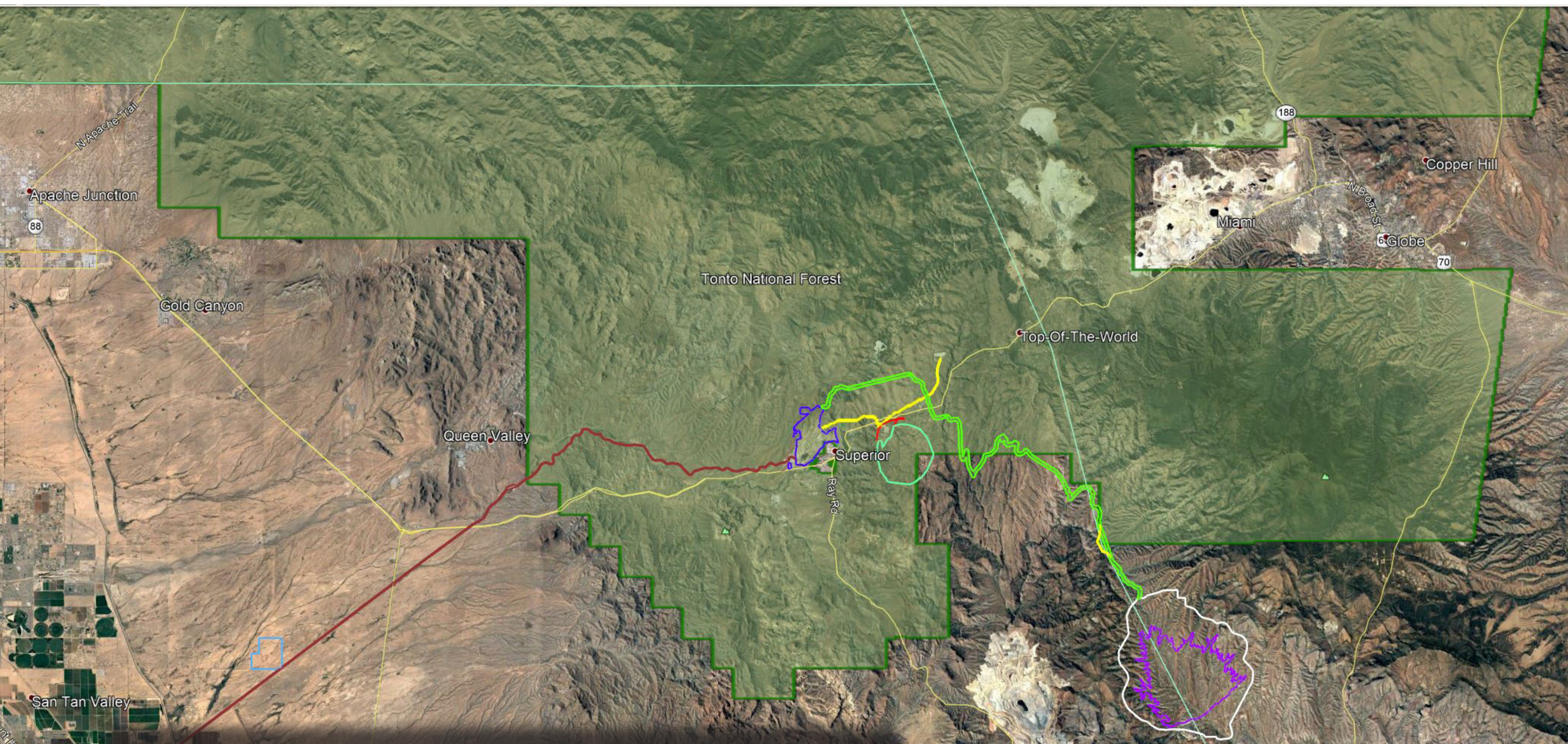
USDA
United States Department of Agriculture

FINAL Environmental Impact Statement
Resolution Copper Project and Land Exchange



Volume 2

Forest Service Tonto National Forest MB-R3-12-10 January 2021

Front Cover photo captions:

Top: Map of the Preferred Alternative Project location and the Tonto National Forest

Bottom Left: Oak Flat Federal Parcel

Table of Contents

Volume 1

Volume 2

Volume 3

Volume 4

Volume 5

Volume 6

Appendix R. Response to Comments Received on the Draft EIS

Appendix S. Consultation History

Figures

Tables

3.7 Water Resources

3.7.1 Groundwater Quantity and Groundwater-Dependent Ecosystems

3.7.1.1 Introduction

This section describes the analysis and predicted effects on the groundwater-dependent ecosystems (GDEs), public and private water supply wells, and subsidence from dewatering.

Resolution Copper has monitored the quantity and quality of water in streams, springs, and riparian areas as far back as 2003. Dozens of wells were installed for the sole purpose of understanding the local and regional hydrogeology, not just below Oak Flat but throughout the region. To assess impacts on groundwater resources, the long history of baseline data collection was considered holistically alongside

- the large geographic area involved;
- the complex geology and multiple aquifers, including the incorporation of the block caving itself, which would fundamentally alter the geological structure of these aquifers over time;
- the long time frames involved for mining (decades) as well as the time for the hydrology to adjust to these changes (hundreds of years); and
- the fact that even relatively small changes in water levels can have large effects on natural systems.

Overview

Natural water features are scarce and important to tribes, wildlife, residents, and recreationists. The Resolution Copper Project could affect both water availability and quality in several ways. In order to construct mine infrastructure, dewatering of the deep groundwater system below Oak Flat began in 2009, and would continue through mining. As the block caving and subsidence progress, eventually the effects of dewatering would extend to overlying aquifers. Changes in these aquifers, as well as capture of runoff by mine facilities and the subsidence area, could in turn affect springs, flowing streams, and riparian areas. In addition to loss of water, water quality changes could result from stormwater runoff, tailings seepage, or exposure of rock in the block-cave zone.

A numerical groundwater flow model is the best available tool to assess groundwater impacts. Like all modeling, the Resolution Copper Mine groundwater model requires great care to construct, calibrate, and properly interpret. The Forest Service collaborated with a broad spectrum of agencies and professionals over several years to assess the groundwater modeling. This diverse group (see section 3.7.1.2) vetted the construction, calibration, and use of the groundwater model, and focused on understanding any sensitive areas with the potential to be negatively affected, including Devil's Canyon, Oak Flat, Mineral Creek, Queen Creek, Telegraph Canyon, Arnett Creek, and springs located across the landscape. The Forest Service refers to such areas as GDEs, which are "communities of plants, animals, and other organisms whose extent and life processes are dependent on access to or discharge of groundwater" (U.S. Forest Service 2012b).

Just as much care was taken to understand the limitations of the groundwater model. Specific model limitations are described in section 3.7.1.2 and reflect a careful assessment of how the results of a groundwater model can reasonably be used, given the uncertainties involved.

The Forest Service undertook a two-part strategy to manage uncertainty. First, all GDEs were assumed to be connected with the regional aquifers (and therefore potentially affected by the mine) unless direct evidence existed to indicate otherwise. Second, regardless of what the model might predict, a monitoring plan would be implemented to ensure that actual real-world impacts are fully observed and understood.

This section analyzes impacts on GDEs and local water supplies from dewatering and block caving, the amount of water that would be used by each alternative, the impacts from pumping of the mine water supply from the Desert Wellfield, and the potential for ground subsidence to occur because of groundwater pumping. Some aspects of the analysis are briefly summarized in this section. Additional details not included here are in the project record (Newell and Garrett 2018d).

Changes from the DEIS

We received a number of technical comments on the groundwater modeling effort used in the DEIS. We assessed these comments with the assistance of the reconvened Water Resources Workgroup. Many of the comments represented alternative modeling choices but not errors in the modeling process (Garrett 2020e). A review of these comments resulted in several clarifications and additions to this section, including details of baseline conditions and model calibration.

This section incorporates updated information with respect to springs and hydrologic conditions at the Skunk Camp location. We added further discussion of the development of the Desert Wellfield model in the East Salt River valley, and a refined analysis of potential subsidence impacts in that area.

The cumulative effects analysis was revised for the FEIS to better quantify impacts. It is described in detail in chapter 4 and summarized in this section. We received numerous comments concerned with water use by the mine and potential water scarcity due to drought, climate change, and competing water uses. The cumulative effects analysis now includes an expanded discussion of these issues. Mitigations developed between the DEIS and FEIS are summarized in appendix J and, if applicable to water quantity, are analyzed for effectiveness in this section.

3.7.1.2 Analysis Methodology, Assumptions, and Uncertain and Unknown Information

Analysis Area

The analysis area for assessing impacts on groundwater quantity and GDEs comprises the groundwater model boundary for the mine site (figure 3.7.1-1) as well as the groundwater model boundary for the East Salt River valley model (figure 3.7.1-2). Models were run up to 1,000 years in the future, but as described below, quantitative results were reasonably applied up to 200 years in the future.

Modeling Process

In September 2017, the Tonto National Forest convened a multidisciplinary team of professionals, referred to as the Groundwater Modeling Workgroup. The Groundwater Modeling Workgroup included Tonto National Forest and Washington-level Forest Service hydrologists, the groundwater modeling experts on the project NEPA team, representatives from ADWR, AGFD, the EPA, the San Carlos Apache Tribe, and Resolution Copper and its contractors. This group included not only hydrologists working on the groundwater model itself, but also the biologists and hydrologists who have conducted monitoring in the field and are knowledgeable about the springs, streams, and riparian systems in the project vicinity. The Groundwater Modeling Workgroup tackled three major tasks: defining sensitive areas, evaluating the model and assisting the Tonto National Forest in making key decisions on model construction and methodology, and assisting the Tonto National Forest in making key decisions on how to use and present model results.

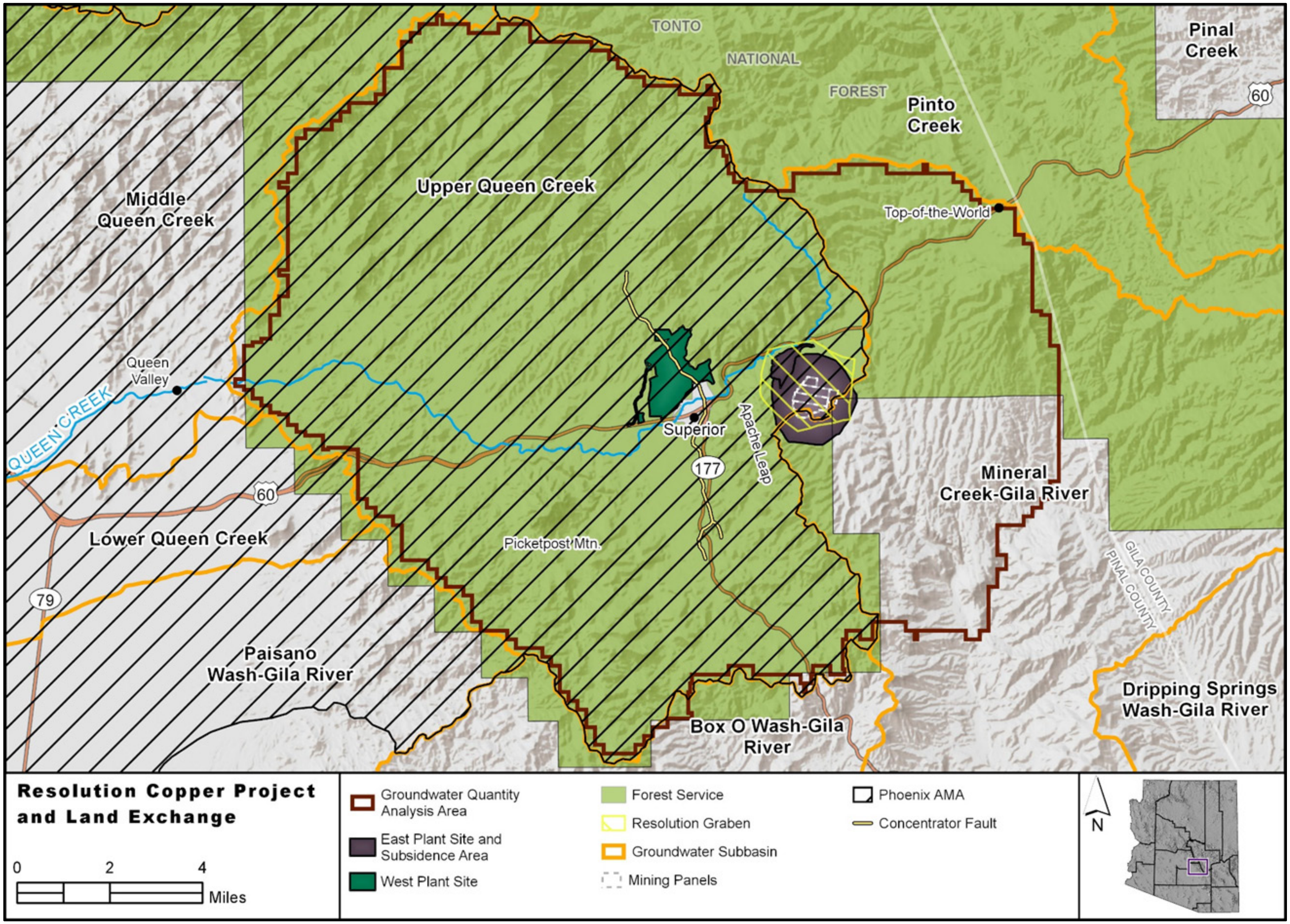


Figure 3.7.1-1. Overview of groundwater modeling analysis area

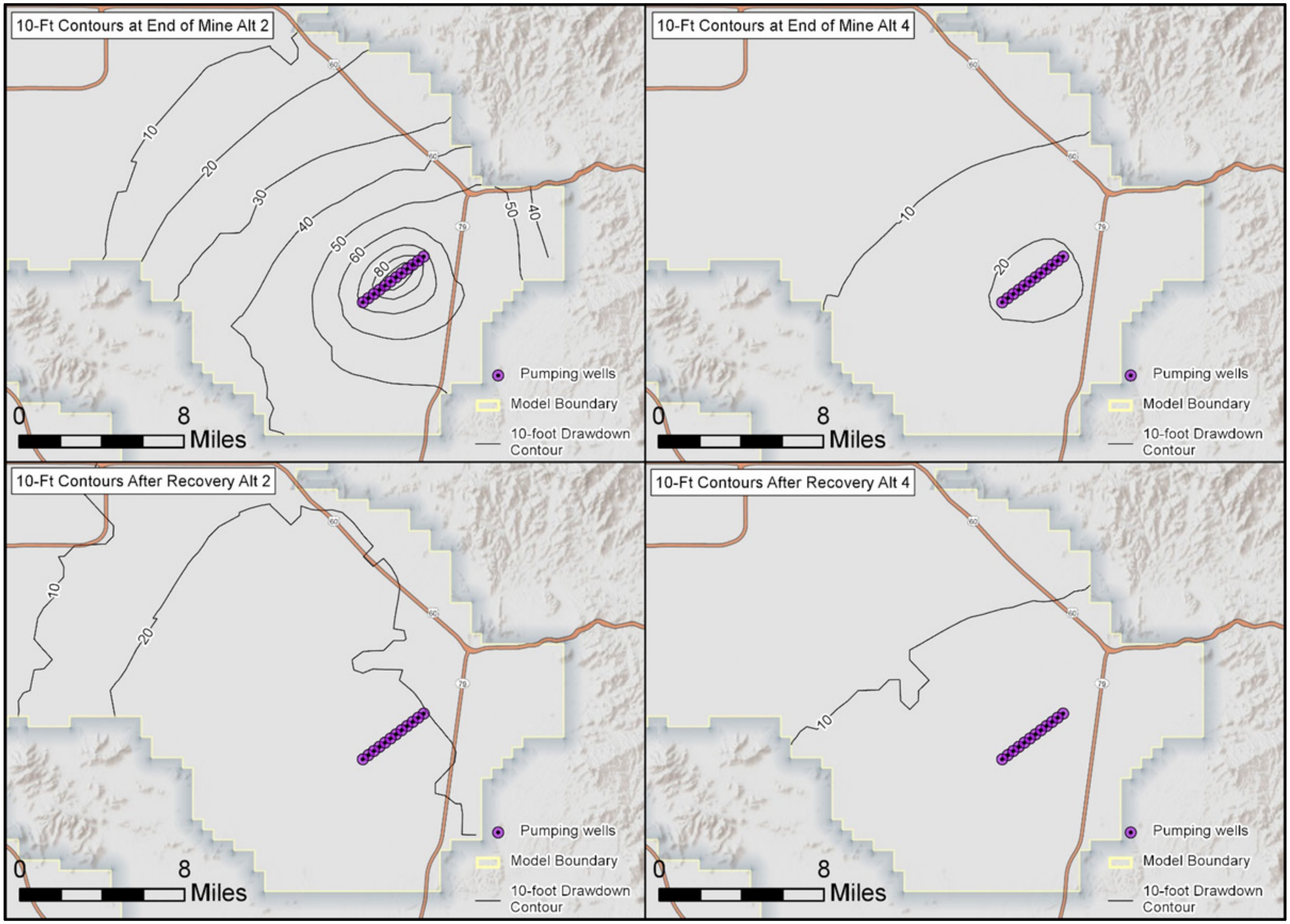


Figure 3.7.1-2. Desert Wellfield modeling analysis area and maximum (Alternative 2, left) and minimum (Alternative 4, right) modeled pumping impacts

Left side of figure: drawdown for scenario with the most pumping (Alternative 2). Upper left shows drawdown at end of mining; lower left shows maximum geographic extent of drawdown (124 years after end of mining). Right side of figure: drawdown for scenario with the least pumping (Alternative 4). Upper right shows drawdown at end of mining; lower right shows maximum geographic extent of drawdown (11 years after end of mining).

A new Water Resources Workgroup convened in January 2020, following receipt of public comments on the DEIS. The reconvened Workgroup assisted the Tonto National Forest in assessing public comments related to water resources, including groundwater modeling, water quality and water quality modeling, and monitoring and mitigation. The Workgroup's efforts led to numerous requests for additional data, clarification, and analysis from the modelers, in order to inform the responses to the comments and the use of the model. Workgroup members disagreed with the approaches taken by the Tonto National Forest on some issues. These disagreements, as well as the results and proceedings of the reconvened Water Resources Workgroup, are documented in several summary memos (BGC Engineering USA Inc. 2020b; Garrett 2020j).

SELECTED MODEL APPROACH

The groundwater model selected for the project is the MODFLOW-SURFACT program, selected in part because of the ability to change aquifer properties over time because of the effects of the block caving. This computer program code specifically was selected for use on this project for several reasons: "MODFLOW-SURFACT has the advantages of being more numerically stable when solving for groundwater flow in systems with steep hydraulic gradients and large differences in hydraulic conductivity across short distances, and in systems where drying and rewetting of model cells occurs. MODFLOW-SURFACT has been used on numerous large, complex mining projects, and is the most appropriate code for this project" (WSP USA 2019).

The assessment of the model by the Groundwater Modeling Workgroup, as well as the assessment of the conceptual hydrologic model upon which the numerical model is based, can be found in the technical memorandum summarizing the workgroup process and conclusions (BGC Engineering USA Inc. 2018d, 2020b). A description of the model construction can be found in WSP USA (2019). Predictive and sensitivity results can be found in Meza-Cuadra et al. (2018b) and Meza-Cuadra et al. (2018c).

IDENTIFYING AND DEFINING GROUNDWATER-DEPENDENT ECOSYSTEMS

The Groundwater Modeling Workgroup developed the list of GDEs based on multiple sources of information; it ultimately evaluated in detail 67 different locations (Garrett 2018e). Any riparian vegetation or aquatic habitat around the GDEs is considered an integral part of the GDE.

The source of water for each GDE is important. Most of the 67 GDE locations the Groundwater Modeling Workgroup assessed were identified because of the persistent presence of water, year-to-year and season-to-season. In most cases this persistent water suggests a groundwater connection; however, the specific type of groundwater is important for predicting impacts on GDEs. There are generally two regional aquifers in the area: the Apache Leap Tuff, and the deep groundwater system. Any GDEs tied to these two aquifers have the potential to be impacted by mining. The deep groundwater system is being and would continue to be actively dewatered, and once block caving begins the Apache Leap Tuff would begin to dewater as well.

In addition to the regional groundwater systems, another type of groundwater results from precipitation that is temporarily stored in near-surface fractures or alluvial sediments. While temporary, this water still may persist over many months or even years as it slowly percolates back to springs or streams or is lost to evapotranspiration. These near-surface features are perched well above and are hydraulically disconnected from both the Apache Leap Tuff aquifer and the deep groundwater system; therefore, this groundwater source does not have the potential to be impacted by mine dewatering. However, changes in the surface watershed could still affect these shallow, perched groundwater sources. Predictions of reductions in runoff caused by changes in the watershed are discussed in section 3.7.3; these changes are also incorporated into this section (3.7.1) in order to clearly identify all the combined effects that could reduce water available for a GDE.

Identifying whether a GDE derives flow from the deep groundwater system, the Apache Leap Tuff, or shallow, perched aquifers was a key part of the Groundwater Modeling Workgroup's efforts. Several lines of evidence helped determine the most likely groundwater source for a number of GDEs: hydrologic and geological framework, inorganic water quality, isotopes, riparian vegetation, and the flow rate or presence of water. However, many more GDEs had little or no evidence to consider, or the evidence was contradictory. In these cases the Forest Service policy is to assume that a GDE has the potential to be impacted (Garrett 2018e; Newell and Garrett 2018a). In addition to identifying GDEs, the Groundwater Modeling Workgroup identified three key public water supply areas to assess for potential impacts from the mine.

After completion of the DEIS, additional field inventories were undertaken to identify other GDEs in the vicinity of the Skunk Camp tailings storage facility. Several additional springs were identified; however, no impacts to these springs by the facility footprint or changes in groundwater quantity are anticipated (WestLand Resources Inc. and Montgomery and Associates Inc. 2020). Potential changes in groundwater and surface water quality as a result of tailings seepage is assessed in section 3.7.2.

EVALUATING THE MODEL AND MODELING APPROACH

The Groundwater Modeling Workgroup reviewed the work done by WSP (a contractor of Resolution Copper) and assisted the Tonto National Forest in determining the appropriate methodologies and approaches that should be used. In practice, this consisted of an open, iterative process by which the Groundwater Modeling Workgroup requested data, the data were prepared and presented, and the results and meaning were discussed in Groundwater Modeling Workgroup meetings. All fundamental parts of developing a numerical groundwater flow model were discussed: developing a conceptual model, numerical model construction, model calibration, model sensitivity, model predictive runs, and model documentation. The results and conclusions of the Groundwater Modeling Workgroup's effort are documented in a final Groundwater Modeling Workgroup report (BGC Engineering USA Inc. 2018d). Results and conclusions of the post-DEIS reconvened Water Resources Workgroup are documented as well (BGC Engineering USA Inc. 2020b; Garrett 2020j).

The conceptual understanding of the hydrogeology and the geological framework of the area is fundamental to developing a valid groundwater flow model. A separate but related workgroup focused specifically on the geological data collection and interpretation, and the subsidence modeling. The results of this workgroup are discussed in Section 3.2, Geology, Minerals, and Subsidence, and documented in a final workgroup report (BGC Engineering USA Inc. 2018a). Several team members collaborated in both workgroups and facilitated sharing of information.

After receiving input from the Groundwater Modeling Workgroup, the Forest Service and its contractors ultimately determined that WSP's groundwater model, as amended and clarified over the course of the workgroup meetings, is a reasonable and appropriate tool for assessing hydrologic changes.

MODEL CALIBRATION

One specific topic raised in public comments is the calibration of the groundwater model. The selected approach for predicting project impacts requires three different steps: a steady-state model run to provide starting water levels representative of 1910; a transient model run between 1910 and 2016 used to calibrate the model; and predictive transient model runs.[48] The predictive transient models are described

[48] A "transient" model run occurs over a specified period of time, with each time step using the model results from the previous time step as a starting point. A "steady-state" model has no time component, and the model simply runs until all the inflows and outflows specified in the model reach a balance.

in more detail in the section below titled "Summary of Models Used for Mine Site Dewatering/Block Caving Effects."

Few details exist for groundwater levels in 1910, so the calibration target for the steady-state model was to attempt to replicate what was known about the general hydrology of the area, particularly where groundwater discharge was present in Queen Creek above Superior. The resulting steady-state water levels, calibrated in this way, form the starting point for the transient calibration run from 1910 to 2016. Ultimately, given the long time frame (over 100 years), the initial steady-state water levels in 1910 have relatively little effect on the transient modeling results.

Multiple calibration targets were used for the 1910–2016 transient calibration runs. These included:

- Groundwater levels. Groundwater levels formed the primary means of calibration for the transient model, with a strong focus on the time period from 1998 to 2016, which was a period of intensive monitoring of groundwater levels. Ultimately this calibration data set consisted of over 5,900 measurements at 93 different locations. These calibration targets were assessed statistically and visually (scatter plots and hydrographs comparing field-measured versus modeled water levels).
- Groundwater contours. Groundwater levels also were qualitatively assessed by comparing the modeled contours to real-world conditions, to identify how well gradients and flow directions match.
- Aquifer tests. Numerous aquifer tests were conducted by Resolution Copper as part of hydrogeologic characterization efforts. Two of these tests were particularly long: HRES-20 (90 days) and HRES-09 (23 days). These aquifer tests were replicated using the groundwater model, which is largely useful for calibrating storage parameters.
- Water budget. Groundwater models are built on a conceptual model, which is an understanding of the general characteristics of inflows to, and outflows from, an aquifer. A large part of the conceptual model is the water budget. Water budget components are estimated in a variety of ways, including field measurements. Part of the calibration approach is to compare the water budget from the calibrated model to the original conceptual model to identify what components have changed, and whether they still conform to field observations.
- Model fluxes. A primary purpose of the groundwater model at the mine site is to predict potential impacts to sensitive GDEs that have ties to the regional aquifers, including springs and perennial streams like Devil's Canyon and Mineral Creek. There are multiple ways to model groundwater/surface water interactions. Regardless of the methods used, the resulting model should qualitatively replicate the location and extent of surface water flows dependent on groundwater. This comparison was done in several ways, including comparing modeled flow through drains along Devil's Canyon to baseflow rates measured in the field, and comparing the model-predicted groundwater discharge to the field observations of continuously saturated stream reaches.

Ultimately, the transient calibration was successful. One common measurement used to assess calibration success is the scaled root mean squared (RMS) error, which is in the form of a percentage. Generally, scaled RMS error values less than 10 percent are considered acceptable, provided other qualitative calibration targets also are reasonable. The scaled RMS error for the entire calibration data set was 3 percent, and specifically for the Apache Leap Tuff calibration data set—which represents the aquifer of most importance to perennial waters in springs and in Devil's Canyon—the scaled RMS error was 3.3 percent (WSP USA 2019).

GEOTHERMAL GRADIENTS

Geothermal water is present at the mine site. Temperatures over 150 degrees Fahrenheit (°F) were documented in the deep groundwater system during sampling by Resolution Copper. The groundwater modeling does not incorporate geothermal effects and public comments raised the issue of whether geothermal gradients would have an effect on model results. This is a legitimate concern about a documented site-specific condition, as geothermal gradients can result in circulation within the aquifer.[49] Upon close examination, we determined that the geothermal conditions would not affect the results of the groundwater model as specifically used in the EIS.

- Impacts to GDEs result from water availability and are predicted solely through drawdown. Geothermal gradients have no effect on the amount or presence of water, only on circulation patterns within the aquifer.
- The huge stresses imposed by pumping to dewater the mine and the block caving itself render geothermal effects negligible. The system is anticipated to operate under extreme hydraulic gradients during operations.
- Geothermal gradients could be important for mixing within the block caving zone after operations cease. We evaluated the potential for this to occur in section 3.7.2. Ultimately, the analysis in that section shows that there are no outlets for groundwater within the block caving zone through mine infrastructure or tunnels, natural caves, or lake formation in the subsidence crater.

KEY DECISION ON USE OF MODEL RESULTS – BASELINE CONDITIONS

The Groundwater Modeling Workgroup made four specific key decisions about how the groundwater modeling results would be used:

1. Define appropriate baseline conditions,
2. Select an appropriate time frame for model output,
3. Select an appropriate precision for model output, and
4. Develop a strategy to deal with uncertainties.

The first key decision is how potential impacts from the mine operations are to be defined. With many resources, this is a simple task: predicted conditions during or after mine operations are compared with the affected environment, and the difference is considered the “impact” caused by the mine. In this case, renewed dewatering of the deep groundwater system has taken place since 2009 to allow construction and maintenance of mine infrastructure; this is described further in “Current and Ongoing Pumping and Water Level Trends” later in this section. This dewatering pumping is legal and has been properly permitted by the ADWR (see the “Current and Ongoing Pumping and Water Level Trends” section). Resolution Copper is continuing this dewatering and would continue dewatering throughout the mine life. Further, even if the mine is not operated, Resolution Copper will continue legally dewatering to preserve its infrastructure investment.

[49] Technically speaking, changes in temperature can also affect the material properties of water which ultimately can change properties like hydraulic conductivity, which incorporates aspects of both the aquifer materials and the fluid flowing through them. These effects are negligible when considering the range of uncertainty in the groundwater model.

The Tonto National Forest made the decision to handle this situation in two ways. First, continued dewatering of the mine would be included as part of the no action alternative. Second, the Tonto National Forest is ensuring that any effects of the past dewatering are disclosed as ongoing trends as part of the affected environment (Garrett 2019f).

As such, two separate models were prepared: a No Action model (with continued dewatering, but no block caving), and a Proposed Action model (with continued dewatering and block caving as proposed).

- For the no action alternative, the potential impact from the mine is defined as the drawdown as predicted in the no action groundwater flow model, up to 200 years after the start of mining (see next section for discussion on time frames).
- For the action alternatives, the potential impact from the mine is defined as the drawdown predicted in the proposed action groundwater flow model, up to 200 years after the start of mining (see next section for discussion on time frames). However, some of the GDEs impacted by proposed action drawdown would have been impacted by the no action alternative as well. The GDEs anticipated to be impacted by both models are disclosed for comparison, to clearly identify which impacts result from ongoing dewatering alone and which impacts result from the block caving.

The selection of baseline conditions was a specific point of disagreement in the Groundwater Modeling Workgroup. This same difference of opinion was expressed in public comments on the DEIS as well, noting that hydrologic conditions prior to the onset of Resolution Copper dewatering were not discussed in the DEIS, and that these pre-Resolution water levels should have been the appropriate baseline from which to measure impacts.

Large-scale dewatering activity began at Magma Mine in 1910 and continued until 1998, with the exception being the period between 1986 and 1989, when no significant pumping occurred. Active mining ceased in the Magma Mine in 1996, and the underground dewatering system continued operation until May 1998. Pumping averaged between 500 and 700 gallons per minute and resulted in over 3,000 feet of dewatering (WSP USA 2019).

The best estimate of water levels in 1910 before any dewatering is that they were at an elevation of 3,150 feet amsl (Short et al. 1943). While water levels recovered following the shutdown of dewatering in 1998, the 2009 water levels only rose to about 2,100 feet amsl, still well below the pre-1910 water levels (WSP 2019).

We confirmed our choice to use the current groundwater conditions at the site as the baseline to which project-related impacts are compared (Garrett 2018d). Aside from being the appropriate approach under NEPA, groundwater was documented to be substantially affected by mining in the Superior area for over a century. Selecting a past point in time as a baseline does not reflect the environment as it exists today. However, regardless of the baseline selected to disclose project-related impacts, the drawdown caused by past pumping by Resolution Copper is clearly disclosed in table 3.7.1-1.

Table 3.7.1-1. Changes in groundwater head in the deep groundwater system due to dewatering

Deep Groundwater System Wells*	Earliest Groundwater Head Elevation, in feet amsl (date shown in parentheses)	Groundwater Head Elevation in 2019 (in feet amsl)	Overall Change (feet)
Deep groundwater system wells: east of the Concentrator Fault within the Resolution Graben			
DHRES-01 (water level in Kvs)	2,090 (2009)	−300	−2,390

Deep Groundwater System Wells*	Earliest Groundwater Head Elevation, in feet amsl (date shown in parentheses)	Groundwater Head Elevation in 2019 (in feet amsl)	Overall Change (feet)
DHRES-02 (water level in Kvs)	2,100 (2008)	−580	−2,680
DHRES-08 (DHRES-08_-231 in Kvs)	1,920 (2010)	90	−1,830
Deep groundwater system wells: east of the Concentrator Fault outside of the Resolution Graben			
DHRES-06 (water level in Pz [Pnaco, Me, Dm, Cb, pCdiab])	3,250 (2010)	3,240	−10
DHRES-07 (DHRES-07_-108 in Pz [Cb])	3,000 (2010)	2,880	−120
DHRES-09 (water level in pCdsq and pCdiab)	2,990 (2011)	2,940	−50
DHRES-10	N/A	N/A	N/A
DHRES-11 (water level in Pz and pCy)	3,300 (2011)	2,780	−520
DHRES-13 (water level in pCy and pCpi)	2,790 (2011)	2,670	−120
DHRES-14 (water level in Tw and pCpi)	3,510 (2012)	3,480	−30
DHRES-15 (water level in Dm and Cb)	3,210 (2015)	3,240	+30
Deep groundwater system wells: west of the Concentrator Fault			
DHRES-03 (DHRES-03_335 in Tvs)	2,530 (2009)	2,500†	−30
DHRES-04 (water level in Tvs)	2,570 (2009)	2,620	+50
DHRES-05B (water level in Tal)	2,620 (2010)	2,560	−60
DHRES-16 (DHRES-16_-387 in Tal)	2,320 (2014)	2,190	−130

Source: All data taken from Montgomery and Associates Inc. and Resolution Copper (2016).

