January 30, 2019

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
DEIS Design for Alternative 6 - Skunk Camp Doc. # CCC.03-81600-EX-REP-0006 - Rev.2
Appendix IV Seepage Estimate Amendment

Klohn Crippen Berger Ltd. (KCB) completed a design for the draft Environmental Impact Statement (DEIS) Tailings Storage Facility (TSF) Alternative 6 – Skunk Camp for the Resolution Copper Project[1]. A seepage assessment was conducted to provide an indication of potential seepage losses from the impoundment, included in Appendix IV of the report (KCB 2018[1]).

The seepage control measures presented in the DEIS report include underdrains, seepage collection ponds, a nominal depth grout curtain and pumpback well(s) (KCB 2018[1]). However, KCB has assessed several levels of seepage control (Demonstrated Control Technologies (DCT)) at the request of the US Forest Services (the Forest). The seepage estimate appendix (Appendix IV from the Alternative 6 – Skunk Camp DEIS design report) has been amended with the results of the additional seepage control levels and is attached to this letter.

Additional site information would be collected, and the seepage collection system design may be refined if this site were selected and the project applied for an Aquifer Protection Permit (APP).

Yours truly,

KLOHN CRIPPEN BERGER LTD.

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

KP:dl

Attachment

[1] Klohn Crippen Berger Ltd., 2018, Resolution Copper Project - DEIS Design for Alternative 6 – Skunk Camp - Doc. # CCC.03-81600-EX-REP-00006 – Rev. 2, September 2018.

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Appendix IV
Alternative 6 - Seepage Estimate Amendment

IV-1 INTRODUCTION

This appendix summarizes the seepage assessment methodology and results for the Draft Environmental Impact Statement (DEIS) Alternative 6 – Skunk Camp Tailings Storage Facility (TSF). The basis for the seepage assessment is the ultimate TSF layout (see Appendix II), the tailings properties (see the design basis memorandum (DBM) in Appendix I) and available foundation conditions for the Skunk Camp site, which is based on available background information, including regional geology maps, well log information for a small number of wells, and preliminary site reconnaissance visits by RC and KCB as of the date of the DEIS report[1].

The seepage model was developed based on a previous version of the TSF layout. The TSF layout has since been updated after initial submittal and review by the Forest to reduce the exposed Pyrite Cell pond surface area as a best practice technology for the management of pyritic material, to limit the effect of evaporation and reduce the area of seepage and overall improve water management. The revised layout consists of two pyrite cells: Pyrite Cell 1, operated from Year 1 to Year 15 and subsequently covered by scavenger tailings in Year 16, and Pyrite Cell 2, operated from Year 16 to Year 41. The seepage model is assumed to be appropriate for the new layout because of the similar configuration in two-dimensions (2D), as shown on Figure IV-1.

The seepage control measures presented in the DEIS report include underdrains, seepage collection ponds, a nominal depth grout curtain and pumpback well(s). However, KCB has assessed several additional levels of seepage control (Demonstrated Control Technologies (DCT)) and included the results in this amended Appendix. Additional site information would be collected, and the seepage collection system design may be refined if this site were selected and the project applied for an Aquifer Protection Permit (APP).

IV-2 HYDROGEOLOGICAL SETTING

Characterization of the hydrogeological setting has been developed based on a review of regional mapping by the U.S. Geological Survey (Cornwall and Krieger 1978, Cornwall and Banks 1971) and Arizona Geological Survey (Dickinson 1992), as well as notes from preliminary site visits by KCB and RC staff, commentary from the Arizona Department of Water Resources (2009), and existing well logs and springs inventory, where available. Depth to water has been measured by RC staff in a few wells during their site visits.

Further details on the site characterization is included in Section 2 of the main text of the report.

[1] Klohn Crippen Berger Ltd., 2018, Resolution Copper Project - DEIS Design for Alternative 6 – Skunk Camp - Doc. # CCC.03-81600-EX-REP-00006 – Rev. 2, September 2018.

A conceptual understanding of the hydrogeological setting has been developed based on a desktop review of available literature, which is to be updated during later stages of design through site specific geotechnical and hydrogeological investigations.

Regional groundwater is assumed to flow from northwest to southeast within the proposed TSF area at the Skunk Camp site. The majority of groundwater flow is expected to occur within the surface alluvial channels and upper weather zone of the bedrock (Gila Conglomerate). Recent measurements of depth to groundwater levels within the Gila Conglomerate, undertaken by RC, indicate that groundwater levels are approximately 70 ft below the ground surface in the valley bottom (Dripping Springs Wash), or deeper, in the ridges along the valley sides.

