Resolution Copper Mining LLC

Resolution Copper Project

DEIS Design for Alternative 4 - Silver King Filtered

Doc. # CCC.03-26000-EX-REP-00006 - Rev. 0

ISO 9001
ISO 14001
OHSAS 18001

M09441A20.736

June 2018

Klohn Crippen Berger

June 4, 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 4 - Silver King Filtered -
Doc. # CCC.03-26000-EX-REP-00006 – Rev. 0

We are pleased to provide the Draft Environmental Impact Statement (DEIS) Design for the Tailings Storage Facility (TSF) Alternative 4 - Silver King Filtered design for the Resolution Copper Project.

Yours truly,

KLOHN CRIPPEN BERGER LTD.

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

KP:dl

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M09441A20.736

Resolution Copper Mining LLC

Resolution Copper Project

DEIS Design for Alternative 4 - Silver King Filtered

Doc. # CCC.03-26000-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.

RC and the Forest are 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) alternatives are currently being assessed and will be included in the draft EIS (DEIS). This report summarizes Alternative 4 – Silver King Filtered TSF.

Key elements of Alternative 4 are summarized below:

- The concentrate filter plant and loadout facility would be located at the West Plant site, just below the concentrator on the existing railhead north of U.S. 60. Pipelines for copper concentrate and filtrate water would be located within the West Plant Site.
- Two 50-railcar trains would use the MARRCO corridor twice a day to transport copper concentrate to market (concentrate loads would be transferred at Magma Junction to container cars of the Union Pacific Railroad for transport to an off-site smelter). The MARRCO corridor track would require upgrades along the entire length, bridge replacement at Queen Creek Bridge, and significant upgrades for crossing at Queen Creek, U.S. 60, SR 79, the Arizona National Scenic Trail, Hewitt Canyon Road, and other NFS roads. Water pipelines, groundwater wells, pump stations, and 12-kV power line would be included along the MARRCO corridor.
- The TSF would be located at the Silver King site which is located within the Superior Basin entirely on Forest land, approximately 1.5 miles north of the town of Superior, and 1 mile south of the Superstition Wilderness Area. It is founded primarily on bedrock with localized deposits of unconsolidated alluvium confined to ephemeral drainages. The site is primarily used for livestock grazing, ranching, and road access to recreational areas. The Arizona Trail passes through the site for 2.5 miles where it follows Whitford Canyon into Reevis Canyon. Vegetation comprises mainly desert shrubs and cacti. The TSF would occupy the lower end of Silver King Canyon in the Silver King Wash, the lower portion of Whitford Canyon (downstream of Reevis Rail Canyon and upstream of Potts Canyon) and Peachville Tank (which drains into Whitford Canyon).
- Non-potentially acid generating (NPAG) scavenger (scavenger) and potentially acid generating (PAG) pyrite (pyrite) tailings would be filtered using pressure filters at separate plant facilities located at the TSF site. Filtering would remove a significantly greater portion of water from the tailings slurry compared to thickeners and produce a material that behaves like a solid rather than a liquid.

- Filtered tailings would be conveyed from the plant to separate filtered tailings “piles” for scavenger and pyrite tailings using overland and walking-stacker conveyors and then placed by mobile earthmoving equipment.
- Non-contact water would be diverted around the tailings piles through ditches, tunnels and overland pipelines. Two earthfill diversion dams would be required upstream of the piles to attenuate flows from the large upstream catchments.
- Contact water would be shed from the tailings piles and collected in downstream external water collection facilities (lined ponds retained by earthfill dams).
- Piles would be constructed with a compacted structural zone of tailings around the perimeter to provide physical support. Compaction required would be reduced for the other portions of the piles.
- Dust would be minimized via progressive reclamation of the pile slopes, compaction of the pile surface, and, if necessary, through the use of dust suppressants or means other than surface wetting.
- Temporary slurry storage ponds would be required near the West Plant as emergency disposal locations in the event of planned or unplanned shutdowns. The slurry storage ponds would be lined and be retained by earthfill dams.
- Approximately 5.5 miles of the Arizona National Scenic Trail would need to be rerouted around the TSF.

The main perceived benefits of Alternative 4 are:

- By dewatering the tailings to low moisture contents prior to placement and minimizing evaporative surfaces, this alternative would have the lowest external makeup water requirements.
- The impact of seepage water on downstream surface and groundwater receptors is a function of both seepage water quality and volume. Placing filtered tailings partially-saturated, and shedding surface water, significantly reduces seepage into the foundation from the tailings in comparison to the same facility operated with slurry tailings and a reclaim pond.
  - However, seepage water quality from partially-saturated pyrite filtered tailings which are allowed to oxidize would be poorer than if they were stored saturated such as in the “wet” alternatives being considered. The relative impact on downstream water quality from a filtered alternative compared to a slurry alternative would be based on the benefit received from lower seepage volume, given seepage water quality would be worse.
- Placing filtered tailings in horizontal lifts allow for progressive reclamation of the slope. Filtered tailings are also placed and compacted at low moisture contents, significantly reducing the tailings draindown and settlement quantity and period. This allows filtered tailings to be reclaimed to passive closure shortly after operations.

Several key risks have been identified for Alternative 4 that should be considered when comparing alternatives. These are summarized below.

- Precedents for Scale of Filtered Tailings Operation
  - There is currently no precedent for a filtered tailings operation at the production rate, height of tailings piles required, and filtering high-pyrite content tailings as proposed for the Resolution Project. The uncertainty with this approach and inability to benchmark operations and management practices introduce significant risk and likely justify inclusion of a slurry tailings contingency.
- Processing and Transportation
  - Most filtered tailings projects have reported challenges achieving target moisture contents and throughputs from filter plants on a reliable basis, especially at start-up.
  - The rough terrain at the Silver King site poses a significant challenge for tailings conveyance to and around the tailings piles.
- Construction and Operations
  - Due to potential upsets/unreliability of the filter plant and conveyor systems (e.g. planned and unplanned downtime, unsuitable tailings moisture content and/or gradation) multiple layers of secondary storage for slurry tailings would be required.
  - At the Resolution Project's production rates, a back-up facility or stockpile that has the capacity for even 15% of the tailings would not be feasible within the current proposed disturbance footprints. Therefore, there would be significant additional disturbance on National Forest Service land.
- Surface Water Management
  - The current TSF configuration has tailings stored in large natural drainages. To manage this risk, upstream diversion dams with high capacity outlets would be required in perpetuity or until tailings are relocated.
  - Runoff and seepage contact water would be managed in large downstream collection ponds rather than within the reclaim pond of a conventional tailings impoundment. Therefore, there will be additional larger water retaining dams around the site, and increased associated disturbance on National Forest Service land.
- Dust Management
  - Walking stacker conveyors for transporting and placement of filtered tailings would require a large active placement area, which cannot be progressively reclaimed. Therefore, there will be large areas susceptible to dusting during operations.
  - Partially-saturated filtered tailings are prone to dusting and require active dust management if exposed surfaces cannot be progressively reclaimed; requiring compaction, temporary covers, and/or application of synthetic dust suppressants.

- Downstream Water Quality
  - If the pyrite tailings were filtered and stacked, they would be placed and kept in a partially-saturated state. Thus, the pyrite tailings would oxidize under wetting and drying cycles from storm events, which would generate acid rock drainage (ARD) and produce poorer water quality runoff compared to pyrite tailings stored in a saturated state (e.g. beneath a pond in a conventional facility). In a submittal to the USFS dated March 9, 2017 Resolution Copper provided a detailed technical report evaluating the chemistry of unsaturated pyrite tailings. The relative impact on downstream water quality from a filtered TSF compared to a conventional TSF would be based on the relative benefits of reduced seepage quantity from the filtered alternative to better water quality from an alternative that keeps the pyrite tailings saturated.

TABLE OF CONTENTS

TABLE OF CONTENTS
(continued)

List of Tables

List of Figures

TABLE OF CONTENTS
(continued)

List of Appendices

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.

RC submitted a General Plan of Operations (GPO) (RC 2016) 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[1] and Segregated PAG[2] Cell);
- Alternative 4 – Silver King Filtered;
- Alternative 5 – Peg Leg Lined;
- Alternative 6 – Peg Leg Unlined;

Two additional Alternatives for review and consideration by the Forest are:

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

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

KCB prepared the Alternative 2 design to support to the GPO (KCB 2014). The Silver King Filtered alternative (Alternative 4) presented herein was developed to potentially respond to issues of water use, air quality, public health and safety, and groundwater quality through the use of filtered tailings instead of thickened slurry tailings (as proposed in the modified proposed action) at an alternative location on Tonto National Forest land known as Silver King.

The scope of the Alternative 4 DEIS design is to use the referenced information to provide a basis for comparing impacts from TSF alternatives.

1.2 Key Elements of Alternative 4

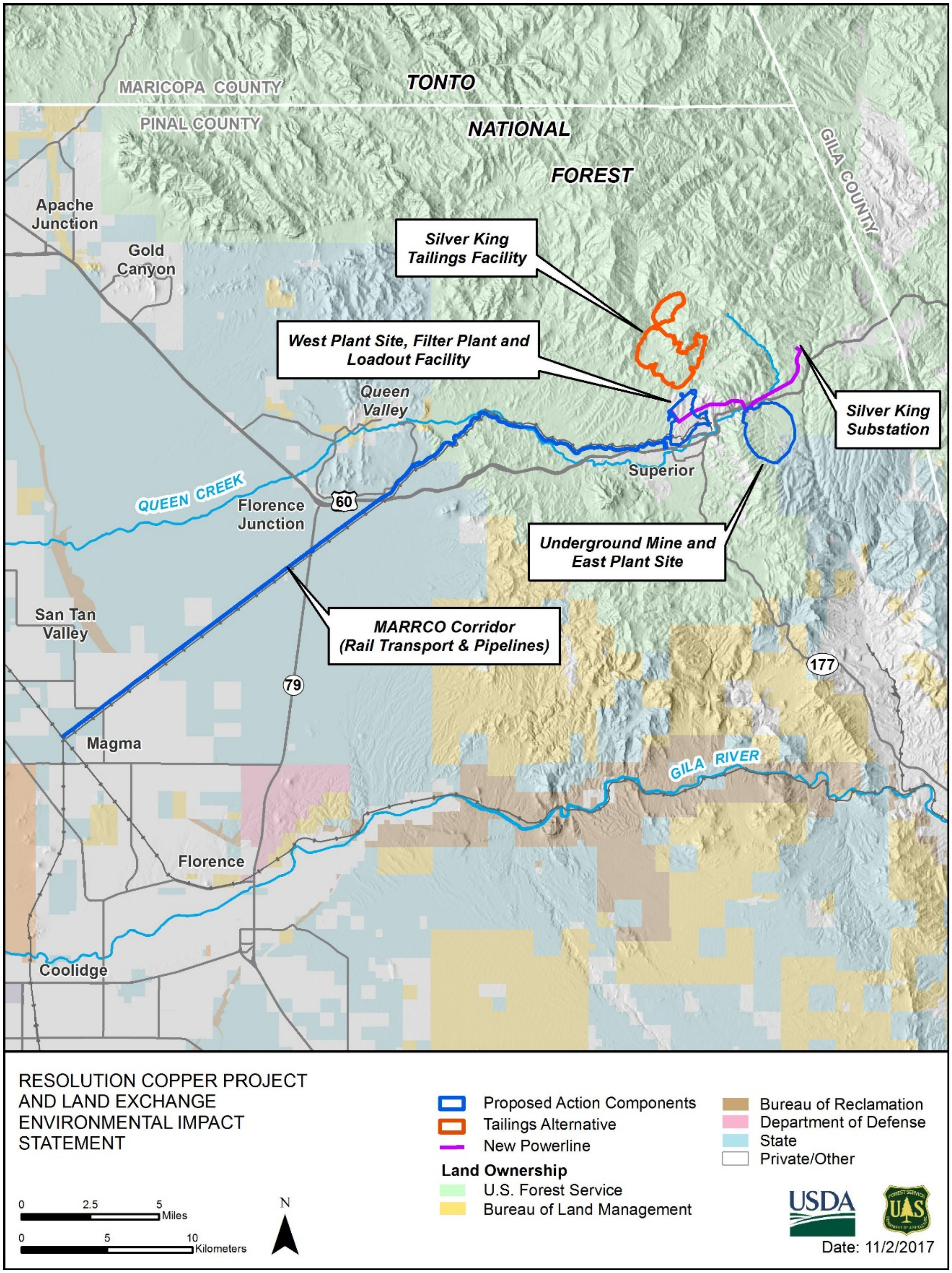
Key elements of Alternative 4 are summarized below:

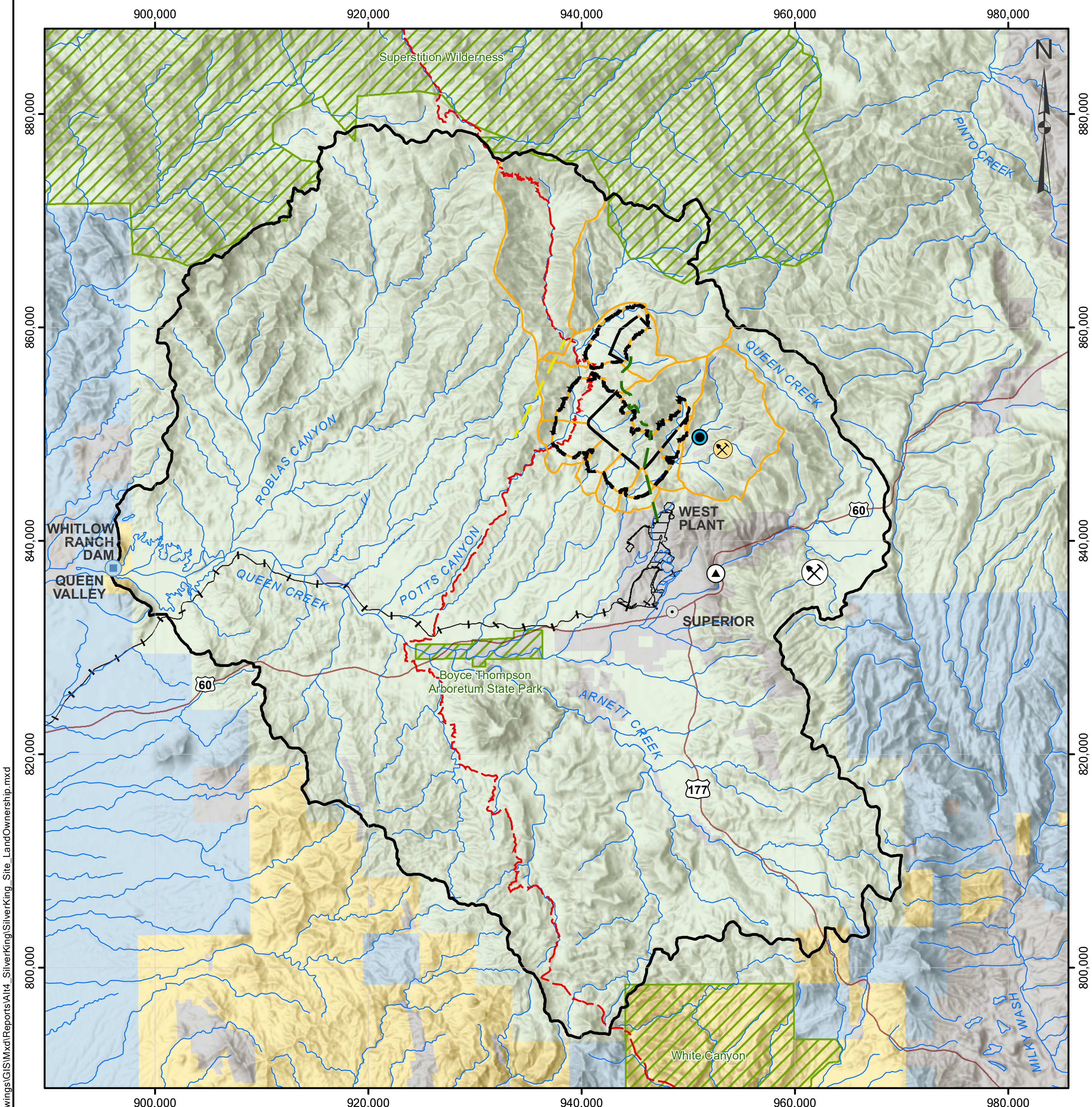
- The concentrate filter plant and loadout facility would be located at the West Plant site, just below the concentrator on the existing railhead north of U.S. 60, refer to Figure 1.1. Pipelines for copper concentrate and filtrate water would be located within the West Plant Site.
- Two 50-railcar trains would use the MARRCO corridor twice a day to transport copper concentrate to market (concentrate loads would be transferred at Magma Junction to container cars of the Union Pacific Railroad for transport to an off-site smelter). The MARRCO corridor track would require upgrades along the entire length, bridge replacement at Queen Creek Bridge, and significant upgrades for crossing at Queen Creek, U.S. 60, SR 79, the Arizona National Scenic Trail, Hewitt Canyon Road, and other NFS roads. Water pipelines, groundwater wells, pump stations, and 12-kV power line would be included along the MARRCO corridor.
- The TSF would be located at the Silver King site, occupying the lower end of Silver King Canyon in the Silver King Wash, the lower portion of Whitford Canyon (downstream of Reevis Rail Canyon and upstream of Potts Canyon) and Peachville Tank (which drains into Whitford Canyon), see Figure 1.2.
- Non-potentially acid generating (NPAG) scavenger (scavenger) and potentially acid generating (PAG) pyrite (pyrite) thickened slurry tailings would be filtered using pressure filters at separate plant facilities located at the TSF site. Filtering would remove a significantly greater portion of water from the tailings slurry compared to thickeners and produce a material that behaves like a solid rather than a liquid.
- Filtered tailings would be conveyed from the TSF filter plants to separate filtered tailings "piles" for scavenger and pyrite tailings using overland and walking-stacker conveyors and then placed by mobile earthmoving equipment.
- Non-contact water would be diverted around the tailings piles through ditches, tunnels and overland pipelines. Two earthfill diversion dams would be required upstream of the piles to attenuate flows from the large upstream catchments.
- Contact water would be shed from the tailings piles and collected in downstream external water collection facilities (lined ponds retained by earthfill dams). Treatment of this water

may be required especially for pyrite tailings contact water before being reintroduced into the process circuit.

- Piles would be constructed with a compacted structural zone of tailings around the perimeter to provide physical support. Compaction required would be reduced for the other portions of the piles.
- Dust would be minimized via progressive reclamation of the pile slopes, compaction of the pile surface, and, if necessary, through the use of dust suppressants or means other than surface wetting.
- Temporary slurry storage ponds would be required near the West Plant as emergency disposal locations in the event of planned or unplanned shutdowns of the TSF filter plants or tailings conveying systems. The slurry storage ponds would be lined and be retained by earthfill dams.
- Approximately 5.5 miles of the Arizona National Scenic Trail would need to be rerouted around the TSF.

Figure 1.1 Site Location and Land Ownership Overview





LEGEND

- RESOLUTION OREBODY
- ALTERNATIVE 4: SILVER KING TSF
- SUPERIOR BASIN
- TSF CATCHMENT
- WEST PLANT
- WILDERNESS AREA
- ARIZONA NATIONAL SCENIC TRAIL (ARIZONA TRAIL)
- TUNNEL
- SLURRY PIPELINE
- WHITLOW RANCH DAM
- TOWN
- SILVERKING MINE
- CEMETERY
- UMBRELLA CAVE
- HIGHWAY
- 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

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
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DEIS DESIGN FOR ALTERNATIVE 4 - SILVER KING FILTERED

TITLE
SITE LOCATION AND
LAND OWNERSHIP DETAILS

PROJECT No. M09441A20

FIG No. 1.2

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1.3 Previous Studies

Previous studies that are relevant to the Alternative 4 design are summarized below:

- The Alternative Portfolio for Alternative 4 (Forest 2018) provides a high-level overview of the conceptual design. This document was produced before any of the modeling or analysis presented in this report were completed.
- RC's response to the Forest's Alternatives Data Request #3 – Comment F (RC 2017) provides a summary of the challenges and risks associated with using filtered tailings as the management strategy for the Resolution Project.
- A subsurface site investigation (SI) at the nearby Near West site that included drilling and pit trenches to support the design of a Near West TSF was completed in 2016/2017. In general, the findings of the site investigation and information from the reports listed below are taken from the Near West site characterization but some of the rock units are also present at Silver King.
    - Based on the geotechnical information collected during the site investigation and subsequent laboratory testing, KCB completed a Geotechnical Site Characterization (KCB 2017a). A few of the site investigation locations are located just downstream of the Silver King site.
    - Montgomery and Associates (M&A) observed and documented the hydrogeological SI's (M&A 2017a) and completed a hydrogeological site characterization report (M&A 2017b).
    - Duke Hydrochem collected samples of foundation rock units from the SI and tested them for geochemical characterization to support solute transport modeling at the Near West site (Duke 2017a).
- An embankment design alternatives trade-off study which assessed the stability of filtered tailings piles (KCB 2017c).
- Montgomery and Associates' (M&A) hydrogeological characterization of the Silver King site and other TSF site alternatives (M&A 2012).
- Geochemical characterization of scavenger and pyrite tailings (Duke Hydrochem 2016 and 2017b).
- A site-specific seismic hazard assessment and investigation of possible faults located within the TSF footprint at the Near West site were conducted by Lettis Consultants International, Inc. (LCI) in 2017 (LCI 2017a and 2017b).

Aspects of all these studies are discussed in this report. Reference should be made to the original reports for further information.

2 SITE CHARACTERIZATION

2.1 Setting & Topography

The Silver King site is in the Superior Basin, which is drained by Queen Creek to the Whitlow Ranch Dam, refer to Figure 2.1. The Superstition Mountains to the north of site separate the site from the Superstition Wilderness Area.

The site is within the Basin and Range physiographic zone of Arizona (see Figure 2.2), near its northern boundary with the Central Highlands Transition physiographic zone, marked by the southern edge of the Superstition Mountains (Trapp and Reynolds 1995). The Basin and Range province is characterized by broad basins trending northwest-southeast, bounded by isolated mountain ranges composed of fault-block mountains formed during extensional faulting and crustal thinning (Rasmussen 2012). 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. The Superior area is the northernmost extent of the Basin and Range province (Trapp and Reynolds 1995).

The Silver King site is founded on predominantly bedrock on the foothills of the Superstition Mountains. The filtered tailings piles are located in two major drainages: Whitford Canyon and Silver King Wash (see Figure 2.1). Both drainages drain towards Queen Creek. The drainages are separated by Peachville Mountain which rises up to 2,000 ft above the drainage bottoms. A number of small ephemeral drainages flow from Peachville Mountain to Whitford Canyon and Silver King Wash, or south into Happy Canyon.

Within the TSF area, all drainages are ephemeral, the bases of which are infilled with sand and gravel alluvial deposits.

2.2 Land Use

The land management status for the Silver King site and surrounding area is shown on Figure 1.2. The site is entirely on US Forest Service Land. Other key aspects with respect to existing land use, include the following:

- The Arizona Trail passes through the Silver King site for approximately 2.5 miles where it follows Whitford Canyon into Reevis Rail Canyon (shown on Figure 2.1). Approximately 5.5 miles of the trail would need to be rerouted to avoid the TSF.
- A cemetery associated with the mine is about 500 ft downstream of the proposed toe on the west side of Silver King Wash, 600 ft upstream of the confluence with Comstock Wash.
- The site is primarily used for livestock grazing, ranching and road access to recreational areas. Vegetation comprises mainly desert shrubs and cacti.

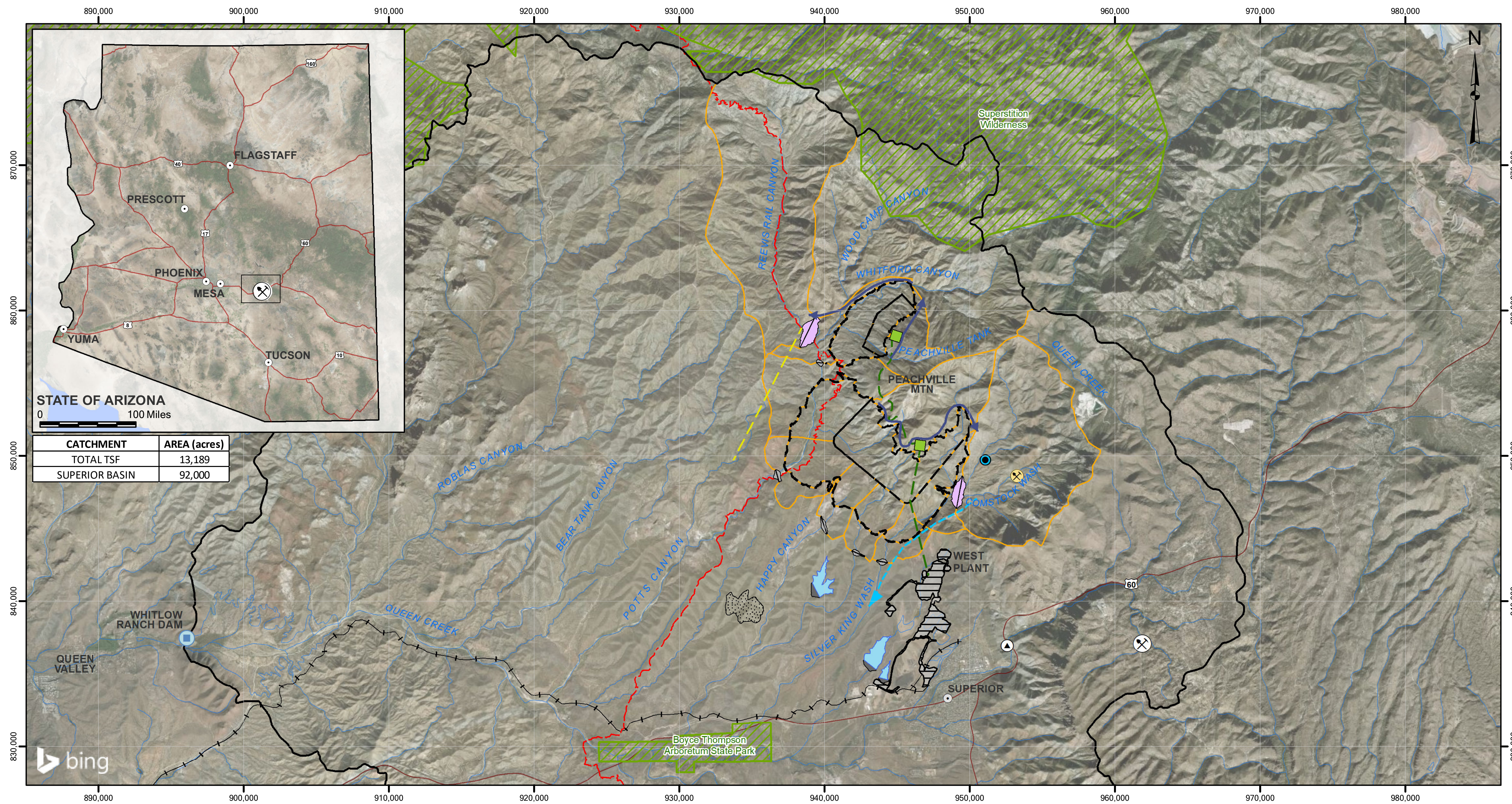
Historically mining and exploration has taken place within and near the proposed Silver King TSF. The Silver King Mine is 0.7 miles to the east of the site, and is reported to have flooded underground workings to depths of up to 1,000 ft, and lateral extents of up to 200 ft (Short et. al 1943). None of these workings are expected to extend within the footprint of the TSF. The TSF would cut off the northern portion of the Silver King Mine Road, which follows Silver King and Comstock Washes, and is the main southern access route to the mine area (see Figure 2.3).