Notes: Some elevations approximated to nearest 10 feet for clarity. N/A = Data not available; amsl = above mean sea level.

Tal = Apache Leap Tuff; Tw = Whitetail conglomerate; Tvs = Tertiary sedimentary and volcanic rocks; Kvs = Cretaceous sedimentary and volcanic rocks; Pz = Paleozoic sedimentary rocks (Pnaco = Naco formation; Me = Escabrosa limestone; Dm = Martin formation; Cb = Bolsa quartzite); pCy = Precambrian Apache Group; pCdiab = Precambrian diabase; pCdsq = Precambrian Dripping Springs quartzite; pCpi = Precambrian Pinal schist

* For wells with multiple monitoring depths, specific monitoring location is shown in parentheses.

† 2016 water level shown

KEY DECISION ON USE OF MODEL RESULTS – TIME FRAME

Groundwater models are generally run until they reach a point where the aquifer has sufficient time to react to an induced stress (in this case, the effects of block caving) and reach a new point of equilibrium. In some systems this can take hundreds or even thousands of years. The groundwater flow model for the Resolution Copper project was run for 1,000 years, or roughly 950 years after closure of the mine, to approach equilibrium conditions. The Groundwater Modeling Workgroup recognized that a fundamental limitation of the model—of any model—is the unreliability of predictions far in the future, and the workgroup was tasked with determining a time frame that would be reasonable to assess. Based on combined professional judgment, the Groundwater Modeling Workgroup determined that results could be reasonably assessed up to 200 years into the future. All quantitative results disclosed in the EIS are restricted to this time frame.

The Groundwater Modeling Workgroup also recognized that while quantitative predictions over long time frames were not reliable, looking at the general trends of groundwater levels beyond the 200-year time frame still provides valuable context for the analysis. In most cases, the point of maximum groundwater drawdown or impact for any given GDE does not occur at the end of mining. Rather, it takes time for the full impacts to be observed—decades or even centuries. Even if quantitative results are unreliable at long time frames, the general trends in modeled groundwater levels can indicate whether the drawdown or impact reported at 200 years represents a maximum impact, or whether conditions might still worsen at that location. These trends are qualitatively explored, regardless of time frame. Specifically, see the discussions in section 3.7.1.5 titled “Longer Term Modeled Impacts”. These qualitative discussions include impacts beyond the 200-year time frame for springs, Devil’s Canyon, Queen Creek, Telegraph Canyon, Arnett Creek, and water supplies.

Time frames are only pertinent for transient models. Some public comments suggest that alternative approaches could have been used for the EIS analysis, either using a steady-state model to predict post-mine conditions or simply assuming that post-mine conditions would eventually (many centuries in the future) return to pre-mining conditions. Neither of these approaches is supportable for predicting impacts from the mine.

Steady-state modeling requires aquifer conditions and boundary conditions that are unchanging and in equilibrium. Regarding the mine, the use of block caving will incrementally change the aquifer characteristics over time during operations. Additionally, the amount of pumping is anticipated to change during operations. A transient model that allows for these changes is the only approach that can predict the groundwater levels as conditions change during operations. A steady-state model conceivably could have been used after operations cease to predict post-closure conditions. However, the modeling suggests equilibrium in the aquifer likely will not be achieved for over 1,000 years. Any results from a steady-state model would take place beyond 1,000 years. Thus, we considered such results to be remote and speculative.

Modeling could be avoided entirely if the assumption could be supported that post-mine conditions would eventually return to pre-mining conditions. This will never occur. Block caving is anticipated to fundamentally alter the hydrogeologic framework of the aquifer system, effectively eliminating the Whitetail Conglomerate unit that to date has separated the deep groundwater system from the Apache Leap Tuff aquifer. There is no expectation that the post-mine aquifer system eventually will look the same as it does today. Modeling is the most appropriate tool to predict how an altered aquifer system, fundamentally different from current conditions, would function.

KEY DECISION ON USE OF MODEL RESULTS – LEVEL OF PRECISION

Numerical groundwater models produce highly precise results (i.e., many digits beyond the decimal point). Even in a well-calibrated model, professional hydrologists and modelers recognize that there is a realistic limit to this precision, beyond which results are meaningless. The Groundwater Modeling Workgroup was tasked with determining the appropriate level of precision to use for groundwater modeling results.

Based on combined professional judgment, the Groundwater Modeling Workgroup determined that to properly reflect the level of uncertainty inherent in the modeling effort, results less than 10 feet should not be disclosed or relied upon, as these results are beyond the ability of the model to predict. For values greater than 10 feet, the Groundwater Modeling Workgroup decided to use a series of ranges to further reflect the uncertainty: 10 to 30 feet, 30 to 50 feet, and greater than 50 feet. Regardless of these ranges, the quantitative modeled results for each GDE are still provided in the form of hydrographs (see appendix L). Several strategies were developed to help address the uncertainties associated with the groundwater modeling results, as described in the remainder of this section.

The precision of the results (10 feet) also reflects the inability of a regional groundwater model to fully model the interaction of groundwater with perennial or intermittent streams (see BGC Engineering USA Inc. (2018d) for a full discussion). This limitation means that impacts on surface waters are based on predicted groundwater drawdown, rather than modeled changes in streamflow. Note that while we are not relying quantitatively on modeled water levels less than 10 feet, the hydrographs included in appendix L of the EIS still qualitatively show all modeled drawdown, including drawdowns less than 10 feet.

KEY DECISION ON USE OF MODEL RESULTS – STRATEGIES TO ADDRESS UNCERTAINTY

Two key strategies were selected to deal with the uncertainty inherent in the groundwater model: the use of sensitivity model runs and the use of monitoring. The model runs used to predict impacts are based on the best-calibrated version of the model; however, there are many other variations of the model and model parameters that may also be reasonable. Sensitivity model runs are used to understand how other ways of constructing the model change the results. In these sensitivity runs, various model parameters are increased or decreased within reasonable ranges to see how the model outcomes change. In total, 87 model sensitivity runs were conducted, in addition to the best-calibrated version of the model.

Because of the uncertainty and limitations of the model, the Groundwater Modeling Workgroup decided that it would be most appropriate to disclose not only impacts greater than 10 feet based on the best-calibrated model, but also impacts greater than 10 feet based on any of the sensitivity runs. The predicted model results disclosed in this section represent a range of results from the best-calibrated model as well as the full suite of sensitivity runs. These are considered to encompass a reasonable range of impacts that could occur as a result of the project.

As can be seen in figure 3.7.1-3, which shows the 10-foot drawdown contour that encompasses all sensitivity runs (yellow area), some of the sensitivity runs show drawdown abutting the eastern edges of the model domain, which is an undesirable situation for a groundwater model. This result is driven by a single sensitivity run that looked at an increased hydraulic conductivity in the Apache Leap Tuff aquifer. This has been taken into consideration when interpreting the model results. For some GDEs, this particular sensitivity run represents the sole outcome where impact is anticipated; for these, impacts are considered possible but unlikely, given that the base case and all other model sensitivity runs show consistent results.

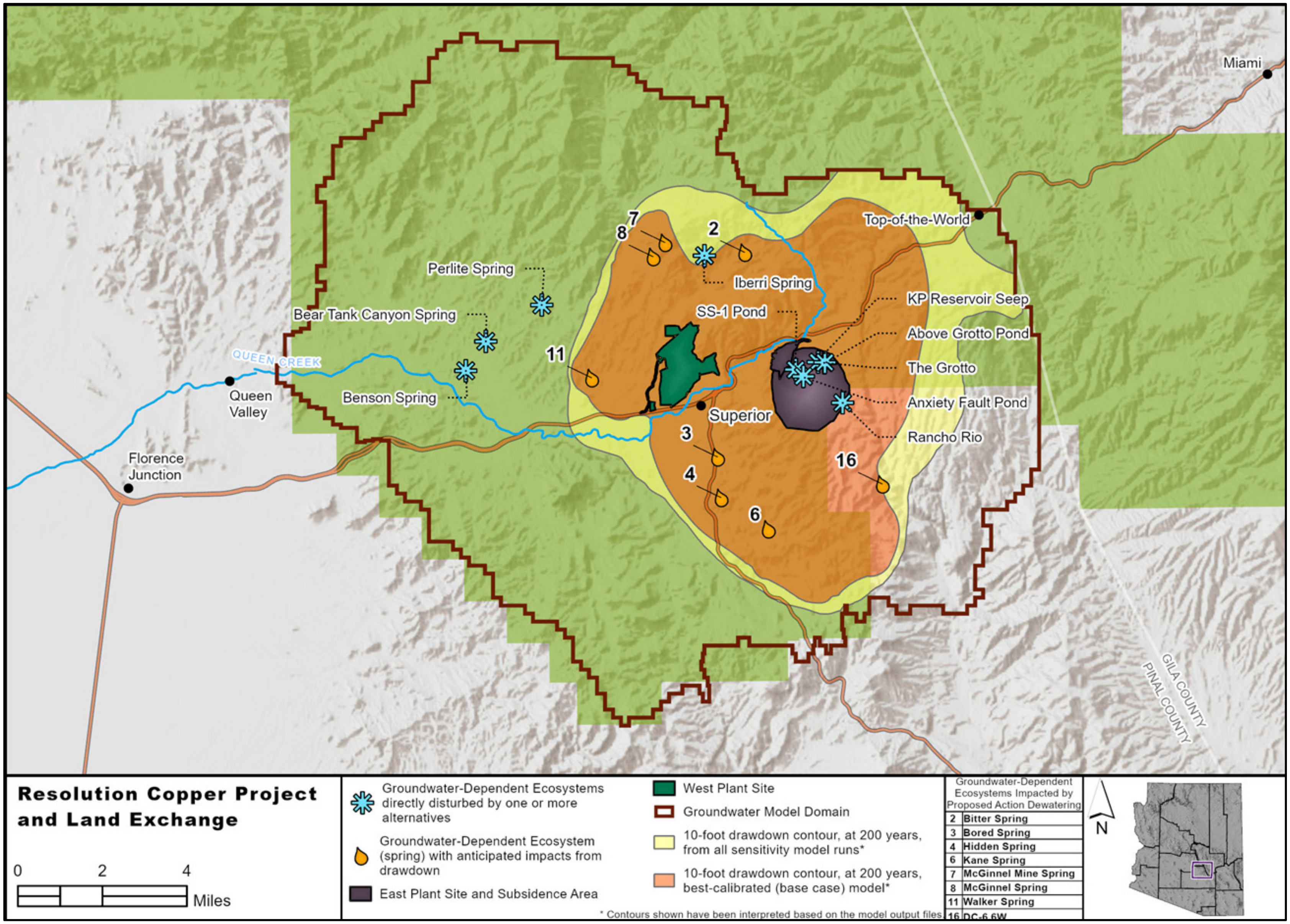


Figure 3.7.1-3. Modeled groundwater drawdown—proposed action, 200 years after start of mine

The Groundwater Modeling Workgroup recognized that while the model may not be reliable for results less than 10 feet in magnitude, changes in aquifer water level much less than 10 feet still could have meaningful effects on GDEs, even leading to complete drying. The Groundwater Modeling Workgroup explored several other modeling techniques, including explicitly modeling the interaction between groundwater and surface water to predict small changes in streamflow, but found that these techniques had similar limitations. To address this problem, monitoring of GDEs would be implemented during mine operations, closure, and potentially beyond. For many of these GDEs, this monitoring effort simply continues monitoring that has been in place from as early as 2003. Details of monitoring conducted to date are available in the project record for springs and surface waters (Montgomery and Associates Inc. 2017d), water quality sampling (Montgomery and Associates Inc. 2016), and well construction and groundwater levels (Montgomery and Associates Inc. and Resolution Copper 2016). If monitoring identifies real-world impacts that were not predicted by the modeling, mitigation would be implemented. Mitigation is not restricted to unanticipated impacts; mitigation may also be undertaken for those GDEs where impacts are expected to occur.[50]

Summary of Models Used for Mine Site Dewatering/Block Caving Effects

The following groundwater flow models provide the necessary impact predictions. Each of the models included best-calibrated, base-case modeling runs as well as sensitivity runs:

- **No Action model, Life of Mine.** This model assumes that no mining occurs and that therefore no block caving occurs that connects the Apache Leap Tuff aquifer to the deep groundwater system. While dewatering of the deep groundwater system is assumed to continue, for the most part those dewatering effects are confined to the deep groundwater system, and the Apache Leap Tuff aquifer does not dewater. This model was run for 51 years, until closure of the mine.
- **No Action model, Post-closure.** This model continues after 51 years, with dewatering being curtailed at the end of the Life of Mine model. This model was run to 1,000 years, but quantitative results are only used out to 200 years after start of the model, which is 149 years after closure of the mine. Model results beyond 200 years are still used but are discussed qualitatively.
- **Proposed Action model, Life of Mine.** This model assumes that mining and block caving occur as proposed, along with the dewatering necessary to maintain project infrastructure. Under these conditions, the Apache Leap Tuff aquifer becomes hydraulically connected to and partially drains downward into the deep groundwater system. This model was run for 51 years, until closure of the mine. The proposed action model is applicable to all action alternatives.

Proposed Action model, Post-closure. This model continues after 51 years, with dewatering being curtailed at the end of the Life of Mine model. This model was run to 1,000 years, but quantitative results are only used out to 200 years after start of the model, which is 149 years after closure of the mine. Model results beyond 200 years are still used but are discussed qualitatively. The proposed action model is applicable to all action alternatives.

Model Used for Mine Water Supply Pumping Effects

One additional model was part of the analysis process. Resolution Copper also ran a model to predict pumping impacts from the water supply wellfield located along the MARRCO corridor in the East Salt River valley. This groundwater flow model was built from an existing, calibrated, regulatory model prepared by ADWR. In some form, this model has been used widely for basin-wide planning purposes since the 1990s, as well as to estimate project-specific water supply impacts. This model was evaluated

[50] In appendix J of the DEIS, this mitigation was found in measure RC-211. In appendix J of the FEIS, this mitigation can be found in measure FS-WR-01.

for applicability to the Desert Wellfield modeling and found to be acceptable for assessing drawdown caused by mine water supply pumping under different alternatives (Walser 2020a).

3.7.1.3 Affected Environment

Relevant Laws, Regulation, Policies, and Plans

The State of Arizona has jurisdiction over groundwater use; however, the Forest Service also has pertinent guidance on analyzing groundwater impacts, disclosing these impacts appropriately during NEPA analysis, and managing GDEs on NFS land.

Primary Legal Authorities and Technical Guidance Relevant to the Groundwater Analysis

- Arizona Groundwater Management Act of 1980, along with implementing regulations that govern groundwater use within Active Management Areas
- Forest Service Manual 2520 (management of riparian areas, wetlands, and floodplains), 2530 (collecting water resource data), and 2880 (inventory and analysis of GDEs)

Existing Conditions and Ongoing Trends

REGIONAL HYDROLOGIC FRAMEWORK

The project is located within a geological region known as the Basin and Range province, near the boundary with another geological region known as the Arizona Transition Zone. The Basin and Range aquifers generally consist of unconsolidated gravel, sand, silt, and clay, or partly consolidated sedimentary or volcanic materials. These materials have filled deep fault-block valleys formed by large vertical displacement across faults. Mountain ranges that generally consist of impermeable rocks separate adjacent valleys (Robson and Banta 1995), leading to compartmentalized groundwater systems. Stream alluvium is present along most of the larger stream channels. These deposits are about 100 feet thick and 1 to 2 miles wide along the Gila, Salt, and Santa Cruz Rivers in Arizona aquifers (Robson and Banta 1995). The hydrology of the Arizona Transition Zone is generally more complex, characterized largely by fractured rock aquifers with some small alluvial basins.

The semiarid climate in the region limits the amount of surface water available for infiltration, resulting in slow recharge of the groundwater with an average annual infiltration of 0.2 to 0.4 inch per year (Woodhouse 1997). Much of this recharge occurs as mountain-front recharge, where runoff concentrates along ephemeral channels.

GROUNDWATER IN THE ANALYSIS AREA

The analysis area contains several distinct groundwater systems, as shown on the conceptual cross section in figure 3.7.1-4:

- Groundwater east of the Concentrator Fault:
    - a shallow, perched groundwater system
    - the Apache Leap Tuff aquifer
    - a deep groundwater system

- Groundwater west of the Concentrator Fault in the Queen Creek watershed:
    - alluvial groundwater, primarily in floodplain alluvium along Queen Creek
    - deep groundwater system in poorly permeable basin-fill sediments

The groundwater underlying most of the analysis area is within the Phoenix AMA, as defined by the Arizona Groundwater Management Act, and is in the East Salt River valley groundwater subbasin of the AMA, as shown in figure 3.7.1-1. Groundwater use within the AMA is administered by the ADWR (Newell and Garrett 2018d).

Summaries of the geology of the area are found in Section 3.2, Geology, Minerals, and Subsidence; the following discussion focuses on the hydrology and groundwater of the area.

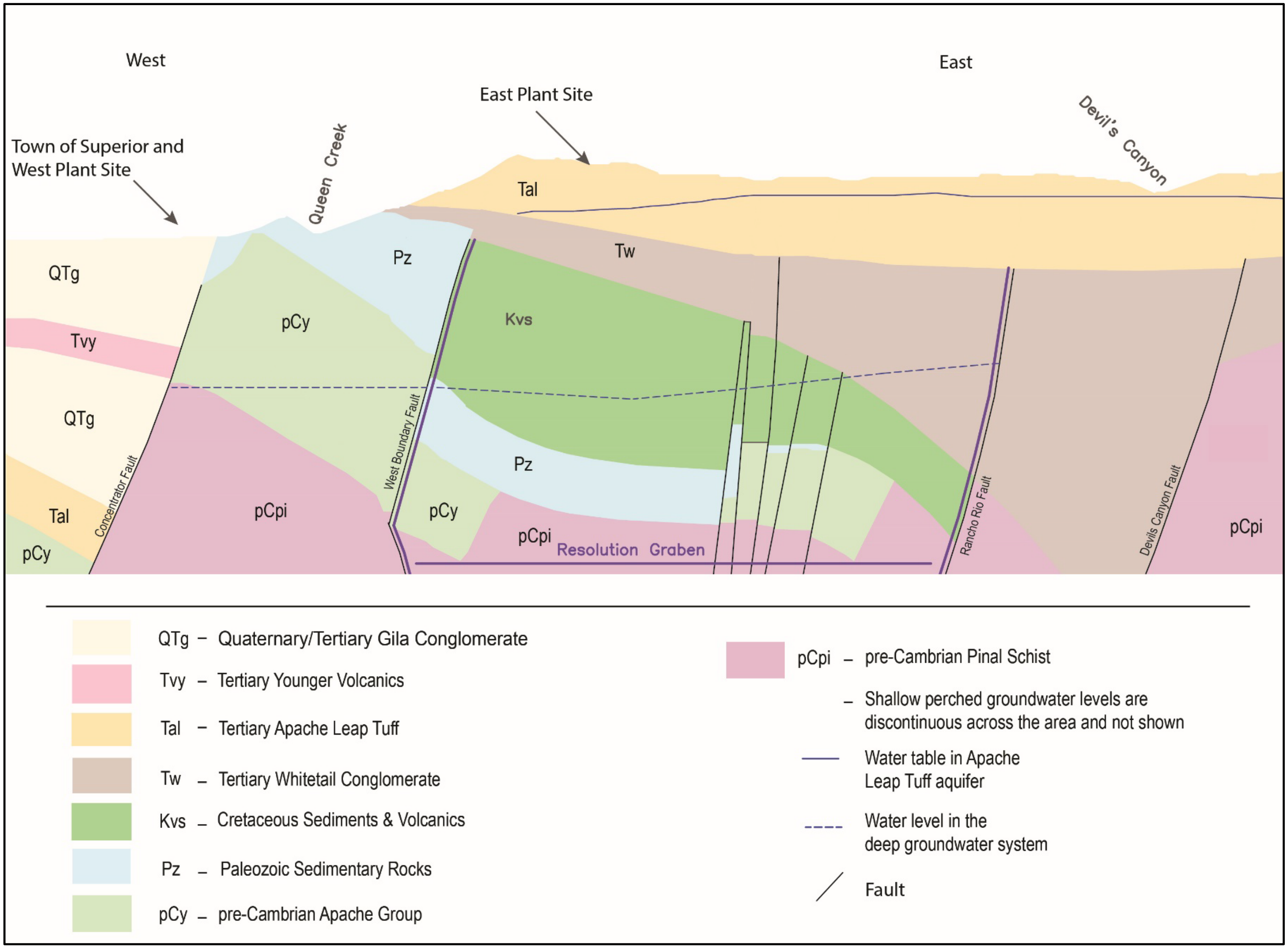


Figure 3.7.1-4. Conceptual cross section of the groundwater systems

East Plant Site

The East Plant Site is located on Oak Flat, east of the Concentrator Fault. The Concentrator Fault is a barrier to flow in the deep groundwater systems on either side of the fault. Groundwater characterization wells for the shallow, perched groundwater, the Apache Leap Tuff aquifer, and the deep groundwater system are shown in figure 3.7.1-5.

The shallow groundwater system consists of several shallow, perched aquifers of limited areal extent hosted in alluvial deposits and the uppermost weathered part of the Apache Leap Tuff. The primary shallow aquifers in this area are located near Top-of-the-World and JI Ranch, and to a lesser degree along some of the major drainages such as Hackberry Canyon and Rancho Rio Canyon.

The Apache Leap Tuff aquifer is a fractured-rock aquifer that extends throughout much of the Upper Queen Creek and Devil's Canyon watersheds, and the western part of the Upper Mineral Creek watershed. The Apache Leap Tuff aquifer is separated from the deep groundwater system by a thick sequence of poorly permeable Tertiary basin-fill sediments (the Whitetail Conglomerate). In general, the direction of groundwater movement in the Apache Leap Tuff follows surface drainage patterns, with groundwater moving from areas of recharge at higher elevations to natural discharge areas in Devil's Canyon and in Mineral Creek. Regional water levels in the Apache Leap Tuff aquifer, and general flow directions, are shown in figure 3.7.1-6.

The deep groundwater system east of the Concentrator Fault is compartmentalized, and faults separate individual sections of the groundwater system from each other. Depending on their character, faults can either inhibit or enhance groundwater flow. Based on available evidence, the faults in the project area tend to restrict groundwater flow between individual sections. The ore body and future block-cave zone lie within a geological structure called the Resolution Graben, which is bounded by a series of regional faults. The deep groundwater system in the Resolution Graben is hydraulically connected to existing mine workings, and a clear decrease in water levels in response to ongoing dewatering of the mine workings has been observed (Resolution Copper 2016c).

Three wells monitor the deep groundwater system inside the Resolution Graben (see table 3.7.1-1). As noted earlier in this section, groundwater levels in the deep groundwater system below Oak Flat (close to the pumping, within the Resolution Graben) have declined more than 2,000 feet since 2009 (Montgomery and Associates Inc. and Resolution Copper 2016) (see table 3.7.1-1). The deep groundwater system east of the Concentrator Fault, but outside the Resolution Graben, appears to have a limited hydraulic connection with the deep groundwater system inside the graben. Resolution Copper monitors groundwater levels at eight locations in the deep groundwater system outside the Resolution Graben (see table 3.7.1-1). Outside the graben, groundwater level decreases have been smaller, with a maximum decline of about 500 feet since 2009, while near Superior, water levels associated with similar connected units have declined up to 130 feet since 2009 (see table 3.7.1-1) (Montgomery and Associates Inc. and Resolution Copper 2016).

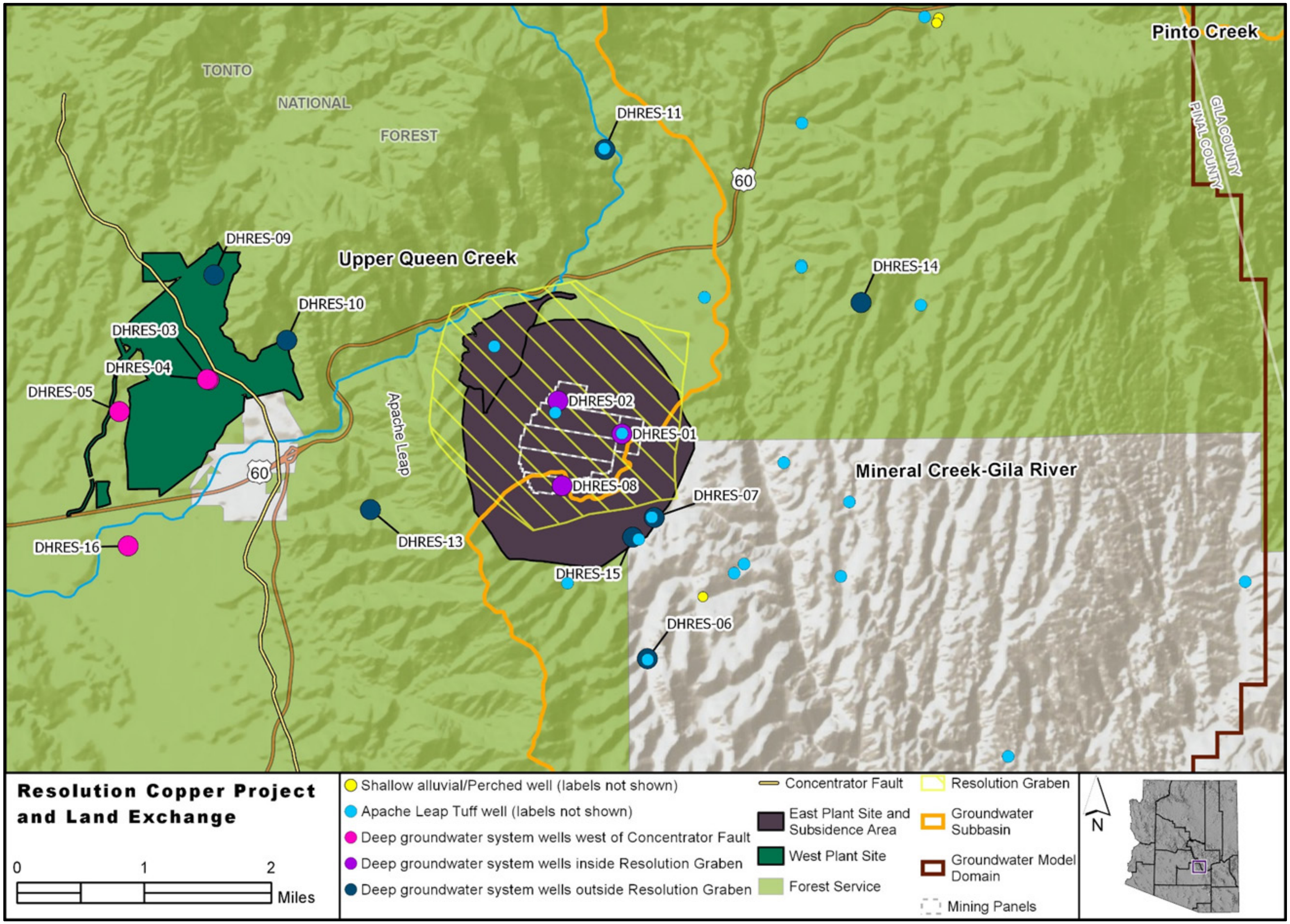


Figure 3.7.1-5. Characterization wells for the shallow, perched groundwater, the Apache Leap Tuff aquifer, and the deep groundwater system

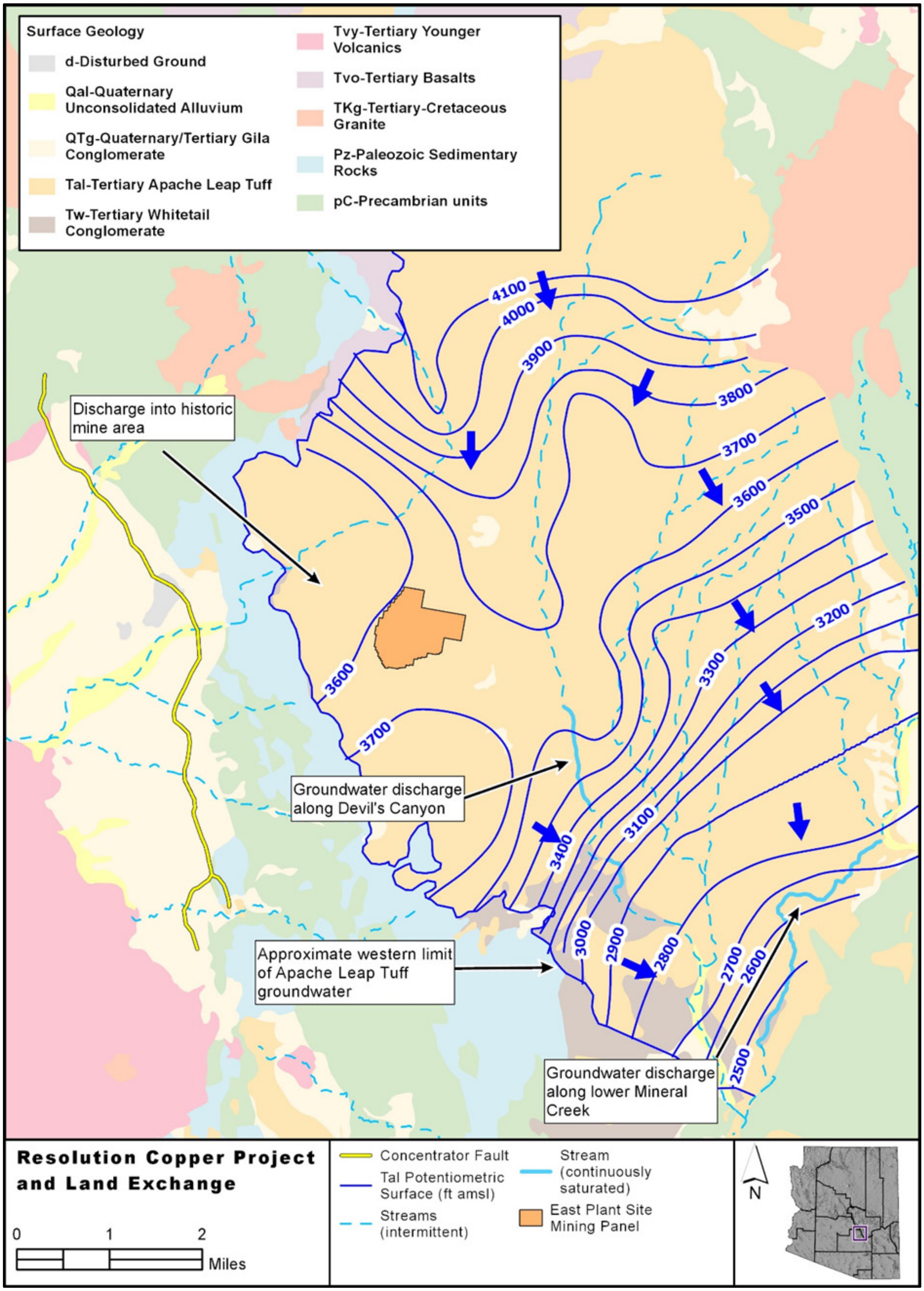


Figure 3.7.1-6. Apache Leap Tuff aquifer water-level elevations and general flow directions

West Plant Site

At the West Plant Site, shallow and intermediate groundwater occurs in the Gila Conglomerate. In addition, groundwater occurs in shallow alluvium to the south of the West Plant Site and in fractured bedrock (Apache Leap Tuff) on the eastern boundary of the West Plant Site.

Groundwater in the shallow, unconfined Gila Conglomerate discharges locally, as evidenced by the presence of seeps and evaporite deposits. The groundwater deeper in the Gila Conglomerate, below a separating mudstone formation, likely flows to the south or southwest toward regional discharge areas (Resolution Copper 2016c). Several wells monitor the Gila Conglomerate near the West Plant Site. Most of these wells have shown steady long-term declines in water level since 1996. These declines are consistent with water level declines occurring regionally in response to drought conditions (Montgomery and Associates Inc. 2017b).