It is anticipated that several regional features may also affect the regional groundwater flow and potential TSF seepage within the basin, including:

- The Gila Conglomerate, which forms the foundation of the proposed facility, is highly variable across the site. Preliminary results from the Skunk Camp Site Investigation indicate weak to moderate cementation in the shallow bedrock, grading to moderate cementation at depth with occasional sand and gravel layers with higher permeability throughout.
- The highland areas of Dripping Springs Wash Basin, including Pinal Peak, are anticipated to be areas of high groundwater recharge for the region. These recharge areas cover a large proportion of the surface area within the catchment upstream of the proposed Skunk Camp TSF, which would result in groundwater flow contributing to the site from the catchment to the northeast of the facility.
- A surface water divide is located between Dripping Springs Wash, where Skunk Camp TSF is proposed to be located, and Mineral Creek. It is anticipated that this surface water divide is also a potential groundwater divide, to be confirmed through ongoing site investigations.
- Downstream of the site, the Gila River acts as the regional drainage point. This river collects surface and groundwater runoff from the surrounding areas and flows year-round.
- The Ray Mine open pit is located in an adjacent surface water catchment, across a catchment divide, to the east of the proposed Skunk Camp TSF area. This operational pit likely acts as a regional groundwater sink; however, it is not clear if the faults and associated bedrock units located between the Skunk Camp site and the Ray Mine Open Pit would act as a low permeability boundary between the sites.

IV-3 FOUNDATION ASSUMPTIONS FOR THE SEEPAGE ASSESSMENT

Based on this understanding of the hydrogeological setting for the proposed TSF, the working assumptions for the seepage assessment are:

- the alluvium and upper weather Gila Conglomerate is the major pathway for groundwater flow, and acts as the primary aquifer in the region;

- in general, the Gila Conglomerate at depth has a relatively low permeability compared to the upper weather Gila Conglomerate, alluvium and some of the other bedrock units in the area and may also act as a limited regional aquifer;
- the direction of groundwater flow is predominantly northwest to southeast, with no groundwater flow contribution towards the north across the catchment divide to Mineral Creek; and
- groundwater flow contribution from the Pinal Peak catchment to the east of the facility does not contribute to near-surface groundwater flow at the proposed TSF location; and, groundwater flow/seepage towards the north of Ray Mine from the proposed TSF does not occur.

These working assumptions are based on our current understanding of the foundation.

IV-4 CONCEPTUAL MODELS

Based on the hydrogeological setting described above, two conceptual two-dimensional (2D) seepage models for the basin were developed in order to undertake an estimate of groundwater seepage and to aid in locating seepage collection measures for the DEIS design for operation, and following closure. Steady-state models of the groundwater regime for operations and post-closure were developed using the software package SEEP/W. 2D models were assumed to be reasonable at this level of design as the majority of the groundwater flow is anticipated to be from the upstream catchment into the Dripping Springs Wash, which flows from the northwest to the southeast within the near-surface alluvium. The steady-state condition was assumed to be applicable and conservative at this level of design.

The conceptual models consider 2D sections through the proposed TSF centerline, see Figure IV-1.

IV-4.1 Operations Seepage Model

The conceptual representation of seepage during operation is presented as Figure IV-2, which shows the simplified geometry for the TSF and the boundary conditions. The conceptual model incorporates the effects of natural groundwater recharge upstream of the pyrite tailings cell (between the groundwater divide to Mineral Creek and the TSF), and downstream of the TSF, as well as the anticipated infiltration from the tailings into the natural ground.

