 (450 ft ultimate depth)) and one of the four Zone 3 columns (scavenger overflow tailings, initial placement during Mine Year 5 (350 ft ultimate depth)) are presented in Figure II-13 and Figure II-14, respectively.

For Zone 2 – Near Dam Scavenger Beach (Scavenger Total Tailings):

- When the effects of consolidation are not accounted for in modeling the peak flux into the foundation significantly increases (from 4 gpm/acre [Base Case] to 5.5 gpm/acre [Sensitivity Scenario 1] or 10 gpm/acre [Sensitivity Scenario 2]), but the percent increase of flux is decreased after approximately Mine Year 7.

For Zone 3 – Scavenger Beach (Scavenger Overflow Tailings):

- When the effects of consolidation are accounted for porosity in modeling but the saturated hydraulic conductivity remains unchanged [Sensitivity Scenario 1] the fluxes into the foundation decrease.
- When the effects of consolidation are not accounted for in modeling [Sensitivity Scenario 2] the peak flux into the foundation does not increase and the incremental increase during operations is approximately 0.5 gpm/acre from around Mine Year 5 to the end of operations.

Figure II-12 Zone 2 – Near Dam Scavenger Beach (Scavenger Total Tailings) Sensitivity Scenarios Basal Leakage Flux – Operations (41 years)

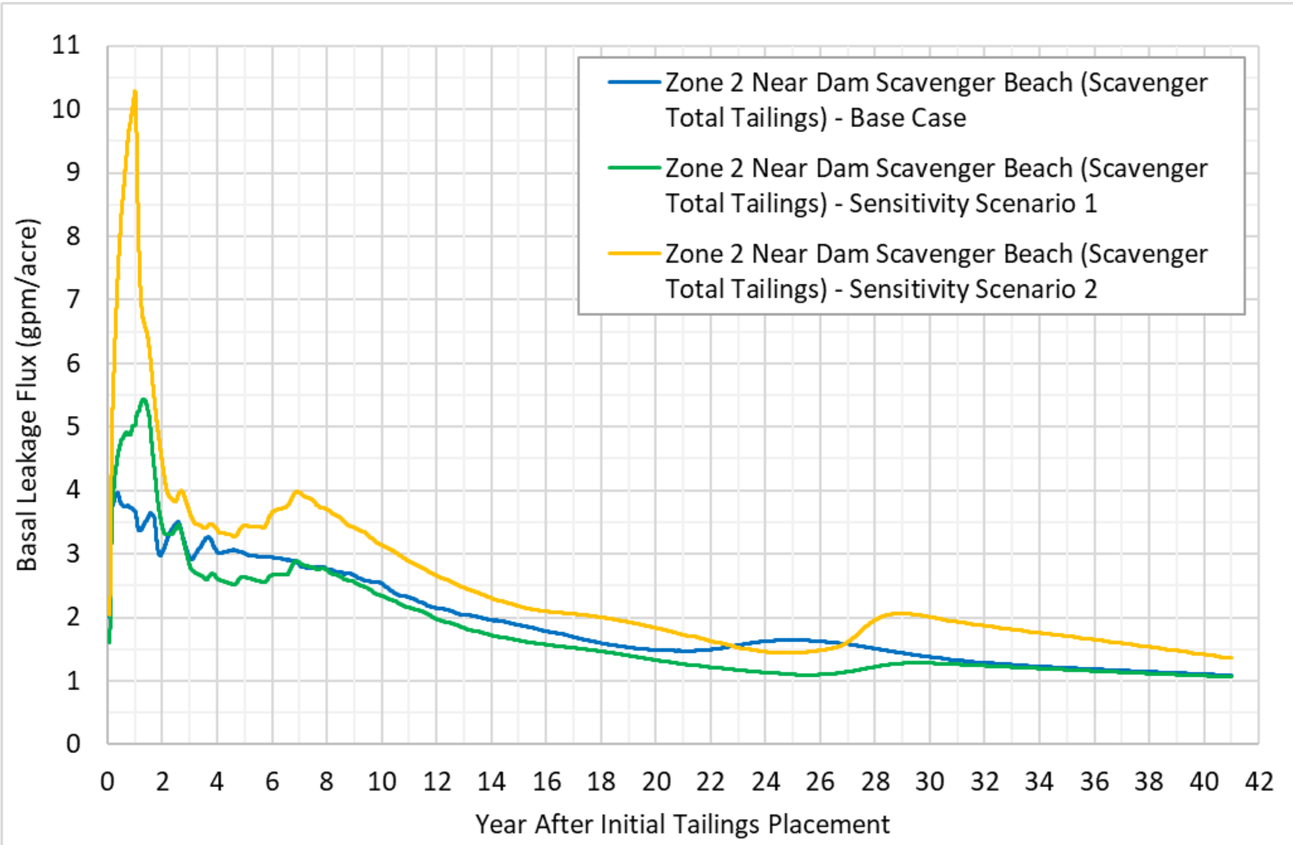
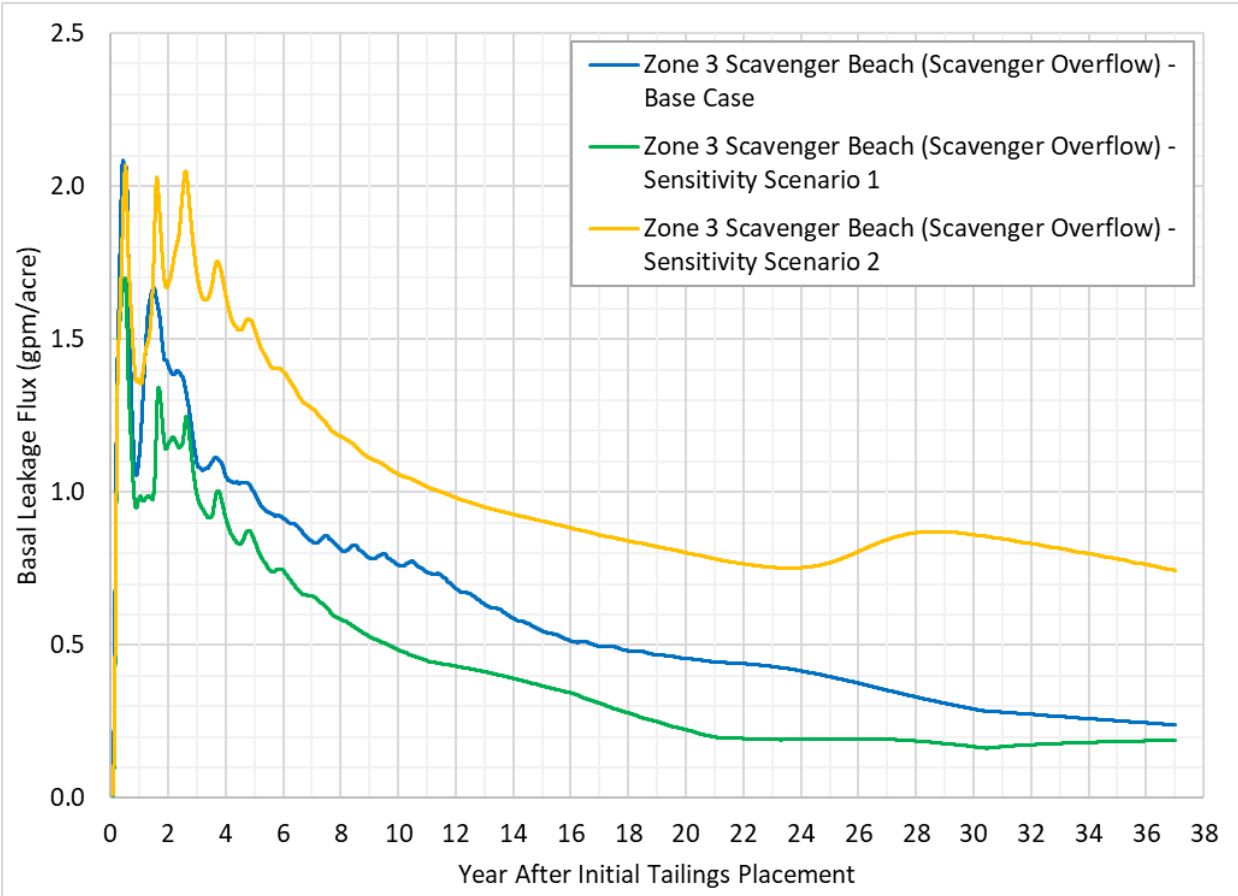


Figure II-13 Zone 3 – Scavenger Beach (Scavenger Overflow Tailings) Sensitivity Scenarios Basal Leakage Flux – Operations (41 years)



II-4.3.3 Climate

A climate sensitivity analysis completed with the precipitation and evapotranspiration for the 10 year period from October 1, 1993, to September 30, 2002. This period was selected for a sensitivity analysis of “wet” conditions and “dry” conditions. As described in Section II-3.3, the dataset includes:

- a wet year (1993), with an annual water year precipitation of 32.6 in and an ARI of about +50;
- two dry years (2000 and 2002), each with an annual water year precipitation of 5.4 in and an ARI of about -140.

Predicted basal leakage fluxes for Zone 2 and Zone 3 for the climate sensitivity are shown in Figure II-14 and Figure II-15, respectively. These results indicate that the basal leakage from the tailings profiles are not sensitive to extreme climatic conditions (within the expected range for the site), particularly extreme climate conditions (e.g. “wet year”). A comparison of results between the sensitivity analyses and Base Case scenarios indicate similar trends in the basal leakage flux (a function of the TSF operation, material properties and infiltration mechanisms) and similar flux values.

Figure II-14 Zone 2 – Near Dam Scavenger Beach (Scavenger Total Tailings) Climate Sensitivity Basal Leakage Flux – Operations (41 years)