The deep groundwater west of the Concentrator Fault is hosted in low permeability Quaternary and Tertiary basin-fill deposits, fractured Tertiary volcanic rocks, and underlying Apache Leap Tuff. Four wells monitor the deep groundwater system west of the Concentrator Fault. These wells have shown varying rises and declines (Montgomery and Associates Inc. 2017b).

MARRCO Corridor, Filter Plant and Loadout Facility, and Desert Wellfield

Along much of the MARRCO corridor, groundwater is present in a shallow aquifer within the alluvium along Queen Creek. The groundwater flow direction in this part of the corridor generally follows the Queen Creek drainage to the west.

In the portion of the corridor between Florence Junction and Magma, where the filter plant and loadout facility would be located, the groundwater is present in deep alluvial units. The regional groundwater flow direction in this area is generally toward the northwest (Resolution Copper 2016c).

The makeup water supply[51] for the mine would come from a series of wells installed within the MARRCO corridor, drawing water from these deep alluvial units of the East Salt River valley. These wells are known as the "Desert Wellfield." Although groundwater development in the vicinity of the Desert Wellfield has heretofore been limited, historically areas of the East Salt River valley to the west and south have been heavily used for agriculture. Until the late 1980s to early 1990s, groundwater levels were declining in much of the basin. Passage of the 1980 Groundwater Management Act which imposed limits on pumping, the availability of a renewable source of water, and the development of a regulatory framework allowing for recharge of the aquifer, all of which in combination with reduced agricultural pumping, have contributed to rising water levels. In the NMIDD to the southwest, groundwater levels have recovered on the order of 170 feet over the past three decades, with somewhat lesser water level increases occurring in the area of the Desert Wellfield (Bates et al. 2018). Current depths to groundwater in the vicinity of the Desert Wellfield range from 400 to 600 feet below ground surface. Because of these depths to groundwater, there are no GDEs in the East Salt River valley supported by regional groundwater that potentially could be impacted by drawdown from the mine water supply pumping.

[51] The mine process incorporates numerous means of recycling water back into the process wherever possible. However, for all alternatives, there remains the need for substantial additional fresh water for the processing. The fresh water fed into the processing stream is termed "makeup" water.

Tailings Storage Facility – Alternatives 2 and 3 – Near West

Thin alluvial deposits on the floors of canyons and washes at the location of the proposed tailings storage facility contain small amounts of shallow, perched groundwater. The majority of the tailings storage facility site is underlain by rocks with little permeability, with no indication of a water table within the upper 150 to 300 feet of ground surface (Montgomery and Associates Inc. 2017c). Where those rocks are fractured, they have the potential to store groundwater and allow for groundwater flow. Three springs are in the footprint of the proposed tailings storage facility: the Perlite, Benson, and Bear Tank Canyon Springs (see figure 3.7.1-3). Groundwater flow generally follows the topography toward Queen Creek. Several wells were installed in the tailings storage facility area to provide information on groundwater levels (Montgomery and Associates Inc. 2017c).

Tailings Storage Facility – Alternative 4 – Silver King

Similar to the Near West site, thin alluvial deposits on the floors of canyons and washes, especially in Silver King Wash, contain small amounts of shallow, perched groundwater (Cross and Blainer-Fleming 2012; Klohn Crippen Berger Ltd. 2018c). The majority of the tailings storage facility site is underlain by rocks with little permeability. Groundwater moves generally southwest (Cross and Blainer-Fleming 2012). A number of perennial springs are located near Alternative 4. McGinnel Spring and Iberri Spring are located within the footprint of Alternative 4, and several other perennial springs (McGinnel Mine Spring, Rock Horizontal Spring, and Bitter Spring) are located within 1 mile (see figure 3.7.1-3).

Tailings Storage Facility – Alternative 5 – Peg Leg

A broad alluvial groundwater basin underlies the Peg Leg location (Ludington et al. 2007). Limited site water level data suggest that groundwater depths below the facility footprint are relatively shallow, with depths less than 50 feet (Golder Associates Inc. 2018a). Groundwater flow is to the northwest, generally following the ground surface topography. The site is located in the Donnelly Wash groundwater basin, outside of any AMA.

Tailings Storage Facility – Alternative 6 – Skunk Camp

A number of field investigations that took place at the Skunk Camp location were completed and reported after publication of the DEIS (Fleming, Shelley, et al. 2018; KCB Consultants Ltd. 2019; Montgomery and Associates Inc. 2019a, 2020a, 2020e, 2020g; WestLand Resources Inc. and Montgomery and Associates Inc. 2020; Wong et al. 2020b). The specific reports and types of investigations are detailed in section 3.2.

Overall, on-site investigations confirmed the previous understanding of hydrology and geology at the site, as detailed in section 3.2. Deposits of sand and gravel less than 100 feet thick underlie the Skunk Camp location and contain shallow groundwater. Regional groundwater flows from northwest to southeast within the proposed tailings storage facility area toward the Gila River. Shallow groundwater flow is expected to be primarily through the surface alluvial channels and upper weathered zone of the Gila Conglomerate (Klohn Crippen Berger Ltd. 2018d). The site is located in the Dripping Spring Wash groundwater basin, outside of any AMA.

GROUNDWATER BALANCE WITHIN MODELING ANALYSIS AREA

Groundwater systems are considered to be at steady state when outflow equals inflow. In the modeling analysis area, outflows due to mine dewatering exceed inflows, with the result that the groundwater system is not at steady state and water is removed from storage.

Inflow components of the groundwater balance include recharge from precipitation, groundwater inflows from adjacent groundwater basins, and deep percolation from irrigation and from the Town of Superior Wastewater Treatment Plant. Recharge from precipitation is the largest component of inflow into the groundwater of the analysis area.

Groundwater outflows include mine dewatering, groundwater pumping, subsurface and surface flow at Whitlow Ranch Dam (a flood control structure located on Queen Creek, just upstream of the community of Queen Valley), and groundwater evapotranspiration. The largest component of groundwater outflow for both the shallow perched groundwater and the Apache Leap Tuff aquifer is groundwater evapotranspiration, primarily from where vegetation has access to near-surface groundwater. The largest component of groundwater outflow for deep groundwater is mine dewatering, primarily from Resolution Copper but also from an open-pit perlite mining operation near Queen Creek. In 2017, mine dewatering removed approximately 1,360 acre-feet of water from the deep groundwater system (Montgomery and Associates Inc. 2018).

ONGOING CLIMATIC TRENDS AFFECTING WATER BALANCE

The annual mean and minimum temperatures in the lower Colorado River Basin have increased 1.8°F to 3.6°F for the time period 1900–2002, and data suggest that spring minimum temperatures for the same time period have increased 3.6°F to 7.2°F (Dugan 2018). Winter temperatures have increased up to 7.2°F, and summer temperatures 1.6°F. Increasing temperature has been correlated with decreasing snowpack and earlier runoff in the lower Colorado River Basin, with runoff increasing between November and February and decreasing between April and July (April to July is traditionally recognized as the peak runoff season in the basin).

Future projected temperature increases are anticipated to change the amount of precipitation only by a small amount but would change the timing of runoff and increase the overall evaporative demand. Groundwater recharge is most effective during low-intensity, long-duration precipitation events, and when precipitation falls as snow. With ongoing trends for the southwestern United States toward higher temperatures with less snow and more high-intensity rainstorms, more runoff occurs, but groundwater recharge may decline, leading to a decrease in groundwater levels. Increased demand for groundwater, due to higher water demand under higher temperatures, may also lead to greater stresses on groundwater supplies.

CURRENT AND ONGOING PUMPING AND WATER LEVEL TRENDS

Mining near Superior started about 1875, and dewatering of the Magma Mine began in earnest in 1910 as production depths increased. Dewatering continued with little interruption until 1998, after active mining ceased at the Magma Mine. In 2009, Resolution Copper resumed dewatering as construction began on Shaft 10 (WSP USA 2019). Since 2009, Resolution Copper has reported pumping about 13,000 acre-feet of groundwater under their dewatering permit.[52] Almost all of this water is treated and delivered to the NMIDD. Most historical dewatering pumping took place east of the Concentrator Fault, primarily at the Magma Mine, but also at the Silver King, Lake Superior and Arizona, and Belmont mines (Keay 2018).

Resolution Copper removes groundwater from sumps in Shafts 9 and 10, effectively dewatering the deep groundwater system that lies below the Whitetail Conglomerate unit (the bottom of Shaft 10 is about 7,000 feet below ground level). Groundwater levels in the deep groundwater system below Oak Flat (close to the pumping) have dropped over 2,000 feet since 2009. These same hydrogeological units

[52] The current mine infrastructure lies almost entirely within the Phoenix AMA. In this area, pumping groundwater requires a groundwater right from the ADWR. Resolution Copper's dewatering right (59-524492) is permitted through 2029 (Rietz 2016b).

extend west, below Apache Leap, and into the Superior Basin. Near Superior, water levels associated with these units have declined roughly 20 to 90 feet since 2009 (Montgomery and Associates Inc. and Resolution Copper 2016).

In the Oak Flat area, the Apache Leap Tuff aquifer overlies the deep groundwater system, and the Whitetail Conglomerate unit separates the two groundwater systems. The Whitetail Conglomerate unit acts as an aquitard—limiting the downward flow of groundwater from the Apache Leap Tuff. Groundwater level changes in the Apache Leap Tuff that have been observed have generally been 10 feet or less since 2009.

Groundwater levels in the Apache Leap Tuff are important because they provide water to GDEs, such as the middle and lower reaches of Devil's Canyon (Garrett 2018e). Resolution Copper has extensively monitored Devil's Canyon since as early as 2003. Most hydrologic indicators show no significant change over time in Devil's Canyon (Garrett 2019f). A number of other water sources have been monitored on Oak Flat and show seasonal drying, but these locations have been demonstrated to be disconnected from the Apache Leap Tuff aquifer, relying instead on localized precipitation (Garrett 2018e; Montgomery and Associates Inc. 2017a). Other pumping also occurs within the Superior Basin, but is substantially less than the Resolution Copper dewatering, roughly accounting for less than 10 percent of groundwater pumped within the model area (Montgomery and Associates Inc. 2018).

GROUNDWATER-DEPENDENT ECOSYSTEMS

The Tonto National Forest evaluated 67 different spring or stream locations in the project area as potential GDEs. These include the following:

- **Queen Creek watershed.** Areas evaluated include Queen Creek itself from its headwaters to Whitlow Ranch Dam, four tributaries (Number Nine Wash, Oak Flat Wash, Arnett Creek, and Telegraph Canyon), and 29 spring locations.
- **Devil's Canyon watershed.** Areas evaluated include Devil's Canyon from its headwaters to the confluence with Mineral Creek at the upper end of Big Box Reservoir, three tributaries (Hackberry Canyon, Rancho Rio Canyon, and Iron Canyon), and seven spring locations. Four of these springs are located along the main stem of Devil's Canyon and contribute to the general streamflow.
- **Mineral Creek watershed.** Areas evaluated include Mineral Creek from its headwaters to the confluence with Devil's Canyon at the upper end of Big Box Reservoir, and five spring locations. Three of these springs are located along the main stem of Mineral Creek and contribute to the general streamflow.

After evaluating available lines of evidence for portions of Queen Creek, Devil's Canyon, Mineral Creek, Telegraph Canyon, and Arnett Creek, the Groundwater Modeling Workgroup thought it likely that some stream segments within these watersheds could have at least a partial connection to regional aquifers, and each is described in more detail in the following text of this section. In addition, the Groundwater Modeling Workgroup identified 17 springs that demonstrate at least a partial connection to regional aquifers. The remainder of the potential GDEs were eliminated from analysis for various reasons (Garrett

2018e).[53] GDEs with a likely or possible regional groundwater source, and therefore analyzed in this section, are listed in table 3.7.1-2 and shown in figure 3.7.1-7.

Table 3.7.1-2. GDEs identified as having at least a partial connection to regional groundwater

Type of Feature	Name/Description*	Type of Impact Analysis Used in EIS
Queen Creek Watershed		
Stream segments	Queen Creek, between km 17.39 and 15.55 (downstream of Superior and upstream of Boyce Thompson Arboretum); approximately 1.2 miles long Queen Creek at Whitlow Ranch Dam Arnett Creek, near the confluence with Telegraph Canyon (km 4.5) and upstream at Blue Spring (km 12.5) Telegraph Canyon, near the confluence with Arnett Creek	Groundwater flow model (all stream segments); Surface water flow model (Queen Creek only)
Springs (10 total)	Bitter, Bored, Hidden, Iberri, Kane, McGinnel, McGinnel Mine, No Name, Rock Horizontal, and Walker	Groundwater flow model
Devil's Canyon Watershed		
Stream segments	Devil's Canyon, from km 9.14 to confluence with Mineral Creek/Big Box Reservoir; approximately 5.7 miles long	Groundwater flow model; Surface flow water model
Springs (4 total)	DC-8.2W, DC-6.6W, DC-6.1E, DC-4.1E	Groundwater flow model
Mineral Creek Watershed		
Stream segments	Mineral Creek from km 8.7 to confluence with Devil's Canyon/Big Box Reservoir, approximately 5.4 miles long	Groundwater flow model
Springs (3 total)	Government Springs, MC-8.4C, MC-3.4W (Wet Leg Spring)	Groundwater flow model

* Many of the stream descriptions reference the distance upstream of the confluence, measured in kilometers. This reference system is also incorporated into many stream/spring monitoring locations. For instance, spring "DC-8.2W" is located 8.2 km upstream of the mouth of Devil's Canyon, on the west side of the drainage.

[53] To summarize, potential GDEs were eliminated from analysis using the groundwater flow model because they did not appear to exist within the analysis area (five springs); or had sufficient evidence to indicate a shallow groundwater source instead of a connection to the regional aquifers (19 springs; most of Queen Creek; upper Devil's Canyon; two tributaries to Queen Creek; and three tributaries to Devil's Canyon). Some of these GDEs may still be affected by changes in surface runoff, and these changes are still analyzed in this section.

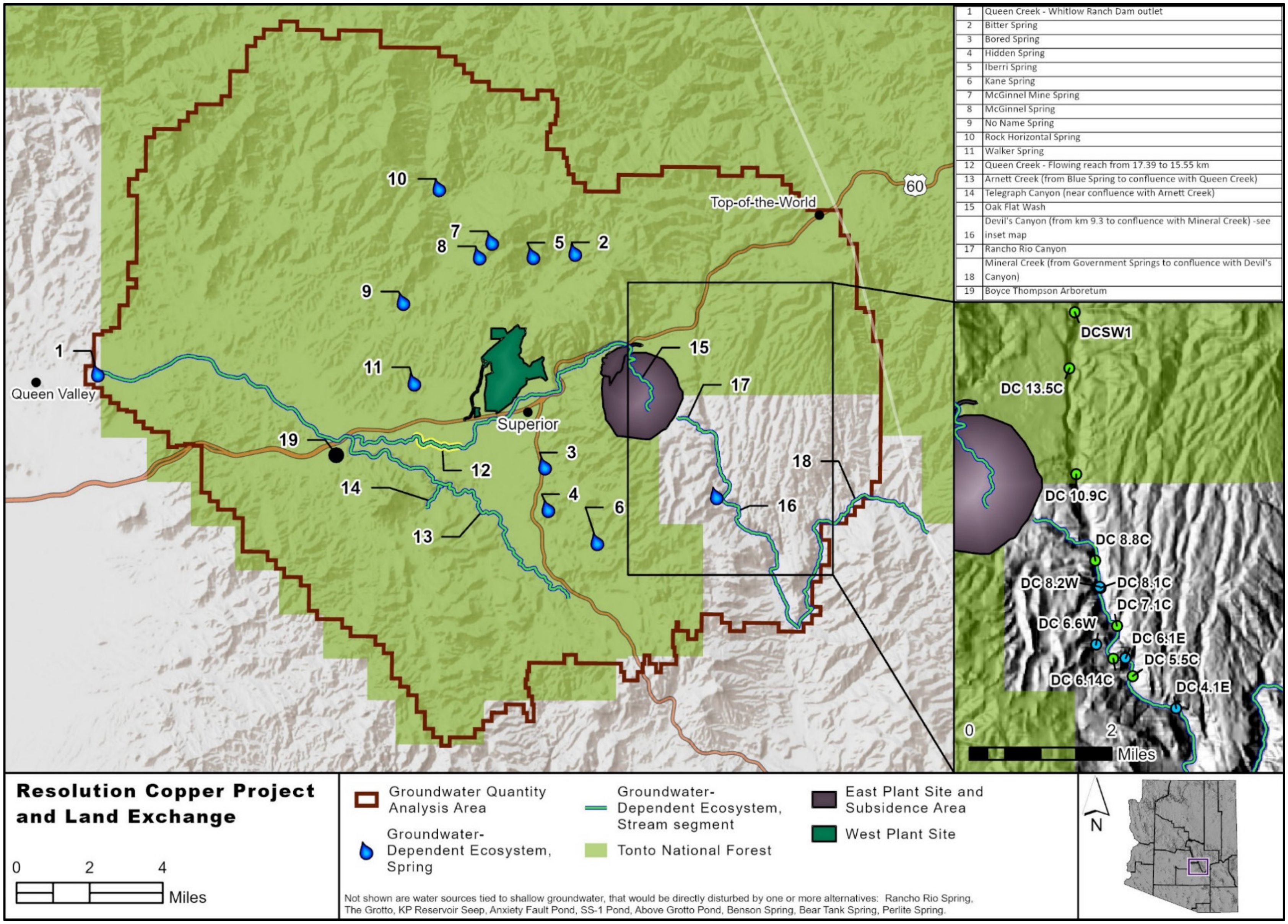


Figure 3.7.1-7. Groundwater-dependent ecosystems of concern

Devil's Canyon

The upper reach of Devil's Canyon (from above the U.S. 60 bridge to approximately km 9.3) includes a reach of perennial flow from approximately DC-11.0 to DC-10.6. The geohydrology suggests that this section of Devil's Canyon lies above the water table in the Apache Leap Tuff aquifer and is most likely supported by snowmelt or precipitation stored in near-surface fractures, and/or floodwaters that have been stored in shallow alluvium along the stream, before slowly draining into the main channel. Further evaluation of hydrochemistry and flow data support this conclusion (Garrett 2018e). Streamflow in Upper Devil's Canyon is not considered to be connected with the regional Apache Leap Tuff aquifer and would not be expected to be impacted by groundwater drawdown caused by the block-cave mining and dewatering. This portion of Devil's Canyon is also upstream of the subsidence area and unlikely to be impacted by changes in surface runoff.

Moving downstream in Devil's Canyon, persistent streamflow arises again about km 9.3. From this point downstream, Devil's Canyon contains stretches of perennial flow, aquatic habitat, and riparian galleries. Flow arises both from discrete springs along the walls of the canyon (four total), as well as groundwater inflow along the channel bottom. These reaches of Devil's Canyon also are supported in part by near-surface storage of seasonal precipitation; however, the available evidence indicates that these waters arise primarily from the regional Apache Leap Tuff aquifer. Streamflow in middle and lower Devil's Canyon is considered to be connected with the regional aquifer, which could potentially be impacted by groundwater drawdown caused by the block-cave mining and dewatering. These reaches of Devil's Canyon also receive runoff from the area where the subsidence area would occur and therefore may also lose flow during runoff events.

Queen Creek

The available evidence suggests that Queen Creek from headwaters to Whitlow Ranch Dam is ephemeral in nature, although in some areas above Superior it may be considered intermittent, as winter base flow does occur and likely derives from seasonal storage of water in streambank alluvium, which slowly seeps back in to the main channel (Garrett 2018e). This includes three springs located along the main stem of Queen Creek above Superior.

An exception for Queen Creek is a perennially flowing reach between km 17.39 and 15.55, which is located downstream of Superior and upstream of Boyce Thompson Arboretum. Originally this flowing reach had been discounted because it receives effluent discharge from the Superior Wastewater Treatment Plant. However, discussions within the Groundwater Modeling Workgroup suggested that a component of baseflow supported by regional aquifer discharge may exist in this reach as well. Regardless of whether baseflow directly enters the channel from the regional aquifer, substantial flow in this reach also derives from dewatering discharges from a small open-pit perlite mining operation, where the mine pit presumably intersects the regional aquifer (Garrett 2018e). Therefore, for several reasons, this reach was included as a potential GDE, with the potential to be impacted by regional groundwater drawdown. The AGFD conducted surveys on this reach in 2017 and found that while flow fluctuated throughout the survey reach, aquatic wildlife and numerous other avian and terrestrial species use this habitat, and that aquatic species appeared to be thriving and reproducing (Warnecke et al. 2018).

Queen Creek also has perennial flow that occurs at Whitlow Ranch Dam and supports a 45-acre riparian area (primarily cottonwood, willow, and saltcedar). This location is generally considered to be where most subsurface flow in the alluvium along Queen Creek and other hydrologic units exits the Superior Basin. Queen Creek above and below Superior receives runoff from the area where the subsidence area would occur and therefore may also lose flow during runoff events. About 20 percent of the average annual runoff above Magma Avenue Bridge would be lost to the subsidence area (described in more detail in Section 3.7.3, Surface Water Quantity).

Mineral Creek

Mineral Creek is similar in nature to lower Devil's Canyon. While flows are supported in part by near-surface storage of seasonal precipitation, the available evidence indicates that these waters arise partially from the Apache Leap Tuff aquifer and other regional sources. For the purposes of analysis, Mineral Creek is considered to be connected with regional aquifers, which could potentially be impacted by groundwater drawdown caused by the block-cave mining and dewatering; whether this impact is predicted to occur or not is determined using the results of the groundwater modeling.

Approximately the lower 4 miles of Mineral Creek exhibits perennial flow that supports riparian galleries and aquatic habitat. Three perennial springs also contribute to Mineral Creek (Government Springs, MC-8.4C, and MC-3.4W or Wet Leg Spring). Government Springs is the farthest upstream, roughly 5.4 miles above the confluence with Devil's Canyon (Garrett 2018e).

Mineral Creek is designated as critical habitat for Gila chub. The AGFD has conducted fish surveys on Mineral Creek periodically since 2000 and has not identified Gila chub in Mineral Creek since 2000. While the presence of amphibians suggested acceptable water quality in this reach, until 2006 no fish populations were observed despite acceptable habitat. AGFD stocked native longfin dace in Mineral Creek downstream of Government Springs in 2006, and as of 2017, these fish were still present in the stream, though Gila chub have not been seen (Crowder et al. 2014; WestLand Resources Inc. 2018a).

Arnett Creek

Fairly strong and consistent evidence indicates that several reaches of Arnett Creek likely receive some contribution from groundwater that looks similar to the Apache Leap Tuff aquifer, though these units are not present in this area. This includes Blue Spring (located in the channel of Arnett Creek above Telegraph Canyon) and in the downstream portions of Arnett Creek immediately downstream of Telegraph Canyon. Arnett Creek is considered to be connected with regional aquifers, which could potentially be impacted by groundwater drawdown caused by the block-cave mining and dewatering; whether this impact is predicted to occur or not is determined using the results of the groundwater modeling.

Telegraph Canyon

Telegraph Canyon is a tributary to Arnett Creek. Unlike Arnett Creek, there was insufficient evidence to determine whether or not these waters were tied to the regional aquifers. In such cases, the Forest Service policy is to assume that a connection exists; therefore, Telegraph Canyon is also considered to be connected with the regional aquifers, which could potentially be impacted by groundwater drawdown caused by the block-cave mining and dewatering; whether this impact is predicted to occur or not is determined using the results of the groundwater modeling.

Tributaries to Queen Creek and Devil's Canyon

A number of tributaries were evaluated originating in the Oak Flat area and feeding either Queen Creek or Devil's Canyon. These include Number 9 Wash and Oak Flat Wash (Queen Creek watershed) and Iron Canyon, Hackberry Canyon, and Rancho Rio Canyon (Devil's Canyon watershed). Sufficient evidence existed for all of these tributaries to demonstrate that they most likely have local water sources that are not connected to the regional Apache Leap Tuff aquifer (Garrett 2018e).

WATER SUPPLY WELLS

GDEs represent natural systems that could be impacted by the project, but human communities also rely on groundwater sources in the area. In lieu of analyzing individual wells, typical wells in key communities were analyzed using the groundwater flow model (Newell and Garrett 2018d). These areas include the following:

- **Top-of-the-World**. Many wells in this location are relatively shallow and rely on near-surface fracture systems and shallow perched alluvial deposits (see Garrett (2018e:Attachment 7)); these wells would not be impacted by changes in the regional aquifers. However, other wells in this area could be completed deeper into the Apache Leap Tuff aquifer. Impacts on well HRES-06 is used as a proxy for potential impacts on water supplies and individual wells in this area.
- **Superior**. The Arizona Water Company serves the Town of Superior; the water comes from the East Salt River valley. Even so, there are assumed to still be individual wells within the town that use local groundwater (stock wells, domestic wells, commercial wells). As with Top-of-the-World, some of these wells may rely on near-surface groundwater and would not be impacted by changes in the regional aquifers. Other wells could be completed in geological units in hydraulic connection to the deep groundwater system. Well DHRES-16_743 is used as a proxy for potential impacts on water supplies and individual wells in this area.
- **Boyce Thompson Arboretum**. The Gallery Well is used as a proxy for impacts on water supplies associated with Boyce Thompson Arboretum. This well likely uses groundwater from local sources, but for the purposes of analysis it is assumed to be connected to regional aquifers.

Public comments suggested that focusing on proxies instead of specific individual wells was an inappropriate approach. The rationale for using proxies was provided in DEIS references (Newell and Garrett 2018c), but bears repeating here.

In order to evaluate the effects of groundwater drawdown on an individual well, a number of details need to be known about the well construction and operation. These include depth to water, depth of well, location of perforated intervals, and the type and depth of pump equipment in the well. In general, individual water supply wells vary so much a hypothetical 10-foot drop in the water table could leave a shallow well completely dry (requiring it to be redrilled), could cause a different well to lower a pump but otherwise remain unaffected, or could have no noticeable effect at all for deeper wells. Most of these key details are unknown through existing data sources, and unable to be collected without disrupting water service.

The proxy wells described above provide a reasonable estimate of impacts that any individual well owner could apply to their own well if located in the same area. If an individual well owner is not located near these areas, drawdown can be spatially seen in figures 3.7.1-2 (for drawdown near the Desert Wellfield) and 3.7.1-3 (for drawdown near the mine site). Drawdown also is detailed for any of the GDE locations (see hydrographs in appendix L, with the specific location shown on figure 3.7.1-7). If proxy wells are insufficient for a given individual well owner, all of these sources also are indicative of drawdown in the regional aquifer that could impact individual wells.

3.7.1.4 Environmental Consequences of Implementation of the Proposed Mine Plan and Alternatives

Alternative 1 – No Action

ALTERNATIVE 1 – NO ACTION

Under the no action alternative, which includes continued dewatering pumping of the deep groundwater system, no perennial streams are anticipated to be impacted, but six perennial springs would experience drawdown greater than 10 feet. These springs are Bitter, Bored, Hidden, McGinnel, McGinnel Mine, and Walker Springs, as shown in figures 3.7.1-8 and 3.7.1-9, and summarized in table 3.7.1-3. Hydrographs showing drawdown under the no action alternative for all GDEs with connections to regional aquifers are included in appendix L.

The 10-foot drawdown contour shown on figure 3.7.1-8 represents the limit of where the groundwater model can reasonably predict impacts with the best-calibrated model (orange area). GDEs falling within this contour are anticipated to be impacted. GDEs outside this contour may still be impacted, but it is beyond the ability of the model to predict.

It is not possible to precisely predict what impact a given drawdown in groundwater level would have on an individual spring; however, given the precision of the model (10 feet), it is reasonable to assume any spring with anticipated impact of this magnitude could experience complete drying.

Bored Spring has the highest riparian value, supporting a standing pool and a 500-foot riparian string of cottonwood, willow, mesquite, saltcedar, and sumac. The loss of water to this spring would likely lead to complete loss of this riparian area.

Bitter, Hidden, McGinnel, McGinnel Mine, and Walker Springs all have infrastructure improvements to some degree and host relatively little riparian vegetation, although standing water and herbaceous and wetland vegetation may be present. The loss of flowing water would likely lead to complete loss of these pools and fringe vegetation.

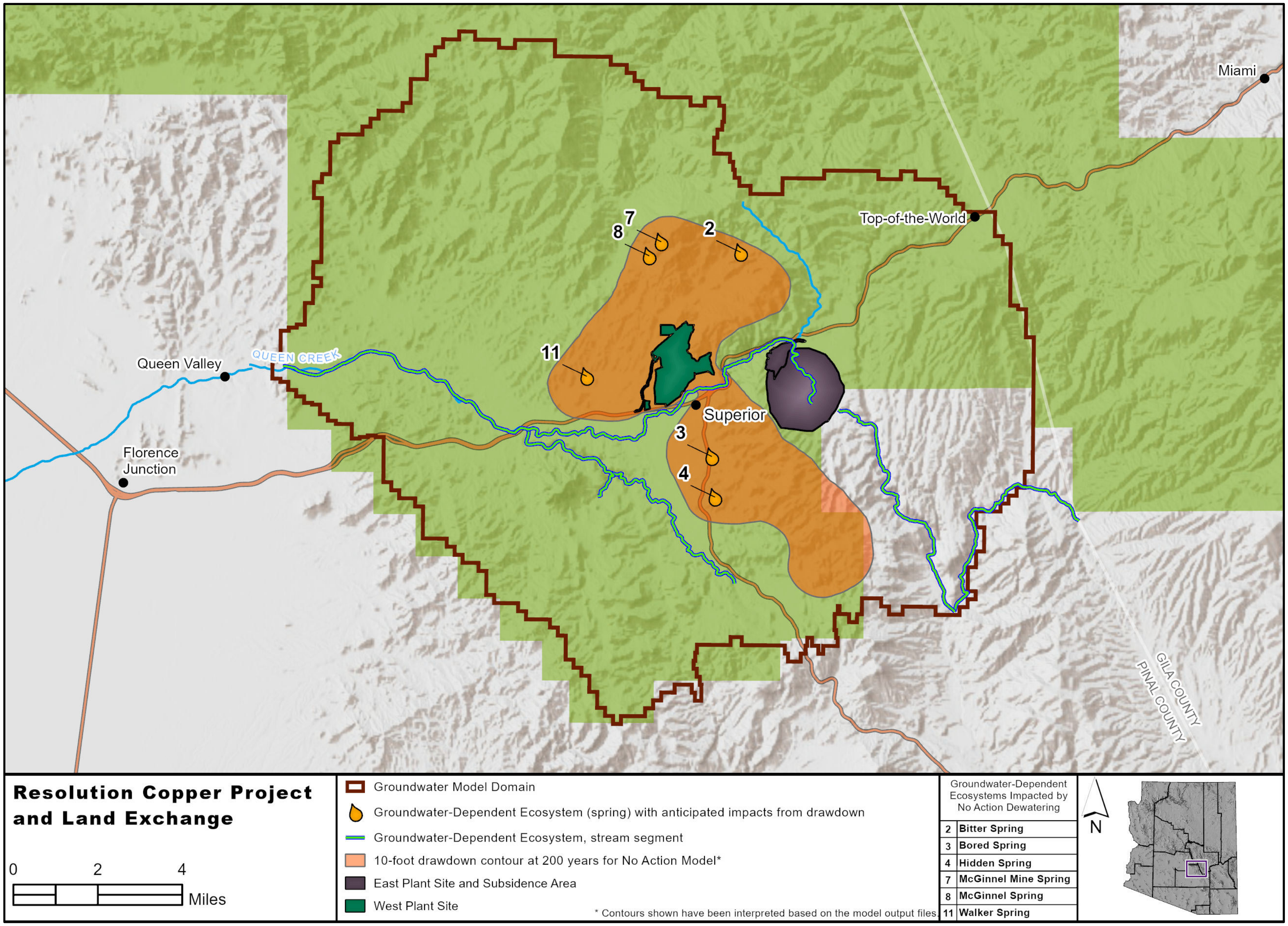


Figure 3.7.1-8. Modeled groundwater drawdown—no action

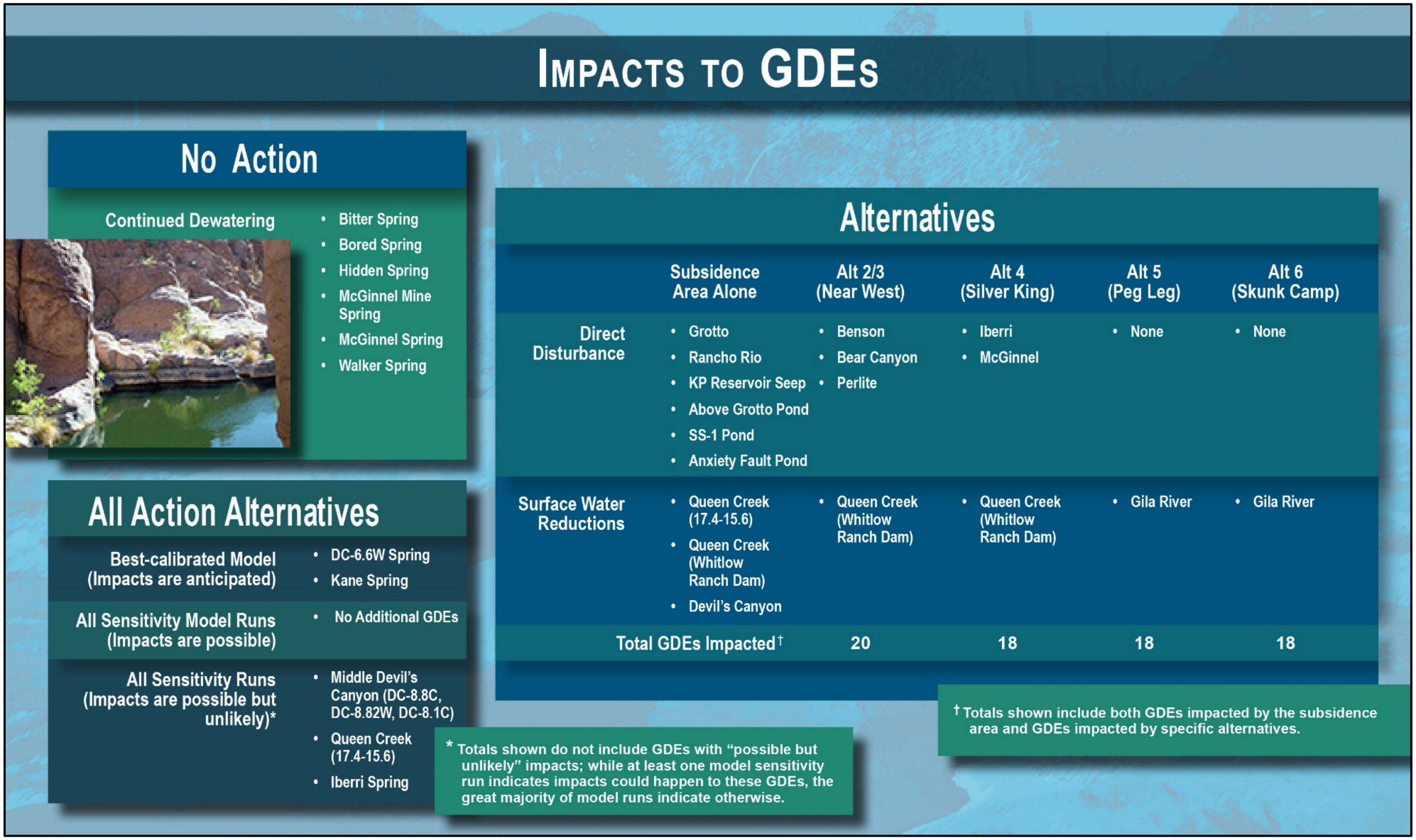


Figure 3.7.1-9. Summary of impacts on GDEs by alternative

ANTICIPATED IMPACTS ON WATER SUPPLY WELLS

Many domestic and stock water supply wells in the area are shallow and likely make use of water stored in shallow alluvium or shallow fracture networks. These wells are unlikely to be impacted by groundwater drawdown from mine dewatering under the no action alternative. However, groundwater drawdown caused by the mine could affect groundwater supplies for wells that may draw from either the regional Apache Leap Tuff aquifer or the deep groundwater system. Drawdown from 10 to 30 feet is anticipated in wells in the Superior area, as shown in table 3.7.1-4.

