Klohn Crippen Berger

Resolution Copper Mining LLC

Resolution Copper Project

DEIS Design for Alternative 8 – Skunk Camp

Doc. # CCC.03-81600-EX-REP-00006 - Rev. 0

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M09441A20.738

June 2018

Klohn Crippen Berger

June 12, 2018

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 8 - Skunk Camp
Doc. # CCC.03-81600-EX-REP-00006 – Rev. 0

We are pleased to provide the Draft Environmental Impact Statement (DEIS) Design for the Tailings Storage Facility (TSF) Alternative 8 – Skunk Camp for the Resolution Copper Project.

Yours truly,

KLOHN CRIPPEN BERGER LTD.

KBPatterson

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

KP:dl

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Resolution Copper Mining LLC

Resolution Copper Project

DEIS Design for Alternative 8 – Skunk Camp

Doc. # CCC.03-81600-EX-REP-00006 - Rev. 0

EXECUTIVE SUMMARY

Resolution Copper Mining LLC (RC) is proposing to develop the Resolution Copper project (the Project), an underground copper mine, using the block cave mining method. The mine site is approximately two miles east of the town of Superior in the Pioneer Mining District, Pinal County, Arizona. The project mine plan includes generation of approximately 1.37 billion tons (Bt) of tailings over a 41-year mine life.

The Tonto National Forest (the Forest) is currently in the "alternatives development" portion of the NEPA process which the Forest will use as a component of the Project's environmental impact statement (EIS). A number of tailings storage facility (TSF) designs are currently being assessed and will be included in the draft EIS (DEIS). This report presents Alternative 8 – Skunk Camp.

Select key elements of Alternative 8 are summarized below:

- Alternative 8 would use a centerline-raised compacted cycloned sand embankments. A portion of the scavenger tailings would be cycloned to create two products: cycloned (underflow) sand used to construct the embankment; and finer overflow tailings would be deposited into the scavenger beach.
- Pyrite tailings would be discharged subaqueously from a floating barge or pipelines directly into the reclaim pond, to maintain pyrite tailings saturation during operations for the benefit of water quality.
- A low-permeability, segregated pyrite tailings cell (contained by a cross-valley embankment); potentially with selective use of engineered low-permeability layers[1] to manage downstream water quality. The reclaim pond would be maintained within the pyrite tailings cell. Pyrite tailings would be kept saturated to prevent oxidation, in order to control water quality concerns associated with pyrite tailings.
- Tailings will be piped to the Skunk Camp TSF site from West Plant via an approximate 22 mile to 25 mile-long pipeline. The pipeline route has not yet been finalized, however is anticipated to require at least one major pipeline crossing.
- Tailings would be pumped to the TSF rather than flow by gravity to increase reliability and reduced potential for pipeline upsets (i.e. sanding of the lines) and associated spills.

The main benefits of Alternative 8 are:

- that it is located far from population centers and close to other mining areas, in an area of low-density population, and generally out of public view;
- that the site location may reduce the impact to National Forest System lands;

[1] Low-permeability containment details could comprise of one or more of the following: geomembrane liner, compacted fine tailings, asphalt core, slurry bentonite, cemented paste tailings, etc.

- that it utilizes cross-valley embankments requiring less embankment fill to retain tailings, compared to a ring dyke impoundment, thus reducing operational and construction complexity associated with the required embankment rate of rise;
- that it has topography that is amenable for embankment construction and tailings storage, and potential favorable foundation for seepage control and borrow availability (to be evaluated); and,
- that the downstream receiving environment is located approximately 13 miles from the TSF.

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1 INTRODUCTION

1.1 General

Resolution Copper Mining LLC (RC) is proposing to develop the Resolution Copper project (the Project), an underground copper mine, using the block cave mining method. The mine site is approximately two miles east of the town of Superior in the Pioneer Mining District, Pinal County, Arizona. The project mine plan includes generation of approximately 1.37 billion tons (Bt) of tailings over a 41-year mine life.

RC submitted a General Plan of Operations (GPO) (RC 2016a) for the Project to the Tonto National Forest (the Forest). The subsequent issue of a Notice of Intent by the Forest (GPO 2016) triggered the beginning of the Forest's environmental analysis of the Project, in accordance with the National Environmental Policy Act (NEPA). The analysis will ultimately lead to the issuance of a Record of Decision on the Project by the Forest.

The Forest is currently in the "alternatives development" portion of the NEPA process which the Forest will use as a component of the Project's environmental impact statement (EIS). Klohn Crippen Berger Ltd. (KCB) has been commissioned by RC to prepare select tailings storage facility (TSF) designs to support the alternatives development process and the draft EIS (DEIS). The alternatives being considered are:

- Alternative 1 – No Action;
- Alternative 2 – Near West GPO Proposed Action (not to be considered further in the DEIS, but included for comparison);
- Alternative 3A – Near West Modified Proposed Action (Modified Centerline Embankment – "wet");
- Alternative 3B – Near West Modified Centerline Embankment (High-density thickened NPAG[2] Scavenger and Segregated PAG[3] Pyrite Cell);
- Alternative 4 – Silver King Filtered;
- Alternative 5 – Peg Leg Lined;
- Alternative 6 – Peg Leg Unlined;

Two additional Alternatives for review by the Forest are:

- Alternative 7 – Peg Leg, Combined; and
- Alternative 8 – Skunk Camp.

[2] The Forest use the term (Non-Potentially Acid Generating) NPAG tailings to refer to scavenger tailings described in the GPO (RC 2016a).
[3] The Forest uses (Potentially Acid Generating) PAG tailings to refer to cleaner tailings described in the GPO (RC 2016a), also referred to as pyrite tailings.

Alternative 8 utilizes two centerline raised cycloned sand embankments constructed from non-potentially acid generating (NPAG) scavenger tailings. The potentially acid generating (PAG) pyrite tailings would be deposited subaqueously and stored in a segregated low-permeability cell.

The scope of the Alternative 8 DEIS design is to use the referenced information to provide a basis for comparing potential impacts of the TSF alternatives.

1.2 Key Elements of Alternative 8

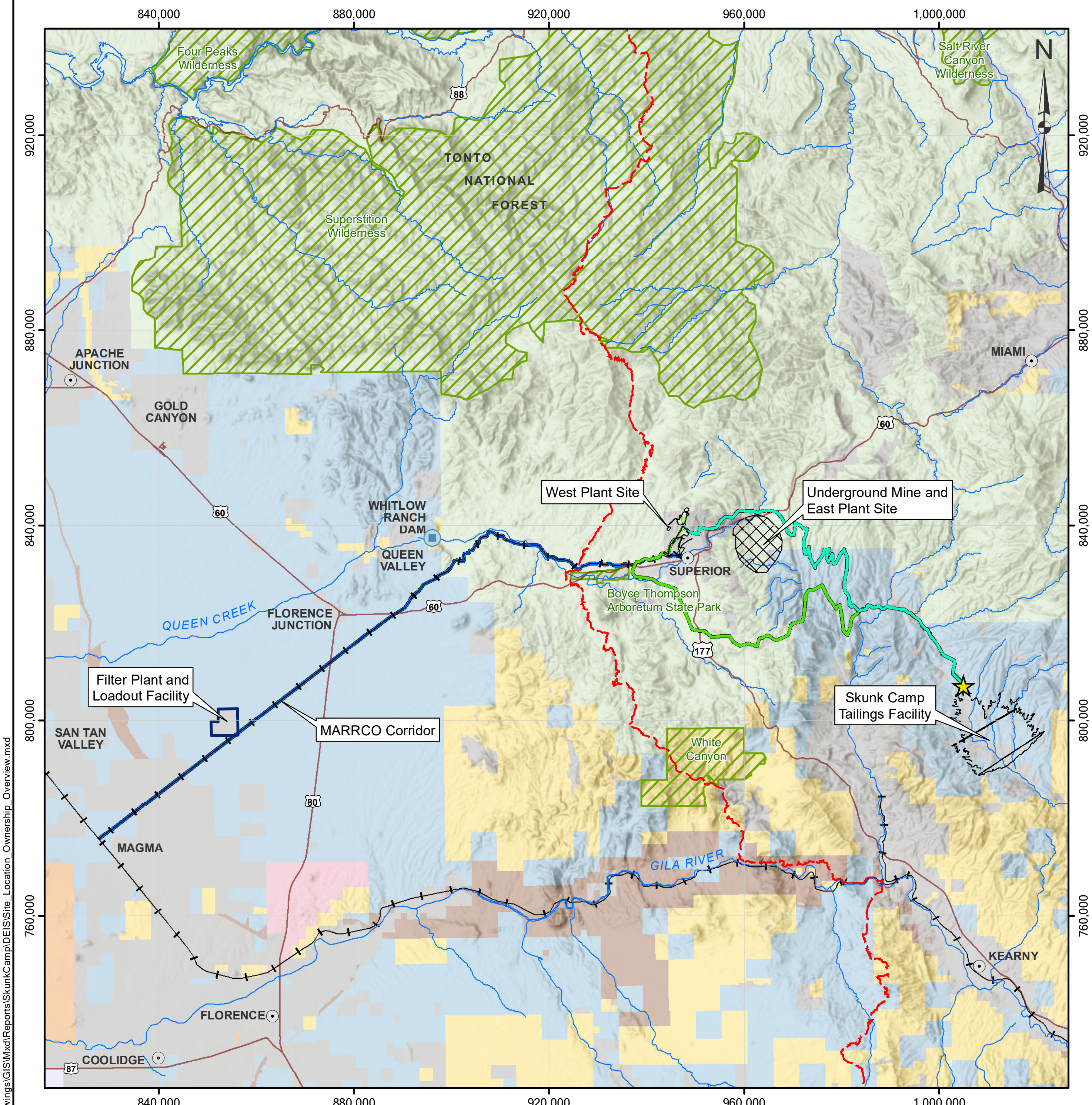
Key elements of Alternative 8 are summarized below:

- Alternative 8 proposes to use centerline-raised compacted cycloned sand embankments. A portion of the scavenger tailings would be cycloned to create two products: cycloned (underflow) sand used to construct the embankment; and finer overflow tailings would be deposited onto the scavenger beach.
- Pyrite tailings would be discharged subaqueously from a floating barge or pipelines into the reclaim pond during operations, to maintain saturation for the benefit of water quality.
- A low-permeability, segregated pyrite tailings cell and reclaim pond would be contained by a cross-valley embankment; potentially with selective use of engineered low-permeability layers[4] to manage downstream water quality and maintain the pond.
- Tailings would be piped to the Skunk Camp TSF site from West Plant via an approximate 22 mile to 25 mile-long pipeline.

The main benefits of Alternative 8 are:

- that it is located far from population centers and close to other mining areas, in an area of low-density population, and generally out of public view;
- that it utilizes cross-valley embankments requiring less embankment fill to retain tailings compared to a ring dyke impoundment, thus reducing operational and construction complexity associated with the required embankment rate of rise;
- that it has topography that is amenable for embankment construction and tailings storage, and potentially favorable foundation for seepage control and borrow availability; and
- that the downstream receiving environment is located approximately 13 miles from the TSF.

[4] Low-permeability containment details could comprise of one or more of the following: geomembrane liner, compacted fine tailings, asphalt core, slurry bentonite, cemented paste tailings, etc.



LEGEND

ALTERNATIVE 8: SKUNK CAMP
ZONE OF SUBSIDENCE
MARRCO CORRIDOR
TSF - WEST PLANT PIPELINE CORRIDOR NORTH ROUTE
TSF - WEST PLANT PIPELINE CORRIDOR SOUTH ROUTE
WEST PLANT
FILTER PLANT AND LOADOUT FACILITY
WILDERNESS AREA OR STATE PARK
ARIZONA NATIONAL SCENIC TRAIL (ARIZONA TRAIL)
CYCLONE HOUSE AND PIPELINE CORRIDOR TIE-IN POINT
WHITLOW RANCH DAM
TOWN OR CITY
ROAD
RAILWAY
RIVER OR MAJOR DRAINAGE

LAND OWNERSHIP

BUREAU OF LAND MANAGEMENT
BUREAU OF RECLAMATION
COUNTY
INDIAN RESERVATION
LOCAL OR STATE PARKS
MILITARY
NATIONAL PARKS
PRIVATE
STATE TRUST LAND
STATE WILDLIFE AREA
UNITED STATES FOREST SERVICE

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NOTES:
1. NAD83, ARIZONA STATE PLANE CENTRAL
2. HILLSHADE PROVIDED BY ESRI
3. LANDUSE FROM THE ARIZONA BUREAU OF LAND MANAGEMENT (1:100,000) CURRENT AS OF DEC 19TH, 2012.

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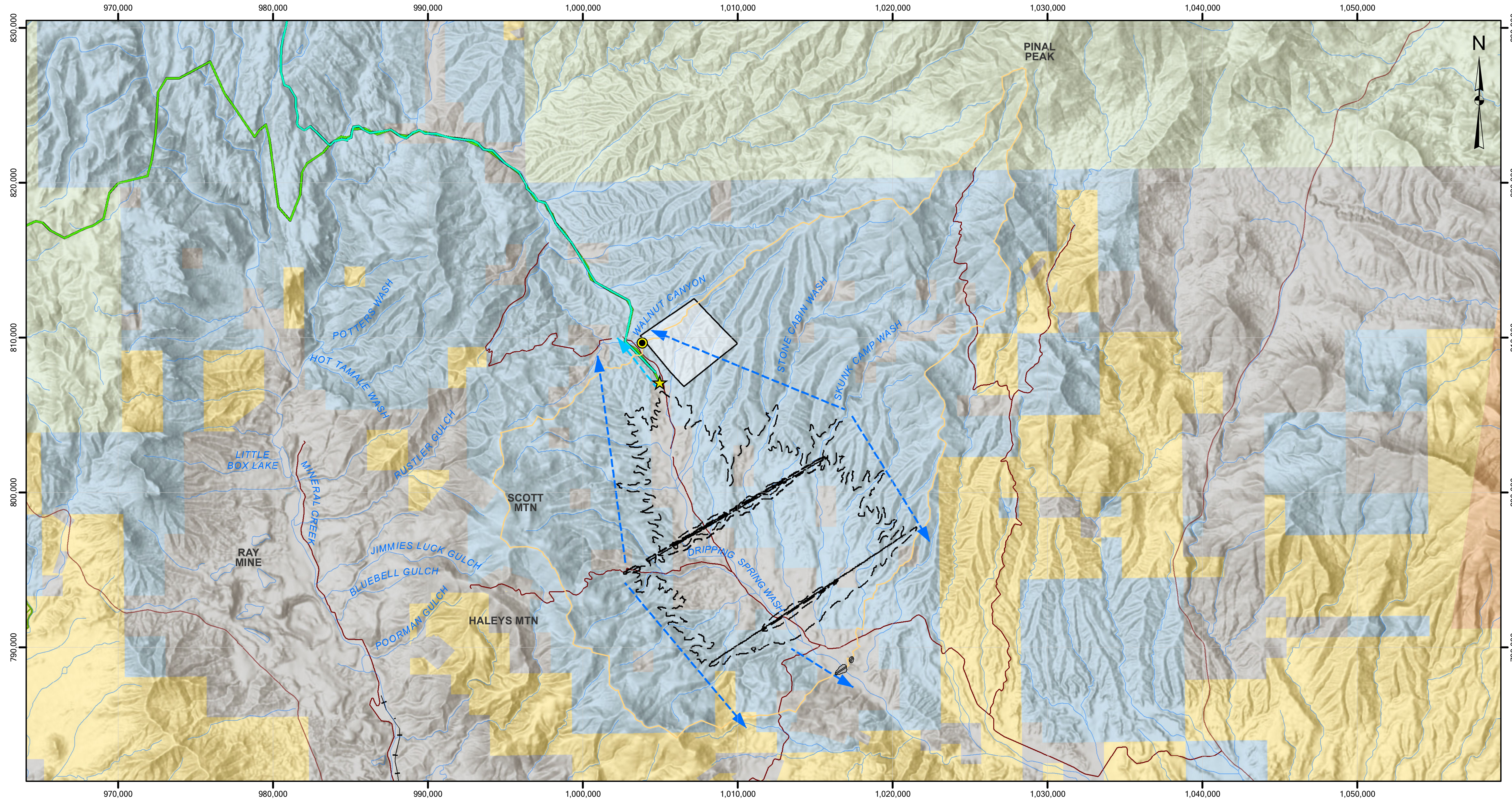
PROJECT
RESOLUTION COPPER PROJECT
ALTERNATIVE 8: SKUNK CAMP PORTFOLIO

TITLE
SITE LOCATION AND LAND OWNERSHIP OVERVIEW

PROJECT No. M09441A20

FIG No. 1.1



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LEGEND

- ALTERNATIVE 8: SKUNK CAMP
- SEEPAGE COLLECTION DAM
- FACILITIES
- DIVERSION
- CLOSURE SPILLWAY
- TSF - WEST PLANT PIPELINE CORRIDOR NORTH ROUTE
- TSF - WEST PLANT PIPELINE CORRIDOR SOUTH ROUTE
- TSF CATCHMENT
- CYCLONE HOUSE AND PIPELINE CORRIDOR TIE-IN POINT
- PIPELINE END POINT
- ROAD
- RAILWAY
- RIVER OR MAJOR DRAINAGE

LAND OWNERSHIP

- BUREAU OF LAND MANAGEMENT
- BUREAU OF RECLAMATION
- COUNTY
- INDIAN RESERVATION
- LOCAL OR STATE PARKS
- MILITARY
- NATIONAL PARKS
- PRIVATE
- STATE TRUST LAND
- STATE WILDLIFE AREA
- UNITED STATES FOREST SERVICE

0 2 Mile

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PROJECT	RESOLUTION COPPER PROJECT ALTERNATIVE 8: SKUNK CAMP PORTFOLIO
TITLE	SITE LOCATION AND LAND OWNERSHIP DETAILS
PROJECT No. M09441A20	FIG No. 1.2

1.3 Previous Studies

Relevant studies that have been utilized in the design for Alternative 8, many of which have been adopted from the Near West site, include:

- An embankment design alternatives trade-off carried out for the Near West site to identify the preferred embankment design (KCB 2017a).
- Summary reports of the subsurface site investigation (SI) program at the Near West site in 2016/2017 which included drilling and pit trenches have been adopted for this study, specifically the characterization of the Gila Conglomerate:
  - Geotechnical site characterization report (KCB 2017b) including summary of related SI activities and laboratory testing.
  - Hydrogeological site characterization report prepared by Montgomery and Associates (M&A 2017b).
  - Geochemical characterization of bedrock units prepared by Duke Hydrochem (Duke 2017a).
- Geochemical characterization report of scavenger and pyrite tailings (Duke Hydrochem 2016 and 2017b).
- Site-specific seismic hazard assessment of the Near West site prepared by Lettis Consultants International, Inc. (LCI 2017).

In addition, from the public domain:

- Geology maps (Cornwall and Banks 1971, Cornwall and Krieger 1978, Dickinson 1992); and
- Well logs and spring inventory from Arizona Department of Water Resources (ADWR).

Information adopted from these and other reference reports are cited herein as appropriate. Original reports should be referred to for specific information and further discussion.

2 SITE CHARACTERIZATION

2.1 Setting & Topography

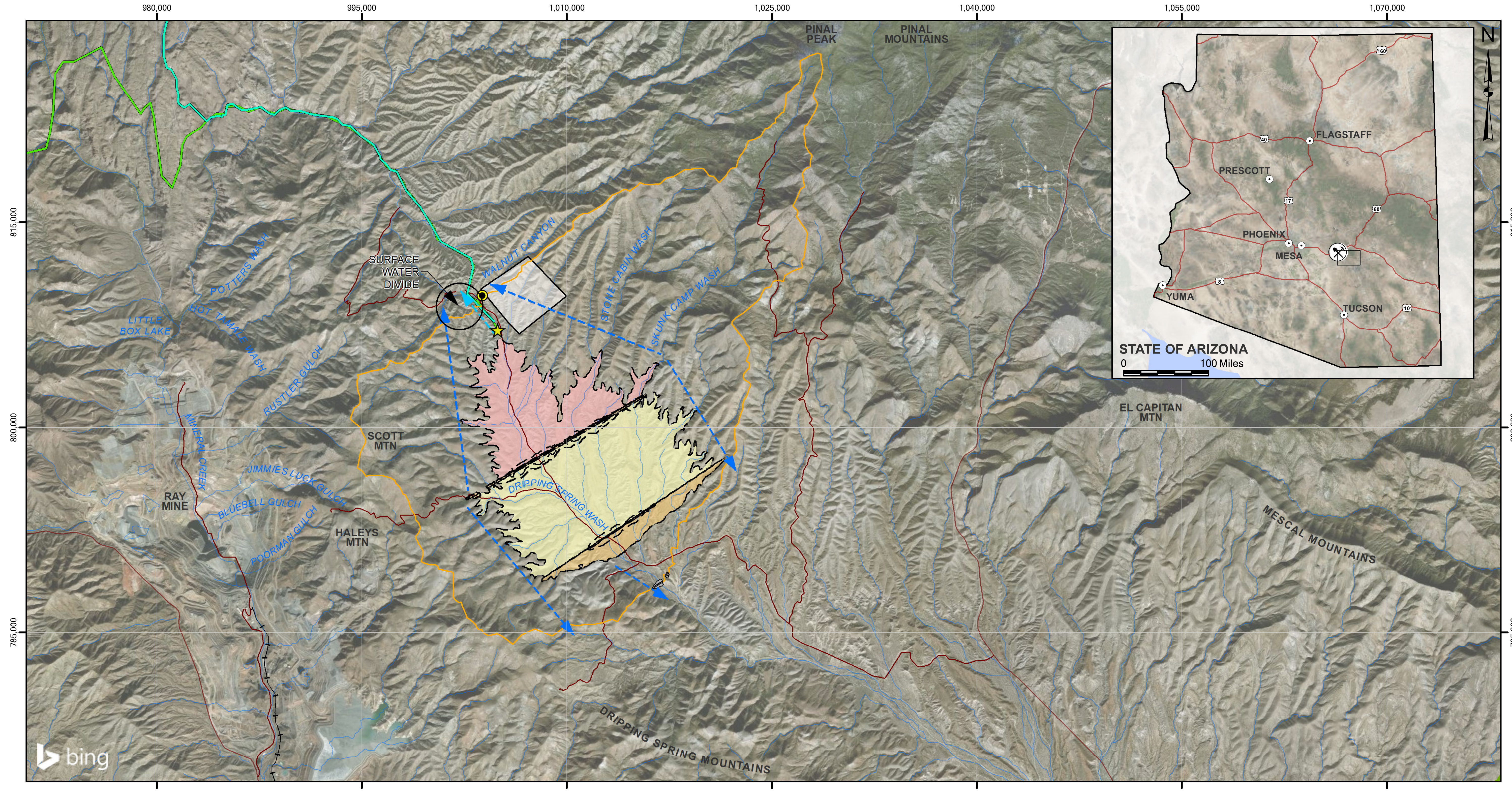
The Skunk Camp TSF site is in the Dripping Springs Wash Basin (refer to Figure 2.1), approximately 13 miles upstream of its confluence with the Gila River. The Dripping Springs Wash Basin is approximately 378 square miles in area and is described by the Arizona Department of Water Resources (2009) as consisting of a mid-elevation mountain range and Arizona uplands Sonoran desert scrub.

The Dripping Spring Mountains define the western boundary of the site, and the Mescal Mountains and Pinal Mountains define the eastern boundary. The base elevation of the TSF is approximately 3,160 ft and the peaks of adjacent mountains are (Figure 2.1): 4,566 fasl at Haley Mountain, 6,568 ft at El Capitan Mountain, and 7,848 fasl at Pinal Peak.

The site is within the Basin and Range physiographic zone of Arizona, near its northern boundary with the Central Highlands Transition physiographic zone, marked by the southern edge of the Superstition Mountains (URS 2013). The site location, relative to West Plant, is shown on Figure 1.1.

The Basin and Range mountain ranges are composed of fault-block mountains formed during extensional faulting and crustal thinning. The Central Highlands Transition zone is a northwest trending escarpment marking the transition from the Colorado Plateau to the north with the Basin and Range province to the south (see Figure 2.3).

Within the proposed TSF area, the base of the valleys are infilled with sand and gravel alluvial deposits and are ephemeral drainages. When present, surface water flows from north to south, discharging to the Gila River, approximately 13 miles downstream of the site. The proposed site is located south of a surface water divide, see Figure 2.1. Surface water south of the divide flows through the site, roughly southeast through Dripping Springs Wash Basin to the Gila River, whereas surface water north of the divide flows into the Mineral Creek basin, which flows into the Gila River approximately 16 miles downstream.



LEGEND

- ALTERNATIVE 8: SKUNK CAMP
- NPAG TAILINGS BEACH
- PAG TAILINGS CELL
- CYCLONED SAND EMBANKMENT AND SPLITTER BERM
- SEEPAGE COLLECTION DAM
- FACILITIES
- DIVERSION
- CLOSURE SPILLWAY
- TSF - WEST PLANT PIPELINE CORRIDOR NORTH ROUTE
- TSF - WEST PLANT PIPELINE CORRIDOR SOUTH ROUTE
- TSF CATCHMENT
- CYCLONE HOUSE AND PIPELINE CORRIDOR TIE-IN POINT
- PIPELINE END POINT
- ROAD
- RAILWAY
- RIVER OR MAJOR DRAINAGE

0 2 Mile

NOTES:
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PROJECT
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ALTERNATIVE 8: SKUNK CAMP PORTFOLIO

TITLE
SITE LOCATION DETAILS

PROJECT No. M09441A20

FIG No. 2.1

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2.2 Land Use

The site is outside of the Arizona Department of Water Resources Aquifer Management Areas, on a mixture of State Trust and Private Land. Other aspects of the Skunk Camp TSF site, with respect to land-use, include (See Figure 2.1 and Figure 2.2):

- The area is currently used for livestock grazing, ranching and road access to recreational areas. Vegetation comprises mainly desert shrub and cacti.
- Access within the site is by compacted gravel roads, accessed from Highway 77, located southeast of the area.
- Within the proposed footprint, and immediately downstream of the proposed site, there are a few ranch properties which include permanent dwellings. The nearest residential area is located along Highway 77 near Christmas, near the confluence of Dripping Spring Wash with the Gila River approximately 11 miles downstream of the proposed TSF.
- There are no known historic mines within the TSF footprint, but there are known historic and active mining in the region. There is potential for interactions between the sites:
    - **Ray Mine**, 5 miles to the west of the proposed Skunk Camp TSF area (over the Dripping Spring Mountains), is an active open pit copper mine currently owned and operated by ASARCO Grupo Mexico (see Figure 2.2).
    - **Troy Mine,** 5.4 miles to the south of the proposed Skunk Camp area (within the Dripping Spring Mountain Range), is an inactive underground copper / base metals mine currently optioned by Q-Gold Resources, and actively undergoing exploration activities (see Figure 2.2).
    - **Dripping Spring Mine,** 6.0 miles to the south-southeast of the proposed Skunk Camp area (within the Dripping Spring Mountain Range), is a closed polymetallic underground and open pit mine which operated from 1925 to 1995 (see Figure 2.2). Workings at the site reached shallow depths of 50 to 75 feet. Adjacent historic workings include C & B Mine and Cowboy Mine, both inactive underground workings.
    - **Christmas Mine**, 14.8 miles to the southeast of the proposed Skunk Camp area, is a closed underground and open pit copper mine, which closed in 1992. The property is currently owned by Freeport McMoRan. A number of historic mine workings are also identified in the area around Christmas Mine.
- In addition to the mines noted above, other unidentified mine workings may be present in the region and would be further investigated. The proposed TSF would be founded on a deep Gila Conglomerate deposit, which is not typically mined.

2.3 Regional Geology

The regional basement in the area of the Skunk Camp TSF site are facies of the Precambrian Pinal Schist. The schist is overlain by the younger Precambrian Apache Group, comprising the silt and sandstones of the Pioneer Formation, Dripping Spring Quartzite, Mescal Limestone and basalt, and the Troy Quartzite. The Precambrian rocks are in turn overlain by Paleozoic sedimentary rocks, including the Bolsa Quartzite and Martin, Escabrosa and Naco limestones. All of the Precambrian rocks are intruded by Precambrian diabase dykes and sills, and the entire sequence is intruded by Late Cretaceous and Tertiary dikes and plutons. Tertiary tuffs and conglomerates were deposited over the older rocks in the region (Cornwall et al. 1971).

The pre-Tertiary rocks in the region have been intricately deformed, mostly by tilting and faulting, with most faults dipping steeply, indicating normal movement. Normal faulting has produced graben features with stratigraphic displacements in excess of 2,000 ft. Dripping Spring Wash runs through one such graben which is infilled with a thick package of Tertiary (Gila) Conglomerate (Cornwall et al. 1971). There is little mapped evidence of faulting within the Tertiary sedimentary rocks.

2.4 Site Geology

Data on the regional geology is available from Dickinson (1992), Cornwall et al. (1971) and Cornwall and Krieger (1978). As discussed in Section 1.3, supplementary data from the Near West site characterization reports have been adopted for this assessment. The bedrock geology of the Near West and Skunk Camp TSF sites generally comprises similar rock units.

Where available, well log information has also been reviewed, to aid in estimating the thickness of Gila Conglomerate present within the basin, and preliminary site reconnaissance visits have been carried out by RC and KCB staff. A single well log, for a location near to the proposed scavenger embankment toe, notes that the Gila Conglomerate at that location as over 1,500 ft thick.

2.4.1 Foundation Geology

As noted in Section 2.4, the regional basement rock at site is the Precambrian Pinal Schist, unconformably overlain by Younger Precambrian Apache Group rocks (Dripping Spring Quartzite, Mescal Limestone) and diabase. Tertiary age Gila Conglomerate, which overlays the diabase, forms the majority of the foundation for the proposed facility. Quaternary pediment and alluvium has formed erosion surfaces, ridges, and valley infill deposits, within the region.

The proposed TSF would be founded primarily on Tertiary Gila Conglomerate, partially covered by Quaternary deposits, including alluvium in the base of the major valleys, and pediment along local ridges, as well as occasional travertine deposits in various valley walls.

Based on topography and regional geology maps, surface water diversion channels would be excavated into Gila Conglomerate, quartzite and diabase. Based on current knowledge, the main design considerations for this foundation are:

- removal of Quaternary deposits from embankment footprints as part of foundation preparation or borrow activities;
- potential for reduced foundation strength resulting from Gila Conglomerate saturation; and
- groundwater flowpaths.