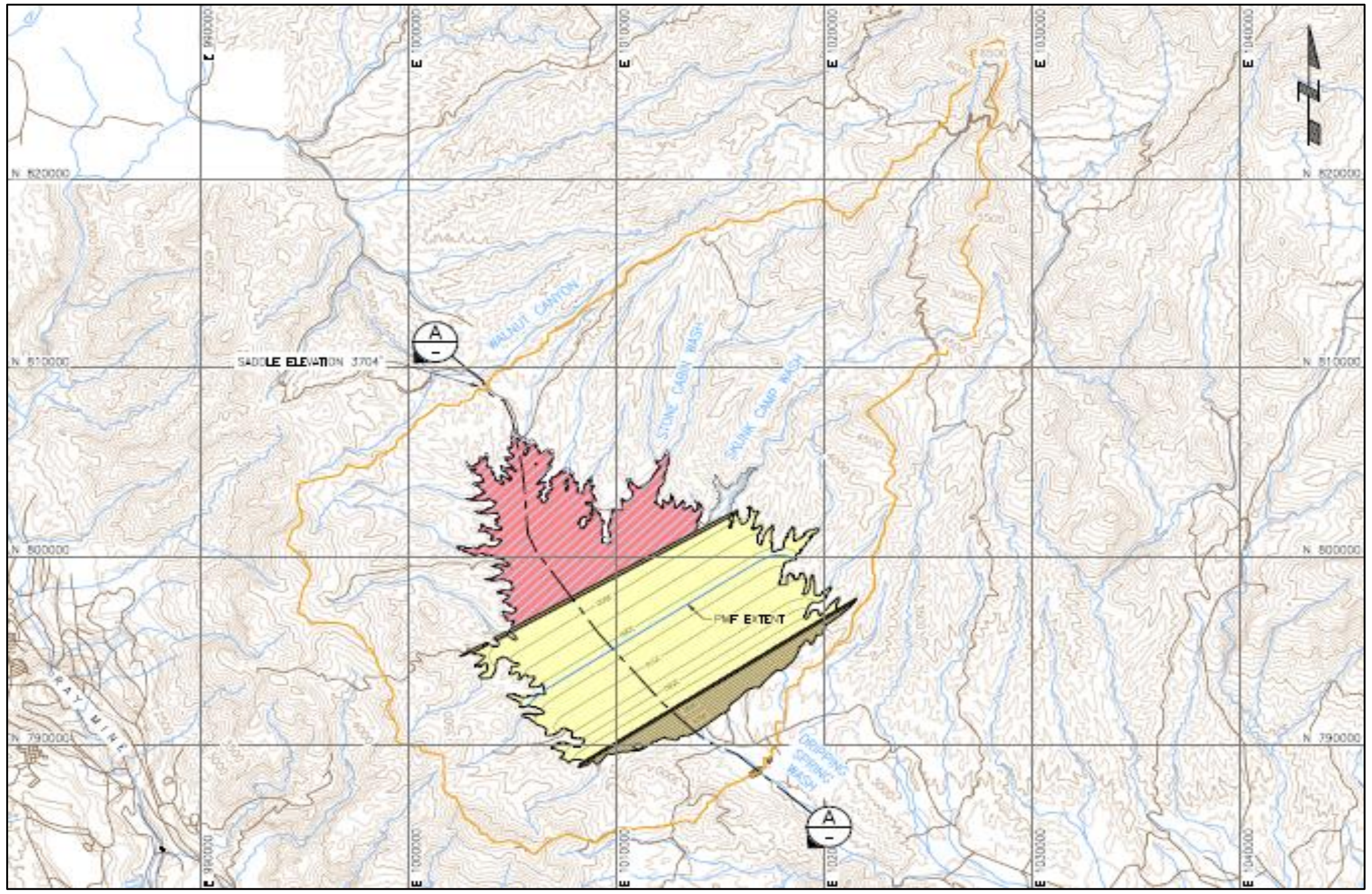
Based on available information at the time the seepage modelling was undertaken, the foundation of the facility is assumed to be on an approximately 20 ft thick alluvium layer, which is assumed to directly overlying a 50 ft thick weathered Gila Conglomerate layer, which is assumed to overlie the more competent Gila Conglomerate. For the purposes of analysis, we have assumed that the underlying competent Gila Conglomerate extends to 1,000 ft below the ground surface, based on regional well logs reviewed during model development.

The proposed Skunk Camp TSF includes two cycloned sand embankments that separately store the scavenger tailings and pyrite tailings. Both embankments are proposed to be centerline-raised, cross-valley embankments. Uncycloned scavenger tailings and cyclone overflow would be stored behind the main embankment. The pyrite tailings would be subaqueously deposited behind a second embankment, upstream from the main embankment and scavenger tailings. The pyrite tailings cell would include engineered, low-permeability layers to minimize seepage and maintain a pond for pyrite tailings saturation, which is modeled as a constant head boundary condition.