Unlike the action alternative, the applicant-committed environmental protection measures that would remedy any impacts on water supply wells caused by drawdown from the project (discussed later in this section) would not occur under the no action alternative.

LONGER TERM MODELED IMPACTS

The only GDEs impacted under the no action alternative are the six distant springs identified earlier in this section, which are modeled as having connections to the regional deep groundwater system. Based on long-term modeled hydrographs, these springs generally see maximum drawdown resulting from the continued mine pumping within 150 to 200 years after the end of mining; the impacts shown in table 3.7.1-3 likely represent the maximum impacts that would be experienced under the no action scenario.

SUBSIDENCE IMPACTS

Under the no action alternative, small amounts of land surface displacement could continue to occur due to ongoing pumping (Newell and Garrett 2018d). These amounts are observable using satellite monitoring techniques but are unlikely to be observable on the ground.

Table 3.7.1-3. Summary of potential impacts on groundwater-dependent ecosystems from groundwater drawdown

Reference Number on Figure 3.7.1-7	Specific GDE	Drawdown (feet) from Dewatering under No Action Alternative (end of mining)	Drawdown (feet) from Dewatering and Block Caving under Proposed Action (end of mining)	Drawdown (feet) from Dewatering under No Action Alternative (200 years after start of mine)	Drawdown (feet) from Dewatering and Block Caving under Proposed Action (200 years after start of mine)	Number of Sensitivity Runs with Drawdown greater than 10 Feet (based on Proposed Action, 200 years after start of mine)	Summary of Expected Impacts on GDEs
	Queen Creek and Tributaries						
12	Queen Creek – Flowing reach from km 17.39 to 15.55	<10	<10	<10	<10	4 of 87 sensitivity runs show impacts greater than 10 feet; impacts are possible but unlikely	No Action – Drawdown is not anticipated.* Proposed Action – Additional drawdown due to block caving is not anticipated with the base case model. Drawdown is possible but unlikely under the sensitivity modeling runs.* Reach has two other documented and substantial water sources.
1	Queen Creek – Whitlow Ranch Dam Outlet‡	<10	<10	<10	<10	Not available	No Action – Drawdown is not anticipated.* Proposed Action – Additional drawdown due to block caving is not anticipated.†
13	Arnett Creek (from Blue Spring to confluence with Queen Creek)	<10	<10	<10	<10	0 of 87 sensitivity runs show impacts greater than 10 feet	No Action – Drawdown is not anticipated.* Proposed Action – Additional drawdown due to block caving is not anticipated.*
14	Telegraph Canyon (near confluence with Arnett Creek)	<10	<10	<10	<10	0 of 87 sensitivity runs show impacts greater than 10 feet	No Action – Drawdown is not anticipated.* Proposed Action – Additional drawdown due to block caving is not anticipated.*

Reference Number on Figure 3.7.1-7	Specific GDE	Drawdown (feet) from Dewatering under No Action Alternative (end of mining)	Drawdown (feet) from Dewatering and Block Caving under Proposed Action (end of mining)	Drawdown (feet) from Dewatering under No Action Alternative (200 years after start of mine)	Drawdown (feet) from Dewatering and Block Caving under Proposed Action (200 years after start of mine)	Number of Sensitivity Runs with Drawdown greater than 10 Feet (based on Proposed Action, 200 years after start of mine)	Summary of Expected Impacts on GDEs
	Devil's Canyon and Springs along Channel						
16	Middle Devil's Canyon (from km 9.3 to km 6.1, including springs DC8.2W, DC6.6W, and DC6.1E)	<10	<10	<10	10–30 (Spring DC-6.6W)	For spring DC6.6W, 76 of 87 sensitivity runs show impacts greater than 10 feet; confirms base case impacts For the main channel (DC8.8C, DC 8.1C) and spring DC8.2W, 1 of 87 sensitivity runs shows impacts greater than 10 feet; impacts are possible but unlikely For spring DC6.1E, 0 of 87 sensitivity runs show impacts greater than 10 feet	No Action – Drawdown is not anticipated.* Proposed Action – Addition drawdown due to block caving is anticipated in spring DC-6.6W with the base case model and most sensitivity modeling runs (see description of impacts).*† Drawdown is possible but unlikely under the sensitivity modeling runs for main channel groundwater inflow and spring DC6.1E.2.
16	Lower Devil's Canyon (from km 6.1 to confluence with Mineral Creek, including spring DC4.1E)	<10	<10	<10	<10	0 of 87 sensitivity runs show impacts greater than 10 feet	No Action – Drawdown is not anticipated.* Proposed Action – Additional drawdown due to block caving is not anticipated.*
	Mineral Creek and Springs along Channel						
18	Mineral Creek (from Government Springs [km 8.7] to confluence with Devil's Canyon, including springs MC8.4C and MC3.4W [Wet Leg Spring])	<10	<10	<10	<10	0 of 87 sensitivity runs show impacts greater than 10 feet	No Action – Drawdown is not anticipated.* Proposed Action – Additional drawdown due to block caving is not anticipated.*

Reference Number on Figure 3.7.1-7	Specific GDE	Drawdown (feet) from Dewatering under No Action Alternative (end of mining)	Drawdown (feet) from Dewatering and Block Caving under Proposed Action (end of mining)	Drawdown (feet) from Dewatering under No Action Alternative (200 years after start of mine)	Drawdown (feet) from Dewatering and Block Caving under Proposed Action (200 years after start of mine)	Number of Sensitivity Runs with Drawdown greater than 10 Feet (based on Proposed Action, 200 years after start of mine)	Summary of Expected Impacts on GDEs
	Queen Creek Basin Springs						
2	Bitter Spring	10–30	10–30	<10	10–30	87 of 87 sensitivity runs show impacts greater than 10 feet; confirms base case impacts	No Action – Drawdown is anticipated (see description of impacts).*† Proposed Action – Additional drawdown due to block caving is anticipated (see description of impacts).*†
3	Bored Spring	30–50	30–50	>50	>50	87 of 87 sensitivity runs show impacts greater than 10 feet; confirms base case impacts	No Action – Drawdown is anticipated (see description of impacts).*† Proposed Action – Additional drawdown due to block caving is anticipated (see description of impacts).*†
4	Hidden Spring	10–30	10–30	30–50	>50	87 of 87 sensitivity runs show impacts greater than 10 feet; confirms base case impacts	No Action – Drawdown is anticipated (see description of impacts).*† Proposed Action – Additional drawdown due to block caving is anticipated (see description of impacts).*†
5	Iberri Spring	<10	<10	<10	<10	1 of 87 sensitivity runs show impacts greater than 10 feet; impacts are possible but unlikely	No Action – Drawdown is not anticipated.* Proposed Action – Addition drawdown due to block caving is not anticipated with the base case model. Drawdown is possible but unlikely under the sensitivity modeling runs.*
6	Kane Spring	<10	<10	<10	>50	84 of 87 sensitivity runs show impacts greater than 10 feet; confirms base case impacts	No Action – Drawdown is not anticipated.* Proposed Action – Additional drawdown due to block caving is anticipated (see description of impacts).*†

Reference Number on Figure 3.7.1-7	Specific GDE	Drawdown (feet) from Dewatering under No Action Alternative (end of mining)	Drawdown (feet) from Dewatering and Block Caving under Proposed Action (end of mining)	Drawdown (feet) from Dewatering under No Action Alternative (200 years after start of mine)	Drawdown (feet) from Dewatering and Block Caving under Proposed Action (200 years after start of mine)	Number of Sensitivity Runs with Drawdown greater than 10 Feet (based on Proposed Action, 200 years after start of mine)	Summary of Expected Impacts on GDEs
7	McGinnel Mine Spring	<10	<10	10–30	10–30	86 of 87 sensitivity runs show impacts greater than 10 feet; confirms base case impacts	No Action – Drawdown is anticipated (see description of impacts).*† Proposed Action – Addition drawdown due to block caving is anticipated (see description of impacts).*†
8	McGinnel Spring	<10	<10	10–30	10–30	85 of 87 sensitivity runs show impacts greater than 10 feet; confirms base case impacts	No Action – Drawdown is anticipated (see description of impacts).*† Proposed Action – Addition drawdown due to block caving is anticipated (see description of impacts).*†
9	No Name Spring	<10	<10	<10	<10	0 of 87 sensitivity runs show impacts greater than 10 feet	No Action – Drawdown is not anticipated.* Proposed Action – Additional drawdown due to block caving is not anticipated.*
10	Rock Horizontal Spring	<10	<10	<10	<10	0 of 87 sensitivity runs show impacts greater than 10 feet	No Action – Drawdown is not anticipated.* Proposed Action – Additional drawdown due to block caving is not anticipated.*
11	Walker Spring	10–30	10–30	10–30	30–50	87 of 87 sensitivity runs show impacts greater than 10 feet; confirms base case impacts	No Action – Drawdown is anticipated (see description of impacts).*† Proposed Action – Additional drawdown due to block caving is anticipated (see description of impacts).*†

* Regardless of anticipated impacts, monitoring would occur during operations for verification. Predictions of drawdown are approximations of a complex physical system, inherently limited by the quality of input data and structural constraints imposed by the model grid and modeling approach. The groundwater model does not predict changes to flow magnitude and timing at a given GDE. By extension, drawdown contours may not represent the aerial extent of anticipated impacts on GDEs. These contours will be used to inform more site-specific impact monitoring and mitigation.

† For all springs, streams, and associated riparian areas potentially impacted, impacts could include a reduction or loss of spring/stream flow, increased mortality or reduction in extent or health of riparian vegetation, and reduction in the quality or quantity of aquatic habitat from loss of flowing water, adjacent vegetation, or standing pools.

‡ Whitlow Ranch Dam outlet is not modeled specifically, as this cell is defined by a constant head in the model. Output described is based on estimated head levels at this location.

Table 3.7.1-4. Summary of potential impacts on groundwater supplies from groundwater drawdown

Water Supply Area	Drawdown (feet) from Dewatering under No Action Alternative (end of mining)	Drawdown (feet) from Dewatering and Block Caving under Proposed Action (end of mining)	Drawdown (feet) from Dewatering under No Action Alternative (200 years after start of mine)	Drawdown (feet) from Dewatering and Block Caving under Proposed Action (200 years after start of mine)	Potential for Greater Drawdown Based on Sensitivity Runs?	Summary of Expected Impacts on Groundwater Supplies
DHRES-16_743 (Superior)	<10	10–30	<10	10–30	86 of 87 sensitivity runs show impacts greater than 10 feet; confirms base case impacts	No Action – Drawdown is not anticipated. Proposed Action – Additional drawdown due to block caving is anticipated for water supply wells in this area, except for those completed solely in alluvium or shallow fracture systems. Impacts could include loss of well capacity, the need to deepen wells, the need to modify pump equipment, or increased pumping costs. Applicant-committed remedy if impacts occur.
Gallery Well (Boyce Thompson Arboretum)	<10	<10	<10	<10	0 of 87 sensitivity runs show impacts greater than 10 feet	No Action – Drawdown is not anticipated. Proposed Action – Additional drawdown due to block caving is not anticipated.
HRES-06 (Top-of-the-World)	<10	<10	<10	<10	17 of 87 sensitivity runs show impacts greater than 10 feet; impacts are possible beyond base case impacts	No Action – Drawdown is not anticipated. Proposed Action – Additional drawdown due to block caving is anticipated for water supply wells in this area, except for those completed solely in alluvium or shallow fracture systems. Impacts could include loss of well capacity, the need to deepen wells, the need to modify pump equipment, or increased pumping costs. Applicant-committed remedy if impacts occur.

Impacts Common to All Action Alternatives

EFFECTS OF THE LAND EXCHANGE

The land exchange would have effects on groundwater quantity and GDEs.

The Oak Flat Federal Parcel would leave Forest Service jurisdiction. Several GDEs were identified on the Oak Flat Federal Parcel, including Rancho Rio Canyon, Oak Flat Wash, Number 9 Wash, the Grotto (spring), and Rancho Rio spring. The role of the Tonto National Forest under its primary authorities in the Organic Administration Act, Locatable Minerals Regulations (36 CFR 228 Subpart A), and Multiple-Use Mining Act is to ensure that mining activities minimize adverse environmental effects on NFS surface resources; this includes these GDEs. The removal of the Oak Flat Federal Parcel from Forest Service jurisdiction negates the ability of the Tonto National Forest to regulate effects on these resources.

The offered lands parcels would enter either Forest Service or BLM jurisdiction. A number of perennial water features are located on these lands, including the following:

- Tangle Creek. Features of the Tangle Creek Parcel include Tangle Creek and one spring (LX Spring). Tangle Creek is an intermittent or perennial tributary to the Verde River and bisects the parcel. It includes associated riparian habitat with mature hackberry, mesquite, ash, and sycamore trees.
- Turkey Creek. Features of the Turkey Creek Parcel include Turkey Creek, which is an intermittent or perennial tributary to Tonto Creek and eventually to the Salt River at Roosevelt Lake. Riparian vegetation occurs along Turkey Creek with cottonwood, locus, sycamore, and oak trees.
- Cave Creek. Features of the Cave Creek Parcel include Cave Creek, an ephemeral to intermittent tributary to the Agua Fria River, with some perennial reaches in the vicinity of the parcel.
- East Clear Creek. Features of the East Clear Creek Parcel include East Clear Creek, a substantial perennial tributary to the Little Colorado River. Riparian vegetation occurs along East Clear Creek, including boxelder, cottonwood, willow, and alder trees.
- Lower San Pedro River. Features of the Lower San Pedro River Parcel include the San Pedro River and several large, ephemeral tributaries (Cooper, Mammoth, and Turtle Washes). The San Pedro River itself is ephemeral to intermittent along the 10-mile reach that runs through the parcel; some perennial surface water is supported by an uncapped artesian well. The San Pedro is one of the few remaining free-flowing rivers in the Southwest and it is recognized as one of the more important riparian habitats in the Sonoran and Chihuahuan Deserts. The riparian corridor in the parcel includes more than 800 acres of mesquite woodlands that also features a spring-fed wetland.
- Appleton Ranch. The Appleton Ranch Parcels are located along ephemeral tributaries to the Babocomari River (Post, Vaughn, and O’Donnel Canyons). Woody vegetation is present along watercourses as mesquite bosques, with very limited stands of cottonwood and desert willow.
- No specific water sources have been identified on the Apache Leap South Parcel or the Dripping Springs Parcel.

Specific management of water resources on the offered lands would be determined by the agencies, but in general when the offered lands enter Federal jurisdiction, these water sources would be afforded a level of protection they currently do not have under private ownership.

EFFECTS OF FOREST PLAN AMENDMENT

The Tonto National Forest Land and Resource Management Plan (1985b) provides guidance for management of lands and activities within the Tonto National Forest. It accomplishes this by establishing a mission, goals, objectives, and standards and guidelines. Missions, goals, and objectives are applicable on a forest-wide basis. Standards and guidelines are either applicable on a forest-wide basis or by specific management area.

A review of all components of the 1985 forest plan was conducted to identify the need for amendment due to the effects of the project, including both the land exchange and the proposed mining plan of operations (Shin 2020). A number of standards and guidelines (16) were identified applicable to management of groundwater resources. None of these standards and guidelines were found to require amendment to the proposed project, either on a forest-wide or management area-specific basis.
For additional details on specific rationale, see Shin (2020).

EFFECTS OF COMPENSATORY MITIGATION LANDS

None of the activities anticipated on the compensatory mitigation lands are expected to require groundwater use or have an impact on groundwater availability. Overall, the planned activities are designed and intended to improve the function of GDEs associated with these riparian areas.

EFFECTS OF RECREATION MITIGATION LANDS

The recreation mitigation lands are not anticipated to affect groundwater quantity or GDEs. None of the activities associated with the recreation mitigation lands are expected to require groundwater use or have an impact on groundwater availability.

SUMMARY OF APPLICANT-COMMITTED ENVIRONMENTAL PROTECTION MEASURES

A number of environmental protection measures are incorporated into the design of the project that would act to reduce potential impacts on groundwater quantity and GDEs. These are non-discretionary measures and their effects are accounted for in the analysis of environmental consequences.

From the GPO (2016c), Resolution Copper has committed to various measures to reduce impacts on groundwater quantity and GDEs:

- Groundwater levels will be monitored at designated compliance monitoring wells located downstream of the tailings storage facility seepage recovery embankments in accordance with the requirements of the APP program;
- All potentially impacted water will be contained on-site during operations and will be put to beneficial use, thereby reducing the need to import makeup water;
- Approximately one-half of Resolution Copper’s water needs will be sourced from long-term storage credits (surface stored underground);
- As much water as possible will be recycled for reuse; and
- The water supply will also include the beneficial reuse of existing low-quality water sources such as impacted underground mine dewatering water.

HYDROLOGIC CHANGES ANTICIPATED FROM MINING ACTIVITIES

The block caving conducted to remove the ore body would unavoidably result in fracturing and subsidence of overlying rocks. These effects would propagate upward until reaching the ground surface approximately 6 years after block caving begins (Garza-Cruz and Pierce 2017). It is estimated that the subsidence area that would develop at the surface would be approximately 800 to 1,100 feet deep (see Section 3.2, Geology, Minerals, and Subsidence).

Fracturing and subsidence of rock units would extend from the ore body to the surface. This includes fracturing of the Whitetail Conglomerate that forms a barrier between the deep groundwater system and the Apache Leap Tuff aquifer. When the Whitetail Conglomerate fractures and subsides, a hydraulic connection is created between all aquifers. Effects of dewatering from the deep groundwater system would extend to the Apache Leap Tuff aquifer at this time.

CHANGES IN BASIN WATER BALANCE – MINE DEWATERING

Mine dewatering is estimated to remove approximately 87,000 acre-feet of water from the combined deep groundwater system and Apache Leap Tuff aquifer over the life of the mine, or about 1,700 acre-feet per year (Meza-Cuadra et al. 2018a).

ANTICIPATED IMPACTS FOR GDES (UP TO 200 YEARS AFTER START OF MINING)

As assessed in this EIS, GDEs can be impacted in several ways:

- Ongoing dewatering (described in the no action alternative section)
- Expansion of dewatering impacts caused by the block caving (described in this section)
- Direct physical disturbance by either the subsidence area or tailings storage facilities (described in following sections for each individual alternative)
- Reduction in surface flow from loss of watershed due to subsidence area or tailings facility (described in section 3.7.3 and also summarized in this section)

Six springs experienced drawdown greater than 10 feet under the no action alternative, and these springs are also impacted under the proposed action (Bitter, Bored, Hidden, McGinnel, McGinnel Mine, and Walker Springs). Under the proposed action, the hydrologic changes caused by the block caving would allow the dewatering impacts to expand, impacting two additional springs: Kane Spring and DC6.6W. Impacts on springs under the proposed action are summarized in table 3.7.1-3 and figure 3.7.1-9 and are shown along with the model results (10-foot drawdown contour) in figure 3.7.1-3. Hydrographs of drawdown under the proposed action for all GDEs are also included in appendix L.

As one strategy to address the uncertainty inherent in the groundwater model, sensitivity modeling runs were also considered in addition to the base case model. The sensitivity modeling runs strongly confirm the impacts on the eight springs listed earlier in this section. Sensitivity runs show additional impact could be possible in Middle Devil's Canyon (locations DC8.8C, DC8.2CW, and DC8.1C), in Queen Creek below Superior, and at Iberri Spring. In each case, however, the large majority of sensitivity runs are consistent with the base case modeling and show drawdown less than 10 feet. Based on the sensitivity runs, impacts at these locations may be possible but are considered unlikely.

The 10-foot drawdown contour shown on figure 3.7.1-3 represents the limit of where the groundwater model can reasonably predict impacts, either with the best-calibrated model (orange area) or the model sensitivity runs (yellow area). GDEs falling within this contour are anticipated to be impacted. GDEs outside this contour may still be impacted, but it is beyond the ability of the model to predict.

ANTICIPATED IMPACTS ON DEVIL'S CANYON

Groundwater inflow along the main stem of Devil's Canyon is not anticipated to be impacted using the best-calibrated groundwater model; however, tributary flow from spring DC-6.6W along the western edge of Devil's Canyon is anticipated to be impacted. Based on field measurements, flow from this spring contributes up to 5 percent of flow in the main channel downstream at location DC-5.5C (Newell and Garrett 2018d). There is little indication that any other springs along Devil's Canyon or groundwater contribution to the main stem of the stream would be impacted; out of 87 modeling runs, only a single modeling run indicates impact on GDE locations in Devil's Canyon besides spring DC-6-6W.

Potential runoff reductions in Devil's Canyon are summarized in table 3.7.1-5. Percent reductions in average annual flow due to the subsidence area range from 5.6 percent in middle Devil's Canyon to 3.5 percent at the confluence with Mineral Creek; percent reductions during the critical low-flow months of May and June are approximately the same. Combined with loss from spring DC-6.6W due to groundwater drawdown, total estimated flow reductions along the main stem of lower Devil's Canyon caused by the proposed project could range from 5 to 10 percent.

The habitat in Devil's Canyon downstream of spring DC-6.6W and the subsidence area that would potentially lose flow includes a roughly 2.1-mile-long, 50-acre riparian gallery, and a 0.5-mile-long continuously saturated reach that includes several large perennial pools. Riparian vegetation in this portion of the canyon ranges from 40 to 300 feet wide. Dominant riparian species are sycamore, cottonwood, ash, alder, and willow, as well as wetland species at spring locations.

The anticipated 5 to 10 percent loss in flow during the dry season could contribute to a reduction in the extent and health of riparian vegetation and aquatic habitat.

Groundwater and surface flow declines have altered riparian ecosystems throughout the Southwest. Studies have linked declines in pioneer riparian trees such as cottonwood and willow to changes in hydrologic conditions. Statistically, the presence of these trees is linked to the persistence of surface flow, depths to groundwater, and inter-annual fluctuations in groundwater depth. Changes in riparian makeup are not restricted solely to mortality, caused when groundwater depths exceed the limit at which cottonwood and willow trees can readily access the water table. Smaller changes in water availability can affect the overall health and vitality of these species, leading to a shift in species composition towards more drought-tolerant saltcedar and mesquite. While complete drying of the downstream habitat, loss of dominant riparian vegetation, or loss of standing pools is unlikely, smaller flow reductions could still drive material changes in the riparian habitat.

ANTICIPATED IMPACTS ON SPRINGS

It is not possible to precisely predict what impact a given drawdown in groundwater level would have on an individual spring; however, given the precision of the model (10 feet), it is reasonable to assume any spring with anticipated impact of this magnitude could experience complete drying.

Bored Spring has the highest riparian value, supporting a standing pool and a 500-foot riparian string of cottonwood, willow, mesquite, saltcedar, and sumac. The loss of water to this spring would likely lead to complete loss of this riparian area.

Hidden, McGinnel, McGinnel Mine, Walker, Bitter, and Kane Springs all have infrastructure improvements to some degree and host relatively little riparian vegetation, although standing water and herbaceous and wetland vegetation may be present. The loss of flowing water would likely lead to complete loss of these pools and fringe vegetation.

ANTICIPATED IMPACTS ON QUEEN CREEK

Impact on the flowing reach of Queen Creek between Superior and Boyce Thompson Arboretum is not anticipated under the best-calibrated model run, and impact is anticipated under less than 5 percent of the sensitivity model runs (4 of 87 sensitivity runs suggest an impact). Impacts on groundwater inflow in this reach are considered possible, but unlikely.

This reach is believed to potentially have three sources of flow (Garrett 2018e):

- groundwater inflow into this reach is possible and assumed, but not certain;
- effluent from the Town of Superior Wastewater Treatment Plant occurs and is estimated at 170 acre-feet per year; and
- discharge of groundwater from a perlite mine pit southwest of Superior is estimated at 170 acre-feet per year.

Aside from groundwater drawdown, this reach of Queen Creek also would see reductions in runoff due to the subsidence area, ranging from about 19 percent in Superior to 13 percent at Boyce Thompson Arboretum (see table 3.7.1-5). The anticipated 13 to 19 percent loss in flow during the dry season could contribute to a reduction in the extent and health of riparian vegetation and aquatic habitat. The complete drying of the downstream habitat, loss of dominant riparian vegetation, or loss of standing pools would be unlikely.

Between Boyce Thompson and Whitlow Ranch Dam, Queen Creek is largely ephemeral, and habitat is generally xeroriparian in nature, accustomed to ephemeral, periodic flows. Impacts on this type of vegetation would be unlikely due to surface flow reductions. The riparian area along Queen Creek at Whitlow Ranch Dam would be impacted by reductions in surface flow of roughly 3.5 percent. The groundwater levels in this area are primarily controlled by the fact that this area represents the discharge point for the Superior basin and the influence of Whitlow Ranch Dam impounding flow. Given this control, a 3.5 percent change in surface flow would be unlikely to greatly affect groundwater levels at this location, nor does the groundwater flow model predict any drawdown at this distance from the mine. Impacts on the riparian area at Whitlow Ranch Dam would not be expected to be substantial.

The location on Queen Creek most at risk is likely above Superior, with possible surface flow losses of more than 19 percent. Reduction in runoff volume could reduce the amount of water temporarily stored in shallow alluvium or fracture networks. Impacts above Superior could include a reduction or loss of spring/stream flow, increased mortality or reduction in extent or health of riparian vegetation similar to that described for Devil’s Canyon, and reduction in the quality or quantity of aquatic habitat from loss of flowing water, adjacent vegetation, or standing pools.

POTENTIAL IMPACT ON SURFACE WATER RIGHTS FROM GROUNDWATER DRAWDOWN

Arizona law allows for the right to appropriate and use surface water, generally based on a “first in time, first in right” basis. This function is administered by the ADWR, which maintains databases of water right filings, reviews applications and claims, and when appropriate issues permits and certificates of water right. However, water right filings can be made on the same surface water by multiple parties, and at this time almost all Arizona surface waters are over-appropriated with no clear prioritization of overlapping water rights. In addition, the State of Arizona has a bifurcated water rights system in which groundwater and surface water use are considered separately, and state law as of yet provides no clear framework for the interaction between groundwater and surface water uses.

Table 3.7.1-5. Summary of potential impacts on groundwater-dependent ecosystems from surface flow losses due to subsidence from block caving or tailings storage facility stormwater controls

Reference Number on Figure 3.7.1-7	GDE	Summary of Expected Impacts on GDEs
	Queen Creek and Tributaries	
Not numbered on figure	Queen Creek above Superior (from confluence with Oak Flat Wash [~km 26] to Magma Avenue Bridge [km 21.7], including springs QC23.6C [Boulder Hole], Queen Seeps, and QC22.6E [Karst Spring])	No Action – No reduction in runoff would occur from subsidence. Proposed Action – Reduction in surface runoff volume due to subsidence is estimated to be 18.6% at Magma Avenue Bridge (see Section 3.7.3, Surface Water Quantity). Reduction in runoff volume could reduce amount of water temporarily stored in shallow alluvium or fracture networks. Impacts above Superior could include a reduction or loss of spring/stream flow, increased mortality or reduction in extent or health of riparian vegetation, and reduction in the quality or quantity of aquatic habitat from loss of flowing water, adjacent vegetation, or standing pools.
Not numbered on figure	Queen Creek below Superior (from Magma Avenue Bridge [km 21.7] to Whitlow Ranch Dam [km 0])	No Action – No reduction in runoff would occur from subsidence or tailings alternatives. Proposed Action/Subsidence – Reduction in surface runoff volume due to subsidence is estimated to range from 13.4% reduction at Boyce Thompson Arboretum to 3.5% reduction at Whitlow Ranch Dam. Channel largely ephemeral and habitat is generally xeroriparian in nature, accustomed to ephemeral, periodic flows. Impacts on this type of vegetation would be unlikely due to surface flow reductions of this magnitude. For the effluent- and groundwater-supported reach between Superior and Boyce Thompson Arboretum, the anticipated 13 to 19 percent loss in flow during the dry season could contribute to a reduction in the extent and health of riparian vegetation and aquatic habitat. Alternative 2 and 3 – The combined reduction in runoff volume from subsidence with a reduction in runoff volume due to a tailings storage facility at the Near West location (Alternative 2 or 3) is estimated as 6.5% at Whitlow Ranch Dam. Channel largely ephemeral and habitat is generally xeroriparian in nature, accustomed to ephemeral, periodic flows. Impacts on this type of vegetation would be unlikely due to surface flow reductions of this magnitude. Alternative 4 – The combined reduction in runoff volume from subsidence with a reduction in runoff volume due to a tailings storage facility at the Silver King location (Alternative 4) is estimated to range from a 19.9% reduction at Boyce Thompson Arboretum to an 8.9% reduction at Whitlow Ranch Dam. Reduction in runoff volume could reduce the amount of water temporarily stored in shallow alluvium or fracture networks. Impacts at Boyce Thompson Arboretum could include a reduction or loss of spring/stream flow, increased mortality or reduction in extent or health of riparian vegetation, and reduction in the quality or quantity of aquatic habitat from loss of flowing water, adjacent vegetation, or standing pools.
1	Whitlow Ranch Dam Outlet	No Action – Drawdown is not anticipated. Proposed Action – Additional drawdown due to block caving is not anticipated, and reduction in surface runoff is anticipated 3.5%, but impacts on riparian vegetation are unlikely due to geological controls on groundwater levels. Location would be monitored during operations for verification of potential impacts.