Preliminary field reconnaissance suggests that the Gila Conglomerate at the Skunk Camp TSF site is coarser grained than the Gila Conglomerate reviewed at Near West. However, in the absence of site specific characterization, the following general characterization of the unit from Near West is included in this report for context:

- Gila Conglomerate at Near West has an average unconfined compressive strength (UCS) of roughly 1800 psi, classifying as a very weak to weak rock. This strength is significantly higher than that of the tailings and does not impact the stability of the TSF.
- Gila Conglomerate at Near West has been observed to lose strength when saturated. Reduced shear strength ($\phi' = 26°$) was assigned to the upper 10 ft of Gila Conglomerate for the Near West DEIS designs to account for this potential. Stability assessments completed for the Near West site are assumed to be applicable for the Skunk Camp TSF site until more information is available.
- Hydraulic conductivity of the Gila Conglomerate at the Near West site varies widely between 1×10^{-2} cm/s to 1×10^{-8} cm/s (based on packer testing) with the higher values being associated with localized discontinuities. Hydraulic conductivities in the middle of this range were assumed for the analyses completed to support the Skunk Camp DEIS: 1×10^{-4} cm/s for weathered Gila at surface; and 1×10^{-5} cm/s for deeper Gila.

The proposed surface water management system will consist of a series of diversion channels, and associated diversion dams and ponds located to route non-contact water around the TSF. Although the alignments of the proposed channels and locations of proposed dams and ponds are not yet finalized, regional geology information indicate that these features will be founded on three major geologic units, namely:

- Gila Conglomerate;
- Diabase; and
- Troy Quartzite.

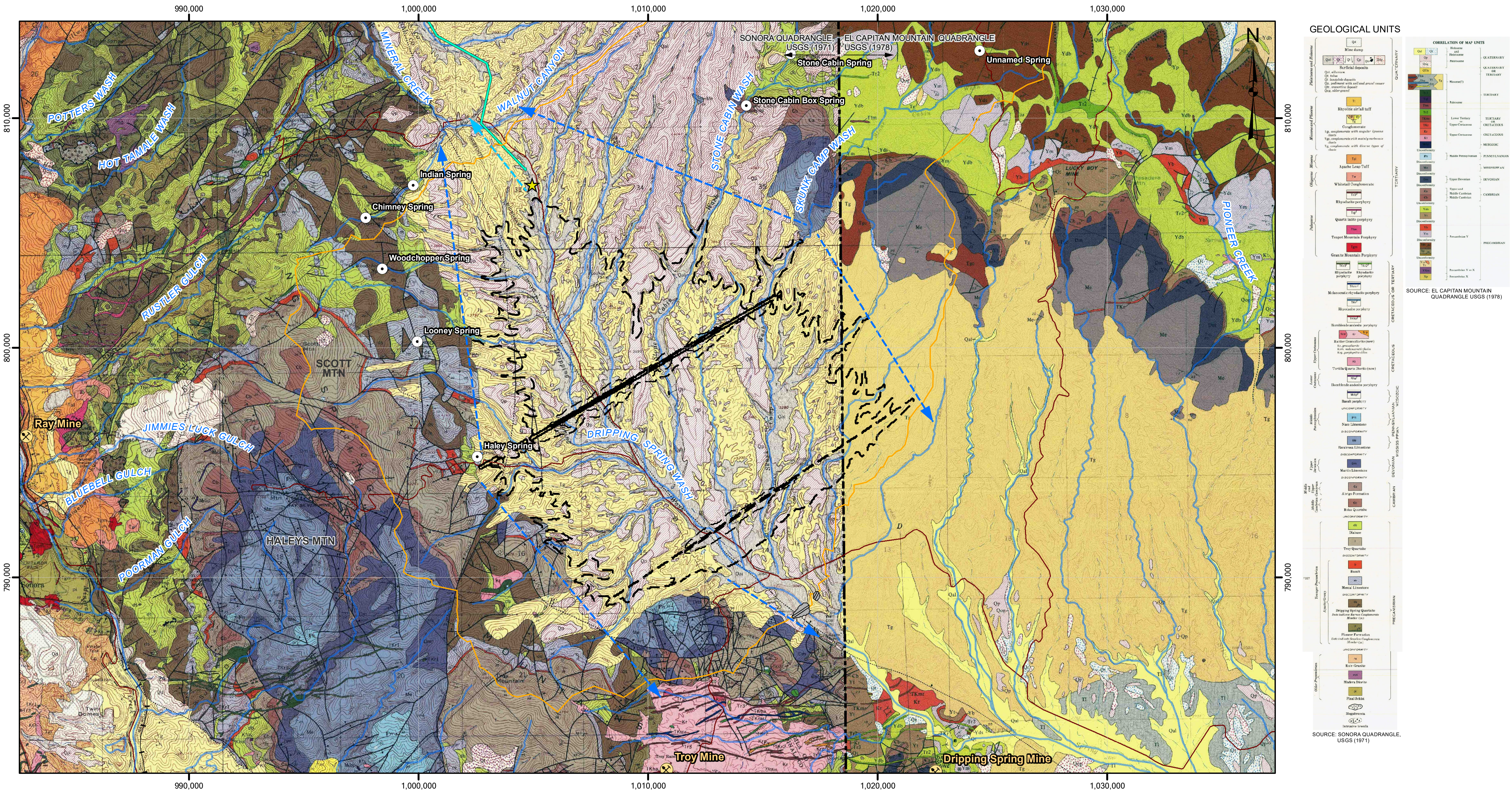
Specific requirements with respect to excavation and foundation preparation for the surface water management system need to be investigated further.

2.4.2 Faults

Along the proposed centerline of the impoundment is a north-trending normal fault, aligned roughly along Dripping Spring Wash. The fault is noted in literature as having a stratigraphic displacement of more than 2,900 ft, east side down (Cornwall et al. 1971).

To the west of the proposed impoundment, the Ransome Fault, and associated sub-faults, separate the Tertiary and Quaternary geologic units from the Dripping Spring Quartzite, Mescal Limestone, and Rhyodacite Porphyry.

These faults are not considered to be potential sources of seismicity, as they are not thought to have been active throughout the Quaternary Period (LCI 2017). It is not known at this time whether these faults act as preferential flow paths, or low permeability boundaries, for groundwater flows.



LEGEND

- ALTERNATIVE 8: SKUNK CAMP
- SEEPAGE COLLECTION DAM
- SPRING
- LOCAL MINES
- CYCLONE HOUSE AND PIPELINE CORRIDOR TIE-IN POINT
- DIVERSION
- CLOSURE SPILLWAY
- TSF CATCHMENT
- TSF - WEST PLANT PIPELINE CORRIDOR
- ROAD
- RAILWAY
- RIVER OR MAJOR DRAINAGE

NOTES:
1. NAD83, ARIZONA STATE PLANE CENTRAL
2. REFER TO REPORT FOR SOURCE OF GEOLOGY

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PROJECT: RESOLUTION COPPER PROJECT ALTERNATIVE 8: SKUNK CAMP PORTFOLIO

TITLE: SITE GEOLOGY

PROJECT No. M09441A20

FIG No. 2.2

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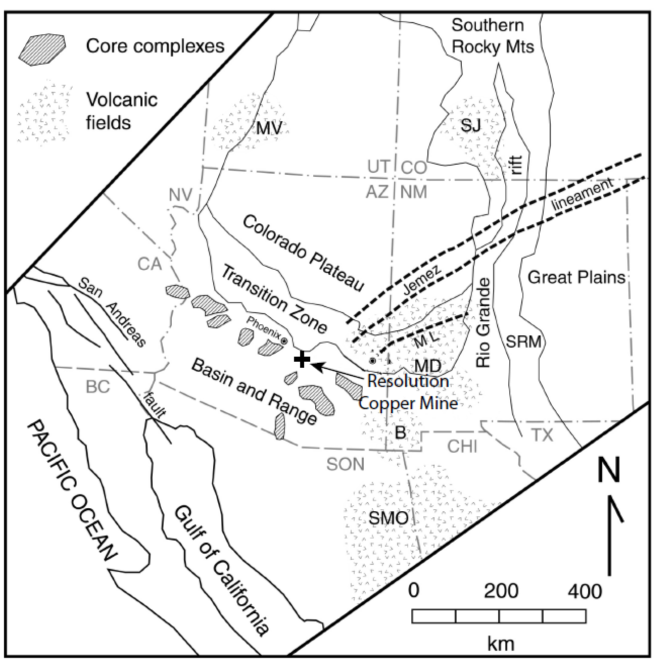
2.5 Seismicity

The Skunk Camp TSF site is 19 miles away from the Near West site and for the purposes of this assessment is assumed to have a similar seismic hazard to the Near West “Gila Conglomerate” from LCI (2017). The Near West site has low historic seismicity (LCI 2017); 16 earthquakes within 62 mi (100 km) and 51 earthquakes within 124 mi (200 km) are part of the seismic record that dates back to 1830. Only two of the recorded earthquakes have had a moment magnitude greater than 5, both in excess of 62 mi (100 km) of the site. None of the recorded earthquakes have had a moment magnitude greater than 6.

The site-specific seismic hazard assessment completed for Near West calculated the peak ground acceleration (PGA) and spectral acceleration at return periods up to 10,000 years, and provided both uniform hazard spectra (UHS) and conditional mean spectra (CMS). The results indicated that the hazard from short period ground motions is controlled by the background seismicity (seismicity not associated with known faults) close to the site, whereas the distant San Andreas Fault influences the hazard for longer periods which are typical for most large earthfill structures.

The Skunk Camp TSF site sits across the mapped Dripping Spring and Ransome Faults. These faults are not believed to have been active within the Quaternary period (2.6 Ma to present) (LCI 2017). The Skunk Camp TSF site is closer in proximity to the Quaternary active faults which may result in slight increases to the short period seismic loads at the Near West site.

Figure 2.3 Regional Seismic Zone (URS 2013)



Modified from: Drewes *et al.* (1985)

2.6 Site Hydrogeology

A conceptual understanding of the hydrogeological setting has been developed based on a desktop review of available literature.

Regional groundwater is assumed to flow from northwest to southeast within the proposed TSF area towards the Gila River. The groundwater flow from surface infiltration near the site is expected to be primarily through the surface alluvial channels and upper weather zone of the Gila Conglomerate. Alluvium is the principal aquifer for wells within the region (ADWR 2009), noted in literature as being less than 150 ft thick. Recent measurements of depth to groundwater (at one location) within the alluvium and Gila Conglomerate, undertaken by RC, suggest that groundwater levels are approximately 70 ft below the ground surface, or deeper, along the eastern edge of the site.

Several identified, regional features and local observations that may also affect the regional groundwater flow and potential TSF seepage within the basin, include:

- The Gila Conglomerate, which forms the foundation of the proposed facility, is variable across the site, and has been noted to be less cemented at surface than the Gila Conglomerate observed at the Near West site, particularly in areas towards the north of the site (see Figure 2.3).
- The highland areas of Dripping Springs Wash Basin, including Pinal Peak, which form a large portion of the upstream catchment are anticipated to be areas of high groundwater recharge for the region (see Figure 2.1).
- The surface water divide between Dripping Springs Wash and Mineral Creek is also a potential groundwater divide.
- Downstream of the site, the Gila River, which flows year-round, acts as the regional drainage point. The river and channel deposits are assumed to be a discharge point for surface and groundwater runoff from the surrounding areas, including the Dripping Springs Wash Basin.
- The Ray Mine open pit, located in a western, adjacent surface water catchment, is a potential regional groundwater sink as a result of dewatering activities; however, it is not clear if the groundwater regimes at the proposed site and the open pit are hydraulically connected or not (e.g. faults and associated bedrock units act as a low permeability boundary between the sites).

Based on this understanding of the hydrogeological setting for the proposed TSF, the assumption for the hydrogeological conceptualization are:

- that the alluvium is the major pathway for groundwater flow, and acts as the primary aquifer in the region;
- that the Gila Conglomerate at depth is relatively low permeability compared to the 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 and that no groundwater flows north across the catchment divide to Mineral Creek; and
- groundwater flow from the catchment to the east of the facility, Pinal Peak, 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.

2.7 Climate and Hydrology

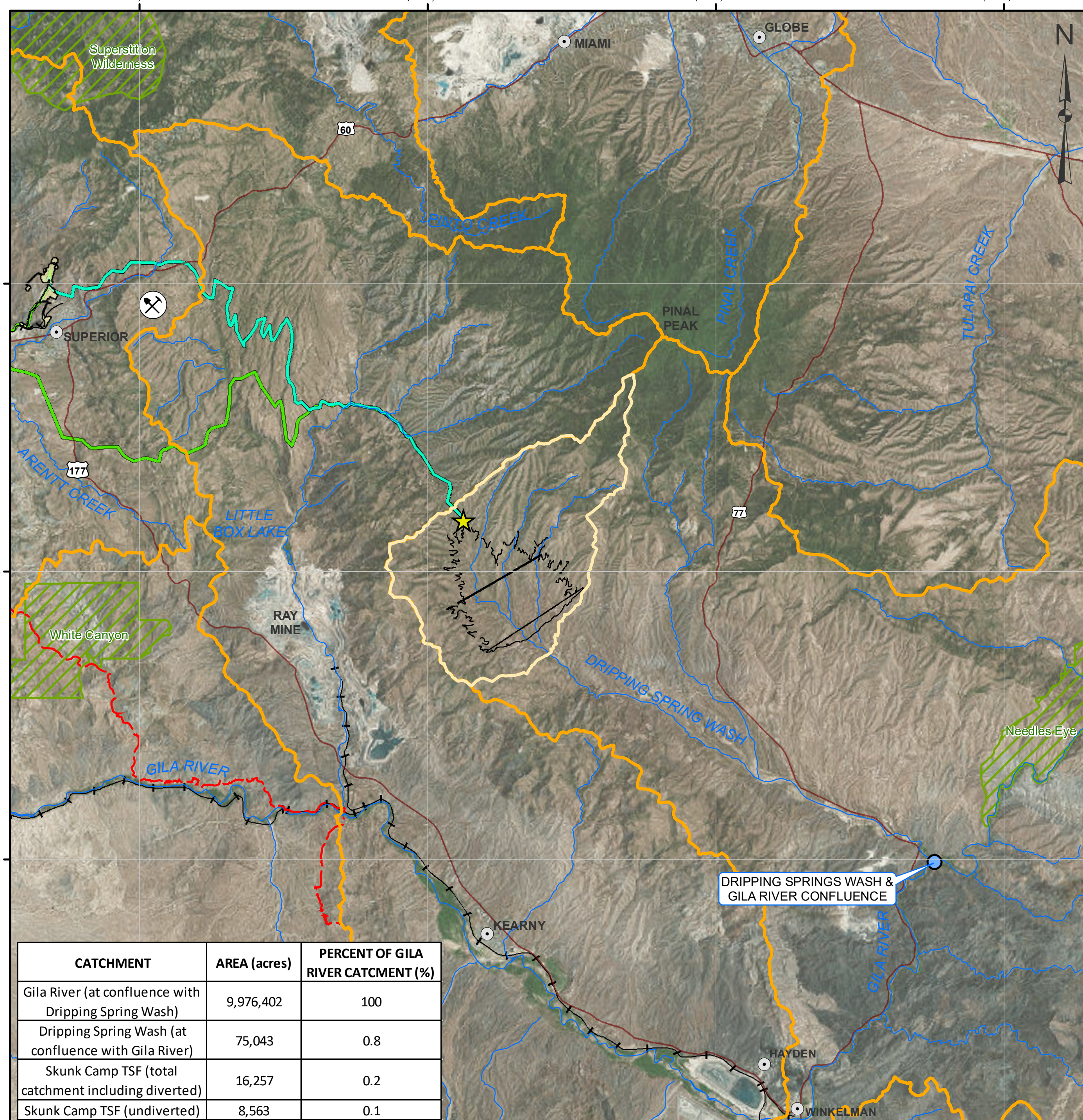
The Skunk Camp TSF site is within a semi-arid climate zone with low average annual precipitation (19 inches to 20 inches) and high estimated average annual potential evapotranspiration, or PET (estimated to be 72 inches, similar to the Near West site). The average temperature range is between an average minimum of 46^{o}F and an average maximum of 87^{o}F.

The region experiences three seasonable types of precipitation events:

- Winter storms that occur during October through March. These are typically long duration, low intensity events.
- Summer monsoonal storms that occur during June through September. These are typically short duration, high intensity thunderstorms, and are common throughout the monsoon season.
- Tropical storms that occur during August through October. These are rare events but produce the most extreme rainfalls in southern Arizona. They are the dying remnants of oceanic storms and typhoons and are typically moderate duration (~24 hours), high intensity events.

Storm event depths were taken from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 and Applied Water Associates (AWA) Probable Maximum Precipitation (PMP) estimator. The climate and design storm details are included in the design basis memorandum (DBM) in Appendix I.

In its current state, drainage at the site occurs through a series of valleys (or canyons) that report to Dripping Spring Wash, which reports to the Gila River. The drainage valleys located within the Skunk Camp area are ephemeral streams that are typically dry. A number of springs are located to the west of the proposed site, with limited to no associated typical flows. The surface water catchments, and their relation to the Gila River catchment, is shown on Figure 2.4.



CATCHMENT	AREA (acres)	PERCENT OF GILA RIVER CATCMENT (%)
Gila River (at confluence with Dripping Spring Wash)	9,976,402	100
Dripping Spring Wash (at confluence with Gila River)	75,043	0.8
Skunk Camp TSF (total catchment including diverted)	16,257	0.2
Skunk Camp TSF (undiverted)	8,563	0.1

LEGEND

- ALTERNATIVE 8: SKUNK CAMP
- TSF - WEST PLANT PIPELINE CORRIDOR NORTH ROUTE
- TSF - WEST PLANT PIPELINE CORRIDOR SOUTH ROUTE
- RESOLUTION OREBODY
- CYCLONE HOUSE AND PIPELINE CORRIDOR TIE-IN POINT
- WEST PLANT
- TSF CATCHMENT
- WATERSHED
- WILDERNESS AREA OR STATE PARK
- TOWN OR CITY
- ARIZONA NATIONAL SCENIC TRAIL (ARIZONA TRAIL)
- ROAD
- RAILWAY
- RIVER OR MAJOR DRAINAGE

NOTES:
1. NAD83, ARIZONA STATE PLANE CENTRAL
2. IMAGERY PROVIDED BY ESRI/BING AERIAL IMAGERY.

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PROJECT
RESOLUTION COPPER PROJECT
ALTERNATIVE 8: SKUNK CAMP PORTFOLIO

TITLE
SURFACE WATER CATCHMENTS

PROJECT No. M09441A20

FIG No. 2.4

3 TAILINGS CHARACTERIZATION

3.1 Tailings Types

The Resolution project will generate two physically, mineralogically and geochemically discrete tailings streams known as scavenger tailings and pyrite tailings; scavenger tailings will account for approximately 84% of tailings produced by weight and pyrite tailings the remaining 16%.

KCB (2018) has summarized the existing geotechnical laboratory testing data for the tailings and geotechnical characterization for the DEIS design.

Duke HydroChem (2016 and 2017b) summarized the tailings geochemical laboratory data and characterization for the DEIS design (Duke Hydrochem 2016 and 2017b).

3.2 Geochemical

The scavenger tailings contain a low percentage of pyrite (with a mean sulfide content of less than 0.1% by weight) and low neutralization potential. Additionally, the release of acidity, sulfate and metal/metalloids from the scavenger tailings is limited by the very low sulfide and residual metal contents (Duke HydroChem 2016).

The pyrite tailings contain a much higher percentage of pyrite (>20% by weight) and are classified as PAG (Duke HydroChem 2016). The pyrite tailings' specific gravity ranges from 3.23 to 4.33, with an average of 3.87, which reflects the variability in high-density pyrite content of the samples.

3.3 Geotechnical

Geotechnical properties of the tailings for the DEIS were characterized based on laboratory testing, literature review and comparison with similar projects, refer to Table 3.1 and Table 3.2. Key comments regarding the tailings geotechnical characterization are as follows:

- Index properties and behaviors (particle size distributions, plasticity, specific gravity, consolidation behavior, and hydraulic conductivity) of the pyrite tailings and scavenger "total" tailings were measured in the laboratory. The same suite of testing was performed on the scavenger "beach" and scavenger overflow tailings, except for consolidation.
- Properties of the cycloned sand and cyclone overflow were estimated from numerical cyclone simulations, pilot-scale cyclone tests, and comparison of scavenger and pyrite tailings index properties with those at other sites.
- The scavenger beach "composite" is not a discrete tailings type, rather an interlayered deposit of scavenger tailings and cyclone overflow that will form the tailings beach. Properties of the composite beach were guided by the characterization of the other tailings types, with consideration for the method of deposition and experience on other projects.
- Shear strength values were estimated based on similar materials at other mines including Bingham Canyon Mine (Kennecott), Pinto Valley Operations and a literature review.

- Average consolidated tailings densities for slurry tailings were selected based on large-strain consolidation testing and KCB experience on similar projects.
- The compacted density of cycloned sand was estimated using the specific gravity of the tailings and a typical void ratio for compacted sand with a similar gradation.

Further details on tailings characterization and engineering design property selection are reported in KCB (2018).

Ranges or “base case” values for engineering design properties based on laboratory testing and case histories are summarized in Table 3.1. Ranges of values selected for hydrogeological properties are summarized in Table 3.2. Engineering properties have been selected from available characterization data.

Table 3.1 Summary of Tailings Engineering Properties used in Design Assessments

<table>
<tr><th rowspan="2">Material</th><th rowspan="2">Specific Gravity[1]</th><th rowspan="2">Atterberg Limits[1,4]</th><th rowspan="2">USCS Class</th><th colspan="2">Particle Size Distribution[2]</th><th rowspan="2">Deposition Method</th><th rowspan="2">Dry Unit Weight for Tailings Staging (pcf)[3]</th><th rowspan="2">Effective Friction Angle (ϕ')</th><th rowspan="2">Peak Undrained Shear Strength Ratio (Su-p/σ'v)</th><th rowspan="2">Liquefied Undrained Shear Strength Ratio (Su-LIQ/σ'v)</th></tr>
<tr><th>% fines <74 micron</th><th>% clay <2 micron</th></tr>
<tr><td>Pyrite Tailings</td><td>3.87</td><td>LL: 18%
PI: 3%</td><td>ML</td><td>80</td><td><20</td><td>Subaqueous deposition at 50% solids content</td><td>106</td><td>27°</td><td>0.2</td><td>0.05</td></tr>
<tr><td>Scavenger “Total” Tailings</td><td rowspan="6">2.78</td><td rowspan="6">LL: 20%
PI: 1%</td><td>ML</td><td>50</td><td><10</td><td rowspan="3">Subaerial deposition at 60% solids content</td><td rowspan="2">87</td><td rowspan="5">32°</td><td rowspan="5">0.25</td><td rowspan="5">0.1
(base case);
0.05
(sensitivity)</td></tr>
<tr><td>Scavenger “Beach” Tailings</td><td>SM</td><td>25</td><td>2</td></tr>
<tr><td>Scavenger “Fines” Tailings</td><td>ML</td><td>94</td><td>7</td><td rowspan="3">81</td></tr>
<tr><td>Cyclone Overflow</td><td>ML</td><td>90</td><td>15</td><td>Subaerial deposition at 60% solids content</td></tr>
<tr><td>Scavenger Beach “Composite”</td><td>-</td><td>-</td><td>-</td><td>Mixture of spigotted scavenger tailings and cyclone overflow</td></tr>
<tr><td>Cycloned Sand</td><td>SP-SM</td><td><20</td><td>0</td><td>Discharged to hydraulic cells at 60% solids content and compacted</td><td>113</td><td>34°</td><td>N/A</td><td>N/A</td></tr>
</table>

Notes:
1. Represent averages from the tailings tested or cyclone numerical simulations.
2. “Beach” and “Fines” values directly measured from laboratory testing. For rationale behind values selected for other materials refer to the DBM (Appendix I)
3. For long-term, consolidated dry density estimates to be used in other analyses, refer to Appendix II.
4. LL = Liquid Limit; PI = Plasticity Index.
5. Su-p = peak undrained strength; Su-LIQ = liquefied undrained strength; and σ'v = vertical effective stress.

Table 3.2 Summary of Engineering Hydraulic Parameters

Material	Horizontal Saturated Hydraulic Conductivity k_h (cm/s)	Anisotropy Ratio k_h/k_v	Total Porosity n_{total}	Effective Porosity $n_{effective}$	Specific Yield S_y
Pyrite Tailings	1×10^{-6} to 1×10^{-7}	1 to 10	0.40 to 0.50	0.25 to 0.50	0.20 to 0.30
Scavenger “Total” Tailings	5×10^{-5} to 5×10^{-6}	1 to 10	0.30 to 0.40	0.25 to 0.40	0.20 to 0.30
Scavenger “Beach” Tailings	5×10^{-4} to 5×10^{-5}	1 to 10	0.30 to 0.40	0.25 to 0.40	0.25 to 0.35
Scavenger “Fines” Tailings	1×10^{-6} to 1×10^{-7}	1 to 10	0.40 to 0.50	0.25 to 0.50	0.20 to 0.30
Scavenger Beach “Composite”	5×10^{-5} to 5×10^{-6}	10 to 100	0.40 to 0.50	0.25 to 0.50	0.20 to 0.30
Cyclone Overflow	1×10^{-6} to 1×10^{-7}	1 to 10	0.40 to 0.50	0.25 to 0.50	0.20 to 0.30
Cycloned Sand	5×10^{-2} to 1×10^{-3}	1 to 10	0.30	0.30	0.30

3.4 Tailings Deposition Slopes

Tailings deposition slopes are a function of particle size distribution, percent solids of discharged slurry, specific gravity, spigot design/arrangement, distance from deposition point and whether tailings will be deposited subaerially or sub aqueously. Slopes should be monitored regularly during operations and the tailings deposition plan adjusted as required. Deposition slopes for discharged slurry tailings adopted for deposition modeling are summarized in Table 3.3. They were chosen based on review of case history data from operating cycloned sand tailings impoundments and subaqueous pyrite tailings facilities.

Table 3.3 Tailings Slopes

Tailings Type	Tailings Slopes	Justification
Scavenger Beach "Composite"	Above Water: 1% for the first 1,500 ft, 0.5% after 1,500 ft Below Water: not applicable for Alternative 8	Based on topography and bathymetry surveys from two large, cycloned sand impoundment beaches and slopes below water.
Pyrite Tailings	Below Water: 10.0% for the first 100 ft, 0.5% after 100 ft	Based on topography and bathymetry surveys of subaqueous disposal of high-pyrite tailings from floating barges.

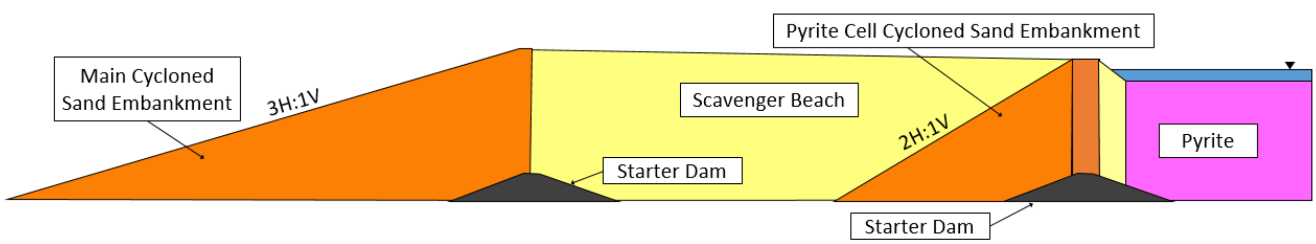
4 DESIGN BASIS

4.1 General

The DBM, refer to Appendix I, was developed with input and agreement from RC. A summary of key design basis and objectives are outlined below; however, the DBM (Appendix I) should be referenced for further details.

- The pyrite tailings are to be deposited subaqueously from a floating barge into a pond with low-permeability layers so they can remain saturated throughout operations. This is done to reduce potential for acid rock drainage (ARD) and metal leaching (ML) that can be triggered by pyrite tailings exposure to water and oxygen (Duke 2017b).
- For stability analysis, all potentially liquefiable contractive tailings are assumed to liquefy regardless of the triggering mechanism.
- The design cross-section for the perimeter embankment includes an outer compacted cycloned sand structural zone that is raised using a centerline approach (Figure 4.1).
- The downstream slope of the cycloned sand embankment was set to 3H:1V based on the results of stability analyses (KCB 2017a). Localized flattening or excavation of potentially weak foundation layers, may be required to meet stability criteria in all areas.

Figure 4.1 Schematic Section of Proposed Facility



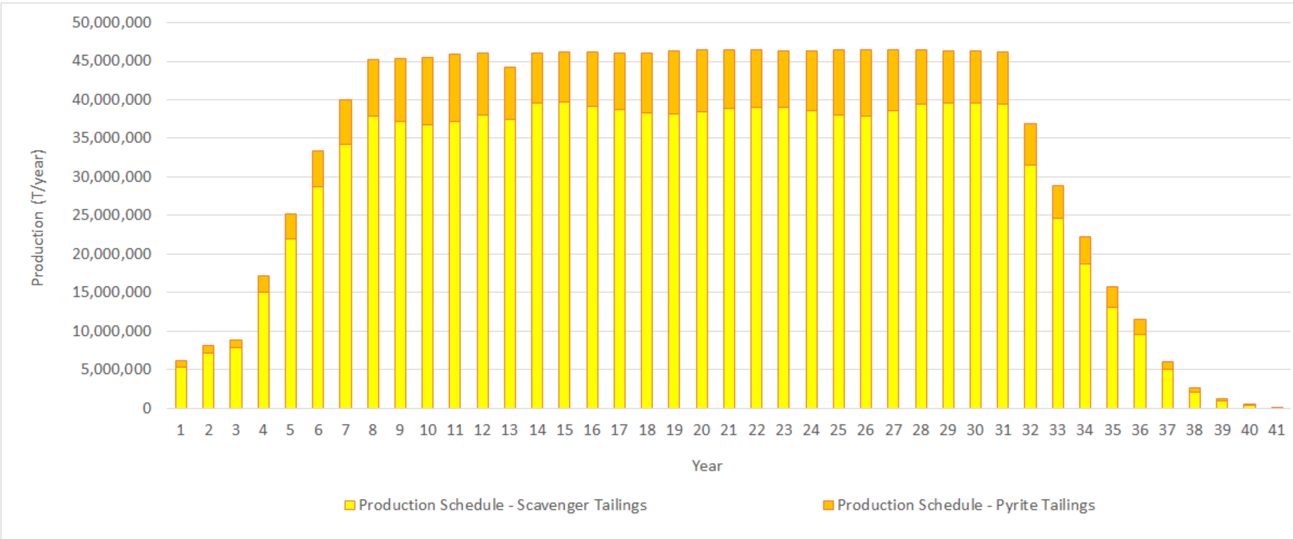
4.2 Tailings Production Rate

The tailings production schedule is summarized in Table 4.1 and illustrated on Figure 4.2.