Several isolated claims, exploration shafts, and small mines are shown around Peachville Wash see Figure 2.3:

- Silverona Mine – located in the headwaters of Peachville Wash in Pinal Schist;
- Fortuna Mine – located in the headwater of Fortuna Wash at northern contact of quartz diorite;
- Black Eagle Mine – located north in quartz diorite; and
- Unnamed Mine – located in Peachville Wash.

The McGinnel Claim is located at the intersection of Main and Concentrator Faults ½ mile north of Silver King Wash, within the footprint of the scavenger tailings pile.

Abandoned mine workings within the TSF footprint could potentially impact the TSF by collapsing under the tailings piles. The existence and extent of mine workings within the TSF footprint would need to be investigated further.



CATCHMENT	AREA (acres)
TOTAL TSF	13,189
SUPERIOR BASIN	92,000

LEGEND

- RESOLUTION OREBODY
- ALTERNATIVE 4: SILVER KING TSF
- EXTERNAL WATER COLLECTION DAM
- UPSTREAM DIVERSION DAM
- BORROW AREA
- DIVERSION
- PIPELINE
- TUNNEL
- SLURRY AND WATER PIPELINE
- WEST PLANT
- FILTER PLANT

EMERGENCY SLURRY STORAGE FACILITY

- SLURRY POND
- SLURRY POND DAM
- TSF CATCHMENT
- SUPERIOR BASIN
- WILDERNESS AREA
- WHITLOW RANCH DAM
- SILVER KING MINE
- CEMETERY
- UMBRELLA CAVE
- TOWN
- HIGHWAY
- ARIZONA NATIONAL SCENIC TRAIL (ARIZONA TRAIL)
- RAILWAY
- RIVER OR MAJOR DRAINAGE

NOTES:
1. NAD83, ARIZONA STATE PLANE CENTRAL
2. IMAGERY PROVIDED BY ESRI/BING AERIAL IMAGERY
3. WATERSHEDS PROVIDED BY NATURAL RESOURCE CONSERVATION SERVICE.

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PROJECT
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DEIS DESIGN FOR ALTERNATIVE 4 - SILVER KING FILTERED

TITLE
SITE LOCATION DETAILS

PROJECT No. M09441A20

FIG No. 2.1

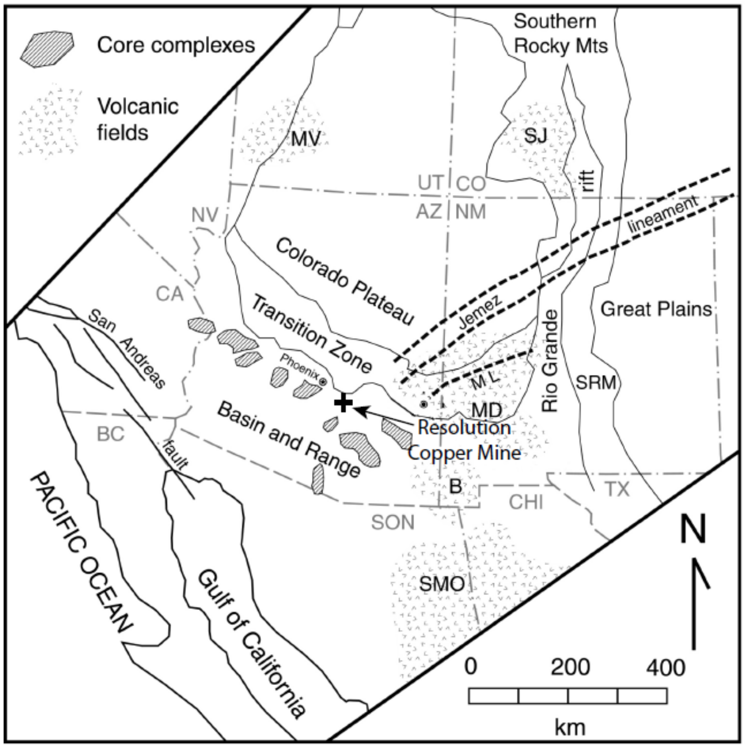
2.3 Seismicity

The Silver King site is located in an area of low historic seismicity (LCI 2017); 17 earthquakes within 124 mi (200 km) are part of the seismic record that dates back to 1830. Only five of the recorded earthquakes have had a moment magnitude greater than 5. None of the recorded earthquakes have had a moment magnitude greater than 6.

No site-specific seismic hazard assessments have been carried out for the Silver King site to date, however, the results of the Near West seismic hazard assessment (LCI 2017) can be used as a reasonable analogue at this stage of study (Near West is approximately 5 miles southwest of Silver King) and the similarity of rock types exposed. The study calculated peak ground accelerations (PGA) 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 (~250 miles from Silver King, see Figure 2.2) influences the hazard for longer periods similar to the period of most large earthfill structures. Earthquake design ground motions would be selected for appropriate return period events.

The Silver King site sits across the mapped Concentrator, Main and Conley Springs faults (Figure 2.3). These faults are not believed to have been active within the Quaternary period (2.6 Ma to present) (LCI 2017). Regional scale mapping of faults was carried out by Spencer and Richards (1995) and Peterson (1969) (Figure 2.3). More detailed mapping has been carried out by 4D Geo (4D Geo 2017), confirming the presence of the faults and refining the understanding of past movements.

Figure 2.2 Regional Seismic Zone (URS 2013)



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

2.4 Regional Geology

The oldest rocks exposed in the Silver King area are facies of the early Proterozoic Pinal Schist (1.7 Ga), which forms the regional basement (Spencer and Richard 1995). West of the site most of the Schist is pelitic, with compositional banding reflecting a combination of metamorphic differentiation and original bedding. The planar fabric typically dips between 25 degrees and 60 degrees to the southeast (Spencer and Richard 1995). Schist facies in the center of the site are mapped as undifferentiated, but are likely also pelitic (Peterson 1969).

Pinal Schist is disconformably overlain by the middle Proterozoic Apache Group (1.4 Ga to 1.1 Ga), comprising Pioneer Shale, Dripping Spring Quartzite, and Mescal Limestone. Apache Group rocks are highly fractured and in places brecciated as a result of distributed extensional deformation during the Tertiary (21 Ma to 19 Ma; Spencer and Richards 1995). During the middle Proterozoic (~1.1 Ga), the Apache Group was intruded by diabase, causing contact metamorphism. Diabase generally intrudes along sills; however, it is extensive throughout the Apache Group (Hammer and Webster 1962). The Apache Group is depositionally overlain by Paleozoic rocks including various quartzite and limestone units (Spencer and Richards 1995); of this group, only Bolsa Quarzite is mapped within the footprint of the Silver King site. No rocks with ages between the Mississippian (350 Ma) and the middle Tertiary (34 Ma) are found in the area except Laramide granitic intrusives: Cretaceous (146 Ma to 66 Ma) quartz diorite is present on the eastern edge of the TSF footprint. Tertiary granite is found northwest of the TSF footprint.

Tertiary age extensional faulting was accompanied by the deposition of middle Tertiary age volcanic tuffs and flows, including Apache Leap Tuff (21 Ma to 19 Ma: Dickinson 1991), poorly welded Tuff, Rhyolite, and Basalt. These units are not typically found at the surface beneath the TSF footprints, but are more extensive farther south, in the area of external water collection and slurry ponds. Tertiary Gila conglomerate and sandstone overlie the volcanics, except at the contact of these units, where they are locally interbedded. These units are also present to the south of the TSF footprints.

2.5 Site Geology

2.5.1 Data Sources

Data on the site geology are available from the following sources:

- Regional geological mapping by Spencer and Richards (1995) and Peterson (1969).
- Reconnaissance hydrogeological mapping by M&A (2012).
- Structural mapping by 4D Geo (2017).

Supplementary data are available from the Near West site characterization report (KCB 2017a) due to the proximity of Near West to the Silver King site (5 miles southwest) The bedrock geology of the Near West and Silver King sites generally comprises similar rock units.

2.5.2 Foundation Geology

The footprint of the pyrite tailings pile is located mostly on Pinal Schist, locally covered by Quaternary deposits, including colluvium, towards the toe of the facility.

The footprint of the scavenger embankment is located over a complex geological sequence including Pinal Schist, Apache Group units, localized areas of Bolsa Quartzite from the Paleozoic units, localized areas of Tertiary volcanics, and a cover of Quaternary sediments and alluvium in the drainages. An extensive region of Quartz Diorite is located in the northeastern corner of the embankment. The remainder of this pile is founded on Pinal Schist.

The external water collection ponds to the south of the scavenger tailings pile are founded on either Tertiary Gila Conglomerate or Tertiary Tuff. The pond located to the west is founded on quartzite units from the Apache Group, and the pond to the west of the pyrite pile is founded on a combination of landslide deposits and Pinal Schist.

The upstream diversion dam to the west of the pyrite tailings pile is founded on a combination of Tertiary Granite, Pinal Schist and Quaternary sediments, and the diversion dam to the east of the scavenger pile is founded on a variable combination of Pinal Schist, Proterozoic Diabase and Cretaceous Quartz Diorite.

The slurry ponds to the south of the scavenger pile are mostly founded on Gila Conglomerate.

2.5.3 Faults

Mapping by Spencer and Richards (1995) and Peterson (1969) show the following faults:

- Conley Springs, Main, and Concentrator Faults underlie the facilities, with several major fault intersections within the footprints.
  - Conley Springs fault dips to the northeast at 70 degrees.
  - Main fault dips southeast at 55 to 85 degrees.
  - Concentrator fault dips southwest at 65 degrees.

These faults are not considered potential sources of seismicity because they are not thought to have been active throughout the Quaternary Period (LCI 2017). These faults are also not thought to represent preferential flow paths because they are typically considered to be healed and represent low permeability boundaries (M&A 2012). Based on this, these faults are not currently considered problematic for the TSF development.

2.5.4 Engineering Considerations

The main design considerations from this desktop review are:

Potentially Weak Units

- Pinal Schist may have reduced strength along foliations, and foliation direction appears adverse at the southeast margin of the TSF. Weakness in the Pinal Schist is also apparent from the presence of landslide deposits originating from this unit towards the toe of the pyrite pile. Weak regions of Pinal Schist and adverse structural orientation may require localized buttressing and/or excavation and replacement with shear keys.
- Landslide deposits are also likely to require excavation.
- Tertiary Tuff may be weathered to clay with reduced strength in Happy Camp Canyon. Weathered tuff also has a potential to develop a metastable structure that can collapse on wetting. As a result, weathered tuff will require stripping if it is found at the toe of the scavenger pile and beneath external water collection ponds.
- Quaternary alluvium and landslide deposits could contain loose granular deposits that are potentially susceptible to liquefaction. It is likely that any granular material beneath the embankments would be stripped for use in underdrains; therefore, no additional mitigations have been considered for these units.

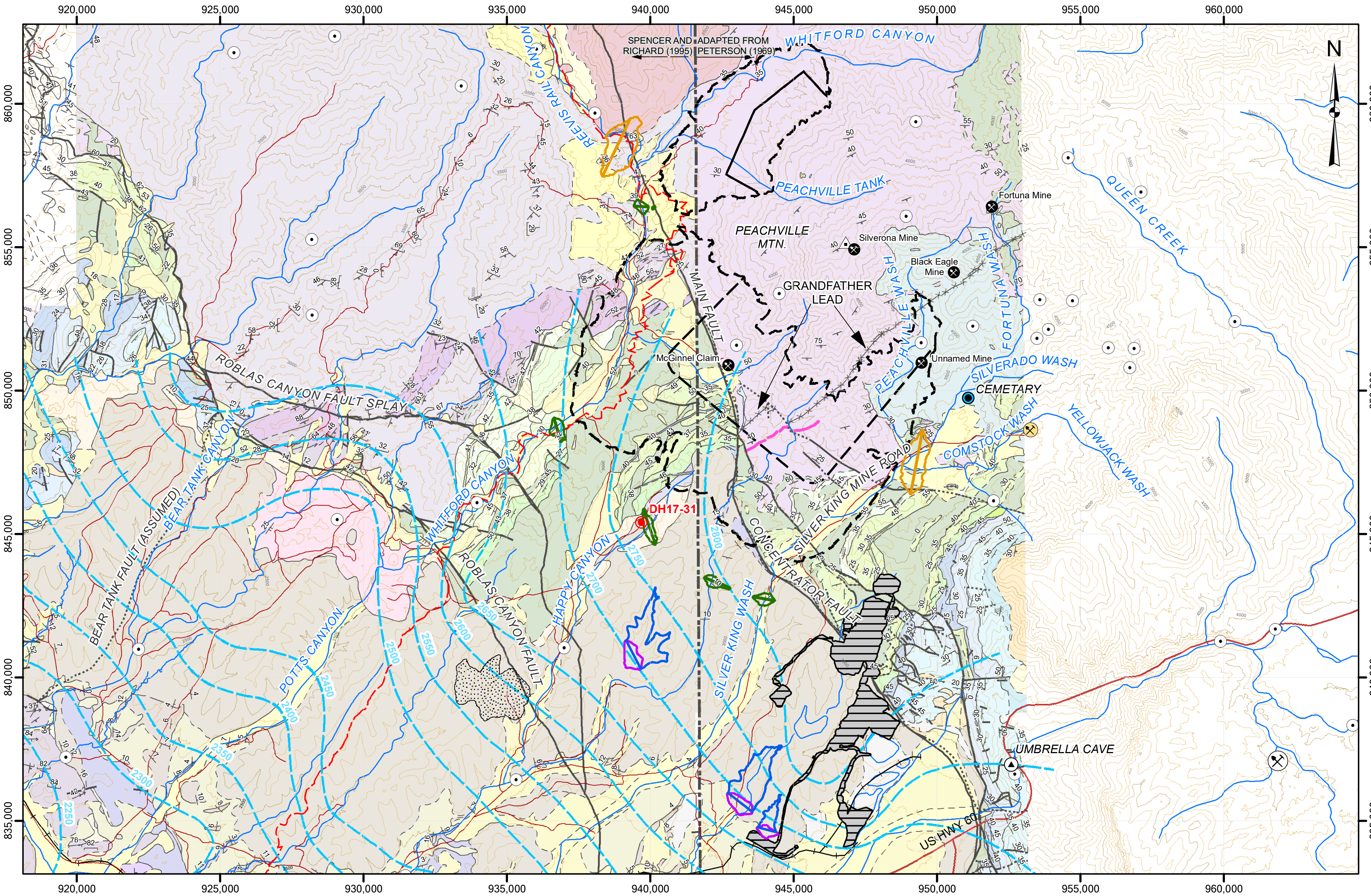
High Permeability Units

- There are several potentially high permeability foundation units including:
  - Quaternary sediments
  - Tertiary Gila Conglomerate
  - Tertiary Tuff

  - Bolsa Quartzite
  - Mescal Limestone, and
  - Dripping Spring Quartzite
- Because the tailings are filtered and seepage from the piles is likely to be low, it is assumed for this stage of design that no additional seepage control measures will be required beyond the underdrain system beneath the embankment. The need for additional seepage control would be investigated.

Potential for Dissolution Features

- Several limestone units exist in the region. Only the older Apache Group Mescal Limestone is present at the surface beneath the scavenger pile; however, the Devonian Martin, Carboniferous Naco and Mississippian Escabrosa are present in the area and could underlie the diversion dams, slurry ponds and external water collection dams at depth. Due to the limited extent of these units beneath the facilities, it is currently assumed that any existing dissolution features are isolated and could be identified and treated before construction (e.g. using geophysics). It is also assumed that any seepage resulting from the filtered tailings pile would be insufficient to develop additional dissolution.



GEOLOGICAL UNITS

QTls	Older Landslide Deposits (Quaternary or Tertiary)
Qs	Undivided Surficial Deposits (Quatenary)
Qtd	Disturbed Surficial Deposits (Holocene)
Qtc	Talus and Colluvium (Quaternary)
Qal	Unconsolidated Alluvium (Quaternary)
Qoa	Old Alluvium (Quaternary)
QTs	Older Alluvium (Early Quaternary to Late Tertiary)
Tcg	Conglomerate (Pliocene to Late Miocene)
Tss	Sandstone (Pliocene to late Miocene)
Tb	Basalt (Mid-Miocene to Early Miocene)
Tp	Perlitic Aphyric Rhyolite (Middle Tertiary)
Tal	Apache Leap Tuff (Early Miocene)
Tt	Tuff (poorly welded) (Miocene)
Tf	Felsic Volcanic Rocks, undivided (Middle Tertiary)
Tda	Aphanitic Felsic to Intermediate Dikes (Middle Tertiary)
Tfa	Andesitic Volcanic Rocks (Middle Tertiary)
Tdf	Felsic Dikes (Middle or Early Tertiary or Cretaceous)
Tg	Granite (Middle Tertiary)
Tbl	Lower Basalt (Middle Tertiary)
Tx	Rock Avalanche or Talus Breccia (Middle Tertiary)
Tw	Whitetail Conglomerate
Tdb	Basaltic Dikes (Middle Tertiary)
Kqd	Quartz Diorite (Cretaceous)
Me	Escabrosa Limestone (Mississippian)
Pn	Naco Limestone (Carboniferous)
Dm	Martin Limestone (Devonian)
Cb	Bolsa Quartzite (Cambrian)
Yd	Diabase (Middle Proterozoic)
Ym	Mescal Limestone (Middle Proterozoic)
Yb	Basalt (Middle Proterozoic)
Yds	Dripping Spring Quartzite, undivided (Middle Proterozoic)
Ydsu	Dripping Spring Quartzite, Upper Unit (Middle Proterozoic)
Ydsl	Dripping Spring Quartzite, Lower Unit (Middle Proterozoic)
Yp	Pioneer Shale (Middle Proterozoic)
Ypt	Pioneer Shale, Tuff Unit (Middle Proterozoic)
YXd	Diorite (Early or Middle Proterozoic)
Xp	Pinal Schist, undivided (Early Proterozoic)
Xpc	Pinal Schist, Calc-silicate Facies (Early Proterozoic)
Xpcs	Pinal Schist, Calc-silicate and Schist Facies (Early Proterozoic)
Xpm	Pinal Schist, Psammite Facies (Early Proterozoic)
Xpp	Pinal Sctist, Phyllite Facies (Early Proterozoic)
Xpq	Pinal Schist, Quartzite Layers (Early Proterozoic)
Xps	Pinal Schist, Pelitic Schist (Early Proterozoic)

LEGEND

- RESOLUTION OREBODY
- SILVERKING MINE
- ABANDONED MINE OR CLAIM
- GEOTECH DRILLHOLE
- SPRING
- BEDDING
- FOLIATION
- ALTERNATIVE 4: SILVER KING TSF
- WEST PLANT
- EXTERNAL WATER COLLECTION DAM
- UPSTREAM DIVERSION DAM
- BORROW AREA

EMERGENCY SLURRY STORAGE FACILITY
- SLURRY POND
- SLURRY POND DAM

TRANSPORTATION
- ROAD
- HIGHWAY
- ARIZONA NATIONAL SCENIC TRAIL (ARIZONA TRAIL)

- FELSIC DYKE
- FAULT
- FAULT - APPROXIMATE
- FAULT - CONCEALED
- MARKER HORIZON (LOCAL)
- QUARTZ VEIN
- CONTACT (BETWEEN GEOLOGIC UNITS)
- CONTACT - APPROXIMATE
- CONTACT - INFERRED
- GROUNDWATER LEVEL CONTOURS
- CONTOUR (100ft)
- CONTOUR (500ft)

NOTES:
1. NAD83, ARIZONA STATE PLANE CENTRAL
2. REFER TO REPORT FOR SOURCE OF GEOLOGY
3. GROUNDWATER CONTOURS AND SPRING LOCATIONS ACQUIRED (MARCH 16, 2018). PROVIDED BY MONTGOMERY & ASSOCIATES. CONTOURS BASED ON STABALIZED GROUNDWATER LEVELS IN THE AREA.

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PROJECT
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DEIS DESIGN FOR ALTERNATIVE 4 - SILVER KING FILTERED

TITLE
SITE GEOLOGY

PROJECT No. M09441A20
FIG No. 2.3

Z:\M\VCR\M09441A20 - RES-Near West PFS-PES\400 Drawings\GIS\Mxd\Reports\Alt4_SilverKing\SilverKing_Site_Geology.mxd 2018-05-30 12:29:17 PM

2.6 Site Hydrogeology

The regional groundwater flows from northeast to southwest, draining to Potts Canyon or Queen Creek. The predicted regional groundwater contours are shown on Figure 2.3 (developed by M&A).

As noted in Section 2.3, the facility sits across the Concentrator, Main and Conley Springs faults. These faults are perpendicular to the regional groundwater flow, and are likely barriers to flow, causing higher groundwater levels to the northeast of the faults. Once the TSF is built, the south-east portion of the embankment may induce seepage flow to the southeast, parallel to the faults. Shallow groundwater is encountered in wells just up gradient of the faults (M&A 2012). Springs downstream of the facility in Gila Conglomerate are likely related to sub-horizontal bedding planes and are not likely connected to the regional groundwater system (M&A 2012).

Drill hole DH17-31 (GT-34) (KCB 2017a) is located in Happy Canyon, within the footprint of the external water collection dam (see Figure 2.3), and showed permeabilities of 10^{-4} cm/s to 10^{-5} cm/s in Gila Conglomerate and up to 10^{-1} cm/s in Mescal Limestone. Drill holes in Gila Conglomerate downstream of Silver King showed permeabilities of up to 10^{-4} cm/s cm/s to depths of several 100 ft, which differs from Near West. Apache Leap Tuff is also present and has permeabilities of 10^{-4} cm/s.

2.7 Climate and Hydrology

The Silver King site is within a semi-arid climate zone with low average annual precipitation (18 inches) and high estimated average annual potential evapotranspiration, or PET (72 inches). The annual average temperature is 69°F and daily temperatures typically range from 40°F to 100°F.

The region experiences three seasonal types of precipitation event (Applied Weather Associates 2013), comprising the following:

- 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 tropical storms and typhoons and are typically moderate duration (~24 hrs), high intensity events.

Storm events depths were taken from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 and 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 Whitford Canyon, Happy Camp Canyon and Silver King Wash towards Queen Creek in the south. These drainage valleys are ephemeral streams that are typically dry, but are locally fed by springs Two mapped springs within the Pinal Schist are located within the footprint of the scavenger tailings pile, refer to Figure 2.3.

3 TAILINGS CHARACTERIZATION

3.1 Tailings Types

The Resolution project would generate two physically, mineralogically and geochemically discrete tailings streams known as scavenger tailings and pyrite tailings[3]; scavenger tailings will account for approximately 84% of tailings produced by weight and pyrite tailings the remaining 16%.

KCB has summarized the current tailings geotechnical characterization for the DEIS design, including laboratory testing (KCB 2018).

Duke HydroChem has summarized the tailings geochemical characterization, including laboratory testing (Duke HydroChem 2016, 2017b).

3.2 Geochemical

The scavenger tailings contain a very low percentage of pyrite (with a mean sulfide content of less than 0.1% by weight) and low neutralization potential. 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 were characterized based on laboratory testing, literature review and comparison with similar projects (KCB 2018):

- Strength values were estimated based on results from similar filtered tailings testing at other mines, and the work presented by Friedel and Murray (2010).
- Average dry and bulk densities for the structural and non-structural zones were estimated from tailings specific gravity and void ratios and optimum moisture contents determined from compaction tests performed on similar filtered tailings at other mines. Tailings placed in the structural zones was assumed to be compacted to 98% Standard Proctor maximum dry density (SPMDD); tailings placed in the non-structural zones was assumed to compacted to 90% SPMDD.

[3] The characterization of Resolution tailings to date is based on the Bulk Flowsheet which produced cleaner tailings as an end-product. However, RC updated their preferred process flow sheet to the Selective Flowsheet in 2012, which produces "pyrite tailings" as the end-product instead of cleaner tailings. In the Selective Flowsheet, the scavenger tailings are further desulfurized. The cleaner tailings and the scavenger concentrate de-sulfurization by-product are combined to produce pyrite tailings. Further laboratory testing to characterize the scavenger and pyrite tailings from the Selective Flowsheet is currently ongoing. For the purposes of this study, it is assumed that the cleaner tailings and pyrite tailings are physically and geochemically similar.

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

Engineering design properties based on the tailings characterization are summarized in Table 3.1. Ranges of values are specified for hydrogeological properties (Table 3.2) which should be considered in sensitivity analyses. Engineering properties have been selected from available characterization data with specific consideration to the objectives of the analysis. Appropriate sensitivity analysis would be used to assess the influence of variability and uncertainty of the results.

Table 3.1 Summary of Tailings Engineering Properties used in Design Assessments (KCB 2018)

Material	Specific Gravity[1]	Atterberg Limits[1,4]	USCS Class	Particle Size Distribution[2]		Deposition Method	Dry Unit Weight for Tailings Staging (pcf)[3]	Effective Friction Angle (ϕ')	Peak Undrained Shear Strength Ratio (Su-p/σ'v)	Liquefied Undrained Shear Strength Ratio (Su-LIQ/σ'v)
				% fines <74 micron	% clay <2 micron					
Pyrite Tailings (Structural)	3.87	LL: 18% PI: 3%	ML	80	<20	Placed by conveyors and mobile earthmoving equipment. Tailings placed in the structural zones is compacted to achieve a target density.	137	34°	N/A	N/A
Pyrite Tailings (Non-Structural)							125	32°	0.5	0.3
Scavenger "Total" Tailings (Structural)	2.78	LL: 20% PI: 1%	ML	50	<10		110	34°	N/A	N/A
Scavenger "Total" Tailings (Non-Structural)							1103	32°	0.5	0.3

Notes:
1. Represent averages from the tailings tested.
2. From the DBM, refer to Appendix I.
3. For bulk density estimates to be used in other analyses, refer to KCB (2018).
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 Parameters Selected for Seepage Analysis (KCB 2018)

Material	Saturated Hydraulic Conductivity k_{SATh}	Anisotropy Ratio k_h/k_v	Total Porosity n_{total}	Effective Porosity $n_{effective}$	Specific Yield S_y
Pyrite Tailings (Structural and Non-Structural)	1×10^{-6} to 1×10^{-7}	4 to 10	0.40 to 0.50	0.25 to 0.50	0.20 to 0.30
Scavenger "Total" Tailings (Structural and Non-Structural)	5×10^{-5} to 5×10^{-6}	4 to 10	0.35 to 0.45	0.25 to 0.40	0.25 to 0.30

4 DESIGN BASIS

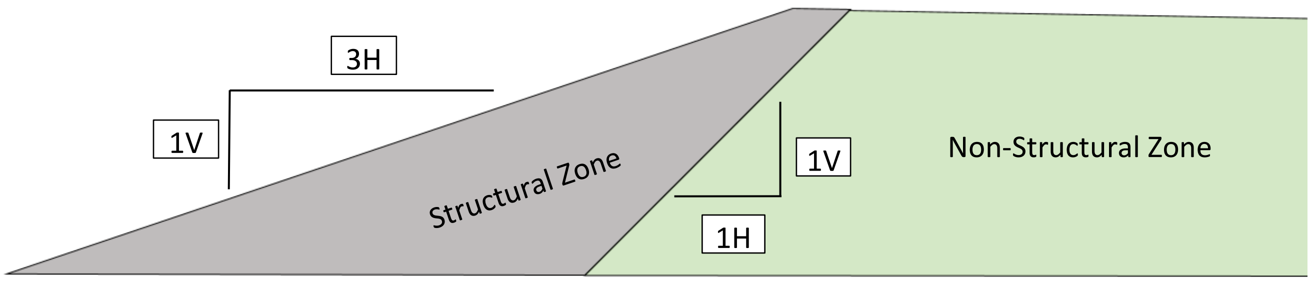
4.1 General

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.