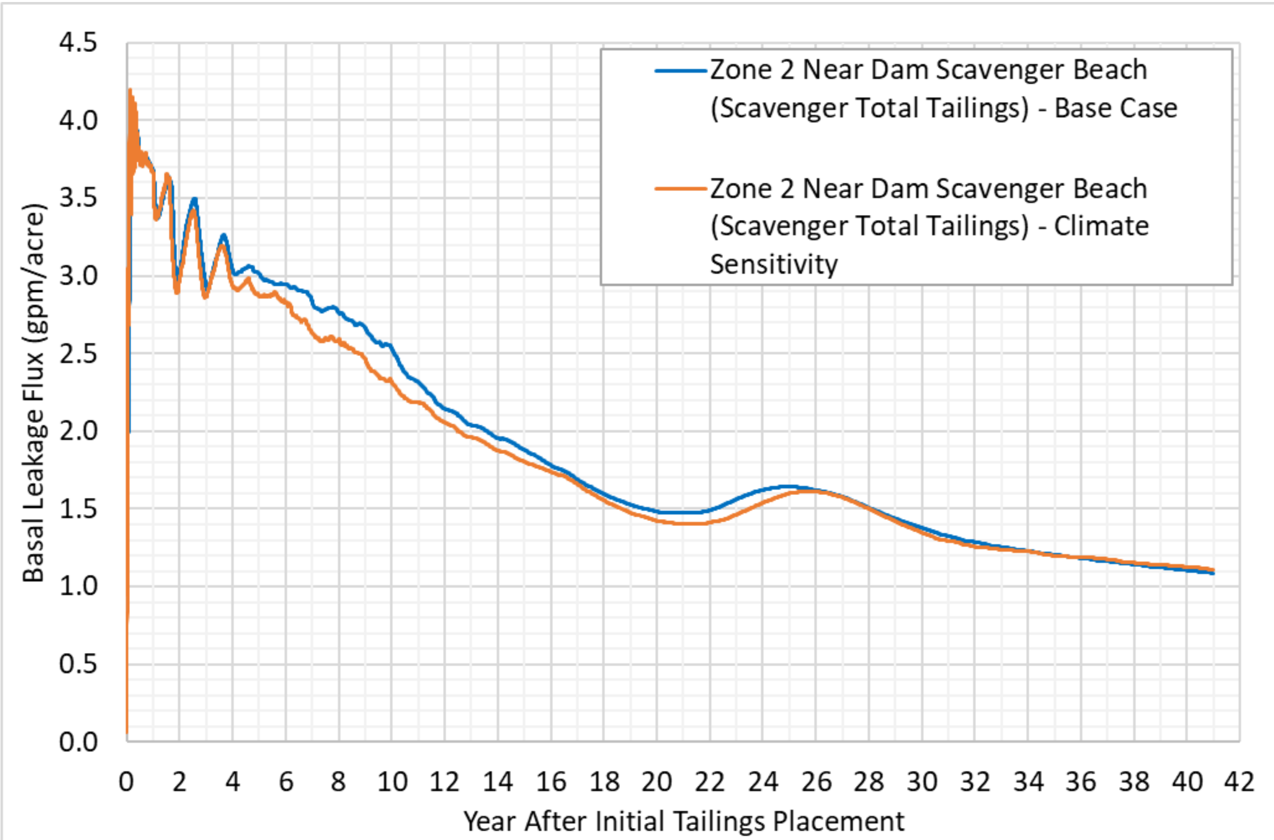
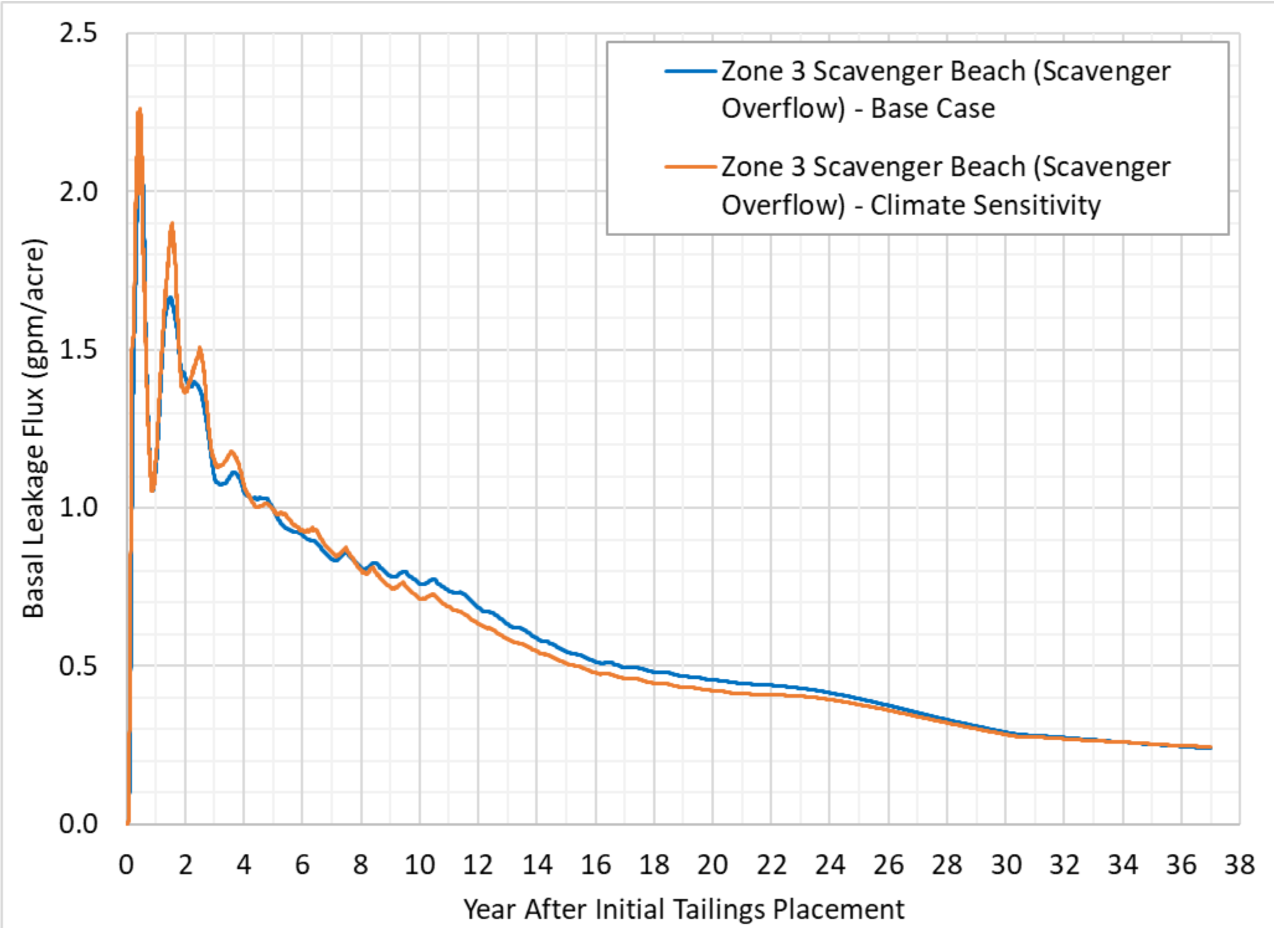


Figure II-15 Zone 3 – Scavenger Beach (Scavenger Overflow Tailings) Climate Sensitivity Basal Leakage Flux – Operations (41 years)



II-5 CONSOLIDATION MODEL COMPARISON

TOUGH2 is not a typical program for modeling consolidation, particularly because it does not incorporate the volume change in the cells in the model domain, see Section II-3.7. In order to assess whether the TOUGH2 model was appropriately incorporating the changes in tailings properties (e.g., void ratio) with depth throughout the tailings column the results were compared to results estimated from the 1D large-strain consolidation modeling program, FSConsol (GWP 2014), a more standard program for modeling consolidation. FSConsol is based on the large strain consolidation theory developed by Gibson, England & Hussey (1967) and has been used extensively for tailings consolidation modeling in the mining industry. Details of the FSConsol modeling to estimate post-closure settlements are further described in the Skunk Camp TSF Reclamation Plan (KCBCL 2020).

The TOUGH2 and FSConsol comparison are shown in Figure II-16 and Figure II-17. The results indicate that the TOUGH2 model estimates the changes in tailings properties from consolidation adequately.

Figure II-16 Zone 2 – Near Dam Scavenger Beach (Scavenger Total Tailings) Consolidation Model Comparison

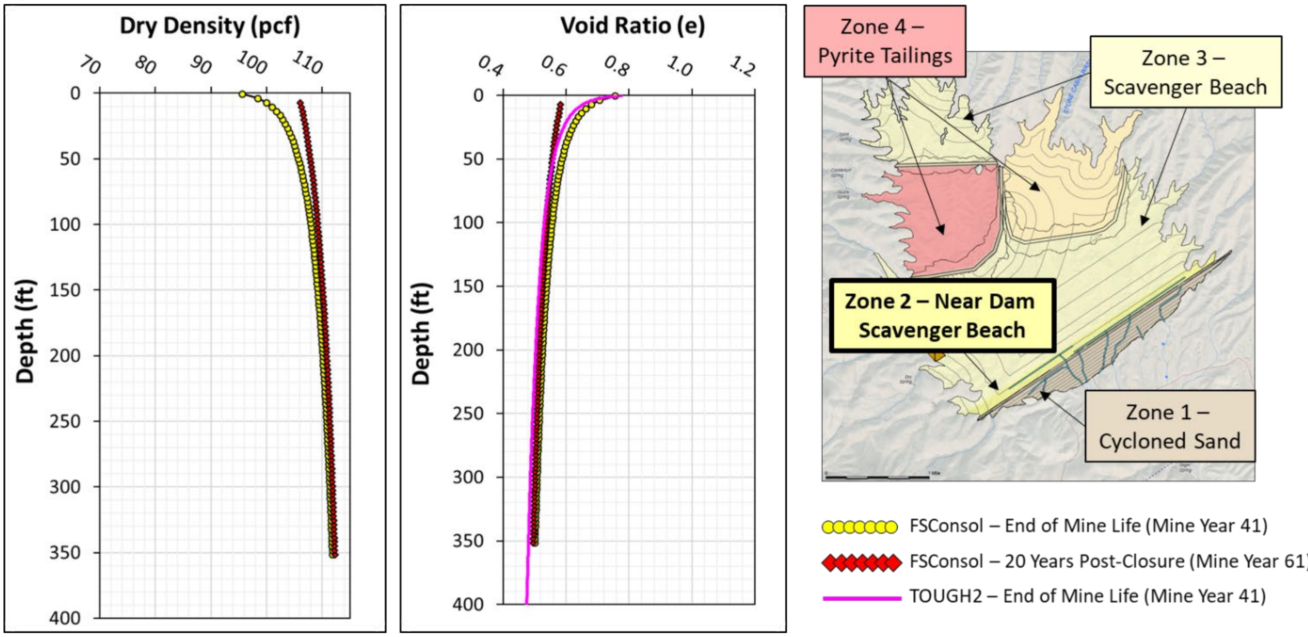
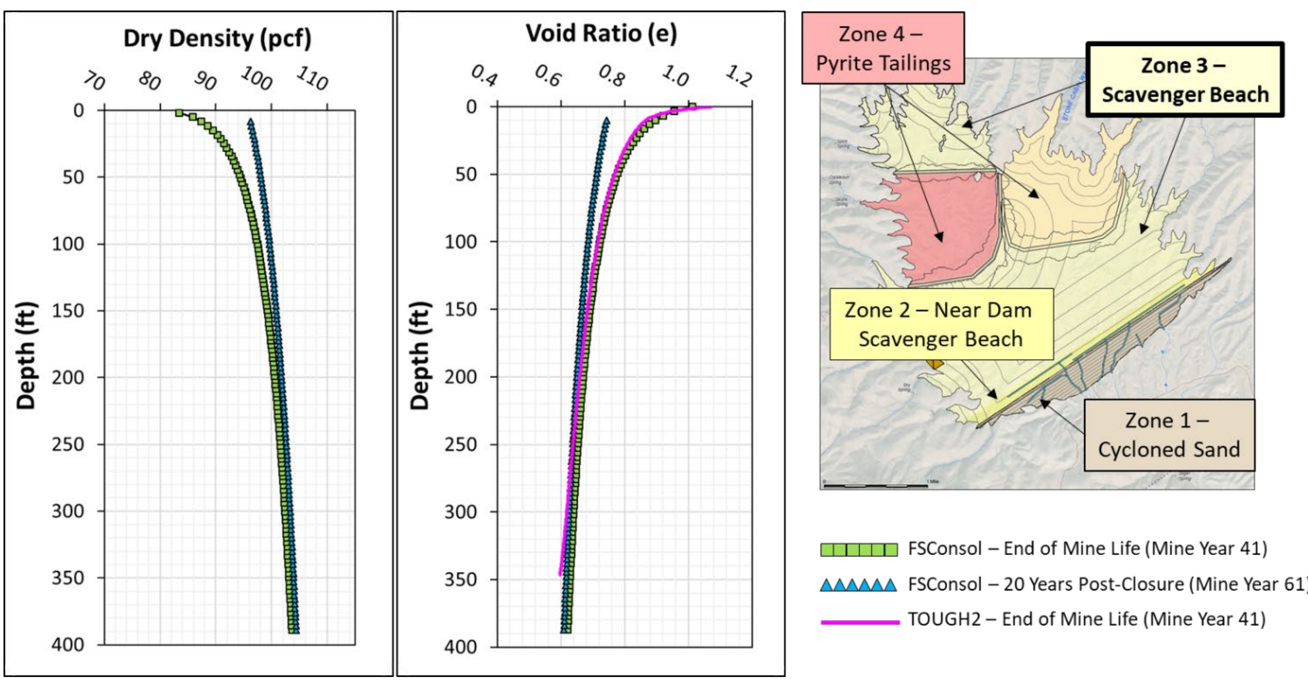


Figure II-17 Zone 3 – Scavenger Beach (Scavenger Overflow Tailings) Consolidation Model Comparison



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Gibson, R.E., England, G.L. and Hussey, M.J.L., 1967. The Theory of one-dimensional consolidation of saturated clays: 1. finite non-Linear consolidation of thin homogeneous layers. *Geotechnique*, 17(3), pp.261-273.