Table 4.1 Production Schedule Summary

Item	Production Schedule
	DEIS
NPAG Scavenger Tailings	1,151 Mtons
PAG Pyrite Tailings	220 Mtons
Total Tailings (Scavenger and Pyrite)	1,371 Mtons
Percentage of Pyrite Tailings by Mass	16%
Number of Production Years	41

Figure 4.2 Annual Tailings Production Schedule



4.3 BADCT Approach

The TSF would apply for an Aquifer Protection Permit (APP) with an “individual” Best Available Demonstrated Control Technology (BADCT) approach, which is performance based, and allows the applicant to select from all available Demonstrated Control Technologies (DCTs) that constitute BADCT. This process considers site specific characteristics, operational controls, and other DCTs.

Under the individual BADCT approach, the TSF is considered a “tailings impoundment” and will be designed in accordance with Section 3.5 of the BADCT manual (ADEQ 2005). The seepage dams are considered to be “surface ponds” and will be designed in accordance with Section 3.6 of the BADCT manual (ADEQ 2005) and the regulations pertaining to water dams (A.A.C. R12-15).

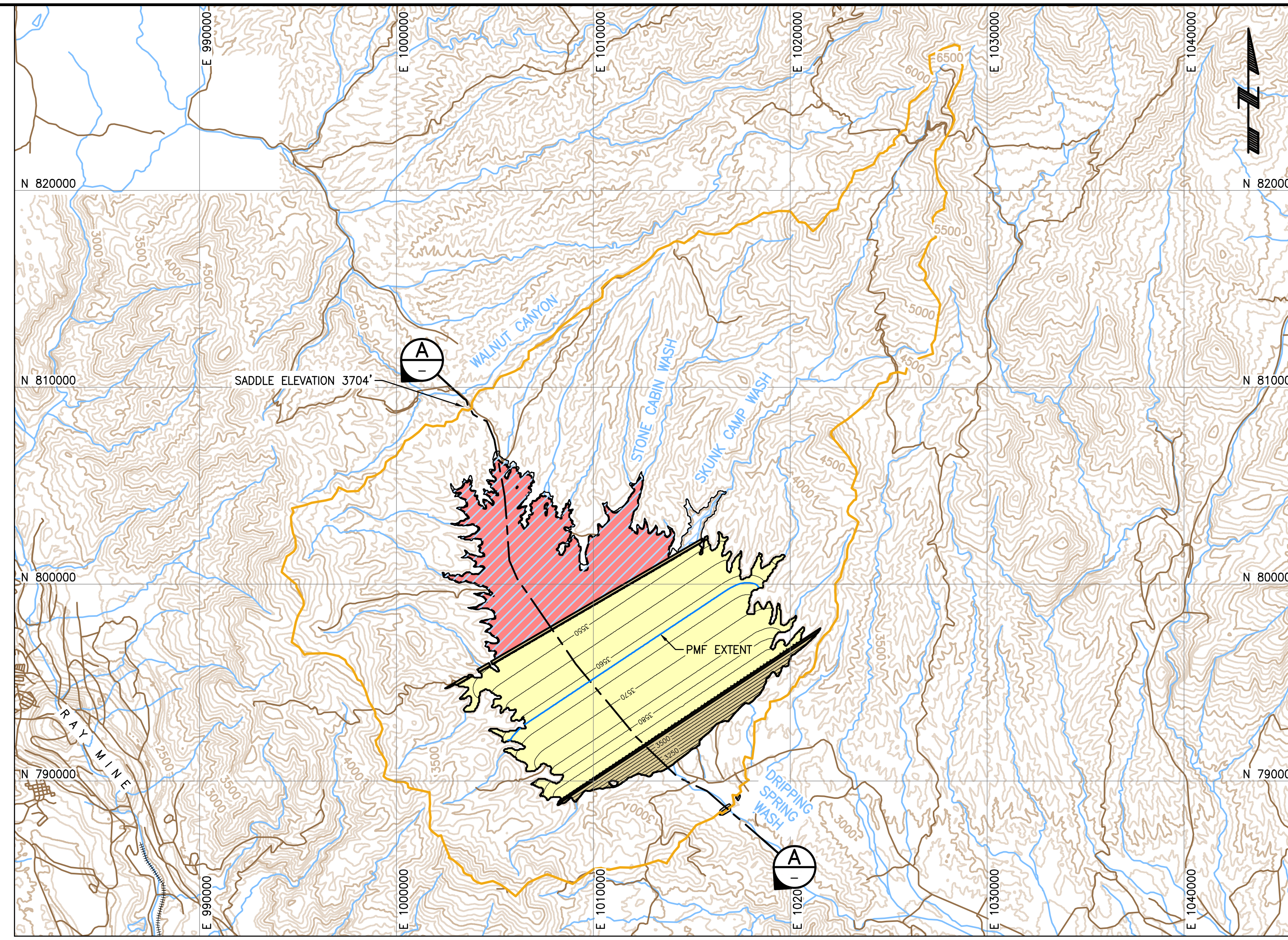
5 TAILINGS MANAGEMENT PLAN

5.1 TSF Features

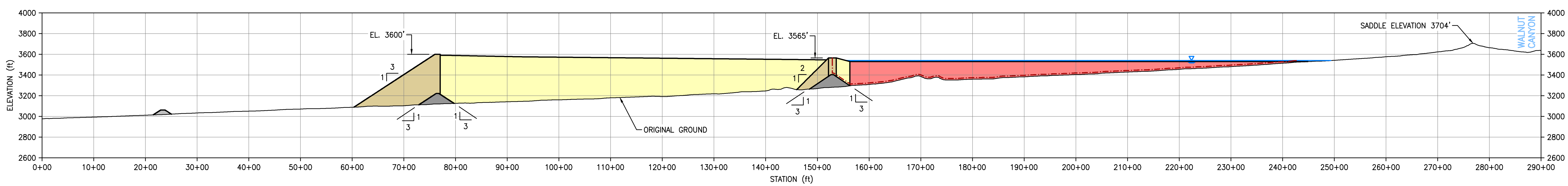
Key features of the TSF during start-up and operations include the following:

- General fill borrow area within the Gila Conglomerate and rock quarries (quartzite and diabase) developed within and near to the TSF footprint to source fill and erosion protection materials.
- Cross-valley, earthfill starter dams to facilitate tailings placement before the cycloned sand embankment is established.
- Segregated cell to retain pyrite tailings upstream of the scavenger beach.
- Embankment underdrain system comprised of a sand and gravel blanket drain and rockfill finger drains.
- Non-contact surface water management system, comprising upslope diversion channels and dams to divert non-contact water around the facility.
- Tailings delivery system that transports scavenger total tailings and pyrite tailings to the TSF from the West Plant for cycloning and/or deposition.
- A reclaim pond maintained within the pyrite cell to maintain pyrite tailings saturation and allow for excess water to be reclaimed to the West Plant via floating pump barge and pipeline.
- A pyrite tailings deposition barge, associated pipelines and support systems to facilitate subaqueous deposition of pyrite tailings in the segregated cell.
- A cyclone system that processes a portion of scavenger total tailings to produce cyclone underflow (cycloned sand) for embankment construction. A by-product of this operation is cyclone overflow which is thickened before being deposited into the TSF impoundment.
- Tailings thickeners located at the TSF to increase solids content of the scavenger tailings overflow prior to deposition in the TSF.
- All components of the seepage management system comprise the items listed below, refer to discussion on seepage management in Section 8:
  - A primary Seepage Collection Pond constructed in the natural valley downstream of the cycloned sand embankment.
  - A groundwater cut-off installed downstream of the Seepage Collection Pond to improve seepage collection.
  - Associated mechanical and electrical infrastructure required to return collected seepage water to either:
    - the reclaim pond located within the pyrite tailings cell, or;
    - the reclaim water tank.

The general layout and cross section of the TSF is shown on Figure 5.1.



PLAN
SCALE A



SECTION A
SCALE B

LEGEND

- SEEPAGE COLLECTION DAM
- STARTER DAMS
- CYCLONED SAND MAIN EMBANKMENT AND PYRITE CELL EMBANKMENT
- SCAVENGER TAILINGS
- PYRITE TAILINGS
- RECLAIM POND
- ENGINEERED LOW-PERMEABILITY LAYER
- EXISTING ROAD
- RAILWAY
- MAJOR NATURAL DRAINAGE
- TSF CATCHMENT BOUNDARY

NOTES

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

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SCALE A 4000 0 4000 FT

SCALE B 1000 0 1000 FT

CLIENT	PROJECT	
RESOLUTION COPPER	RESOLUTION COPPER PROJECT DEIS DESIGN FOR ALTERNATIVE 8 – SKUNK CAMP	
Klohn Crippen Berger	TITLE: ULTIMATE LAYOUT	
SCALE: AS SHOWN	PROJECT No.: M09441A20	FIG. No.: 5.1

Date: 2018-05-30 Time: 11:52 AM
Drawing File: Z:\M\VCR\M09441A20 – RES–Near West PFS–PES\400 Drawings\CAD\Alt 8 Skunk Camp\DEIS\FIG_5.1.dwg – 5.1 (jbokic)

KCB-FIG-D-L

5.2 Embankment Design

5.2.1 Overview

The scavenger and pyrite cells would be impounded by separate cross-valley starter embankments constructed of borrow material prior to plant commissioning and then raised during operations with compacted cycloned sand fill using the centerline construction approach. Key components of the design include the following:

- Cycloned sand shell to provide structural support to tailings, will require fill be placed to a specified density to achieve a dilative behavior during shear.
- Underdrain system comprising a sand and gravel blanket drain with gravel primary drains along main drainages and some extended beneath the scavenger beach to maintain a low phreatic surface in the tailings embankment, intercept and direct seepage from the impoundment and hydraulic placement to the downstream Seepage Collection Pond.

5.2.2 Downstream Embankment Slope and Stability

A 3H:1V downstream slope for the scavenger beach cycloned sand embankment is assumed which would meet slope stability criteria (Appendix I) with typical expected foundation conditions based on the preliminary stability analysis summarized in KCB (2017a). Localized flattening of the slope or excavation of potentially weak foundation layers may be required to meet stability criteria in select areas.

A 3H:1V downstream slope for the pyrite cell cycloned sand embankment is assumed. A steeper slope is assumed for this embankment which is buttressed along the toe by the rising scavenger beach.

5.3 Tailings Management Strategy

Figure 5.1 presents the proposed layout of the Skunk Camp TSF at ultimate configuration (end of mine life). The overall tailings management strategy is as follows:

- Scavenger tailings and pyrite tailings earthfill starter dams would be constructed to store tailings at start-up before the cycloned sand embankments are established. The pyrite starter cell would include a low-permeability layer and be flooded for subaqueous deposition of pyrite tailings.
- During operations, a portion of scavenger tailings would be cycloned and the coarser underflow by-product (cycloned sand) would be used as embankment fill which would be placed in hydraulic placement cells.
- Scavenger tailings cyclone overflow would be thickened at the TSF to minimize slurry bleed water and then discharged from the embankment crest. Thickening and thin-lift deposition strategy would be adopted to avoid formation of a continuous pond in the scavenger beach cell.

- Maintain a reclaim pond in the pyrite cell to allow subaqueous deposition and prevent oxidation of the pyrite tailings, refer to Section 5.4.
- Floating barge would be used to recycle excess water from the pyrite cell pond to the West Plant for ore processing.
- Raise cell embankments primarily with cycloned sand throughout operations to maintain adequate capacity for tailings and flood storage.
- Transition to a "dry-cover" facility would be made for closure to promote runoff (i.e. avoid ponding) on the tailings surface and reduce infiltration over the long-term.

The overall strategy is discussed further herein, including information regarding the supplementary structures necessary to meet project requirements.

5.4 Tailings Delivery and Process Facilities

Scavenger and pyrite tailings slurry would be thickened at the West Plant to 60% and 50% solids, respectively, and delivered to the cyclone house at the north end of the TSF site (see Figure 5.1). As discussed previously, scavenger tailings would be cycloned to produce embankment fill with the cyclone overflow being thickened at the TSF before discharge into the impoundment.

Pyrite tailings would be sent directly to a floating deposition barge for subaqueous deposition located within the pyrite cell.

The key auxiliary facilities located at the TSF site are summarized below:

- cyclone system which includes a building, slurry dilution tanks, storage tanks, pumps and cyclones;
- scavenger cyclone overflow tailings thickeners;
- electrical substation and distribution lines;
- vehicle maintenance and fueling shop;
- warehouse for spares along with outside storage areas;
- administration and locker room facilities; and
- parking facilities.

Tailings delivery and water reclaim distribution lines include:

- cycloned sand distribution pipelines to hydraulic cells for embankment construction;
- scavenger tailings ("total" tailings and cyclone overflow) distribution pipelines to the embankment crests;
- pyrite distribution pipeline to the deposition barge and/or floating pipelines; and
- return water line from the reclaim pond.

Further details on the tailings delivery and process facilities is provided in Golder (2018).

5.5 Pyrite Tailings Management

Pyrite tailings would be deposited subaqueously from a floating barge throughout operations. As discussed previously, the primary advantage of this management approach is that pyrite tailings would not oxidize which would increase the potential to impact downstream receptors.

5.6 Tailings Staging Plan

Tailings deposition strategy would comprise the following:

- Stage I – Years 0 to 2 (1% of total tailings volume)
  - Scavenger and pyrite tailings would be deposited behind their respective starter dams.
  - Slurry bleed water or runoff that collects on the scavenger beach surface would be collected in low points and pumped to the pyrite cell pond. Water from the reclaim pond in the pyrite cell is reclaimed to the cyclone house or West Plant.
  - Pyrite tailings would be deposited by a floating barge or from pipelines extended into the pyrite cell.
  - Cycloning of scavenger tailings to produce fill for the embankment crest raises.
- Stage II – Years 2 to 41 (99% of total tailings volume)
  - As Stage I, except scavenger and pyrite tailings are retained by the cycloned sand embankments.
  - Scavenger beach would continue to be maintained with no continuous pond and excess water pumped to the pyrite cell pond.
  - Excess water from the pyrite cell pond would be reclaimed back to the cyclone house or West Plant.
  - Cycloning of scavenger tailings to produce fill for the embankment crest raises.
  - Towards the end of Stage II, scavenger tailings are deposited within the TSF to cover the pyrite tailings and promote drainage towards the north (where a closure spillway would be constructed) and within the southern portion of the pyrite cell, reducing the area of pyrite tailings that would need to be covered and reclaim pond to be managed at the end of operations.

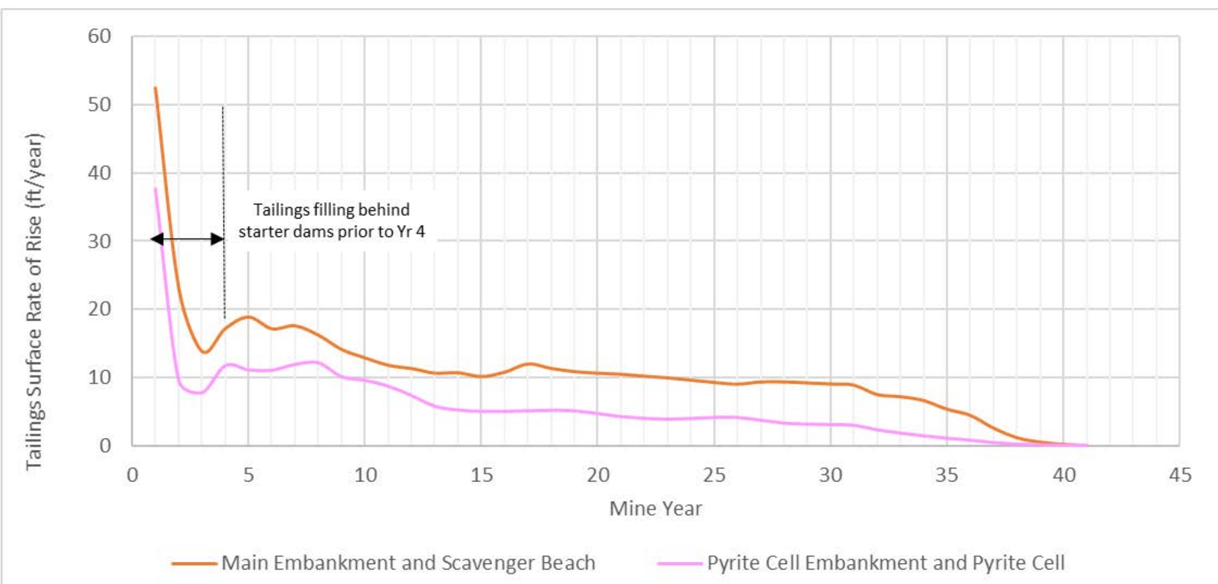
The tailings staging plan described above was modeled using the software program MUCK3D (MineBridge Software Inc., version 1.0.5). A detailed discussion on the modeling approach, key assumptions and results are summarized in Appendix II.

Key observations from the tailings deposition models include the following:

- Pyrite tailings can be deposited subaqueously at all stages to maintain saturation.

- The pyrite cell would have the capacity, above the operating pond level, to store the Probable Maximum Flood (PMF) for the pyrite cell catchment and the Environmental Design Flood (EDF) from the scavenger beach catchment. The PMF for the scavenger and pyrite cell catchments could be stored within the impoundment although the flood would inundate the scavenger beaches. At the peak flood level during the PMF, a wide beach (>400 ft) would be maintained between the pond and dam crest, assuming ultimate TSF configuration.
- The ultimate scavenger cell slope height, toe to crest (490 ft) is within precedent for this type of structure.
- The scavenger embankment and scavenger tailings beach rate of rise starts at 20 ft/yr and drops to 10 ft/yr by Year 13. (See Figure 5.2)
- The pyrite cell embankment, pyrite tailings and pyrite cell pond rate of rise starts at approximately 10 ft/yr and slowly drops to 1 ft/yr at the end of operations. (See Figure 5.2)
- The pyrite cell embankment can be constructed in horizontal lifts, and would be covered with temporary erosion protection and eventually the scavenger beach.
- The ultimate downstream slope of the scavenger embankment could start to be progressively reclaimed around Year 10 until Year 16 when it can be constructed in horizontal lifts, when the annual lift can be reclaimed shortly afterwards.

Figure 5.2 Skunk Camp Rate of Rise



6 WATER MANAGEMENT PLAN

6.1 Surface Water Management System

The objectives of the operational water management plan are to:

- divert non-contact water around the TSF to keep it separate from contact water;
- minimize water losses through tailings thickening of the scavenger tailings cyclone overflow, and maximize contact water reclaimed from the TSF to the West Plant for ore processing;
- intercept embankment toe seepage and contact surface runoff from the TSF and reclaim to either the pyrite cell pond, or the reclaim water tank;
- maintain a reclaim pond in the pyrite cell to keep pyrite tailings saturated;
- store the inflow design flood within the impoundment with adequate freeboard; and
- protect the TSF and diversion structures from excessive erosion during flood events.

The surface water management system includes the following components:

Diversions Channels

Four diversion channels would be constructed along the east and west of the TSF to intercept and route the upstream catchments around the facility. The channels would be cut into the valley slopes and generally follow the topography. To maintain a constant slope, it is anticipated that diversion dams will need to be constructed across smaller side valleys. The diversion channel general layouts are shown on Figure 5.1. They are sized to convey the peak flow from a 24-hr duration, 100-year return period storm. During higher storm events, the channels could overtop and flow would report to the TSF.

Embankment Runoff Collection Ditches

Collection ditches would be constructed along the embankment toe and at underdrain discharges to convey water to the Seepage Collection Pond.

Seepage Collection Pond

A Seepage Collection Pond would be constructed to collect seepage water from the tailings embankment underdrain system and surface runoff from the embankment slope. The location of the Seepage Collection Pond is shown on Figure 5.1.

Water from the Seepage Collection Pond would be pumped to the pyrite cell pond or the cyclone house. The design criteria for the Seepage Collection Pond sizing is included in the DBM (Appendix I). The storage capacity would have allowance for the minimum operating volume, maximum seasonal volume (for an average climatic year), allowance for operational upset, flood storage for critical duration storm events including sediment and minimum freeboard above peak flood level.

Additional ponds may be required to manage fines suspended in water decanted from cycloned sand hydraulic placement cells, if the planned ponds are not suitable.

6.2 Water Balance

A preliminary operational and post-closure water balance was completed to provide inputs into the following assessments completed by others:

- site-wide water balance to estimate make-up water requirements; and
- downstream solute transport.

The conceptual operational TSF water balance is represented schematically on Figure 6.1; the inputs, assumptions and results are summarized in Appendix III.

The water balance was simplified to be focused around the water ponds (i.e. seepage collection ponds, the pyrite cell pond). The West Plant water requirements and TSF reclaim rates are shown on Figure 6.2. A summary of the TSF system losses and surpluses are given in Table 6.1 and Table 6.2, with average flow rates summarized in Table 6.3.

Table 6.1 Summary of TSF System Water Requirements from Other Sources

Flow Description	Operations (acre-ft)	Post-Closure Phase 1 (acre-ft)	Post-Closure Phase 2 (acre-ft)	Post-Closure Phase 3 (acre-ft)
Additional water required for Pyrite Pond (to maintain saturation)	22,880 (Year 8; Years 35 - 41)	0	0	0
TSF system loss (water required for the West Plant from other sources)	586,400	0	0	0

Table 6.2 Summary of TSF Active Water Management Requirements (System Surplus)

Flow Description	Operations (acre-ft)	Post-Closure Phase 1 (acre-ft)	Post-Closure Phase 2 (acre-ft)	Post-Closure Phase 3 (acre-ft)
Surplus from Pyrite Pond	0	0	0	0
Surplus from Seepage Collection Pond	0	0	1,500[1]	0

Note 1: surplus means water is not required at the West Plant and the water would be treated and released

In summary, the water balance suggests that at the end of operations a large pond will be present, leading to large water losses, with no reclaim. Following closure, active water management of the TSF will occur for 4 years, followed by an additional 15 years of active water management at the Seepage Collection Pond. Further details of the water balance are included in Appendix III.

Table 6.3 Select Mine-Life TSF Average Flow Rates

Flow Description	TSF Inflow or Outflow	Total Volume during Operation (acre-ft)	Average Flow Rate during Operation[1] (gpm)
Reclaim from Seepage Collection Pond to Pyrite Cell Pond or Reclaim Water Tank	Inflow	120,300	3380 (Year 5 to 17) 1,100 (Year 0 to 4; Year 18 to 41) [2]
Reclaim from Pyrite Cell Pond or Reclaim Water Tank to West Plant	Inflow	140,000	4520 (Year 4 to 17) 1300 (Year 0 to 3; Year 18 to 32)
Additional water required for Pyrite Pond Saturation	Inflow	22,880	60 (Year 8) 1750 (Year 35 to 41)
TSF Seepage Lost to Bedrock	Outflow	2,80	4
TSF Pond Evaporation	Outflow	205,000	3,100

1. Average for Years 1 to 41 unless noted otherwise.
2. Net of captured seepage, embankment construction water, and rain water minus SCD pond evaporation.

Figure 6.1 Water Balance Schematic

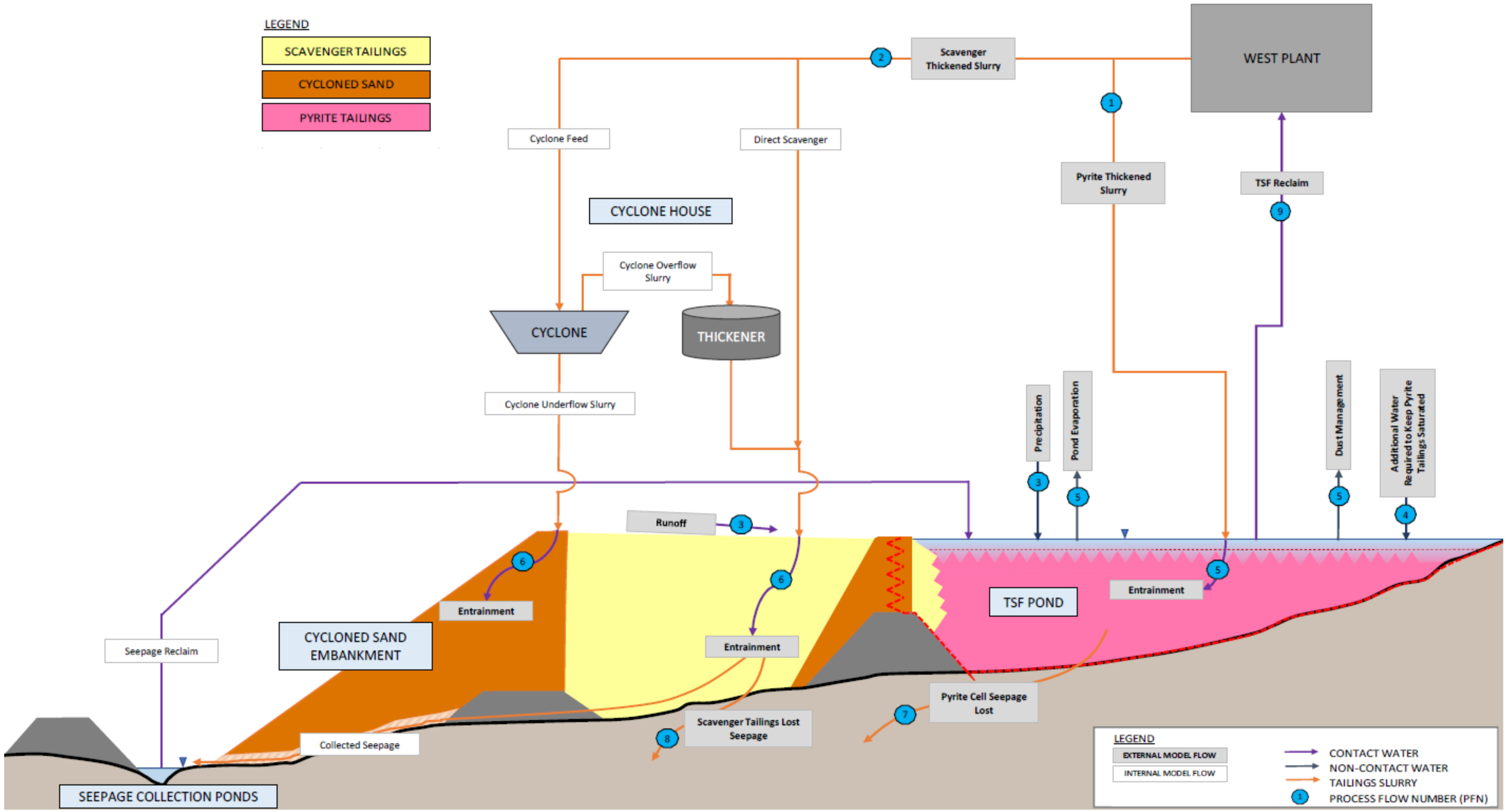
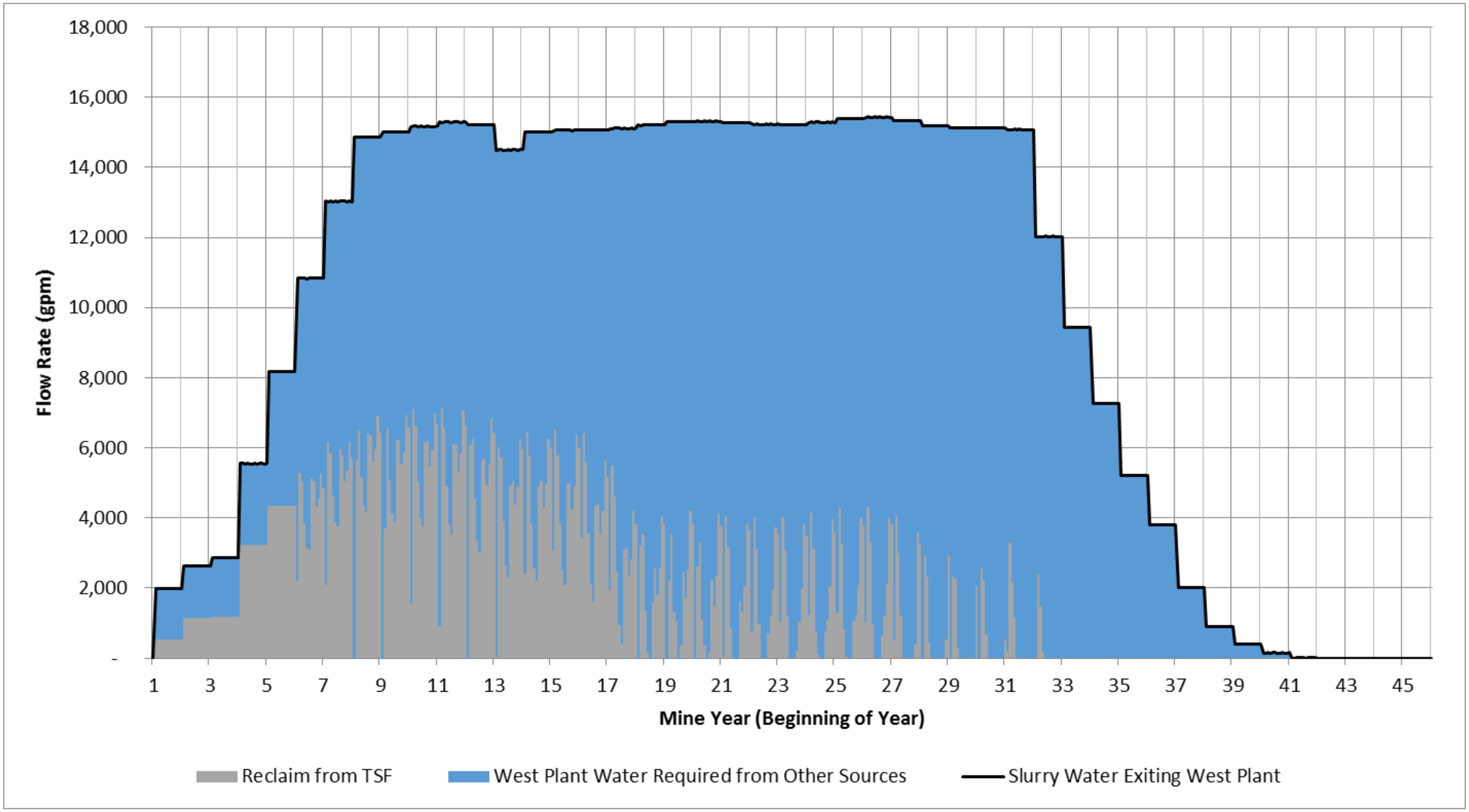


Figure 6.2 West Plant Water Requirements from TSF and Other Sources



7 SEEPAGE MANAGEMENT PLAN

Engineered low-permeability layers for the pyrite cell and managing the scavenger beach as dry as possible would be implemented to reduce seepage from the TSF. Embankment underdrains would be used depress the phreatic surface within the cycloned sand and to direct seepage from the facility to the seepage collection pond. Embankment and local catchment runoff would also be collected in the Seepage Collection Pond.