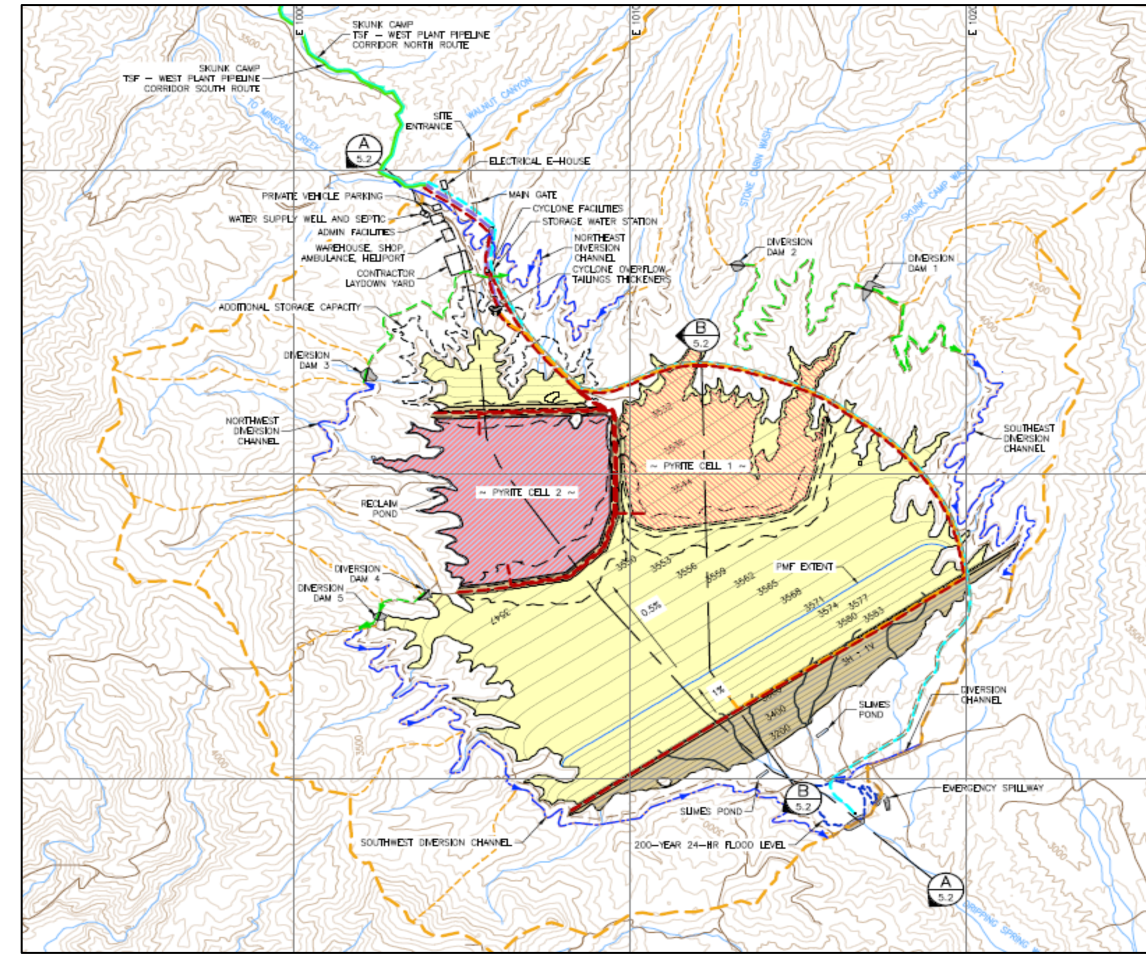
Boundary conditions for the model include a no-flow boundary established at the surface water / groundwater divide north of the proposed facility, groundwater recharge in areas not covered by the proposed TSF and infiltration through the tailings for areas covered by the proposed TSF. Boundary conditions are further described in Section IV-4.2.

The seepage assessment considers three scenarios for operations, each with different downstream grout curtain and seepage collection pumping well configurations:

- Scenario 1 (as presented in the DEIS design): A low-permeability grout curtain extends from the ground surface to 70 feet below ground. A seepage collection pumping well (represented by a seepage face in the conceptual model) is installed at 20 feet below ground (at the base of the alluvium layer).
- Scenario 2: The grout curtain extends from the ground surface to 100 feet below ground. The pumping well is installed at 70 feet below ground (at the base of the weathered Gila Conglomerate layer).
- Scenario 3: The grout curtain extends from the ground surface to 100 feet below ground. The pumping well is installed at 100 feet below ground (within the competent Gila Conglomerate layer).

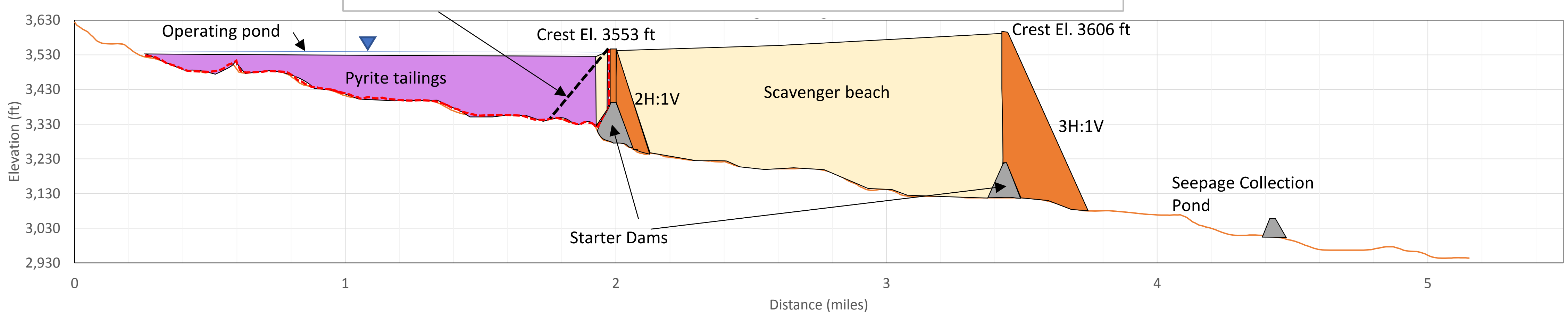


Previous Skunk Camp Design



Updated Skunk Camp Design

The seepage model was developed based on a previous version of the TSF layout. The TSF layout has since been updated with multiple pyrite tailings storage cells that have downstream raised dams after initial submittal and review by the Forest.