- There would be no continuous ponding on the tailings piles surface.
- Tailings would be pumped as a thickened slurry to the Silver King site, filtered near to the optimum moisture content[4], and then conveyed to tailings piles for mechanical placement.
- Filtered tailings are not completely dry and could have the potential to liquefy if not compacted to a non-liquefiable state and degree of saturation is high enough. Best practice is to have (at minimum) a dilatant structural zone around the filter pile perimeter for structural stability. The structural zone would be compacted filtered tailings, see Figure 4.1.
- The top of the tailings piles would be sloped into the hillside to limit surface water runoff over, and erosion of, the outer slopes.
- Contact water would be collected and managed in exterior water collection facilities. The water collection facilities are assumed to be considered Non-Storm Water Ponds under ADEQ, and would follow BADCT design for a Non-Storm Water Pond (ADEQ 2005). However, from the BADCT manual: *Non-Storm Water Ponds include lined ponds that receive seepage from tailing impoundment, waste dump and/or process areas where potential pollutant constituents in the seepage have concentrations that are relatively low (e.g., compared to process solutions) but exceed Arizona Surface Water Quality Standards. Non-Storm Water Ponds also include secondary containment structures and overflow ponds that contain process solution for short periods of time due to process upsets or rainfall events. Ponds that continually contain process solution as a normal function of facility operations are considered Process Solution Ponds.* Depending on the expected water quality of the ponds, they may need to be designed as Process Solution Ponds.
- Non-contact water would be diverted around the TSF where practical.
- The tailings piles downstream slopes would be progressively reclaimed and non-contact runoff would be diverted around the water collection dams, when possible. The tailings piles surface would be active placement area and reclaimed at the end of operations.

[4] The optimum moisture content is the moisture content at which the maximum density can be achieved through compaction, typically the optimum moisture content is estimated with a Proctor compaction test.

Figure 4.1 Filtered Tailings Pile Typical Cross-Section



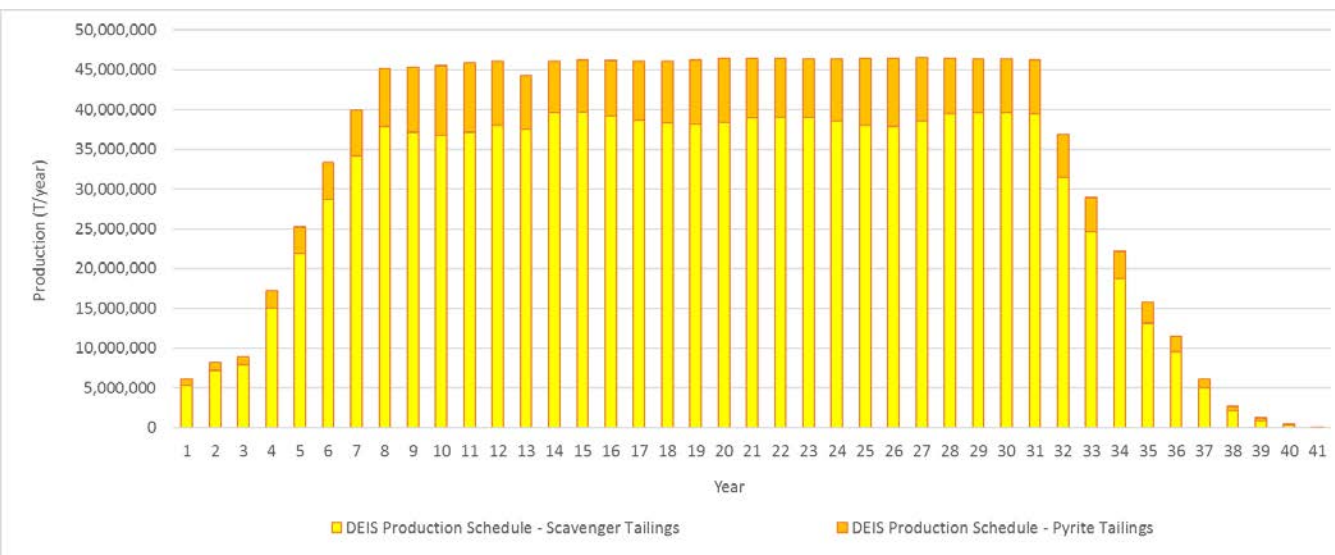
4.2 Tailings Production Schedule

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

Table 4.1 Production Rate

Item	Production Schedule
Scavenger Tailings	1,151 Mtons
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 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[5]" and will be designed in accordance with Section 3.5 of the BADCT manual (ADEQ 2005). The external water collection 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] BADCT (ADEQ 2005) defines a tailings impoundment as one storing thickened tailings slurry and does not provide separate guidance for filtered tailings piles. For this DBM, design criteria for tailings impoundments are applied for filtered tailings piles.

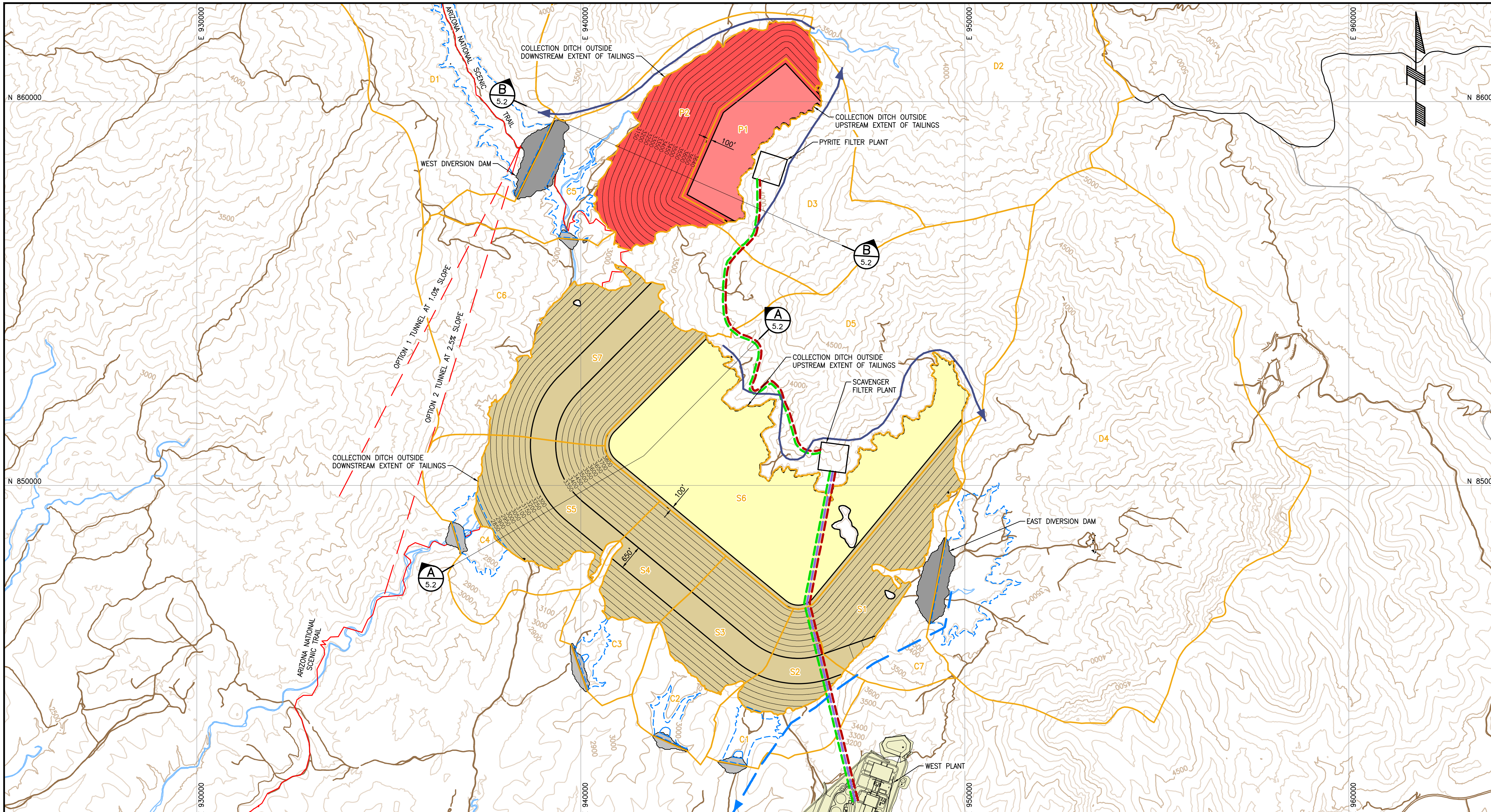
5 TAILINGS MANAGEMENT PLAN

5.1 TSF Features

Key features of the TSF during start-up and operations are shown on Figure 2.1, Figure 5.1 and Figure 5.2, and include the following:

- A borrow area would be developed within Gila Conglomerate (favorable borrow material for dam construction) as a construction fill source for water diversion and collection dams. Potential borrow source locations are within the TSF disturbance area, if suitable (e.g. diversion ditch excavations) or downstream of the TSF in Happy Canyon (see Figure 2.1).
- Tailings slurry pipelines that convey tailings from the West Plant to tailings filter plants would be located above the ultimate tailings piles (see Figure 2.1).
- Filter plants would dewater the tailings near to the optimum moisture content (see Figure 2.1 and Figure 5.1). The filter plants would include a laydown area for temporary stockpile storage and additional drying of filtered tailings, if required, should the filter plant not achieve the required tailings moisture content for conveyance and placement.
- An overland conveyance system comprising fixed overland and walking stacker conveyors to transport tailings from the tailings filter plants to the tailings piles.
- Pyrite and scavenger tailings would be placed and stored in separate piles (see Figure 5.1).
- Once filtered tailings are conveyed to the piles, they would be spread and compacted with mobile earthmoving equipment (dozers, compactors, scrapers, etc.). The tailings piles are comprised of a structural outer shell that supports a non-structural tailings zone placed upstream with lower compaction requirements, refer to Section 5.3 for further discussion.
- An underdrain system that underlies the tailings pile structural zones (and potentially non-structural zones) comprised of a sand and gravel blanket drain and/or rockfill finger drains.
- Contact Water Collection Structures
    - Water collection reservoirs located in natural valleys downstream of the TSF to collect filter pile contact water (predominately pile surface runoff). Containment dams would be built of locally borrowed materials. The external water collection ponds would follow the prescriptive BADCT design for Non-Storm Water Pond (ADEQ 2005), which includes a geomembrane on prepared subgrade.
    - Lined contact water collection ditches that collect tailings pile runoff and convey it to the water collection reservoirs.
- Non-Contact Water Diversion Structures
    - Diversion ditches and reservoirs upstream of the tailings piles to convey non-contact water around the TSFs.

    - Reservoirs to attenuate and temporarily store non-contact water storms from upstream catchments. The containment dams for these reservoirs would be built of locally borrowed fill.
    - A diversion tunnel and pipelines to convey water from the upstream diversion dams to existing drainages downstream of the TSF.
- Emergency slurry storage ponds retained by earthfill dams to store tailings slurry in the event that either of the filter plants or conveyors shut down, operational upsets occur, or target moisture contents are not being met.



LEGEND

- DIVERSION CHANNEL
- RAILWAY
- EXISTING ROAD
- MAJOR NATURAL DRAINAGE
- EXTERNAL WATER COLLECTION DAM
- MINIMUM POND ELEVATION
- INFLOW DESIGN FLOOD ELEVATION
- UPSTREAM DIVERSION DAM
- SCAVENGER PIPELINE
- PYRITE PIPELINE
- WATER PIPELINE
- WATER DIVERSION PIPELINE
- CATCHMENT BOUNDARY
- SCAVENGER STRUCTURAL ZONE
- PYRITE STRUCTURAL ZONE
- SCAVENGER NON-STRUCTURAL ZONE
- PYRITE NON-STRUCTURAL ZONE

NOTES

1. PROJECTION AND DATUM: ARIZONA STATE PLANE CENTRAL NAD 83 – INTERNATIONAL FOOT.
2. TOPOGRAPHY BASED ON LIDAR 2013 SURVEY.
3. FILTER PLANTS AND PIPELINES TO WEST PLANT DESIGNED BY OTHERS.

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PROJECT	RESOLUTION COPPER PROJECT DEIS DESIGN FOR ALTERNATIVE 4 – SILVER KING FILTERED
TITLE	GENERAL LAYOUT
SCALE	AS SHOWN
PROJECT No.	M09441A20
FIG. No.	5.1

Klohn Crippen Berger

KCB-FIG-D-L

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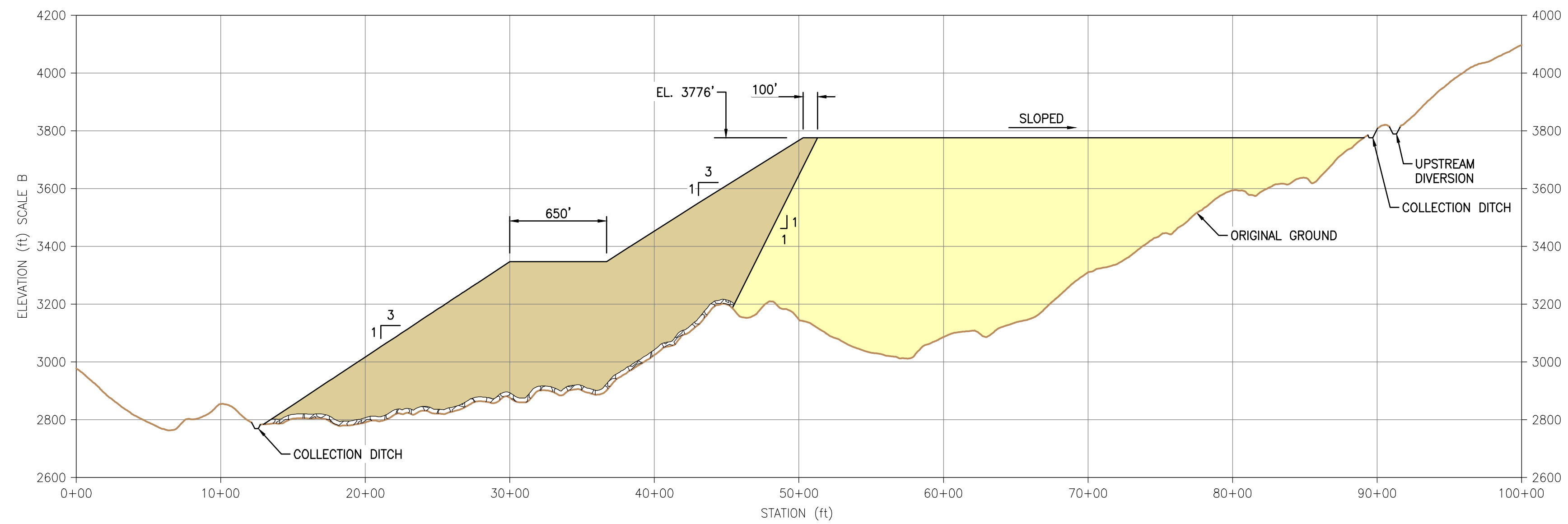
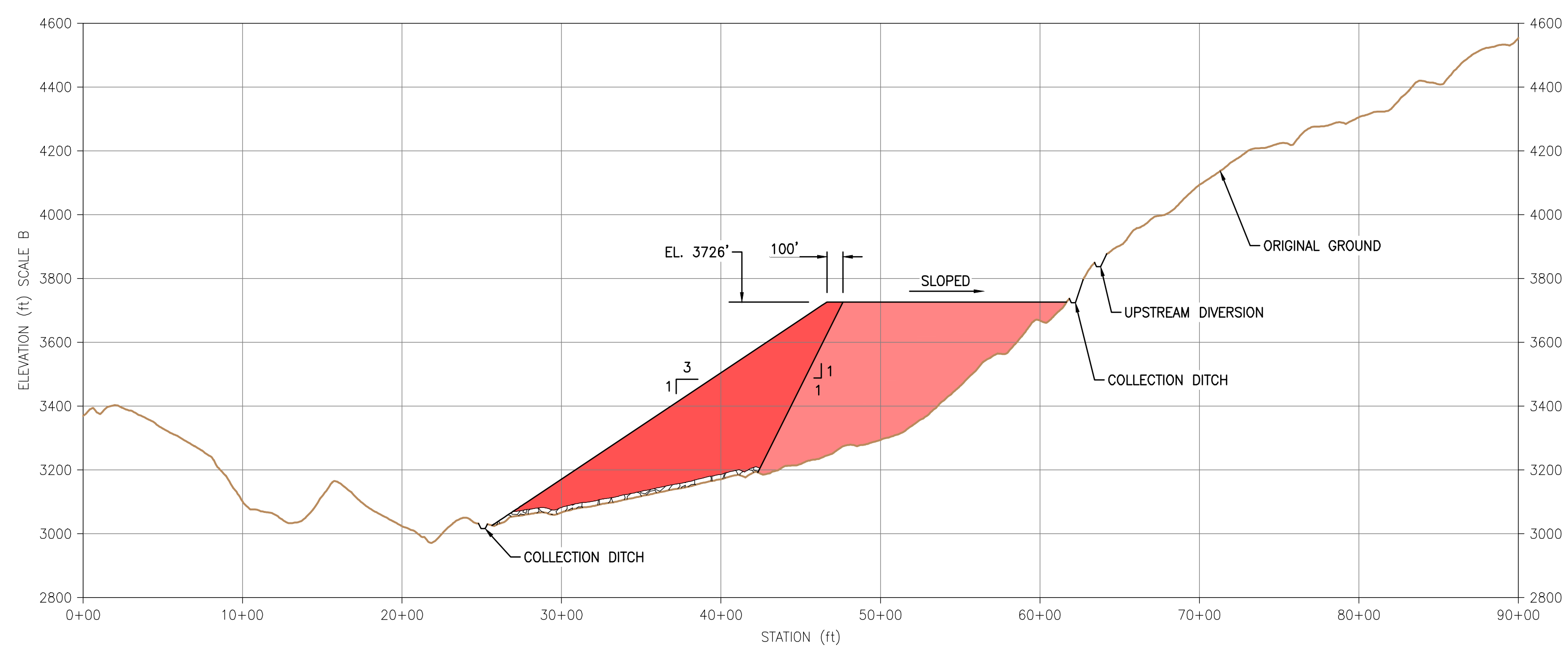


SECTION A
SCALE A 5.1



SECTION B
SCALE A 5.1

LEGEND

- FILTERED SCAVENGER TAILINGS STRUCTURAL ZONE
- FILTERED SCAVENGER TAILINGS NON-STRUCTURAL ZONE
- FILTERED PYRITE TAILINGS STRUCTURAL ZONE
- FILTERED PYRITE TAILINGS NON-STRUCTURAL ZONE
- UNDERDRAINS

NOTES

1. PROJECTION AND DATUM: ARIZONA STATE PLANE CENTRAL NAD 83 – INTERNATIONAL FOOT.
2. TOPOGRAPHY BASED ON LIDAR 2013 SURVEY.

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SCALE B 300 0 300 FT

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PROJECT: RESOLUTION COPPER PROJECT
DEIS DESIGN FOR ALTERNATIVE 4 – SILVER KING FILTERED

TITLE: TYPICAL CROSS-SECTIONS AND DETAILS

SCALE	PROJECT No.	FIG. No.
AS SHOWN	M09441A20	5.2

KCB-FIG-D-L

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5.2 Tailings Processing and Transportation

5.2.1 Filter Plant Design

A filter plant will be located near the tailings piles to reduce the transport distance and dust potential after dewatering by overland conveyors. The plant was assumed to be sited on high ground above the piles to allow for conveyance downhill (see Figure 2.1 and Figure 5.1).

Based on the Resolution tailings properties, the target moisture contents for the scavenger and pyrite tailings are estimated to be 11% and 14%, respectively. Due to the moisture content requirements and fine-grained nature of the tailings, pressure filters are the preferred option for tailings dewatering.

A case study review of filtered tailings projects (RC 2017) was completed and indicates that operations can have difficulty achieving the target moisture contents consistently, especially during start-up (RC 2017). Depending on the moisture content, the non-spec material may be suitable for the non-structural zones. If that option is not available or material is not suitable, a back-up storage area would be required. Some filtered tailings projects that do not have back-up storage (i.e. a shed for filtered tailings or TSF for conventional slurry tailings), require mill shut-downs or produce over-wet material that can cause stability and seepage issues.

At the proposed tailings production rates, the number of filters was estimated using the information in the DBM (Appendix I), refer to Table 5.1. These results are based on preliminary assumptions and analogs from other tailings projects at lower production rates thus uncertainty exists in the numbers related to scaling and execution. Due to the fine-grained nature of the pyrite tailings, Table 5.1 likely underestimates the requirements for the pyrite tailings.

Table 5.1 Filter Plant Design

Tailing Type	Target Filter Solids Content[1]	Cycle Time (min)	Filtration Rate ($kg/m^2/hr$)	Total Number of Filters [2]
Pyrite Tailings	86%	11	~260	6
Scavenger Total Tailings	89%	17	~160	41

Notes:

1. To achieve the optimum moisture content for compaction
2. Assuming industry standard filter size (2 m x 2 m), filter availability of 85%, and 15% contingency on the number of filters; see the DBM (Appendix I) for further assumptions.

To house the filtering infrastructure (including a laydown area for temporary stockpile storage and additional drying of filtered tailings, if required), the area is assumed to be approximately 10 acres.

5.2.2 Transportation

Tailings slurry pumps and pipelines would convey tailings from the West Plant (approximately 3,200 fasl) to tailings filter plants (at approximately 4,000 fasl), see Figure 2.1. The slurry pipelines would need to cross Silver King Wash likely via a pipeline bridge. Once the scavenger tailings pile has filled in the Silver King wash, the slurry pipelines would be placed and raised on the scavenger tailings pile. The pyrite tailings pipelines would continue around Peachville Mountain to the pyrite tailings filter plant. Water removed from the tailings during filtering would be reclaimed to the West Plant via a filtrate water pipeline which would run along the same corridor as the slurry pipelines.

From the tailings filter plants, overland conveyance systems comprising overland and walking stacker conveyors (see Figure 5.3) would transport tailings from the filter plants to the tailings piles. The piles would be constructed in horizontal lifts starting at the lowest elevation and progress up to the ultimate elevation. Therefore, the conveyors would be transporting the tailings over uneven, natural ground and over a relatively flat surface on the piles in windrows, as shown on Figure 5.3.

The large walking-stacker conveyors required to handle the production require relatively flat ground with defined transit pathways (i.e. rectangular shaped piles are ideal) to operate. This would not be possible for much of the placement area, especially as steep valleys are filled. Once the filter piles are built above the lower rugged terrain, conveyance would be simplified. However, some re-handling of the tailings may be required to achieve the desired pile configurations and surface sloping. Therefore, additional equipment (i.e. scrapers) may be required to transport the tailings to the final placement area.

Several filtered tailings projects had trafficability challenges on filtered tailings piles (RC 2017) with heavy civil and mining equipment, especially when the filter plant is not meeting target moisture contents or during precipitation events. During non-trafficable times, some mines use a back-up tailings storage area.

Figure 5.3 Walking stacker conveyor placing filtered tailings (FLSmidth)

5.3 Pile Construction and Structural Stability

Tailings deposited by walking conveyors form windrows which must be spread and compacted by mobile equipment to meet compaction requirements in structural zones, provide an adequate surface for conveyor traffic, and seal the tailings surface to limit water infiltration.

As noted in Section 4.1, the DBM has been revised from the GPO (RC 2016) to include the assumption that all potentially liquefiable tailings liquefy regardless of the triggering mechanism. Filtered tailings are potentially liquefiable if not compacted to a dense, dilative state and if the degree of saturation is high enough. Thus, a perimeter structural zone is required to be compacted to a dilative state and include an underdrainage system, comprised of granular drains to depress the piezometric conditions in the pile. Downward seepage is expected to be low relative to “wet” alternatives but underdrains would act as a capillary break with the foundation and intercept any upward flow.

Compaction requirements for tailings placed in the interior of the pile can be less stringent than in the structural zone, allowing for placement of tailings with moisture content above optimum. It is important to determine at the start of pile construction what the final geometry is so that the zone of compaction is well defined (KCB 2017b).

The results of previously performed stability analysis (KCB 2017c) were used to define the dimensions of the structural zone shown on Figure 5.2. The extents of the structural zone are likely conservative, and could be optimized.

5.4 Pyrite Tailings Management

The filtered pyrite tailings would be placed in a separate pile to allow for management of contact water separately for each tailings type which reduces the volume of water impacted by pyrite tailings.

Seepage from filtered pyrite tailings is expected to be very low relative to “wet” alternatives. However, depending on the foundation conditions and the potential impacts to the downstream environment, an engineered low-permeability layer may be required over select areas of the foundation. The rugged terrain makes geomembrane liner (i.e. HDPE or LLDPE) placement impractical over most of the site. Alternative low-permeability barriers would be considered, such as amending the base layer of the tailings to decrease the permeability.