GWP Geo Software Inc. (GWP). 2014. FSConsol Version 3.49 *[Software]*.

KCB Consultants Ltd. (KCBCL). 2020. Resolution Copper Project: Skunk Camp TSF Reclamation Plan. Doc. # CCC.03-81600-EX-REP-00023-Rev. 0. June 10.

APPENDIX III

Pyrite Cell Low Permeability Layer Leakage Estimate

Appendix III
Pyrite Cell Low Permeability Layer Leakage Estimate

III-1 INTRODUCTION

The Skunk Camp tailings storage facility (TSF) includes deposition of pyrite tailings into two, segregated, engineered low permeability layer lined cells (KCB 2018b). The objectives of the low permeability layer are to:

- maintain an operating pond and water cover above the pyrite tailings during operations; and
- limit seepage into the foundation during operations and post-closure.

Potential materials for the layer include geomembrane liner, locally-sourced low permeability borrow material, compacted (and potentially amended) fine tailings, asphalt, slurry bentonite or a combination of the previous.

The purpose of this assessment is to estimate the low permeability layer's seepage rate into the foundation and develop an Equivalent Porous Medium (EPM) hydraulic conductivity and thickness that can be used for more complex numerical seepage modeling (e.g., the closure cover evaluation (KCBCL 2020) and regional groundwater model developed by Montgomery & Associates (M&A 2020)).

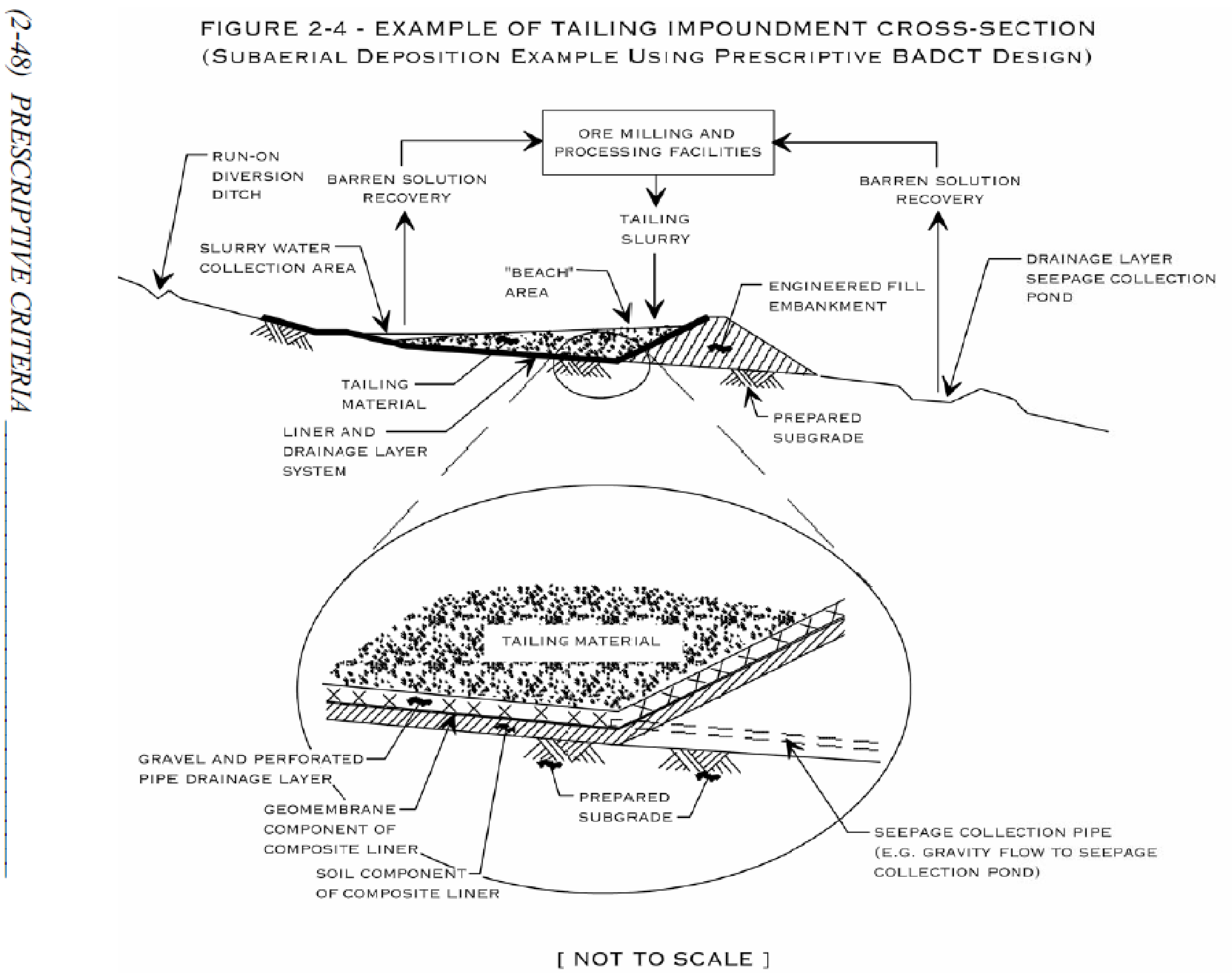
For the purposes of this assessment, it is assumed that the low permeability layer consists of tailings being deposited on a single geomembrane liner. EPM hydraulic conductivity values used for other seepage assessments were adjusted to be in the upper or mid-range of the expected values to account for variations or multiple approaches in the engineered low permeability layer design (see Section 4 of the main report).

III-2 BEST AVAILABLE DEMONSTRATED CONTROL TECHNOLOGY (BADCT) APPROACH

The Skunk Camp TSF will require an Aquifer Protection Permit (APP) issued by the Arizona Department of Environmental Quality (ADEQ). RCM's TSF application will be for an "individual" Best Available Demonstrated Control Technology (BADCT) approach, which is performance based, and allows the applicant to select the most applicable and practical Demonstrated Control Technologies (DCTs) that constitute BADCT. This process considers site specific characteristics, operational controls, and other DCTs. The alternative, "prescriptive" BADCT approach for TSFs, includes a geomembrane liner placed on low permeability soil and a drainage layer above the liner, see Figure III-1.

An individual BADCT approach would be selected for the entire TSF impoundment, including the pyrite cells.

Figure III-1 TSF Prescriptive BADCT Design (ADEQ 2005)



For the purposes of this assessment, it is assumed that the pyrite tailings will be deposited directly on the geomembrane liner, and will not include a gravel and perforated pipe drainage layer (as opposed to Figure III-1). There are several reasons for this:

- The purpose of the drainage layer is to reduce head on the liner, thus reducing seepage through defects, as well as providing downward drainage to increase the rate of consolidation of the tailings. However, these potential benefits of the drainage layer would not be realized for the pyrite tailings cells because the pyrite cell needs to maintain a pond (i.e., water cover).
- Rowe et. al. (2016) has demonstrated that tailings can “self-heal” defects and decrease seepage losses when placed directly on a geomembrane liner.

III-3 MODELING APPROACH

Minor defects will likely occur even in well-designed and installed geomembrane liners. The United States Bureau of Reclamation (USBR) collected data from liners installed in landfill cells and surface impoundments with varying degrees of quality assurance. The number of defects per acre ranges from approximately 20 to 1 for poor to excellent installation quality, respectively (USBR 2014). Defects are conduits for seepage flow and control the effective permeability of a liner.

The geomembrane liner and defects must be generalized to a simpler geometry for complex seepage models (e.g., the regional groundwater model and the consolidation-seepage one-dimensional modeling), as modeling individual defects over the entire pyrite cell low permeability layer in these types of models is impractical. One approach is to replace the geomembrane liner with a unit of uniform thickness that produces similar seepage rates under the same hydraulic loads. The hydraulic conductivity of this unit is its EPM hydraulic conductivity.

KCBCL completed a seepage analysis with the finite element software SEEP/W (GEOSLOPE 2019) to estimate the EPM hydraulic conductivity of a 3 ft thick low permeability layer at the base of the pyrite cells. The modeling steps were to:

- estimate flow through an individual liner defect for a given tailings profile; and
- determine the hydraulic conductivity of a 3 ft thick continuous layer that results in the same volumetric flux as the above individual liner defect simulation.

The hydraulic boundaries above and below the pyrite cells are:

- an operating pond over the pyrite tailings (KCB 2018b); and
- unsaturated foundation material, with the water table below ground elevation (KCBCL 2019).

Seepage rates through a liner defect are influenced by the hydraulic conductivities of the overlying and underlying materials, as well as the hydraulic gradient across the defect. Therefore, separate analyses were required for sections of the liner beneath pyrite tailings and sections directly in contact with the operating pond. KCBCL developed models for the following tailings profiles:

- 100 ft thickness of pyrite tailings;
- 20 ft thickness of pyrite tailings; and
- operating pond directly on the foundation (no tailings).

KCBCL carried-out sensitivity analyses on the following parameters to evaluate the potential range of EPM hydraulic conductivities:

- hydraulic conductivity of the pyrite tailings; and
- hydraulic conductivity of the foundation unit.

III-3.1 Estimating Volumetric Fluxes through the Geomembrane Defect

KCBCL used a steady-state axisymmetric SEEP/W model (GEOSLOPE 2012) to estimate the volumetric flux though the geomembrane defect. Axisymmetric analyses are used to reduce the three-dimensional seepage through a defect problem into two dimensions by rotating around a vertical axis, see Figure III-2 and Figure III-3.

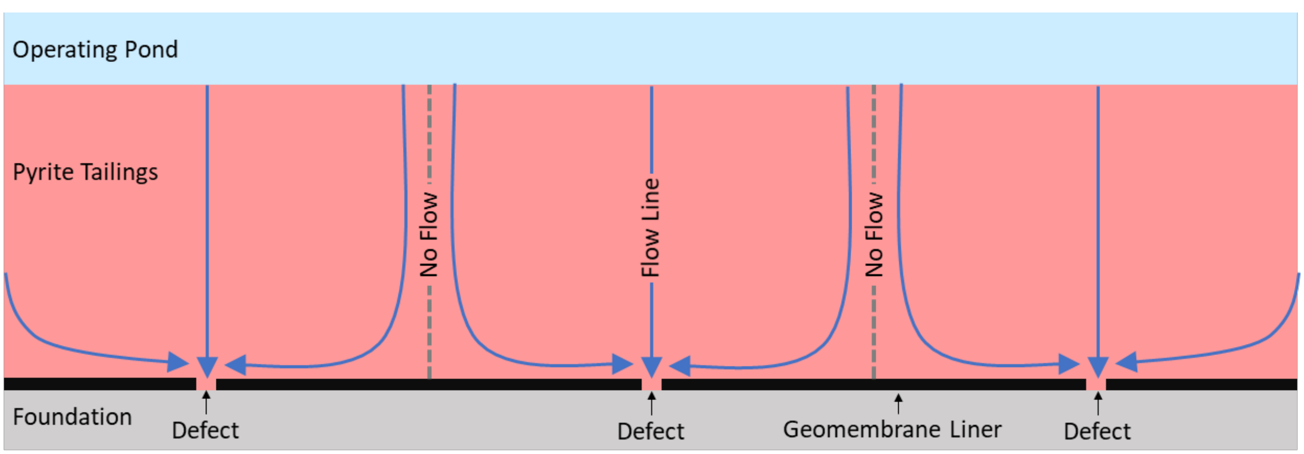
Figure III-2 shows the conceptual model of seepage through tailings on top of a geomembrane liner system. Water flows downward from the operating pond towards the nearest liner defect, forming a seepage divide or “no flow” boundary between defects. The flow through one defect may thus be conceptualized as a three-dimensional (3D) column with the following boundary conditions:

- upper boundary: total hydraulic head equal to the operating pond elevation;
- lower boundary: total hydraulic head equal to the elevation of the water table in the foundation; and
- sides of column: no flow.