CONCEPTUAL CROSS SECTION

LEGEND

- PYRITE TAILINGS
- SCAVENGER TAILINGS
- CYCLONED SAND MAIN EMBANKMENT AND PYRITE CELL EMBANKMENT
- SEEPAGE COLLECTION DAM AND STARTER DAMS
- ENGINEEERED LOW-PERMEABILITY LAYER
- 60 FT CONTOUR INTERVAL

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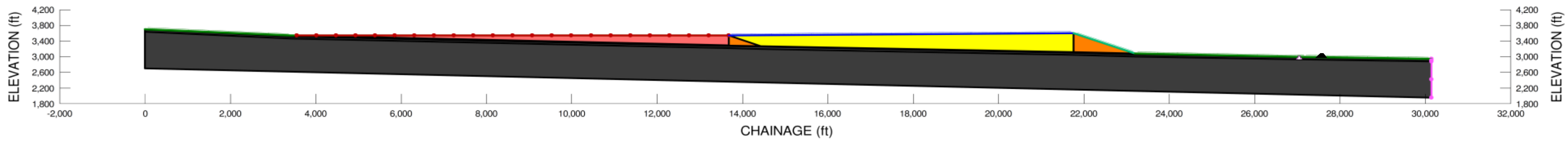
PROJECT: RESOLUTION COPPER PROJECT
DEIS DESIGN FOR ALTERNATIVE 6 - SKUNK CAMP

TITLE: APPROXIMATE CONCEPTUAL SEEPAGE MODEL SECTION LOCATION

PROJECT No. M09441A20 | FIG No. IV-1

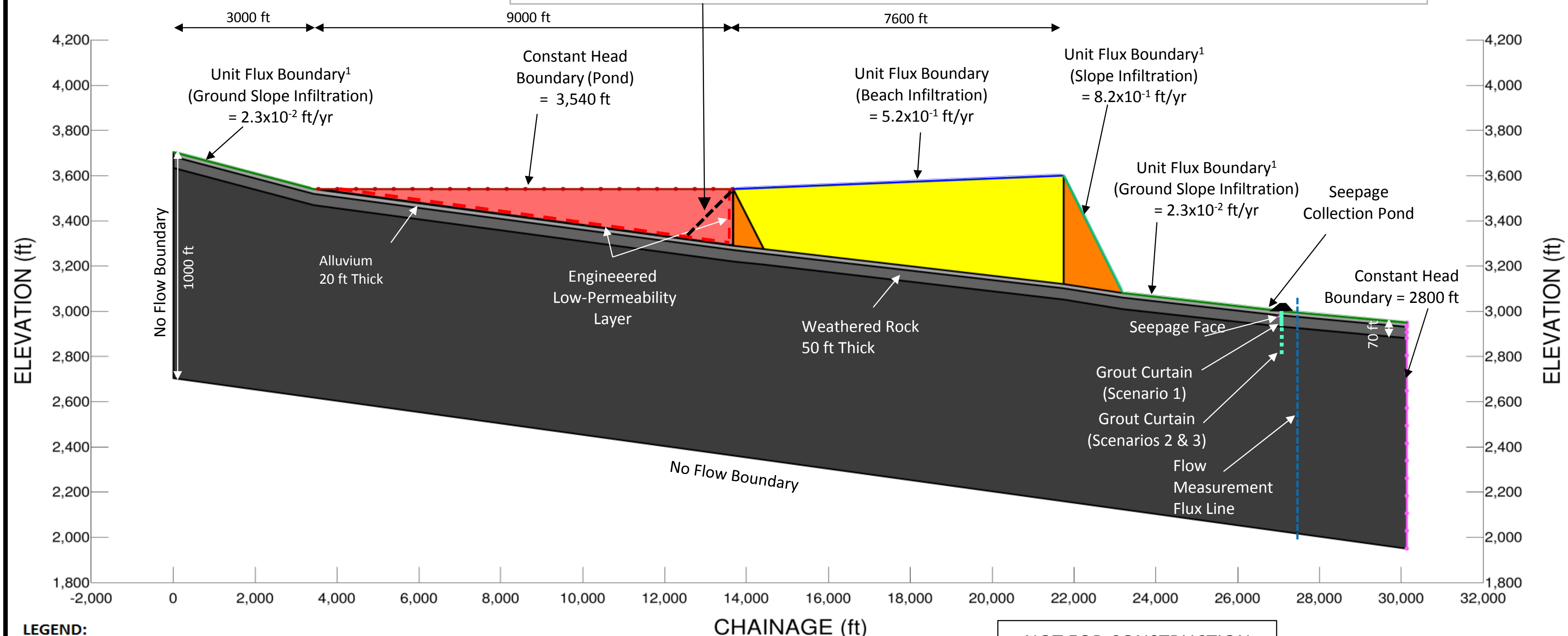
2019-01-27
Z:\M\VCR\M09441A20 - RES-Near West PFS-PES\700 Deliverables\720 Working\780 DEIS Skunk Camp\04-App IV - Seepage\Figures\[Figure IV-1 - final.xlsx]Fig IV-1

Natural Scale:



The seepage model was developed based on a previous version of the TSF layout. The TSF layout has since been updated with multiple pyrite tailings storage cells that have downstream raised dams after initial submittal and review by the Forest.