Seepage that does enter the foundation is expected to predominantly flow south through the alluvium channels and surficial weathered Gila Conglomerate towards the Gila River. Therefore, the Seepage Collection Pond would be located downstream of the TSF with grouting/cut-offs to competent bedrock to restrict groundwater flow through the alluvials.

The embankment underdrainage would include the following:

- The scavenger starter dam would be constructed above the embankment blanket drain. The intention is that the blanket and finger drains would collect water from the tailings and convey it beneath the starter dams to a series of lined channels located within the drainage channels downstream of the TSF. The lined channels would then convey the collected seepage water to the lined seepage collection pond.
- Underdrains would be extended 100 ft to 200 ft into the impoundment to intercept seepage from the scavenger beach area.

The Seepage Collection Pond includes the following elements:

- Excavation of all alluvial soil beneath the crest of the dam and replacement with compacted granular fill.
- An engineered low-permeability layer on the upstream face.
- A cementitious grout curtain that extends to a depth of approximately 100 ft into the foundation, and into each abutment.
- Pumpback wells installed in the granular fill beneath the seepage pond liner on the upstream side of the grouted core.

Preliminary lost TSF seepage rates were estimated in the water balance by two-dimensional (2D) numerical seepage analyses, refer to Table 7.1. The inputs, assumptions and results of the seepage assessments are presented in Appendix III and Appendix IV. The values are appropriate for use in the conceptual water balance but are likely conservative and over estimate seepage as the effect of pit dewatering from the Ray mine has been discounted.

Table 7.1 Lost TSF Seepage Comparison

Mine Years	Water Balance Seepage Estimate			2D Seepage Assessment Lost Seepage (Appendix IV)
	Pyrite Cell Lost Seepage	Scavenger Tailings Lost Seepage	Total Lost Seepage	
	(acre-ft/yr)	(acre-ft/yr)	(acre-ft/yr)	(acre-ft/yr)
1 to 7	1	95	96	-
8 to 31	7	430	437	-
32 to 41	11	509	520	564 to 660[1]
Post-Closure	4	55	59[2]	202 to 258[1]

Note: 1. For ultimate layout using a 2D cross-section and a representative length of 15,000 ft (see Appendix IV).
2. Assumed to be 3% of precipitation over closure beach surface (3,000 acres).

8 DUST MANAGEMENT PLAN

The key considerations for dust management of the Skunk Camp TSF are:

- the surface area of the impoundment;
- susceptibility of beach tailings to wind erosion, when dry;
- susceptibility of cycloned sand to wind erosion, when dry; and
- TSF embankment slopes which cannot be progressively reclaimed until ultimate downstream slopes are established in the later stages of operations.

The conceptual dust management plan is based on the following approach to manage wind erosion of the TSF surface.

- Cycloned sand embankment slopes:
  - The scavenger embankment construction would be sequenced to establish the ultimate downstream slope as soon as practical to allow progressive reclamation of the slope with an erosion resistant cover.
    - Progressive reclamation for the scavenger embankment downstream slope is forecast to start after Year 10, ramping up to Year 16. Thereafter the downstream slope from each annual raise could be progressively reclaimed within 12 months.
  - The pyrite cell embankment would be raised in horizontal lifts. The embankment slopes would eventually be covered by the scavenger tailings beach (downstream) or pyrite tailings (upstream). Temporary dust control measures would be implemented, as necessary, to manage dust while they are exposed.
  - Hydraulic placement cells would be wetted during active placement and, if necessary, could be wetted by sprinklers when inactive.
  - Dust from areas that would be exposed for an extended period (inactive areas that have not been progressively reclaimed) could be managed through temporary erosion controls such as: polymers, wind fences, and/or temporary sand and gravel erosion protection layer.
- Tailings beach:
  - Tailings deposition spigot locations would rotate to keep as much of the beach area wet as practical.
    - Tailings beaches undergoing active tailings deposition are considered wetted with low dust erosion potential.
    - Inactive tailings beaches are considered to be dry and, if left for extended periods, may be wetted by sprinklers or sprayed with polymer, if necessary.

        - Relative to the cycloned sand embankment, tailings beaches are expected to have higher erosion resistance due to desiccation and crusting may form at the surface.

- Reclaim pond:
    - Tailings submerged in the reclaim pond would not be exposed to wind erosion.
    - Service roads would be regularly watered or sprayed with a dust suppressant, as required.

9 BORROW PLAN

Earthfill construction materials are required for the following purposes:

- general fill for starter tailings embankments and water collection dam construction;
- sand and gravel for underdrains, blanket drains and dam zones; and
- riprap for erosion protection.

Based on the regional geology information for the Skunk Camp area (refer to Section 2.4), there are two potential general fill borrow sources within the TSF footprint which may provide suitable fill: the pediment, which forms ridges, and the Gila Conglomerate which forms the foundation for the TSF.

Experience at the West Plant site indicates a surface layer of Gila Conglomerate can be ripped with a dozer, however below approximately 5 ft to 10 ft drilling and blasting is typically required. The pediment material, and alluvium (if appropriate for use) can be easily machine excavated. All of the material must be processed to varying degrees to produce a specified gradation depending on purpose.

A preliminary borrow area has been identified within the scavenger beach area, to provide the added benefit of increased tailings storage (Figure 9.1).

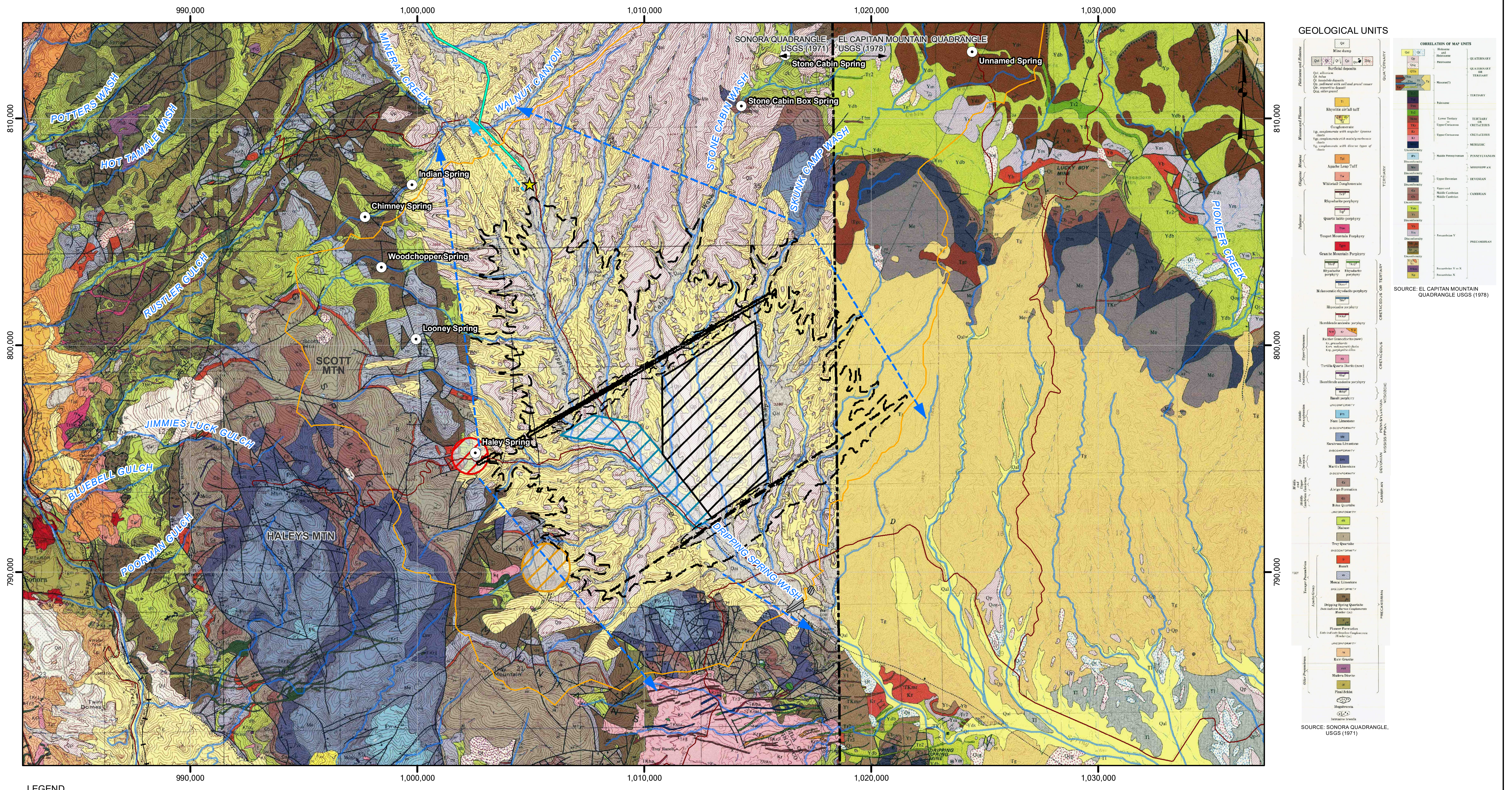
The preferred source of sand and gravel for the blanket drains and underdrains is the alluvial sediments located within the active channels; however, the volume available of suitable material is unknown. If there is a deficit of suitable material, other rock units in the vicinity, such as the diabase, could be quarried and processed as it naturally weathers to sand-sized grains. The suitability of these rock types would be assessed prior to use.

Riprap for erosion protection will be sourced from a Troy Quartz quarry established adjacent to the right abutment of the main dam.

Preliminary estimates of borrow needs for the project are outlined in Table 9.1. A plan showing preliminary outlines of borrow areas is presented as Figure 9.1.

Table 9.1 Anticipated Borrow Volumes Needed for Project

Design Feature	Estimated Volume Needed	Preliminary Borrow Area Reserved (see Figure 10.1)	Anticipated Source
General Dam Fill	291,000 cyd	645 acres	Gila Conglomerate or Pediment
Drains	400,000 cyd	200 acres	Alluvium
		45 acres	Diabase
Riprap	T.B.D.	80 acres	Troy Quartz Quarry



LEGEND

- ALTERNATIVE 8: SKUNK CAMP
- SEEPAGE COLLECTION DAM
- CYCLONE HOUSE AND PIPELINE CORRIDOR TIE-IN POINT
- SPRING

POTENTIAL BORROW AREAS

- POTENTIAL ALLUVIUM BORROW FOR DRAIN MATERIAL
- POTENTIAL DIABASE BORROW FOR DRAIN MATERIAL
- POTENTIAL GILA CONGLOMERATE AND PEDIMENT BORROW FOR GENERAL DAM FILL
- POTENTIAL TROY QUARTZITE QUARRY FOR RIP RAP

- DIVERSION
- CLOSURE SPILLWAY
- TSF CATCHMENT
- TSF - WEST PLANT PIPELINE CORRIDOR
- ROAD
- RAILWAY
- RIVER OR MAJOR DRAINAGE

NOTES:
1. NAD83, ARIZONA STATE PLANE CENTRAL
2. REFER TO REPORT FOR SOURCE OF GEOLOGY

NOT FOR CONSTRUCTION

TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED: JUNE 2018

0 1 Mile

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CLIENT: RESOLUTION COPPER / Klohn Crippen Berger	PROJECT: RESOLUTION COPPER PROJECT ALTERNATIVE 8: SKUNK CAMP PORTFOLIO
	TITLE: PRELIMINARY BORROW AREAS
PROJECT No. M09441A20	FIG No. 9.1

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10 PRELIMINARY CLOSURE PLAN

The closure and cover strategy for the facility begins during operations and tailings deposition planning, and continues through to the onset of closure. The primary performance objectives for closure and reclamation of the TSF are to:

- establish a stable landform;
- establish a sustaining vegetated cover system that limits net infiltration and protects surface water runoff quality;
- minimize ponded water on the closed tailings surface;
- promote high levels of saturation of the pyrite tailings to reduce their exposure to atmospheric oxygen during operations (and post-closure by limiting oxygen ingress);
- protect the reclaimed surface against wind and water erosion; and
- provide a growth medium for vegetation establishment and long-term sustainability.

Management during operations of the PAG pyrite tailings and their location within the facility post-closure is important to reducing the risk of Acid Rock Drainage / Metal Leaching (ARD/ML) in tailings seepage. The tailings deposition strategy is to confine the pyrite tailings within the segregated, low-permeability area to minimize contact with water and oxygen.

During operations, the cycloned sand embankments' slopes would be progressively reclaimed as soon as practical. Towards the end of operations, scavenger tailings would be strategically deposited within the southern portion of the pyrite cell to cover the pyrite tailings and promote drainage towards the north (where a closure spillway would be constructed) reducing the area of pyrite tailings that would need to be covered at the end of operations.

At the end of operations, the remainder of the pyrite tailings cell would be covered with a layer of scavenger tailings while the reclaim pond size is decreased through pumping to the West Plant and active water management. A cover system would be placed over the top of the impoundment surface and be revegetated. The ultimate tailings surface would also be shaped to shed water to a closure spillway, so that no permanent ponds would be impounded on the surface.

The downstream slopes of the embankment would be armored and runoff collection channels would be constructed on the slopes to convey surface runoff around the seepage collection pond.

Post closure is separated into three phases for the water balance: active TSF closure, active seepage pond closure, and passive closure.

Phase 1 – Active TSF Closure (Mine Year 42 to 46)

- Remaining unreclaimed embankment slopes are reclaimed (covered and vegetated).
- The tailings beaches are reclaimed (covered and vegetated).

- Pyrite cell is covered with re-slurried hydraulically deposited or mechanically borrowed and placed scavenger tailings. The pond is expected to evaporate within five years[6]. However, if evaporation alone is insufficient, the pond would be pushed to one end of the pyrite cell during cover placement and managed via active water management[7].
- Draindown that collects at the Seepage Collection Pond is pumped back to the pyrite cell pond while present. Pyrite cell pond and Seepage Collection Pond can be managed without discharge through evaporation, except for large storm events (200 yr 24 hr). If evaporation alone is insufficient, the pond would be pushed to one end of the pyrite cell and managed via active water management.
- Closure spillway and diversions are constructed to divert runoff from the natural catchment and reclaimed TSF surfaces around the Seepage Collection Ponds as practical (assumed to be completed by year five post-closure).

Phase 2 – Active Seepage Pond Closure (Mine Year 47 to 62)

- The closure spillway is commissioned, conveying surface runoff from the tailings surface area north to Mineral Creek.
- Active water management[6] is required to reclaim water from the Seepage Collection Pond.

Phase 3 – Passive Closure (Mine Year 62 onwards)

- The Seepage Collection Pond is able to passively evaporate all inflows without release, except for large storm events, without the need for active water management after the end of operations.
- If water reporting to the Seepage Collection Pond is not suitable for discharge, the collection dams/ponds would remain and passively evaporate the inflows until the seepage quantity is negligible or the seepage quality is suitable for discharge, at which point the Seepage Collection Pond would be decommissioned.

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[6] The pyrite cell has an area of 508 acres. The estimated annual precipitation and potential evaporation are 18 inch/year and 72 inch/year, respectively. Therefore, the evaporative capacity of the pyrite cell is approximately 2,300 acre-ft/year.
[7] Active water management is defined as any required management of water at the seepage collection dams so that the pond does not discharge to the environment below a 200-year 24-hour storm runoff. This can include pumping to another location (e.g. a pond on the tailings surface), treating and releasing to the environment, releasing to the environment directly if the water quality is suitable or using spray evaporators to manage by evaporation.

11 CLOSING

This report is an instrument of service of Klohn Crippen Berger Ltd. The report has been prepared for the exclusive use of Resolution Copper Mining LLC (Client) for the specific application to the Resolution Copper Project, Skunk Camp Design Study. The report's contents may not be relied upon by any other party without the express written permission of Klohn Crippen Berger. In this report, Klohn Crippen Berger has endeavored to comply with generally-accepted professional practice common to the local area. Klohn Crippen Berger makes no warranty, express or implied.

KLOHN CRIPPEN BERGER LTD.

Joseph Quinn, P.Geo. (AB), Ph.D.
Associate, Senior Engineering Geologist

Robert Cross, P.Eng., P.Geo.
Geotechnical Engineer

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

Registered Professional Engineer (Civil)
CERTIFICATE NO.
59393
RICHARD
FRIEDEL
Date Signed 2018/06/13
ARIZONA, U.S.A.
Expires 3/31/2021

Rick Friedel, P.E.
Principal, Senior Geotechnical Engineer

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APPENDIX I

Design Basis Memorandum

Resolution Copper Project

DEIS Design for Alternative 8 – Skunk Camp

Technical Memorandum

Appendix I – Design Basis Memorandum

DISCLAIMER

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1 INTRODUCTION

1.1 General

This is the design basis memorandum (DBM) for the design of Alternative 8 – Skunk Camp which is one of the tailings storage facility (TSF) design alternatives that Resolution Copper Mining LLC (RC) intends to include in the draft environmental impact statement (DEIS) for the proposed Resolution Copper Project. This TSF is located at the Skunk Camp location on the border of Pinal and Gila Counties, Arizona. The DBM outlines the design objective as well as the design criteria and assumptions. This DBM is considered a "live" document that will be reviewed and updated throughout the design process.

1.2 Design Objective

The objective of the TSF is to store the tailings produced by the proposed Resolution Copper Project. The design incorporates findings from the alternative studies. Limited site-specific data has been collected at the site at the time of this study, primarily consisting of regional geological maps, well log information for a small number of wells, and preliminary site reconnaissance visits by RC and KCB staff. This conceptual level design is based on site condition assumptions from similar sites.

The design regulations and guidelines are outlined in Section 1.3, and the design criteria and assumptions are tabulated in Section 2.

The scope of the DEIS design is to provide a basis for comparing impacts from TSF alternatives.

1.3 Design Regulations and Guidelines

The TSF design is governed and guided by the regulations and guidelines listed below. The general approach adopted in this design is to set the design criteria based on the governing regulations, and then to supplement these regulations with guidelines from international practice where the governing regulations are not specific. Where international guidelines are more stringent than the governing regulations, consideration is also given to the additional measures needed to meet the more stringent guidelines.

Governing

Tailings Storage Facility and Seepage Collection Dams

- Arizona State Legislature. 2016. Arizona Administrative Code (A.A.C.).
  - Title 18. Environmental Quality. Chapter 9: Department of Environmental Quality – Water Pollution Control. Chapter 11: Department of Environmental Quality, Article 1: Water Quality Standards.
  - Arizona State Legislature. 2016. Arizona Revised Statues (A.R.S.).
    - Title 49 – The Environment.

- Regulatory agency: Arizona Department of Environmental Quality (ADEQ).
- Environmental Protection Agency (EPA). Clean Water Act (CWA) - 33 U.S.C. §1251 et seq. (1972).
- Rio Tinto. 2017. D5 – Management of Tailings and Water Storage Facilities.

Seepage Collection Dams (only)

In addition to the above governing regulations, the seepage collection dams are regulated by the Arizona Department of Water Resources (ADWR). The additional application Arizona Administrative Code (A.A.C.) is Title 12. Natural Resources. Chapter 15. Department of Water Resources (A.A.C. R12-15).

Guidance

- Arizona Department of Environmental Quality (ADEQ). 2005. Arizona Mining Guidance Manual BADCT (Best Available Demonstrated Control Technology).
- British Columbia Ministry of Energy and Mines (MEM). 2016. *Health, Safety and Reclamation Code for Mines in British Columbia*.
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1.4 BADCT Approach

The TSF will apply for an Aquifer Protection Permit (APP) with an “individual” Best Available Demonstrated Control Technology (BADCT) approach, which is performance based, and allows the applicant to select from all available Demonstrated Control Technologies (DCTs) that constitute BADCT. This process considers site specific characteristics, operational controls, and other DCTs.

Under the individual BADCT approach, the TSF is considered a “tailings impoundment” and will be designed in accordance with Section 3.5 of the BADCT manual (ADEQ 2005). The seepage pond is considered to be a “surface pond” and will be designed in accordance with Section 3.6 of the BADCT manual (ADEQ 2005) and the regulations pertaining to water dams (A.A.C. R12-15).

2 DESIGN CRITERIA

Table 2.1 Design Criteria

	Item	Design Criteria	Reference
1.0	**Tailings Storage Facility (TSF) Embankment Design**		
1.01a	CDA Consequence Classification	To be confirmed following inundation study.	▪ CDA (2007a)
1.01b	Rio Tinto Risk Category	Class IV (considered Class IV until all necessary mitigations have been included in design)	▪ D5 Standard (Rio Tinto 2017)
1.02	Storage capacity	Capacity to store all NPAG scavenger (scavenger) and PAG pyrite (pyrite) tailings production	▪ RC requirement
1.03	Downstream slope	▪ No steeper than 2H:1V	▪ MEM (2016)
1.04	Minimum Factor of Safety	▪ Static (upstream or downstream) – 1.5 (during operation and long term) ▪ Liquefied/post-cyclic – 1.2 ▪ Rapid drawdown – N/A	▪ BADCT (ADEQ 2005) supplemented with MEM (2016) ▪ D5 Rio Tinto (2017) ▪ CDA (2007a) ▪ N/A
1.05	Deformations (seismic or static, e.g. settlement)	▪ For cases with no liquefiable materials, horizontal seismic coefficient for pseudo-static analysis = 0.6 x peak ground acceleration (PGA). This seismic coefficient is selected to maintain consistency with the requirements of the seepage collection dams, as per A.A.C R12-15-1216. ▪ For elements of the TSF sensitive to deformation, a simplified deformation analysis is required. ▪ Predicted deformations shall not jeopardize containment integrity (e.g. does not reduce freeboard sufficiently to lead to an uncontrolled release of fluid tailings, does not impact the functionality of the drains, etc.).	▪ BADCT (ADEQ 2005) ▪ D5 Rio Tinto (2017)
1.06	Seismicity	▪ Maximum Credible Earthquake (MCE). Earthquake design ground motions will be selected in future design stages for appropriate return period events.	▪ BADCT (ADEQ 2005) supplemented with MEM (2016), CDA (2014), D5 Rio Tinto (2017) and industry practice
1.07	Pond Storage Capacity	See Figure 2.1 Storage capacity = minimum operating volume + maximum average seasonal volume + volume required for operational upset + volume for critical duration storm event including sediment (Environmental Design Flood and Inflow Design Flood) + volume required for “dry” freeboard (Table 2.1, Item 1.11)	▪ BADCT (ADEQ 2005)

Table 2.1 Design Criteria (cont'd)

	Item	Design Criteria	Reference
1.08	Storage Volume for Operational Upset Conditions	RC to confirm after RC internal risk audit and to be updated in next stage of design.	
1.09	Environmental Design Flood (EDF)	Minimum requirement for BADCT is 100-year 24 hr. Design will assume 200-year 24 hr; EDF will be confirmed through water balance and water quality modeling.	▪ BADCT (ADEQ 2005)
1.10	Inflow Design Flood (IDF) For Dam Safety	Return Period: Probable Maximum Flood (PMF) Duration: For individual BADCT, the facility-specific critical design storm duration is established by considering several durations and determining which results in the maximum required storage capacity to contain the design flood volume. Therefore, the duration will be confirmed during the flood routing and water balance calculations: ▪ with a spillway: spillway sized for the critical duration of 6 hr to 72 hr; and ▪ without a spillway: minimum of 72 hr (to be confirmed based inflows and discharge rates).	▪ BADCT (ADEQ 2005) ▪ FEMA (2013) ▪ MEM (2016) ▪ D5 Rio Tinto (2017)
1.11	"Dry" Freeboard	▪ Wind and wave run-up + 2 ft ▪ Wind event annual exceedance probability = 2-year ▪ Wave height and run-up to be calculated using industry standard methods ▪ Earthquake-induced settlements of the embankment crest to be assessed and included in minimum freeboard determination	▪ BADCT (ADEQ 2005) ▪ CDA (2007b) ▪ USACE (2002)
1.12	Beach length	Will become part of the Quantitative Performance Objectives (QPO) ▪ Sufficient to achieve seepage and hydraulic gradient criteria during normal operations and periods of flood storage. ▪ Sufficient to provide a secondary defense against loss of fluid tailings in the event of downstream slope displacement.	
1.13	Seepage	Water quality requirements at the point of compliance are to be assessed.	▪ BADCT (ADEQ 2005), Clean Water Act (EPA) and Arizona State Legislature (A.A.C. R18-11)
1.14	Drains	▪ Provide drains/filters satisfying USACE (2004) guidelines to mitigate potential for internal erosion. ▪ Drains designed to maintain phreatic surface to acceptable levels within the embankment with adequate safety factor to account from clogging and uncertainty.	▪ USACE (2004)

Table 2.1 Design Criteria (cont'd)

	Item	Design Criteria	Reference
1.15	Construction and Operations	▪ Quantifiable performance objectives to be defined prior to construction. ▪ All construction and borrow materials with contingency to be defined prior to construction.	▪ MEM (2016)
1.16	Closure	Planned closure landscape is to be a physically stable landform without a permanent water pond that meets point of compliance criteria.	▪ D5 Rio Tinto (2017)
1.17	Closure Surface Diversions	The design criteria will be selected based on consequence of failure, e.g. impact on other structures or environment.	▪ BADCT (ADEQ 2005) ▪ D5 Rio Tinto (2017)
1.18	External Erosion Protection	The design criteria will be selected based on consequence of failure, e.g. impact to structural zones, containment, other structures or the environment. BADCT requires, at a minimum, that if the TSF is within the 100-year flood plain, drainage controls must be designed to protect the TSF from damage or flooding for 100-year peak streamflows.	▪ BADCT (ADEQ 2005)
2.0	**Seepage Collection Pond**		
2.01	Assumed downstream hazard classification for the dam	High (to be confirmed in future design stages)	▪ A.A.C R12-15-1216
2.02	Downstream slope	As per Table 2.1, item 1.03	
2.03	Stability Factor of Safety (FOS)	▪ End of construction – Static (upstream or downstream) – 1.3 (≤ 50 ft high), 1.4 (> 50 ft high) ▪ Steady state seepage – Static – 1.5 ▪ Rapid drawdown – 1.2	▪ A.A.C R12-15-1216 ▪ D5 Rio Tinto (2017)
2.04	Deformations (seismic or static, e.g. settlement)	▪ Pseudo-static – FOS = 1.0 with horizontal seismic coefficient = 0.6 x peak ground acceleration (PGA). ▪ As per Table 2.1, item 1.05, where elements are sensitive to deformations, a simplified deformation analysis will be conducted to identify the potential displacements for comparison with allowable deformations for that element. ▪ Predicted deformations shall not jeopardize containment integrity (e.g. does not impact the integrity of the dam core or the spillway, etc.)	▪ A.A.C R12-15-1216 and BADCT (ADEQ 2005) ▪ D5 Rio Tinto (2017)
2.05	Seismicity	▪ MCE, assumed to be mean 1:10,000 year return period: ♦ Sensitivity to 95th percentile to be considered	▪ A.A.C R12-15-1216 supplemented with MEM (2016) and CDA (2007a)
2.06	Pond Storage Capacity	See Table 2.1, item 1.07	
2.07	Storage Volume for Operational Upset Conditions	One week of average seepage and precipitation to account for a period of pump shut-down	

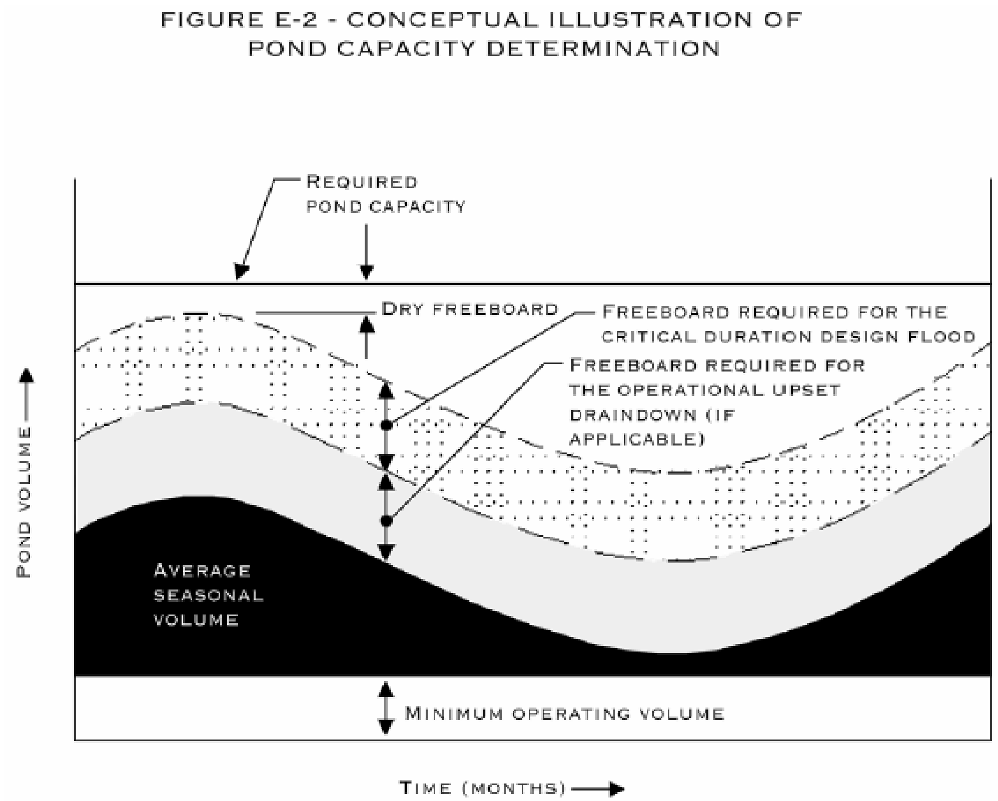
Table 2.1 Design Criteria (cont'd)