The 3D column cross-sectional area is a function of the defect spacing.

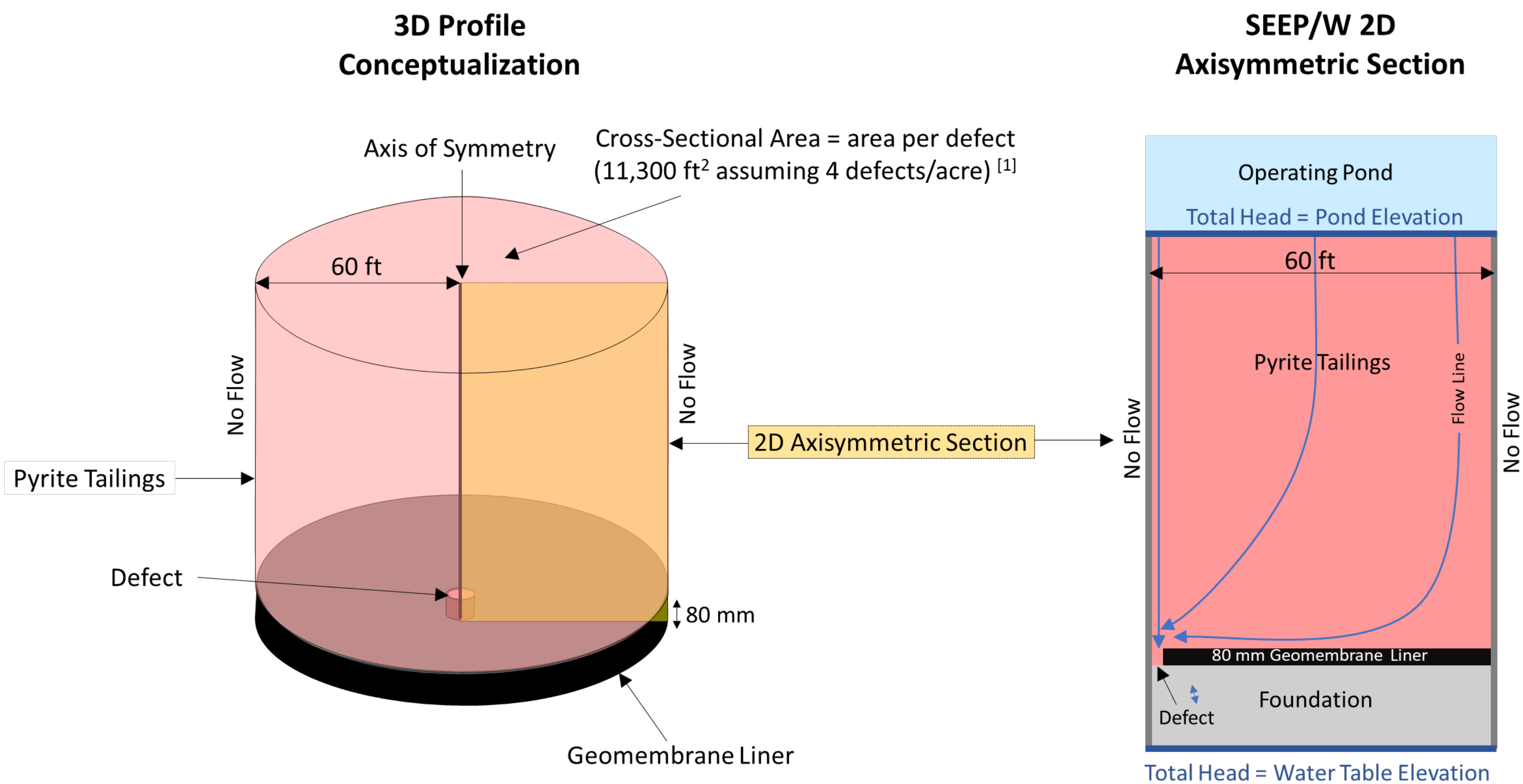
KCBCL modeled the 3D column with a 2D axisymmetric model, as shown on Figure III-3. The width of the axisymmetric section is equal to the radius of the 3D column. Where the liner underlies pyrite tailings, it was assumed the defects are infilled with tailings and are in direct contact with the foundation. Where the liner is below the operating pond (no overlying tailings), it is assumed the defects are in direct contact with the pond and foundation. KCBCL estimated the total volumetric flux through the section by taking the sum of fluxes through the row of model elements immediately below the geomembrane liner and defect.

Figure III-2 Conceptualization of Flow through Geomembrane Liner Defects



Note: Not to scale.

Figure III-3 Geomembrane Liner Axisymmetric Model Conceptualization



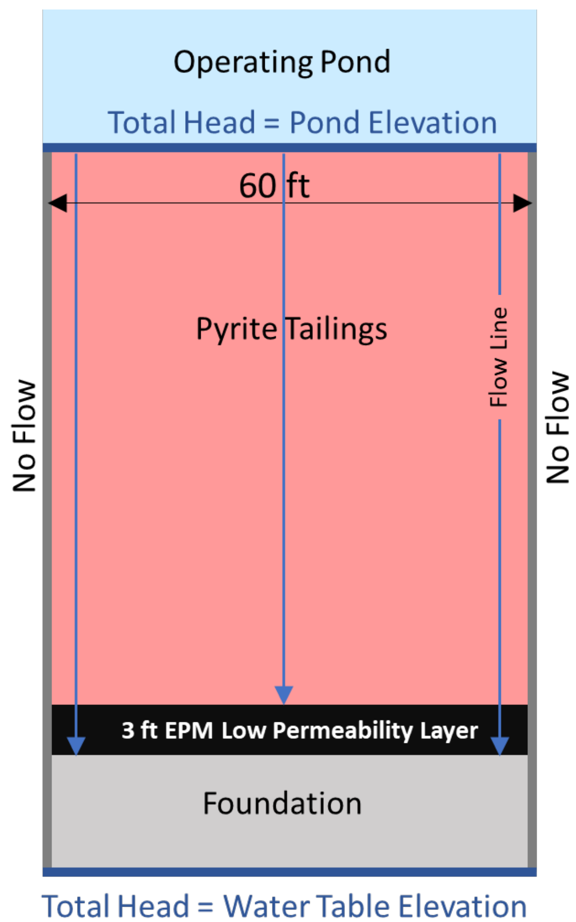
Notes:

1. Per USBR (2014) for fair to good installation quality.
2. Not to scale.

III-3.2 Estimating the 3 ft Low Permeability Layer EPM Hydraulic Conductivity

KCBCL developed a second set of axisymmetric models to estimate the EPM hydraulic conductivity of the equivalent 3 ft thick low permeability layer. The model configuration is the same as the geomembrane defect model (Section III-3.1) except the geomembrane is replaced with a 3-ft thick continuous layer, as shown on Figure III-4. The EPM hydraulic conductivity of the 3-ft thick layer is the hydraulic conductivity at which the total volumetric flux through the liner matches that of the corresponding geomembrane axisymmetric model. Section III-5 summarizes the estimated EPM hydraulic conductivities and unit fluxes.

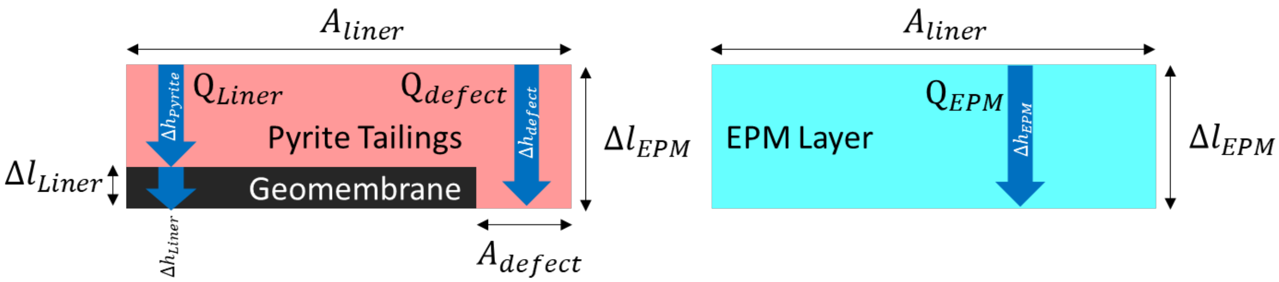
Figure III-4 EPM Low Permeability Layer Axisymmetric Model Conceptualization



III-3.3 EPM Hydraulic Conductivity Calculation Validation

To give confidence in the EPM hydraulic conductivity estimates, an alternative calculation methodology was used as shown on Figure III-5.

Figure III-5 Alternative EPM Hydraulic Conductivity Calculation Conceptualization



The series flow rule states that the headlosses are equal across the following profiles when they are of equal thickness:

- a geomembrane and pyrite tailings composite (volumetric flux Q_{liner} on Figure III-5); and
- pyrite tailings above the geomembrane defect (volumetric flux Q_{defect} on Figure III-5).

Applying the series flow rule to the geomembrane liner profile:

Equation 1

$$\Delta h_{pyrite} + \Delta h_{liner} = \Delta h_{defect}$$

Where:

- Δh_{pyrite} is the headloss across the pyrite tailings above the geomembrane liner;
- Δh_{liner} is the headloss across the geomembrane liner; and
- Δh_{defect} is the headloss across the pyrite tailings above and within the geomembrane defect.

Darcy's law states that:

Equation 2

$$Q = KA\frac{\Delta h}{\Delta l}$$

Where:

- Q is volumetric flux;
- K is hydraulic conductivity;
- Δh change in hydraulic head along the flow path;
- Δl is the flow path length; and
- A is cross-sectional area.

Combining Equation 1 and Equation 2:

Equation 3

$$\frac{Q_{liner}}{A_{liner} - A_{defect}} \times \left(\frac{\Delta l_{EPM} - \Delta l_{liner}}{K_{Pyrite}} + \frac{\Delta l_{liner}}{K_{liner}}\right) = \frac{Q_{defect}}{A_{defect}} \times \frac{\Delta l_{EPM}}{K_{Pyrite}}$$

Where:

- Q_{liner} is the volumetric flux through the geomembrane liner;
- A_{liner} is the liner area;
- A_{defect} is the defect area;
- Δl_{EPM} is the EPM low permeability layer thickness;
- Δl_{liner} is the geomembrane liner thickness;
- K_{Pyrite} is the hydraulic conductivity of the pyrite tailings;
- K_{liner} is the hydraulic conductivity of the geomembrane liner; and
- Q_{defect} is the volumetric flux through the geomembrane defect.