5x Vertical Exaggeration:



LEGEND:

(orange)	Cyclone Sand
(yellow)	Scavenger Tailings
(pink)	Pyrite Tailings
(light grey)	Alluvium
(grey)	Weathered Rock
(dark grey)	Base Rock
(red dashed line)	Engineered Low-Permeability Layer

NOTES:

1. Seepage face review allowed.

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PROJECT: RESOLUTION COPPER PROJECT
DEIS DESIGN FOR ALTERNATIVE 6 - SKUNK CAMP

TITLE: CONCEPTUAL SEEPAGE MODEL
OPERATIONS

PROJECT No. M09441A20

FIG No. IV-2

IV-4.2 Closure Seepage Model

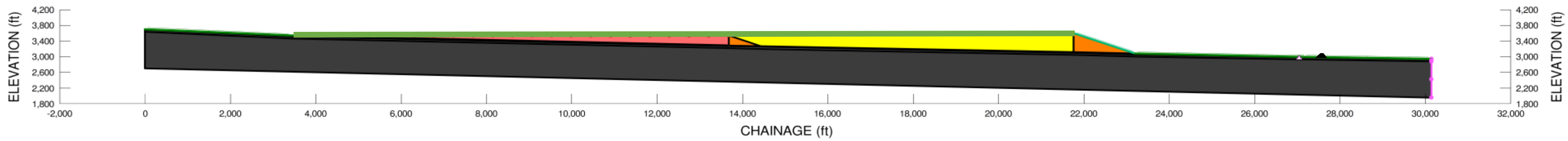
The conceptual representation of seepage post-closure is presented as Figure IV-3, which is based on the simplified geometry for the TSF, as developed for the Operations Seepage Model, with changes to the defined boundary conditions to reflect the closure design for the facility.

At the end of operations, the pyrite tailings cell will be covered with a layer of scavenger tailings, followed by the construction of a cover system, placed over the top of both the scavenger and pyrite impoundment surfaces. This cover would be shaped to shed water to a closure spillway, so that no permanent ponds would be impounded on surface, and the surface would be revegetated.

Boundary conditions assumed for the model include a no-flow boundary established at the surface water / groundwater divide north of the proposed facility, groundwater recharge in areas not covered by the proposed TSF and infiltration through the closure cover for areas covered by the proposed TSF.

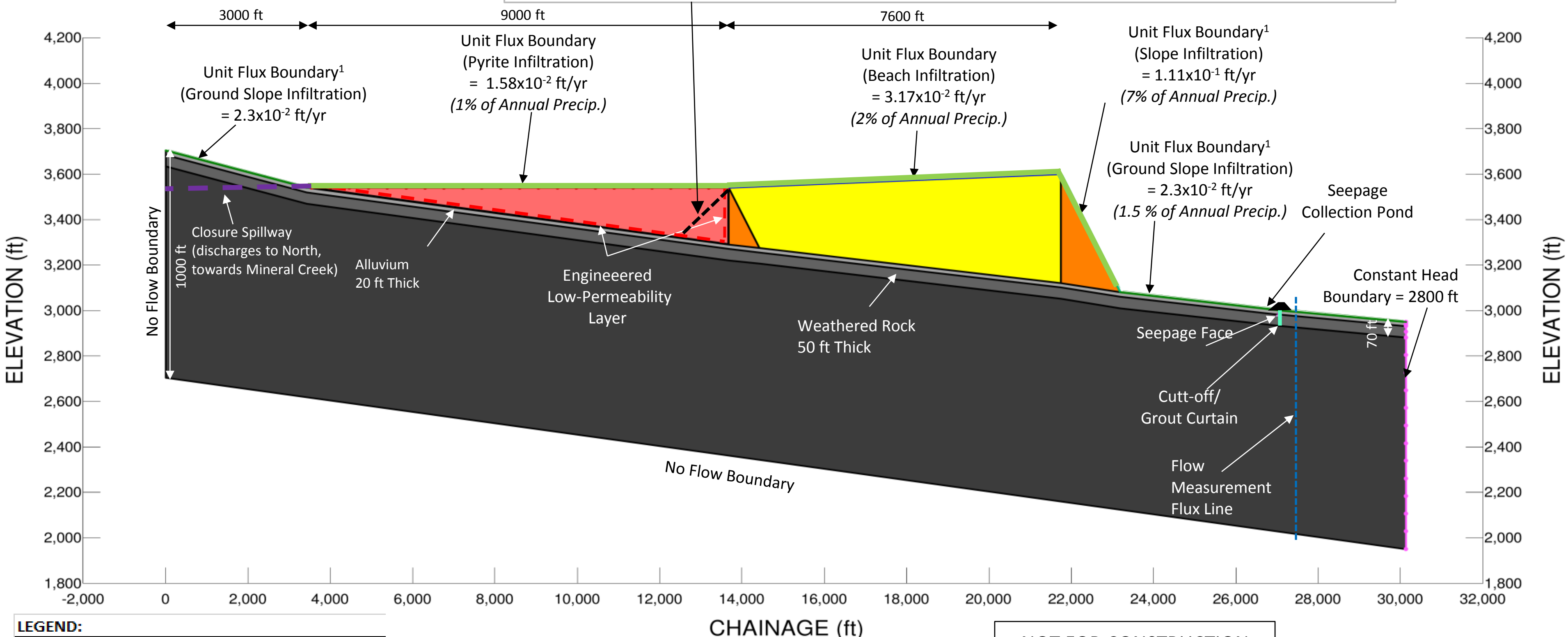
Note that only Scenario 1 for operations (as presented in the DEIS design, with the grout curtain extending from ground surface to 70 feet below ground and the seepage collection pumping well installed at 20 feet below ground) is considered for the closure seepage model.