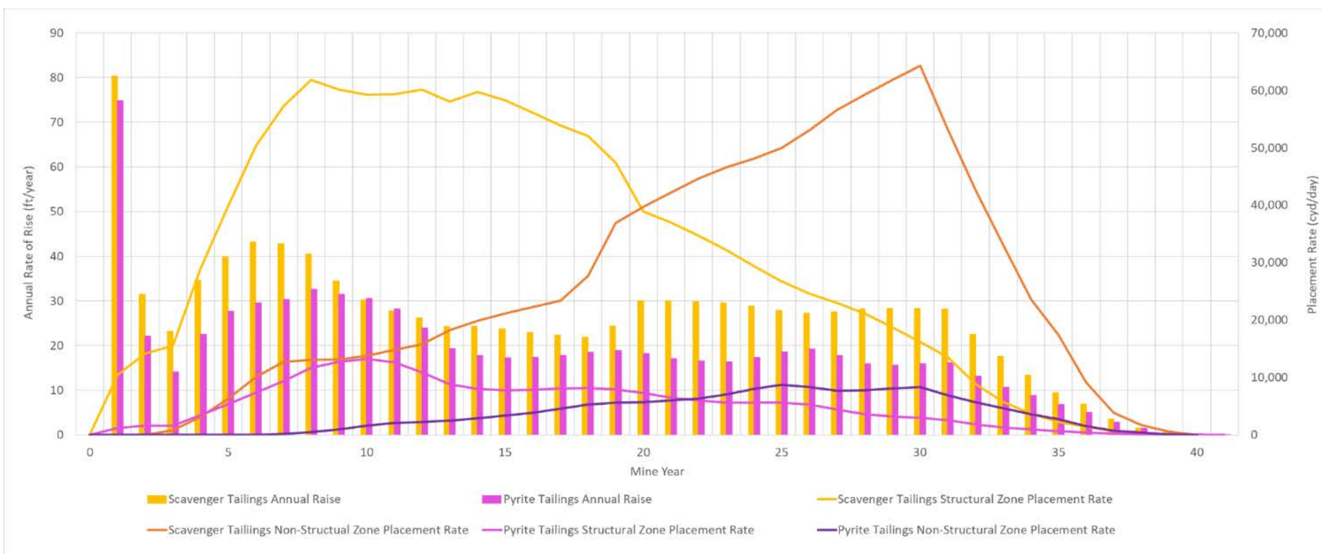
5.5 Tailings Staging Plan

Construction of the tailings piles 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. Figure 5.1 shows the filter piles at the end of operations. Key observations from the tailings deposition models include the following:

- The maximum toe-to-crest height of the tailings piles at end of operations is approximately 1,040 ft (scavenger) and 750 ft (pyrite). The piles are quite high as they are constructed to follow and mimic the existing canyon landscape.

- The thickness of the tailings piles at end of operations is approximately 900 ft (scavenger) and 500 ft (pyrite).
- The piles would be constructed in horizontal lifts. The forecasted rate of pile rise is shown on Figure 5.4. The highest rates of rise occur in early years due to confined placement at the base of natural valleys and steep topography.
- The rate at which tailings must be handled by mobile equipment, is equal to the daily tailings production rate. A large, dedicated fleet of mobile equipment, and potentially a high capacity conveyor system, would be required to support tailings placement. No known comparable system is currently in operation.
- The daily compaction rate is equal to the rate of tailings placed in the structural zone, although some nominal compaction of tailings in the non-structural zone may be required for surface water control and trafficability. The highest compaction rates are realized in the early years of operations, as shown on Figure 5.4.
- This staging plan assumes that the outer slopes of the piles are established as early as practical to allow for progressive reclamation of pile slopes during operations. Progressive reclamation would be delayed if interior portions of the pile were constructed first, since temporary slopes would not be reclaimed and, potentially require some form of temporary dust cover.

Figure 5.4 Tailings Pile Rates of Rise and Placement



5.6 Emergency Slurry Storage Facilities

Emergency slurry storage ponds would be required to store tailings slurry in the event of filter plant or conveyor shut down (planned or unplanned) or operational upsets (e.g. target moisture content not met). When not in use, the emergency facilities can either be permanent (covered and closed) or temporary with tailings later relocated to the piles. Similar to the main TSF, at least two emergency facilities would be required to separately store the scavenger and pyrite tailings. Depending on the volume of tailings storage requirements, the emergency storage facility may have to be expanded during operations or multiple sites may be required.

Three preliminary locations for emergency storage ponds are shown on Figure 2.1. The facilities would be retained by earthfill dams and constructed in accordance with BADCT guidelines. The facilities have been located to optimize storage and dam fill volumes. Further details on the preliminary dam designs and storage capacities are provided in Appendix II.

6 WATER MANAGEMENT PLAN

6.1 Surface Water Management System

The objectives of the operational water management for the Silver King TSF are:

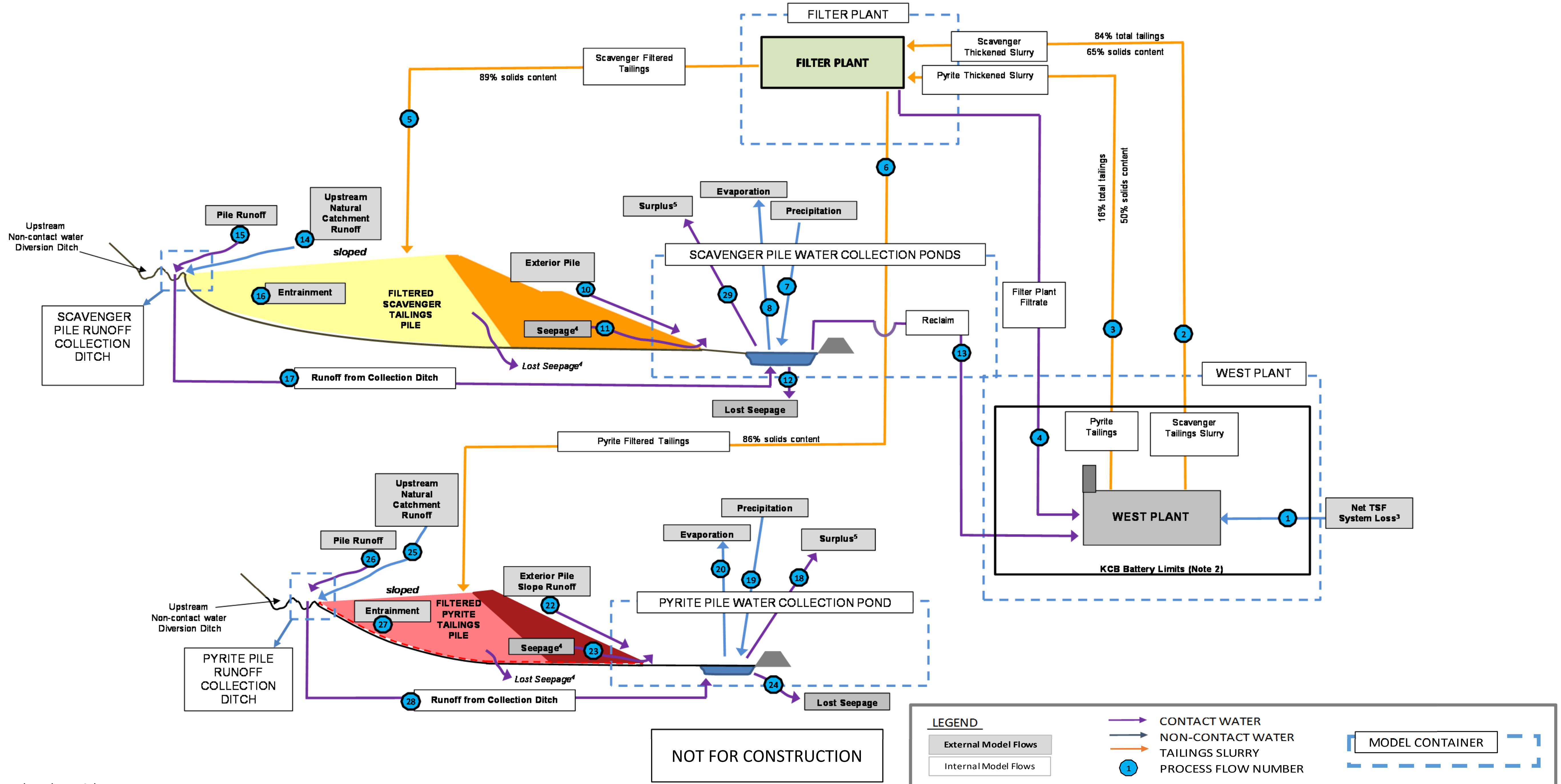
- maximize water recovery from tailings slurry by filtration for re-use in milling;
- divert non-contact water around the tailings piles as much as practical;
- eliminate or minimize ponding on the tailings surfaces;
- collect and manage contact runoff water from the scavenger and pyrite tailings piles separately; and
- provide water storage for mill supply and to attenuate precipitation events.

The operational water management conceptualization is schematically shown on Figure 6.1. Catchments and water management features for the Silver King Filtered TSF are shown on Figure 2.1 and Figure 5.1.

Catchment areas are summarized in Table 6.1. The overall catchment area for the TSF is 13,200 acres, of which 9,500 acres would be diverted through non-contact water diversion structures (e.g. ditches, tunnels and pipelines). The remaining area that could not be diverted (3,700 acres) would report to external water collection ponds. An overview of how contact and non-contact water is treated is described in the following subsections.

Table 6.1 Silver King Catchments

Catchment	Area (acres)	Contact or Non-Contact	Location Relative to Piles (u/s, footprint, d/s)	Reporting Collection or Diversion Structure
D1 (Reevis Rail Canyon)	2,900	Non-contact	u/s of scavenger tailings pile	West Diversion Dam
D2 (Wood Canyon and Whitford Canyon)	3,400	Non-contact	u/s of pyrite tailings pile	West Diversion Dam
D3 (Peachville Tank)	330	Non-contact	u/s of pyrite tailings pile	West Diversion Dam
D4 (Silver King Wash, Comstock Wash)	2,100	Non-contact	u/s of scavenger tailings pile	East Diversion Dam
D5	760	Non-contact	u/s of scavenger tailings pile	East Diversion Dam
C1	120	Contact	d/s of scavenger tailings pile	External Contact Water Collection Dam (C1)
C2	110	Contact	d/s of scavenger tailings pile	External Contact Water Collection Dam (C2)
C3	110	Contact	d/s of scavenger tailings pile	External Contact Water Collection Dam (C3)
C4	190	Contact	d/s of scavenger tailings pile	External Contact Water Collection Dam (C4)
C5	250	Contact	d/s of pyrite tailings pile	External Contact Water Collection Dam (C5)
C6	560	Contact	d/s of scavenger tailings pile	External Contact Water Collection Dam (C4)
C7	130	Contact	d/s of scavenger tailings pile	External Contact Water Collection Dam (C1)
P1	140	Contact	pyrite tailings pile footprint	External Contact Water Collection Dam (C5)
P2	300	Contact	pyrite tailings pile footprint	External Contact Water Collection Dam (C5)
S1	190	Contact	scavenger tailings pile footprint	External Contact Water Collection Dam (C1)
S2	90	Contact	scavenger tailings pile footprint	External Contact Water Collection Dam (C1)
S3	170	Contact	scavenger tailings pile footprint	External Contact Water Collection Dam (C2)
S4	140	Contact	scavenger tailings pile footprint	External Contact Water Collection Dam (C3)
S5	270	Contact	scavenger tailings pile footprint	External Contact Water Collection Dam (C4)
S6	630	Contact	scavenger tailings pile footprint	External Contact Water Collection Dam (C4)



Notes:

1. All percentages reported are by weight.
2. KCB does not account for water balance flows upstream of the West Plant (i.e. ore processing facility, block cave dewatering etc.)
3. The net TSF system loss is the water that the West Plant needs from other sources to be balanced with the TSF system.
4. The filtered tailings would be dewatered and placed in a semi-arid environment, therefore are not expected to generate high seepage quantities compared to a conventional TSF. For this water balance assessment, water placed with the tailings are lost to the system; and only runoff from precipitation is incorporated into the system. Seepage from the filtered tailings should still be considered impacts to the aquifer and for containment design for environmental reasons.
5. Surplus in the scavenger pile and pyrite pile water collection ponds would need to be actively managed.

CLIENT: RESOLUTION COPPER

Klohn Crippen Berger

PROJECT: RESOLUTION COPPER PROJECT
DEIS DESIGN FOR ALTERNATIVE 4 - SILVER KING FILTERED

TITLE: OPERATING WATER BALANCE SCHEMATIC

SCALE	PROJECT No.	FIG No.
AS SHOWN	M09441A20	6.1

Non-Contact Water Management

Permanent diversion channels upslope of the tailings pile would divert non-contact water around the pile and discharge into either the West or East Diversion reservoirs, which are retained by large earthfill dams. Water from the West Diversion reservoir would be discharged downstream of the TSF via a low-level tunnel outlet (shown on Figure 2.1). Water from the East Diversion reservoir would be pumped out via overland pipelines and discharged downstream of the TSF.

The locations and design information of the upstream diversion dams and conveyance structures are shown on Figure 2.1 and Figure 5.1 and summarized in Table 6.2. Design criteria for sizing the structures is discussed in the DBM (Appendix I). Diversion ditches and pipelines have not been sized for this design.

The upstream diversion structures would be required in perpetuity, or until tailings were removed from the existing drainage channels.

Table 6.2 Non-Contact Water Diversion Structure Details

Parameter	Non-Contact Water Diversion Structures	
Dam Name	West Diversion Dam	East Diversion Dam
Critical Design Storm Event	PMP	PMP
Catchment (acre)	6,700	2,800
Pond Bottom Elevation (ft)	3,008	3,279
Maximum PMF Volume (ac-ft)	5457	5281
PMF Routing Depth (ft)	177	134
Freeboard (ft)[2]	6	6
Preliminary Dam Crest Elevation (ft)	3191	3419
Dam Height (toe to crest) (ft)	263	182
Dam Crest Width (ft)	25	25
Dam Slopes	2.5H:1V	2.5H:1V
Dam Structural Fill Volume (Myd^3)	4.8	3.1
Outlet[2]	25 ft x 25 ft unlined concrete box tunnel at 1% slope	3 x 15,000 GPM submersible pumps and overland pipelines

Notes:
1. PMP = Probable Maximum Precipitation.
2. Assumption for preliminary sizing.

Contact Water Management

The key features of the contact surface water management for the tailings piles include:

- Unlike a conventional TSF, in which precipitation falling on the tailings collects in a reclaim pond on the tailings surface, stormwater must be managed on filtered piles to prevent ponding and infiltration (i.e. stormwater would be directed off the surface). During operations the tailings surfaces would be sloped to eliminate ponding and direct runoff to perimeter ditches, sumps and/or underdrains. The tailings piles' top surface would be sloped towards the hillside and surface runoff would be collected in lined ditches and conveyed to the lined contact water collection ponds.
- Contact water from the tailings piles would be directed to one of five lined external water collection ponds (ponds C1 through C5, refer to Figure 5.1). Four of these ponds (C1 through C4) would be used to collect contact water from the scavenger tailings pile; C5 would collect contact water from the pyrite tailings pile. The water collection ponds would be retained by earthfill dams and the reservoirs would be lined with a low-permeability layer. Refer to Table 6.3 for design details.
- The pyrite and scavenger contact water would be managed separately to limit the volume of water impacted by pyrite tailings that would have poorer water quality and may require special treatment before being reused.
- Contact water from the scavenger tailings pile collection ponds would join the filter plant filtrate water and be sent back to the West Plant via pumps and pipelines, as required.
- TSF system surplus (i.e. defined as having more water than the West Plant requires, not including the other West Plant inflows; this occurs during production ramp-down) would need to be managed (potentially treated prior to release to the environment).

Design criteria for sizing the contact water ponds are discussed in the DBM (Appendix I). Contact water conveyance ditches have not been sized for this design.

Table 6.3 External Contact Water Collection Dam Details

Parameters	Units	External Water Collection Dams				
		C1	C2	C3	C4	C5
Tailings pile		Scavenger				Pyrite
Catchment area	acre	835	309	283	1,713	669
Pond Bottom Elevation	feet	2,986	2,920	2,866	2,726	2,894
Environmental Design Flood (EDF) Return Period[1]		200-year 200-year				
EDF Storage Volume[1]	acre-feet	355	131	120	728	485
EDF Storage Elevation[2]	feet	3,045	2,971	2,910	2,803	2,962
Inflow Design Flood (IDF) Return Period[3]		PMP				
Inflow Design Flood Elevation	feet	3,055	2,981	2,920	2,813	2,972
Total Storage Volume at Crest (cumulative)	acre-feet	797	357	435	1,355	1,005
Dam Crest Elevation[4]	feet	3,060	2,986	2,925	2,818	2,977
Dam Height	feet	73	65	59	91	83
Dam Crest Width	feet	25				
Dam Slopes	-	2.5H:1V				
Dam Structural Fill Volume	Myd^3	0.26	0.19	0.28	0.35	0.17

Notes:
1. Environmental Design Flood (EDF) design storm = 200-year 24-hour event for scavenger water collection dams and 200-year 7-day event for pyrite water collection dam (to account for potential additional environmental risk associated with the pyrite tailings contact water); Runoff coefficient of 1.0 assumed.
2. Storage elevation includes the following depth allowances: 10 ft for eroded tailings storage and management and submersible pump; 10 ft for seasonal storage and 10 ft for operational upsets.
3. 10 ft depth allowance for PMF Inflow Design Flood (IDF)
4. 5 ft depth freeboard allowance for wave runup, wind setup and embankment crest settlement.

6.2 Water Balance

An operational and post-closure contact water balance was completed for monthly average inflows and outflows, the assumptions and results are summarized in Appendix III. The main objectives of the water balance were to provide:

- an understanding of monthly average inflows and outflows of the TSF system;
- an estimate of the net TSF system loss (i.e. what the West Plant water supply requirements are to offset losses from the TSF). This can also be a surplus if the West Plant requires less than what the TSF ponds can provide;
- preliminary estimates of seasonal fluctuations of pond water for the sizing of water collection ponds; and
- a basis for further water quality and solute transport assessments (completed by others).

This water balance includes the 41-year mine operating life, and the post-closure period while active water management may be required. The water balance is based on the design basis (see Appendix I) and areas estimated in the TSF staging plan (refer to Appendix II).

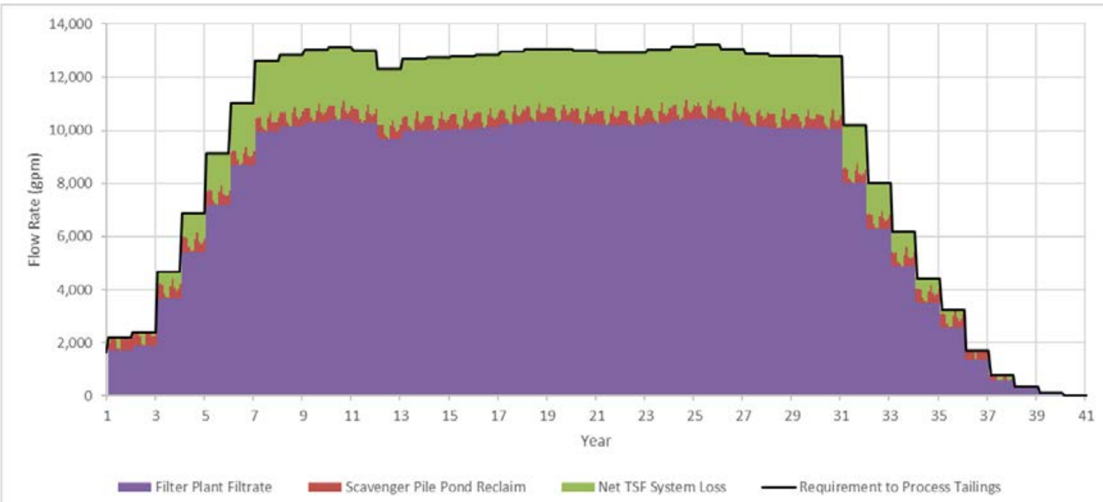
The key considerations for the Silver King Filtered TSF in comparison to a conventional slurry TSF are as follows:

- Most of the water reclaimed from a filtered tailings project comes during thickening and filtration.
- The filtered piles would be shaped to shed water; contact water would be collected in external water collection ponds.
- The filtered tailings are partially saturated; therefore, the water losses due to entrainment in tailings pore spaces are less compared to hydraulically deposited slurry tailings.
- Filtered pyrite tailings are partially saturated and exposed to oxidation. Hence, they have a greater likelihood of producing Metal Leaching / Acid Rock Drainage (ML/ARD) seepage and runoff. Therefore, it is assumed that the contact water from the pyrite filtered pile would be managed separately from the scavenger tailings pile contact water.
- The partially-saturated tailings surfaces are assumed to retain more precipitation and generate less runoff than hydraulically deposited slurry tailings beaches.[6]
- The filtered tailings are dewatered and placed in a semi-arid environment, therefore are not expected to generate high seepage quantities compared to a conventional TSF. For this water balance assessment, seepage losses from the filtered tailings are incorporated into the following assumptions:
    - water placed with the tailings are lost to the system;
    - only runoff from precipitation is incorporated into the system (i.e. precipitation that turns into evaporation or infiltration that may turn into seepage is not explicitly incorporated in the model);
- Seepage from the filtered tailings should still be considered impacts to the aquifer and for containment design for environmental reasons.
- Due to the size of the external water collection facilities and the contingency pond requirements, seepage losses from these ponds would be more significant than from conventional TSF seepage dams, and therefore are included in this assessment.
- Filtered tailings are managed “dry” (i.e. dewatered to partial-saturation and managed as a solid), which has the benefit of minimizing seepage into the foundation, therefore, water would not be used for dust management. Alternatives to water, such as synthetic polymers, would be used to manage dust. If left in place, polymer coatings on tailings surfaces have potential to impact vertical drainage.
- Emergency slurry storage facilities would be required for upset conditions while operating a filtered TSF. However, the operation of these have not been incorporated into this water balance assessment.

[6] This assumption should be reviewed, as runoff is a function of climate, tailings density and saturation and surface slope.

The operational TSF water balance is schematically represented on Figure 6.1. TSF system inflows to the West Plant include: (1) filter plant filtrate; (2) scavenger pile collection pond reclaim; and (3) the net TSF system loss (i.e. what the West Plant requires to be balanced with the TSF system, assuming the pyrite pile collection pond reclaim is lost to the system and ignoring the flows upstream of the West Plant, for example, the underground dewatering flows or fresh water makeup). These inflows are shown on Figure 6.2 over the mine life. Most of the water reclaimed to the West Plant is from tailings thickening and filtration.

Figure 6.2 West Plant Inflows



Note: The net TSF system loss is what the West Plant water supply requirements are to offset losses from the TSF. This can also be a surplus if the West Plant requires less than what the TSF ponds can provide.

The water balance results show that over the mine life the TSF system loss (i.e. water that the West Plant needs from other sources) is approximately 110,000 acre-ft; a surplus of approximately 6,000 acre-ft in the pyrite collection pond during operations, and a surplus of approximately 3,000 acre-ft in the scavenger collection pond in later years of operations. A summary of the net TSF system loss and surplus over the mine life are given in Table 6.4.

Table 6.4 Mine-Life TSF System Deficit and Surplus

Flow Description	Maximum Monthly Flow Rate (gpm)	Average Monthly Flow Rate (gpm)
Surplus from Scavenger Pile Collection Pond(1)	400	340
Surplus from Pyrite Pile Collection Pond	110	90
Net TSF System Loss (i.e. water that the West Plant needs from other sources)	2770	1850

Note: 1. Average rate over last five years of pond operations.

7 SEEPAGE MANAGEMENT PLAN

The impact of seepage water on downstream surface and groundwater receptors is a function of both seepage water quality and volume. Placing filtered tailings partially-saturated, and shedding surface water significantly reduces seepage into the foundation from the tailings in comparison to the same facility operated with slurry tailings and a reclaim pond. Seepage water quality from partially-saturated pyrite filtered tailings which are allowed to oxidize would be poorer than if they were stored saturated such as in the “wet” alternatives being considered (Duke HydroChem 2017b). The lower impact to downstream water quality from a filtered or slurry tailings alternative would be based on the relative benefits of reduced seepage from filtered tailings versus improved water quality from subaqueous disposal of pyrite tailings.

The key seepage management features are summarized below:

- Reduced downward gradients within the tailings and limited seepage from the unsaturated filtered tailings.
- The underdrainage system below the tailings pile structural zones (refer to Section 5.2) would provide a high permeability pathway for seepage to report to downstream collection facilities rather than infiltrate into the foundation and act as a capillary break.
- The external water collection ponds would be constructed with a liner system in accordance with BADCT. This requirement may be less stringent for the scavenger ponds (C1 through C4) based on seepage water quality predictions and the downstream receptors’ capacity to assimilate seepage.
- Channels that convey water to the external collection ponds would be lined.

The seepage management features described above are conceptual, commensurate with the level of study of the DEIS designs. More stringent seepage collection measures, such as additional engineered low-permeability layers, cut-offs and seepage collection wells may be required based on foundation characterization, and seepage modeling.

8 DUST MANAGEMENT PLAN

The key considerations for dust management of the Alternative 4 TSF are:

- the surface area of the piles;
- the partially-saturated state of the filtered tailings during delivery and placement, and the susceptibility of those filtered tailings to wind erosion;
- inability to use water/sprinklers as a dust suppressant on the tailings surfaces because re-introducing water to the tailings would increase seepage, impact pile stability, trafficability and produce low quality contact water; and
- proximity of the Silver King site to sensitive downwind receptors (the town of Superior (1.5 miles north) and the Superstition Wilderness Area (1 mile south)), refer to Figure 2.1

The conceptual dust management is based on the following approach to manage wind erosion of the tailings pile surfaces.

- Tailings pile exterior slopes:
  - The tailings piles would be constructed in horizontal lifts from bottom to top. This construction style allows for establishing the ultimate downstream slope during operations which allows for progressive reclamation (erosion resistant cover and vegetation).
  - The exterior slope that is not progressively reclaimed would be compacted and if compaction is not sufficient synthetic dust suppressants can be used.
    - For example, Kennecott uses an acrylic polymer (EnvirotacII), and New Afton (in British Columbia, Canada) uses a polymer emulsion, Soil-Sement®[7].
- Tailings pile top surfaces:
  - Tailings would be compacted as soon as practical after placement to limit exposure of loose material which is most susceptible to erosion.
  - If compaction of the filtered tailings is insufficient to control wind erosion, synthetic dust suppressants or temporary covers can be used.
- Service roads would be regularly watered or sprayed with a synthetic dust suppressant, as required.

[7] http://midwestind.com/soil-sement/

9 BORROW PLAN

Earthfill construction materials are required for the following purposes:

- general fill for dam construction and tailings pile closure covers;
- sand and gravel for underdrains, blanket drains and dam zones;
- liner bedding; and
- riprap for erosion protection.

Based on the available surficial geology information (refer to Section 2.5) and foundation characterization at the Near West site (KCB 2017a), the most likely general fill borrow source of sufficient quantity is the Gila Conglomerate (Tcg), which outcrops over approximately 15% of the TSF disturbed area. A dedicated general fill borrow area would likely need to be established downstream of the TSF to provide fill throughout operations. One possible location for the borrow excavation is Happy Canyon, shown on Figure 2.1 and Figure 2.3. Experience at the West Plant site indicates a surface layer of Gila Conglomerate can be ripped with a dozer but below approximately 5 ft to 10 ft drilling and blasting is typically required. All of the material must be processed to varying degrees to produce a well graded 12 in. minus fill material suitable for construction.

The preferred source of sand and gravel for the blanket drains and underdrains is the alluvial sediments (Qs and Qal) located within the active channels, the largest deposits of which are likely within Whitford Canyon and Silver King Wash. If there is a deficit of suitable alluvial material, other hard rock units in the vicinity, such as the Tertiary Granite (Tg) and Cretaceous Quartz Diorite (Kqd), could be quarried and processed. The suitability of these rock types would be assessed prior to use. Processed Gila Conglomerate may not suitable as drainage material because there is a potential for particle breakdown or potential cementation over time.