Rearranging Equation 3:

Equation 4

$$Q_{liner} = Q_{defect} \times \frac{A_{liner} - A_{defect}}{A_{defect}} \times \frac{\Delta l_{EPM} K_{liner}}{(\Delta l_{EPM} - \Delta l_{liner}) K_{liner} + \Delta l_{liner} K_{Pyrite}}$$

The parallel flow rule states that volumetric fluxes through the geomembrane liner and defect are equal to volumetric flux through the 3 ft thick low permeability layer:

Equation 5

$$Q_{EPM} = Q_{Defect} + Q_{liner}$$

Where:

- Q_{EPM} is the volumetric flux through the 3 ft thick EPM low permeability layer;
- Q_{Defect} is the volumetric flux through the geomembrane liner defect; and
- Q_{liner} is the volumetric flux through the geomembrane liner.

Combining Equation 4 and Equation 5:

Equation 6

$$Q_{EPM} = Q_{Defect} + Q_{defect}\frac{A_{liner} - A_{defect}}{A_{defect}} \times \frac{\Delta l_{EPM} K_{liner}}{(\Delta l_{EPM} - \Delta l_{liner})K_{liner} + \Delta l_{liner} K_{Pyrite}}$$

Combining Equation 2 and Equation 6:

Equation 7

$$K_{EPM}\frac{\Delta h_{EPM}}{\Delta l_{EPM}}A_{liner} = K_{pyrite}\frac{\Delta h_{defect}}{\Delta l_{EPM}}A_{defect}\left(1 + \frac{A_{liner} - A_{defect}}{A_{defect}} \times \frac{\Delta l_{EPM} K_{liner}}{(\Delta l_{EPM} - \Delta l_{liner})K_{liner} + \Delta l_{liner} K_{Pyrite}}\right)$$

Where:

- K_{EPM} is the hydraulic conductivity of the EPM low permeability layer; and
- Δh_{EPM} is the headloss across the EPM low permeability layer.

Assuming headlosses across the geomembrane profile and the EPM low permeability layer (as shown on Figure III-5) are equal, Equation 7 reduces to:

Equation 8

$$K_{EPM} = K_{pyrite}\frac{A_{defect}}{A_{liner}}\left(1 + \frac{A_{liner} - A_{defect}}{A_{defect}} \times \frac{\Delta l_{EPM} K_{liner}}{(\Delta l_{EPM} - \Delta l_{liner})K_{liner} + \Delta l_{liner} K_{Pyrite}}\right)$$

If the geomembrane is impermeable, Equation 8 reduces to:

Equation 9

$$K_{EPM} = K_{Pyrite}\frac{A_{Defect}}{A_{liner}}$$

III-4 MODEL INPUTS

III-4.1 Geomembrane Liner, Defects and Model Domain

Table III-1 summarizes model inputs associated with the geomembrane liner and defects. The width of the axisymmetric model domain is a function of defect spacing, as discussed in Section III-3.1.

Table III-1 Geomembrane Liner, Defect and Model Width Parameters

Parameter	Value	Source
Geomembrane Liner Thickness	80 mm	Design Assumption
Defect Cross-Sectional Area	0.016 in^2	USBR 2014 for average case conditions
Defect Spacing	4 defects per acre of geomembrane	USBR 2014 for fair to good installation quality
Cross-sectional Liner Area per Defect (see Figure III-3)	11,300 ft^2	Calculated from Defect Spacing
Axisymmetric Model Width	60 ft	Calculated from liner area per defect, assuming a cylindrical geometry (see Section III-3.1)

III-4.2 Boundary Conditions

Table III-1 summarizes the boundary conditions for the axisymmetric models.

Table III-2 Boundary Conditions

Extent	Boundary Condition	Justification
Top of Pyrite Tailings	Constant total hydraulic head of 10 ft above the pyrite tailings	Pyrite cell operating pond depth (KCB 2018b)
Base of Foundation Unit	Constant total hydraulic head of 70 ft below the ground surface	Per KCBCL 2019 Site Investigation Report
Lateral Boundaries	No Flow	See axisymmetric model conceptualization (Section III-3.2)

III-4.3 Material Properties

Table III-3 summarizes the material properties used in the seepage models. Sensitivity analyses were performed on the pyrite tailings and foundation hydraulic conductivities. The range of pyrite tailings hydraulic conductivities reflects the lower, mid and upper bounds of the 2018 tailings characterization program oedometer test on pyrite tailings (KCB 2018a). The oedometer test reported higher hydraulic conductivities than the 2018 Rowe cell test (KCB 2018a); its results were thus considered more conservative for the purpose of this model.

Table III-3 Material Properties

Material	Vertical Saturated Hydraulic Conductivity (K_v) (cm/s)	Anisotropy Ratio (K_v/K_h)	Reference
Pyrite Tailings	$3x10^{-7} – 8x10^{-6}$	0.2	KCB 2018 oedometer test on pyrite tailings (KCB 2018a) and case history data from similar copper TSFs
Foundation (Alluvium or Gila Conglomerate)	$1x10^{-5} – 1x10^{-3}$	0.1	M&A 2020
Geomembrane	Impermeable		Assumed
Low Permeability Layer	See Section III-5.1	1	

III-5 RESULTS

III-5.1 Low Permeability Layer EPM Hydraulic Conductivities

Table III-4 summarizes the low permeability layer EPM hydraulic conductivities estimated with the axisymmetric SEEP/W models described in Section III-3.2.

Key observations from the axisymmetric model results include:

- when the pond is directly on the low permeability layer, the EPM hydraulic conductivity values range from $1x10^{-6}$ to $1x10^{-8}$ cm/s and scale approximately linearly with the foundation hydraulic conductivity (see Figure III-6);
- when the low permeability layer underlies the pyrite tailings, the EPM hydraulic conductivity values range from $1x10^{-12}$ to $3x10^{-11}$ cm/s and scale approximately linearly with the pyrite tailings hydraulic conductivity (see Figure III-7); and
- tailings depth does not significantly affect the low permeability layer EPM hydraulic conductivity (see Figure III-7).

Table III-4 Low Permeability Layer EPM Hydraulic Conductivity from Axisymmetric Models

Axisymmetric Column	Pyrite Tailings Vertical Hydraulic Conductivity (cm/s) *(ft/s)*	Foundation Vertical Hydraulic Conductivity (cm/s) *(ft/s)*		
		1×10^{-3} *(3.3×10^{-5})*	1×10^{-4} *(3.3×10^{-6})*	1×10^{-5} *(3.3×10^{-7})*
		Low Permeability Layer EPM Hydraulic Conductivity (cm/s) *(ft/s)*		
Operating Pond on Low Permeability Layer	N/A	1×10^{-6} *(4×10^{-8})*	1×10^{-7} *(4×10^{-9})*	1×10^{-8} *(4×10^{-10})*
20 ft of Pyrite Tailings on Low Permeability Layer	8×10^{-6} *(3×10^{-7})*	3×10^{-11} *(1×10^{-12})*		
	3×10^{-6} *(1×10^{-7})*	1×10^{-11} *(4×10^{-13})*		
	3×10^{-7} *(9×10^{-9})*	1×10^{-12} *(4×10^{-14})*		
100 ft of Pyrite Tailings on Low Permeability Layer	3×10^{-6} *(1×10^{-7})*	1×10^{-11} *(4×10^{-13})*		

Figure III-6 Low Permeability Layer EPM vs. Foundation Vertical Hydraulic Conductivity

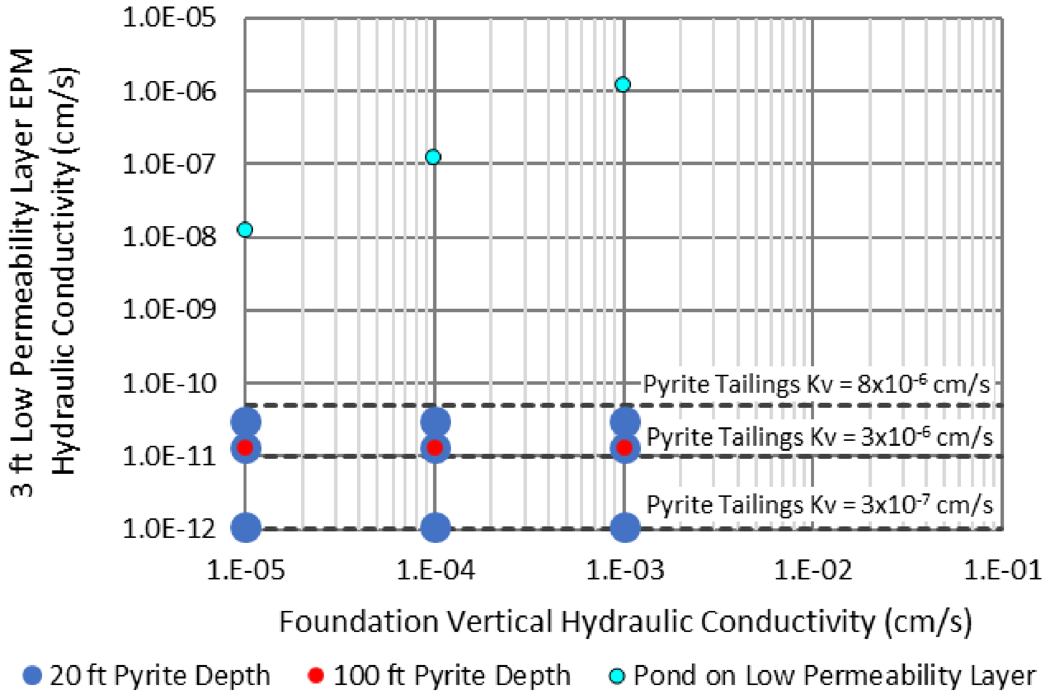


Figure III-7 Low Permeability Layer EPM vs. Pyrite Tailings Vertical Hydraulic Conductivity

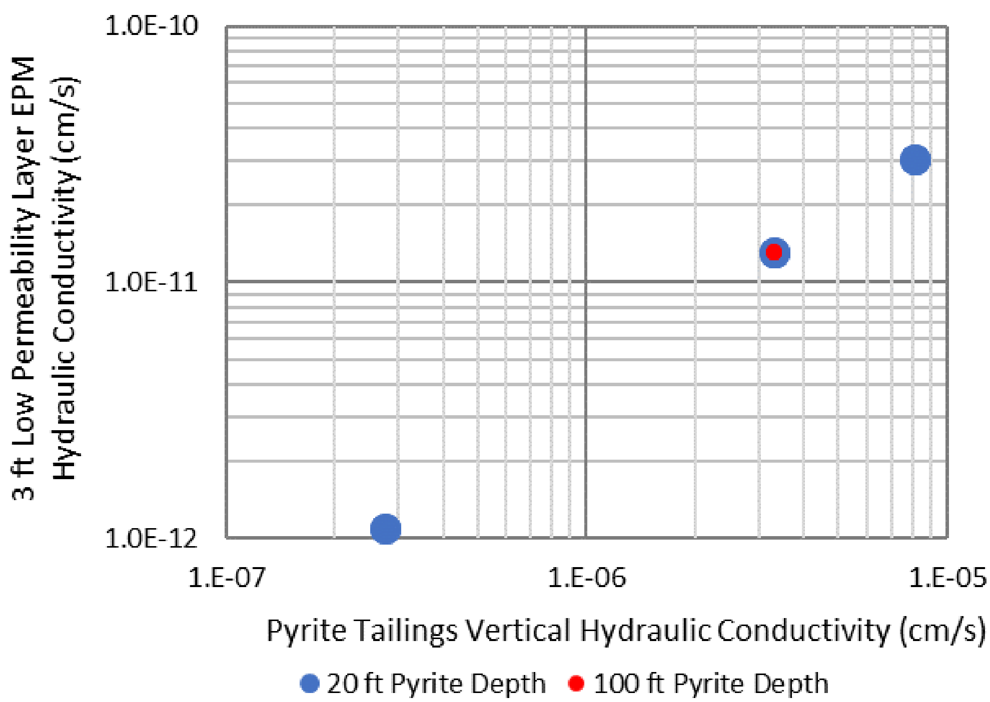


Table III-5 summarizes the EPM hydraulic conductivity estimate with the alternative calculation described in Section III-3.3. The hydraulic conductivities are approximately two orders of magnitude lower than those estimated with the axisymmetric models. This may be because the alternate calculation does not consider 2D flow into the defect from pyrite tailings above the intact geomembrane liner, shown on Figure III-2.