Natural Scale:



The seepage model was developed based on a previous version of the TSF layout. The TSF layout has since been updated with multiple pyrite tailings storage cells that have downstream raised dams after initial submittal and review by the Forest.

5x Vertical Exaggeration:



LEGEND:

	Cyclone Sand
	Scavenger Tailings
	Pyrite Tailings
	Alluvium
	Weathered Rock
	Base Rock
	Engineered Low-Permeability Layer
	Closure Cover

NOTES:

1. Seepage face review allowed.

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PROJECT

RESOLUTION COPPER PROJECT
DEIS DESIGN FOR ALTERNATIVE 6 - SKUNK CAMP

TITLE

CONCEPTUAL SEEPAGE MODEL
STEADY-STATE POST-CLOSURE

PROJECT No. M09441A20

FIG No. IV-3

IV-5 MODEL INPUTS AND ASSUMPTIONS

IV-5.1 Material Properties

The material properties for the units included in the seepage analysis are presented in Table IV-1.

Table IV-1 Summary of Material Properties

Unit	Assumed Foundation Thickness (ft)	Horizontal Hydraulic Conductivity, k_h (ft/yr)	Horizontal Hydraulic Conductivity, k_h (cm/s)	Anisotropic k_h/k_v Ratio	Comments / Reference
Pyrite Cell Low Permeability Layer	--	0.0001	1×10^{-10}	1	Assumed to be a geomembrane liner.
Cycloned Sand	--	5,200	5×10^{-3}	10	KCB 2018a
Pyrite Tailings	--	0.52	5×10^{-7}	1	KCB 2018a
Scavenger Tailings	--	10	1×10^{-5}	10	KCB 2018a
Grout Curtain	--	1.0	1×10^{-6}	1	Low-permeability grout curtain at the seepage collection pond.
Alluvium	20	10,000	1×10^{-2}	1	Assumed to be similar to the Near West site (M&A 2017)
Gila Conglomerate (weathered – 20ft to 70ft below surface)	50	100	1×10^{-4}	10	Assumed to be higher permeability in comparison to the Near West site (M&A 2017) based on less cementation observed at Skunk Camp
Gila Conglomerate (fresh – from 70ft below surface)	930	10	1×10^{-5}	10	Assumed to be higher permeability in comparison to the Near West site (M&A 2017) based on less cementation observed at Skunk Camp. Well logs indicate some cementation at depth, but verified is required during the PFS.

Preliminary results from the Skunk Camp site investigation indicate that hydraulic conductivity values for the weathered and fresh Gila Conglomerate units may be lower than the model input values. Therefore, the results from the model, based on the above adopted material properties can be considered conservative.

IV-5.2 Boundary Conditions

The model boundary conditions are as presented in Table IV-2 for the Operations Seepage Model, and Table IV-3 for the Post-Closure Seepage Model.

Table IV-2 Summary of Model Boundary Conditions – Operations Seepage Model

Boundary	Assumed Condition	Comments
Groundwater Divide	No Flow Boundary	Assumed that groundwater would not flow north. This should be evaluated when more information on the foundation is known.
Natural Ground	Infiltration at 0.23 ft/yr	Assumed to be 1.5% of annual precipitation, which is typical for the area.
Pyrite Cell	Constant Head at 3,540 fasl	Elevation of the pond.
Scavenger Beach	Infiltration at 0.52 ft/yr	Prorated, based on slurry solids contents, from the estimated infiltration for Near West Alternative 3A and Alternative 3B (KCB 2018b, KCB 2018c).
Embankment Face	Infiltration at 0.82 ft/yr	Based on the predicted Near West Alternative 3A infiltration (KCB 2018b).
Downstream	Constant Head at 2,800 fasl	Located 1,000 ft downstream of facility, prior to next major wash. Based on depth to groundwater at 70 fbgs (measured depth at one well at the site).
Foundation	No Flow Boundary	Located at a depth of 1,000 ft below facility, based on the assumption that the majority of flow would be near surface