Riprap for erosion protection will be sourced from hard, durable rock sources, likely either the Tertiary Granite (Tg) and Cretaceous Quartz Diorite (Kqd).

10 PRELIMINARY CLOSURE PLAN

During operations, the filtered pile slopes would be progressively reclaimed, and runoff would be diverted around the contact water collection ponds as soon as practical. The ultimate filter pile surface would be reclaimed at the end of operations. The filtered tailings piles would be covered with a low infiltration cover, erosion resistant layer and then vegetation (amendments may be required to encourage vegetation re-establishment). The pyrite tailings would be covered by an engineered low-permeability layer[8] (to minimize the likelihood of precipitation coming into contact with the pyrite tailings and reporting to the downstream environment), a layer of compacted NPAG material, an erosion resistant layer and vegetated. Armored surface water diversion ditches would be constructed on the pile slopes to direct surface water runoff and limit erosion.

Post closure water management is separated into two phases for (see Appendix III for how this is incorporated in to the water balance): active closure and passive closure.

Phase 1 – Active Closure

- Assumed to be less than five years starting at the end of operations.
- The filtered TSF piles are reclaimed (covered and vegetated).
- Diversions are constructed to convey as much runoff from the natural catchment and reclaimed filtered TSF surfaces around the contact water collection ponds as practical.
- Active water management is required for the contact water collection ponds, when the ponds do not have capacity to passively evaporate the inflows. Active water management is likely to treat and release to the environment.

Phase 2 – Passive Closure

- If water reporting to the collection ponds is of suitable quality to discharge, the collection dams/ponds would be decommissioned at the end of Phase 1 – Active Closure.
- If water reporting to the collection ponds is not suitable for discharge, the collection dams/ponds would remain and passively evaporate the inflows.
- Upstream diversion structures would be left in place for perpetuity to continue directing water away from the tailings piles, protecting them from damage during extreme storm events.

The post-closure water balance (see Appendix III) has assumed that the collection ponds would remain post-closure, results are shown on Figure 10.1 and Figure 10.2, and summarized in Table 10.1. The surpluses shown on Figure 10.1 and Figure 10.2 are the rates of active water management required from the collection ponds during Phase 1 post-closure. The water balance results give a

[8] Engineered low-permeability liner could be comprised of one or more of the following: geomembrane liner, compacted fine tailings/slimes, asphalt, slurry bentonite, cemented paste tailings, etc.

surplus of approximately 2,200 acre-ft in the scavenger pile collection pond and a surplus of approximately 500 acre-ft in the pyrite pile collection pond over Phase 1.

During Phase 2 post-closure (passive closure), the water balance results indicate that if the collection ponds are required, the collection ponds have the evaporative capacity to managed inflows with long-term average water depths of 11 ft and 22 ft for the scavenger and pyrite collection ponds, respectively.

Figure 10.1 Post-Closure Scavenger Pile Collection Pond Volume and Surplus

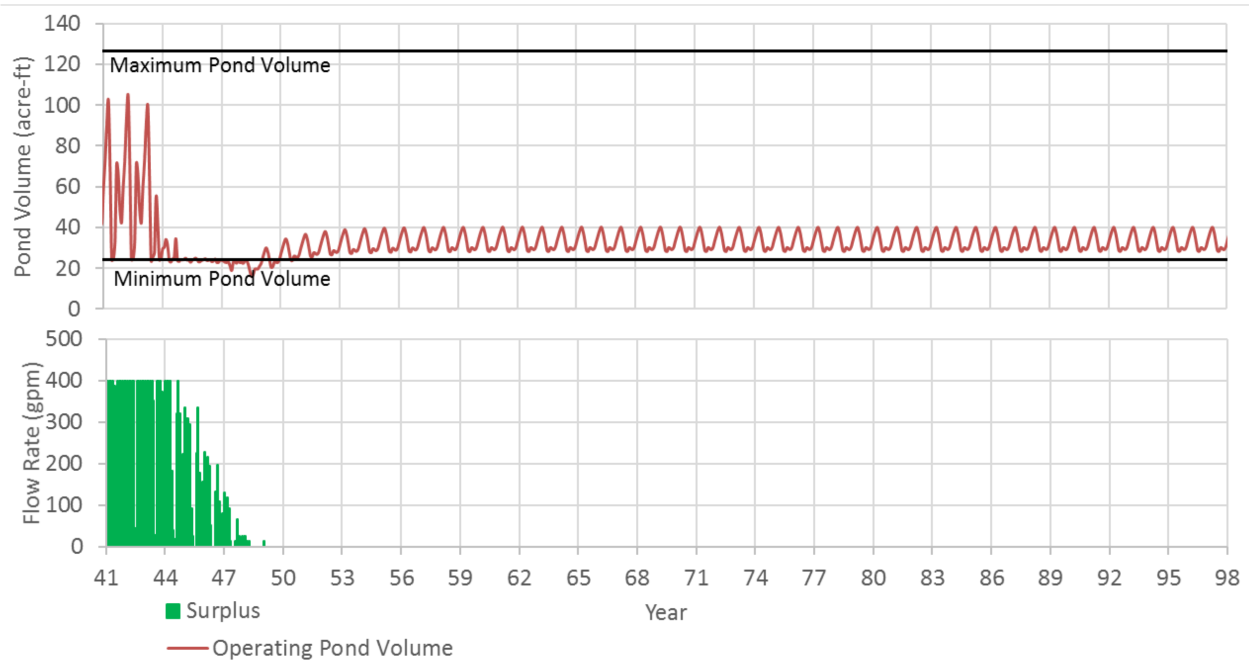


Figure 10.2 Post-Closure Pyrite Pile Collection Pond Volume and Surplus

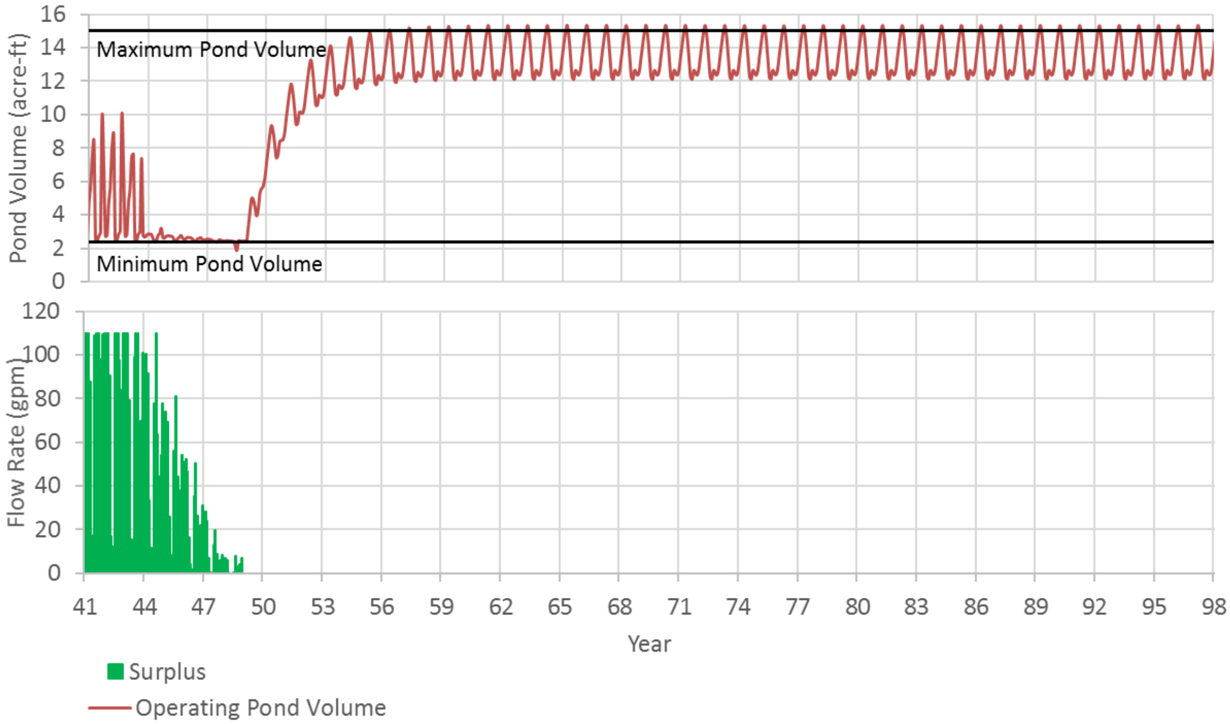


Table 10.1 Post-closure Phase 1 Surplus

Flow Description	Maximum Monthly Flow Rate (gpm)	Average Monthly Flow Rate (gpm)
Surplus from Scavenger Pile Collection Pond	400	250
Surplus from Pyrite Pile Collection Pond	110	50

11 RISKS

Several key risks have been identified for Alternative 4 that should be considered when comparing alternatives, and, if applicable, be further investigated. These are summarized below.

- Precedents for Scale of Filtered Tailings Operation
  - There is currently no precedent for a filtered tailings operation at the production rate, height of tailings piles required, and filtering high-pyrite content tailings as proposed for the Resolution Project. The uncertainty with this approach and inability to benchmark operations and management practices introduce significant risk and likely justify inclusion of a slurry tailings contingency.
- Processing and Transportation
  - Most filtered tailings projects have reported challenges achieving target moisture contents and throughputs from filter plants on a reliable basis, especially at start-up.
  - The rough terrain at the Silver King site poses a significant challenge for tailings conveyance to and around the tailings piles.
- Construction and Operations
  - Due to potential upsets/unreliability of the filter plant and conveyor systems (e.g. planned and unplanned downtime, unsuitable tailings moisture content and/or gradation) multiple layers of secondary storage for slurry tailings would be required.
  - At the Resolution Project's production rates, a back-up facility or stockpile that has the capacity for even 15% of the tailings would not be feasible within the current proposed disturbance footprints. Therefore, there would be significant additional disturbance on National Forest Service land.
- Surface Water Management
  - The current TSF configuration has tailings stored in large natural drainages. To manage this risk, large upstream diversion dams with high capacity outlets would be required in perpetuity or if tailings are relocated.
  - Runoff and seepage contact water would be managed in large downstream collection ponds rather than within the reclaim pond of a conventional tailings impoundment. Therefore, there will be additional large water retaining dams around the site, and increased associated disturbance on National Forest Service land.
- Dust Management
  - Walking stacker conveyors as well as large mobile equipment fleets for transporting and placement of filtered tailings would require a large active placement area, which cannot be progressively reclaimed. Therefore, there will be large areas susceptible to dusting.

  - Partially-saturated filtered tailings are prone to dusting and require active dust management if exposed surfaces cannot be progressively reclaimed; requiring compaction, temporary covers, and/or application of synthetic dust suppressants.
- Downstream Water Quality
  - If the pyrite tailings were filtered and stacked, they would be placed and kept in a partially-saturated state. Thus, they would oxidize under wetting and drying cycles from storm events, which would generate ARD and produce poorer water quality runoff compared to pyrite tailings stored in a saturated state (e.g. beneath a pond in a conventional facility). In a submittal to the USFS dated March 9, 2017 Resolution Copper provided a detailed technical report evaluating the chemistry of unsaturated pyrite tailings (Duke HydroChem 2017b). The relative impact on downstream water quality from a filtered TSF compared to a conventional TSF would be based on the relative benefits of reduced seepage quantity from the filtered alternative versus better water quality from an alternative that keeps the pyrite tailings saturated.

12 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, DEIS Design for Alternative 4 – Silver King Filtered. 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.

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APPENDIX I

Design Basis Memorandum

Resolution Copper Project

DEIS Design for Alternative 4 – Silver King Filtered

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 4 – Silver King Filtered 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 Silver King Canyon location in Pinal County, 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 alternatives studies and site-specific data collected from site investigations, where applicable.

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. The design is tailored to meet United States Forest Service (USFS) requirements for the EIS.

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

<u>Tailings Storage Facility and External Water Collection Dams</u>

- 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 Statutes (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.

<u>External Water Collection Dams (only)</u>

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*.
- Canadian Dam Association (CDA). 2007a. *Dam Safety Guidelines (with 2013 revision).*
- Canadian Dam Association (CDA). 2007b. *Technical Bulletin: Hydrotechnical Considerations for Dam Safety*.
- Canadian Dam Association (CDA). 2014. *Technical Bulletin: Application of Dam Safety Guidelines to Mining Dams*.
- Federal Emergency Management Agency (FEMA). 2005. *Federal Guidelines for Dam Safety – Earthquake Analyses and Design of Dams. FEMA-65.*
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<u>Upstream Diversion Dams (only)</u>

The upstream diversion dams are regulated in the same way as the external water collection dams with the exception of ADEQ, as they are not considered part of the TSF.

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[1]” and will be designed in accordance with Section 3.5 of the BADCT manual (ADEQ 2005). The external water collection 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).

[1] BADCT (ADEQ 2005) defines a tailings impoundment as one storing thickened tailings slurry and does not provide separate guidance provided for filtered tailings piles. For this DBM, design criteria for tailings impoundments are applied for filtered tailings piles.

2 DESIGN CRITERIA

Table 2.1 Design Criteria

	Item	Design Criteria	Reference
1.0	**Tailings Storage Facility (TSF) Scavenger and Pyrite Tailings Pile Design**		
1.01a	CDA Consequence Classification	Runout analysis required to confirm.	▪ CDA (2007a)
1.01b	Rio Tinto Risk Category	Assumed Class IV.	▪ 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 impact the functionality of the drains, engineered low permeability liners, etc.).	BADCT (ADEQ 2005) D5 Rio Tinto (2017)
1.06	Seismicity	▪ Maximum Credible Earthquake (MCE). Earthquake design ground motions would be selected for appropriate return period events.	BADCT (ADEQ 2005) supplemented with MEM (2016), CDA (2014), D5 Rio Tinto (2017) and industry practice
1.07	Tailings Surface Water Management	The tailings pile and collection ditches will be designed to safely pass the Probable Maximum Flood from the tailings surface (e.g. sloped and with sufficient freeboard so that flooded water will not overtop and erode the structural zones).	BADCT (ADEQ 2005)
1.08	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)

Table 2.1 Design Criteria (cont'd)

	Item	Design Criteria	Reference
1.09	Drains	▪ Provide drains/filters satisfying USACE (2004) guidelines. ▪ Drains designed to maintain phreatic surface to acceptable levels within the structural zones with adequate safety factor to account from clogging and uncertainty.	USACE (2004)
1.10	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)
1.11	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)
1.12	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)
1.13	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	**External Water Collection Dams**		
2.01	Assumed downstream hazard classification	High (would need to be assessed for each individual seepage dam).	A.A.C R12-15-1216
2.02	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
2.03	Downstream slope	As per Table 2.1, item 1.03.	
2.04	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)
2.05	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)

Table 2.1 Design Criteria (cont'd)

	Item	Design Criteria	Reference
2.06	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)
2.07	Pond Storage Capacity	Storage capacity = sediment storage + 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 freeboard (see Table 2.1, item 2.11)	BADCT (ADEQ 2005)
2.08	Storage Volume for Operational Upset Conditions	One week of average seepage and precipitation to account for a period of pump shut-down	
2.09	Environmental Design Flood (EDF)	Minimum requirement for BADCT is 100-year 24 hr. Scavenger tailings water collection dam sized for the 200-year 24 hr. Pyrite tailings water collection dam sized more stringently for the 200-year 7-day event (due to concerns with poor water quality). EDF would be confirmed through water balance and water quality modeling.	BADCT (ADEQ 2005)
2.10	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)

Table 2.1 Design Criteria (cont'd)

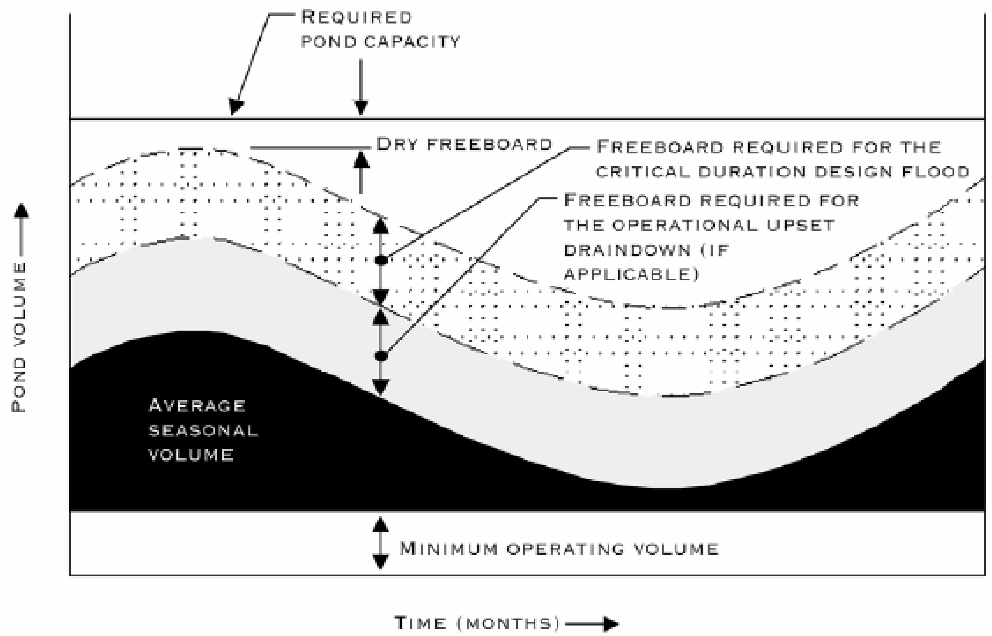
	Item	Design Criteria	Reference
2.11	Freeboard	Largest of: ▪ IDF + wave run up with a critical wind annual exceedance probability of the 1 in 2 year event ▪ IDF + 3 ft ▪ 5 ft	A.A.C R12-15-1216 with consideration from CDA (2007b)
2.12	Low level outlet (or discharge - pump)	Can discharge 90% of storage volume within 30 days (minimum capacity).	A.A.C R12-15-1216
2.13	Seepage	See Table 2.1, item 1.08.	
2.14	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
2.15	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 structure 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)
3.0	**Upstream Diversion Dams**		
3.01	Assumed downstream hazard classification	High (would need to be assessed for each individual dam)	A.A.C R12-15-1216
3.02	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
3.03	Downstream slope	As per Table 2.1, item 1.03.	
3.04	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 Rio Tinto (2017)

Table 2.1 Design Criteria (cont'd)

	Item	Design Criteria	Reference
3.05	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)
3.06	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)
3.07	Inflow Design Flood (IDF) For Dam Safety	A.A.C R12-15-1216: 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. FEMA (2013): PMF for a dam classified as high hazard.	A.A.C R12-15-1216 D5 Rio Tinto (2017) FEMA (2013)
3.08	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)
3.09	Low level outlet (or discharge - pump)	Can discharge 90% of storage volume within 30 days (minimum capacity).	A.A.C R12-15-1216

Figure 2.1 Pond Capacity Determination (ADEQ 2005)

FIGURE E-2 - CONCEPTUAL ILLUSTRATION OF
POND CAPACITY DETERMINATION



3 DESIGN BASIS

Table 3.1 Design Assumptions, Constraints & Data Sources

	Item	Design Basis	Comments
1.0	**General Design Basis**		
1.01	TSF location	▪ Silver King Canyon site, Pinal County, Arizona (USFS land) ▪ Coordinates (Arizona State Plane Central NAD83): 945,000’ E, 850,000’ N	
1.02	Mine Flow Sheet	Selective	
1.03	Mine life	41 years	Received from RC; email dated December 12, 2018
1.04	TSF operating life	41 years	Received from RC; email dated December 12, 2018
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; email dated December 12, 2018
1.06	Tailings technology	Filtered (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; email dated December 12, 2018
1.09	Ore and tailings production schedule	Table 3.2.	
1.10	Units	U.S. Customary	
2.0	**Topography**		
2.01	Projection	Arizona State Plane Central	
2.02	Datum	NAD83	
2.03	Unit of measurement	U.S. Customary	
2.04	Survey	2013 LiDAR survey received from RC on June 5/6, 2013.	
3.0	**Seismicity**		
3.01	Ground Motions	Not analyzed for this design (refer to Table 3.1, Item 7.02).	

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

<table>
<tr><th></th><th>Item</th><th>Design Basis</th><th>Comments</th></tr>
<tr><td>4.0</td><td>Climate and Hydrology</td><td></td><td></td></tr>
<tr><td>4.01</td><td>Average precipitation (in inches)</td><td><table><tr><th>J</th><th>F</th><th>M</th><th>A</th><th>M</th><th>J</th><th>J</th><th>A</th><th>S</th><th>O</th><th>N</th><th>D</th><th>Total</th></tr><tr><td>2.0</td><td>2.0</td><td>2.0</td><td>0.8</td><td>0.3</td><td>0.3</td><td>1.9</td><td>2.8</td><td>1.5</td><td>1.2</td><td>1.4</td><td>2.1</td><td>18.2</td></tr></table></td><td>Data collected at the Superior climate station (ID: 028348) with gaps filled using data from the regional climate stations.</td></tr>
<tr><td>4.02</td><td>Wet and dry year precipitations</td><td>Consideration to wet and dry years for the water balance will not be made for this design.</td><td></td></tr>
<tr><td>4.03</td><td>Average annual pan evaporation</td><td>96.5 in</td><td>Pan evaporation data collected at the Roosevelt 1 WNW climate station (ID: 027281).
Free water surface evaporation determined using the Evaporation Atlas for the Contiguous 48 United States (NOAA 1982).</td></tr>
<tr><td>4.04</td><td>Evapotranspiration for reference surface/crop (in inches)</td><td><table><tr><th>J</th><th>F</th><th>M</th><th>A</th><th>M</th><th>J</th><th>J</th><th>A</th><th>S</th><th>O</th><th>N</th><th>D</th><th>Total</th></tr><tr><td>2.9</td><td>3.4</td><td>5.0</td><td>6.6</td><td>8.5</td><td>9.2</td><td>9.0</td><td>8.0</td><td>7.0</td><td>5.8</td><td>3.8</td><td>3.1</td><td>72.3</td></tr></table></td><td>Calculated using the Penman-Monteith combined equation in Hydrus1D based on the generated Superior climate data set and reference vegetation parameters.</td></tr>
<tr><td>4.05</td><td>Natural catchment runoff coefficient</td><td>0.15</td><td>Calculated by dividing the average annual runoff from the nearby USGS hydromet station by the average annual precipitation at site (KCB 2014).</td></tr>
<tr><td>4.06</td><td>Probable Maximum Precipitation (PMP)</td><td><table><tr><th rowspan="2">Storm Type</th><th colspan="3">PMP Depth (inches)</th></tr><tr><th>6 hour Duration</th><th>24 hour Duration</th><th>72 hour Duration</th></tr><tr><td>General Winter</td><td>6</td><td>11</td><td>16</td></tr><tr><td>Tropical</td><td>15.5</td><td>20.3</td><td>24</td></tr><tr><td>Local</td><td>13.7</td><td>-</td><td>-</td></tr></table></td><td>Applied Weather Associates PMP Evaluation Tool.
Determined as the critical storm for design.
For Whitford Canyon</td></tr>
<tr><td>4.07</td><td>Runoff coefficient during storm events</td><td>1.0</td><td>To account for high antecedent moisture conditions and the predominantly exposed rock in the catchment</td></tr>
<tr><td>4.08</td><td>Extreme point precipitation depths</td><td>See Table 3.3</td><td>From NOAA Atlas 14 (NOAA 2018).</td></tr>
</table>

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

	Item	Design Basis		Comments
5.0	**Tailings Characteristics and Deposition**			
		Scavenger Tailings	**Pyrite Tailings[2]**	
5.01	Target gradation produced at mill	*"Total" Tailings:* Target P80 = 160 microns 50% fines (<74 microns) <10% clay (<2 microns)	Target P80 = 75-80 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	Specific gravity	2.78	3.87	Average values from KCB laboratory testing programs on scavenger "total" tailings and cleaner[1] tailings.
5.03	Solids content pumped from the mill	65%	50%	Provided by RC.
5.04	Liquefaction assumption	All potentially liquefiable tailings will liquefy at the TSF, regardless of triggering mechanism.		
5.05	Pyrite tailings management	N/A	Stored separately from scavenger tailings in a facility with an engineered low-permeability liner (see Table 3.1, item 6.08).	
5.06	Tailings pile surface slopes	Sloped away from structural zones to collection ditches	Sloped away from structural zones to collection ditches.	To limit ponding on tailings surfaces adjacent to the structural zones.

[2] Previous tailings characterization was based on the Bulk Flowsheet which produced cleaner tailings as an end-product. However, RC updated their preferred process flow sheet to the Selective Flowsheet in 2012, which produces "pyrite tailings" as the end-product instead of cleaner tailings. In the Selective Flowsheet, the scavenger tailings are further desulfurized. The cleaner tailings and the scavenger concentrate de-sulfurization by-product are combined to produce pyrite tailings. Further laboratory testing to characterize the scavenger and pyrite tailings from the Selective Flowsheet is currently ongoing. For the purposes of this study, it is assumed that the cleaner tailings and pyrite tailings are physically and geochemically similar.

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

	Item	Design Basis		Comments
5.07	Dry tailings pile surface runoff coefficient (top surfaces)	0.10	0.10	Estimated based on Hydrus1D infiltration modeling. Coefficient was reduced compared to the "wet" alternatives due to higher expected absorption potential of the filtered tailings surface.
5.08	Dry tailings pile surface runoff coefficient (external slopes)	0.15	0.15	Estimated based on Hydrus1D infiltration modeling.
5.09	Dry density for annual staging assessments	structural zone : 110 pcf non-structural zone : 103 pcf	structural zone : 137 pcf non-structural zone : 125 pcf	KCB (2018)
6.0	**Filter Plant Design**			
		Scavenger Tailings	**Pyrite Tailings**	
6.01	Target Filter Plant tailings solids content (for placement)	89%	86%	Based on compaction testing of filtered tailings with similar properties to the RC tailings. Solids content must be high enough (or, conversely, water content must be low enough) to allow for tailings transportation and adequate compaction.
6.02	Target Filter Plant tailings moisture content (weight of water / weight of solids) (for placement and compaction at optimum moisture content)	13.5%	17%	
6.03	Filter cycle time	17 min	11 min	Based on the results of pilot-scale pressure filtration testing performed on scavenger tailings and on copper concentrate (used as an analogue for pyrite tailings) (Pocock 2015). Air blow time was chosen to achieve the target water content (see Table 3.1, Item 6.02)
6.04	Filter availability	85%	85%	Preliminary design assumption
6.05	Filter unit contingency	15%	15%	Preliminary design assumption

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

	Item	Design Basis	Comments
7.0	**Tailings Storage Facility (TSF) Tailings Pile Design**		
7.01	Design criteria	As per Table 2.1.	
7.02	Stability and Deformations	Tailings piles (typical section, refer to Figure 3.2) assumed to meet design stability and deformation criteria for DEIS.	Based on preliminary stability analyses reported in KCB (2017a) and assumed typical foundation conditions at the Near West site, located approximately 5 miles to the southwest (KCB 2017b). The filter pile preliminarily assessed in KCB (2017a) was approximately 500 ft high, whereas the scavenger pile at Silver King is approximately 1,000 ft high (refer to Appendix II). Foundation conditions at Silver King would be investigated further.
7.03	Width of structural zone crest at full pile build-out	100 ft	Sufficient to accommodate 2-way vehicle traffic, pipelines and any other equipment required to be on the crest (e.g. conveyance infrastructure).
7.04	Downstream Slope	3H:1V (see Figure 3.2)	Assumed based on preliminary stability analysis reported in KCB (2017a).
7.05	Slope of Structural/Non-Structural Interface	1H:1V (see Figure 3.2)	Assumed based on preliminary stability analysis reported in KCB (2017a).
7.06	Pond Management	No permanent water ponds on the pile surfaces. Stormwater runoff will be collected and transferred to the external water collection ponds.	
7.07	Surface Erosion and Dust Control	Progressive reclamation of exterior slopes throughout operations; non-water based dust suppressants used on tailings surfaces.	
7.08	Liner	Engineered low-permeability liner[3] below the pyrite tailings pile; no engineered lining below the scavenger tailings pile.	
7.09	Drainage	Sand and gravel drainage blanket and/or finger drains in the structural zone footprint.	
7.10	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 and water ingress by covering with scavenger tailings.	Approach agreed with RC.