	Item	Design Criteria	Reference
2.08	Environmental Design Flood (EDF)	Minimum requirement for BADCT is 100-year 24 hr. TSF design will assume 200-year 24 hr; EDF will be confirmed through water balance and water quality modeling.	▪ BADCT (ADEQ 2005)
2.09	Inflow Design Flood (IDF) For Dam Safety	Storm to be routed through spillway - Probable Maximum Flood (PMF) <u>BADCT:</u> <u>Return Period:</u> if failure of dam would pose an imminent risk to human life and/or high downstream incremental consequences the PMF should be used. <u>Duration:</u> For individual BADCT, the facility-specific critical design storm duration is established by considering several durations and determining which results in the maximum required storage capacity to route the design flood volume. The range of storm duration to be considered are 6 hr to 72 hr. <u>A.A.C R12-15-1216:</u> For a high hazard potential dam, the applicant shall design the dam to withstand an inflow design flood that varies from .5 PMF to the full PMF, with size increasing based on persons at risk and potential for downstream damage. The applicant shall consider foreseeable future conditions. <u>FEMA (2013):</u> PMF for a dam classified as high hazard.	▪ BADCT (ADEQ 2005) ▪ A.A.C R12-15-1216 ▪ D5 Rio Tinto (2017) ▪ FEMA (2013)
2.10	Freeboard	Largest of: ▪ IDF + wave run up with a critical wind annual exceedance probability of the 1 in 2 year event ▪ IDF + 3 ft ▪ 5 ft	▪ A.A.C R12-15-1216 with consideration from CDA (2007b)
2.11	Low level outlet (or discharge - pump)	Can discharge 90% of storage volume within 30 days (minimum capacity).	▪ A.A.C R12-15-1216
2.12	Seepage	See Table 2.1, item 1.13	
2.13	Drains	▪ Provide core and drains/filters satisfying USACE (2004) guidelines to limit potential for internal erosion. ▪ Drains designed to maintain phreatic surface to acceptable levels within the embankment with adequate safety factor to account from clogging and uncertainty.	▪ BADCT (ADEQ 2005), USACE (2004) and A.A.C R12-15-1216
2.14	Crest width	Minimum of dam height (centerline) divided by 5, plus 5 ft. Minimum crest width = 12 ft, maximum crest width = 25 ft.	▪ A.A.C R12-15-1216

Table 2.1 Design Criteria (cont'd)

	Item	Design Criteria	Reference
2.15	Erosion protection	Well graded, durable riprap, sized to withstand wave action, placed on a well graded pervious sand and gravel bedding or geotextile with filtering capacity suitable for the site.	▪ A.A.C R12-15-1216
2.16	External Erosion Protection	The design criteria will be selected based on consequence of failure, e.g. impact on other structures or environment. (BADCT requires, at a minimum, that if the TSF is within the 100-year flood plain, drainage controls must be designed to protect the TSF from damage or flooding for 100-year peak streamflows.)	▪ BADCT (ADEQ 2005)

Figure 2.1 Pond Capacity Determination (ADEQ 2005)



3 DESIGN BASIS

Table 3.1 Design Assumptions, Constraints & Data Sources

	Item	Design Basis	Comments
1.0	**General Design Basis**		
1.01	TSF location	▪ Skunk Camp site, Pinal & Gila Counties, Arizona ▪ State land and private land ▪ Coordinates (Arizona State Plane Central NAD83): 1,014,500' E, 793,000' N	
1.02	Mine Flow Sheet	Selective	
1.03	Mine life	41 years	Received from RC
1.04	TSF operating life	41 years	Received from RC
1.05	Tailings types	Two types of tailings are produced: ▪ scavenger tailings (84% of total weight); and ▪ pyrite tailings (16% of total weight).	Received from RC
1.06	Tailings technology	Thickened slurry (scavenger and pyrite tailings).	
1.07	Tailings delivery	See process schematic (Figure 3.1)	
1.08	Total tailings production	1.37 billion short tons	Received from RC
1.09	Ore and tailings production schedule	Table 3.2	
1.10	Units	U.S. Customary	
1.11	Embankment raise methodology	Hydraulically placed cycloned sand using centerline raised methodology (see Figure 3.2)	
1.12	Cycloned sand availability	Cycloned Sand Recovery: 45% Cyclone uptime: 50% (Year 1-2); 70% (Year 3-5); 80% (Year 6-41) Cycloned sand retention in hydraulic cells: 90%	Lower bound recovery from Krebs simulations (KCB, 2018) To account for reduced efficiency at the start of operations; communicated by RC.
2.0	**Topography**		
2.01	Projection	Arizona State Plane Central	
2.02	Datum	NAD83	
2.03	Unit of measurement	U.S. Customary	

Table 3.1 Design Assumptions, Constraints & Data Sources (cont'd)

	Item	Design Basis	Comments
3.0	**Seismicity**		
3.01	Ground Motions	Not analyzed at this stage of design (refer to Table 3.1, Item 6.02).	
4.0	**Climate and Hydrology**		
4.01	Average precipitation (in inches)	J: 1.5; F: 2.0; M: 2.0; A: 0.7; M: 0.3; J: 0.4; J: 3.1; A: 2.5; S: 1.4; O: 1.6; N: 2.2; D: 1.4; Total: 19.0	Based on elevation-precipitation correlation of regional climate stations; Superior (ID: 028348), Miami (ID: 025512), Kearny (ID: 024590), San Carlos Reservoir (ID: 027480), Roosevelt 1 WNW (ID: 027281) and Oracle 2 SE (ID: 026119). Confirmed with regional estimate from Arizona Water Atlas.
4.02	Wet and dry year precipitations	Consideration to wet and dry years for the water balance will not be made at this stage of design.	
4.03	Average annual pan evaporation	91.3 in	Pan evaporation data collected at the San Carlos Reservoir climate station (ID: 027480)
4.04	Evapotranspiration for reference surface/crop (in inches)	J: 2.9; F: 3.4; M: 5.0; A: 6.6; M: 8.5; J: 9.2; J: 9.0; A: 8.0; S: 7.0; O: 5.8; N: 3.8; D: 3.1; Total: 72.3	Calculated using the Penman-Monteith combined equation in Hydrus1D based on the generated Superior climate data set and reference vegetation parameters.
4.05	Natural catchment runoff coefficient	0.15	Calculated by dividing the average annual runoff from the nearby USGS hydromet station by the average annual precipitation at site (KCB 2014).
4.06	Probable Maximum Precipitation (PMP)	PMP Depth (inches) — General Winter: 6 hour 5.2, 24 hour 9.7, 72 hour 14.9; Tropical: 6 hour 11.8, 24 hour 16.6, 72 hour 22.1; Local: 6 hour 11.7, 24 hour -, 72 hour -	Applied Weather Associates PMP Evaluation Tool. Determined as the critical storm for design. For the Skunk Camp site catchment.
4.07	Runoff coefficient during storm events	1.0	To account for high antecedent moisture conditions and the predominantly exposed rock in the catchment
4.08	Extreme point precipitation depths	See Table 3.3	From NOAA Atlas 14 (NOAA 2018).

Item 4.01 – Average precipitation (in inches):

J	F	M	A	M	J	J	A	S	O	N	D	Total
1.5	2.0	2.0	0.7	0.3	0.4	3.1	2.5	1.4	1.6	2.2	1.4	19.0

Item 4.04 – Evapotranspiration for reference surface/crop (in inches):

J	F	M	A	M	J	J	A	S	O	N	D	Total
2.9	3.4	5.0	6.6	8.5	9.2	9.0	8.0	7.0	5.8	3.8	3.1	72.3

Item 4.06 – Probable Maximum Precipitation (PMP):

Storm Type	PMP Depth (inches)		
	6 hour Duration	24 hour Duration	72 hour Duration
General Winter	5.2	9.7	14.9
Tropical	11.8	16.6	22.1
Local	11.7	-	-

Table 3.1 Design Assumptions, Constraints & Data Sources (cont'd)

	Item	Design Basis		Comments
5.0	**Tailings Characteristics and Deposition**			
		Scavenger Tailings	**Pyrite Tailings**	
5.01	Target gradation produced at mill	*"Total" Tailings:* Target P80 = 160 microns 50% fines (<74 microns) <10% clay (<2 microns)	Target P80 = 75 to 80 microns 80% fines (<74 microns) <20% clay (<2 microns)	Scavenger "Total" Tailings: Provided by RC. Pyrite Tailings: Provided by RC. Clay content assumed from previous test work on cleaner tailings. See Figure 3.3
5.02	Target gradation produced by cyclones	*Cycloned Sand (Underflow)*: Target P80 = 200 microns <20 % fines (<74 microns) 0% clay (<2 microns) *Cyclone Overflow:* Target P80 = 60 microns 90% fines (<74 microns) 15% clay (<2 microns)	N/A	Provided by RC. See Figure 3.3. Target fines content for cycloned sand to be less than 20%, based on seepage performance and constructability from other cycloned sand embankment case histories.
5.03	Specific gravity	2.78	3.87	Average values from KCB laboratory testing programs on scavenger "total" tailings and cleaner tailings.
5.04	Solids content pumped from the mill	60%	50%	Provided by RC
5.05	Cyclone solids content	*Cyclone Feed:* 35% *Cyclone Overflow:* 25% *Cycloned Sand:* 70%	N/A	From most recent Krebs simulations (KCB, 2018).
5.06	Solids content discharged into TSF	*"Total" Tailings:* 60% *Cyclone Overflow:* 60% *Cycloned Sand:* 60%	50%	Cycloned sand solids content based on case history data and construction performance at other large cycloned sand embankments that use hydraulic cell construction. To be confirmed from ongoing rheology testing.

Table 3.1 Design Assumptions, Constraints & Data Sources (cont'd)

	Item	Design Basis		Comments
5.07	Liquefaction assumption	All potentially liquefiable tailings will liquefy at the TSF, regardless of triggering mechanism.		
5.08	Pyrite tailings management	N/A	Subaqueous deposition	
5.09	Tailings beach slopes (above water)	1% within 1,500 ft of discharge point, 0.5% thereafter	N/A	Scavenger Tailings - Based on topography and bathymetry surveys from two large, cycloned sand impoundment beaches and slopes below water. These facilities have long exposed beaches, up to five miles. Pyrite Tailings - Based on topography and bathymetry surveys of subaqueous disposal of high-pyrite tailings from floating barges. To be reviewed in future design stages.
5.10	Tailings beach slopes (below water)	2.5% within 1,000 ft of water's edge; 1.0% thereafter	10% within 100 ft of discharge point; 0.5% thereafter	
5.11	Dry beach runoff coefficient	0.15	N/A	Estimated based on Hydrus1D infiltration modeling
5.12	Dry density for staging assessment	*Interlayered "Total" Tailings and Cyclone Overflow (Composite Beach):* 75 pcf (first 5 years of operations); 81 pcf (remaining years of operations) *Cycloned Sand (compacted):* 113 pcf	106 pcf	KCB (2018)

Table 3.1 Design Assumptions, Constraints & Data Sources (cont'd)

	Item	Design Basis	Comments
6.0	**Tailings Storage Facility (TSF) Impoundment Design**		
6.01	Design criteria	As per Table 2.1.	
6.02	Stability	Embankment section (Figure 3.2) assumed to meet design stability criteria for DEIS	Based on preliminary stability analyses reported in KCB (2017a) and typical assumed foundation conditions for the Near West site (KCB 2017b)
6.03	Main Embankment Crest width	100 ft	Sufficient to accommodate 2-way vehicle traffic, pipelines and any other equipment required to be on the crest (e.g. cyclones).
6.04	Main Embankment Downstream Slope	3H:1V (see Figure 3.2)	
6.05	Main Embankment Upstream Slope	vertical slope (centerline raise; see Figure 3.2)	
6.06	Main Embankment Crest width	100 ft	
6.07	Pyrite Cell Embankment Downstream Slope	2H:1V	
6.08	Pyrite Cell Embankment Upstream Slope	vertical slope (centerline raise; see Figure 3.2)	
6.09	Liner	Pyrite cell: Engineered low-permeability layer[1] beneath the cell, and extended vertically to separate from scavenger tailings Scavenger area: foundation treatment to control seepage	
6.10	Drainage	Sand and gravel drainage blanket in the embankment footprint; gravel/rockfill finger drains in existing drainage channels in the embankment footprint	

[1] The engineered low-permeability layer could be comprised of one or more of the following: compacted fine tailings, geomembrane liner, asphalt, slurry bentonite, and/or cemented paste tailings

Table 3.1 Design Assumptions, Constraints & Data Sources (cont'd)

	Item	Design Basis	Comments
6.11	Closure	TSF Surfaces: slope, cover and revegetate to shed water, limit infiltration, limit erosion and return the landscape to a similar condition prior to mining. Pyrite management: limit oxygen ingress through subaqueous deposition, cover and encourage saturation of the pyrite tailings in the long term (i.e. after removal of the pond).	Approach agreed by RC
7.0		**Pond Management**	
7.01	Pond Management	▪ No permanent water pond in the scavenger tailings area; permanent pond maintained in the pyrite cell. Ponded water on the scavenger tailings surfaces will be collected and transferred to the pyrite cell.	D5 Rio Tinto (2017)
7.02	Minimum operating pond volume	▪ Minimum amount to keep pyrite tailings saturated and provide operating pond depth.	
7.03	Minimum operating pond depth	▪ Seepage Collection Dam: 10 ft for reclaim pump (could be accounted for by a sump or other means). ▪ Minimum Water Cover above Maximum Tailings El. in pyrite cell: 10 ft	

Table 3.2 Mine and Tailings Production Schedule

Description	Year	Mine Year	Modeling Year	Tailings Tonnage (tons/year)		
				Scavenger	Pyrite	Total
Care and Maintenance	2017	-	1	-	-	-
Care and Maintenance	2018	-	2	-	-	-
Care and Maintenance	2019	-	3	-	-	-
Care and Maintenance	2020	-	4	-	-	-
Construction	2021	-	5	-	-	-
Construction	2022	-	6	-	-	-
Construction	2023	-	7	-	-	-
Construction	2024	-	8	-	-	-
Construction	2025	-	9	-	-	-
Construction	2026	-	10	-	-	-
Construction	2027	-	11	-	-	-
First Ore	2028	1	12	5,346,486	766,631	6,113,118
Ramp up	2029	2	13	7,187,504	991,640	8,179,144
Ramp up	2030	3	14	7,897,945	1,014,556	8,912,501
Ramp up	2031	4	15	15,085,826	2,110,526	17,196,352
Ramp up	2032	5	16	21,902,288	3,328,288	25,230,577
Ramp up	2033	6	17	28,780,765	4,569,518	33,350,283
Ramp up	2034	7	18	34,178,734	5,793,075	39,971,810
Full Production	2035	8	19	37,849,588	7,340,459	45,190,047
Full Production	2036	9	20	37,128,274	8,184,034	45,312,308
Full Production	2037	10	21	36,749,978	8,772,867	45,522,845
Full Production	2038	11	22	37,121,210	8,792,910	45,914,120
Full Production	2039	12	23	38,040,923	8,019,027	46,059,950
Full Production	2040	13	24	37,486,298	6,800,935	44,287,232
Full Production	2041	14	25	39,582,789	6,518,836	46,101,626
Full Production	2042	15	26	39,666,729	6,589,905	46,256,634
Full Production	2043	16	27	39,211,923	6,919,174	46,131,097
Full Production	2044	17	28	38,679,739	7,360,739	46,040,478
Full Production	2045	18	29	38,273,841	7,838,027	46,111,868

Table 3.2 Mine and Tailings Production Schedule (cont'd)

Description	Year	Mine Year	Modeling Year	Tailings Tonnage (tons/year)		
				Scavenger	Pyrite	Total
Full Production	2046	19	30	38,130,733	8,150,877	46,281,610
Full Production	2047	20	31	38,448,597	7,968,471	46,417,068
Full Production	2048	21	32	38,926,908	7,537,946	46,464,854
Full Production	2049	22	33	39,028,952	7,382,565	46,411,517
Full Production	2050	23	34	39,006,219	7,367,901	46,374,120
Full Production	2051	24	35	38,564,309	7,824,341	46,388,650
Full Production	2052	25	36	38,008,651	8,406,901	46,415,552
Full Production	2053	26	37	37,822,090	8,629,862	46,451,952
Full Production	2054	27	38	38,599,981	7,902,469	46,502,450
Full Production	2055	28	39	39,472,443	6,988,070	46,460,513
Full Production	2056	29	40	39,579,974	6,796,869	46,376,843
Full Production	2057	30	41	39,595,841	6,786,681	46,382,522
Full Production	2058	31	42	39,503,382	6,740,343	46,243,725
Ramp Down	2059	32	43	31,481,866	5,391,484	36,873,350
Ramp Down	2060	33	44	24,576,943	4,320,111	28,897,054
Ramp Down	2061	34	45	18,707,166	3,478,519	22,185,685
Ramp Down	2062	35	46	13,146,108	2,643,079	15,789,186
Ramp Down	2063	36	47	9,566,562	1,952,428	11,518,989
Ramp Down	2064	37	48	4,993,554	1,079,281	6,072,835
Ramp Down	2065	38	49	2,121,484	545,241	2,666,725
Ramp Down	2066	39	50	928,110	274,819	1,202,929
Ramp Down	2067	40	51	326,877	99,724	426,602
Ramp Down	2068	41	52	19,505	4,936	24,440
Closure	2069	-	53	-	-	-
			TOTAL TAILINGS	**1,150,727,095**	**219,984,066**	**1,370,711,161**

Notes: Tailings production schedule supplied by RC.
Mine plan descriptions, mine years and modeling years supplied by Resolution Copper.

Table 3.3 Precipitation Depth-Duration-Frequency Estimates for the TSF

Average Recurrence Interval (years)	5 min	10 min	15 min	30 min	60 min	2 hr	3 hr	6 hr	12 hr	24 hr	2 day	3 day	4 day	7 day	10 day	20 day	30 day	45 day	60 day
Precipitation in inches																			
1	0.3	0.4	0.5	0.7	0.9	1.0	1.0	1.3	1.6	2.0	2.3	2.5	2.7	3.1	3.4	4.3	5.2	6.2	7.2
2	0.4	0.5	0.7	0.9	1.1	1.3	1.3	1.6	2.0	2.5	2.9	3.2	3.4	3.9	4.3	5.5	6.6	7.8	9.1
5	0.5	0.7	0.9	1.2	1.5	1.7	1.7	2.0	2.4	3.1	3.7	4.1	4.4	5.1	5.5	7.0	8.4	10.0	11.5
10	0.6	0.9	1.1	1.4	1.8	2.0	2.0	2.4	2.8	3.6	4.4	4.8	5.3	6.1	6.6	8.3	9.9	11.7	13.3
25	0.7	1.0	1.3	1.7	2.1	2.4	2.5	2.8	3.4	4.3	5.3	5.9	6.5	7.6	8.1	10.0	12.0	14.0	15.8
50	0.8	1.2	1.5	2.0	2.4	2.7	2.8	3.2	3.8	4.9	6.0	6.7	7.4	8.8	9.3	11.4	13.6	15.8	17.7
100	0.9	1.3	1.6	2.2	2.7	3.0	3.2	3.6	4.2	5.5	6.8	7.6	8.5	10.1	10.7	12.9	15.3	17.6	19.6
200	0.9	1.4	1.8	2.4	3.0	3.3	3.5	3.9	4.6	6.1	7.6	8.6	9.6	11.6	12.1	14.4	17.1	19.5	21.6
500	1.1	1.6	2.0	2.7	3.4	3.8	4.0	4.4	5.2	6.9	8.8	10.0	11.2	13.7	14.2	16.5	19.5	22.1	24.2
1000	1.2	1.8	2.2	3.0	3.7	4.1	4.4	4.8	5.6	7.6	9.7	11.1	12.5	15.5	16.0	18.2	21.5	24.2	26.2

Note: From NOAA Atlas 14 (NOAA 2018) for the Skunk Camp site.

Figure 3.1 Process Schematic

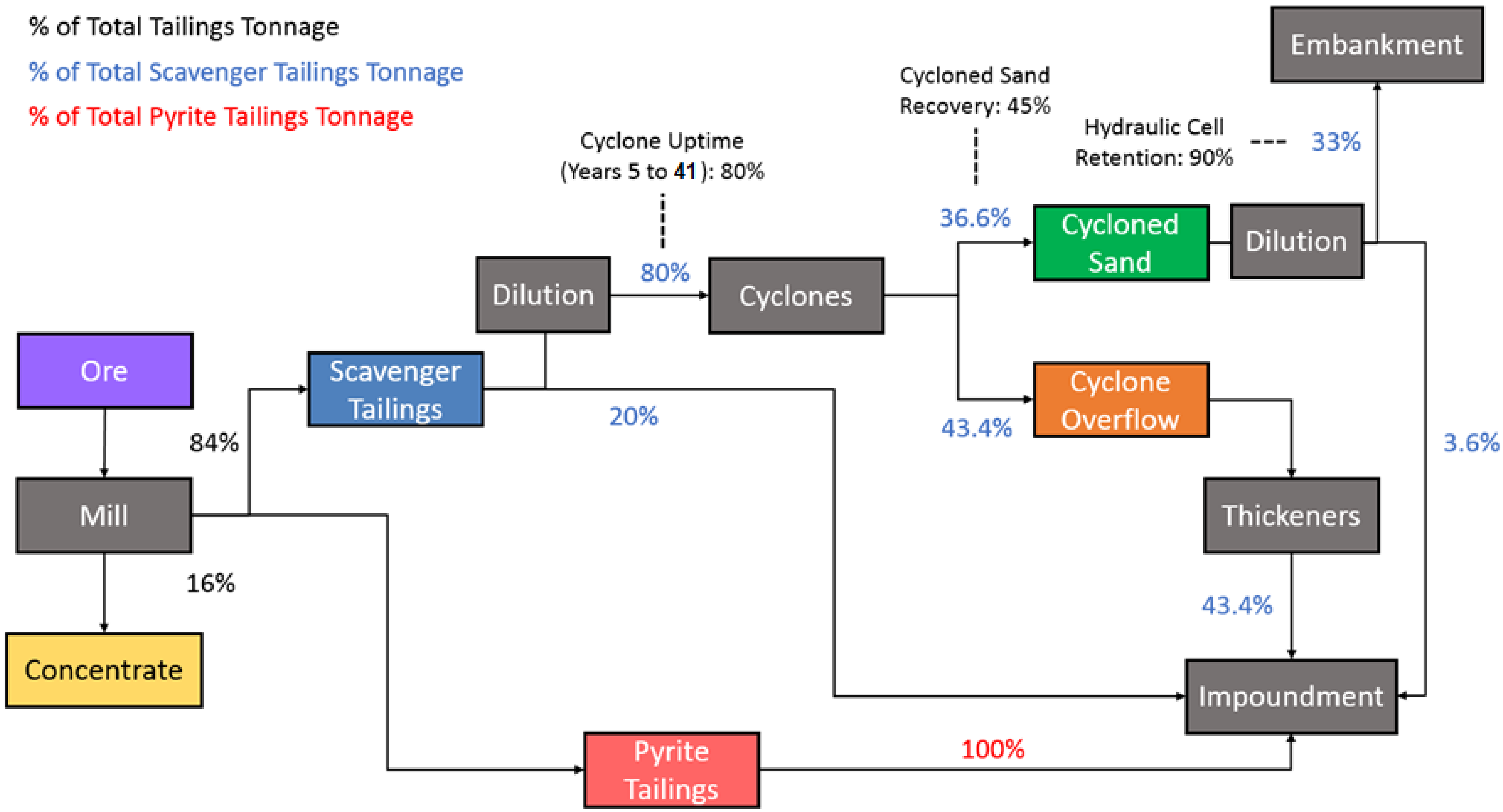


Figure 3.2 Embankment Centerline Raise and Embankment Design Schematic

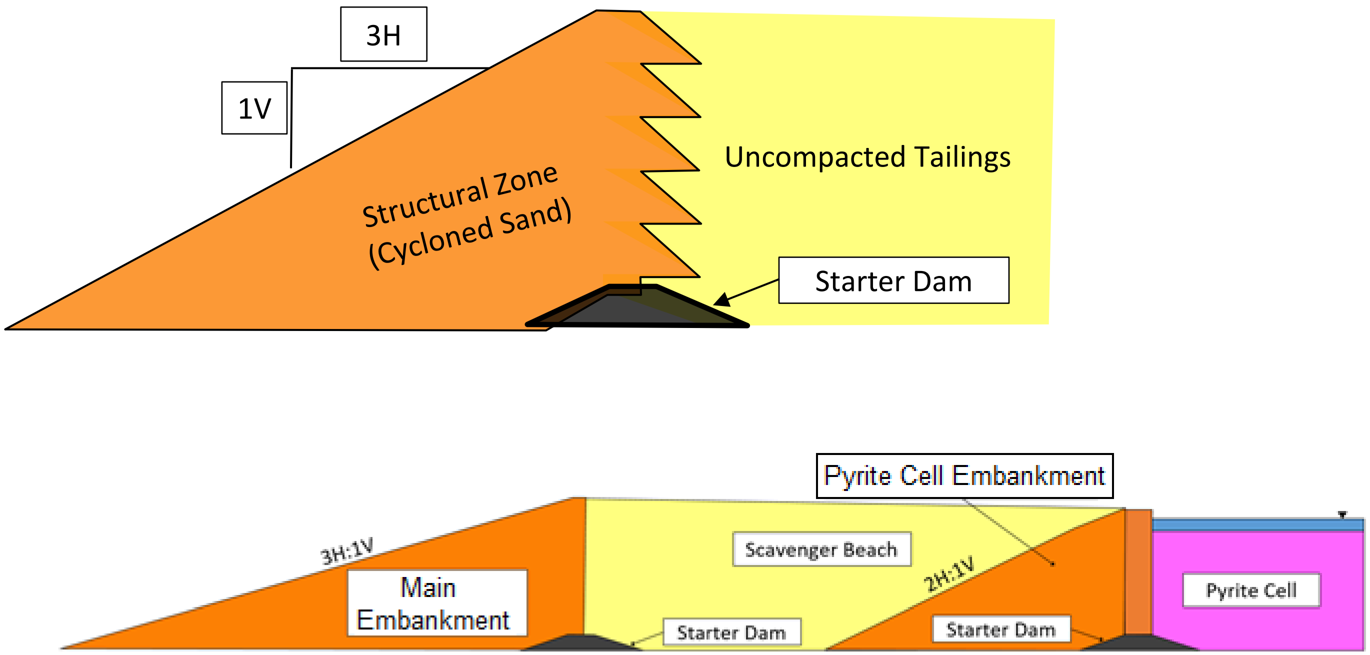
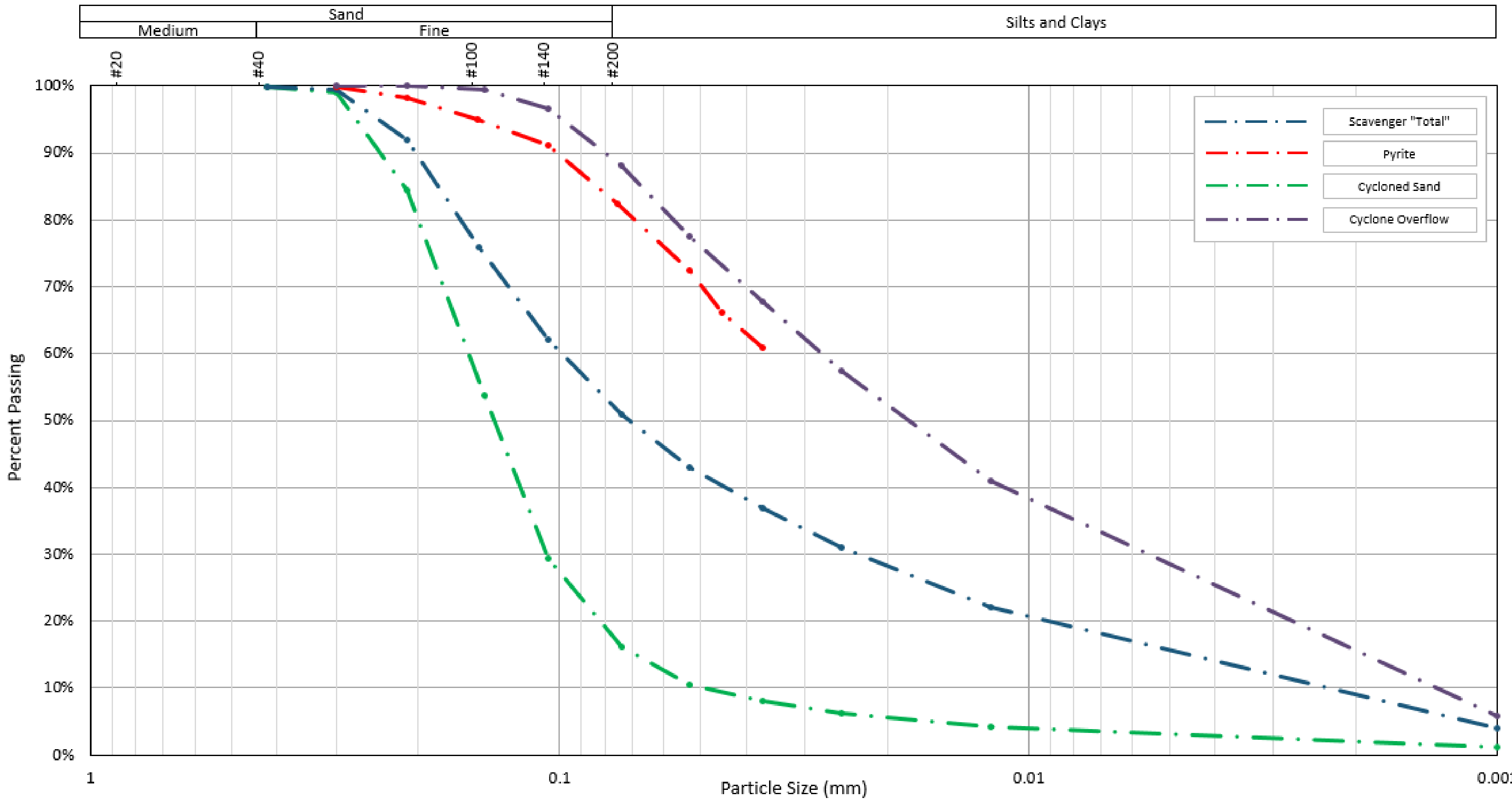


Figure 3.3 Target Tailings Gradations for Design



ADDITIONAL REFERENCES

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APPENDIX II

Impoundment Layout and Tailings Staging

Resolution Copper Project

DEIS Design for Alternative 8 – Skunk Camp

Technical Memorandum

Appendix II – Impoundment Layout and Tailings Staging

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Appendix II
Impoundment Layout and Tailings Staging
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II-1 INTRODUCTION

This appendix presents the tailings staging plan for the Draft Environmental Impact Statement (DEIS) design for the Alternative 8 Skunk Camp tailings storage facility (TSF). The ultimate configuration and volume-elevation estimates presented herein was completed using the tailings deposition software Muck3D (MineBridge Software Inc., version 1.0.5). The TSF raising schedule was estimated based on the ultimate configuration, stage-storage curves, tailings production schedule and assumed tailings densities.