Table III-5 Low Permeability Layer EPM Hydraulic Conductivity from Alternate Calculation

Pyrite Tailings Vertical Hydraulic Conductivity (cm/s) *(ft/s)*	Low Permeability Layer EPM Hydraulic Conductivity (cm/s) *(ft/s)*
8×10^{-6} *(3×10^{-7})*	8×10^{-14} *(3×10^{-15})*
3×10^{-6} *(1×10^{-7})*	3×10^{-14} *(1×10^{-15})*
3×10^{-7} *(9×10^{-9})*	3×10^{-15} *(1×10^{-16})*

III-5.2 Seepage Rates

Table III-6 summarizes seepage rates into the foundation from the axisymmetric models.

Table III-6 Axisymmetric Model Seepage Rates through Low Permeability Layer

Axisymmetric Column	Pyrite Tailings Vertical Hydraulic Conductivity (cm/s) *(ft/s)*	Foundation Vertical Hydraulic Conductivity (cm/s) *(ft/s)*		
		1×10^{-3} *(3.3×10^{-5})*	1×10^{-4} *(3.3×10^{-6})*	1×10^{-5} *(3.3×10^{-7})*
		Low Permeability Layer Vertical Unit Flux (cm/s) *(gpm/acre)*		
Operating Pond on Low Permeability Layer	N/A	4×10^{-4} *(250)*	4×10^{-5} *(25)*	4×10^{-6} *(2.5)*
20 ft of Pyrite Tailings on Low Permeability Layer	8×10^{-6} *(3×10^{-7})*	2×10^{-8} *(1×10^{-2})*		
	3×10^{-6} *(1×10^{-7})*	9×10^{-9} *(6×10^{-3})*		
	3×10^{-7} *(9×10^{-9})*	9×10^{-10} *(6×10^{-4})*		
100 ft of Pyrite Tailings on Low Permeability Layer	3×10^{-6} *(1×10^{-7})*	2×10^{-8} *(1×10^{-2})*		

III-6 CONCLUSIONS

The results of this assessment were used to select low permeability layer hydraulic conductivities for two seepage models:

- Montgomery and Associates Regional Groundwater Model (M&A 2020)
- KCBCL Pyrite Tailings Closure Cover Model (KCBCL 2020)

Table III-7 summarizes the low permeability layer input parameters for the two seepage models as well as the low permeability layer leakage model results.

This assessment identifies an analogous EPM vertical hydraulic conductivity of a 3 ft thick low permeability layer as 1x10^{12} to 3x10^{-11} cm/s. These hydraulic conductivity values represent the lower bound of the expected range because the low permeability layer was assumed to be a geomembrane liner. The EPM hydraulic conductivity values selected for the other seepage models reflect the upper or mid-bounds of the expected range to account for variability and multiple approaches that may be used in the engineered low permeability layer design (see Section 4 of the main report), as well as for modeling efficacy purposes.

Table III-7 Model Results and Low Permeability Layer Parameters for Seepage Models

Model	Low Permeability Layer Thickness	Low Permeability Layer Hydraulic Conductivity
Low Permeability Layer Leakage Estimate Model Results	3 ft	1x10^{-12} to 3x10^{-11} cm/s
Montgomery and Associates 3D Regional Groundwater Model (M&A 2020)	3 ft	1x10^{-8} cm/s
KCBCL 1D Pyrite Closure Cover Model (KCBCL 2020)	1 ft	1x10^{-9} cm/s

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APPENDIX IV

Cycloned Sand Embankment Leakage Estimate

Appendix IV
Cycloned Sand Embankment Leakage Estimate

IV-1 INTRODUCTION

This appendix summarizes the water balance approach used to estimate infiltration through the cycloned sand embankments of the Skunk Camp Tailings Storage Facility (TSF) (Zone 1) during operations and closure; and, that would be available as leakage into the foundation or collection into the underdrainage systems[1]. The scope of the water balance includes inflows and outflows from embankment construction and climate. The water balance does not include horizontal seepage inflows from adjacent scavenger or pyrite tailings, which are assessed under seepage estimates for the Near Dam Scavenger Beach (Zone 2), Scavenger Beach (Zone 3), and Pyrite Tailings (Zone 4).

The water balance was developed for the three cycloned sand embankments:

- Main Embankment;
- Pyrite Cell 1 Embankment; and
- Pyrite Cell 2 Embankment.

This appendix has the following format:

- Section 2: Description of the conceptual water balance
- Section 3: Summary of model parameters and assumptions
- Section 4: Presentation of conceptual water balance results

IV-2 CONCEPTUAL WATER BALANCE

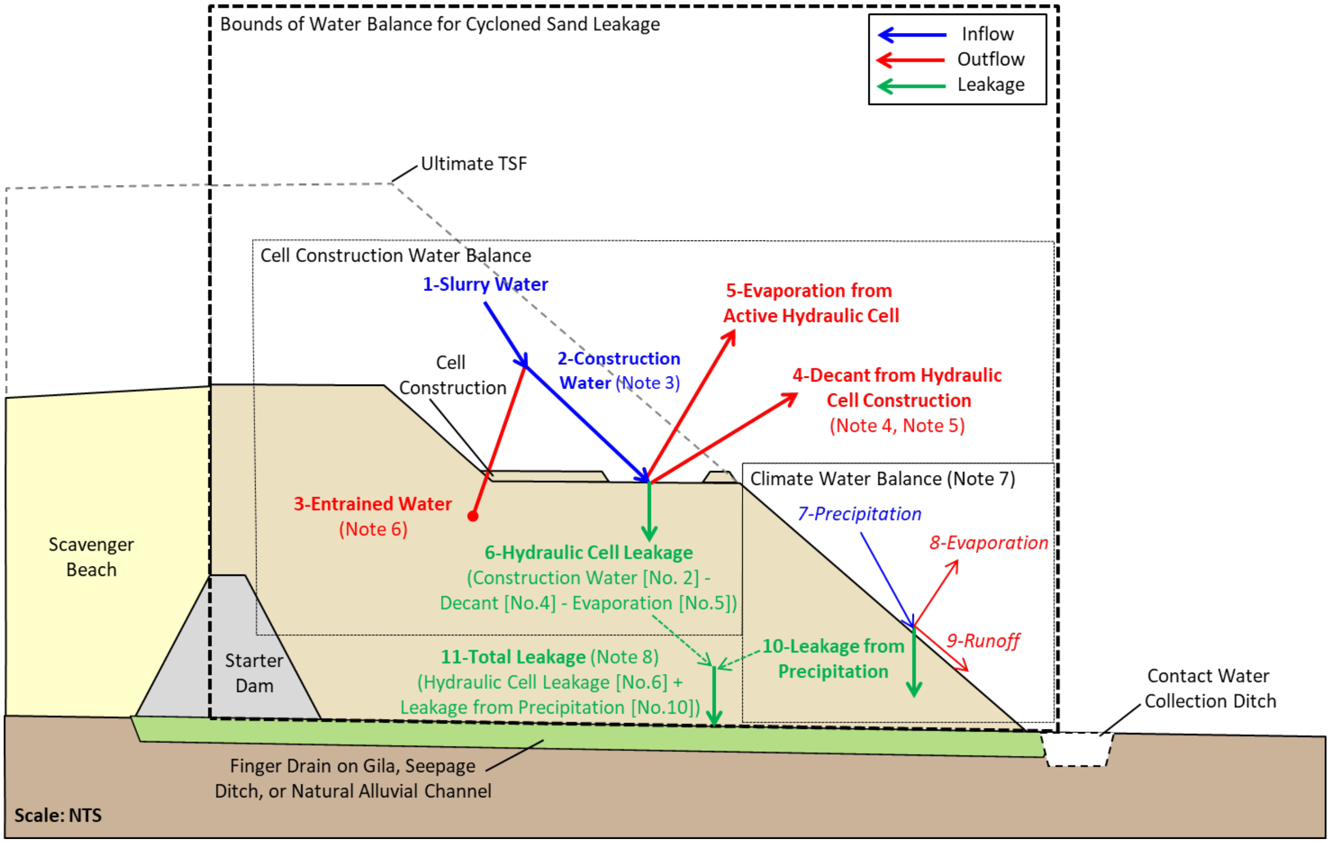
Figure IV-1 presents the conceptual water balance schematic of the cyclone sand embankment, while Table IV-1 summarizes the inflows, outflows, and the assumptions adopted for the estimation of leakage from the embankments. The conceptual water balance was divided into two sub-water balances:

1. Cell Construction Water Balance; and
2. Climate Water Balance.

The assumptions used to estimate the magnitude of the flows are provided in Section IV-3.

[1] KCBCL's scope was to estimate the quantity of leakage from the cycloned sand embankments. Evaluation of where the seepage goes (e.g., underdrainage systems or foundation) will be assessed by Montgomery and Associates (M&A) using a Regional Groundwater Model (M&A 2020).

Figure IV-1 Cycloned Sand Embankment Water Balance Schematic



Notes:

1. **Bolded Flows** were developed as part of the Cycloned Sand Embankment Leakage Estimate.
2. *Italicized Flows* were developed outside of this assessment. They are important to understand the overall water balance approach, but were not used to inform the Cycloned Sand Embankment Leakage Estimate.
3. Construction Water [No.2] = Slurry Water [No.1] - Entrained Water [No.3]
4. Decant from Hydraulic Cell Construction [No.4] = 70% of Construction Water [No.2], based on experience with similar sites.
5. Hydraulic cells will be decanted towards the SCP until the end of Mine Year 19, after which, the Main Embankment will reach horizontal construction and hydraulic cells will be decanted to the TSF impoundment.
6. Entrained Water [No.3] is the water retained in the cycloned sand tailings pores at initial placement.
7. The Climate Water Balance was developed using Hydrus-1D modeling software for cycloned sand tailings with and without a closure cover. Results of the Hydrus-1D model informed the Leakage from Precipitation [No.10] estimate.
8. Leakage could enter the foundation or underdrainage system, to be determined by M&A's Regional 3D Groundwater Model.

Table IV-1 Summary of Flows and Calculation Assumptions

Flow No.	Description	Calculation
Cell Construction Water Balance		
Inflows		
1	Slurry Water	$$\frac{CSPR * (1 - SC)}{SC}$$ Where: ▪ CSPR = Cycloned Sand Placement Rate (by mass) ▪ SC = Slurry Solids Content (by weight)
2	Construction Water	Slurry Water [No.1] – Entrained Water [No.3]
Outflows		
3	Entrained Water	Volume of Cycloned Sand Placed[1] * Porosity * Saturation
4	Decant from Hydraulic Cell Construction	Decant Coefficient[2] * Construction Water [No.2]
5	Evaporation from Active Hydraulic Cell	Active Hydraulic Cell Area[3] * Average Annual Evaporation
Net Flows (Inflows – Outflows)		
6	Hydraulic Cell Leakage	Construction Water [No.2] – Decant from Hydraulic Cell Construction [No.4] – Evaporation from Active Hydraulic Cell [No.5]
Climate Water Balance		
Inflows		
7	Precipitation	N/A[4]
Outflows		
8	Evaporation	N/A[4]
9	Runoff	N/A[4]
Net Flows (Inflows – Outflows)		
10	Leakage from Precipitation	Embankment Area[5] * Average Annual Precipitation * % to Leakage[6]
Total Leakage		
11	Total Leakage	Hydraulic Cell Leakage [No.6] + Leakage from Precipitation [No.10]

Notes:
1. Volume of cycloned sand placed at the initial placement density.
2. Assumed to be 70%, developed based on experience with similar sites, see Section IV-3.5.
3. Developed based on experience with similar sites, see Section IV-3.5.
4. Developed using Hydrus-1D modeling software for cycloned sand tailings with and without a closure cover, see Section IV-3.3. These flows are not required to estimate cycloned sand embankment leakage.
5. Embankment area was taken to be the 2D (planar) area of cycloned sand exposed to the atmosphere (i.e., the area of an embankment slope covered by pyrite or scavenger tailings was not included).
6. The percent of precipitation that infiltrates to the cycloned sand was developed based on Hydrus-1D modeling, refer to Section IV-3.3.