[3] The engineered low-permeability liner 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
8.0	**External Water Collection Dams**		
8.01	Design Criteria	As per Table 2.1.	
8.02	Crest width	25 ft, as per Table 2.1., item 2.02.	Preliminary allowances.
8.03	Downstream and upstream slopes	2.5H:1V, as per Table 2.1., item 2.03.	Preliminary allowances.
8.04	Minimum operating water pond depth	10 ft depth for reclaim pump (could be accounted for by a sump)	Preliminary allowances.
8.05	Maximum average seasonal volume	10 ft depth	Preliminary allowances.
8.06	Volume required for operational upset	10 ft depth, as per Table 2.1., item 2.08	Preliminary allowances.
8.07	Environmental Design Flood	200-year 24-hour for scavenger tailings water collection dam and 200-year 7-day for pyrite tailings water collection dam, as per Table 2.1., item 2.09	Preliminary allowances.
8.08	Inflow Design Flood	10 ft depth allowance to route the Probable Maximum Flood (PMF), as per Table 2.1., item 2.10	Preliminary allowances.
8.09	Freeboard	5 ft depth to account for wind runup, wave setup and embankment crest settlement, as per Table 2.1., item 2.11	Preliminary allowances.
9.0	**Upstream Diversion Structures**		
9.01	Design Criteria	As per Table 2.1.	
9.02	Crest width	25 ft, as per Table 2.1., item 3.02.	Preliminary allowances
9.03	Downstream and upstream slopes	2.5H:1V, as per Table 2.1., item 3.03.	Preliminary allowances
9.04	Inflow Design Flood	PMF with a duration that is the critical duration of 6 hr to 72 hr, as per Table 2.1., item 3.07.	Preliminary allowances
9.05	"Dry" Freeboard	6 ft depth to account for wind runup, wave setup and embankment crest settlement, as per Table 2.1., item 3.08.	Preliminary allowances
9.06	Tunnel outlets	Sized to optimize dam height and tunnel dimension using a slope of 1% and a manning's n of 0.035 for rock cuts.	Preliminary allowances Manning's n reference (FHWA, 2005).
9.07	Pump and pipe discharge	Capacity to be determined as per Table 2.1., item 3.09.	

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 Resolution Copper in an email dated December 12, 2017.
Mine plan descriptions, mine years and modeling years supplied by Resolution Copper in an email dated January 12, 2018.

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	0.2	0.4	0.4	0.6	0.7	0.9	0.9	1.1	1.3	1.6	1.8	2.0	2.1	2.4	2.7	3.3	4.0	4.7	5.5
2	0.3	0.5	0.6	0.8	1.0	1.1	1.2	1.4	1.7	2.0	2.3	2.5	2.7	3.0	3.4	4.2	5.1	6.0	6.9
5	0.4	0.6	0.8	1.1	1.3	1.5	1.5	1.8	2.1	2.6	2.9	3.2	3.5	3.9	4.3	5.4	6.5	7.7	8.7
10	0.5	0.8	0.9	1.3	1.6	1.7	1.8	2.1	2.4	3.0	3.5	3.8	4.1	4.7	5.1	6.4	7.6	8.9	10.1
25	0.6	0.9	1.1	1.5	1.9	2.1	2.2	2.5	2.8	3.6	4.2	4.6	5.0	5.8	6.2	7.7	9.1	10.6	11.9
50	0.7	1.0	1.3	1.7	2.2	2.4	2.5	2.8	3.2	4.1	4.7	5.2	5.7	6.7	7.2	8.7	10.3	12.0	13.3
100	0.8	1.2	1.5	2.0	2.4	2.7	2.8	3.1	3.5	4.6	5.3	5.9	6.5	7.6	8.2	9.8	11.6	13.3	14.7
200	0.9	1.3	1.6	2.2	2.7	3.0	3.1	3.4	3.9	5.1	5.9	6.6	7.4	8.7	9.2	10.9	12.9	14.6	16.1
500	1.0	1.5	1.8	2.4	3.0	3.4	3.6	3.9	4.4	5.8	6.8	7.7	8.5	10.2	10.7	12.4	14.7	16.5	17.9
1000	1.1	1.6	2.0	2.7	3.3	3.7	3.9	4.2	4.7	6.4	7.4	8.5	9.5	11.4	12.0	13.6	16.1	17.9	19.3

Note: From NOAA Atlas 14 (NOAA 2018) for the Near West site.

Figure 3.1 Process Schematic

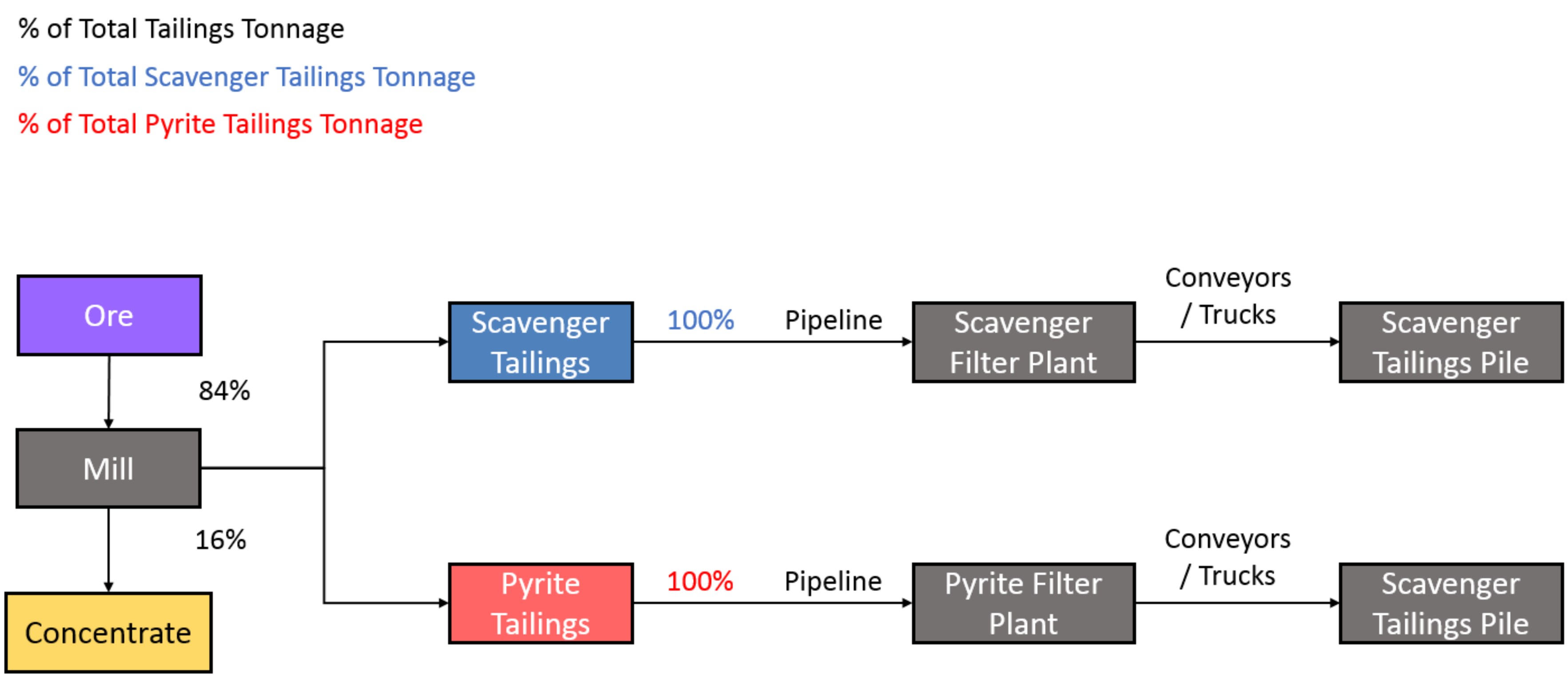


Figure 3.2 Tailings Pile Cross Section

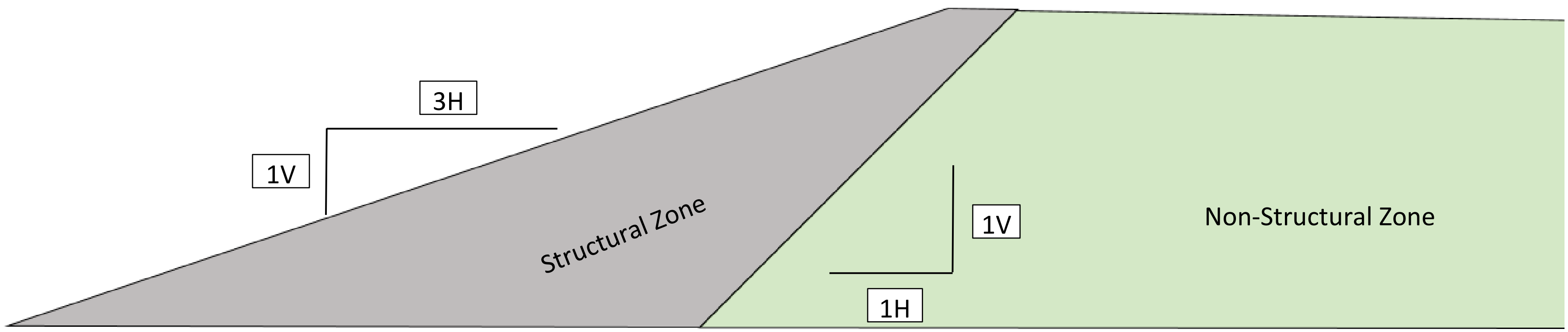
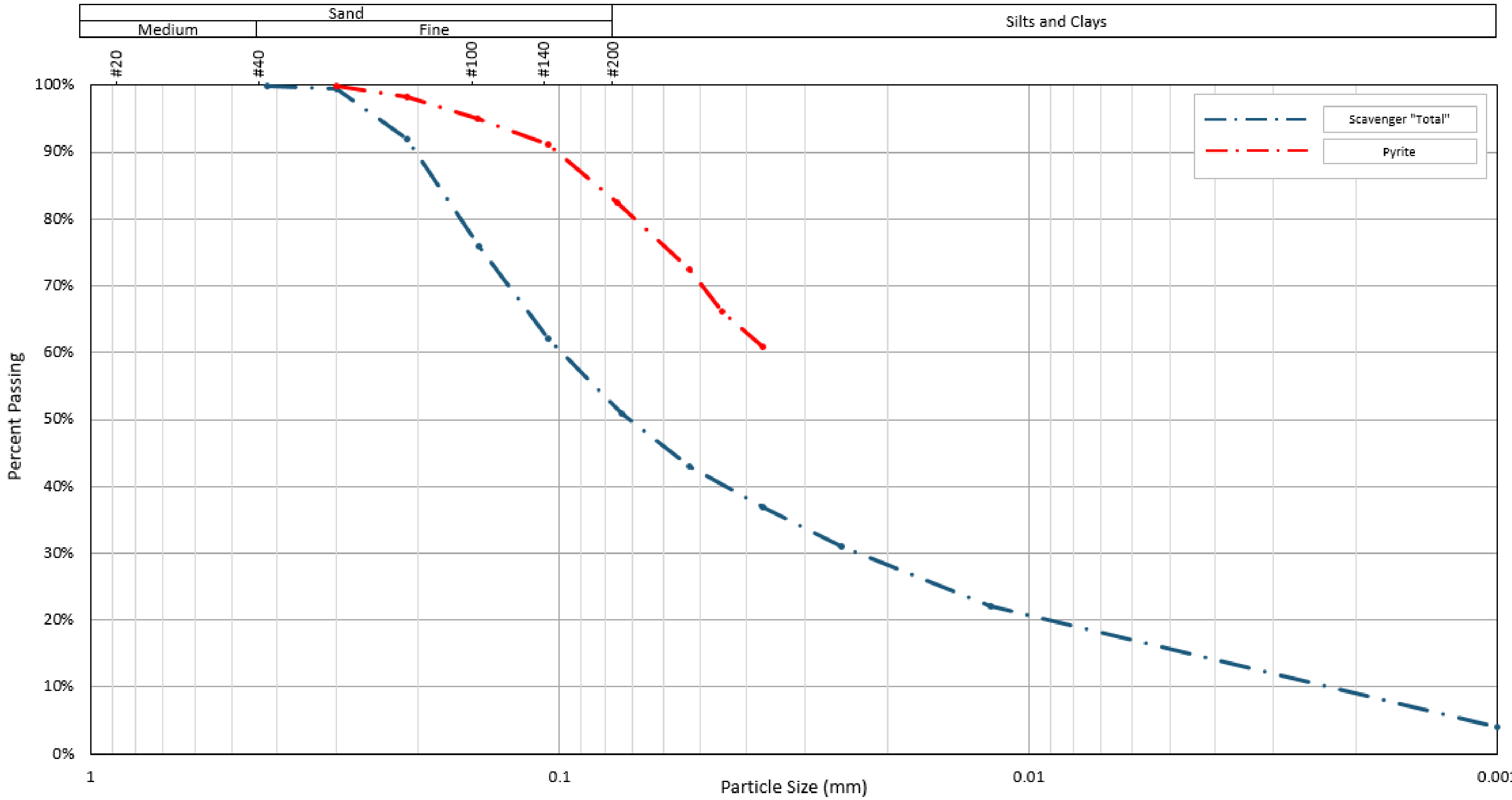


Figure 3.3 Target Tailings Gradations for Design



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APPENDIX II

Tailings Staging Plan

Resolution Copper Project

DEIS Design for Alternative 4 – Silver King Filtered

Technical Memorandum

Appendix II – Tailings Staging Plan

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Appendix II
Tailings Staging Plan

Table of Contents

List of Tables

List of Figures

List of Appendices

II-1 INTRODUCTION

This appendix presents the tailings staging plan for the Draft Environmental Impact Statement (DEIS) design of the Alternative 4 – Silver King Filtered (Alternative 4) tailings storage facility (TSF). Modeling of the NPAG scavenger (scavenger) and PAG pyrite (pyrite) tailings placement was completed using the tailings deposition software Muck3D (MineBridge Software Inc., version 1.0.5).

The tailings pile locations and arrangement details were chosen by the United States Forest Service (the Forest) (Forest 2017). KCB adjusted the heights of the piles to accommodate the expected tailings volume based on the estimated tailings densities and other assumptions specified in the design basis memorandum (DBM) (Appendix I) but have not changed the ultimate arrangement/footprint from what the Forest proposed. Key objectives of the staging were to determine:

- the tailings pile heights;
- rate of rise of the tailings piles;
- volumes placed and compacted in structural zones and non-structural zones;
- annual reclaimed and exposed areas of the tailings piles; and
- locations and volumes for emergency tailings slurry storage facilities, required to store tailings if the filter plants are not operating or tailings moisture contents are not being achieved.

II-2 TAILINGS PLACEMENT STRATEGY

Alternative 4 was proposed by the Forest and consists of separate filtered tailings piles for the pyrite and the scavenger tailings.

Filtered tailings are not completely dry and could have the potential to liquefy if not compacted to a non-liquefiable state and degree of saturation is high enough. Best practice is to have (at minimum) a dilatant structural zone around the filter pile perimeter for structural stability. The structural zone can be constructed of borrow material or of compacted filtered tailings, which is the assumption made for this assessment, refer to Section II-3.5.

For the purposes of the staging assessment, the piles were assumed to be constructed in horizontal lifts starting at the lowest elevation and progress up to the ultimate elevation. In reality, the tailings placement approach would be dependent on the method of transportation chosen and other site-specific factors. The crest elevation of the structural zone has been set to meet or exceed the elevation of the non-structural zone at each stage. The top of the tailings piles would be sloped into the hillside to limit flow over, and erosion of, the downstream slope. Contact water would be routed around the tailings piles and managed in downstream water collection ponds. Downstream slopes would be progressively reclaimed and non-contact runoff would be diverted around the water collection dams, as much as practical.

II-3 MODELING INPUT PARAMETERS AND ASSUMPTIONS

II-3.1 General

The model input parameters and assumptions for the filter pile staging assessment, emergency tailings slurry storage pond layout and sizing are discussed in the following sections and summarized in the DBM (Appendix I).

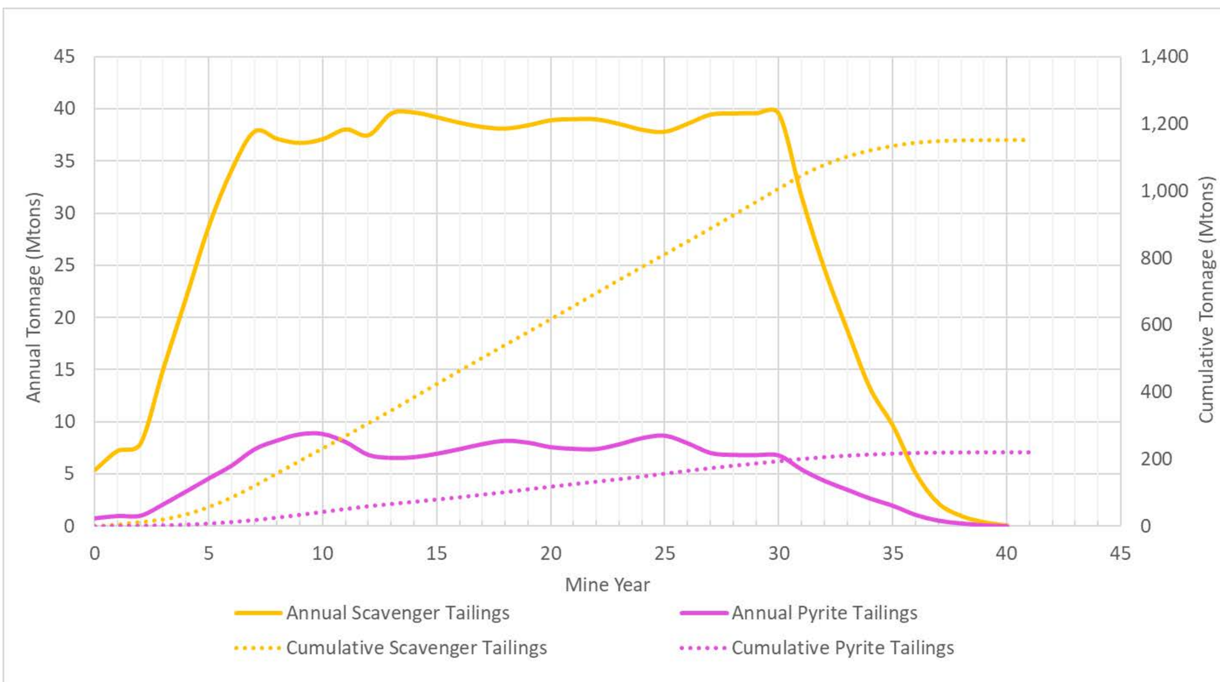
II-3.2 Tailings Production Schedule

The DEIS tailings production schedule is summarized in Table II-1 and Figure II-1. The annual tailings quantities are reported in tabular form in the DBM (Appendix I).

Table II-1 Total Tailings Production

Total Tailings (Scavenger + Pyrite) (tons)	Scavenger Tailings (tons)	Pyrite Tailings (tons)
1,370,711,161	1,150,727,095	219,984,066

Figure II-1 Tailings Production Schedule



II-3.3 Filter Plant Target Water Content

Filtered tailings piles require structural zones (as described in Section II-2), which could consist of compacted filtered tailings. Tailings placed and compacted in structural zones need to be at or close to the optimum water content[1] and compacted with adequate energy to achieve a dilatant, non-liquefiable state.

Based on the tailings properties, the optimum water contents (and therefore, the filter plant target water content[2]) for the scavenger and pyrite tailings are estimated to be approximately 11% and 14%, respectively. These values are based on compaction testing data on filtered tailings with similar gradation from other copper mining projects, and would be confirmed for the Resolution project. The optimum water contents equate to solids contents for the scavenger and pyrite tailings of approximately 89% and 86%, respectively. At this solids content, the filtered tailings would behave as a solid and must be transported by conveyor or truck to the filter piles.

At the proposed tailings production rates and assumed filter capacity, approximately 50 pressure filters would be required to meet the production demands and target water contents, refer to Appendix I.

II-3.4 Tailings Properties

The tailings properties are provided in the DBM (Appendix I) and summarized in Table II-2. A singular dry density value, representative of nominal compaction, was used for each tailings type for structural and non-structural zones. This is a conservative assumption for the purposes of tailings pile sizing.

Table II-2 Filtered Tailings Dry Densities

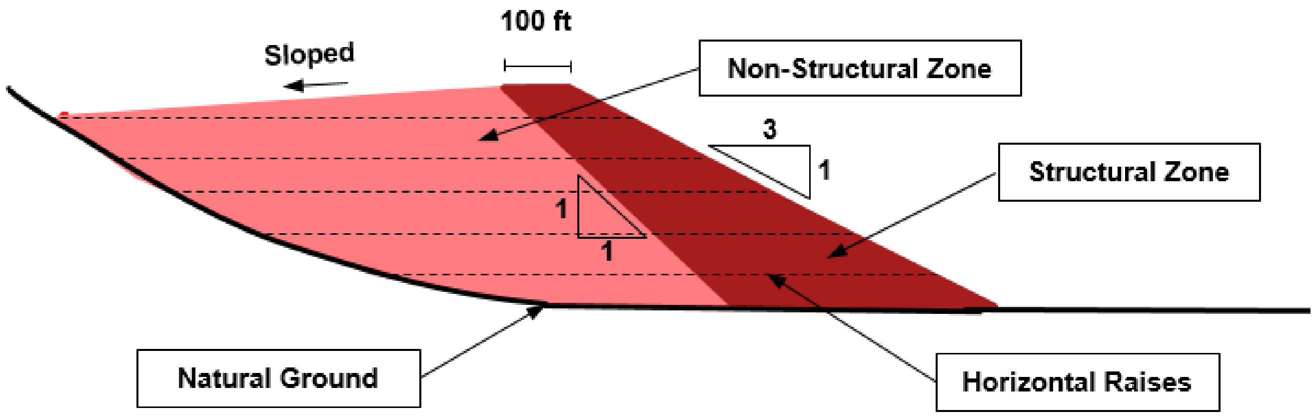
Filtered Tailings	Density (pcf)
Scavenger Tailings	103
Pyrite Tailings	125

II-3.5 Tailings Pile Cross Section

Both the scavenger and the pyrite tailings piles would comprise a structural outer tailings shell that contains a non-structural tailings zone. The structural zone would have a 3H:1V exterior slope and a 1H:1V interface with the non-structural zone. The width of the structural zone at full height would be 100 ft. A typical filter pile schematic cross section is shown on Figure II-2. At this conceptual level, the dimensions of the structural zone are based on previous stability analyses (KCB 2017).

[1] The optimum water content is the water content that allows for the maximum relative density to be achieved at a given energy input. Based on laboratory compaction testing.
[2] Weight of water / total weight of solids and water

Figure II-2 Pile Raising Scheme



II-3.6 Emergency Tailings Slurry Storage Facilities

Emergency slurry storage ponds would be required to store tailings slurry in the event that either of the filter plants shut down, operational upset occurs, or target water contents are not being met. When not in use, the emergency facilities can either be emptied and tailings filtered and placed in the piles; or covered and closed. If the emergency slurry storage facilities are emptied after each use, at least two emergency facilities would be required to separately store the scavenger and pyrite tailings. If a single emergency facility is constructed, all of the tailings from that facility would need to be deposited in the pyrite filtered tailings pile which must be accounted for in design of the pyrite tailings pile. If the emergency slurry storage facilities are not emptied after each use, new facilities would need to be constructed.

The emergency slurry storage facilities would include an engineered low-permeability liner[3] and be retained by perimeter earthfill dam(s) constructed from borrow fill. The design assumptions used to size the emergency slurry storage facilities are summarized in Table II-3 and as follows:

- facilities would be lined to meet prescriptive Best Available Demonstrated Control Technology (BADCT) (ADEQ 2005);
- dam dimensions: 40 ft crest width; 3H:1V downstream slope; 2.5H:1V upstream slope; and
- dam crest elevations based on the surrounding topography; with aim to maximize storage volume and minimize dam fill volume.

Emergency slurry storage facility locations and capacities are discussed in Section II-4.3.

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

Table II-3 Emergency Tailings Slurry Storage Facility Assumptions for Sizing

Quantity	Scavenger Tailings	Pyrite Tailings	Total Tailings
Maximum Annual Production (tons/year)	39,666,729	8,792,910	48,459,639
Slurry Density (pcf)	75	106	N/A
Maximum Annual Production (yd^3/year)	36,060,663	6,148,888	42,209,551
Maximum Weekly Production (yd^3/week)	691,574	117,924	809,498

II-4 MODELING RESULTS

II-4.1 Filter Pile Layout

The Alternative 4 configuration details are summarized in Table II-4. Screenshots of the tailings piles at select stages of TSF development are presented in Appendix II-A.

Table II-4 Alternative 4 Filtered Piles Layout

Item	Scavenger Pile	Pyrite Pile
Footprint Area (acre)	1,817	474
Ultimate Elevation (feet)	3,776	3726
Ultimate Height[1] (feet)	1,038	751
Mid-Slope Bench Elevation (feet)	3,346	N/A
Mid-Slope Bench Width (feet)	650	N/A
Maximum Bench Height	608	N/A

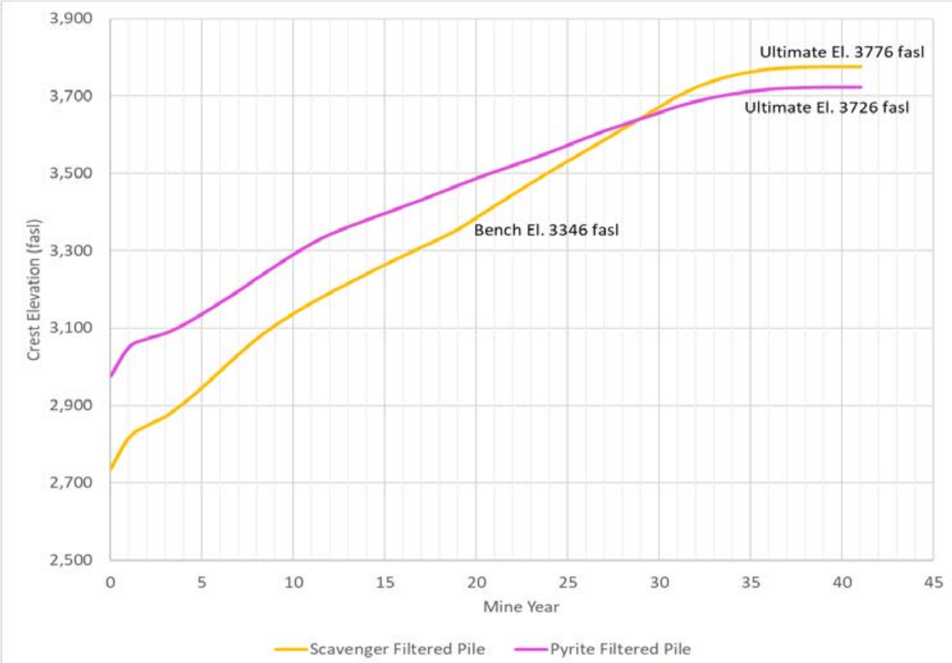
Notes: 1. Maximum height; measured from toe to crest.