Key objectives of the tailings staging scope were as follows:

- confirm ultimate configuration required to meet storage requirements;
- develop a preliminary tailings deposition strategy that:
  - deposits the potentially acid generating PAG pyrite (pyrite) tailings subaqueously in a segregated cell;
  - accommodates flood storage volumes; and
  - sequences embankment construction to establish the ultimate exterior embankment slope as soon as practical to allow progressive reclamation.
- estimate annual and cumulative cycloned sand requirements[1] to support main embankment and pyrite cell embankment construction; and
- estimate the main embankment and pyrite cell embankment crest elevations and rate of rise over the life of the mine.

II-2 ULTIMATE LAYOUT

The ultimate Alternative 8 layout is shown in the attachment, Figure II-A.1. The key features of Alternative 8 TSF layout include the following:

- Upstream non-contact water diversions.
- Cross-valley starter dams for the scavenger and pyrite cells constructed of locally sourced borrow material to store tailings in early years of operations before the cycloned sand embankments are established.
- The main embankment crest raises constructed of cycloned sand in a centerline configuration with a 100 ft crest width, 3H:1V downstream slope.
- The pyrite cell would be contained by an embankment constructed of cycloned sand in a centerline configuration and engineered low-permeability layers[2] for vertical and lateral containment.

[1] At this conceptual level, the main embankment and pyrite cell embankment are assumed to be constructed of cycloned sand. A potential optimization is to use total scavenger tailings, which will be considered in future design stages.
[2] Low-permeability containment details to be determined in future design stages but could comprise of one or more of the following: geomembrane liner, compacted fine tailings, asphalt core, slurry bentonite, cemented paste tailings, polymers, etc.

- The pyrite cell embankment would have a 100 ft wide crest with 2H:1V downstream slope (an additional 50 ft allowance for the crest width was included in the staging assessment). The pond in the pyrite cell would be sized to maintain a water cover over the pyrite tailings with flood storage and freeboard outlined in Section II-4.7 and II-4.8.
- Contingency storage is included in the pyrite cell (approximately 15%) to account for variations in production and uncertainties with tailings density estimates.

The tailings and pond management strategy would comprise the following:

- Scavenger tailings would be cycloned for embankment construction. Scavenger total tailings that bypass the cyclones and cyclone overflow would be thickened and deposited upstream of the embankment crest.
- Scavenger beach would be maintained dry (i.e. no pond) where possible. Precipitation runoff from scavenger beach would be temporarily collected in designated low spots or routed directly to storage tanks or the reclaim pond in the pyrite cell[3].
- Pyrite tailings would be deposited from a floating barge or pipelines into the pyrite cell.
- Water in the reclaim pond would be reclaimed from a floating barge to a tank/pumps back to the West Plant where it would be reintroduced back into the processing circuit.

II-3 TAILINGS DEPOSITION MODELING APPROACH

For this preliminary deposition modeling, the ultimate TSF configuration (developed in MUCK3D) was divided into four regions and stage-storage relationships developed for each: main cycloned sand embankment; pyrite cell cycloned sand embankment; scavenger beach; and pyrite tailings cell (refer to Figure II-1). The forecasted annual tailings production in each region was used to estimate the annual crest/impoundment level, based on the following:

- Main cycloned sand embankment crest must be approximately 35 ft higher than the average scavenger beach elevation, to account for scavenger beach tailings deposition slopes, which are not considered in the stage storage curves.
- Scavenger tailings that are not cycloned for embankment construction report to the scavenger beach.
- Tailings elevations in the pyrite cell is maintained approximately 25 ft below the crest of the pyrite cell cyclone sand embankment crest, to account for the pyrite cell storage requirements outlined in Section II-4.7 and Section II-4.8.
- Minimum water cover of 10 ft over the average pyrite tailings elevation is maintained which is a preliminary estimate to allow for pyrite tailings underwater deposition slopes, water cover and pyrite deposition barge draft.

[3] The Environmental Design Flood (EDF) for the scavenger tailings surface would be the 200-yr 24-hr storm event. The Inflow Design Flood (IDF) required for dam safety would be the Probable Maximum Flood (PMF).

Figure II-1 TSF Regions for Staging Assessment

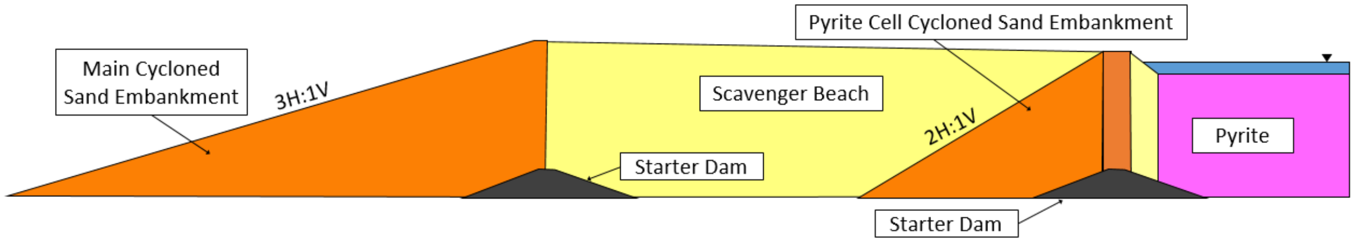
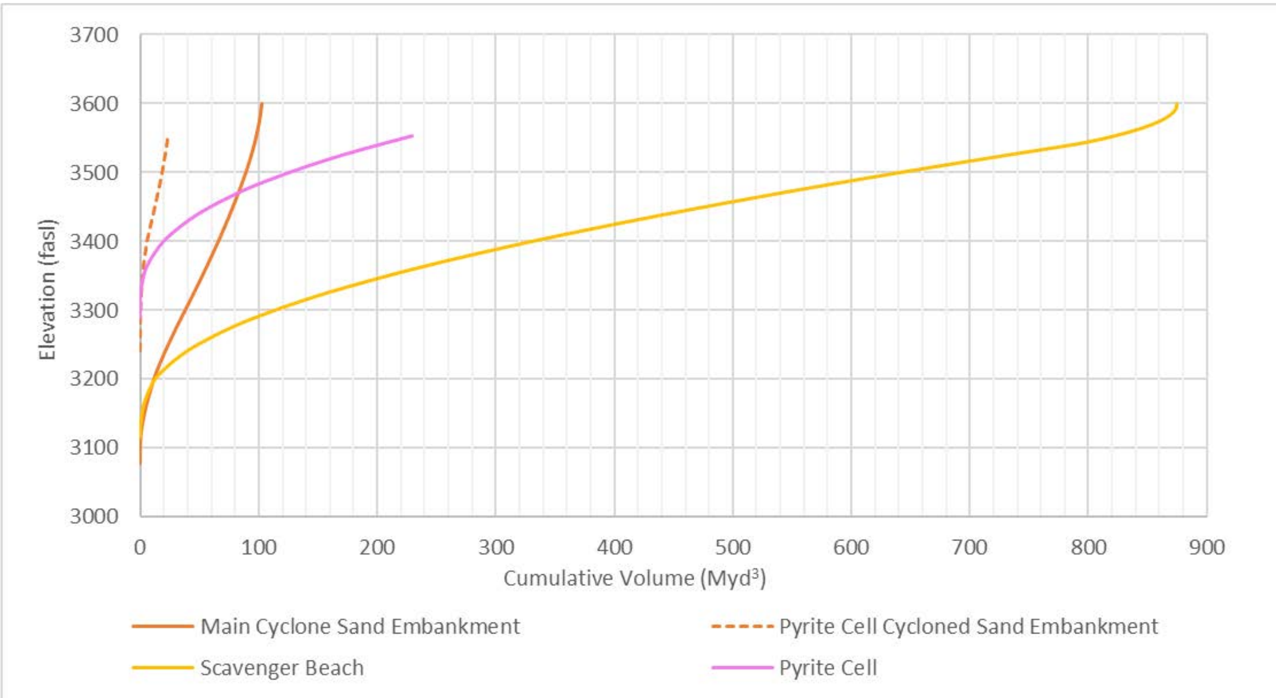


Figure II-2 TSF Region Horizontal Stage-Storage Curves



II-4 MODELING INPUT PARAMETERS AND ASSUMPTIONS

II-4.1 Ultimate TSF Configuration

The required model input parameters for the ultimate TSF Muck3D modeling are:

- baseline topography;
- discharge locations (i.e. spigots);
- tailings subaerial beach and below water slopes (see Section II-4.5);
- tailings dry density (see Section II-4.5); and
- tailings production (tons) (see Section II-4.3).

The baseline topography was based on the United States National Elevation Dataset (NED) with 10 m resolution.

II-4.2 Starter Dams

The scavenger and pyrite starter dams are to be constructed out of borrow materials. Preliminary assumptions and results for the starter dam sizing are summarized in Table II-1; see the design basis memorandum (DBM) for design criteria (Appendix I). No additional tailings storage benefits from borrowing within the impoundment have been accounted for in this assessment which is a future opportunity to be investigated. Details related to potential borrow areas would be developed in future design stages, however it is anticipated that the majority of the borrow would be sourced from within the TSF footprint.

Table II-1 Starter Dam Sizing Assumptions and Results

Parameter	Scavenger Starter Dam	Pyrite Starter Dam Assumptions
Crest width	50 ft	
Side Slopes	3H:1V	
Tailings storage requirement to contain two years' worth of tailings	12.4 Myd^3	1.2 Myd^3
Design flood storage to contain the PMF[1]	10.3 Myd^3	9.8 Myd^3
Allowance for pyrite slope and minimum operating pond volume	N/A	10 ft
Minimum "Dry" Freeboard	3 ft	
Required fill volume/borrow	4.0 Myd^3	5.6 Myd^3
Required Dam Height	103 ft	111 ft

Notes: 1. Based on scavenger and pyrite starter dam catchment areas (with diversions) of 3,446 acres and 3,308 acres, respectively; and PMP-72-hr depth = 22.1 inches (see Appendix I DBM).

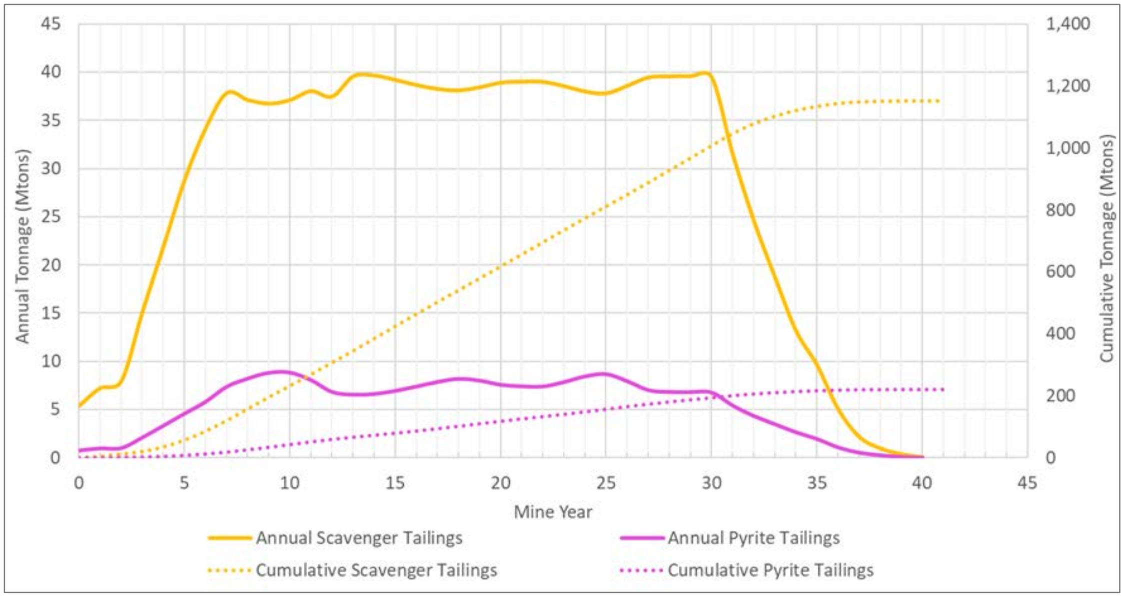
II-4.3 Tailings Production Schedule

The tailings production schedule is shown on Figure II-3 and summarized in Table II-2.

Table II-2 Total Tailings Production Comparison

Item	Production Schedule
Scavenger Tailings	1,151 Mtons (84% of total tailings by weight)
Pyrite Tailings	220 Mtons (16% of total tailings by weight)
Total Tailings (scavenger and pyrite)	1,371 Mtons
Number of Production Years	41

Figure II-3 Tailings Production Schedule

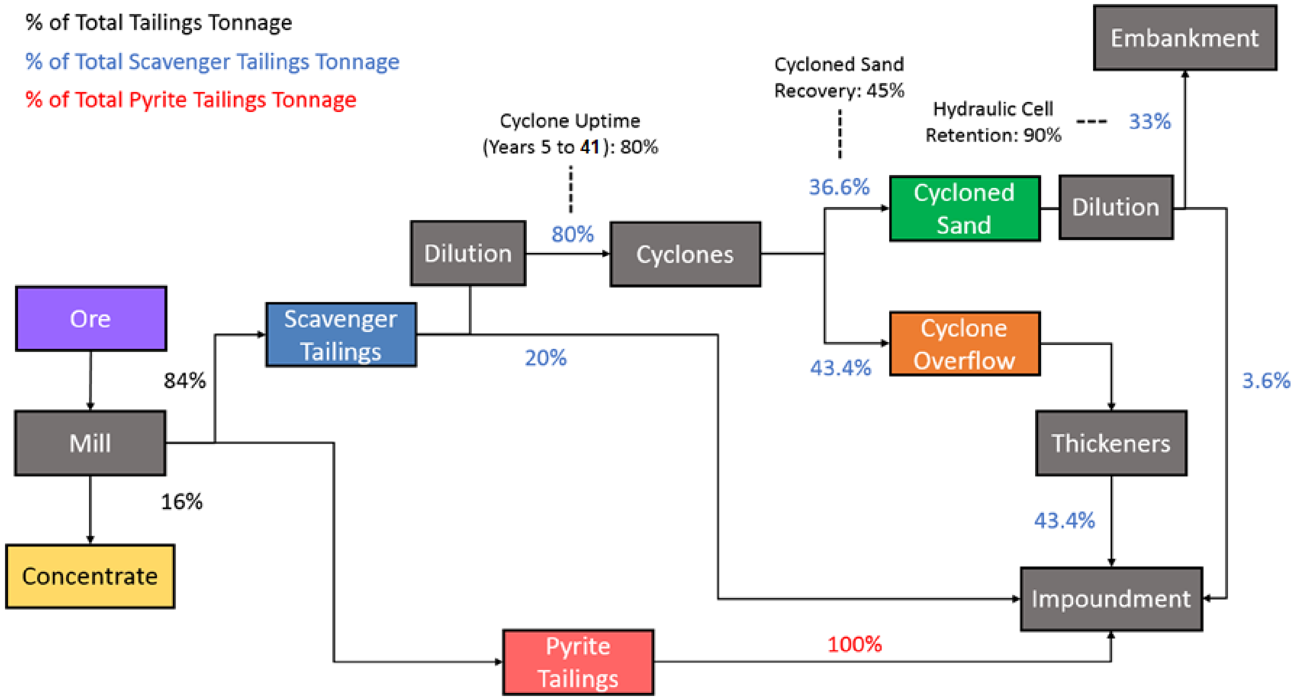


II-4.4 Tailings Process Flow Diagram

A simplified tailings process flow diagram for Alternative 8 is shown schematically on Figure II-4. The maximum amount of cycloned sand that could be produced and placed in the cycloned sand embankment, as a percentage of the total scavenger tailings tonnage, is approximately 32% to 33% (from Year 5 onwards). This assumption is based on the following, as per the DBM:

- 45% cycloned sand recovery from the cyclone system, based on cyclone simulations performed by Krebs;
- 90% cycloned sand retention in the hydraulic cells used for perimeter embankment and splitter berm construction; and
- 50% cyclone uptime in Years 1 to 2, 70% in Years 3 to 4 and 80% in Years 5 to 41 (to account for reduced cyclone efficiency and adjustments to the milling process at the start of operations).

Figure II-4 Tailings Process Flow Diagram[1,2]



Notes:

1. The water balance appendix (Appendix III) includes an expanded process flow chart.
2. Cycloned sand not retained from the embankment cells (3.6% of scavenger tailings tonnage) was deposited within the impoundment using the total scavenger/overflow in-situ dry density.

II-4.5 Tailings Properties

Tailings deposition properties are summarized in Table II-3, refer to the DBM in Appendix I for further details. A lower density for the total scavenger tailings and cyclone overflow was assumed in Years 1 through 5 for staging to account for increased rate of rise and reduced consolidation.

For this preliminary stage of assessment, the same deposition slopes as Near West Alternative 3A were assumed for the ultimate TSF configuration; the beach slopes would be monitored throughout operations and the staging plan adjusted as necessary.

Table II-3 Tailings Deposition Properties

Tailings Stream	Tailings Type	Dry Density (pcf)	Deposition Solids Content (%)	Tailings Slopes[1]	Total Tonnage (Mtons)	Total Available Volume (Myd^3)[2]
Scavenger	Total	Years (0-5): 75 Years (6-41): 81	60%	Above Water: 1% for the first 1,500 ft, 0.5% after 1,500 ft	1150	958
	Cyclone Overflow		60%		544	499
	Cycloned Sand	113	60%		370	243
Pyrite	Total	106	50%	Below Water: 10% for the first 100 ft, 0.5% after 100 ft. Pyrite tailings was modelled assuming horizontal filling and 5 ft depth allowance for pyrite deposition slopes.[2]	220	154

Notes:

1. Scavenger tailings slopes are based on topography and bathymetry surveys from two benchmark projects with large, cycloned sand impoundment beaches and slopes below water. These facilities have long exposed beaches, up to five miles. Pyrite tailings slopes are based on topography and bathymetry surveys of subaqueous disposal of high-pyrite tailings from floating barges.
2. These slopes are preliminary estimates at this stage of design and will be reviewed in future design stages.
3. Volumes given assume all available scavenger tailings is cycloned. Therefore, these are the same as the final staging results presented in Section II-5.

II-4.6 Cycloned Sand Embankment Raise Methodology

Two approaches to modeling the construction of the cycloned sand embankments were considered:

- "sloped methodology": Downstream slope of the embankment steps downstream with each raise, refer to Figure II-5. This represents the minimum amount of cycloned sand volume to be placed to meet the crest elevation requirement during early years. Dam fill volume increases significantly with each raise. This method does not allow for progressive reclamation during operations.
- "horizontal slice methodology": The embankment is constructed in horizontal slices that extend to the ultimate downstream face, refer to Figure II-6. This represents the maximum amount of cycloned sand that must be placed annually to meet the crest elevation requirement during early years. Fill volume reduces with each raise and the ultimate downstream slope is established early in operations for progressive reclamation can begin. The stage-storage curve shown in Figure II-2 is based on this construction methodology.

During the mine life, adequate cycloned sand is forecast to be available for embankment construction using the sloped embankment construction methodology (Figure II-5). For this preliminary assessment, when there is not enough cycloned sand available to construct the embankment using the horizontal slice methodology (Figure II-6), it was assumed that the embankment would be constructed using the combined raising methodology (Figure II-7).

Figure II-5 Downstream Sloped Embankment Raises

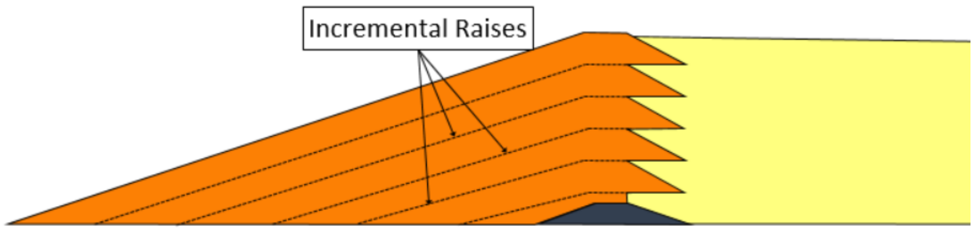


Figure II-6 Horizontal Slice Embankment Raises

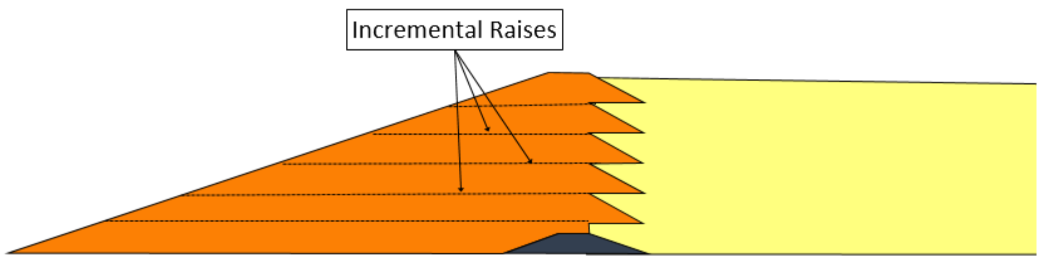
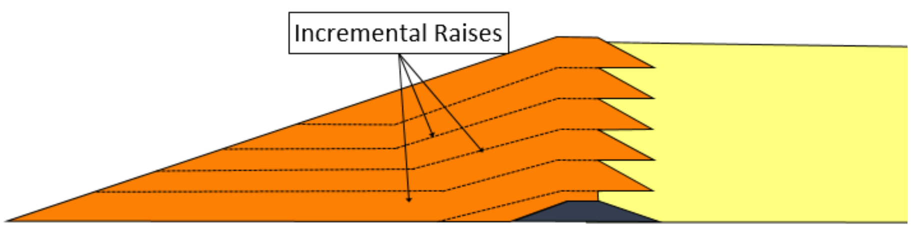


Figure II-7 Combination of Raising Methodologies



II-4.7 Flood Management

Surface runoff (bleed water and precipitation) from the scavenger beach would be pumped or routed through ditches or internal spillway to the pyrite cell pond for events up to the Environmental Design Flood (EDF), which is the 200-yr 24-hr storm event.

The pyrite cell would have the capacity, above the operating pond level, to store the 72-hr PMF for the pyrite cell catchment and the EDF from the scavenger beach catchment. Runoff volumes greater than this would extend onto the scavenger beach.

To meet dam safety design criteria, the impoundment (scavenger beach and pyrite cell) would have capacity, above operating pond level, to store the 72-hour PMF on the surface with a minimum 400 ft wide scavenger beach and adequate freeboard. The PMF flood pond extents are shown on Figure II-A.1.

II-4.8 Pyrite Cell Sizing

The pyrite cell was sized for pyrite tailings, the operating pond, flood storage (Section II-4.7), 'dry' freeboard, and contingency for variations in tailings production and properties as per the DBM and summarized in Table II-4. The horizontal filling method was assumed.

Table II-4 Pyrite Cell Sizing Assumptions

<table>
<tr><th>Item</th><th>Design Assumptions</th><th colspan="3">Comments</th></tr>
<tr><td>Pyrite Tailings</td><td>220 Mt
(154 Myd^3)</td><td colspan="3">DBM (Appendix I)</td></tr>
<tr><td>Depth Allowance for Underwater Deposition Slopes</td><td>5 ft</td><td colspan="3">Based on:
Subaqueous deposition slope = 10%
"Point of Deposition" Spacing[1] = 100 ft
Depth between the lowest and highest portions of the pyrite tailings surface = 10 ft</td></tr>
<tr><td>Minimum Depth of Operating Pond</td><td>5 ft</td><td colspan="3">Allowance for water cover over the pyrite tailings and floating barge tailings pipeline discharge</td></tr>
<tr><td rowspan="2">Depth Allowance for Storm Storage within pyrite cell</td><td rowspan="2">9.8 ft</td><td>Scenario 1
depth =
6.5 ft</td><td>scavenger beach catchment area with diversions = 3,446 acres
200yr 24hr depth = 6.1 inches
flood volume = 1,752 ac-ft</td><td>Pyrite cell catchment area with diversions = 3,308 acres
PMP-72-hour depth = 22.1 inches
flood volume = 6,105 ac-ft</td></tr>
<tr><td>Scenario 2
Depth =
9.8</td><td colspan="2">Pyrite cell catchment area without diversions =9,971 acres
PMP-72-hour depth = 22.1 inches
flood volume = 18,404 ac-ft</td></tr>
<tr><td>Freeboard</td><td>3 ft</td><td colspan="3">'dry' freeboard above peak flood level for wind setup and wave runup</td></tr>
<tr><td>Contingency Storage in the Pyrite Tailings</td><td>23 Myd^3</td><td colspan="3">15% contingency storage volume for pyrite tailings and constructability allowance for developing a scavenger beach.</td></tr>
</table>

Notes: 1. Pyrite tailings would be deposited by a floating barge or from pipelines extended into the pyrite cell. Details will be confirmed in future design stages.

II-5 TAILINGS DEPOSITION RESULTS

II-5.1 General

Figure II-8 , Figure II-9 and Figure II-10 show the relative elevations of the TSF regions over the mine life.

There is adequate cycloned sand available for embankment construction during the mine life using the sloped embankment construction methodology (see Figure II-5); however, to meet the minimum height requirements above the tailings surfaces as outlined in Section II-3 and allow for progressive reclamation of downstream embankment slope, the following construction methodologies are proposed for the different TSF regions:

- The elevation differences between pyrite and scavenger tailings levels shown in Figure II-8. Prior to Year 28 the scavenger tailings does not reach the pyrite cell elevation. Due to this, the pyrite cell cannot be raised vertically as a splitter dyke, and instead, a pyrite cell embankment is proposed.
- Both scavenger and pyrite tailings would be below the starter dam crest elevations (which are sized for the first two years of tailings) prior to Year 4 (not accounting for required flood storage).
- As shown in Figure II-9, the main cycloned sand embankment could be built using the combined raising methodology prior to Year 16, and could be built using the horizontal filling methodology from Year 16 onwards.
- As shown in Figure II-10, the pyrite cell cyclone sand embankment could be built using horizontal filling methodology.