Reference Number on Figure 3.7.1-7	GDE	Summary of Expected Impacts on GDEs
15	Oak Flat Wash	No Action – No reduction in runoff would occur from subsidence. Proposed Action – A portion of the Oak Flat Wash watershed is within the subsidence area, and a reduction in surface water volume is anticipated. These impacts are already incorporated into the quantitative modeling for Queen Creek.
	Devil's Canyon and Tributaries	
16	Devil's Canyon (from km 9.3 to confluence with Mineral Creek [km 0])	No Action – No reduction in runoff would occur from subsidence. Proposed Action – Reduction in surface runoff volume due to subsidence ranges from 5.6% reduction at DC8.1C to 3.5% reduction at confluence with Mineral Creek (see Section 3.7.3, Surface Water Quantity). During critical dry season (May/June), percent reductions are approximately the same. Flow reductions could contribute to a reduction in the extent and health of riparian vegetation and aquatic habitat. Complete drying of the downstream habitat, loss of dominant riparian vegetation, or loss of standing pools would be unlikely.
17	Rancho Rio Canyon (RR1.5C)	No Action – No reduction in runoff would occur from subsidence. Proposed Action – A portion of the Rancho Rio Canyon watershed is within the subsidence area, and a reduction in surface water volume is anticipated. These impacts are already incorporated into the quantitative modeling for Devil's Canyon.

To remedy these issues, a legal proceeding called the General Stream Adjudication of the Gila River is being undertaken through the Arizona court system. Goals of the adjudication include clarifying the validity and priority of surface water rights and providing a clear legal framework for when groundwater withdrawals would impinge on surface water rights. The adjudication has been underway for several decades, and while progress has been made, many issues remain unresolved, including any prioritization or validation of water rights in the analysis area.

Groundwater drawdown associated with the project is anticipated to impact eight GDEs. Known surface water filings associated with these GDEs are summarized in table 3.7.1-6. The Forest Service analysis identifies and discloses possible loss of water to these GDEs; however, the impact on any surface water rights from a legal or regulatory standpoint cannot yet be determined due to the ongoing adjudication.

Table 3.7.1-6. Summary of water right filings associated with GDEs impacted by groundwater drawdown

Specific GDE Potentially Impacted by Groundwater Drawdown	Arizona Water Right Filings
DC-6.6W Spring	Filing of Statement of Claim of Right to Use Public Waters of the State, 36-1757, filed 1986 by ASLD
Bitter Spring	Filing of Statement of Claim of Right to Use Public Waters of the State, 36-24054, filed 1979 by Tonto National Forest
Bored Spring	Application for a Permit to Appropriate Public Waters of the State of Arizona #A-2014, filed 1938 by Crook National Forest Permit to Appropriate #A-1376, issued 1939 to Crook National Forest by State Water Commissioner Certificate of Water Right #955, issued 1941 to Crook National Forest by State Water Commissioner
Hidden Spring	Filing of Statement of Claim of Right to Use Public Waters of the State, 36-24052, filed 1979 by Tonto National Forest
Kane Spring	No filings identified
McGinnel Mine Spring	Application for a Permit to Appropriate Public Waters of the State of Arizona, 33-94335, filed 1988 by Tonto National Forest Proof of Appropriation of Water, 33-94335, filed 1989 by Tonto National Forest Permit to Appropriate Public Waters of the State of Arizona, 33-94335, issued 1989 by ADWR Certificate of Water Right 33-94355, issued 1990 by ADWR
McGinnel Spring	Statement of Claim of Right to Use Public Waters of the State, 36-24049, filed 1979 by Tonto National Forest
Walker Spring	No filings identified

Note that potential impacts to water rights from anticipated changes in surface flow, including for the community of Queen Valley (which was raised specifically in public comments), are discussed in Section 3.7.3, Surface Water Quantity.

ANTICIPATED IMPACTS ON WATER SUPPLY WELLS

Many domestic and stock water supply wells in the area are shallow and likely make use of water stored in shallow alluvium or shallow fracture networks. These wells are unlikely to be impacted by groundwater drawdown from the mine. However, groundwater drawdown caused by the mine could affect groundwater supplies for wells that may draw from either the regional Apache Leap Tuff aquifer or the deep groundwater system. Drawdown from 10 to 30 feet is anticipated in wells in the Superior area, as shown in table 3.7.1-4. In addition, in about 20 percent of sensitivity modeling runs, impacts from 10 to 30 feet could also occur in wells near Top-of-the-World.

The applicant-committed environmental protection measures include remedying any impacts on water supply wells caused by drawdown from the project.

LONGER TERM MODELED IMPACTS – SPRINGS IN THE QUEEN CREEK BASIN

Under the proposed action, drawdown continues to propagate well beyond 200 years. The modeled groundwater level trends generally suggest maximum drawdown does not occur until 600 to 800 years after the end of mining at the distant spring locations (Morey 2018d).

As described earlier in this section, eight of the springs (Bitter, Bored, Hidden, Kane, McGinnel, McGinnel Mine, Walker, and DC6.6W) see impacts great enough under either the no action alternative or proposed action to effectively dry the spring. The remaining springs without anticipated impacts (Iberri, No Name, and Rock Horizontal) may still experience drawdown beyond 200 years, but the magnitude and trends of drawdown observed are unlikely to change the anticipated impacts (see hydrographs in appendix L).

LONGER TERM MODELED IMPACTS – DEVIL'S CANYON

For most of Devil's Canyon (including spring DC-6.6W), drawdown under the proposed action scenario reaches its maximum extent within 50 to 150 years after the end of mining; the impacts shown in table 3.7.1-3 likely represent the maximum impacts under the proposed action scenario.

LONGER TERM MODELED IMPACTS – QUEEN CREEK, TELEGRAPH CANYON, AND ARNETT CREEK

Predicted drawdown at Queen Creek, Telegraph Canyon, and Arnett Creek did not exceed the quantitative 10-foot drawdown threshold, except in a small number of sensitivity modeling runs. However, predicted groundwater level trends indicate that the maximum drawdown would not occur at these locations for roughly 500 to 900 years, suggesting impacts could be greater than those reported in table 3.7.1-3 (Morey 2018d).

For Telegraph Canyon and Arnett Creek, while drawdown may still be occurring beyond 200 years, the magnitude and trends of drawdown observed are unlikely to change the anticipated impacts (see hydrographs in appendix L).

For the flowing reach of Queen Creek below Superior, while the impacts predicted by the best-calibrated model did not exceed the quantitative threshold of 10 feet, trends of drawdown suggest this could occur after 200 years. With consideration to the uncertainties in the analysis, impacts on the groundwater-related flow components of Queen Creek appear to be possible to occur at some point.

LONGER TERM MODELED IMPACTS – WATER SUPPLIES

Potential impacts on groundwater supplies associated with the regional aquifer were already identified as possible for both Top-of-the-World and Superior. The predicted groundwater trends suggest that the impacts shown in table 3.7.1-4 for Top-of-the-World are likely the maximum impacts expected (Morey 2018d). However, the groundwater trends for wells in Superior (represented by well DHRES-16_753) suggest that maximum drawdown would not occur until roughly 600 years after the end of mining. Impacts on groundwater supplies relying on the regional deep groundwater system near Superior may continue to worsen beyond the results report in table 3.7.1-4.

POTENTIAL FOR LAND SUBSIDENCE DUE TO GROUNDWATER PUMPING

Two areas have the potential for land subsidence due to groundwater pumping: the area around the East Plant Site and mining panels where dewatering pumping would continue to occur, and the area around the Desert Wellfield. While small amounts of land subsidence attributable to the dewatering pumping have been observed around the East Plant Site using satellite techniques (approximately 1.5 inches, between 2011 and 2016), once mining operations begin, any land subsidence due to pumping would be subsumed by subsidence caused by the block caving (estimated to be 800 feet deep, and possibly as deep as 1,100 feet at the end of mining).

Drawdown associated with the Desert Wellfield would contribute to lowering of groundwater levels in the East Salt River valley subbasin, including near two known areas of known ground subsidence. In the DEIS, we noted that further detailed analysis of land subsidence resulting from groundwater withdrawal is not feasible beyond noting the potential for any pumping to contribute to drawdown and subsidence. Subsidence effects are a basin-wide phenomenon, and the impact from one individual pumping source cannot be predicted or quantified.

Public comments on the DEIS questioned this premise, suggesting that analytical tools exist to model subsidence attributable to a sole water user. We discussed this concept with the reconvened Water Resources Workgroup. While recognizing that all water users contribute to basin subsidence, we developed a methodology for assessing the potential magnitude of such impacts and applied it to the Desert Wellfield water supply pumping (Walser 2020b).

Groundwater levels in and around the Desert Wellfield declined from the earliest records around 1960 until about the mid-1990s. Magnitudes of drawdown near the Desert Wellfield range from 80 to 130 feet. Groundwater levels subsequently recovered in the vicinity of the Desert Wellfield due to changes in water management, rising 60 to 85 feet.

A well-known subsidence area in the East Salt River valley occurs near Apache Junction, close to a geographic feature known as Hawk Rock. This area is located about 6 miles northwest of Desert Wellfield. Subsidence in the Hawk Rock area has been mapped since 1933. This information, when combined with measurements of groundwater levels, approximates the amount of subsidence a certain amount of groundwater drawdown could cause. Rates of subsidence in the Hawk Rock area between roughly 1992 and 2000 were about 0.8 to 1.2 inches per year. During this same time frame, groundwater drawdown averaged 2.8 feet per year, corresponding to 0.3 to 0.4 inch of subsidence per foot of groundwater drawdown.

The maximum drawdown estimate in the center of the Desert Wellfield is about 210 feet at the end of mine operations. An important aspect of subsidence is that it is irreversible; once sediment layers collapse when dewatered, they remain collapsed even if water levels recover. Because of this, we can estimate that no subsidence would occur until groundwater levels decline below their historic lows, which were 80 to 130 feet lower than current water levels. The maximum drawdown modeled for the Desert Wellfield (210 feet under Alternative 2) would decline from 80 to 130 feet beyond the historic lows. These declines could contribute to subsidence. Using Hawk Rock as an analog, drawdowns associated with the Desert Wellfield likely would result in subsidence of roughly 24 to 52 inches.

It is important to note the limitations of this estimate. Subsidence occurred in the Hawk Rock area because groundwater levels were declining across a wide swath of the East Salt River valley. By contrast, the groundwater level declines from the Desert Wellfield are focused in a relatively small area. Modeled groundwater drawdown beyond historic lows is not anticipated to occur more than 2 miles from the Desert Wellfield; this is different from the basin-wide declines contributing to earlier subsidence.

Alternative 2 – Near West Proposed Action

GROUNDWATER-DEPENDENT ECOSYSTEMS IMPACTED

Three GDEs would be directly disturbed by a tailings facility at the Near West site: Bear Tank Canyon Spring, Benson Spring, and Perlite Spring. All three of these GDEs are believed to be disconnected from the regional aquifers, relying on precipitation stored in shallow alluvium or fracture networks. Benson Spring is located near the front of the facility, potentially under the tailings embankment. Bear Tank Canyon Spring is located in the middle of the facility under the NPAG tailings, and Perlite Spring is located at the northern edge of the facility, near the PAG tailings cell.

Alternative 2 likely will impact 20 GDEs (see figure 3.7.1-9):

- Six springs are anticipated to be impacted from continued dewatering under the no action alternative.
- Two additional springs are anticipated to be impacted under the proposed action, because of the block-cave mining.
- Three springs and three ponds are directly disturbed by the subsidence area.
- Three springs are directly disturbed by the Alternative 2 tailings storage facility.
- One perennial stream (Devil's Canyon) is impacted by reduced runoff from the subsidence area.
- Two perennial stream reaches on Queen Creek are impacted by reduced runoff from both the subsidence area and the tailings.

CHANGES IN TAILINGS WATER BALANCE

The substantial differences in water balance between alternatives are directly related to the location and design of the tailings storage facility. There are five major differences, as shown in table 3.7.1-7:

- **Entrainment**. The tailings deposition method affects the amount of water that gets deposited and retained with the tailings. Alternative 2 entrains about the same amount of water as the other slurry tailings alternatives (Alternatives 3, 5, and 6), but substantially more than Alternative 4.
- **Evaporation**. The tailings deposition method also affects the amount of water lost through evaporation, even among slurry tailings. Alternative 2 evaporates a similar amount of water as Alternatives 5 and 6, but substantially more than Alternatives 3 and 4.
- **Watershed losses**. Watershed losses from the capture of precipitation depend primarily on the location of the tailings storage facility and where it sits in the watershed. Surface runoff losses are summarized in table 3.7.1-5, and are analyzed in greater detail in Section 3.7.3, Surface Water Quantity.
- **Seepage.** Differences in seepage losses are substantial between alternatives. Three estimates of seepage are shown in table 3.7.1-7. The amount of seepage based on the initial tailings designs using only the most basic level of seepage controls is shown, and primarily reflects the type of tailings deposition and geology (WestLand Resources Inc. 2018b). After these initial designs, the engineered seepage controls were refined as part of efforts to reduce impacts on water quality from the seepage (Klohn Crippen Berger Ltd. 2019d). The estimated reduced seepage rates with all engineered seepage controls in place, both during operations and post-closure, are also shown in table 3.7.1-7. Alternative 2 loses more seepage than Alternatives 3 and 4, but less seepage than Alternatives 5 and 6. The effects of seepage on groundwater and surface water quality are analyzed in greater detail in Section 3.7.2, Groundwater and Surface Water Quality.

Table 3.7.1-7. Primary differences between alternative water balances

Alternative	Water Entrained with Tailings (acre-feet, life of mine)	Precipitation or Runoff Intercepted (acre-feet, life of mine)*	Percentage Loss to Downstream Waters†	Water Lost to Evaporation from Tailings Storage Facility (acre-feet, life of mine)*	Water Lost as Seepage from Tailings Storage Facility without Engineered Seepage Controls (acre-feet, life of mine)	Water Lost as Seepage to Aquifer after Engineered Seepage Controls during Operations (acre-feet, life of mine)	Water Lost as Seepage to Aquifer, Post-Closure (acre-feet per year)	Makeup Water Pumped from Desert Wellfield (acre-feet, life of mine)
2	271,839	68,780	6.5	307,903	5,741	849	20.7	586,508
3	305,443	60,531	6.5	174,742	2,891	111	2.7	494,286
4	71,017	110,854	8.9	135,102	3,148	369–680	15.2–31.9	175,800
5	308,404	278,639	0.2	384,702	53,184	10,701	261	544,778
6	277,710	205,297	0.3	384,427	17,940	2,665–7,298	202–258	544,858

Source: Ritter (2018). For seepage losses after engineered seepage controls, during operations and post-closure, see Klohn Crippen Berger Ltd. (2019d) and Gregory and Bayley (2019)

Note that entrainment for Alternative 3 is based on an assumption of 100% saturation used in the global water balance and is known to be overestimated, compared with more detailed seepage modeling conducted for each alternative. See Garrett (2020d) for further details.

* Alternatives 5 and 6 include total precipitation on and evaporation from the tailings beach. However, precipitation onto the tailings beach that evaporates before contributing to the mine water balance is not included in the estimated precipitation and evaporation volumes for Alternatives 2, 3, and 4. These different accounting methods for evaporation and precipitation do not impact the total makeup water demand estimates for the Desert Wellfield

† Alternatives 2, 3, and 4 reflect change in percentage of annual flow in Queen Creek at Whitlow Ranch Dam. Alternatives 5 and 6 reflect change in percentage of annual flow in the Gila River at Donnelly Wash. These numbers only account for precipitation captured by tailings facilities or subsidence area. Water rerouted around the facilities or seepage reappearing downstream is not incorporated.

CHANGES IN DESERT WELLFIELD PUMPING

The water balances for the alternatives are very complex, with multiple water sources and many recycling loops. However, ultimately a certain amount of makeup water is needed, which must be pumped from Desert Wellfield in the East Salt River valley. Alternative 2 requires the most makeup water, roughly 600,000 acre-feet over the life of the mine. The amount of groundwater in storage in the East Salt River valley subbasin (above a depth of 1,000 feet) is estimated to be about 8.1 million acre-feet. Pumping under Alternative 2 represents about 7.3 percent of the available groundwater in the East Salt River valley subbasin.

Projected drawdown would be greatest in the center of the Desert Wellfield, reaching a maximum drawdown of 228 feet, as shown in figure 3.7.1-2. These groundwater levels recover after mining ceases, eventually recovering to less than 20 feet. Drawdown decreases with distance from the wellfield. At the north and south ends of the wellfield, maximum drawdown ranges from 109 to 132 feet, and farther south within NMIDD, maximum drawdown is roughly 49 feet (Bates et al. 2018; Garrett 2018a).

Alternative 3 – Near West – Ultrathickened

GROUNDWATER-DEPENDENT ECOSYSTEMS IMPACTED

Alternative 3 likely will impact the same GDEs as those under Alternative 2.

CHANGES IN TAILINGS WATER BALANCE

The following water balance components for Alternative 3 are summarized in table 3.7.1-7:

- **Entrainment.** Alternative 3 entrains about the same amount of water as the other slurry tailings alternatives (Alternatives 3, 5, and 6), but substantially more than Alternative 4.
- **Evaporation.** Alternative 3 evaporates less water than Alternatives 2, 5, and 6, and almost matches the filtered tailings alternative (Alternative 4) for reductions in evaporation.
- **Watershed losses.** Watershed losses are the same as Alternative 2.
- **Seepage.** With engineered seepage controls in place, Alternative 3 loses the least amount of seepage of any alternative, including the filtered tailings alternative (Alternative 4).

CHANGES IN DESERT WELLFIELD PUMPING

Alternative 3 requires less makeup water than Alternative 2, roughly 500,000 acre-feet over the life of the mine. Pumping under Alternative 3 represents about 6.1 percent of the estimated 8.1 million acre-feet of available groundwater in the East Salt River valley subbasin (Garrett 2018a).

Maximum drawdown for Alternative 3 reaches about 177 feet, eventually recovering to less than 20 feet. At the north and south ends of the wellfield, maximum drawdown ranges from 87 to 105 feet, and farther south within NMIDD maximum drawdown is roughly 42 feet (Bates et al. 2018; Garrett 2018a).

Alternative 4 – Silver King

GROUNDWATER-DEPENDENT ECOSYSTEMS IMPACTED

Two GDEs would be directly disturbed by a tailings facility at the Silver King site: Iberri Spring and McGinnel Spring. Both of these springs are assumed to be at least partially connected to the regional aquifers; both are located under the NPAG tailings facility.

Alternative 4 likely will impact 18 GDEs (see figure 3.7.1-9):

- Six springs are anticipated to be impacted from continued dewatering under the no action alternative.
- Two additional springs are anticipated to be impacted under the proposed action, because of the block-cave mining.
- Three springs and three ponds are directly disturbed by the subsidence area.
- Two springs are directly disturbed by the Alternative 4 tailings storage facility; however, one of these was already impacted under the no action alternative.
- One perennial stream (Devil's Canyon) is impacted by reduced runoff from the subsidence area.
- Two perennial stream reaches on Queen Creek are impacted by reduced runoff from both the subsidence area and the tailings.

For the other action alternatives, there was an anticipated 7 to 15 percent loss in flow in Queen Creek below Superior to Boyce Thompson Arboretum. Because of the location of Alternative 4 at the head of the watershed, these flow losses are more substantial, ranging from 7 percent in Superior, to 20 percent at Boyce Thompson Arboretum, to 9 percent at Whitlow Ranch Dam. Reduction in runoff volume could reduce the amount of water temporarily stored in shallow alluvium or fracture networks.

Impacts at Boyce Thompson Arboretum could include a reduction or loss of spring/stream flow, increased mortality or reduction in extent or health of riparian vegetation, and reduction in the quality or quantity of aquatic habitat from loss of flowing water, adjacent vegetation, or standing pools. Substantial impacts on the riparian vegetation at Whitlow Ranch Dam are still unlikely due to the geological controls, although the reductions in runoff are greater under Alternative 4 than other alternatives.

CHANGES IN TAILINGS WATER BALANCE

The following water balance components for Alternative 4 are summarized in table 3.7.1-7:

- **Entrainment.** Because water is filtered from the tailings before placement, Alternative 4 entrains the least amount of water of all alternatives, approximately only one-quarter of that entrained under Alternative 2.
- **Evaporation.** Because Alternative 4 does not have a standing recycled water pond, Alternative 4 also evaporates the least amount of water of all alternatives, approximately only one-half of that of Alternative 2.
- **Watershed losses.** Watershed losses are higher than Alternatives 2 and 3, due to the position of Alternative 4 higher in the Queen Creek watershed, and the need for stringent stormwater control to avoid contact of water with exposed PAG tailings.
- **Seepage.** Alternative 4 loses the least amount of seepage of all alternatives, except for Alternative 3 (ultrathickened).

CHANGES IN DESERT WELLFIELD PUMPING

Alternative 4 requires the least amount of makeup water of all alternatives, roughly 180,000 acre-feet over the life of the mine, or roughly 30 percent of the makeup water required for the slurry tailings alternatives (Alternatives 2, 3, 5, and 6). Pumping under Alternative 4 represents about 2.2 percent of the estimated 8.1 million acre-feet of available groundwater in the East Salt River valley subbasin (Garrett 2018a).

Alternative 4 also results in the least amount of drawdown, as shown in figure 3.7.1-2. Maximum drawdown for Alternative 4 reaches about 53 feet, eventually recovering to roughly 5 feet. At the north and south ends of the wellfield, maximum drawdown ranges from 30 to 35 feet, and farther south within NMIDD maximum drawdown is roughly 17 feet (Bates et al. 2018; Garrett 2018a).

Alternative 5 – Peg Leg

GROUNDWATER-DEPENDENT ECOSYSTEMS IMPACTED

No GDEs have been identified within the vicinity of the Peg Leg site or are expected to be directly disturbed. In total, 14 GDEs are anticipated to be impacted under Alternative 5 (see figure 3.7.1-9):

- Six springs are anticipated to be impacted from continued dewatering under the no action alternative.
- Two additional springs are anticipated to be impacted under the proposed action because of the block-cave mining.
- Two springs are directly disturbed by the subsidence area.
- Three perennial stream reaches in Devil’s Canyon and Queen Creek are impacted by reduced runoff from the subsidence area.
- One perennial stream reach of the Gila River is impacted by reduced runoff from the tailings facility.

CHANGES IN TAILINGS WATER BALANCE

The following water balance components for Alternative 5 are summarized in table 3.7.1-7:

- **Entrainment.** Alternative 5 entrains about the same amount of water as the other slurry tailings alternatives (Alternatives 2, 5, and 6), but substantially more than Alternative 4.
- **Evaporation.** Alternative 5 loses the most amount of water to evaporation of all alternatives, about 25 percent more than Alternative 2.
- **Watershed losses.** Watershed losses (as a percentage change in perennial flow) are relatively low for Alternative 5, largely due to the large watershed and flow of the Gila River.
- **Seepage.** Because of the location over a deep alluvial basin, Alternative 5 loses substantially more seepage than all other alternatives.

CHANGES IN DESERT WELLFIELD PUMPING

Alternative 5 requires more water to move the tailings slurry over long distances, and to make up for seepage losses. Alternative 5 uses only slightly less water than Alternative 2, about 550,000 acre-feet over the life of the mine. Pumping under Alternative 5 represents about 6.7 percent of the estimated 8.1 million acre-feet of available groundwater in the East Salt River valley subbasin (Garrett 2018a).

Maximum drawdown for Alternative 5 reaches about 199 feet, eventually recovering to less than 20 feet. At the north and south ends of the wellfield, maximum drawdown ranges from 96 to 115 feet, and farther south within NMIDD maximum drawdown is roughly 46 feet (Bates et al. 2018; Garrett 2018a).

Alternative 6 – Skunk Camp

GROUNDWATER-DEPENDENT ECOSYSTEMS IMPACTED

No GDEs have been identified within the vicinity of the Skunk Camp site based on site-specific information. Alternative 6 likely will impact 18 GDEs, the same as under Alternative 5 (see figure 3.7.1-9):

- Six springs are anticipated to be impacted from continued dewatering under the no action alternative.
- Two additional springs are anticipated to be impacted under the proposed action, because of the block-cave mining.
- Three springs and three ponds are directly disturbed by the subsidence area.
- Three perennial stream reaches in Devil's Canyon and Queen Creek are impacted by reduced runoff from the subsidence area.
- One perennial stream reach of the Gila River is impacted by reduced runoff from the tailings facility.

CHANGES IN TAILINGS WATER BALANCE

The following water balance components for Alternative 6 are summarized in table 3.7.1-7:

- **Entrainment.** Alternative 6 entrains about the same amount of water as the other slurry tailings alternatives (Alternatives 2, 5, and 6), but substantially more than Alternative 4.
- **Evaporation.** Alternative 6 loses almost as much water to evaporation as the alternative with the greatest evaporative losses (Alternative 5), about 25 percent more than Alternative 2.
- **Watershed losses.** Watershed losses (as a percentage change in perennial flow) are relatively low for Alternative 6, largely due to the large watershed and flow of the Gila River.
- **Seepage.** Because of the location over an alluvial basin, Alternative 6 loses substantially more than Alternatives 2, 3, and 4, but still less than Alternative 5.

CHANGES IN DESERT WELLFIELD PUMPING

Alternative 6 requires more water to move the tailings slurry over long distances, and to make up for seepage losses. Alternative 6 uses only slightly less water than Alternative 2, about 550,000 acre-feet over the life of the mine, and about the same as Alternative 5. Pumping under Alternative 6 represents about 6.7 percent of the estimated 8.1 million acre-feet of available groundwater in the East Salt River valley subbasin (Garrett 2018a).

Drawdown from Alternative 6 is nearly identical to that of Alternative 5.

Cumulative Effects

Full details of the cumulative effects analysis can be found in chapter 4. The following represents a summary of the cumulative impacts resulting from the project-related impacts described in Section 3.7.1.5, Environmental Consequences, that are associated with groundwater quantity or GDEs, when combined with other reasonably foreseeable future actions.

The following action was determined through the cumulative effects analysis process to be reasonably foreseeable, and has impacts that likely overlap in space and time with impacts from the Resolution Copper Project:

- Ray Land Exchange and Proposed Plan Amendment

The cumulative effects analysis area encompasses two separate modeling areas used to assess direct and indirect impacts to groundwater resources and GDEs: a large model area centered on the block-cave zone and encompassing much of the upper Queen Creek watershed, the Superior basin, and Oak Flat (where dewatering would occur), and the East Salt River valley (where the mine water supply would be pumped). Both model areas are sufficiently large to encompass other water users that could combine with the project effects and impact groundwater resources. The metrics used to quantify the cumulative impacts to groundwater quantity and GDEs are (1) the amount of water pumped within the same groundwater basin or aquifer [acre-feet]; (2) drawdown caused by pumping within the same groundwater basin or aquifer [feet]; (3) drawdown in the East Salt River valley around the Desert Wellfield will be based on cumulative modeling results [model results]; and (4) GDEs lost or impacted [number].

The Ray Land Exchange parcels were the only reasonably foreseeable future actions that passed screening and potentially affect the same aquifer as the Resolution Copper Project mine area. As no mine plans have been prepared to date, it is unknown how much water future activities associated with the Ray Land Exchange might use. If groundwater is extracted and used on these parcels, there could be impacts to some of the same regional aquifers impacted by the Resolution Copper Project, though the distance suggests that overlap of drawdown is unlikely to occur (or if it does, is unlikely to be substantial). In general, Ray Mine obtains much of its water supply from sources to the south, including the Hayden well field. Continued reliance on these sources is not anticipated to have any cumulative effect with drawdown or groundwater use associated with the Resolution Copper Project.

Given the overall high level of concern associated with water supply, the number of reasonably foreseeable future actions associated with the cumulative effects analysis and listed above seems remarkably small. Indeed, there are a number of other reasonably foreseeable future actions that were identified that would directly overlap with the Desert Wellfield that would contribute to overall impacts to regional water supplies in the East Salt River valley. These include the following:

- Arizona’s Drought Contingency Plan,
- Resolution Copper’s potential allocation of CAP water,
- Town of Florence housing developments,
- Population change,
- Recent modeling reports projecting water shortages in Pinal County,
- Assured Water Supplies in the East Salt River valley, and
- Future Superstition Vistas development area on Arizona State Trust land.

The overall cumulative effects of the Resolution Copper Project with these and similar projects on these regional water supplies, in light of competing water uses, ongoing climatic trends, and drought, are discussed in detail in Chapter 4, Cumulative Effects on Regional Water Supplies.

Mitigation Effectiveness

Mitigation Identifier and Title	Authority to Require
FS-WR-01: GDEs and water well mitigation	Required – Forest Service

We developed a robust monitoring and mitigation strategy to avoid, minimize, rectify, reduce, or compensate for resource impacts that have been identified during the process of preparing this EIS. Appendix J contains descriptions of mitigation measures that are being required by the Forest Service and mitigation measures voluntarily brought forward and committed to by Resolution Copper. Appendix J also contains descriptions of monitoring that would be needed to identify potential impacts and mitigation effectiveness.

This section contains an assessment of the effectiveness of design features associated with mitigation and monitoring measures found in appendix J that are applicable to groundwater quantity and GDEs. See appendix J for full descriptions of each measure noted below.

MITIGATION EFFECTIVENESS AND IMPACTS OF REQUIRED MITIGATION MEASURES APPLICABLE TO GROUNDWATER QUANTITY AND GROUNDWATER-DEPENDENT ECOSYSTEMS

Appendix J contains mitigation and monitoring measures being required by the Forest Service under its regulatory authority or because these measures are required by other regulatory processes (such as the PA or Biological Opinion). These measures are assumed to occur, and their effectiveness and impacts are disclosed here. The unavoidable adverse impacts disclosed below take the effectiveness of these mitigations into account.

GDEs and water well mitigation (FS-WR-01). In April 2019, the Forest Service received from Resolution Copper a document titled "Monitoring and Mitigation Plan for Groundwater Dependent Ecosystems and Water Wells" (Montgomery and Associates Inc. 2019b). This plan was revised and finalized in September 2020 (Montgomery and Associates Inc. 2020b). This document outlines a monitoring plan to assess potential impacts on each GDE, identifies triggers and associated actions to be taken by Resolution Copper to ensure that GDEs are protected, and describes mitigation measures for each GDE if it is shown to be impacted by future mine dewatering. Note that this plan includes actions both for GDEs and water supply wells.

The plan focuses on the same GDEs described in this section of the EIS, as these are the GDEs that are believed to rely on regional groundwater that could be impacted by the mine. The stated goal of the plan is "to ensure that groundwater supported flow that is lost due to mining activity is replaced and continues to be available to the ecosystem." The plan specifically notes that it is not intended to address water sources associated with perched shallow groundwater in alluvium or fractures.

The specific GDEs addressed by this plan include the following:

- Bitter, Bored, Hidden, Iberri, Kane, McGinnel, McGinnel Mine, No Name, Rock Horizontal, and Walker Springs
- Queen Creek below Superior (reach km 17.39 to 15.55) and at Whitlow Ranch Dam
- Arnett Creek in two locations
- Telegraph Canyon in two locations
- Devil's Canyon springs (DC4.1E, DC6.1E, DC6.6W, and DC8.2W)
- Devil's Canyon surface water in two locations (reach km 9.1 to 7.5, and reach km 6.1 to 5.4)
- Mineral Creek springs (Government Springs, MC3.4W)
- Mineral Creek surface water in two locations (MC8.4C, and reach km 6.9 to 1.6)

Monitoring frequency and parameters are discussed in the plan, and include such things as groundwater level or pressure, surface water level, presence of water or flow, extent of saturated reach, and phreatophyte area. In general, groundwater level or pressure and surface water level would be monitored daily (using automated equipment), while other methods would be monitored quarterly or annually.

Water supplies to be monitored are Superior (using well DHRES-16_743 as a proxy), Boyce Thompson Arboretum (using the Gallery Well as a proxy), and Top-of-the-World (using HRES-06 as a proxy).

A variety of potential actions are identified that could be used to replace water sources if monitoring reaches a specified trigger. Specific details (likely sources and pipeline corridor routes) are shown in the plan. These include the following:

- Drilling new wells, applicable to both water supplies and GDEs. The intent of installing a well for a GDE is to pump supplemental groundwater that can be used to augment flow. The exact location and construction of the well would vary; it is assumed in many cases groundwater would be transported to GDEs via an overland pipeline to minimize ground disturbance. Wells require maintenance in perpetuity, and likely would be equipped with storage tanks and solar panels, depending on specific site needs.
- Installing spring boxes. These are structures installed into a slope at the discharge point of an existing spring, designed to capture natural flow. The natural flow is stored in a box and discharged through a pipe. Spring boxes can be deepened to maintain access to water if the water level decreases. Spring boxes require little ongoing maintenance to operate.
- Installing guzzlers. Guzzlers are systems for harvesting rainwater for wildlife consumption. Guzzlers use an impermeable apron, typically installed on a slope, to collect rainwater which is then piped to a storage tank. A drinker allows wildlife and/or livestock to access water without trampling or further degrading the spring or water feature. Guzzlers require little ongoing maintenance to operate.
- Installing surface water capture systems such as check dams, alluvial capture, recharge wells, or surface water diversions. All of these can be used to supplement diminished groundwater flow at GDEs by retaining precipitation in the form of runoff or snowmelt, making it available for ecosystem requirements.
- Providing alternative water supplies from a non-local source. This would be considered only if no other water supply is available, with Arizona Water Company or the Desert Wellfield being likely sources of water.