Table II-5 Alternative 4 Staging Layout

Mine Year	Scavenger Pile				Pyrite Pile			
	Pile Elevation (fasl)	Pile Height[1] (ft)	Slope Area (acres)	Pile Top Area (acres)	Pile Elevation (fasl)	Pile Height[1] (ft)	Slope Area (acres)	Pile Top Area (acres)
10	3,138	400	182	580	3,290	315	86	113
20	3,385	647	707	585	3,487	512	182	165
41	3,776	1,038	1,175	634	3,726	751	310	141

Notes: 1. Maximum height; measured from toe to crest.

Figure II-3 Alternative 4 Pile Elevations



II-4.2 Tailings Pile Construction

Tailings pile rate of rise and placement rates are shown on Figure II-4. Cumulative pile volumes are shown on Figure II-5. Key details are summarized in Table II-6.

The highest rate of rise occurs early in operations due to confined placement areas at the base of natural valleys and steep topography. Opportunities to reduce rate of rise include stacking tailings at higher elevations within the TSF and/or constructing borrow fill “starter platforms” for tailings placement.

The rate at which tailings must be handled by mobile equipment, is equal to the daily tailings production rate. A large, dedicated fleet of mobile equipment, and potentially a high capacity conveyor system, would be required to support tailings placement. No known comparable system is currently in operation.

The daily compaction rate is equal to the rate of tailings placed in the structural zone, although some nominal compaction of tailings in the non-structural zone may be required for surface water control and trafficability. The highest compaction rates are realized in the early years of operations, as shown on Figure II-4.

Table II-6 Tailings Pile Construction Details

Tailings Pile	Average Annual Rate of Rise (ft/year)	Average Placement Rate (yd^3/day)	Average Compaction Rate (yd^3/day)	% of Tailings Placed in Structural Zone
Scavenger	25	55,300	30,300	55%
Pyrite	18	8,700	5,200	60%

Figure II-4 Alternative 4 Piles Rate of Rise

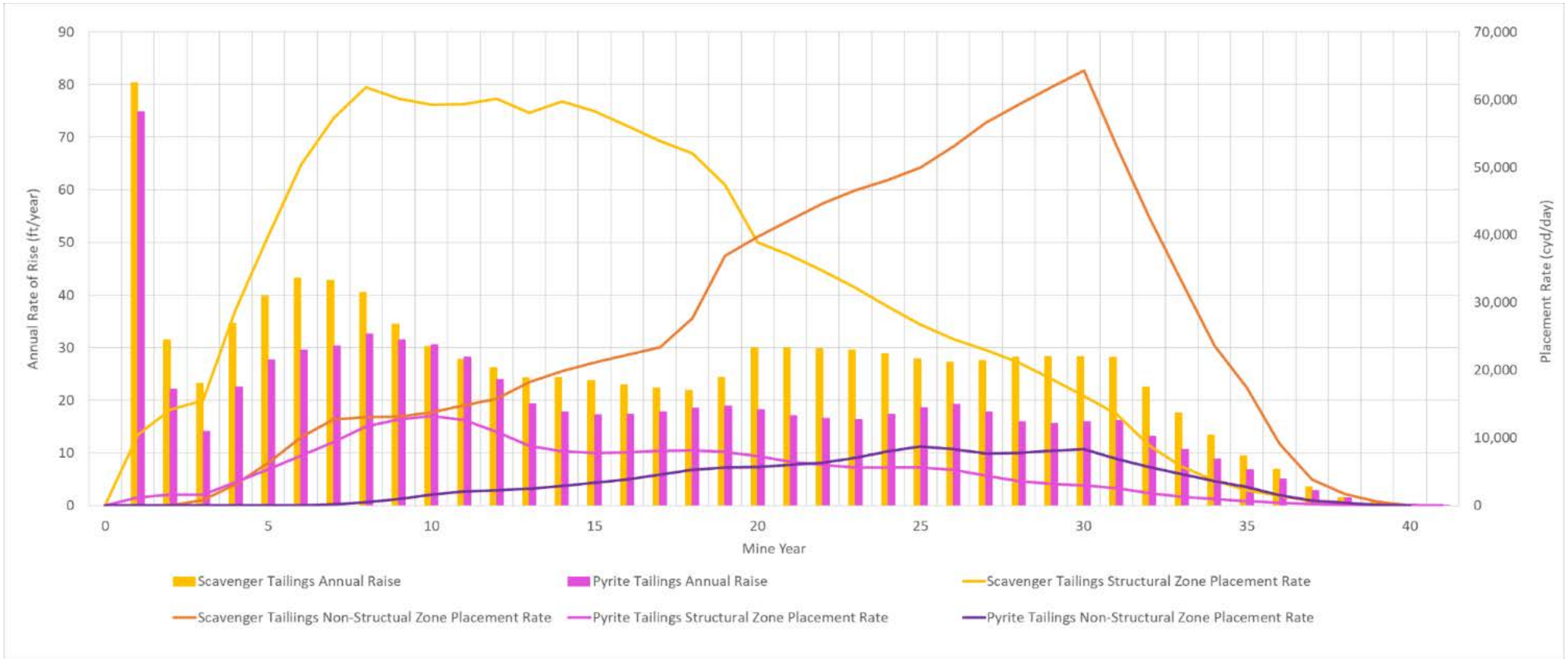
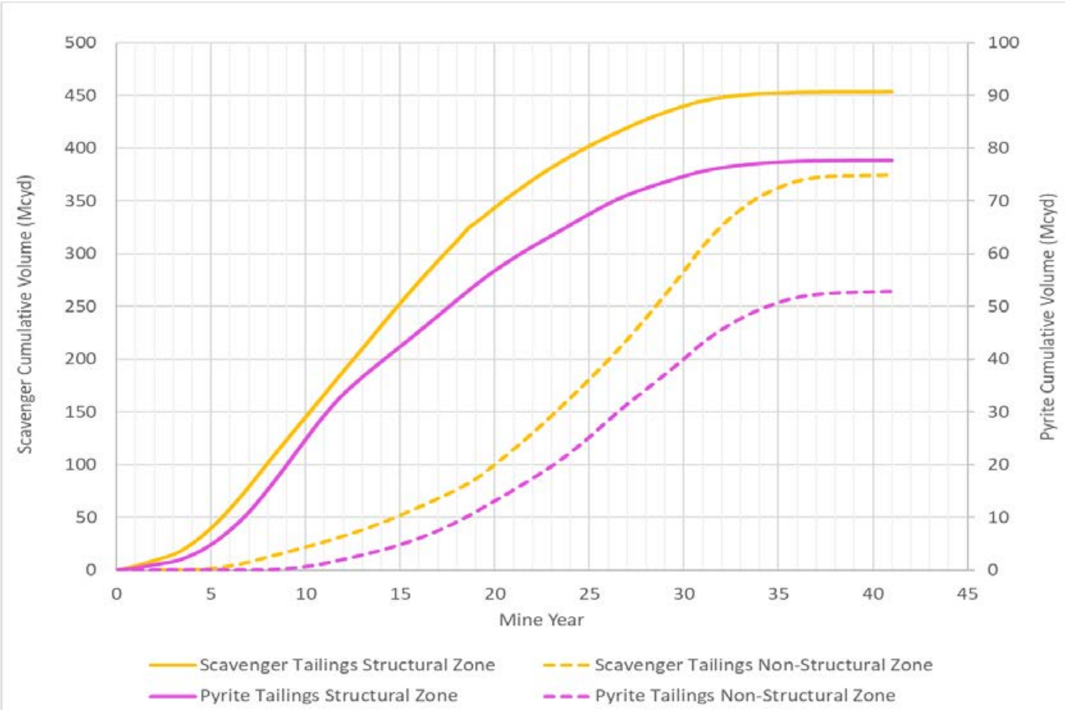


Figure II-5 Alternative 4 Pile Volumes



II-4.3 Emergency Tailings Slurry Storage Facilities

Three preliminary emergency slurry storage facilities were identified, based on the design assumptions discussed in Section II-3.6. Refer to Figure II-A.4 in Appendix II-A for plan views of the preliminary locations. Key details are summarized in Table II-7. The locations were selected based on favorable topography, foundation conditions, and proximity to the West Plant. The number of emergency facilities and required cumulative capacity depends on how emergency tailings slurry storage is handled in operations, for example, whether the facility is emptied after each use. Further discussion is provided in Section II-3.6.

Table II-7 Emergency Slurry Storage Facilities

Item	Location 1 Northeast of West Plant	Location 2 South of Scavenger Pile	Location 3 North of West Plant
Catchment Area (acre)	50	158	126
Dam Elevation (fasl)	2,800	2,850	2,830
Dam Height (ft)	83	78	102
Dam Fill Volume (yd^3)	178,000	732,000	569,000
Storage Volume to Crest Elevation ($yd^{3)}$	395,000	2,345,000	2,574,000
Storage Volume to 5 ft Below Crest Elevation (yd^3)[2]	315,000	2,010,000	2,209,000
Approximate Number of Days of Storage[1]	2	16	18

Notes: 1. Estimated based on the maximum tailings production rate for both scavenger and pyrite tailings.
2. The emergency TSF would require all the storage allowances for flood management described in the DBM (Appendix I), however, for preliminary sizing a 5 ft freeboard was used to estimate volume available for tailings storage.

REFERENCES

Arizona Department of Environmental Quality (ADEQ). 2005. Arizona Mining Guidance Manual BADCT (Best Available Demonstrated Control Technology).

Klohn Crippen Berger Ltd. (KCB). 2017. Near West Tailings Storage Facility Embankment Design Alternatives Analysis. March.

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APPENDIX II-A

Staging Figures

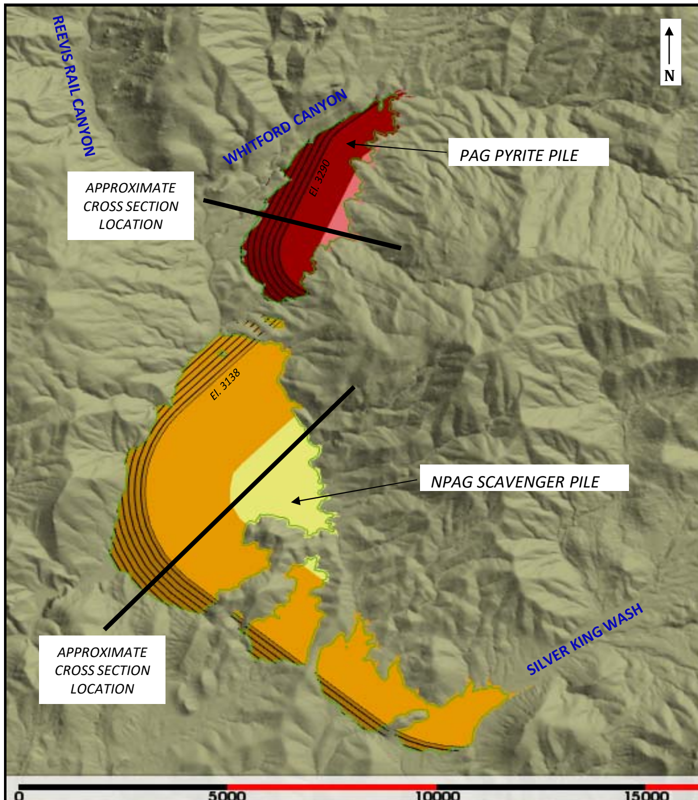

FIGURE 1 NPAG SCAVENGER PILE CROSS-SECTION SCHEMATIC

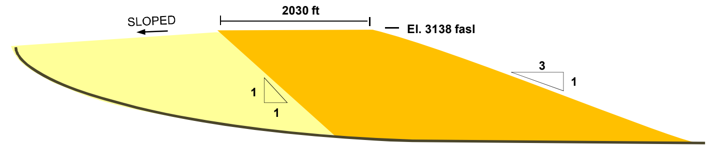

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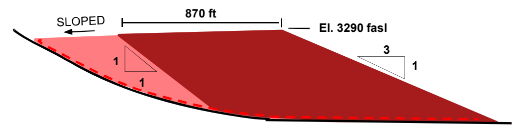
FIGURE 2 PAG PYRITE PILE CROSS-SECTION SCHEMATIC



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LEGEND

- NPAG SCAVENGER - STRUCTURAL ZONE
- NPAG SCAVENGER - NON-STRUCTURAL ZONE
- PAG PYRITE - STRUCTURAL ZONE
- PAG PYRITE - NON-STRUCTURAL ZONE
- PILE FOOTPRINT
- 50 ft CONTOUR
- CROSS SECTION LINE
- ENGINEERED LOW-PERMEABILITY LINER

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TITLE

LAYOUT YEAR 10

SCALE	PROJECT No.	FIG No.
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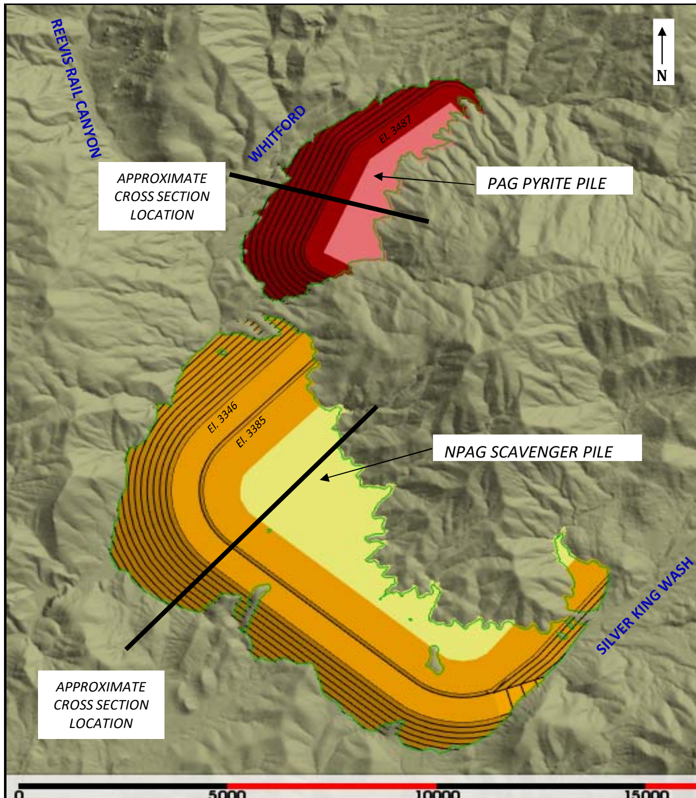


FIGURE 1 NPAG SCAVENGER PILE CROSS-SECTION SCHEMATIC

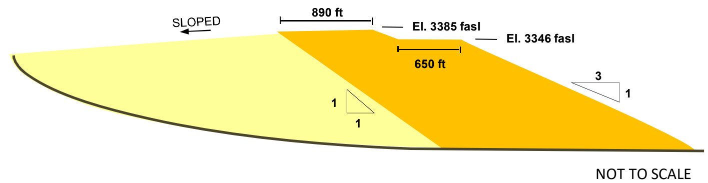
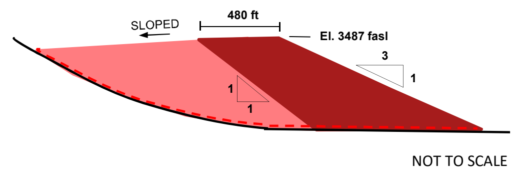


FIGURE 2 PAG PYRITE PILE CROSS-SECTION SCHEMATIC



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- PAG PYRITE - STRUCTURAL ZONE
- PAG PYRITE - NON-STRUCTURAL ZONE
- PILE FOOTPRINT
- 50 ft CONTOUR
- CROSS SECTION LINE
- ENGINEERED LOW-PERMEABILITY LINER

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TITLE: LAYOUT YEAR 20

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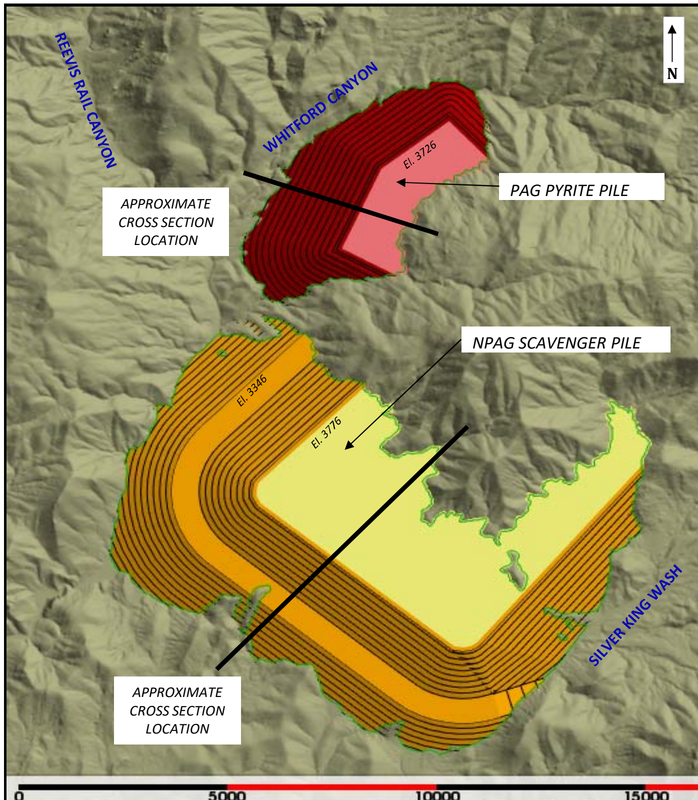


LEGEND

NPAG SCAVENGER - STRUCTURAL ZONE
NPAG SCAVENGER - NON-STRUCTURAL ZONE
PAG PYRITE - STRUCTURAL ZONE
PAG PYRITE - NON-STRUCTURAL ZONE
PILE FOOTPRINT
50 ft CONTOUR
CROSS SECTION LINE
ENGINEERED LOW-PERMEABILITY LINER

FIGURE 1 NPAG SCAVENGER PILE CROSS-SECTION SCHEMATIC

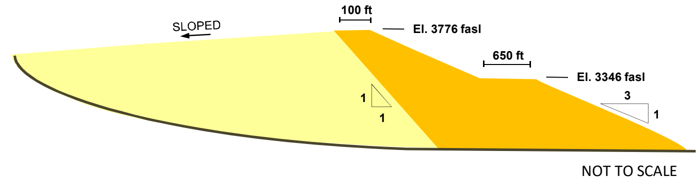
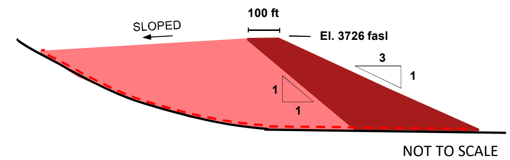


FIGURE 2 PAG PYRITE PILE CROSS-SECTION SCHEMATIC



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TITLE
LAYOUT YEAR 41

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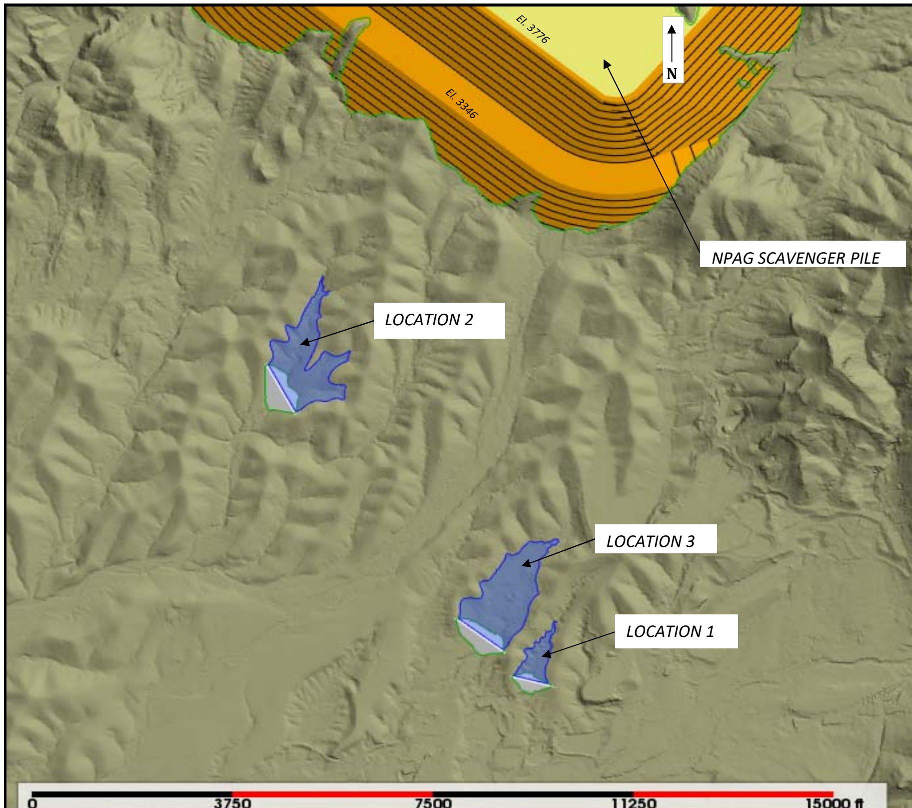

LEGEND

- NPAG SCAVENGER - STRUCTURAL ZONE
- NPAG SCAVENGER - NON-STRUCTURAL ZONE
- PAG PYRITE - STRUCTURAL ZONE
- PAG PYRITE - NON-STRUCTURAL ZONE
- EARTHFILL DAM
- SLURRY POND SURFACE
- FOOTPRINT
- SLURRY POND OUTLINE
- 50 ft CONTOUR
- ENGINEERED LOW-PERMEABILITY LINER

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TITLE

EMERGENCY SLURRY STORAGE PONDS

SCALE	PROJECT No.	FIG No.
AS SHOWN	M09441A20	II-A.4

APPENDIX III

Water Balance

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DEIS Design for Alternative 4 – Silver King Filtered

Technical Memorandum

Appendix III – Water Balance Assessment

DISCLAIMER

Appendix III
Alternative 4 - Water Balance

Table of Contents

List of Tables

List of Figures

III-1 INTRODUCTION

This appendix summarizes the seepage assessment and water balance methodology and results for Draft Environmental Impact Statement (DEIS) Alternative 4 – Silver King Filtered Tailings Storage Facility (TSF). The basis for the seepage and water balance assessment is the TSF design basis memorandum (DBM), and the TSF layout and staging plan, which are outlined in Appendix I and Appendix II, respectively.

The purpose of the water balance assessment is 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 scope of this work is separated into two parts:

- estimate seepage from the scavenger and pyrite filtered tailings piles; and
- 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.

The water balance results presented herein have been estimated using simplified analyses and are meant for comparative analyses between TSF alternatives only.

III-2 TAILINGS SEEPAGE MODELING AND RESULTS

Filtered tailings would be dewatered to relatively low moisture contents (resulting in relatively low unsaturated hydraulic conductivity) and placed in a semi-arid environment (on average 18 inches/yr of precipitation and 72 inches/yr of anticipated potential evapotranspiration), therefore, seepage through the tailings and into the foundation is expected to be very low relative to slurry tailings with reclaim pond alternatives. However, the seepage rates from a filtered tailings pile can be highly variably depending on tailings properties, climate, filter plant operations, foundation conditions and tailings placement, thickness and management. Therefore, any seepage estimates have a high-level of uncertainty associated with some of the key factors controlling seepage at this level of study.

Preliminary seepage estimates from the tailings were made by simplified one-dimensional (1D) seepage modeling using VADOSE/W to simulate of the variably saturated and unsaturated system and the climatic interactions. Figure III-1 illustrates the conceptual model, model parameters and assumptions. Figure III-2 presents the tailings thicknesses and seepage rate estimates.

Limitations to this preliminary, simplified modeling approach are outlined in Table III-2.1, which should be considered when interpreting the results of the analyses.

The main conclusions of the seepage assessment were that the climate conditions, initial saturation of the tailings and thickness of tailings have the largest impact on the seepage rate.

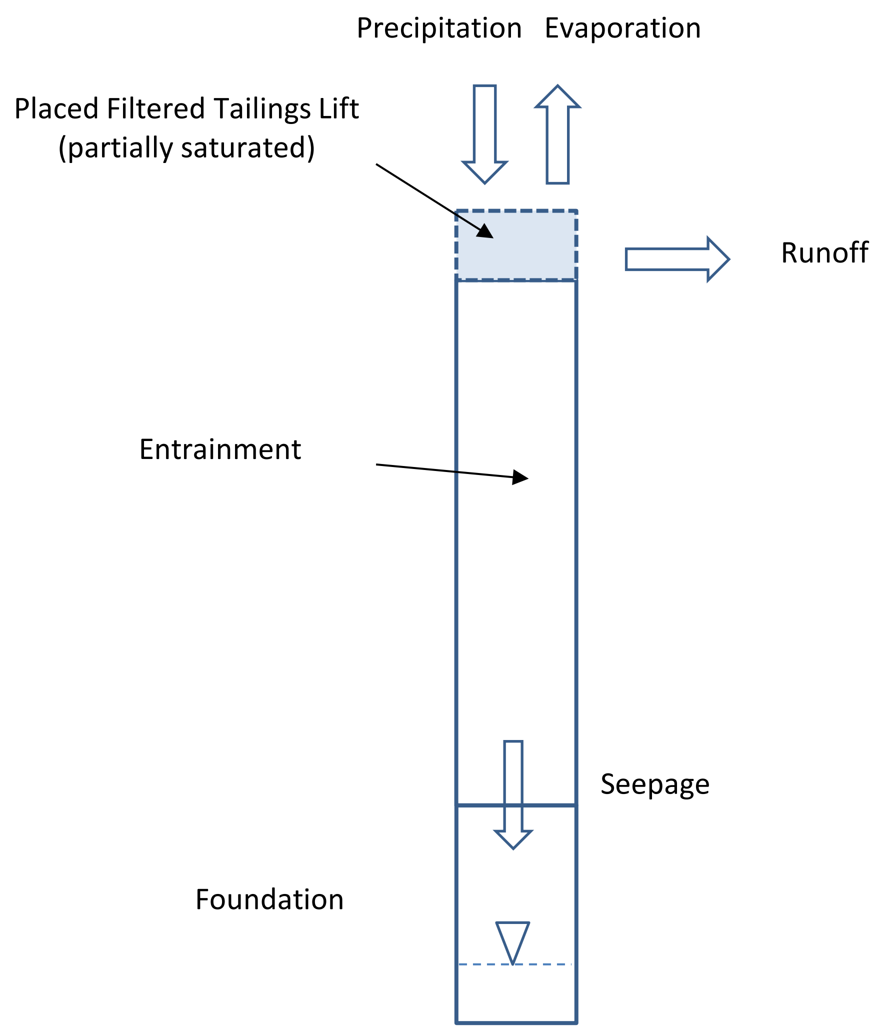
Estimated potential seepage rates from the filtered tailings into the foundation based on the predicted pile thicknesses over time using the target filter plant moisture content are shown in Figure III-2. However, given the limitations outline in Table III-1, these estimates are considered approximate and meant for comparative analyses at this preliminary design stage only.