IV-3 MODEL PARAMETERS

IV-3.1 General

Appendix II of the Skunk Camp TSF Reclamation Plan (KCBCL 2020) describes the TSF layout and staging and was used to inform this water balance assessment (e.g., the cycloned sand area throughout the mine life and rate of cycloned sand placement during operations). Water balance flows were calculated on an annual timestep assuming average climate conditions. The methodology adopted for this preliminary assessment of flow, and the assumptions listed herein (e.g., hydraulic cell size, saturation of tailings, etc.), may vary during construction and can be reviewed and updated in future design stages or upon receipt of additional information that address the adopted assumptions.

IV-3.2 Climate Conditions

Leakage from the cycloned sand embankments were estimated under average climate conditions, which are summarized in Table IV-2. Average annual precipitation and potential evaporation values were developed based on a long-term climate data set scaled to the Skunk Camp site (refer to Appendix IV-A of the Skunk Camp TSF Reclamation Plan for details (KCBCL 2020)).

Table IV-2 Average Precipitation and Evaporation

Month	Precipitation[1] (in)	Potential Evaporation[2] (in)
January	2.1	3.0
February	1.9	3.6
March	2.2	5.4
April	0.7	7.0
May	0.4	9.0
June	0.3	9.3
July	1.8	8.7
August	2.7	7.8
September	1.4	6.5
October	1.2	5.1
November	1.4	3.6
December	2.1	3.0
Annual	**18.2**	**72.1**

Notes:

1. Precipitation values are based on data collected at the Superior climate station (ID: 028348) with gaps filled using data from the regional climate stations to create the Near West Modeling Dataset. Values shown were adjusted from the Near West to Skunk Camp Site (see Appendix IV-A of the Skunk Camp TSF Reclamation Plan (KCBCL 2020)).
2. Calculated using the Penman-Monteith combined equation in Hydrus-1D based on the Near West Modeling climate data set scaled to the Skunk Camp Site (KCBCL 2020).

IV-3.3 Climate Water Balance

To support the Skunk Camp TSF Reclamation Plan, One-dimensional (1D) climatic unsaturated flow modeling was completed using a Hydrus-1D model to estimate the net infiltration from precipitation into the tailings and to estimate the efficacy of closure cover systems (KCBCL 2020). The Hydrus-1D modeling software accepts inputs of:

- climate (i.e., precipitation and potential evapotranspiration);
- vegetation parameters (applicable for the closure cover);
- tailings hydraulic properties; and
- boundary conditions and initial conditions.

The model then calculates a water balance in the tailings column with the following outputs:

- potential evapotranspiration;
- actual evaporation;
- surface runoff;
- net infiltration at the base of the model column (into the underlying tailings or natural ground); and
- suction head and saturation profiles.

Results of “Net infiltration at the base of the model column” were averaged across a 56-year climate sequence and normalized as a percent of average annual precipitation, which was used to estimate Leakage from Precipitation [No.10]. Table IV-3 summarizes the average results of the Hydrus-1D modeling. Cycloned sand tailings will be exposed to the environment during operations and a 3 ft “soil-like” Gila Conglomerate cover will be placed on the tailings after operations (refer to the Skunk Camp TSF Reclamation Plan for details on properties of the adopted closure cover and the Hydrus-1D model development (KCBCL 2020)).

Table IV-3 Infiltration from Precipitation

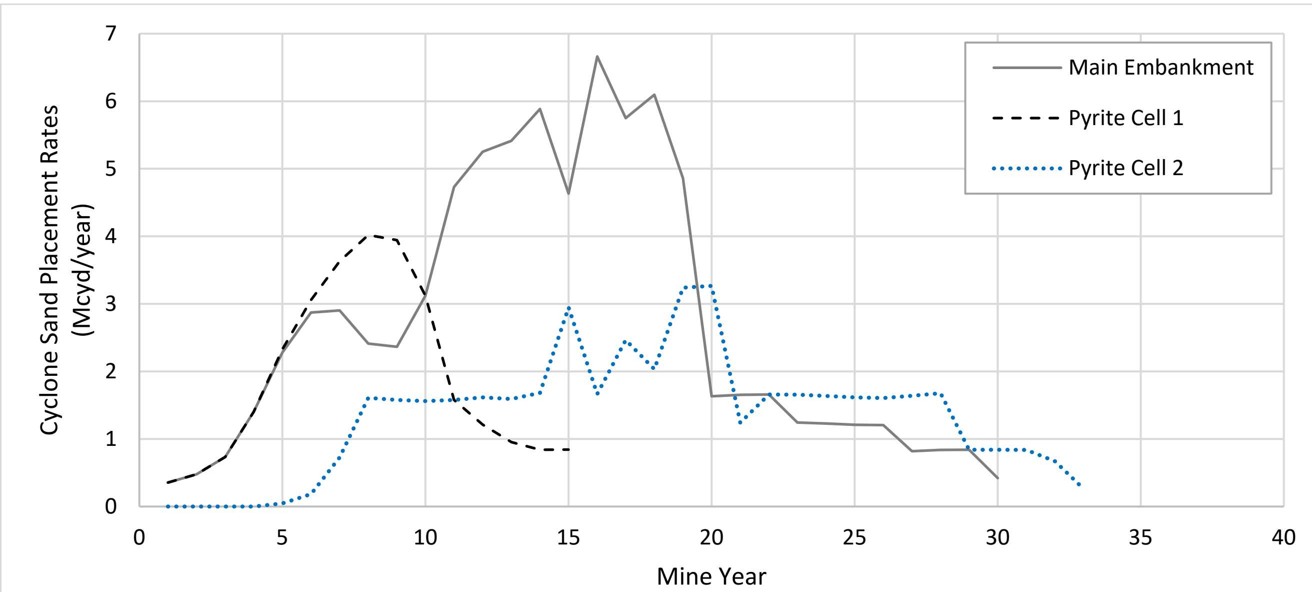
Scenario	Percent of Average Annual Precipitation that will Infiltrate to Embankment During Average Climate Conditions
Operations (uncovered cycloned sand)	~30%
Post-closure (cycloned sand covered with 3 ft “soil-like” Gila Conglomerate Cover)	~3%

IV-3.4 Cycloned Sand Tailings Parameters

IV-3.4.1 Cycloned Sand Placement Rate

The cycloned sand placement rates for the three embankments were developed to match the requirements to raise the dam in accordance with the storage elevation curve (KCBCL 2020), the cycloned sand requirements are summarized in Figure IV-2.

Figure IV-2 Cycloned Sand Placement Rates



IV-3.4.2 Cycloned Sand Tailings Properties

The assumed tailings properties used in the Cell Construction Water Balance are outlined in Table IV-4.

Table IV-4 Cycloned Sand Tailings Properties

Parameter	Value[1]	Source
Void Ratio (e) at Placement	0.70	DEIS Tailings Geotechnical Characterization (KCB 2018a)
Porosity (n) at Placement	0.41	
Specific Gravity	2.72	
Cycloned Sand Dry Density at Placement	100 pcf	
Slurry Solids Content (by weight)	60%	Skunk Camp DEIS (KCB 2018b)
Degree of Saturation at Placement	50%	Assumed average saturated during construction, typical at similar facilities

Note:

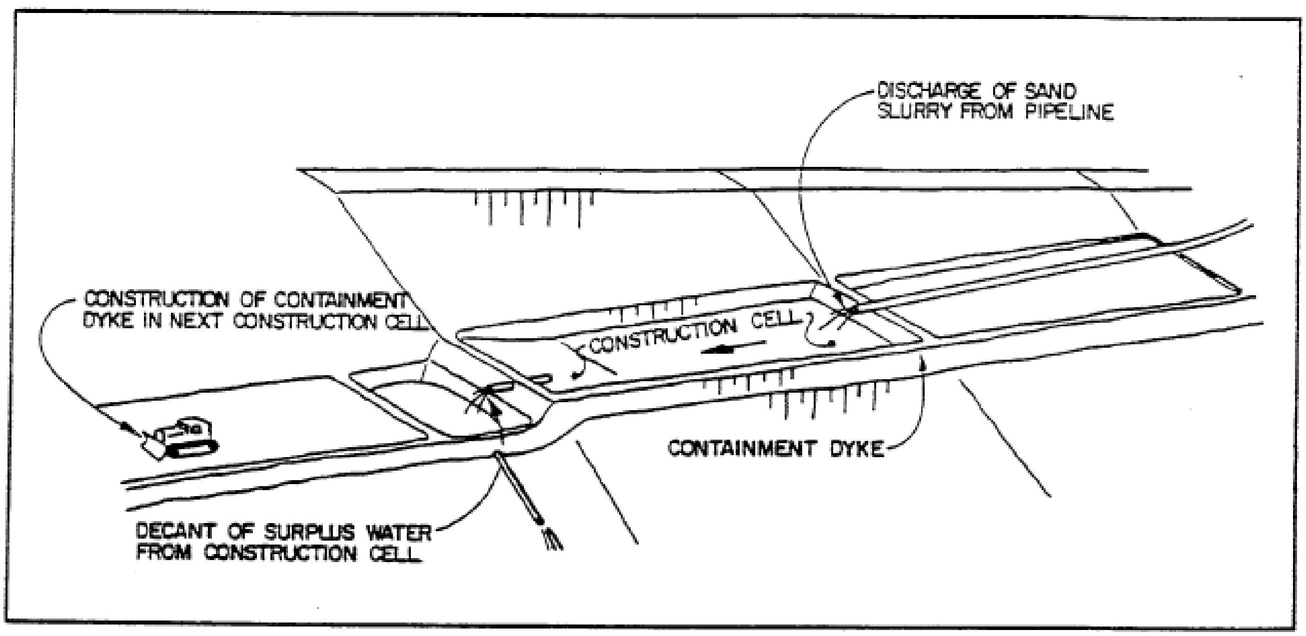
1. Cycloned sand tailings properties developed based on 98% Standard Proctor maximum dry density (SPD).

IV-3.5 Cycloned Sand Cell Construction

The cycloned sand embankments will be constructed using the hydraulic cell construction method, described below and shown on Figure IV-3.

> *Cell construction is the method whereby slurry flows are discharge to a hydraulic fill cell. The solids are allowed to settle and surplus water and fines are decanted from the end of the cell opposite the point of discharge. Wide-track bulldozers are used to maintain containment dykes around the perimeter of the cell and to compact the sand in the base of the cell* (KLL 1989).

Figure IV-3 Hydraulic Cell Construction Schematic (KLL 1989)



Cell geometry properties, summarized in Table IV-5, were assumed based on KCB's previous experience with similar cycloned sand constructed TSF embankments.