Table IV-3 Summary of Model Boundary Conditions – Post-Closure Seepage Model

Boundary	Assumed Condition	Comments
Groundwater Divide	No Flow Boundary	Assumed that groundwater would not flow north. This should be evaluated when more information on the foundation is known.
Natural Ground	Infiltration at 0.23 ft/yr	Assumed to be 1.5% of annual precipitation, which is typical for the area.
Reclaimed Pyrite Cell	Infiltration at 0.16 ft/yr	Assumed to be 1% of annual precipitation (based on KCB 2016).
Reclaimed Scavenger Beach	Infiltration at 0.32 ft/yr	Assumed to be 2% of annual precipitation (based on KCB 2016).
Embankment Face	Infiltration at 1.11 ft/yr	Assumed to be 7% of annual precipitation (based on KCB 2016).
Downstream	Constant Head at 2,800 fasl	Located 1,000 ft downstream of facility, prior to next major wash. Based on depth to groundwater at 70 fbgs (measured depth at one well at the site).
Foundation	No Flow Boundary	Located at a depth of 1,000 ft below facility, based on the assumption that the majority of flow would be near surface

IV-6 RESULTS

Assuming a representative length of 15,000 ft (approximately 2.8 miles) for the TSF embankment, cross-valley length, the results of the model are as presented in Table IV-4 for the Operations Seepage Model, and Table IV-5 for the Post-Closure Seepage Model.

Table IV-4 Summary of Model Results – Operations Seepage Model

Model Location	Flow (gpm)		
	Scenario 1 - Base Case - Assuming a representative length of 15,000 ft (approximately 2.8 miles) and foundation permeabilities one order of magnitude greater than Near West	Scenario 2 - Base Case assumptions with grout curtain extended to 100 ft below ground and pumping well at 70 ft below ground	Scenario 3 - Base case assumptions with grout curtain extended to 100 ft below ground and pumping well at 100 ft below ground
Pyrite Cell Leakage	30	30	30
Scavenger Tailings Leakage	1130	1140	1140
Seepage Collected at Seepage Pond	800	1000	1130
Flux Downstream of Seepage Dam and Grout Curtain(1)	410	230	110
Uncollected TSF Seepage(2)	360 - 410	170 - 230	40 - 110

Notes:

1. Calculated from a flux line and includes inflow from natural recharge and the TSF.
2. Range is estimated based on TSF seepage (tailings leakage less collected tailings leakage at the seepage collection pond) and total groundwater flux past the seepage dam.

Table IV-5 Summary of Model Results – Post-Closure Seepage Model

Model Location	Flow (gpm)
Pyrite Cell Leakage	35
Scavenger Tailings Leakage	90
Seepage Collected at Seepage Pond	0
Flux Downstream of Seepage Dam and Grout Curtain(1)	160
Uncollected TSF Seepage(2)	125 - 160

Notes:

1. Calculated from a flux line and includes inflow from natural recharge and the TSF.
2. Range is estimated based on TSF seepage (tailings leakage less collected tailings leakage at the seepage collection pond) and total groundwater flux past the seepage dam.

REFERENCES

Arizona Department of Water Resources (ADWR). 2009. "Arizona Water Atlas - Section 3.6 Dripping Springs Wash Basin".

Cornwall, H.R., and Krieger, M.H. 1978. "Geologic Map of the El Capitan Mountain Quadrangle, Gila and Pinal Counties, Arizona". Scale 1:24,000, U.S. Geological Survey.

Cornwall, H.R., and Banks, N.G. 1971. "Geologic Map of the Sonora Quadrangle, Pinal and Gila Counties, Arizona". Scale 1:24,000, U.S. Geological Survey.

Dickinson, W.R. 1992. "Geologic Map of Catalina Core Complex and San Pedro Trough, Pima, Pinal, Gila, Graham and Cochise Counties, Arizona". Scale 1:125,000. Arizona Geological Survey.

Klohn Crippen Berger Ltd. (KCB). 2016. Near West Tailings Storage Facility Closure Cover Study. Prepared for Resolution Copper Mining. March.

Klohn Crippen Berger (KCB). 2018a. Resolution Copper Project - Tailings Storage Facility DEIS Designs Tailings Geotechnical Characterization, Rev. 2. Prepared for Resolution Copper Mining LLC on June.

Klohn Crippen Berger (KCB). 2018b. Resolution Copper Project – DEIS Design for Alternative 3A – Near West Modified Proposed Action (Modified Centerline Embankment – "wet") –Rev. 0. June.

Klohn Crippen Berger (KCB). 2018c. Resolution Copper Project – DEIS Design for Alternative 3B – Near West Modified Proposed Action (High-density thickened NPAG Scavenger and Segregated PAG Pyrite Cell). June.

Montgomery and Associates. (M&A). 2017. Conceptual Hydrogeologic Model for Proposed Near West Tailings Storage Facility. November 25.