Figure II-8 Elevation vs Mine Year

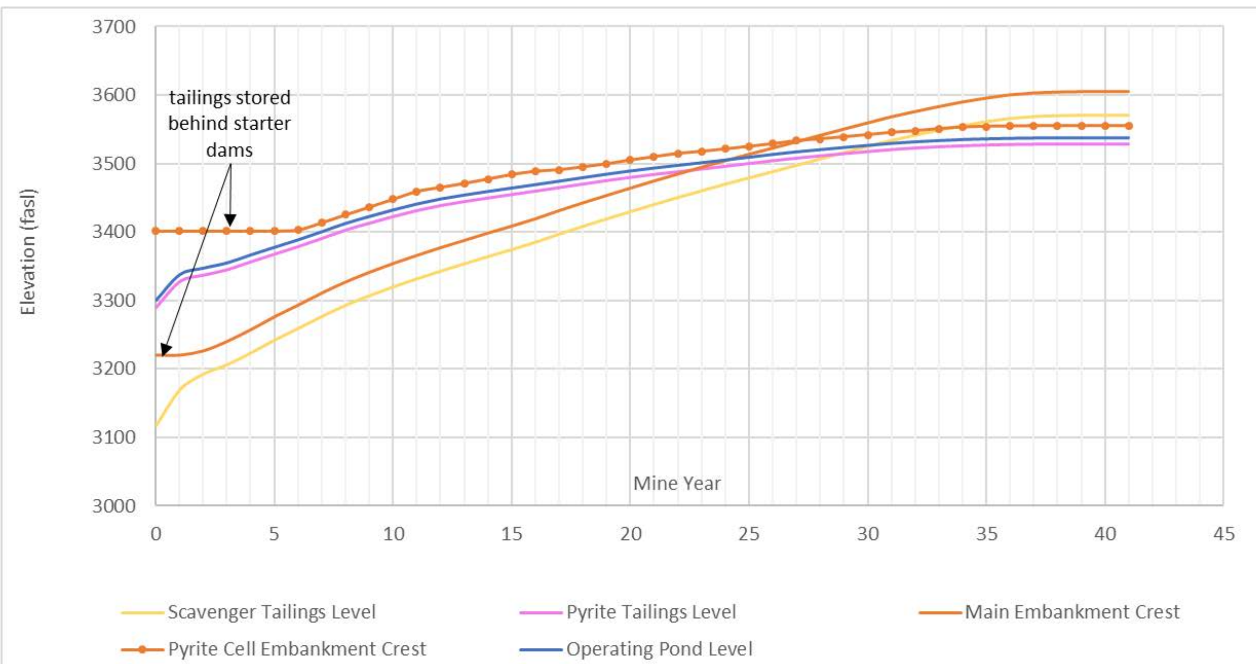


Figure II-9 Main Embankment Elevation vs Mine Year

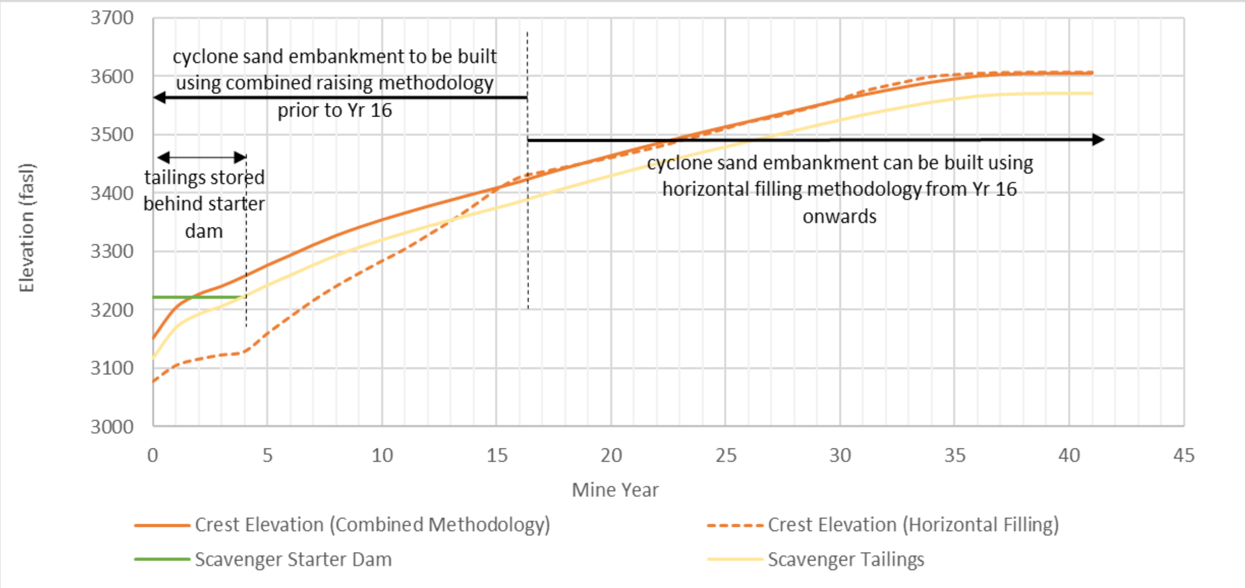
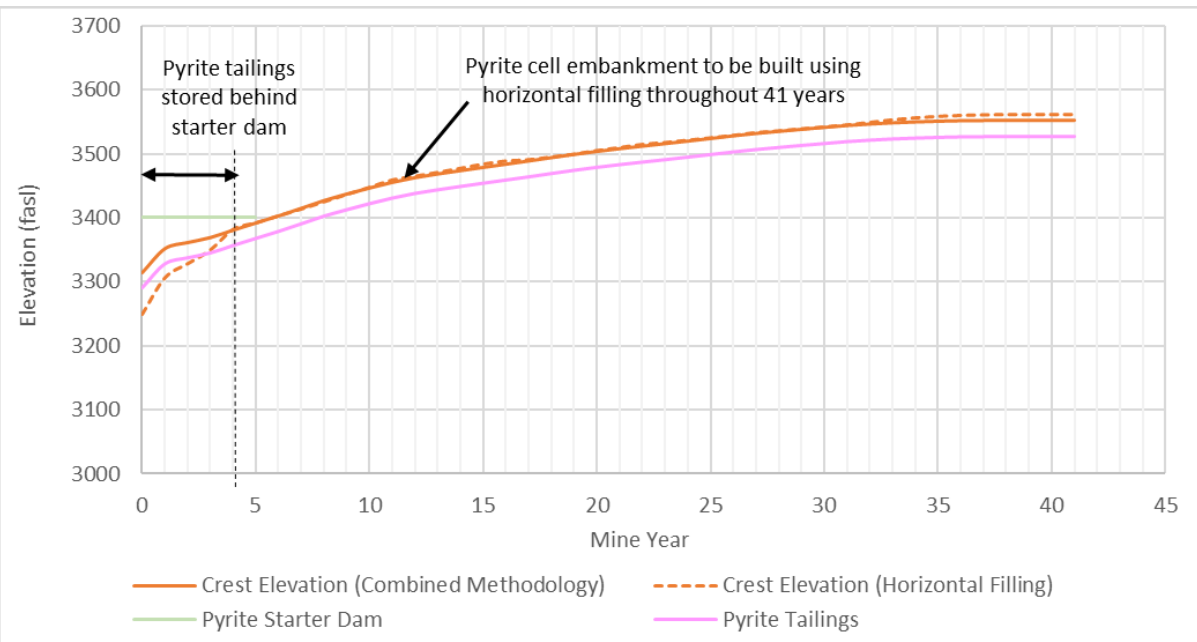


Figure II-10 Pyrite Cell Embankment Elevation vs Mine Year



II-5.2 Cycloned Sand Usage and Progressive Reclamation

Figure II-11 shows the required and available cycloned sand over the mine life. The required total cycloned sand requirement is about 52% of the total cycloned sand available.

Figure II-12 shows the placement percentages of maximum available cyclone sand and scavenger overflow over mine life. Assuming the available cycloned sand is only used for embankment construction, the downstream embankment slope can be progressively reclaimed starting in Year 10 and using the horizontal slice construction methodology by Year 16 (as shown in Figure II-12). If cycloned sand is utilized for other construction activities (e.g. road construction, liner bedding, etc.), the year at which the downstream embankment slope can be reclaimed and horizontal slice construction can start would be delayed.

Figure II-11 Available and Required Cycloned Sand vs. Mine Year

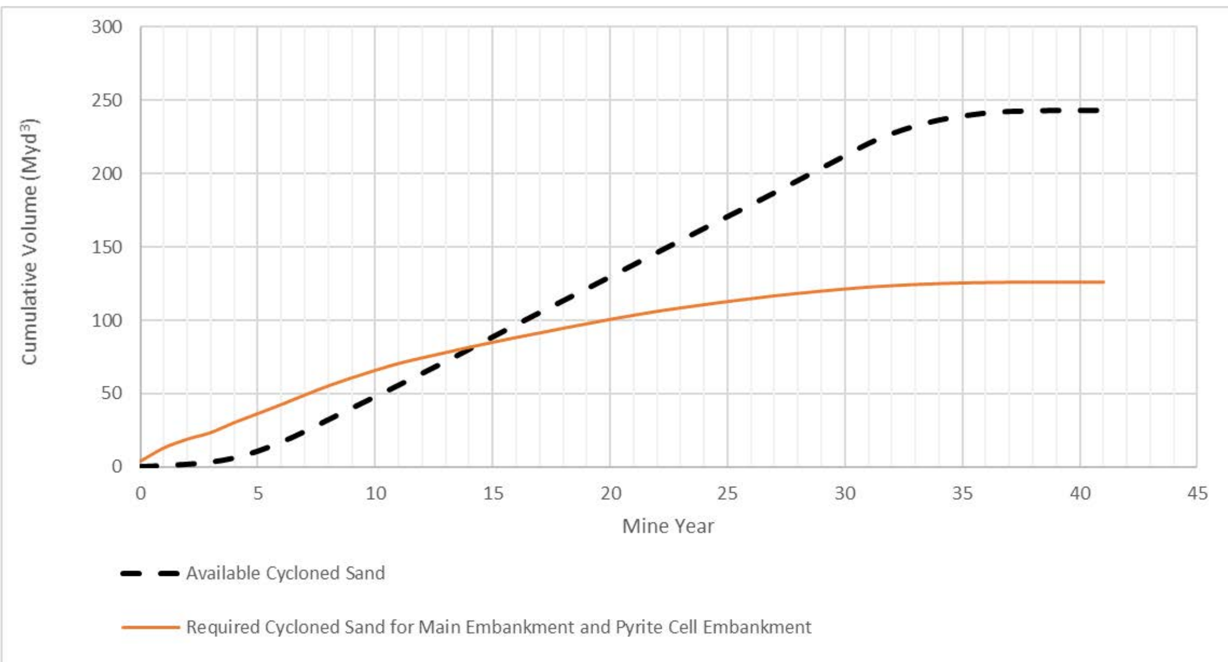
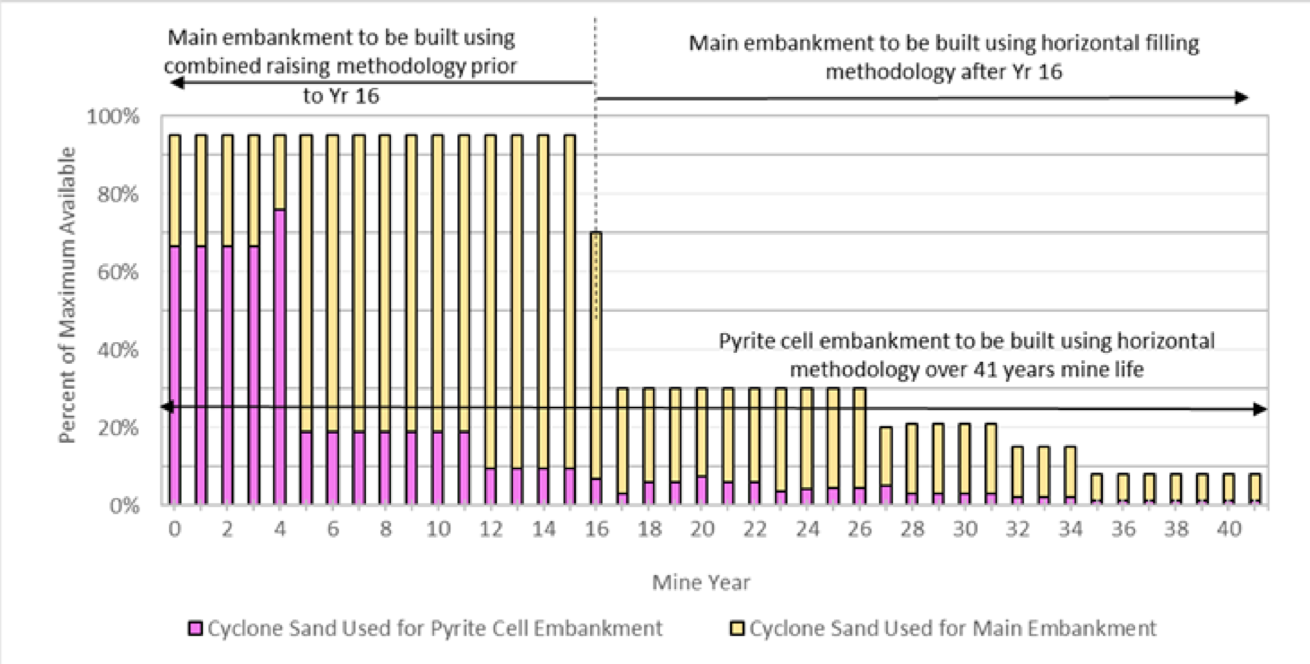


Figure II-12 Percentage of Available Cyclone Sand Used



II-5.3 Cumulative Tailings Volume and Rate of Rise

Figure II-13 shows the cumulative tailings volumes deposited over mine life, and Figure II-14 shows the rate of rise for the TSF regions over mine life. The high rate of rise during early operations is due to the narrow valley bottoms being filled and needs to be refined during future design stages. The rate of rise reduces in later years of operation to approximately 10 ft/year, which is consistent with similar scale operations.

Figure II-13 Cumulative Volume vs Mine Year

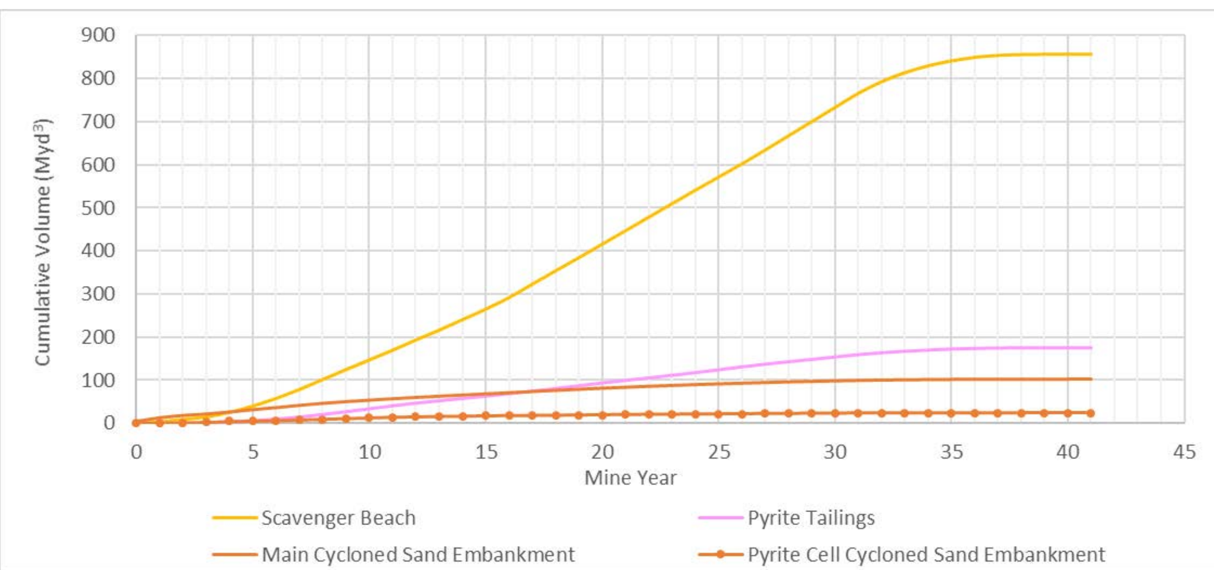
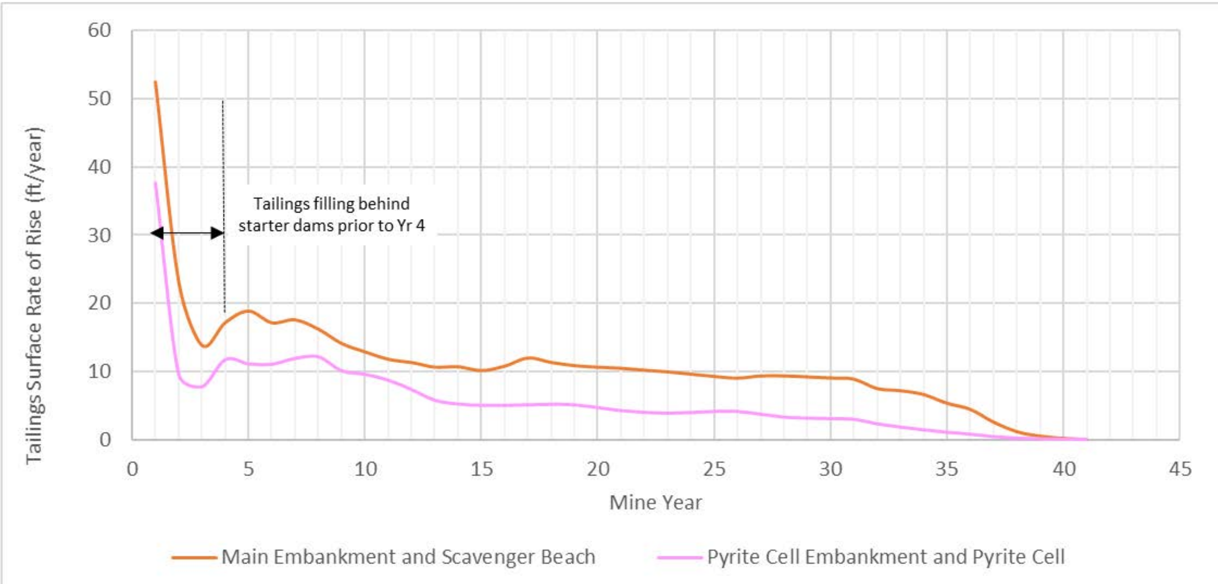


Figure II-14 Rate of Rise



REFERENCES

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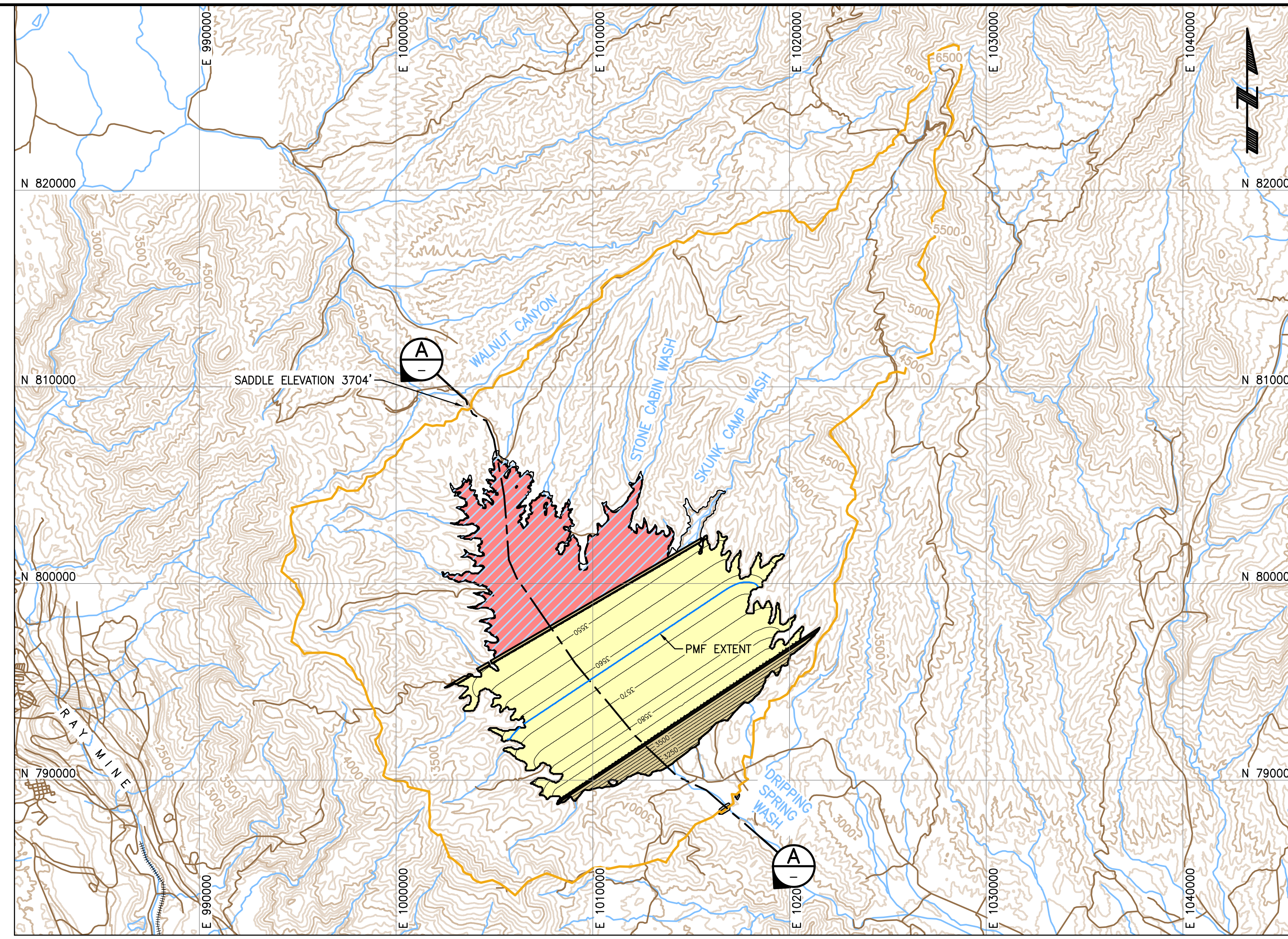
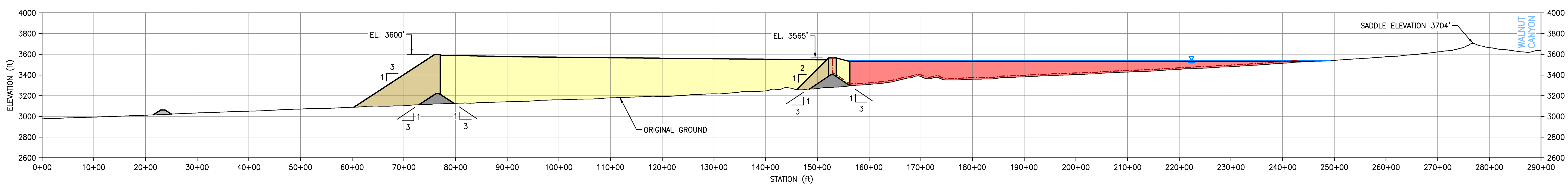
APPENDIX II-A

Ultimate Layout

Date: 2018-05-30 Time: 11:52 AM
Drawing File: Z:\M\VCR\M09441A20 - RES-Near West PFS-PES\400 Drawings\CAD\Alt 8 Skunk Camp\DEIS\FIG_II-A.1.dwg - II-A.1 (jbokic)



PLAN
SCALE A



SECTION A
SCALE B

LEGEND

- SEEPAGE COLLECTION DAM
- STARTER DAMS
- CYCLONED SAND MAIN EMBANKMENT AND PYRITE CELL EMBANKMENT
- SCAVENGER TAILINGS
- PYRITE TAILINGS
- RECLAIM POND
- ENGINEERED LOW-PERMEABILITY LAYER
- EXISTING ROAD
- RAILWAY
- MAJOR NATURAL DRAINAGE
- TSF CATCHMENT BOUNDARY

NOTES

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

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TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED: JUNE 2018

SCALE A 4000 0 4000 FT
SCALE B 1000 0 1000 FT

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PROJECT
RESOLUTION COPPER PROJECT
DEIS DESIGN FOR ALTERNATIVE 8 – SKUNK CAMP

TITLE
ULTIMATE LAYOUT

SCALE	PROJECT No.	FIG. No.
AS SHOWN	M09441A20	II–A.1

KCB-FIG-D-L

APPENDIX III

Water Balance

Resolution Copper Project

DEIS Design for Alternative 8 – Skunk Camp

Technical Memorandum

Appendix III – Water Balance

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Appendix III
Alternative 8 Skunk Camp - Water Balance

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III-1 INTRODUCTION

This appendix summarizes the preliminary water balance results for DEIS Alternative 8 – Skunk Camp Tailings Storage Facility (TSF).

The purpose of the water balance assessment is to provide inputs into the following assessments completed by others, for comparative analysis between TSF alternatives:

- site-wide water balance to estimate make-up water requirements; and
- seepage.

The scope of this work is to estimate the water flows associated with the TSF for three periods of the mine life. These periods are: production ramp-up, full-production and production ramp-down.

III-2 TSF WATER BALANCE

III-2.1 General

A water balance of the TSF was completed to estimate the water flows for three periods of the mine life; these periods are: production ramp-up, full-production and production ramp-down.

The water balance concept is shown in Figure III-1; input parameters and assumptions are summarized in Figure III-2, these are based on the design basis memorandum (DBM) in Appendix I, the tailings staging plan in Appendix II, and the seepage estimate in Appendix IV.

Key assumptions for the Skunk Camp water balance are:

- climate and hydrology inputs are estimated based on regional trends;
- the upstream catchments would be diverted around the proposed TSF as much as possible (runoff from these catchments are not included in this assessment);
- scavenger tailings would be thickened and deposited in the TSF at 60% solids content;
- tailings hydraulic properties are from the tailings characterization (KCB 2018a);
- ponding would be minimized on the scavenger beach surface and in the seepage collection pond to limit evaporation losses; and
- seepage losses are based on the assumptions presented in Section III-2.2.

III-2.2 Seepage Lost to the System Assumptions

Seepage from the TSF was separated into three areas:

1. seepage through the engineered low-permeability layer from the pyrite cell pond directly above the layer;
2. seepage through the engineered low-permeability layer from the pyrite tailings; and
3. seepage from the scavenger tailings.

III-2.2.1 Seepage from the Pyrite Pond

Seepage from the pyrite pond was conservatively assumed to be lost to the system (i.e. not collected downstream). The seepage rate was estimated using the Giroud (1997) equation for flow through a circular defect in a geomembrane liner. The estimated unit seepage flux is multiplied by the defect density and the pond area to get total seepage out of the ponds. A defect density of 4 defects per acre is assumed[1].

Giroud (1997) Unit Seepage = $C_{qo}\,[1 + 0.1(h/t_s)^{0.95}]a^{0.1}h^{0.9}k_s^{0.74}$ [in m^3/s/defect]

where:

- Cqo is 0.21 for good contact conditions between the liner and the foundation;
- h is the liquid head above the liner (m), which is taken as the height of water cover (estimated in the water balance model) divided by 2 to represent the average head above the liner;
- ts is the thickness of the soil beneath the liner (m), assumed to be 1 m (conservative value to estimate seepage, however, increasing the thickness has only a minor effect on the seepage rates at the operating pond levels);
- a is the area of the defect (m^2/defect) (assumed to be 1.03×10^{-5} m^2/defect, see footnote[2]); and
- ks is the permeability of the soil beneath the liner (m/s), assumed to be 8.2×10^{-6} cm/s based on Near West site investigation permeability estimate for Pinal Schist (KCB 2017).

The resulting flux through the engineered low-permeability layer is approximately 4×10^{-8} cm/s, which is corrected for the pyrite cell pond area over the mine life.

III-2.2.2 Seepage from the Pyrite Tailings

Seepage from the pyrite tailings was assumed to be lost to the system (i.e. not collected downstream). The flux of seepage through tailings and a low-permeability layer would be much less (orders of magnitude) than the flux from a free pond through a low-permeability layer. Therefore, the seepage flux from the pyrite tailings was assumed to be one order of magnitude less than the seepage flux estimated for the pyrite pond.

The resulting flux through the engineered low-permeability layer is approximately 4×10^{-9} cm/s, which is corrected for the pyrite tailings area over the mine life.

[1] For good installation, based on U.S. Department of the Interior Bureau of Reclamation (USBR). 2014. Design Standards No 13 – Embankment Dams. Chapter 20: Geomembranes. DS-13(20)-16 Phase 4 (Final). March.

[2] For average condition, based on U.S. Department of the Interior Bureau of Reclamation (USBR). 2014. Design Standards No 13 – Embankment Dams. Chapter 20: Geomembranes. DS-13(20)-16 Phase 4 (Final). March.

III-2.2.3 Seepage from the Scavenger Tailings

Seepage from the scavenger tailings was assumed to be collected downstream at the seepage collection pond (50%) with the rest lost to the system (i.e. not collected downstream). The seepage rate through the tailings into the foundation was assumed to be prorated, based on slurry solids contents, from the estimated infiltration for Near West Alternative 3A and Alternative 3B (KCB 2018b, KCB 2018c).

The seepage rate through the engineered low-permeability layer is approximately 0.32 gpm/acre, which is corrected for the scavenger tailings area over the mine life.

III-2.2.4 Comparison to 2D Seepage Results

The lost seepage rates estimated for the water balance are compared to the seepage rates estimated from the two-dimensional (2D) seepage assessment described in Appendix IV. Results from the water balance and 2D seepage assessment are comparable and similarly over estimated.

Table III-1 Lost Seepage Comparison

Mine Years	Water Balance Seepage Estimate			2D Seepage Assessment Lost Seepage (Appendix IV)
	Pyrite Cell Lost Seepage	Scavenger Tailings Lost Seepage	Total Lost Seepage	
	(acre-ft/yr)	(acre-ft/yr)	(acre-ft/yr)	(acre-ft/yr)
1 to 7	1	95	96	-
8 to 31	7	430	437	-
32 to 41	11	509	520	564 to 660[1]
Post-Closure	4	55	59[2]	125 to 160[1]

Note: 1. For ultimate layout using a 2D cross-section and a representative length of 15,000 ft (see Appendix IV).
2. Assumed to be 3% of precipitation over closure beach surface (3,000 acres).

III-2.3 Results

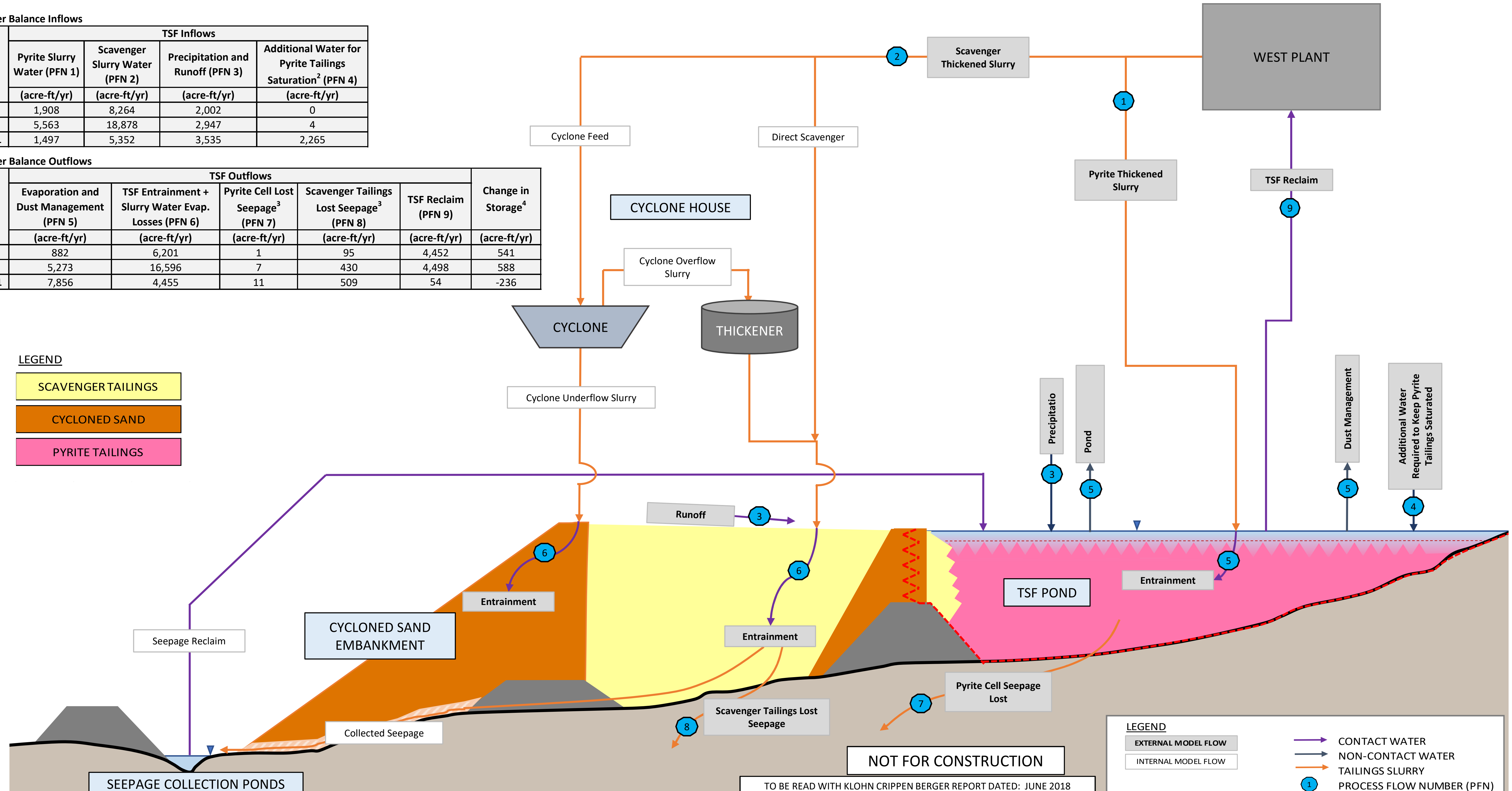
The water balance results are given on Figure III-1 and the estimated losses from the TSF system over the mine life are shown on Figure III-3.