Table IV-5 Cycloned Sand Hydraulic Cell Properties

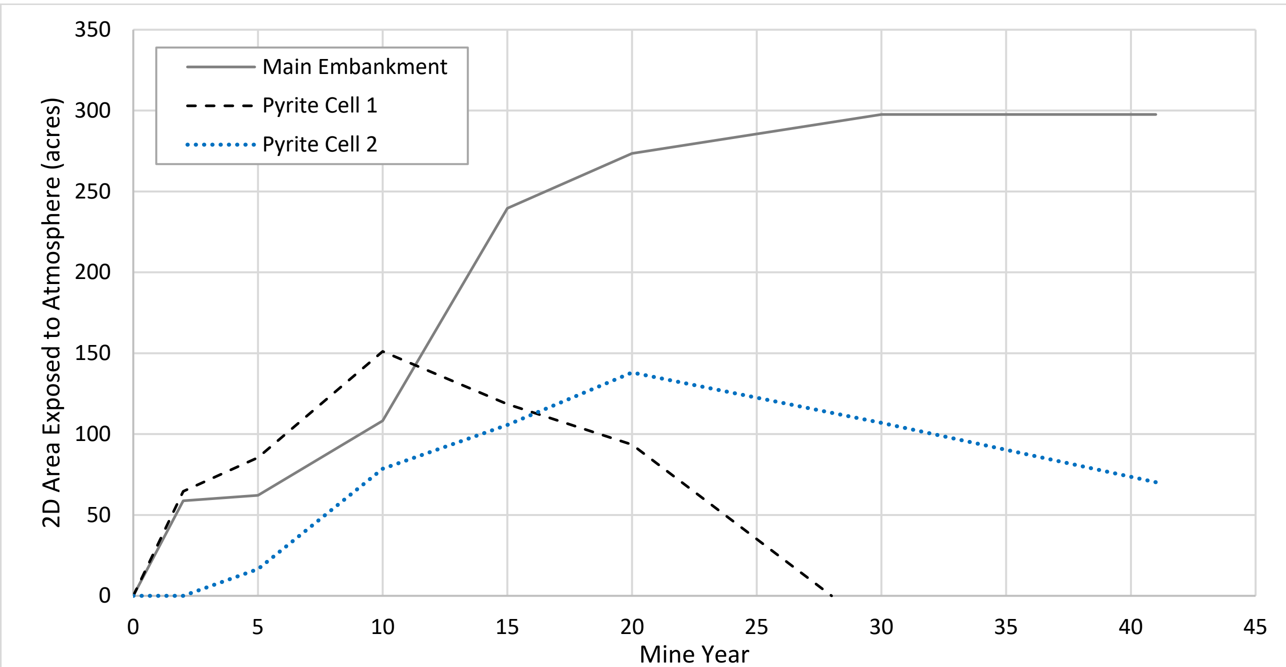
Parameter	Assumed Value
Hydraulic Cell Width	400 ft
Hydraulic Cell Length	2000 ft
Hydraulic Cell Maximum Thickness (for compaction)	10 ft
Volume of Hydraulic Cell	~300,000 cyd
Time for Construction per Hydraulic Cell	~90 days

Based on experience with similar sites, the amount of water decanted from the hydraulic cell [No.4] was estimated as 70% of construction water [No.2].

IV-3.6 Cycloned Sand Total Area

Figure IV-4 shows the two-dimensional (2D) (planar) area of cycloned sand, based on staging (KCBCL 2020), exposed to the atmosphere during operations. The area was linearly interpolated between the key years. The areas were used to estimate the volume of leakage from precipitation [No.10].

Figure IV-4 Cycloned Sand Areas



Note:

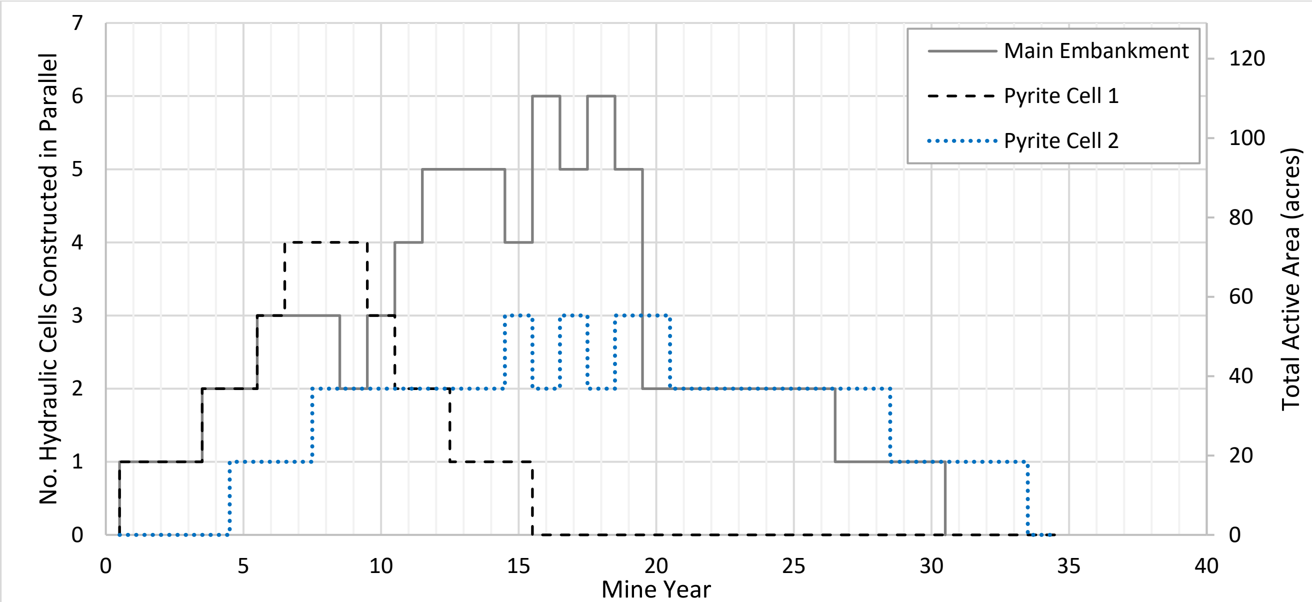
1. The Pyrite Cell 1 Embankment will be covered by scavenger tailings in Mine Year 28.

IV-3.7 Cycloned Sand Hydraulically Active Area

The number of active hydraulic cells was based on the cycloned sand placement rate (Section IV-3.4.1) and the assumed hydraulic cell sizing parameters (Section IV-3.5). Given the total number of cells required and the time required to construct a single cell, the number of cells that will have to be constructed in parallel (i.e., constructed at the same time) was estimated and is summarized on Figure IV-5.

For the Cell Construction Water Balance, it was assumed that evaporation will only occur from the active hydraulic areas. The Climate Water Balance accounts for the climatic boundary (Section IV-3.3). The total active hydraulic area was estimated by multiplying the number of hydraulic cells constructed in parallel by the surface area of a typical hydraulic cell area (400 ft by 2000 ft). The total active hydraulic area was used to estimate Evaporation from Active Hydraulic Cell [No.5].

Figure IV-5 Number of Active Hydraulic Cells and Total Active Hydraulic Cell Area



IV-3.8 Leakage During Closure

Table IV-6 summarizes the final Mine Year of construction at each of the embankments. For the purposes of the cycloned sand embankment leakage estimate, KCBCL assumed that the 3 ft "soil-like" Gila Conglomerate cover would be placed over the embankments immediately following the end of construction. This is a simplifying assumption, refer to the Skunk Camp TSF Reclamation Plan for details on the implementation of the closure cover (KCBCL 2020).

Table IV-6 Embankment Final Mine Year of Construction

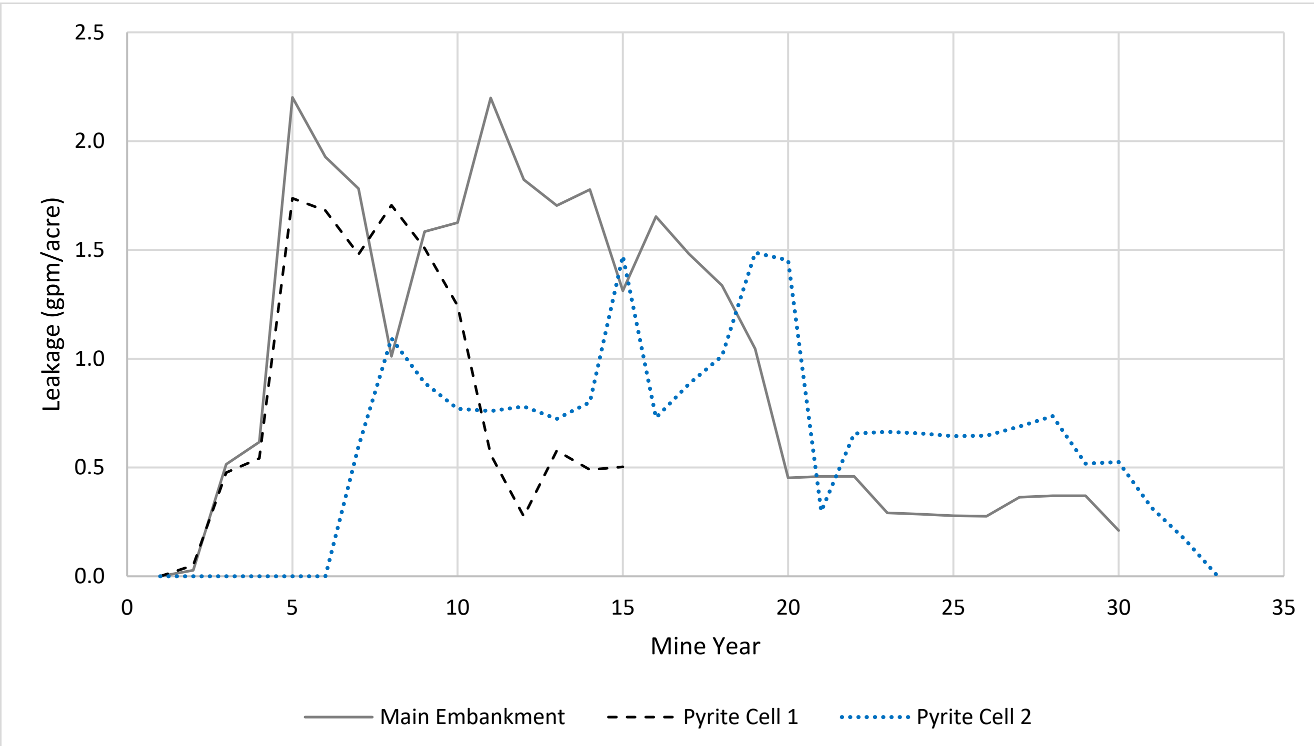
Embankment	Final Mine Year of Construction
Main Embankment	Mine Year 30
Pyrite Cell 1 Embankment	Mine Year 15 (Covered with scavenger tailings in Mine Year 28)
Pyrite Cell 2 Embankment	Mine Year 33

At closure, all Cell Construction Water Balance flows ([No.1] to [No.6]) will be zero. As such, Total Leakage [No.11] will be equal to Leakage from Precipitation [No.10] (i.e., 3% of average annual precipitation, see Table IV-3).

IV-4 RESULTS

The conceptual water balance was used to estimate the Total Leakage [No.11] from the cycloned sand embankments to the underdrainage or natural foundation for operations and post-closure. Results of the 1D leakage rates during operations are summarized in Figure IV-6 for the three embankments. The post-closure leakage rate from the reclaimed cycloned sand embankments is ~3% of the average annual precipitation or 0.03 gpm/acre (See Section IV-3.3 and Section IV-3.8).

Figure IV-6 Cycloned Sand Embankment Leakage Results During Operations



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