Table III-1 Modeling Limitations

Consideration	Explanation
Climate	▪ Climate variability and precipitation distribution can have a significant impact on infiltration. The modeling applied two single-year climate pattern considered to be reflective of "typical" years, both in terms of precipitation amount and frequency distribution. Results may be considered "indicative" but not reflective of natural variations in the site's climate. Extended periods of precipitation or lower potential evaporation could result in increased infiltration beyond the rates predicted in this modeling. Unusually dry years could limit the saturation and therefore constrain infiltration further than predicted.
Tailings pile management	▪ Filtered tailings piles should be shaped to shed water to avoid ponding and saturation of the tailings. ▪ Expected seepage from the tailings pile reduces with increasing thickness of filtered tailings. Therefore, seepage is dependent of tailings thickness at any given location in the pile or time in the mine life. ▪ If the filtered tailings require sprinkler application for dust management, that would increase the volume of saturated tailings and resulting seepage.
Tailings properties variability	▪ Simplification of the tailings column does not account for horizontal and vertical variability in material types/properties. A single "tailings type" (with one vertical hydraulic conductivity and one soil-water-characteristic curve, SWCC) was used for the modeling. This does not account for potential variability in the tailings properties. ▪ Where lower moisture contents are not achieved (i.e. if the target specification is not met), the tailings may be placed near saturation. Therefore, the filter plant design and consistency in achieving the design targets would have an impact on seepage rate. ▪ If tailings are geochemically altered (e.g. the pyrite tailings oxidize), their hydraulic properties may also change, which is not accounted for in the model.
Consolidation	▪ The modeling does not account for long-term consolidation processes. Consolidated tailings would have decreased saturated hydraulic conductivities (decreasing seepage) but would also increase the saturation, thus increase the effective hydraulic conductivity (increasing seepage).
Foundation properties	▪ Foundation properties have been assumed to be equivalent to weathered bedrock typical of the area and modeled as equivalent porous media. A similar column of tailings beach placed on a different foundation could produce different results, however, for the intent of this modeling the adoption of these properties (which has higher vertical hydraulic conductivity than the tailings) is considered appropriate.
Three-dimensional effects	▪ The modeling is a simplified 1D representation of a three-dimensional (3D) system. The 3D effects, particularly if there are springs within the foundation, could have significant influences from horizontal flow.

Conceptual Model

one-dimensional column



Model Inputs

Parameter	Scavenger Value	Pyrite Value	Assumption
Climate			
Precipitation (in/year)	20	20	1980 and 1987 daily climate data from Superior climate station used in assessment. Assumed to be a "typical" years.
Potential Evaporation (in/year)	75	75	Calculated in Vadose/W using the 1980 and 1987 daily climate data from Superior climate station
Tailings Properties			
Specific Gravity	2.78	3.87	Assumed to be mid-range for tailings based on laboratory testing (see DBM, Appendix I)
Vertical Hydraulic Conductivity (kv) (in cm/s	5.00E-06	5.00E-07	Assumed to be mid-range for tailings based on laboratory testing (see Tailings Characterization, KCB 2018)
Rate of Rise (ft/year)	25	18	Average over the mine-life (see tailings staging plan, Appendix II)
In-situ Porosity (n)	0.442	0.50	Assumed to be mid-range for expected scavenger tailings based on laboratory testing (see Tailings Characterization, KCB 2018)
In-situ void ratio (e)	0.79	1.00	*Calculated*
Placed Saturation (%)	60%	83%	*Calculated*
Initial volumetric water content (ft^3/ft^3)	0.26	0.41	*Calculated*

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TITLE: TAILINGS SEEPAGE MODELING ASSUMPTIONS

PROJECT No. M09441A20

FIG No. III-1

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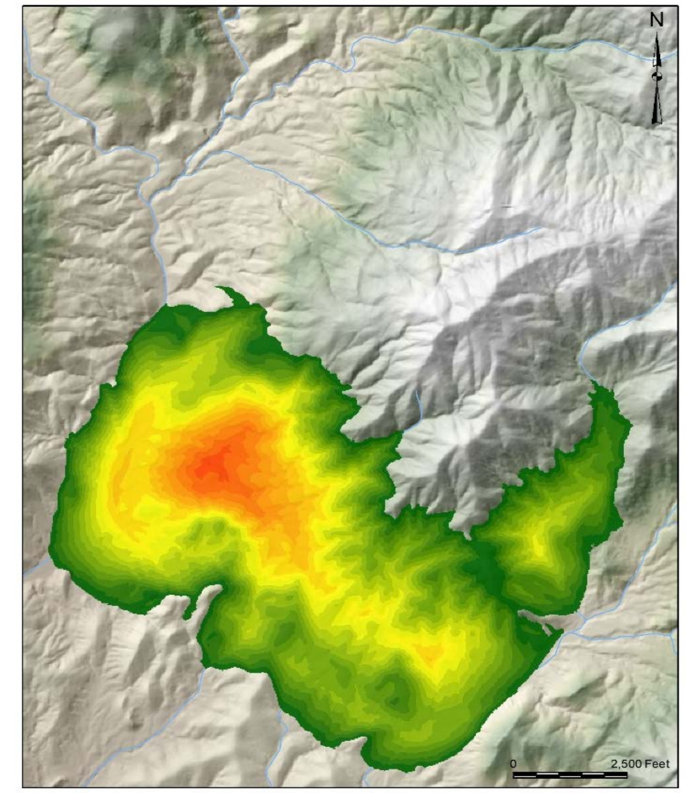
Scavenger Pile

Thickness (feet)	Seepage (gpm/acre)	Area (acres) Year 2	Year 10	Year 20	Ultimate
0-50	0.24	130	192	179	192
50-100	0.01	0	152	154	166
100-150	0.00	0	101	157	169
150-200	0.00	0	77	175	168
200-250	0.00	0	73	180	189
250-300	0.00	0	74	100	156
300-350	0.00	0	65	81	149
350-400	0.00	0	13	70	128
400-450	0.00	0	0	63	109
450-500	0.00	0	0	122	94
500-550	0.00	0	0	0	95
550-600	0.00	0	0	0	53
600-650	0.00	0	0	0	39
650-700	0.00	0	0	0	33
700-750	0.00	0	0	0	31
750-800	0.00	0	0	0	25
800-850	0.00	0	0	0	8
850-900	0.00	0	0	0	0
Total Area	**acres**	130	746	1,283	1,801
Seepage	**gpm**	32	48	45	48
	L/s	2.0	3.0	2.8	3.0

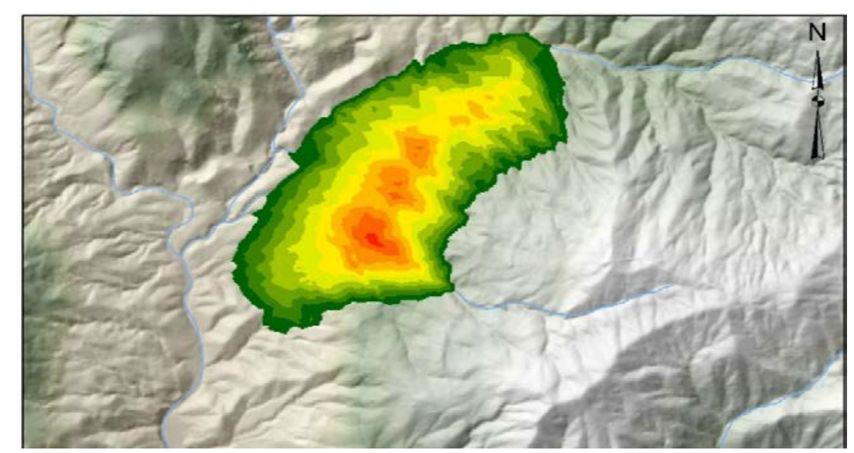
Ultimate Pile:



Pyrite Pile

Thickness (feet)	Seepage (gpm/acre)	Area (acres) Year 2	Year 10	Year 20	Ultimate
0-50	0.018	23	66	72	64
50-100	0.000	0	59	70	59
100-150	0.000	0	51	65	61
150-200	0.000	0	21	64	71
200-250	0.000	0	0	45	63
250-300	0.000	0	0	21	56
300-350	0.000	0	0	4	37
350-400	0.000	0	0	0	26
400-450	0.000	0	0	0	9
450-500	0.000	0	0	0	1
Total Area	**acres**	23	197	341	445
Seepage	**gpm**	0.4	1.2	1.3	1.2
	L/s	0.03	0.08	0.08	0.07

Ultimate Pile:



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TSF THICKNESSES AND SEEPAGE ESTIMATES

PROJECT No. M09441A20
FIG No. III-2

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III-3 TSF WATER BALANCE

III-3.1 General

A simplified 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 simplified water balance concept is shown in Figure III-4; input parameters and assumptions are summarized in Figure III-5. These are based on the DBM in Appendix I and the tailings staging plan in Appendix II. The approach for estimating seepage from the TSF and collection ponds that is lost to the system is summarized in Section III-3.2.

The simplified water balance results are given on Figure III-4 and the estimated losses from the TSF system over the mine life are shown (in green) on Figure III-6.

III-3.2 Seepage Lost to the System Assumptions

III-3.2.1 From TSF

Seepage lost to the system from the filtered tailings were estimated using the 1D assessment discussed in Section III-2.

III-3.2.2 From Collection Ponds

The water collection dams for the TSF would be considered Non-Storm Water Ponds under the Arizona Department of Environmental Quality (ADEQ) and constructed with a Prescriptive BADCT[1] design (see Figure III-3) (ADEQ 2005).

Seepage through the liner of the water collection dams was estimated using the Giroud (1997) equation for flow through a circular defect. 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[2].

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:

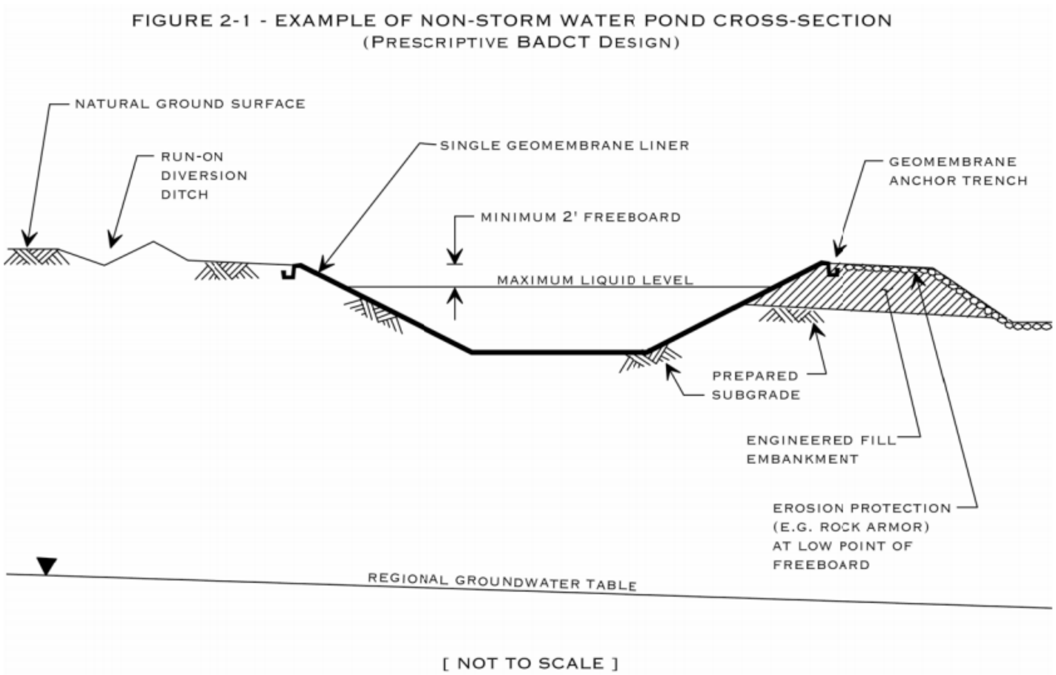
- C_{qo} is 0.21 for good contact conditions between the liner and the foundation;
- h is the liquid head above the liner (m), which is taken as the height of water cover (estimated in the water balance model) divided by 2 to represent the average head above the liner;
- t_s is the thickness of the soil 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);

[1] Best Available Demonstrated Control Technology

[2] 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.

- a is the area of the defect (m^2/defect) (assumed to be $1.03 \times 10^{-5} m^2$/defect, see footnote[3]); and
- k_s 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).

Figure III-3 Prescriptive BADCT Design for a Non-Storm Water Pond (ADEQ 2005)



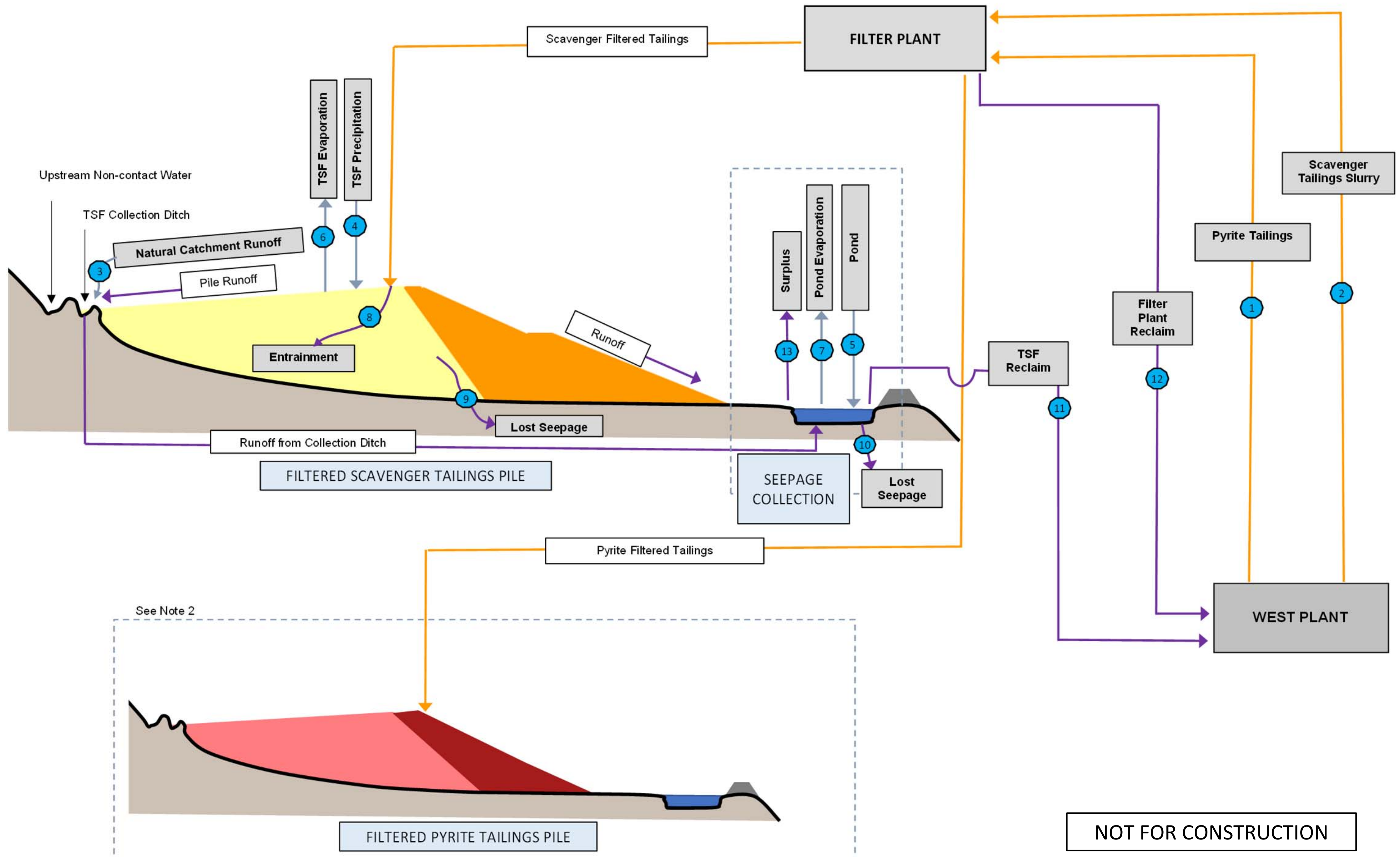
[3] For average condition, based on U.S. Department of the Interior Bureau of Reclamation (USBR). 2014. Design Standards No 13 – Embankment Dams. Chapter 20: Geomembranes. DS-13(20)-16 Phase 4 (Final). March.

TSF Water Balance Inflows

Mine Years	TSF Inflows				
	Pyrite Slurry Water (PFN 1)	Scavenger Slurry Water (PFN 2)	Natural Catchment Runoff (PFN 3)	TSF Precipitation (PFN 4)	Collection Pond Precipitation (PFN 5)
	(acre-ft/yr)	(acre-ft/yr)	(acre-ft/yr)	(acre-ft/yr)	(acre-ft/yr)
1 to 7	1,952	6,813	769	529	14
8 to 31	5,568	15,262	513	2,234	12
32 to 41	1,456	4,194	365	3,219	13

TSF Water Balance Outflows

Mine Years	TSF Outflows								Change in Storage[4]
	TSF Evaporation (PFN 6)	Collection Pond Evaporation (PFN 7)	TSF Entrainment (PFN 8)	Collection Pond Lost Seepage (PFN 9)	TSF Lost Seepage[3] (PFN 10)	TSF Reclaim (PFN 11)	Filter Plant Reclaim (PFN 12)	TSF Pond Surplus (PFN 13)	
	(acre-ft/yr)	(acre-ft/yr)	(acre-ft/yr)	(acre-ft/yr)	(acre-ft/yr)	(acre-ft/yr)	(acre-ft/yr)	(acre-ft/yr)	(acre-ft/yr)
1 to 7	1,414	55	1,021	1	66	626	6,739	149	6
8 to 31	3,911	46	2,390	1	79	612	16,405	144	0
32 to 41	3,134	49	651	1	79	339	4,584	410	1



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LEGEND

- EXTERNAL MODEL FLOW
- INTERNAL MODEL FLOW
- CONTACT WATER
- NON-CONTACT WATER
- TAILINGS SLURRY
- PROCESS FLOW NUMBER (PFN)

Notes:

1. See Figure III-5 for process flow summary tables and equations.
2. Process flow numbers for the Filtered Pyrite Tailings Pile are the same as for the Filtered Scavenger Tailings Pile, but are not shown for clarity. These flows include precipitation, evaporation, entrainment, seepage, reclaim and surplus.
3. Lost seepage from tailings pile is estimated from the 1D modeling (see Section III-2). Lost seepage from the collection ponds is estimated using prescriptive BADCT design for a non-storm water pond and the Giroud (1997) equation for seepage through composite liners.
4. Change in storage reflects change in water volume stored in the TSF Pond and Seepage Collection Ponds, and excludes water entrained in tailings.

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SCALE	PROJECT No.	FIG No.
AS SHOWN	M09441A20	III-4

Process Flow 1 - Pyrite Slurry Water

Years	Pyrite Production[1] (million ton/yr)	Pyrite Solids Content[1] (%)	Pyrite Water Content	Pyrite Slurry Water (PFN 1) (acre-ft/yr)
1 to 7	2.7	50%	1.00	1,952
8 to 31	7.6	50%	1.00	5,568
32 to 41	2.0	50%	1.00	1,456

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

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

Process Flow 2 - Scavenger Slurry Water

Years	Thickened Scavenger[1] (million ton/yr)	Scavenger Solids Content[1] (%)	Scavenger Water Content	Scavenger Slurry Water (PFN 2) (acre-ft/yr)
1 to 7	17.2	65%	0.54	6,813
8 to 31	38.5	65%	0.54	15,262
32 to 41	10.6	65%	0.54	4,194

Process Flows 3, 4 and 5 - Precipitation and Runoff

Years	Precipitation[1] (ft/yr)	Undiverted Natural Catchment (acre)	Natural Catchment Runoff[3] (PFN 3) (acre-ft/yr)	TSF Area[2] (acre)	TSF Precipitation (PFN 4) (acre-ft/yr)	Collection Pond[2] Area (acre)	Collection Pond Precipitation (PFN 5) (acre-ft/yr)
1 to 7	1.52	3378	769	349	529	9	14
8 to 31	1.52	2254	513	1473	2,234	8	12
32 to 41	1.52	1605	365	2122	3,219	8	13

Natural catchment runoff and precipitation volumes are calculated using Equations 2 and 3 below.

$$Natural\ Catchment\ Runoff = catchment\ area\ x\ precipitation\ x\ runoff\ coefficient^{(3)} \quad \textit{(Equation 2)}$$

$$TSF\ or\ Pond\ Precipitation = catchment\ area\ x\ precipitation \quad \textit{(Equation 3)}$$

Process Flows 6 and 7 - Evaporation

Years	Soil Evaporation (ft/yr)	TSF Area[2] (acre)	TSF Evaporation (PFN 6) (acre-ft/yr)	Open Water Evaporation[1] (ft/yr)	Pond Area[2] (acre)	Collection Pond Evaporation (PFN 7) (acre-ft/yr)
1 to 7	4.1	349	1414	6.0	9	55
8 to 31	2.7	1473	3911	6.0	8	46
32 to 41	1.5	2122	3134	6.0	8	49

Evaporation is calculated using Equations 4 and 5 below.

$$TSF\ Evaporation = TSF\ area\ x\ soil\ evaporation \quad \textit{(Equation 4)}$$

$$Collection\ Pond\ Evaporation = pond\ area\ x\ open\ water\ evaporation \quad \textit{(Equation 5)}$$

Process Flow 8 - TSF Entrainment

Years	Production Rates[1] (million ton/yr)				TSF Entrainment
	Scavenger (Structural)	Scavenger (Non-structural)	Pyrite (Structural)	Pyrite (Non-structural)	(PFN 8) (acre-ft/yr)
1 to 7	9.5	7.7	1.6	1.1	1021
8 to 31	21.2	17.3	4.5	3.0	2390
32 to 41	5.8	4.8	1.2	0.8	651

Tailings Properties

Property	Scavenger (Structural)	Scavenger (Non-structural)	Pyrite (Structural)	Pyrite (Non-structural)
Specific Gravity[1]	2.78	2.78	3.87	3.87
Placed Dry Density[1] (pcf)	110	103	137	125
Long-term In-Situ Saturation[1]	0.30	0.30	0.40	0.40
Long-term In-Situ Water Content	0.062	0.074	0.079	0.096

Entrainment is calculated as the water stored in the pores of the tailings at the long-term saturation using Equation 6 below.

$$water\ entrained\ in\ tailings\ (tons) = tailings\ mass\ (tons)\ x\ in\ situ\ tailings\ water\ content \quad \textit{(Equation 6)}$$

Long-term in situ tailings water content is calculated using Equation 7 below.

$$in\ situ\ water\ content = \frac{saturation\ x\ \left(\frac{specific\ gravity\ of\ tailings\ x\ density\ of\ water}{dry\ density\ of\ tailings} - 1\right)}{specific\ gravity\ of\ tailings} \quad \textit{(Equation 7)}$$

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 8 below.

$$TSF\ Entrainment = Total\ Water\ Entrained\ - Collected\ Seepage \quad \textit{(Equation 8)}$$

Notes:
1. Values taken from DBM (Appendix I).
2. Values taken from Tailings Staging (Appendix II).
3. Based on a natural catchment runoff coefficient of 0.15 (DBM, Appendix I)

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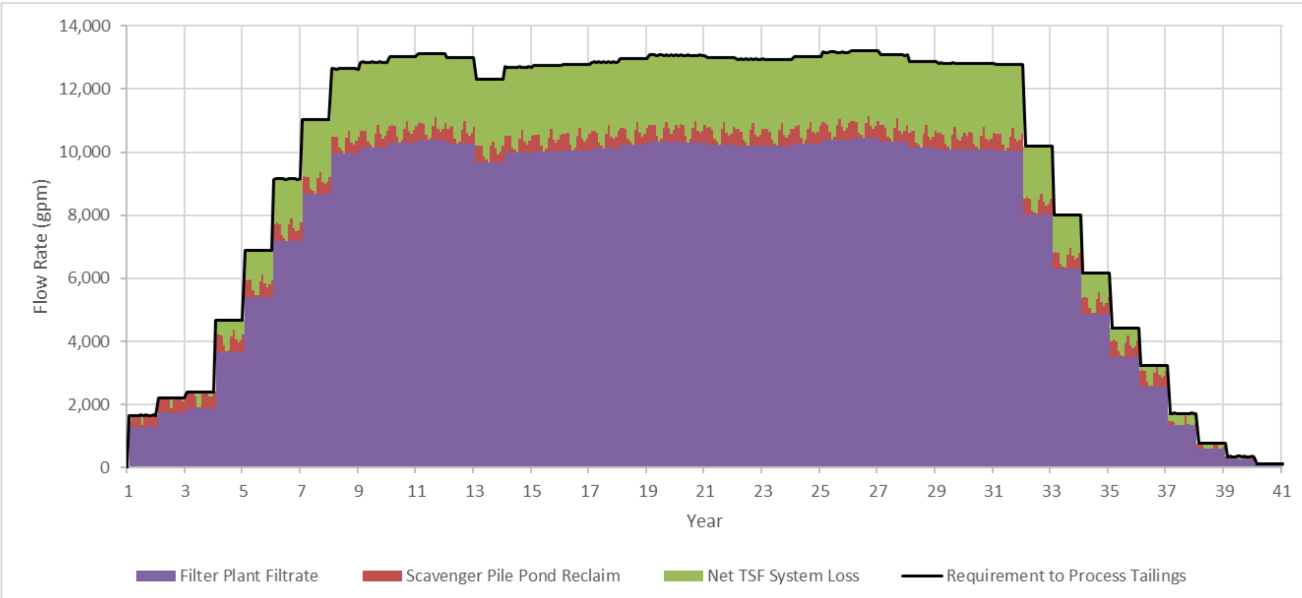
SCALE: AS SHOWN | PROJECT No. M09441A20 | FIG No. III-5

Figure III-6 West Plant Inflows From TSF



Note: The net TSF system loss is what the West Plant requires to be balanced with the TSF system, assuming the pyrite collection pond reclaim is lost to the system and ignoring the flows upstream of the West Plant, for example, the underground dewatering flows or fresh water makeup.

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