EFFECTIVENESS OF MONITORING

The monitoring as proposed has sufficient frequency and includes the necessary parameters to not only identify whether changes in GDEs are taking place, but also to inform whether the mine drawdown is responsible. For instance, conducting daily automated monitoring allows for an understanding of normal seasonal and drought-related fluctuations in water level or flow, which can be taken into consideration when evaluating the possible effects from the mine.

EFFECTIVENESS OF MITIGATION

Replacement of water sources using the techniques described (replacement wells or alternative water sources) would be highly effective for public water supplies. For GDEs, the effectiveness would depend on the specific approach. Engineered replacements like pipelines, guzzlers, or spring boxes would be effective at maintaining a water source and maintaining a riparian ecosystem, but the exact type, location, and extent of riparian vegetation could change to adapt to the new discharge location and frequency of the new water source. Changes in water quality are unlikely to be an issue, since new water sources would likely derive from the same source as natural spring flow (i.e., the Apache Leap Tuff aquifer, or stored precipitation).

While water flow, riparian ecosystems, and associated terrestrial and aquatic habitat would be maintained, there would still likely be a noticeable change in the overall environment that could affect wildlife, or the recreating public. The presence of infrastructure like wells and pipes near some natural areas could change the sense of place and nature experienced in these locations.

IMPACTS FROM MITIGATION ACTIONS

The mitigation actions identified would result in additional ground disturbance, though minimal. Mitigation for any given GDE would likely result in less than 1 acre of impact, assuming a well pad and pipeline installation, or installation of check dams. If all mitigations were installed as indicated in the plan, impacts could total 20 to 30 acres of additional ground disturbance.

MITIGATION EFFECTIVENESS AND IMPACTS OF VOLUNTARY MITIGATION MEASURES APPLICABLE TO GROUNDWATER QUANTITY AND GROUNDWATER-DEPENDENT ECOSYSTEMS

Appendix J contains mitigation and monitoring measures brought forward voluntarily by Resolution Copper and committed to in correspondence with the Forest Service. These measures are assumed to occur but are not guaranteed to occur. Their effectiveness and impacts if they were to occur are disclosed here; however, the unavoidable adverse impacts disclosed below do not take the effectiveness of these mitigations into account. No additional mitigation measures were voluntarily brought forward for groundwater quantity and GDEs.

OTHER POTENTIAL FUTURE MITIGATION MEASURES APPLICABLE TO GROUNDWATER QUANTITY AND GROUNDWATER-DEPENDENT ECOSYSTEMS

Appendix J contains several other potential future mitigation measures that the Forest Service is disclosing as potentially useful in mitigating adverse effects, but for which there is no authority to require. There is no expectation that these measures would occur, and therefore the effectiveness is not considered in the EIS.

Mitigation of effects of water level declines (PF-WR-03). The required measure above applied only to GDEs or wells located near the mine site, where dewatering impacts could occur. Similar concerns have been raised regarding drawdown from the Desert Wellfield, in the East Salt River valley. The permitting process for the wellfield will determine whether there are unavoidable impacts that may need mitigation, in which case Resolution Copper has indicated a willingness to consider additional measures.

UNAVOIDABLE ADVERSE IMPACTS

Given the effectiveness of mitigation, there would be no residual impacts on public water supplies near the mine site. All lost water supplies would be replaced.

For GDEs expected to be impacted by groundwater drawdown, the mitigation measures described would result in no net loss of riparian ecosystems or aquatic habitat on the landscape, although the exact nature and type of ecosystems would change to adapt to new water sources. However, impacts on the sense of place and nature experienced at these perennial streams and springs, rare in a desert environment, would not be mitigated by these actions.

The mitigation plan would not mitigate any GDEs lost directly to surface disturbance, depending on the tailings alternative.

Impacts on water supplies in the East Salt River valley in the form of groundwater drawdown and reduction of regional groundwater supply would not be fully mitigated when only required mitigation is considered.

Other Required Disclosures

SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

Groundwater pumping would last the duration of the mine life. At the mine itself, groundwater levels would slowly equilibrate over a long period (centuries). Groundwater drawdown from dewatering of the underground mine workings would constitute a permanent reduction in the productivity of groundwater resources within the long time frame expected for equilibrium. Groundwater in the vicinity of the Desert Wellfield would equilibrate more quickly, but there would still be an overall decline in the regional water table due to the Resolution Copper Project and a permanent loss of productivity of groundwater resources in the area.

Seeps and springs could be permanently impacted by drawdown in groundwater levels, as could the riparian areas associated with springs, but these impacts would be mitigated. GDEs or riparian areas directly lost to surface disturbance would be a permanent impact.

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

Mine dewatering at the East Plant Site under all action alternatives would result in the same irretrievable commitment of 160,000 acre-feet of water from the combined deep groundwater system and Apache Leap Tuff aquifer over the life of the mine.

Changes in total groundwater commitments at the Desert Wellfield vary by alternative for tailings locations and tailings type. Alternative 4 would require substantially less water overall than the other alternatives (176,000 acre-feet, vs. 586,000 acre-feet for Alternative 2). Loss of this water from the East Salt River valley aquifer is an irretrievable impact; the use of this water would be lost during the life of the mine.

While several GDEs and riparian areas could be impacted by groundwater drawdown, these changes are neither irreversible nor irretrievable, as mitigation would replace water sources as monitoring identifies problems. However, even if the water sources are replaced, the impact on the sense of nature and place for these natural riparian systems would be irreversible. In addition, the GDEs directly disturbed by the subsidence area or tailings alternatives represent irreversible impacts.

3.7.2 Groundwater and Surface Water Quality

3.7.2.1 Introduction

The proposed mine could potentially impact groundwater and surface water quality in several ways. The exposure of the mined rock to water and oxygen, inside the mine as well as in stockpiles prior to processing, can create depressed pH levels and high concentrations of dissolved metals, sulfate, and dissolved solids. After processing, the tailings would be transported for disposal into the tailings storage facility. Seepage from the tailings has the potential to enter underlying aquifers and impact groundwater quality. In addition, contact of surface runoff with mined ore, tailings, or processing areas has the potential to impact surface water quality.

This section contains analysis of existing groundwater and surface water quality; results of a suite of geochemical tests on mine rock; predicted water quality in the block-cave zone and potential exposure pathways, including the potential for a lake to form in the subsidence area; impacts on groundwater and surface water from tailings seepage; impacts on surface water from runoff exposed to tailings; impacts on assimilative capacity of perennial waters; impacts on impaired waters; whether chemicals added during processing would persist in the tailings storage facility; the potential for asbestiform minerals to be present; and the potential for naturally occurring radioactive materials to be present. Some additional details not discussed in detail here are captured in the project record (Newell and Garrett 2018d).

Changes from the DEIS

We revised the Groundwater and Surface Water Quality section since the DEIS in response to numerous public comments regarding the water quality analysis, seepage, and anticipated water quality impacts.

As described in chapter 2, Alternatives 5 and 6 no longer have alternative pipeline routes to reach the tailings storage facility, but only a single route each. We further revised the Alternative 6 pipeline route to address potential impacts to habitat and resources along Mineral Creek. The water quality analysis does not rely upon the number of acres disturbed; therefore, these route changes had no impact on the water quality analysis.

One analysis conclusion we reached in the DEIS was that the release of stormwater coming in contact with tailings or processing facilities was not anticipated, due to the stormwater controls implemented. After review of public comments, we identified a scenario in which stormwater could be released during the normal course of operations and we added analysis of that event to this section. This includes further description of the storms and flood events for which the facilities are designed. We also clarify the existing AZPDES discharge permits held by Resolution Copper and the conditions under which water would be released to Queen Creek.

One approach we took in the DEIS was to analyze downstream water quality impacts caused by tailings seepage, not only in the groundwater downgradient from the tailings storage facility, but also in the nearest downstream perennial water fed by groundwater. Comments suggested the need to extend this analysis beyond the nearest downstream perennial water, particularly in the context of community water supplies along the Gila River or in Queen Valley. We added this analysis to this section.

Some comments focused on the ability to properly characterize and store the two tailings streams (NPAG and PAG). We added information to this section describing the design contingencies in the event the predicted volumes of these tailings vary during operation, and also added analysis of the effectiveness of the planned subaqueous deposition of PAG tailings.

Many comments questioned whether a lake would form in the subsidence area. In response to these comments, we revised the analysis to reflect more uncertainties in the modeling outcomes. We still conclude that formation of a subsidence crater lake remains remote and speculative.

The quality of groundwater in the reflooded block-cave zone is difficult to predict; upon consideration of comments, we changed the approach used in the DEIS to estimate this water quality and rely in this section on different methodologies and data sources. This updated and more appropriate analysis suggests that post-closure water quality may not represent an environmental concern, however uncertainty remains with the estimates.

One change from the DEIS is the refinement of the water quality modeling conducted for the preferred alternative (Alternative 6). The refinement uses a numeric groundwater flow model instead of a mixing cell model. The refined model responds to several concerns raised with the DEIS water quality model by including a more explicit simulation of seepage controls and by assessing flow through multiple geologic units (alluvium and underlying Gila Conglomerate). After publication of the DEIS, several field investigations were completed for the Skunk Camp area, including well drilling, aquifer tests, water quality samples, and geotechnical investigations. The refined water quality model makes use of these additional site-specific data. We describe these investigations in this section and disclose additional water quality modeling to supplement the approach used in the DEIS; this results in a range of conclusions for water quality impacts for the preferred alternative, though the fundamental outcome remains much the same.

New mitigation measures have also been brought forward to directly address surface water impacts, including the direct replacement of water in Queen Creek. These are analyzed in the “Mitigation Effectiveness” discussion in this section. To better quantify impacts, the cumulative effects analysis has been revised. Details are described in chapter 4 and relevant portions are summarized in this section.

3.7.2.2 Analysis Methodology, Assumptions, and Uncertain and Unknown Information

Analysis Area

The analysis area is shown in figure 3.7.2-1 and encompasses all areas where groundwater or surface water quality changes could potentially occur due to the proposed project and alternatives. This includes the block-cave zone, each alternatives tailings footprint, aquifers downgradient from each tailings facility, and downstream surface waters. In the DEIS, the downstream limit of the analysis area is the location of the first perennial water, specifically Queen Creek at Whitlow Ranch Dam and the Gila River either at Donnelly Wash or Dripping Spring Wash. The analysis area now extends to encompass potential impacts to downstream communities, including Queen Valley downstream of Whitlow Ranch Dam, and communities along the Gila River downstream of Donnelly Wash or Dripping Spring Wash. The goal of this section is to identify potential risks to water quality, including surface water. These perennial surface water locations are the point at which seepage would enter the surface water system and represent the location at which surface water quality is most at risk and any impacts on surface water or aquatic habitat would be greatest.

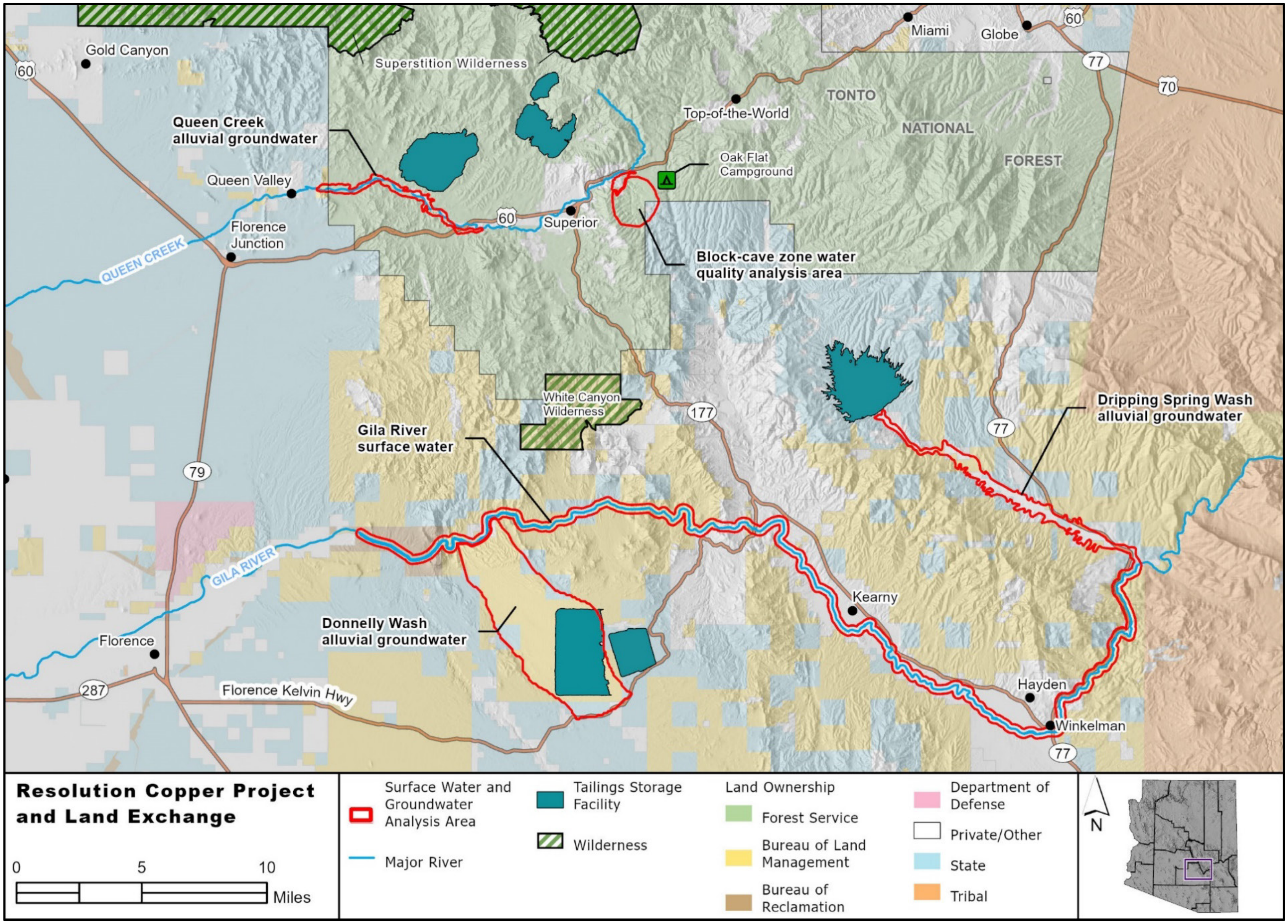


Figure 3.7.2-1. Analysis area for groundwater and surface water quality

Geochemistry Modeling Process

All tailings storage facilities—including filtered tailings—lose water to the environment in the form of seepage that drains by gravity over time. This seepage into groundwater is the primary source of potential water contamination from the project and has the potential to affect the quality of underlying aquifers as well as downstream surface waters fed by those aquifers. The water quality of tailings seepage reflects a mixture of different water sources used in the mining process (see figure 2.2.2-16) as well as geochemical changes that occur over time within the tailings storage facility and changes that occur as seepage moves downgradient through the aquifer.

Modeling the water quality changes caused by seepage from the tailings storage facility[54] requires a series of interconnected analyses, as shown on figure 3.7.2-2. These analyses include the following:

- The amount of water that must be removed from the block-cave zone during operations to allow mining. This is estimated using the **groundwater flow model** discussed in detail in section 3.7.1.
- The geochemical changes of the groundwater within the underground block-cave zone caused by the interaction of exposed rock surfaces to water and oxygen. These changes are estimated using a **block-cave geochemistry model**.
- The tailings slurry that leaves the processing facility is a mix of tailings and process water. As the tailings are deposited in the tailings storage facility, some process water is collected in the recycled water pond and sent back to the West Plant Site, but some process water stays trapped in the pore space of the tailings (this is known as “entrainment”). Eventually some of this water can seep or drain out of the tailings facility. The water quality at various locations in the tailings facility is estimated using a **tailings solute geochemistry model.**[55]
- Some of the tailings that are deposited in the tailings storage facility would remain saturated indefinitely with little possibility of oxidation occurring. However, within the embankment and beach areas, sulfide-containing minerals in the tailings would be exposed to oxygen over time, which would cause geochemical changes. These changes are estimated using the **embankment sulfide oxidation model**.
- A wide variety of engineered seepage controls are in place to intercept and collect entrained water that seeps out of the tailings facility, but despite these controls some seepage still enters the environment. The effectiveness of engineered seepage controls is estimated using a variety of **tailings seepage models**.
- The seepage not captured and entering the environment causes water quality changes in the downgradient aquifers and eventually in surface waters fed by those aquifers. The changes in groundwater and surface water quality are estimated using a series of **bypass seepage mixing/loading models**. Figure 3.7.2-2 shows the groundwater modeling cells (QC3, QC2, and QC1) and surface water modeling cells (Queen Creek at Whitlow Ranch Dam) downstream of Alternatives 2 and 3 – Near West tailings storage facility. The groundwater and surface water modeling cells would vary based on alternative tailings storage facility location.

[54] For details of the geochemistry modeling workgroup formed to direct and review the water quality modeling, see Newell and Garrett (2018d).

[55] The term “solute” refers to substances that are dissolved in water, such as metals like arsenic or selenium, or inorganic molecules like sulfate or nitrate.

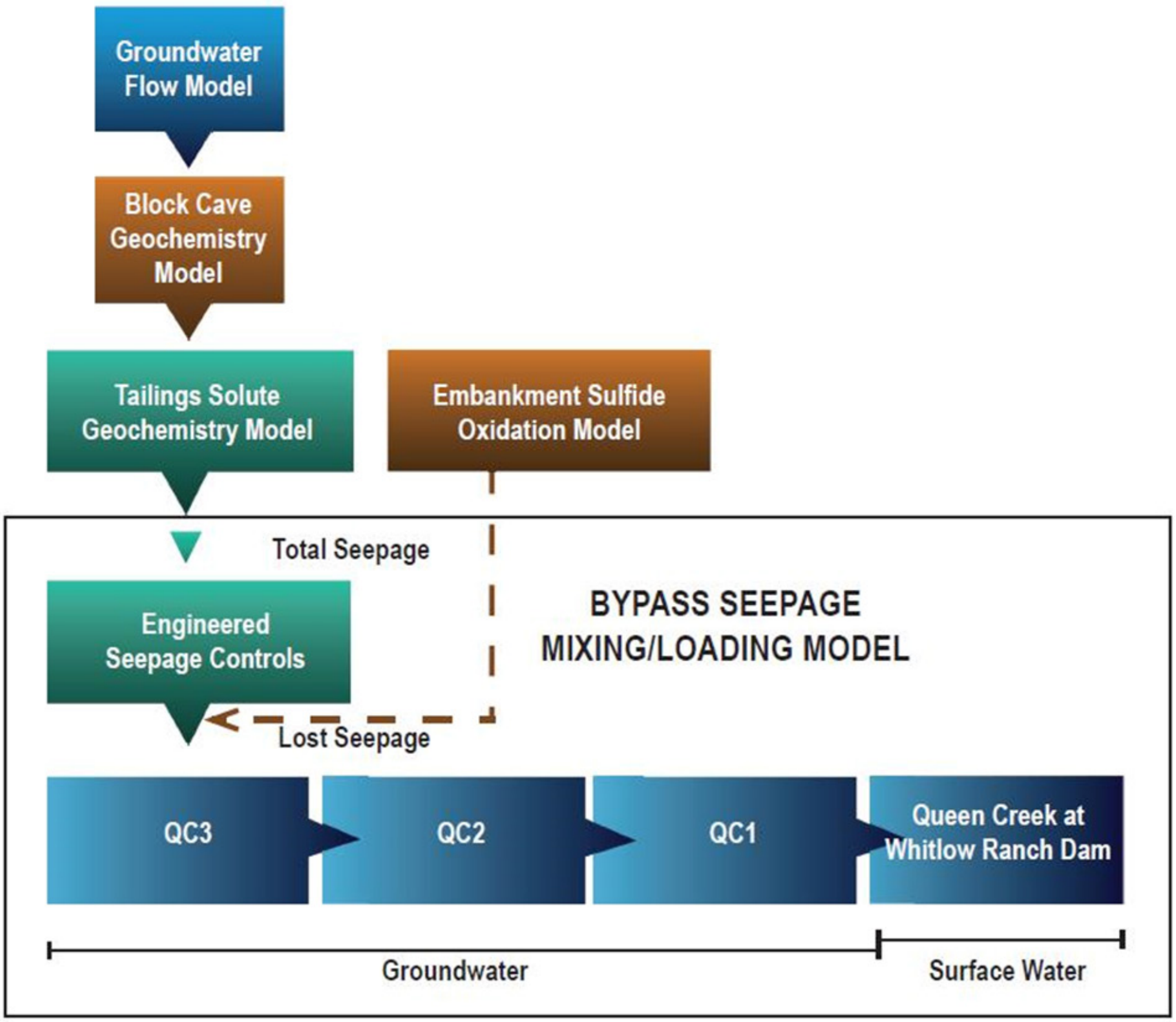


Figure 3.7.2-2. General components and process flow for water quality modeling analysis

Assumptions, Uncertain and Unknown Information for Geochemistry Models

BLOCK-CAVE GEOCHEMISTRY MODEL

Modeling Details

Water collects in the sump of the block-cave zone during operations and is derived from several sources:

- Groundwater inflow from the Apache Leap Tuff,
- Groundwater inflow from the deep groundwater system,
- Blowdown water from ventilation and cooling systems, and
- Excess mine service water.[56]

[56] Mine service water is used for a variety of tasks underground, including dust suppression and cooling. Much of this water evaporates or leaves with the ore; any excess water left over would likely find its way to the sump.

The block-cave sump water is pumped out during operations and incorporated into the processing water stream and therefore is one of the sources ultimately contributing to the water in the tailings facility. A block-cave geochemistry model was constructed to blend these flows and their associated chemical composition over the time of operation of the mine (Eary 2018f). Groundwater flow modeling was used to assign the flow rate for how much groundwater flows into the block-cave zone (WSP USA 2019). The rate of supply of blowdown water from ventilation systems is based on the overall water balance for the mine (WestLand Resources Inc. 2018b).

Apache Leap Tuff and deep groundwater chemistries are based upon analysis of site groundwater samples. The chemical composition of blowdown water is based upon analysis of CAP water and groundwater sourced from the Arizona Water Company (Arizona Water Company 2017). Resolution Copper projects this blended water to be composed of 25 percent CAP water and 75 percent Arizona Water Company water. Owing to evaporation associated with cooling, this water mixture is concentrated to an assumed value for total dissolved solids of 2,500 milligrams per liter (mg/L).

The model time frame is 41 years and ends with the cessation of mining. Inflows to the block-cave sump vary over time, but their chemical composition does not. The mixed waters reporting to the sump from their individual sources are equilibrated with any chemical precipitates that are oversaturated and likely to precipitate from solution. This precipitation of solids removes chemical mass from the mixed water. Results for model year 41, at the end of mining, are reported in table 3.7.2-1.

Note that the discussion about block-cave sump water chemistry here refers to a single input during mine operations that ultimately is part of the prediction of tailings solute chemistry. A separate question regarding anticipated block-cave water quality occurring after closure as the block-cave zone is reflooded is addressed later in this section).

Table 3.7.2-1. Modeled block-cave sump water chemistry

Constituent	Eary Block-Cave Geochemistry Model* Predicted Concentrations (mg/L)	Arizona Aquifer Water Quality Standard (mg/L)
Ca	237	–
Mg	63	–
Na	130	–
K	28	–
Cl	46	–
HCO_3	114	–
SO_4	934	–
SiO_2	22.4	–
F	2.3	4
N	0.8	–
Al	0.0857	–
Sb	0.0047	0.006
As	0.0227	0.05
Ba	0.0199	2
Be	0.0003	0.004
B	0.342	–
Cd	0.0008	0.005

Constituent	Eary Block-Cave Geochemistry Model* Predicted Concentrations (mg/L)	Arizona Aquifer Water Quality Standard (mg/L)
Cr	0.0027	0.1
Co	0.0063	–
Cu	0.0158	–
Fe	0.0025	–
Pb	0.005	0.05
Mn	0	–
Hg	Not reported	0.002
Mo	0.0135	–
Ni	0.0076	0.01
Se	0.0051	0.05
Ag	0.0039	–
Tl	**0.0043**	0.002
Zn	0.221	–
pH s.u.	8.58	–
TDS	1528	–

Notes: Modeled concentrations that are above Arizona aquifer water quality standards are show in **bold** and shaded. Model data are not specific to total or dissolved fractions.

Dash indicates no Arizona numeric aquifer water quality standard exists for this constituent.

* Eary (2018f)

Assumptions, Uncertain and Unknown Information

The block-cave geochemistry model, like all models, necessarily includes assumptions in its effort to forecast future conditions. Assumptions are made to constrain model components that cannot be conclusively known and therefore represent uncertainty in the model results. The key assumptions in the block-cave geochemistry model, the level of uncertainty, and their potential implications are summarized here:

- The model assumes the chemistry of various water sources (Apache Leap Tuff, deep groundwater system, CAP water, Desert Wellfield) remains constant over time. In reality, the chemical load[57] from these sources could increase or decrease over time.
  - Applies to: all action alternatives.
  - Possible outcome if real-world conditions differ from the assumption: Modeled tailings seepage concentrations could be higher or lower.
  - Likely magnitude of effect for all action alternatives: Low. Water sources are primarily from large aquifers that change slowly in response to climatic trends and are not the primary source of chemical loading to the block-cave zone.

[57] The word “loading” is used throughout this section. In this context, “chemical loading” or “pollutant loading” refers to the total amount, by weight, of a chemical, metal, or other pollutant that enters the environment over some time period (usually a day or year). For example, the total selenium load entering the environment from Alternative 2 seepage has been estimated as 0.0242 kilograms per day.

- The model assumes fractured rock in the collapsed block-cave zone does not contact oxygen and chemical weathering does not supply any chemical load to the sump water. If chemical weathering occurs, percolation of groundwater through these rocks could transport weathering products to the sump.
  - Applies to: all action alternatives.
  - Possible outcome if real-world conditions differ from the assumption: Sump water and modeled tailings seepage concentrations could be higher.
  - Likely magnitude of effect for all action alternatives: High. The sump water only makes up between 20 and 24 percent of the inflow to the West Plant Site (see Ritter (2018)), but the loads for all constituents of concern could substantially increase if this assumption does not match real-world conditions. See section "Overall Effect of Uncertainties on the Model Outcomes" later in this section for more discussion.
- The model assumes that weathering products from ore remain with the ore and report to the tailings storage facility. These weathering products could rinse off ore and report to the sump.
  - Applies to: all action alternatives.
  - Possible outcome if real-world conditions differ from the assumption: Sump chemical load could be higher, but whether traveling with ore or reporting to sump, the weathering products enter the process stream either way, and there would be no change to the overall tailings seepage models.
  - Likely magnitude of effect for all action alternatives: None.

TAILINGS SOLUTE GEOCHEMISTRY MODEL

Modeling Details

The water balance for the mine is complex, with multiple sources and recycling loops, and how these sources mix forms the fundamental basis for predicting the water quality in the tailings facility. The water balance differs for each tailings alternative (Golder Associates Inc. 2018a; Klohn Crippen Berger Ltd. 2018a, 2018b, 2018c, 2018d; WestLand Resources Inc. 2018b). Chemical loading inputs are applied to each water source, and the resulting water quality is calculated with a mixing model (PHREEQC) for the entire operational life of the mine, with a different analysis conducted for each alternative (Eary 2018a, 2018b, 2018c, 2018d, 2018e, 2018g). Water quality is modeled for six different locations:

- the mixture of water entering the West Plant Site;
- the PAG recycled water pond (not applicable to Alternative 4 – Silver King);
- the NPAG recycled water pond (not applicable to Alternative 4 – Silver King);
- the water within the pore space of the tailings embankment;
- the seepage collection ponds; and
- the seepage lost to underlying aquifers not captured by the seepage collection ponds.

The tailings solute geochemistry model determines the chemistry of all water and chemicals reporting to the tailings storage facility, and the degree of evaporative concentration. It produces estimates of dissolved constituent concentrations in the tailings storage facility, a portion of which is lost seepage that is used in modeling impacts on downgradient water resources. The tailings solute geochemistry model results are strongly affected by the water balance for the tailings storage facility, which provides flows for the various components reporting to the tailings storage facility and accommodates for evaporative loss. This loss is used in the tailings solute geochemistry model to concentrate dissolved chemical constituents.

Assumptions, Uncertain and Unknown Information

The tailings solute geochemistry model is largely a mathematical process of tracking and combining chemical masses, given various input flow rates and chemical concentrations. While the inputs have uncertainty (such as the block-cave sump chemistry), the model itself is highly certain. The release of chemical mass from the ore during processing is also part of the tailings solute geochemistry model; this is based on rates observed during site-specific metallurgical testing and is considered reasonable with relatively low uncertainty.

EMBANKMENT SULFIDE OXIDATION MODEL

Modeling Details

During operations, the tailings that are most likely to experience oxidation of sulfide minerals—the PAG tailings—would be kept in a subaqueous state with an overlying water cap (a minimum of 10 feet deep) to prevent oxygen from reaching and interacting with the tailings. During closure, the water cap would gradually be replaced with a cover of NPAG tailings and a reclamation cover to achieve the same result. The fine-grained tailings on the interior of the facility are expected to exhibit a low vertical permeability and a high moisture content, and oxygen is not expected to penetrate the tailings at rates sufficient to affect seepage chemistry for hundreds of years (Wickham 2018). This would eliminate (or greatly reduce) the risk of acid rock drainage from the PAG tailings, which would otherwise have the potential to impact downstream waters and aquifers.

However, the embankments of the NPAG tailings facility would be constructed of well-drained cyclone sands. Oxygen would be able to enter these areas and react with sulfide minerals over time. The same is true of the entirety of the filtered tailings facility (Alternative 4 – Silver King). The embankment sulfide oxidation model determines the chemical quality of seepage derived from the oxidation occurring in the tailings embankment for the 41 years of operation and an additional 204-year post-closure period[58] (Wickham 2018).

Assumptions, Uncertain and Unknown Information

Chemical loading is calculated using theoretical concepts regarding oxygen movement into the tailings that make up the embankment, and an experimentally derived rate equation for the oxidation of sulfide minerals. The rate equation's validity is supported by field and laboratory testing, and the movement of oxygen is supported by literature-based studies; both assumptions are considered reasonable for the estimate of embankment seepage water quality with relatively low uncertainty.

TAILINGS SEEPAGE MODELS

Modeling Details

Management of water in the tailings storage facility must accomplish a variety of outcomes. For structural integrity, it is desirable to allow water to leave the NPAG tailings storage facility and the tailings embankment in the form of seepage (see section 3.10.1 for a further discussion of tailings stability). However, it is undesirable to allow that seepage to enter downstream aquifers or surface waters in

[58] The duration of the geochemical modeling matches a global decision made by the Tonto National Forest with input from the Groundwater Modeling Workgroup that quantitative modeling results are not reliable longer than 200 years in the future. This is described more in section 3.7.1.

amounts that can cause water quality problems. For PAG tailings, which tend to generate the worst seepage water quality, not only is it undesirable to allow seepage from PAG tailings to enter the environment but it is also necessary to prevent seepage in order to maintain saturation of the PAG tailings to prevent oxidation.

Each alternative would use a specific set of engineered seepage controls that are built into the design in order to accomplish these goals. These include such controls as liners, blanket and finger drains, seepage collection ponds, and pumpback wells. The specific controls incorporated into each alternative design are described in section 3.7.2.4.

For a given tailings storage facility, estimates have been made of the “total seepage” and the “lost seepage.” Total seepage is all water that drains from the tailings storage facility by gravity. Lost seepage is seepage that is not recovered with the engineered seepage controls. Lost seepage is assumed to discharge to the environment. The role of consolidation of the tailings over time was incorporated into the seepage estimates, described further in Newell and Garrett (2018d).

All alternative designs use a strategy of layering on engineered seepage controls to reduce the amount of lost seepage to acceptable levels. Some of these controls, such as foundation preparation, liners, drains, and seepage collection ponds, are implemented during construction of the facility. Other controls, such as auxiliary pumpback wells, grout curtains, or additional seepage collection ponds, would be added as needed during operations depending on the amounts of seepage observed and the observed effectiveness of the existing controls.

The amount of seepage entering the environment is modeled in a variety of ways, depending on alternative (Klohn Crippen Berger Ltd. 2019d).[59] Common to all of these models is that the engineered seepage controls described in section 3.7.2.4 are assumed to be in place, and the combined effectiveness of the layered engineered seepage controls is a key assumption in the ultimate predicted impacts on water.