TSF Water Balance Inflows

Mine Years	TSF Inflows			
	Pyrite Slurry Water (PFN 1)	Scavenger Slurry Water (PFN 2)	Precipitation and Runoff (PFN 3)	Additional Water for Pyrite Tailings Saturation[2] (PFN 4)
	(acre-ft/yr)	(acre-ft/yr)	(acre-ft/yr)	(acre-ft/yr)
1 to 7	1,908	8,264	2,002	0
8 to 31	5,563	18,878	2,947	4
32 to 41	1,497	5,352	3,535	2,265

TSF Water Balance Outflows

Mine Years	TSF Outflows					Change in Storage[4]
	Evaporation and Dust Management (PFN 5)	TSF Entrainment + Slurry Water Evap. Losses (PFN 6)	Pyrite Cell Lost Seepage[3] (PFN 7)	Scavenger Tailings Lost Seepage[3] (PFN 8)	TSF Reclaim (PFN 9)	
	(acre-ft/yr)	(acre-ft/yr)	(acre-ft/yr)	(acre-ft/yr)	(acre-ft/yr)	(acre-ft/yr)
1 to 7	882	6,201	1	95	4,452	541
8 to 31	5,273	16,596	7	430	4,498	588
32 to 41	7,856	4,455	11	509	54	-236



Notes:

1. See Figure III-2 for process flow summary tables and equations.
2. Additional make-up water required to maintain a minimum water cover in the Pyrite Cell to maintain saturation of the pyrite tailings.
3. Seepage estimates are discussed in the report text.
4. Change in storage reflects change in water volume stored in the Pyrite Cell Pond and Seepage Collection Ponds, and excludes water entrained in tailings.

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TITLE

OPERATIONAL WATER BALANCE SCHEMATIC AND RESULTS

SCALE	PROJECT No.	FIG No.
AS SHOWN	M09441A20	III-1

Process Flow 1 - Pyrite Slurry Water

Years	Pyrite Production[3] (million ton/yr)	Pyrite Solids Content[3] (%)	Pyrite Water Content	Pyrite Slurry Water (PFN 1) (acre-ft/yr)
1 to 7	2.7	50%	1.00	1,908
8 to 31	7.6	50%	1.00	5,563
32 to 41	2.0	50%	1.00	1,497

Slurry water is calculated based on the tailings production schedules and slurry percent solids using Equation 1 below.

$$slurry\ water\ (tons) = tailings\ mass\ (tons)\ x\ \frac{(100\% - slurry\ \%\ solids)}{slurry\ \%\ solids} \qquad \textit{(Equation 1)}$$

Process Flow 2 - Scavenger Slurry Water

Years	Thickened Scavenger[3] (million ton/yr)	Scavenger Solids Content[3] (%)	Scavenger Water Content	Scavenger Slurry Water (PFN 2) (acre-ft/yr)
1 to 7	17.2	60%	0.67	8,264
8 to 31	38.5	60%	0.67	18,878
32 to 41	10.6	60%	0.67	5,352

Process Flow 3 - Precipitation and Runoff

Years	Pond Area[4] (acre)	Total TSF Area[4] (acre)	Precipitation[3] (ft/yr)	Runoff Coeff.[1]	Precipitation and Runoff (PFN 3) (acre-ft/yr)
1 to 7	132	7701	1.58	0.15	2,002
8 to 31	846	7701	1.58	0.15	2,947
32 to 41	1289	7701	1.58	0.15	3,535

Precipitation on ponds is calculated using Equation 2 below.

$$Precipitation\ on\ Ponds = pond\ area\ x\ precipitation \qquad \textit{(Equation 2)}$$

Runoff from beach, embankment and natural ground areas is calculated using Equation 3 below.

$$Runoff = (TSF\ area\ - pond\ area)\ x\ runoff\ coeff.\ x\ precipitation \qquad \textit{(Equation 3)}$$

Process Flow 5 - Evaporation and Dust Management

Years	Evaporation[3] (ft/yr)	Pond Area[4] (acre)	Embankment Dust Mgmt Area (acre)	Evaporation and Dust Management (PFN 5) (acre-ft/yr)
1 to 7	6.0	132	15	882
8 to 31	6.0	846	33	5,273
32 to 41	6.0	1289	20	7,856

Evaporation and Dust Management is calculated using Equation 4 below.

$$Evaporation\ and\ Dust\ Management\ = (pond\ area + dust\ management\ area)\ x\ evaporation \qquad \textit{(Equation 4)}$$

Process Flow 6 - TSF Entrainment and Slurry Water Evaporation Losses

Years	Production Rates (million ton/yr)				Scavenger Seepage[2] (acre-ft/yr)	TSF Entrainment and Slurry Water Evap. (PFN 6) (acre-ft/yr)
	Cyclone Underflow	Cycloned Overflow[5]	Total Scavenger[5]	Pyrite		
1 to 7	6.0	7.1	4.1	2.7	117	6,201
8 to 31	7.8	9.2	21.6	7.6	533	16,596
32 to 41	0.8	0.9	8.9	2.0	631	4,455

Tailings Properties

Property	Cyclone Underflow	Cyclone Overflow	Total Scavenger	Pyrite
Specific Gravity[3]	2.78	2.78	2.78	3.54
Placed Dry Density (pcf)[3]	113	81	81	106
In-Situ Saturation[3]	0.5	1	1	1
In-Situ Water Content	0.10	0.41	0.41	0.31

Entrainment is calculated as the water stored in the pores of the tailings at the placed saturation using Equation 5 below.

$$water\ entrained\ in\ tailings\ (tons) = tailings\ mass\ (tons)\ x\ in\ situ\ tailings\ water\ content \qquad \textit{(Equation 5)}$$

In situ tailings water content is calculated using Equation 6 below.

$$in\ situ\ water\ content = \frac{saturation\ x\ (\frac{specific\ gravity\ of\ tailings\ x\ density\ of\ water}{dry\ density\ of\ tailings} - 1)}{specific\ gravity\ of\ tailings} \qquad \textit{(Equation 6)}$$

Total Water Entrained is the sum of water entrained in cyclone underflow, cyclone overflow, total scavenger and pyrite tailings. TSF Entrainment is then calculated using Equation 7 below.

$$TSF\ Entrainment = Total\ Water\ Entrained\ - Scavenger\ Seepage \qquad \textit{(Equation 7)}$$

Notes:
1. Runoff coefficient applies to beach, embankment and natural ground areas
2. Includes both collected and lost seepage from the scavenger tailings (see report text).
3. Values taken from DBM (Appendix I).
4. Values taken from Tailings Staging (Appendix II).
5. Slurry water within cyclone overflow and total scavenger tailings is assumed to be lost entirely to entrainment or beach evaporation. PFN 6 is calculated using the slurry water content for cyclone overflow and total scavenger tailings, and the in-situ water content for cyclone overflow and pyrite tailings.

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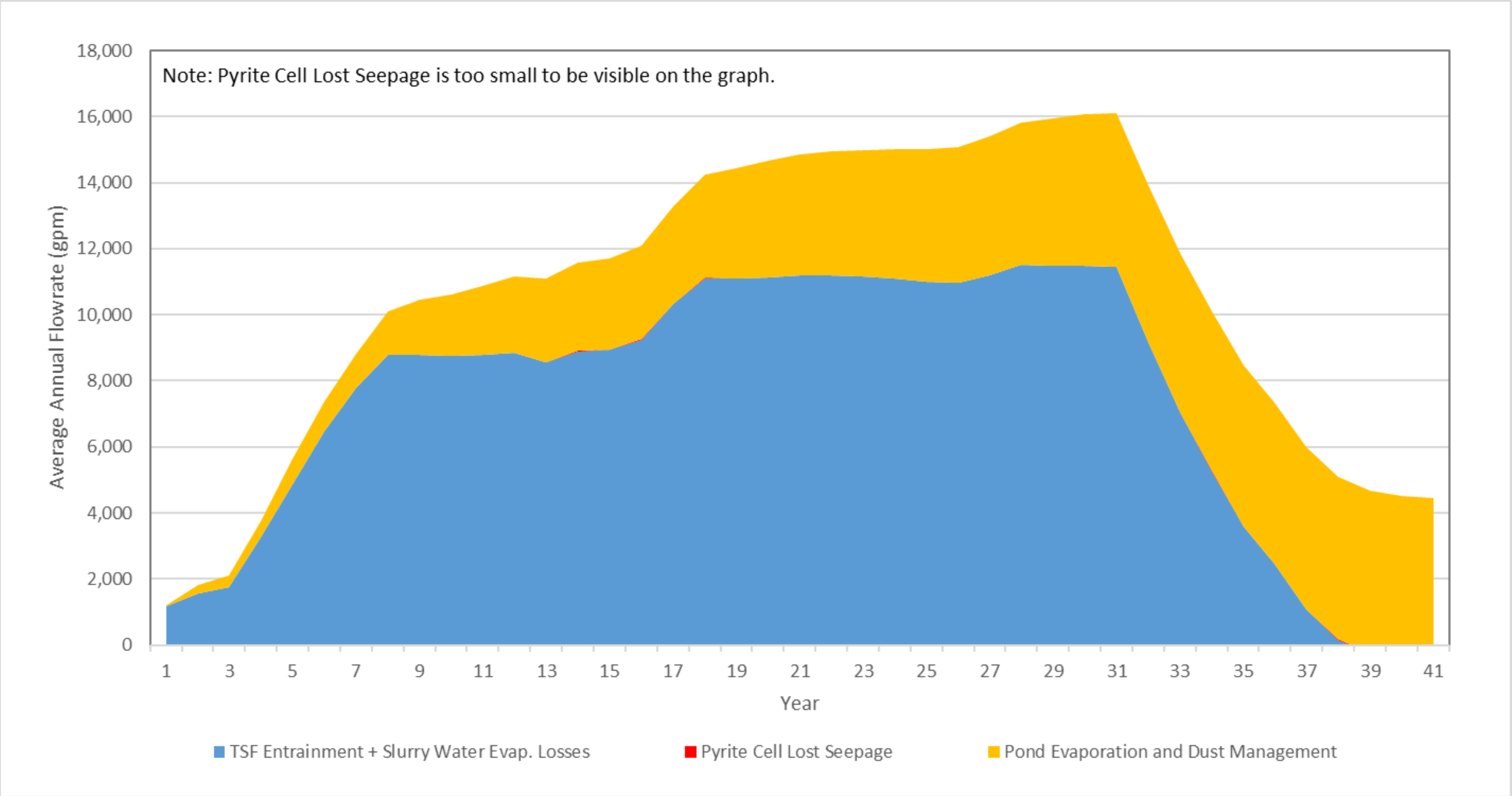
DEIS DESIGN FOR ALTERNATIVE 8 - SKUNK CAMP

TITLE: OPERATIONAL WATER BALANCE ASSUMPTIONS

SCALE: AS SHOWN | PROJECT No.: M09441A20 | FIG No.: III-2

Figure III-3 TSF System Losses during Operation



Notes:

1. Dust management losses include water applied to the unreclaimed area of the embankment.

REFERENCES

Klohn Crippen Berger (KCB). 2018a. Resolution Copper Project - Tailings Storage Facility DEIS Designs Tailings Geotechnical Characterization, Rev. 1. Prepared for Resolution Copper Mining LLC on April 25.

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 8.

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) –Rev. 0. June 8.

APPENDIX IV

Seepage

Resolution Copper Project

DEIS Design for Alternative 8 – Skunk Camp

Technical Memorandum

Appendix IV – Seepage Estimate

DISCLAIMER

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Appendix IV
Alternative 8 - Seepage Estimate

IV-1 INTRODUCTION

This appendix summarizes the simplified seepage assessment methodology and results for the Draft Environmental Impact Statement (DEIS) Alternative 8 – 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 assumed foundation conditions for the Skunk Camp site, which is based on a preliminary review of available background information, including regional geological maps, well log information for a small number of wells, and preliminary site reconnaissance visits by RC and KCB.

IV-2 HYDROGEOLOGICAL SETTING

Limited sub-surface information is available for the Skunk Camp TSF site (the Dripping Springs Wash Basin). 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.

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, the Gila Conglomerate. Alluvium is the principal aquifer for wells within the region (ADWR 2009), noted in literature as being less than 150 ft. thick. 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, or deeper, along the eastern edge of the site.

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 variable across the site, and has been noted to be less cemented at surface than the Gila Conglomerate observed at the Near West site, particularly in areas towards the north of the site.

- 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 east 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. Further assessment of this groundwater divide is required to assess the potential for TSF seepage to migrate towards the north into Mineral Creek, once the Skunk Camp TSF has been established.
- 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. Based on preliminary discussions, we understand that active dewatering is currently being undertaken in the Ray Mine open pit.

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

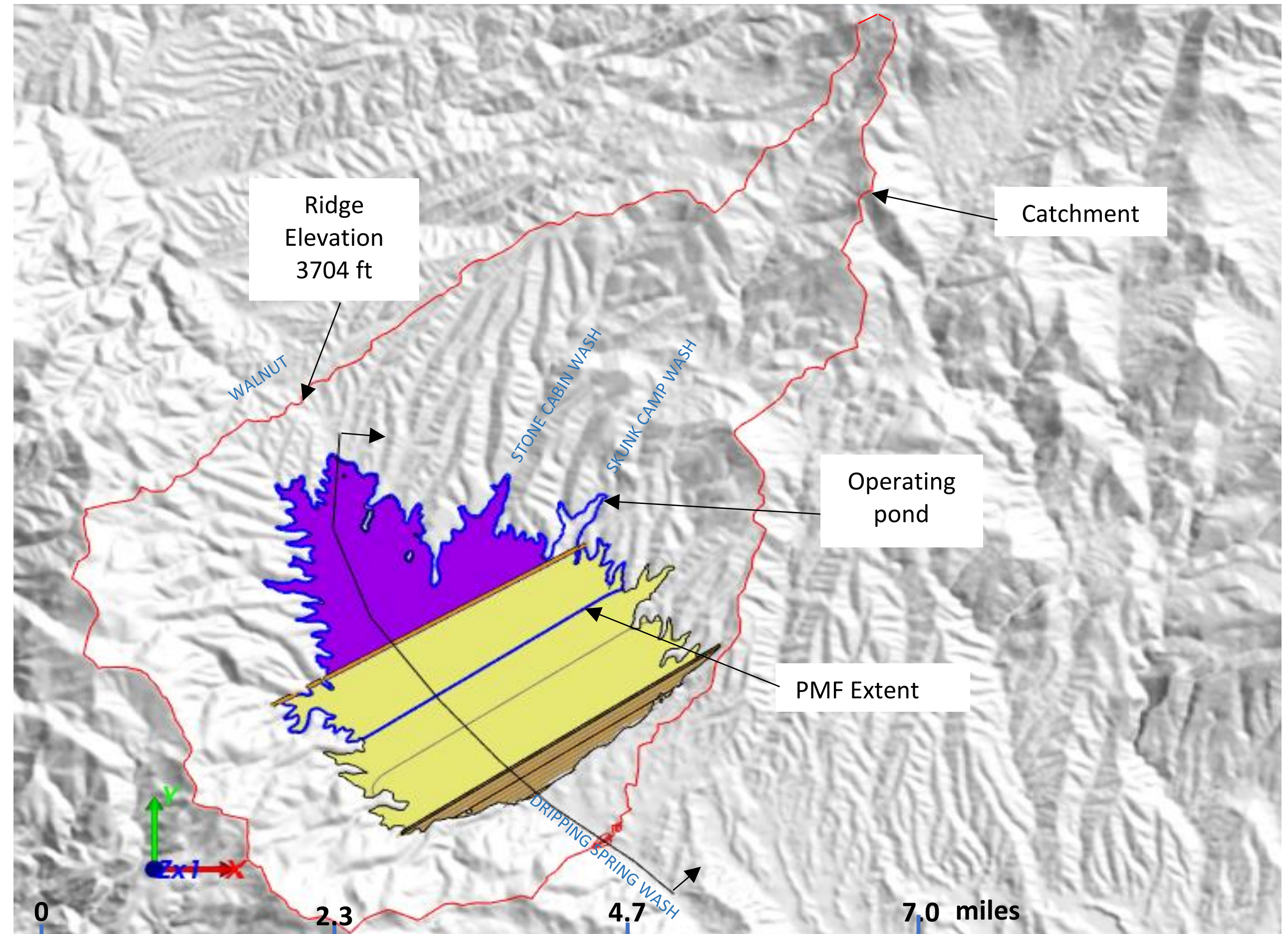
- the alluvium is the major pathway for groundwater flow, and acts as the primary aquifer in the region;
- the Gila Conglomerate at depth has a relatively low permeability compared to the alluvium and some of the other bedrock units in the area and may also act as a limited regional aquifer;
- the direction 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 and should be re-evaluated when more information on the foundation is available.

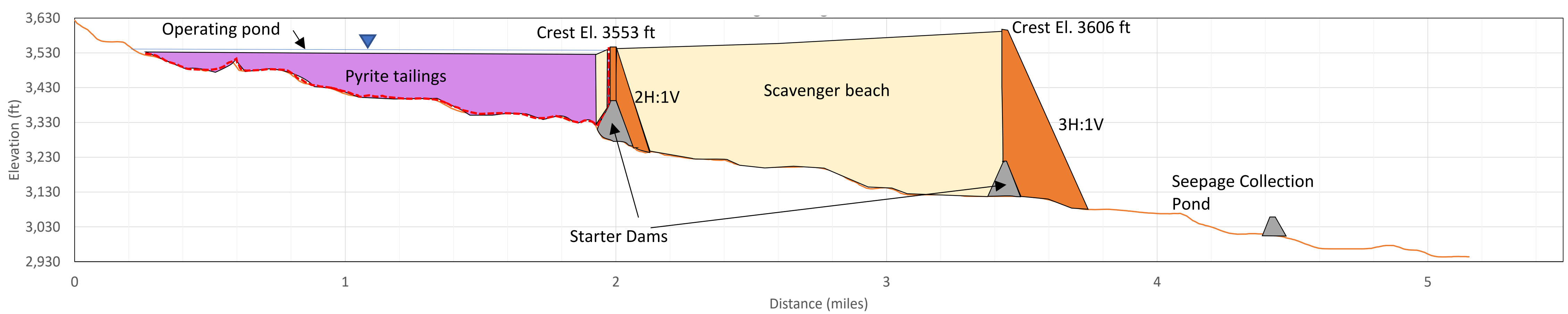
IV-3 CONCEPTUAL MODELS

Based on the hydrogeological setting described above, two conceptual two-dimensional (2D) seepage models for the basin were developed in order to undertake a preliminary estimate of groundwater seepage and to aid in locating seepage mitigation and 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 northwest to the southeast through near-surface alluvium. The steady-state condition was assumed to be applicable and conservative at this level of design; furthermore, due to limited site information a transient simulation was not undertaken.

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



PLAN VIEW



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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CLIENT	RESOLUTION COPPER / Klohn Crippen Berger
PROJECT	RESOLUTION COPPER PROJECT DEIS DESIGN FOR ALTERNATIVE 8 - SKUNK CAMP
TITLE	APPROXIMATE CONCEPTUAL SEEPAGE MODEL SECTION LOCATION
PROJECT No.	M09441A20
FIG No.	IV-1

2018-05-31
Z:\M\VCR\M09441A20 - RES-Near West PFS-PES\700 Deliverables\720 Working\780 DEIS Skunk Camp\4 - App - Seepage\FIGURES\[Figure IV-1.xlsx]Fig IV-1

IV-3.1 Operations Seepage Model

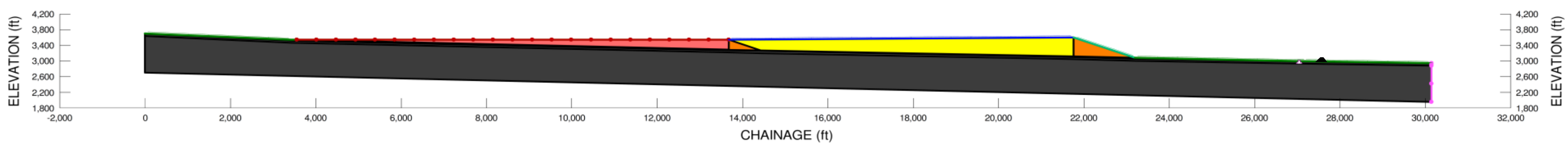
The conceptual representation of seepage during operation is presented as Figure IV-2, which shows the simplified geometry for the TSF and the boundary conditions. The conceptual model incorporates the effects of natural groundwater recharge upstream of the pyrite tailings cell (between the groundwater 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.

The foundation of the facility is assumed to be on an approximately 20 ft thick alluvium layer, which is assumed to directly overlay a 50 ft thick weathered Gila Conglomerate layer, which is assumed to overlay 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.

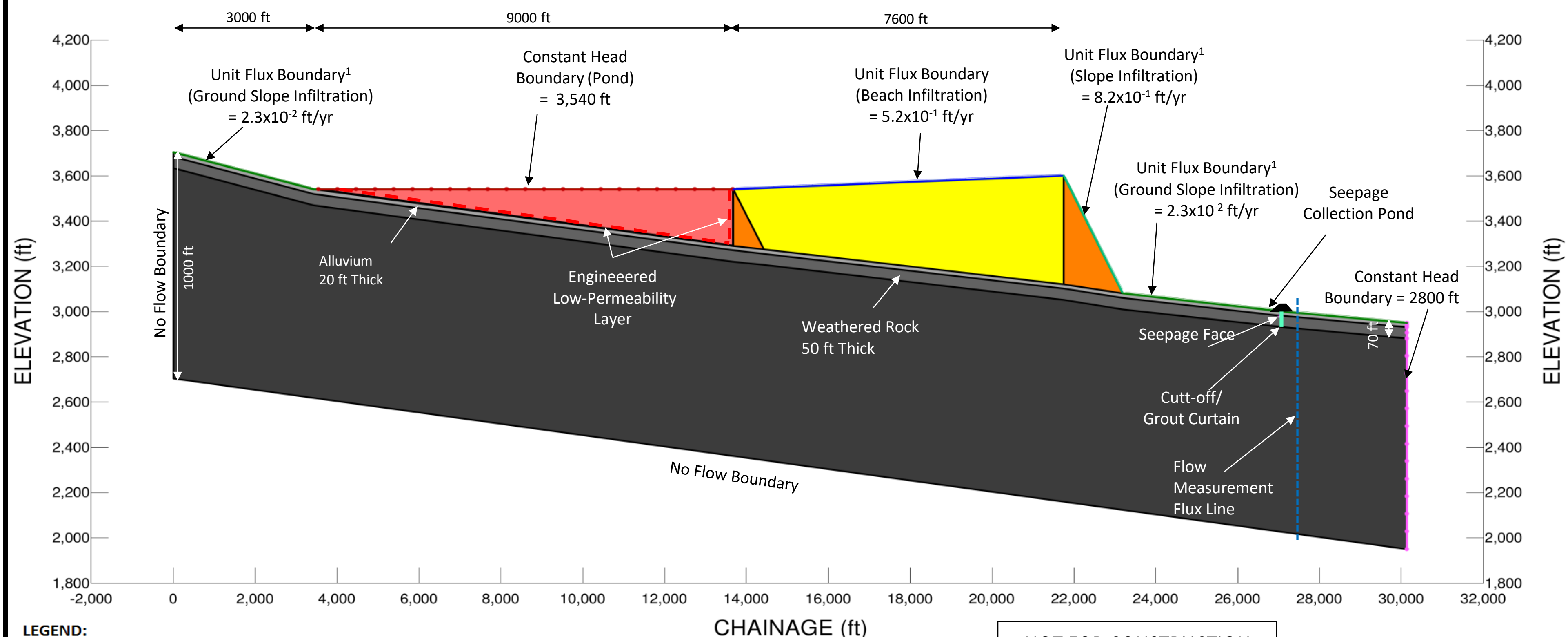
The proposed Skunk Camp TSF includes two cycloned sand embankments that separately store the scavenger tailings and pyrite tailings. Both embankments are proposed to be centerline-raised, cross-valley embankments. Uncycloned scavenger tailings and cyclone overflow would be stored behind the main embankment. 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 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 tailings for areas covered by the proposed TSF. Boundary conditions are further described in Section IV-4.2.

Natural Scale:



5x Vertical Exaggeration:



LEGEND:

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

NOTES:

1. Seepage face review allowed.

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TITLE

CONCEPTUAL SEEPAGE MODEL

OPERATIONS

PROJECT No. M09441A20

FIG No. IV-2

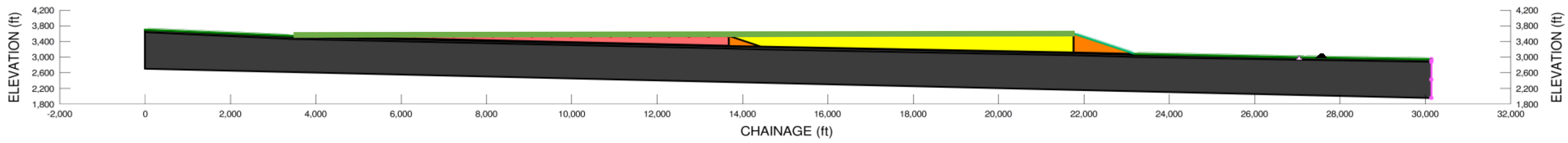
IV-3.2 Closure Seepage Model

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.

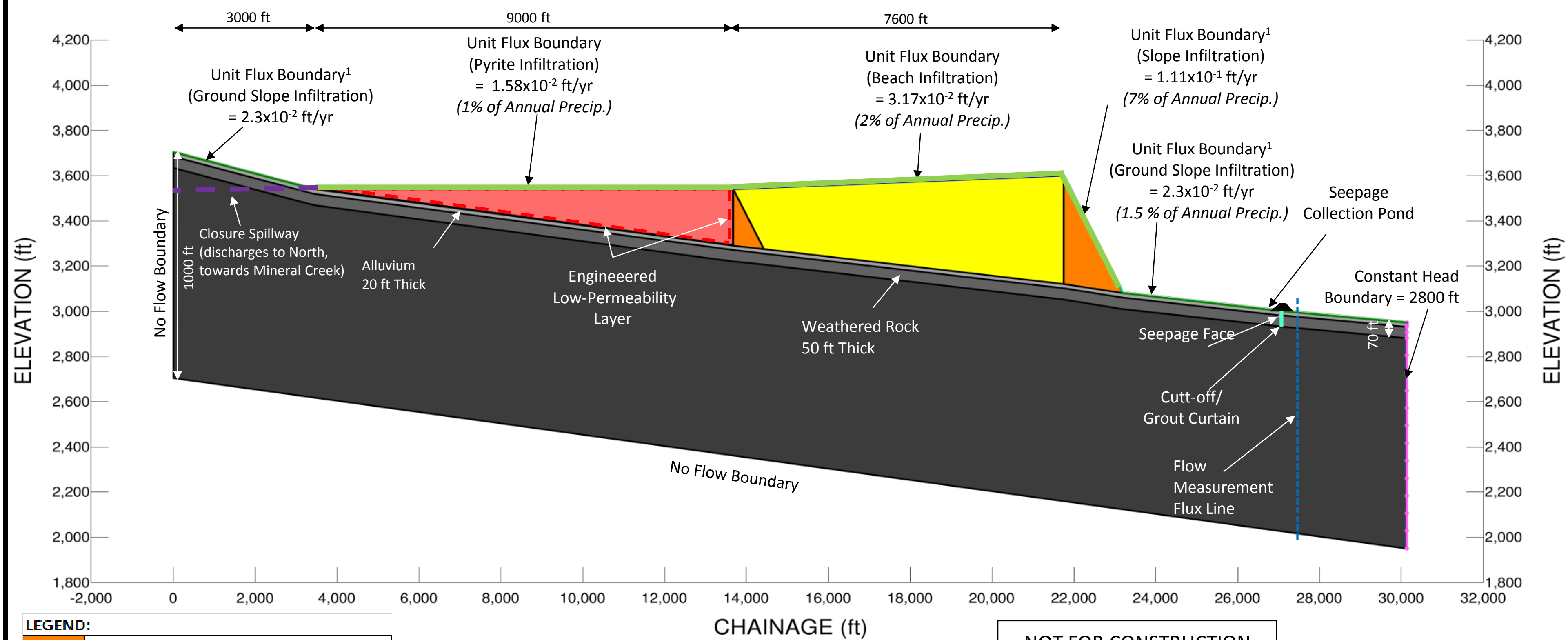
At the end of operations, the pyrite tailings cell will be covered with a layer of scavenger tailings, followed by the construction of a cover system, placed over the top of both the scavenger and pyrite impoundment surfaces. This cover would be shaped to shed water to a closure spillway, so that no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

Natural Scale:



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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	TITLE CONCEPTUAL SEEPAGE MODEL STEADY-STATE POST-CLOSURE
	PROJECT No. M09441A20 / FIG No. IV-3

IV-4 MODEL INPUTS AND ASSUMPTIONS

IV-4.1 Material Properties

The material properties for the units included in the 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
Cut-off/ Grout Curtain	--	1.0	1×10^{-6}	1	70'deep cut-off trench 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 surficial layer)	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, at depth)	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 needs to be verified during PFS.

IV-4.2 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-5 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)
Pyrite Cell Leakage	30
Scavenger Tailings Leakage	1,130
Seepage Collected at Seepage Pond	800
Flux Downstream of Seepage Dam and Grout Curtain(1)	410
Uncollected TSF Seepage(2)	350 – 410

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.

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