The level of engineered seepage controls for each alternative was assigned based on practicability and initial modeling estimates of the “allowable seepage” (Gregory and Bayley 2018a). Allowable seepage is the estimated quantity, as a percentage of total seepage, that can be released without resulting in groundwater concentrations that are above Arizona aquifer water quality standards, or surface water concentrations that are above Arizona surface water quality standards. The allowable seepage target is a significant driver for the design of each facility; engineered seepage controls were increased in the design as needed to limit lost seepage to the allowable amount.

Comparison of Engineered Seepage Controls to a Fully Lined Facility

During alternatives development, the concept of a fully lined tailings storage facility was pursued. Eventually this concept was eliminated from detailed analysis, although liners are still used in some areas and some of the techniques used to control seepage that have been incorporated into the design accomplish similar results as a liner. A full description of this evolution is contained in Newell and Garrett (2018d), as are calculations of expected seepage from a fully lined facility. These calculations are used for comparison in section 3.7.2.4.

[59] The choice of models used to estimate seepage for each alternative was based on the specific location, design, level of information, and seepage controls. Further details of the models are contained in Newell and Garrett (2018d).

Assumptions, Uncertain and Unknown Information

Engineered seepage controls incorporated into the tailings storage facility design serve to ensure geotechnical stability/safety and recover a percentage of the total seepage released, in order to meet the limits of allowable seepage. The bypass seepage mixing/loading model is reliant on the amount of lost seepage, and therefore reliant on both the feasibility and effectiveness of the engineered seepage controls. Details of the engineered seepage controls (broken out by Levels 0 through 4) and an assessment of their ability to control seepage are discussed in section 3.7.2.4. The key assumptions in the tailings seepage models, and the level of uncertainty are summarized here:

- The tailings seepage models calculate seepage during the mine life under full-buildout conditions, with gradual increases in acreage and tapering of seepage over time.
    - Applies to: all action alternatives.
    - Possible outcome if real-world conditions differ from the assumption: Modeled tailings seepage during operations is overestimated.
    - Likely magnitude of effect for all action alternatives: Low to none. This approach overestimates chemical loading, rather than underestimates it, and therefore is conservative. In addition, this applies only during the operational life and would not affect the post-closure seepage estimates.
- Incomplete removal of alluvial channels within the interior of the tailings storage facility would allow for faster transport of seepage.
    - Applies to: Alternatives 2, 3, 4, and 6.
    - Possible outcome if real-world conditions differ from the assumption: Seepage reaches finger drains and blanket drains faster.
    - Likely magnitude of effect for Alternatives 2, 3, 4, and 6: Low to none. This would only enhance the operation of the finger and blanket drainage system, which captures seepage and pumps it back to the recycled water pond.
- The seepage estimates do not account for possible preferential flow along minor faults in the bedrock underlying the tailings storage facility footprint.
    - Applies to: Alternatives 2, 3, and 4. No minor faults were identified in the vicinity of Alternative 5, and faults were explicitly modeled in the refined water quality model for Alternative 6.
    - Possible outcome if real-world conditions differ from the assumption: Seepage bypasses drains and seepage collection ponds, increasing amount of lost seepage and chemical load to downstream aquifer.
    - Likely magnitude of effect for Alternatives 2 and 3: Low to none. While seepage would bypass the drains and seepage collection ponds, for seepage to enter the environment assumes that all foundation treatments (Level 1, Level 4) were ineffective as well as the downstream grout curtain (Level 2, Level 4) and auxiliary pumpback wells (Level 4). The variety of layered controls have a high likelihood of capturing this seepage.
    - Likely magnitude of effect for Alternative 4: Moderate. This alternative has fewer layered seepage controls, and places sole reliance on the drains and seepage collection ponds.
- The modeling used to estimate seepage efficiency assumes ideal placement of all pumpback wells, embankments, and grout curtains. Pumpback wells might not be located in ideal locations and therefore allow more flow to escape than modeled.

- Applies to: Alternatives 2, 3, and 6
- Possible outcome if real-world conditions differ from the assumption: More seepage escapes, increasing chemical load to downstream aquifer.
- Likely magnitude of effect for Alternatives 2 and 3: Low. The primary ring of seepage collection dams (Level 1) is located along alluvial drainages which are highly likely to be the preferential flow paths. The secondary ring of seepage collection dams (Level 3), auxiliary pumpback wells (Level 4), and grout curtains (Level 2, Level 4) are controls that would be installed during operations as needed. Placement of these would be driven by direct observation, and it is reasonable to assume they would be targeted to areas of concern.
- Likely magnitude of effect for Alternative 6: Low. The geometry of Dripping Spring Wash is such that the alluvial flow path is well defined, with few barriers to placement of the seepage collection dams, cutoff walls, grout curtains, and pumpback wells (Level 1).

- The modeled efficiencies for Alternative 2 (99 percent) and Alternative 3 (99.5 percent) could be difficult to achieve in practice. For instance, the length of the Level 4 grout curtain for both alternatives (approximately 7.5 miles) is believed to be larger by a factor of 10 than any other grout curtain in the United States. Similarly, for comparison, the full suite of engineered seepage controls would result in 97 percent less seepage than a fully lined facility.
  - Applies to: Alternatives 2 and 3
  - Possible outcome if real-world conditions differ from the assumption: More seepage escapes, increasing chemical load to downstream aquifer.
  - Likely magnitude of effect for Alternatives 2 and 3: Moderate to high. The overall reliance on a variety of engineered seepage controls in a layered defense reduces the likelihood that the failure of any one control would change the outcome. For the Near West location, however, the proximity to Queen Creek provides little room for flexibility to add or modify controls during operations.
- Unlike Alternatives 2 and 3, there is limited information on the hydrology and geology of the proposed Silver King tailings location (Alternative 4). Seepage capture was not modeled, but instead based on professional judgment of the design engineers and an understanding of the potential flow pathways for seepage. Results could vary widely based on field conditions encountered.
  - Applies to: Alternative 4.
  - Possible outcome if real-world conditions differ from the assumption: More seepage escapes, increasing chemical load to downstream aquifer.
  - Likely magnitude of effect for Alternative 4: Moderate. Filtered tailings involve less initial seepage to control, but concentrations of metals are generally higher. Complex and poorly understood geology complicates control efforts. However, at this location there is also potentially room to layer on additional seepage controls downstream.
- Alternative 5 has limited site-specific information on the foundation conditions. However, the general characteristics of the aquifer are reasonably well understood from site-specific geophysics (resistivity, seismic, and gravity surveys), surface geology mapping, review of records and logs from 20 to 30 wells in the near vicinity, and site-specific water levels from nine wells in the near vicinity (Fleming, Kikuchi, et al. 2018; Hydrogeophysics Inc. 2017).
  - Applies to: Alternative 5.
  - Possible outcome if real-world conditions differ from the assumption: More seepage escapes, increasing chemical load to downstream aquifer.

- Likely magnitude of effect for Alternative 5: Low to none. Unlike Alternatives 2, 3, and 4, the large volume of groundwater flow in the substantial alluvial aquifer downstream creates dilution and can accept larger amounts of seepage without resulting in concentrations above water quality standards. In addition, the lost seepage as modeled is based on a reduced pumping amount from the pumpback well system. Additional pumping could take place as needed. In addition, the nearest perennial water is several miles downstream, so there is substantial room to add or modify seepage controls.

- The DEIS noted uncertainties related to Alternative 6. A number of field investigations took place at the Skunk Camp location that were concluded and reported after publication of the DEIS (KCB Consultants Ltd. 2019; Montgomery and Associates Inc. 2019a, 2020a, 2020e, 2020g; WestLand Resources Inc. and Montgomery and Associates Inc. 2020; Wong et al. 2020b). The specific reports and types of investigations are detailed in Section 3.2. Overall, the on-site investigations largely confirmed the previous understanding of hydrology and geology at the site, as detailed in Section 3.2. Geological and hydrologic characteristics at this location now have reasonably high confidence, supported by the site-specific investigations, and this previous uncertainty is no longer a concern.

BYPASS SEEPAGE MIXING/LOADING MODELS

Modeling Details

The water quality of the tailings seepage (estimated using the tailings solute geochemistry models), the changes in water quality from the embankment (estimated using the embankment sulfide oxidation model), and the predicted amounts of lost seepage from the facility (estimated using the tailings seepage models), are input into a series of bypass seepage mixing/loading models. These models predict the changes in aquifer water quality as lost seepage flows downgradient from each tailings storage facility. The bypass seepage mixing/loading model uses the Goldsim software package to calculate the mass balance and account for dilution from groundwater present in a series of connected mixing cells. The model cells and framework are slightly different for each alternative; all models are run for the 41 years of operation and an additional 204 years post-closure.

- **Near West (Alternatives 2 and 3)**. The mixing/loading model for Alternatives 2 and 3 estimates groundwater quality in five different mixing cells, starting with Roblas Canyon and Potts Canyon, then flowing into Queen Creek. Queen Creek is represented by three mixing cells, which lead downstream to where the model ends at Whitlow Ranch Dam, where groundwater emerges as surface water (Gregory and Bayley 2018e). Background groundwater quality is derived from a well located adjacent to Queen Creek, using the median of nine samples collected between May 2017 and February 2018. Background surface water quality is derived from the median of 15 samples collected at Whitlow Ranch Dam between March 2015 and December 2017.
- **Silver King (Alternative 4)**. Even though this alternative is composed of filtered tailings, some seepage is still expected to occur with Alternative 4, though a very small amount, compared with Alternatives 2, 3, 5 and 6. The downstream mixing model estimates groundwater quality in nine cells, which start with Potts Canyon, Silver King Wash, and Happy Camp Wash East and West, then flowing into Queen Creek. Queen Creek is represented by five mixing cells, which lead downstream to where the model ends at Whitlow Ranch Dam, where groundwater emerges as surface water (Gregory and Bayley 2018b). Background groundwater and surface water quality are derived from the same sources as Alternatives 2 and 3.

- **Peg Leg (Alternative 5)**. The Peg Leg location is fundamentally different from Alternatives 2, 3, and 4 in that much of the facility overlies a large alluvial aquifer, resulting in relatively large seepage rates, compared with other alternatives. The downstream mixing model estimates groundwater quality in five cells along Donnelly Wash, leading to the Gila River where groundwater emerges as surface water (Gregory and Bayley 2018c). Background groundwater quality is derived from a single sample in September 2017 from a well located adjacent to Donnelly Wash. Background surface water quality is derived from a single sample in November 2018 from the Gila River at the confluence with Donnelly Wash.
- **Skunk Camp (Alternative 6)**. There are now two models considered for Alternative 6; these models provide a range of outcomes with respect to water quality. The first model is disclosed in the DEIS (henceforth known as the DEIS water quality model). The Skunk Camp DEIS water quality model is similar to the Peg Leg model, with the alluvial aquifer associated with Dripping Spring Wash located downstream. The downstream mixing model estimates groundwater quality in five cells along Dripping Spring Wash, leading to the Gila River, where groundwater emerges as surface water (Gregory and Bayley 2018d). Background groundwater quality is derived from a single sample in November 2018 from a well located adjacent to Dripping Spring Wash. Background surface water quality is derived from a single sample in November 2018 from the Gila River at the confluence with Dripping Spring Wash.

  The Skunk Camp DEIS water quality model is supplemented with a refined modeling approach that takes advantage of the additional information collected at the Skunk Camp site since the DEIS (termed the FEIS water quality model). The refined modeling approach uses a three-dimensional numerical groundwater model—similar to the model used to predict groundwater drawdown at the mine site and the model used to predict groundwater drawdown at the Desert Wellfield. However, the Skunk Camp FEIS water quality model also incorporates fate and transport of contaminants resulting from tailings seepage.

A relatively straightforward mixing cell model is used to evaluate the impact on water, as shown in figure 3.7.2-2. Lost seepage from a given tailings storage facility alternative mixes with the flow of underlying groundwater in the first model cell. The flow of water and dissolved chemicals from this cell passes to the next cell downgradient and is combined with any other flows reporting to that cell. Flows are passed from one groundwater cell to the next until it discharges to a receiving surface water, which is the last cell in the model. At each step, the concentrations of chemical constituents are calculated.
The model dimensions of the groundwater cells dictate the amount of dilution that is achieved on mixing with lost seepage; the larger the cells, the greater the diluting effect.

The specific geographic points selected to represent the aquifer and surface water modeled impacts are shown in figure 3.7.2-3.

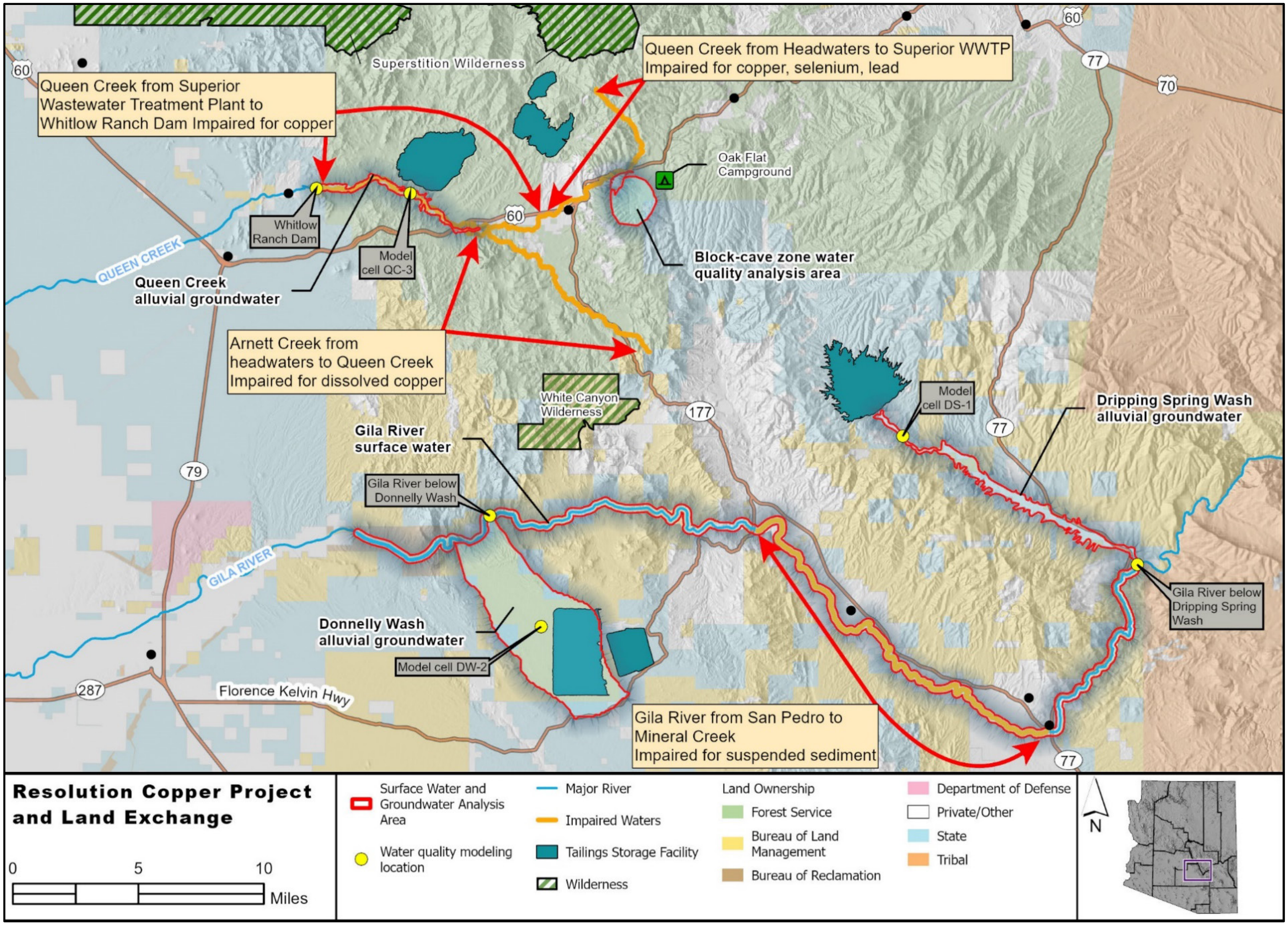


Figure 3.7.2-3. Water quality modeling locations and impaired waters

Assumptions, Uncertain and Unknown Information

The uncertainties described for the block-cave geochemistry model, the tailings solute geochemistry model, and the embankment sulfide oxidation model also add to the uncertainty of the bypass seepage mixing/loading model. Specific uncertainties that affect the bypass seepage mixing/loading model include the following:

- The size of the groundwater cells in the model affects the amount of dilution and the outcome.
  - Applies to: all action alternatives.
  - Possible outcome if real-world conditions differ from the assumption: More or less dilution occurs, changing chemical load to downstream aquifers and perennial waters.
  - Likely magnitude of effect for Alternatives 2 and 3: Low. Substantial site-specific investigation has taken place at the Near West location; this location has the most hydrologic and geological information of any of the alternatives.
  - Likely magnitude of effect for Alternative 4: Low. While the hydrology and geology near the Silver King location is uncertain, the groundwater mixing component happens downstream in Queen Creek, which is relatively well-defined.
  - Likely magnitude of effect for Alternative 5: Low to none. Substantial site-specific investigations have occurred at the Peg Leg location that define the size of the aquifer, which even with uncertainties is substantial.
  - Likely magnitude of effect for Alternative 6: Low. The site-specific investigations confirmed many of the assumptions about the alluvial aquifer that were used in both the DEIS and FEIS water quality modeling.
- There is a limited knowledge of baseline aquifer water chemistry.
  - Applies to: all action alternatives.
  - Possible outcome if real-world conditions differ from the assumption: Baseline chemistry may be higher or lower, leading to different combined concentrations in downstream aquifers.
  - Likely magnitude of effect for Alternatives 2, 3, and 4: Low. Water quality modeling used the median results from nine different samples collected from the nearest downstream well.
  - Likely magnitude of effect for Alternative 5: Moderate. The water quality modeling was based on a single groundwater sample. While water quality modeling did not result in concentrations near aquifer water quality standards for most constituents, selenium approaches the standard late in the modeling run. Even moderate changes in selenium based on additional groundwater sampling could change the outcome of the models.
  - Likely magnitude of effect for Alternative 6: Low. The DEIS water quality modeling was based on a single groundwater sample. However, water quality modeling did not result in concentrations near aquifer water quality standards, allowing some room for variation as future samples are collected. Further, the FEIS water quality modeling utilized a more representative data set for aquifer water chemistry, based on field investigations completed at the tailings site.
- There is a limited knowledge of baseline surface water chemistry.
  - Applies to: all action alternatives
  - Possible outcome if real-world conditions differ from the assumption: Baseline chemistry may be higher or lower, leading to different assimilative capacity and different predicted concentrations in downstream perennial waters.

    - Likely magnitude of effect for Alternatives 2, 3, and 4: Low. Water quality modeling used the median results from 15 different samples collected from Queen Creek at Whitlow Ranch Dam.
    - Likely magnitude of effect for Alternatives 5 and 6: Low. The water quality modeling was based on a single surface water sample for each alternative, driven by the necessity to have recent surface water quality results at two specific locations (Donnelly Wash and Dripping Spring Wash). A longer period of record exists for the Gila River at other locations and these samples have been assessed against the values used; the model outcomes would not substantially change if surface water quality varied similar to the historic record (see Newell and Garrett (2018d)).
- Modeling idealizes mixing and assumes that seepage fully mixes across the full width of the alluvium of Queen Creek, Donnelly Wash, or Dripping Spring Wash. Should only partial mixing occur, this would also increase concentrations in parts of the alluvial aquifer. Modeling also does not take into account seasonal flow patterns of water levels.
    - Applies to: all action alternatives.
    - Possible outcome if real-world conditions differ from the assumption: Preferential mixing or flow paths would effectively reduce the amount of dilution of seepage, resulting in higher downstream concentrations. Changing water levels could result in more or less dilution.
    - Likely magnitude of effect for all action alternatives: Moderate. Flow through alluvial aquifers is relatively straightforward to model as an idealized system, but real-world conditions (like the periodic recharge effects of stormflow) could greatly affect the outcomes. These types of uncertainties are inherent; no amount of hydrologic investigation is likely to resolve these uncertainties.

OVERALL EFFECT OF UNCERTAINTIES ON THE MODEL OUTCOMES

As with all modeling, the modeling used to estimate water quality impacts for each alternative contains assumptions and uncertainty that limit the accuracy and reliability of the associated results.

The model construction includes some intentional bias to skew results that produce a greater negative impact and therefore provide the greatest environmental protection. Examples include the following:

- The assumption that life-of-mine discharge from the tailings storage facility remains at the highest levels associated with the drain down process, rather than decreasing over time. This maximizes the modeled chemical discharge from the tailings storage facility.
- The model does not consider any geochemical processes in the groundwater and surface water flow that might lower concentrations. Examples include potential chemical precipitation of oversaturated solids, or adsorption of chemical constituents onto aquifer solids, which can both lower concentrations in the water.
- For comparisons against surface water standards, median flow values were used which is appropriate when replicating baseflow. Concentrations during runoff events would be expected to be lower due to dilution from stormflows. However, it should be noted that lower flow conditions can occur during the year that would not be reflected by median flow conditions, and for some constituents like copper, studies suggest that stormflows might increase in copper concentrations (Louis Berger Group Inc. 2013). Effects of low-flow conditions are examined later in this section.

- Variations in hardness can change surface water quality standards for some metals, with increasing hardness resulting in a higher water quality standard; for the comparisons in section 3.7.2.4, the best available information on existing hardness was used (as calculated from calcium and magnesium concentrations).

Several uncertainties have been disclosed in this section that affect the ultimate outcome of the water quality modeling. These are summarized in table 3.7.2-2.

Table 3.7.2-2. Compilation of magnitude of uncertainties disclosed for water quality modeling

Modeling Component/ Uncertainty	Potential Effect on Modeled Tailings Seepage	Alternative 2 Likely Magnitude of Effect on Outcomes	Alternative 3 Likely Magnitude of Effect on Outcomes	Alternative 4 Likely Magnitude of Effect on Outcomes	Alternative 5 Likely Magnitude of Effect on Outcomes	Alt 6 Likely Magnitude of Effect on Outcomes
Block-cave model						
Source water chemistry could vary	Higher or lower	Low	Low	Low	Low	Low
Cave-zone in-situ weathering could occur	Higher	High	High	High	High	High
Weathering products stay with ore	None	None	None	None	None	None
Tailings seepage models						
Full-buildout seepage during operations	Lower	Low to none	Low to none	Low to none	Low to none	Low to none
Alluvial channels could remain in footprint	None	Low to none	Low to none	Low to none	–	Low to none
Minor faults could cause preferential flow	Higher	Low to none	Low to none	Moderate	–	–
Ideal placement of controls assumed	Higher	Low	Low	–	–	Low
Seepage efficiency difficult to meet	Higher	Moderate to high	Moderate to high	–	–	–
Limited site-specific hydrologic/geological information	Higher	–	–	Moderate	Low to None	–
Bypass seepage mixing/loading models						
Mixing cells could be different sizes	Higher or lower	Low	Low	Low	Low to None	Low
Limited baseline aquifer water quality	Higher or lower	Low	Low	Low	Moderate	Low
Limited baseline surface water quality	Higher or lower	Low	Low	Low	Low	Low
Idealized mixing	Higher	Moderate	Moderate	Moderate	Moderate	Moderate

Note: A dash indicates that this was not identified as a specific concern for this alternative.

Many of the uncertainties identified could result in either higher or lower concentrations in modeled outcomes, or overall would be expected to have a low (or no) impact on the outcomes.

A number of uncertainties reflect limited information on the geology and hydrology at alternative tailings locations or limited baseline water quality samples. This does not mean that the models are unrealistic or unreasonable. They rely upon the best available hydrologic and geological information and make reasonable assumptions about aquifer conditions. Future hydrologic and geological investigations at these locations would reduce some uncertainty and refine some model parameters; the overall flow regime of the downstream aquifers and surface waters is understood well enough that the model framework would likely remain the same.

One of the most uncertain aspects of the modeling is the assumption about oxidation in the block-cave zone. The block-cave geochemistry model used as a basis for the water quality modeling (Eary 2018f) represents the current conception of the mechanics of block caving and ventilation of the mine and how that would affect the presence of oxygen in the cave zone; this is considered a reasonable interpretation. However, real-world conditions could differ. If greater oxidation occurred in the block-cave zone, it could result in more oxidation products either reporting with the ore to the processing plant, or rinsing into the sump and from there entering the process stream.

As previously noted, this uncertainty is specifically about block-cave sump water chemistry during mine operations that ultimately is part of the prediction of tailings solute chemistry. A separate question regarding anticipated block-cave water quality occurring after closure as the block-cave zone is reflooded is addressed later in this section.

Conclusion as to reasonableness of models

The CEQ regulations provide guidance for dealing with incomplete or uncertain information:

> When an agency is evaluating reasonably foreseeable significant adverse effects on the human environment in an environmental impact statement and there is incomplete or unavailable information, the agency shall always make clear that such information is lacking. . . . If the incomplete information relevant to reasonably foreseeable significant adverse impacts is essential to a reasoned choice among alternatives and the overall costs of obtaining it are not exorbitant, the agency shall include the information in the environmental impact statement. (40 CFR 1502.22)

While future work or additional information could reduce some of these uncertainties, the water quality modeling results disclosed in the EIS (see section 3.7.2.4) are sufficiently different between alternatives that such refinements are not "essential to a reasoned choice among alternatives." In fact, the additional water quality modeling conducted for the FEIS for Alternative 6 (see section 3.7.2.4) used additional site-specific information and more sophisticated modeling techniques, but largely confirmed the results of the DEIS water quality modeling. The broad conclusions in section 3.7.2.4 are not likely to change, specifically:

- It is difficult to meet water quality objectives at Alternatives 2, 3, and 4 without extensive engineered seepage controls.
- Alternatives 5 and 6 not only meet water quality objectives as modeled but have substantial additional capacity to do so, and flexibility to implement additional seepage controls.

Forest Service disclosure and ADEQ permitting requirements

The State of Arizona has the authority to determine whether or not the proposed project would violate State water quality regulations. The person or entity seeking authorization for a regulated discharge (in this case Resolution Copper) has the responsibility to demonstrate to the State of Arizona that the regulated discharge would not violate water quality standards. This demonstration takes place through the application for and issuance of permits. Resolution Copper would be required to obtain a permit under the

AZPDES program for any discharges to surface waters, including stormwater runoff, as well as an APP for any discharges to groundwater, or discharges to the ground that could seep into groundwater.

The Forest Service is responsible for ensuring that mine operators on NFS lands obtain the proper permits and certifications to demonstrate they comply with applicable water quality standards. This constitutes compliance with the CWA. The ROD would require that Resolution Copper obtain the applicable State permits prior to approval of the final mining plan of operations, which authorizes mine activities. If the permits are issued, then ADEQ has determined that the project would be compliant with State law and identified the steps that would occur if monitoring indicates noncompliance.

While the permitting process provides an assurance to the public that the project would not cause impacts on water quality, it does not relieve the Forest Service of several other responsibilities:

- The Forest Service has a responsibility to analyze and disclose to the public any potential impacts on surface water and groundwater as part of the NEPA process, separate from the State permitting process.
- The role of the Tonto National Forest under its primary authorities is to ensure that mining activities minimize adverse environmental effects on NFS lands and comply with all applicable laws and regulations. As such, the Forest Supervisor ultimately cannot select an alternative that is unable to meet applicable laws and regulations.[60] However, it may be after the EIS is published when permits are issued by ADEQ that demonstrate that the project complies with state laws. In the meantime, it would be undesirable for the Forest Service to pursue and analyze alternatives that may not be able to comply. Therefore, a second goal of the analysis in this EIS is to inform the Forest Supervisor of alternatives that may prove difficult to permit.

The analysis approaches used by the Forest Service in this EIS likely differ from those that ADEQ would use in assessing and issuing permits. ADEQ would use the assumptions, techniques, tools, and data deemed appropriate for those permits. The Forest Service has selected to use a series of simpler mixing-cell models to provide a reasonable assessment of potential water quality impacts that is consistent with the level of hydrologic and geological information currently available for the alternative tailings sites. This approach is sufficient to provide the necessary comparison between alternatives and assess the relative risk of violation of water quality standards. It is understood different analysis may be conducted later when ADEQ is reviewing permit applications for the preferred alternative.

There are two specific additional aspects of the analysis in this section of the EIS that have a bearing on the ADEQ permitting process: assimilative capacity, and impaired waters.

ASSIMILATIVE CAPACITY

Assimilative capacity is the ability for a perennial water to receive additional pollutants without being degraded; assimilative capacity is calculated as the difference in concentration between the baseline water quality for a pollutant and the most stringent applicable water quality criterion for that pollutant.

Under Arizona surface water regulations, the addition of a pollutant may be considered “significant degradation” of a perennial water if, during critical flow conditions, the regulated discharge consumes 20 percent or more of the available assimilative capacity for each pollutant of concern (Arizona Administrative Code R18-11-107.01(B)). The addition of contaminants to surface waters through seepage

[60] Note that Alternative 6 would involve a tailings facility located off of Federal lands, and permitting the tailings facility would not be part of the Federal decision. In this case, the State permitting process that would ensue would require that applicable laws and regulations be met.

could result in a reduction in the assimilative capacity of perennial waters. The EIS therefore contains an analysis of reductions in assimilative capacity.

The regulatory determination of significant degradation of perennial waters is under the purview of the State of Arizona. This determination is usually made when a permit is requested for a discharge directly to surface waters. However, Resolution Copper is not proposing any direct discharges to surface waters. Alternatively, ADEQ could consider the indirect effects of seepage from the tailings storage facility to surface waters under the APP program, or under a CWA Section 401 water quality certification (which is only done if a CWA Section 404 permit is required).[61]

The 20 percent threshold that defines significant degradation is not absolute; if ADEQ decides to assess antidegradation standards as part of a permitting action, there are also provisions in Arizona regulations for degradation to be allowed, provided certain criteria are met (Arizona Administrative Code R18-11-107.C).

In other words, neither the regulatory need to assess assimilative capacity, nor the consequences of exceeding the 20 percent threshold can be assessed outside of a specific permitting decision by ADEQ. Regardless, the Forest Service responsibility for the DEIS is to disclose possible water quality concerns. This includes the reduction in assimilative capacity of a perennial water. For this purpose, a threshold of 20 percent loss in assimilative capacity is used.[62]

IMPAIRED WATERS

Under the CWA, the State of Arizona must identify waters that are impaired for water quality.[63] As with assimilative capacity, the regulatory determination of how impaired waters could be affected by a discharge is solely under the purview of the State of Arizona.

For the purposes of disclosure, the Forest Service approach in the EIS is to identify what surface waters have been determined to be impaired, where contaminants from the project could enter these surface waters and exacerbate an already impaired water, and the estimated loading for constituents associated with the impairment.

[61] Note that ADEQ issued the 401 water quality certification on December 22, 2020. The certification does not specifically reference degradation, but does require that the applicant is responsible to ensure that certified activities do not cause or contribute to any exceedances of Arizona surface water quality standards in a water of the U.S.

[62] The calculation of assimilative capacity depends in part on the specific numeric surface water standard being used. Several surface water quality standards for metals change based on the hardness of the water. A hardness of 307 mg/L $CaCO_3$ was used for Queen Creek, which is based on the lowest hardness observed (sample date August 25, 2017); a hardness of 290 mg/L $CaCO_3$ was used for the Gila River below Donnelly Wash (sample date November 13, 2018); and a hardness of 242 mg/L $CaCO_3$ was used for the Gila River below Dripping Spring Wash (sample date November 9, 2018). The addition of the modeled seepage does increase hardness but only slightly (less than 2%). The values of hardness used are based on the best available information at this time; ADEQ could choose to apply different hardness values during permitting.

The calculation of assimilative capacity also depends on specific "critical flow conditions." One technique (often called 7Q10) is to choose the lowest flow over 7 consecutive days that has a probability of occurring once every 10 years. By contrast, the seepage modeling in the EIS uses the median flow for surface waters, which is a common method of estimating baseflow conditions, because it tends to exclude large flood events. While assessing typical baseflow conditions (using the median flow) were determined to be the most appropriate method for the EIS disclosure, ADEQ could choose to apply different flow conditions during permitting. Based on public comments, however, we have added additional analysis of low-flow conditions and the effect those conditions would have on predicted water quality.

[63] "Impaired" refers to a regulatory designation under the CWA, and generally means that existing water quality is degraded to the point that an applicable water quality standard is not being attained.

One reason we take this approach for disclosure is because ADEQ must make several regulatory decisions before assessing how discharges would or would not impact impaired waters. One primary decision is which level of antidegradation standard would be applied. This standard varies depending on whether a drainage is ephemeral/intermittent (Tier 1 antidegradation standards apply) or perennial (Tier 2 antidegradation standards could apply). These specific decisions would be made during the ADEQ permitting process. For the purposes of the EIS, we restrict disclosure of water quality impacts to the following:

- Predicting changes in concentrations in groundwater and surface water, comparing results to numeric water quality standards as a reasonable threshold for identifying impacts. Note that numeric water quality standards are not the only regulatory technique for managing water quality. During permitting, ADEQ can also manage adverse water quality by application of narrative water quality standards, restricting any adverse impacts to water quality uses.
- Assessing the uncertainties and likelihood of these estimates, focusing on the ability to apply seepage controls.
- Identifying where and how much contaminant load reaches a designated impaired water.
- Estimating how much assimilative capacity is reduced due to project discharges.

Constituents of Concern

While the background references and reports contain information for the full suite of metals, inorganic constituents, and field measurements, the analysis we present in this section focuses on selected "constituents of concern." For example, appendix M of this EIS only includes graphs for the following constituents (these are constituents that are typically known to be issues for tailings facilities, or that the bypass seepage mixing/loading models have indicated may be a problem). These include the following:

- Total dissolved solids
- Sulfate
- Nitrate
- Selenium, cadmium, antimony, and copper

3.7.2.3 Affected Environment

Relevant Laws, Regulations, Policies, and Plans

For the most part, impacts on groundwater and surface water quality fall under State of Arizona regulations, which are derived in part from the CWA. Additional details of the regulatory framework for groundwater and surface water quality are captured in the project record (Newell and Garrett 2018d).

Primary Legal Authorities and Technical Guidance Relevant to the Groundwater and Surface Water Quality Analysis

- Clean Water Act and Federal primary and secondary water quality standards
- State of Arizona Aquifer Water Quality Standards and the Aquifer Protection Permit program
- State of Arizona Surface Water Quality Standards and the Arizona Pollutant Discharge Elimination System program (delegated primacy for Clean Water Act Section 402)

Existing Conditions and Ongoing Trends

This section discusses three aspects of the affected environment:

- Existing groundwater quality for various aquifers, including what types and quantity of data have been collected to date; the general geochemistry of the groundwater for major constituents; the occurrence and concentrations of constituents of concern, compared with water quality standards; the age of the groundwater; and existing trends in groundwater quality.
- Existing surface water quality for various streams, including what types and quantity of data have been collected to date; the general geochemistry of surface waters for major constituents; and the occurrence and concentrations of constituents of concern, compared with water quality standards.
- Characterization of mine rock ore, and tailings, including the types and quantity of data for different geological units and alteration types that have been collected to date, and the static and kinetic laboratory testing undertaken to describe the likely changes in water quality when exposed to oxygen in the presence of sulfide minerals.

EXISTING GROUNDWATER QUALITY

Types of Groundwater Present

As more fully described in Section 3.7.1, Groundwater Quantity and Groundwater-Dependent Ecosystems, three types of groundwater exist in the area: shallow groundwater occurring in shallow alluvial materials, perched zones, or shallow fractures; the Apache Leap Tuff aquifer; and the deep groundwater system (units generally below the Whitetail Conglomerate, and extending into the Superior Basin) as seen in figure 3.7.1-4. These groundwater systems are identified as separate based on the different ages of the water within them and because they do not appear to be hydraulically connected based on aquifer testing.

The tailings facilities for Alternatives 2, 3, and 4 in the Superior Basin include shallow alluvial materials along washes and underlying fractured hard rock units like the Gila Conglomerate, which are assumed to be in hydraulic connection with the deep groundwater system. The tailings facilities for Alternatives 5 and 6 are geographically separate from the Superior Basin and overlie alluvial aquifers associated with Donnelly Wash and Dripping Spring Wash, respectively, with some hard rock units along the margins of the facilities.

Period of Record for Groundwater Quality Data

Groundwater quality data have been collected since monitor well drilling and development was initiated in 2003, and collection continues into the present. Groundwater samples from each monitoring well are analyzed for common dissolved constituents when the wells are completed, and then periodically thereafter. Overall, 31 wells in the project area have been sampled since 2003, and over 150 samples have been collected to characterize groundwater in the project area through 2016. These samples are largely focused on the East Plant Site and surrounding areas.

Near the West Plant Site, 48 wells have been developed and sampled, yielding 102 samples of groundwater (including duplicate samples). This sampling has largely been the result of ongoing voluntary cleanup activities at the West Plant Site, and the results are generally geared toward assessing contamination rather than hydrogeological conditions and general water quality.

Additional piezometers and monitoring wells were constructed in the Near West area in 2016 and 2017, where the tailings storage facility for Alternatives 2 and 3 would be located. In total, 68 groundwater samples have been collected from 16 locations between 2017 and 2019.

Several other sampling locations provide the basis for background water quality in the bypass seepage mixing/loading models. These include a well near Queen Creek (nine samples between 2017 and 2018), and a well near Donnelly Wash (one sample in 2018). For the area around Dripping Spring Wash, investigations after publication of the DEIS included analysis of water quality from 42 groundwater samples from both new and existing wells.

Types of Groundwater Quality Data Collected

All samples were analyzed for a wide range of chemical constituents, including water quality measurements made on water samples in the field at the point of collection (e.g., pH, temperature) and analyses conducted by Arizona-certified analytical laboratories. Some of the constituents analyzed are directly related to water quality, including those that have regulatory standards in the state of Arizona. Other constituents such as isotopes were sampled to help understand groundwater dynamics and the potential for interaction with local surface water resources (Garrett 2018e). The number, date range, and types of samples collected are shown in table 3.7.2-3. A summary of existing groundwater quality for each aquifer is shown in appendix N, table N-1.

Table 3.7.2-3. Number of groundwater samples available for analysis

Type of Analysis	Shallow Groundwater Samples	Apache Leap Tuff Samples	Deep Groundwater Samples
General chemistry	28 (June 1986–Sep 2016)	106 (March 2004–Mar 2016)	20 (Nov 2008–Oct 2016)
Metals	28 (June 1986–Sep 2016)	107 (March 2004–Mar 2016)	20 (Nov 2008–Oct 2016)
Isotopes	24 (June 1986–May 2012)	92 (March 2004–Mar 2016)	20 (Nov 2008–Oct 2016)
Radionuclides	12 (June 2007–Dec 2008)	65 (June 2007–Mar 2016)	20 (Nov 2008–Oct 2016)

Chemical Quality of Groundwater

There are differences in water quality among the three principal groundwater sources (shallow, Apache Leap Tuff, deep groundwater system) in the project area (Montgomery and Associates Inc. 2012, 2016).[64] The shallow groundwater system can be described as a calcium/magnesium bicarbonate type with varying amounts of sulfate. The total dissolved solids content is generally low (median of 240 mg/L). Constituents

[64] For a complete summary of the number of samples with concentrations over Arizona or EPA standards to support the qualitative terms used in this section (i.e., “rarely,” “occasionally,” “often”), see Newell and Garrett (2018d).

in water samples from the shallow groundwater system rarely have concentrations above Arizona numeric Aquifer Water Quality Standards (AWQS) and EPA primary maximum contaminant levels, with nitrate and lead being the only constituents with concentrations above these standards. Samples also rarely have concentrations above EPA secondary maximum contaminant levels, but this does occur for iron, manganese, sulfate, aluminum, and total dissolved solids; secondary standards are generally established for aesthetics and taste, rather than safety.

The Apache Leap Tuff aquifer has been sampled much more than either the shallow or deep groundwater systems, since it is the aquifer from which most springs and stream derive their flow. Overall the Apache Leap Tuff is a calcium-magnesium-bicarbonate water type, with low total dissolved solids (median of 219 mg/L). Constituents in water samples from the Apache Leap Tuff rarely appear in concentrations above Arizona numeric AWQS or EPA primary standards, although this has occurred for antimony, thallium, and beryllium. Concentrations above EPA secondary standards occur occasionally for aluminum, iron, and manganese, and rarely for total dissolved solids.

The overall water quality of the deep groundwater system is more variable than the shallow and Apache Leap Tuff systems, with greater total dissolved solids (median of 410 mg/L) that often can be above the EPA secondary standard. Only one sample (in 2011) exhibited concentrations above AWQS values. Concentrations often are above EPA secondary standards for aluminum, iron, manganese, sulfate, and fluoride. Samples with elevated sulfate, total dissolved solids, iron, and manganese appear to be within the proposed mineralized ore zone (Montgomery and Associates Inc. 2012).

Groundwater is also extracted from Shaft 9 as part of the ongoing dewatering. Groundwater associated with discharge from Shaft 9 has very high sulfate concentrations and, by extension, elevated total dissolved solids. Numerous constituents can be found in concentrations above Arizona numeric AWQS and EPA primary and secondary standards. This sampling location should not, however, be considered representative of the deep groundwater system, as it is affected by historical mine activity. The impacts at this location appear to be influenced by sulfide mineral oxidation, although the solution is routinely near neutral pH.

Age of Groundwater

Chemical characteristics of groundwater (isotopes) that may be used to assess age do not have explicit regulatory standards. Carbon-14 (^{14}C) and tritium have both been measured in shallow system, Apache Leap Tuff aquifer, and deep groundwater system sources to constrain age and provide understanding of water movement. These isotopic measurements indicate that shallow groundwater is typically estimated to be less than 700 years old, whereas Apache Leap Tuff and deep groundwater are 3,000–5,000 and 6,000–15,000 years old, respectively.

Trends in Groundwater Quality

Based on groundwater samples collected roughly between 2003 and 2015, over time the groundwater quality, in terms of major chemical constituents (e.g., calcium, magnesium, bicarbonate, sulfate) has remained generally stable in the shallow groundwater system and Apache Leap Tuff aquifer. The shallow system has displayed the greatest amount of variation, largely confined to variations in sulfate concentration. Although data for deep groundwater show significant variation with location, available data indicate there is little seasonal variability.

EXISTING SURFACE WATER QUALITY

Surface water occurs broadly across the entire project area. The settings in which surface water occurs span a wide range, from small to large drainage areas and channels and with highly variable flow rates.

The kinds of surface water present (including springs and perennial streams) are described in further detail in both the “Groundwater Quantity and Groundwater-Dependent Ecosystems” and “Surface Water Quantity” resource sections in this chapter.

Period of Record for Surface Water Quality Data

The surface water baseline monitoring program for the project area was initiated in 2003 and has continued through present, with a 2-year hiatus in 2006 and 2007. Although surface water data have been collected since 2003, the number of samples collected varies from location to location. Water quality data are available for a total of 47 locations. Through 2019, over 630 samples of surface water have been collected and chemically analyzed.

Most surface water monitoring has been conducted in the Devil’s Canyon watershed (main canyon and two tributaries). Queen Creek, along the northern margin of Oak Flat prior to entering the Superior area, has also been extensively characterized (Montgomery and Associates Inc. 2013, 2017d).

Several other sampling locations provide the basis for background water quality in the bypass seepage mixing/loading models. These include Queen Creek at Whitlow Ranch Dam (22 samples between 2015 and 2019), the Gila River below Donnelly Wash (one sample in 2018), and the Gila River below Dripping Spring Wash (six samples between 2018 and 2019).

Types of Surface Water Quality Data Collected

As with groundwater, all samples were analyzed for a wide range of chemical constituents, including water quality measurements made on water samples in the field at the point of collection (e.g., pH, temperature) and analyses conducted by State-certified analytical laboratories. Some of the constituents analyzed are directly related to water quality, including those that have regulatory standards in the state of Arizona. Other constituents such as isotopes were sampled to help understand groundwater dynamics and the potential for interaction with local surface water resources (Garrett 2018e).

Chemical Quality of Surface Waters

In general, surface water in the area is a calcium-sodium-bicarbonate type, with a neutral to alkaline pH. Based on sampling conducted by Resolution Copper, the basic chemistry of surface water does not vary widely across the project site and does not show any identifiable long-term trends, either increasing or decreasing. For the three principal drainages associated with the project—Devil’s Canyon, Queen Creek, and Mineral Creek—water quality is generally considered to be of acceptable quality, although all three have exhibited concentrations above Arizona surface water quality standards at different times for several different constituents (Montgomery and Associates Inc. 2013, 2017d). A summary of the number of surface water samples with concentrations above Arizona numeric surface water standards is included in appendix N, table N-4; the constituents most often noted are arsenic, thallium, copper, lead, and selenium.

Appendix N, table N-2 presents a summary of water quality for defined reaches of the principal drainages, for filtered water samples (dissolved concentrations). Appendix N, table N-3 presents the same types of data for unfiltered samples (total concentrations). A summary of Arizona numeric surface water standards and which bodies they are applicable to is included in appendix N, table N-5. The State of Arizona has conducted more extensive sampling throughout the watershed since 2002–2003, with a focus on identifying sources of pollutants affecting impaired reaches of Queen Creek, Arnett Creek, and several tributary washes. ADEQ found that copper and lead vary across the watershed, with the highest concentrations of copper observed in runoff from Oak Flat and subwatersheds generally north of the West Plant Site. ADEQ also observed variations in runoff hardness (which is important for calculating surface water quality standards) and lead across the watershed (Louis Berger Group Inc. 2013).

Impaired Waters

The objective of the CWA is to restore and maintain the chemical, physical, and biological integrity of the nation’s waters. To fulfill this objective, the State of Arizona is required to assess the existing quality of surface waters and identify any water bodies that do not meet State surface water quality standards. Each pollutant (i.e., copper, lead, suspended sediment) is looked at individually.

When a water body is identified that does not meet water quality standards, the next step taken by ADEQ is to develop a total maximum daily load (TMDL) for that pollutant. The TMDL is the amount to of a pollutant that a stream or lake can receive and still meet water quality standards. The studies to support developing a TMDL look at the point sources (i.e., discharge from municipalities or industries) and nonpoint sources (i.e., stormwater runoff from agriculture or the natural landscape).

Within the Queen Creek, Mineral Creek, and Gila River watersheds, several streams appear on the 303(d) Impaired Waters List (Arizona Department of Environmental Quality 2018). The most recent list (2018) includes the following streams within the analysis area:

- Queen Creek, from headwaters to Superior Wastewater Treatment Plant discharge. Impaired for dissolved copper (since 2002), total lead (since 2010), and total selenium (since 2012). Two unnamed tributaries to this reach are also impaired for dissolved copper (since 2010).
- Queen Creek, from Superior Wastewater Treatment Plant discharge to Potts Canyon. Impaired for dissolved copper (since 2004).
- Queen Creek, from Potts Canyon to Whitlow Canyon. Impaired for dissolved copper (since 2010).
- Arnett Creek, from headwaters to Queen Creek. Impaired for dissolved copper (since 2010).
- Gila River, from San Pedro River to Mineral Creek. Impaired for suspended sediment (since 2006).

Of these, the only two reaches with the potential to receive additional pollutants caused by the Resolution Copper Project are Queen Creek below the Superior Wastewater Treatment Plant, due to runoff or seepage from Alternatives 2, 3, and 4, and the Gila River from the San Pedro River to Mineral Creek, due to runoff or seepage from Alternative 6 (see figure 3.7.2-3).

In investigating the potential sources of copper in the watershed, ADEQ identified that the dominant source of copper to Queen Creek was runoff from the soils and rocks in the watershed, not point source discharges, and was a combination of natural background copper content and historic fallout from copper smelting (Louis Berger Group Inc. 2013). Part of the copper contribution looked at specifically by ADEQ was from Oak Flat. About 20 percent of the runoff reaching Superior would be captured by the subsidence area and potentially could reduce copper loads to Queen Creek. For the purposes of the EIS, no such reductions are being assumed, in order to ensure that the impacts from copper loads from tailings seepage are not underestimated. Copper loads to Queen Creek due to the Resolution Copper Project are discussed in section 3.7.2.4.

Existing AZPDES Permits and Potential for Discharge

Public comments on the DEIS questioned which impaired waters of those identified above needed to be considered, and specifically pointed to Queen Creek from headwaters to the Superior Wastewater Treatment Plant as receiving discharge from the West Plant Site. As noted in chapter 1, Resolution Copper does hold an AZPDES permit that authorizes potential discharge to Queen Creek (Lehman 2020; Resolution Copper 2020g).

The permit allows for discharge of stormwater, but only for discharges resulting from a 100-year, 24-hour storm or greater (Outfall 001). The permit also allows for discharge from the mine water treatment plant, which primarily treats groundwater from mine dewatering (Outfall 002). No discharges have occurred at either outfall under this permit since 2004, when Resolution Copper began operations at the site. Stormwater has been retained on-site and treated water is being sent to NMIDD or used for dust control (Lehman 2020; Resolution Copper 2020g). The potential discharges would enter an impaired reach of Queen Creek as described above. The discharges are subject to water quality limits, with concentrations set by ADEQ to be below the most restrictive surface water standards.

This permit—or a similar renewed AZPDES permit—would likely remain in effect during operations. During operations, the likelihood of discharge from the West Plant Site via this permit is reduced substantially. The water demands of the mine require that all contact stormwater or dewatering water be recycled back into the process stream; redundant systems will be in place to actively remove water from stormwater basins and reincorporate it into the process stream. Any discharges would likely take place under upset conditions. Regardless, since already properly permitted through ADEQ, the discharges would comply within the overall management framework for Queen Creek, including the impaired segment from headwaters to the Town of Superior Wastewater Treatment Plant.

Whitlow Fire Pipeline Break

On April 21, 2020, the Whitlow Fire burning on the Tonto National Forest reached and damaged the pipeline within the MARRCO corridor that sends treated mine dewatering water to the NMIDD. The resulting pipeline break released an estimated 480,000 gallons of treated mine water to the ground surface. Resolution Copper reported the discharge to ADEQ as required under the APP for the West Plant Site (Resolution Copper 2020h). Resolution Copper reported that based on recent sampling, the released water was within permit limits. No impacts to water supplies or surface resources are anticipated from this release.

MINE ROCK ANALYSIS

Rock within the proposed subsurface zone of mining is highly mineralized. However, not all the rock that is mineralized is ore grade and identified for proposed recovery. Much mineralized rock would remain in place during, and after mining. This rock contains sulfide minerals (e.g., pyrite, iron disulfide) and other metal-containing material. During mining, and after mining for some time, exposure of these minerals to oxygen could lead to their chemical weathering. This weathering may contribute acidity and metals to contact water and diminish its overall quality. The mine rock has been sampled and analyzed to assess the extent to which it might affect water that accumulates and is removed during mining, as well as the potential effects on groundwater that floods the mine void after mining is completed.

Amount of Geochemistry Tests Conducted

MWH Americas (2013) reports the rock units and alteration types that have been evaluated, and the number of samples for each. This information is summarized in table 3.7.2-4. Overall, 226 samples were submitted for analysis of Tier 1 procedures, with 13 duplicates for a total of 239 samples. A total of 54 samples was identified and submitted for Tier 2 evaluation using humidity cells; these cells were run for periods lasting from 16 to 74 weeks. Saturated column tests were then performed on samples from 14 of the 54 humidity cell tests, and were run for a 12-week period. Specific Tier 1 and Tier 2 tests are described in the next section.

Table 3.7.2-4. Rock units, alteration types, and number of samples submitted for Tier 1 geochemical evaluation

Code	Rock Unit	Count
Tal	Tertiary Apache Leap Tuff (Ignimbrite)	7
Tw	Tertiary Whitetail Conglomerate	11
Kvs	Cretaceous volcanics and sediments (undifferentiated)	101
Kqs	Cretaceous quartz-rich sediments	1
QEP	Quartz eye porphyry; rhyodacite porphyry	37
FP/LP	Felsic porphyry; latite porphyry	3
Dm	Devonian Martin limestone (skarn)	21
Andesite	Andesite	1
Diabase	Diabase	22
Qzite	Quartzite	17
Breccia/Hbx	Heterolithic breccia	3
Fault	Fault	2
	Total	**226**
	Alteration Type	
AA	Advanced argillic	19
ARG	Argillic	1
HFLRET	Retrograde hornfels	5
PHY	Phyllic	111
POT	Potassic	31
PRO	Propylitic	16
SA	Supergene argillic	7
SIL	Siliceous	1
SKN/SKRET	Skarn/Retrograde skarn	16
UNALT	Unaltered	18
ZEO	Zeolite	1
	Total	**226**

Types of Geochemistry Tests Conducted

Mine rock has been evaluated using a range of established, standard (best practices) methods for the mining industry (International Network for Acid Prevention 2018) as well as those that are regulatorily mandated procedures (Arizona Department of Environmental Quality 2004). These methods assess

- the potential for rock to generate acidic drainage,
- the rate at which such acid generation may occur, and
- what constituents of concern might be released and their associated concentrations.

Specific methods include

- whole rock chemical composition (concentration of wide range of elements),
- acid-base accounting (Sobek et al. 1978),

- net acid generation test (Stewart et al. 2006),
- synthetic precipitation leaching procedure (U.S. Environmental Protection Agency 1994),
- particle size analysis,
- humidity cell testing (American Society for Testing and Materials 1996), and
- saturated column testing (a project-specific test to leach the residual humidity cell testing procedure material.

The first five procedures (whole rock chemical composition, acid-base accounting, net acid generation test, synthetic precipitation leaching procedure, and particle size analysis) are Tier 1 procedures required in the Arizona Best Available Demonstrated Control Technology (BADCT) guidance (Arizona Department of Environmental Quality 2004). The last two are called for in the Tier 2 test-level requirements, which are generally conducted on fewer samples but take place over a longer period of time. Humidity cells are designed to mimic chemical weathering in the laboratory, and assess the rate of acid generation over time, and changes in water quality over time as a sample weathers. Saturated column tests are designed to mimic what would happen when the block-cave zone refloods after mining.

Beyond these chemical testing methods that directly assess potential impacts on the quality of contacting water, mine rock has been evaluated using mineralogical techniques such as

- petrography (microscopic evaluation of mineral grain sizes and contact boundaries),
- X-ray diffraction (identifies actual minerals present and their abundance), and
- scanning electron microscopy (evaluation of mineral formulas and textures).

Geochemical testing fundamentally is meant to determine whether a given rock sample is potentially acid generating or not, and if so, to what extent. The geochemical tests indicate that there are numerous rock units associated with the project that have acid generation potential; geochemical tests on simulated tailings samples similarly have demonstrated the potential for acid generation.

Results of Geochemistry Tests – Mine Rock

Acid-base account testing of mine rock indicates that overall, most rock is classified as likely to generate acid rock drainage. ADEQ (2004) provides guidance for using acid-base account measurements to classify mine rock as either acid generating, non-potentially acid generating (NPAG), or potentially acid generating (PAG). To do this, the net neutralizing potential (NNP) is calculated, which is simply the acid neutralizing potential of the sample minus the acid generating potential of the sample. These prescriptive guidelines (Arizona Department of Environmental Quality 2004) for classifying mine materials use the following definitions:

- If NNP is less than −20, the rock can be considered acid generating.
- If NNP is greater than +20, the rock can generally be considered NPAG.
- Samples that fall between −20 and +20 are considered uncertain and may be tested further using kinetic testing methods.

Table 3.7.2-5 summarizes the percentage of each major rock type, according to hydrothermal alteration type, that is classified as either acid generating, NPAG, or PAG.

Table 3.7.2-5. Acid-generating ion classification of mine rock samples based on geological unit and alteration type

Geological Unit*	Alteration Type	Acid Generating	Non-acid Generating	Potentially Acid Generating
Andesite	Potassic	0.0%	0.0%	100.0%
Breccia	Advanced Argillic	100.0%	0.0%	0.0%
Breccia	Phyllic	50.0%	50.0%	0.0%
Diabase	Phyllic	100.0%	0.0%	0.0%
Diabase	Potassic	73.7%	0.0%	26.3%
Martin limestone	Retrograde Hornfels	16.7%	83.3%	0.0%
Martin limestone	Skarn	40.0%	53.3%	6.7%
Cretaceous volcanics & sediments (undifferentiated)	Advanced Argillic	36.4%	45.5%	18.2%
Cretaceous volcanics & sediments (undifferentiated)	Phyllic	70.8%	12.3%	16.9%
Cretaceous volcanics & sediments (undifferentiated)	Propylitic	85.7%	0.0%	14.3%
Quartz eye porphyry	Advanced Argillic	100.0%	0.0%	0.0%
Quartz eye porphyry	Phyllic	75.0%	12.5%	12.5%
Quartz eye porphyry	Potassic	75.0%	25.0%	0.0%
Quartz eye porphyry	Siliceous	100.0%	0.0%	0.0%
Quartzite	Advanced Argillic	100.0%	0.0%	0.0%
Quartzite	Phyllic	100.0%	0.0%	0.0%
Quartzite	Zeolite	100.0%	0.0%	0.0%
Apache Leap Tuff	Unaltered	0.0%	83.3%	16.7%
Overall		63.7%	22.4%	13.9%

* The percentage of the ore body of each rock type are generally: diabase (30%); quartzite (11%); quartz eye porphyry (15%); breccia (19%); Cretaceous volcanics and sediments (26%); Apache Leap Tuff (0%) (see Garrett (2017b)).

Humidity cell testing (a type of kinetic testing) has been conducted for assessing PAG and NPAG material. The kinetic testing is less for identifying the potential for acid generation, but more importantly for estimating specific weathering rates for developing chemical loading terms to be used in the seepage modeling. Humidity cell testing confirmed that samples identified as PAG in Tier 1 testing continued to produce acid leachates over time.

Results of Geochemistry Tests – Tailings

Tailings samples have been produced as part of metallurgical processing investigations and have been characterized for the potential to produce acid. Tailings would be produced in a such a way that part of the production stream would be highly enriched in acid-generating pyrite (the PAG tailings), and the balance would be depleted in pyrite as a result (the NPAG tailings). As summarized by Duke HydroChem LLC (2016), and reported in table 3.7.2-6, as would be expected all the PAG tailings are classified as acid-generating, whereas NPAG tailings are roughly equal parts non-acid generating and potentially acid generating, with a small percentage considered acid generating.

As noted in chapter 2, we received public comments regarding the terminology we used in the DEIS to describe the tailings as strictly either “NPAG” or “PAG”. The concern raised in public comments was that NPAG tailings still have the potential for acid generation, and therefore use of this term is misleading. Indeed, as disclosed in table 3.7.2-6, samples of the tailings we call NPAG are classified roughly as 15 percent acid-generating, 41 percent non-acid generating, and 44 percent potentially acid generating. By contrast, samples of the tailings we call PAG are classified 100 percent as acid-generating.

Table 3.7.2-6. Acid-generation classification of tailings samples

Tailings Type	Acid Generating	Non-acid Generating	Potentially Acid Generating
NPAG tailings (84% of total amount)	15%	41%	44%
PAG tailings (16% of total amount)	100%	0%	0%

As noted in chapter 2, we accept the validity of this concern, but in order to avoid confusion we have chosen to maintain consistent terminology between the DEIS and FEIS, and with the substantial number of documents in the project record that also use NPAG/PAG terminology.

The predictions of the water quality of seepage are based on the results of the entire body of geochemical tests, both static and kinetic, and these predictions are not affected in any way by the terminology used. The primary concern for operational management of the tailings facility is that the anticipated amounts of each tailings stream could differ, leading either to placement of acid-generating tailings in non-optimal locations in the facility for lack of capacity in the PAG cells, or to insufficient cyclone sand from the NPAG stream to build the embankment. The Water Resources Workgroup explored these issues and the resulting analysis found the following (KCB Consultants Ltd. 2020a):

- With respect to availability of cyclone sand, a less-advantageous split of 75 percent PAG was analyzed. The current design (84 percent NPAG/16 percent PAG) would use 67 percent of the available cyclone sand from the NPAG stream to build the embankment. The less-advantageous split would use 86 percent of the available cyclone sand to build the embankment. Adequate cyclone sand is available in either case, demonstrating that a reasonable buffer exists as a contingency. The analysis also noted that in the event of an interruption in cyclone sand availability, other borrow sources are available for material in the interim. One ramification of a deviation from the 84 percent NPAG/16 percent PAG split is that the ability to perform concurrent reclamation could be delayed by 3 to 4 years.
- A 15 percent contingency was built into the overall design for the volume of the PAG cells to account for operational deviations. Since the PAG cells make use of downstream embankments, any variations in material availability would not affect the overall structure and stability of the PAG cells.
- The selection of design parameters (dry densities) tends to underestimate the amount of consolidation that would occur. Anticipated consolidation over time as seepage drains from the tailings storage facility also provides a contingency factor to handle operational volume discrepancies.

Based on public comments, we want to note that while periodic sampling and analysis of tailings is conducted, this sampling is not conducted for the purposes of identifying and segregating high-pyrite material, as might be done with waste rock. Rather, the NPAG and PAG tailings slurry streams will leave the processing plant, travel via pipeline to the tailings storage facility, and be deposited as per the final design. For example, for Alternative 6, the PAG tailings slurry would be deposited directly into the PAG cells, while the NPAG tailings would be cycloned prior to placement. NPAG cyclone underflow (coarse material) would be used for embankment construction and NPAG cyclone overflow (fine material) would be thickened and placed behind the NPAG embankment. Details of the likely tailings operational sampling were explored by the Water Resources Workgroup (Wickham 2020).

3.7.2.4 Environmental Consequences of Implementation of the Proposed Mine Plan and Alternatives

No Action Alternative

Under the no action alternative, seepage would not develop from a tailings facility and contribute to chemical loading in downgradient aquifers or surface waters, and stormwater would not potentially contact tailings, ore, or process areas. Water quality in the block-cave zone and surrounding aquifers would continue to match current conditions.

Impacts Common to All Action Alternatives

EFFECTS OF THE LAND EXCHANGE

The land exchange would have effects on groundwater and surface water quality.

The Oak Flat Federal Parcel would leave Forest Service jurisdiction. The role of the Tonto National Forest under its primary authorities in the Organic Administration Act, Locatable Regulations (36 CFR 228 Subpart A), and Multiple-Use Mining Act is to ensure that mining activities minimize adverse environmental effects on NFS surface resources; this includes water quality. The removal of the Oak Flat Federal Parcel from Forest Service jurisdiction negates the ability of the Tonto National Forest to regulate effects on these resources.

The offered lands parcels would enter either Forest Service or BLM jurisdiction. A number of perennial water features are located on these lands and entering Federal management would offer additional protection for the water quality of these resources.

EFFECTS OF FOREST PLAN AMENDMENT

The Tonto National Forest Land and Resource Management Plan (1985b) provides guidance for management of lands and activities within the Tonto National Forest. It accomplishes this by establishing a mission, goals, objectives, and standards and guidelines. Missions, goals, and objectives are applicable on a forest-wide basis. Standards and guidelines are either applicable on a forest-wide basis or by specific management area.

A review of all components of the 1985 forest plan was conducted to identify the need for amendment due to the effects of the project, including both the land exchange and the proposed mine plan (Shin 2020). A number of standards and guidelines (16) were identified applicable to management of water resources. None of these standards and guidelines were found to require amendment to the proposed project, either on a forest-wide or management area-specific basis. For additional details on specific rationale, see Shin (2020).

EFFECTS OF COMPENSATORY MITIGATION LANDS

None of the activities proposed on the compensatory mitigation lands would impact groundwater or surface water quality. Ground disturbance could generate small amounts of sediment, but standard stormwater controls and best management practices would be in place to minimize these effects. Overall, the riparian improvements would be anticipated to be beneficial to surface water quality in the respective watersheds.

EFFECTS OF RECREATION MITIGATION LANDS

The recreation mitigation lands are not anticipated to affect groundwater and surface water quality. Ground disturbance during trail construction could generate small amounts of sediment, but standard stormwater controls and best management practices would be in place to minimize these effects. In addition, discouraging the haphazard development of unauthorized trails would reduce soil erosion and prevent sediment yield into nearby ephemeral washes and perennial streams such as Arnett Creek and Telegraph Canyon.

SUMMARY OF APPLICANT-COMMITTED ENVIRONMENTAL PROTECTION MEASURES

A number of environmental protection measures are incorporated into the design of the project that would act to reduce potential impacts on groundwater and surface water quality. These are non-discretionary measures, and their effects are accounted for in the analysis of environmental consequences.

- Stormwater controls (described in detail in "Potential Surface Water Quality Impacts from Stormwater Runoff")
- Engineered seepage controls (described in detail under each alternative in "Potential Water Quality Impacts from Tailings Storage Facility")
- Design changes to the pipeline corridor for Alternative 6 now require a trenchless crossing or directional drilling below Mineral Creek, upstream from Government Springs Ranch. Similarly, the Alternative 5 pipeline corridor could require some type of directional drilling under the Gila River. These are standard techniques to avoid surface impacts, with the primary concern to place the pipelines deep enough to avoid scour effects. In both cases, best practices and protection measures would ensure that flows are uninterrupted, no sediment or slurry discharge occurs during construction, and surface waters remain undisturbed (Golder Associates Inc. 2020). There likely would be no surface flow in Mineral Creek at the crossing location; Mineral Creek has been surveyed roughly annually for surface water occurrence since 2008, with flow typically being encountered only downstream of Government Springs Ranch (Montgomery and Associates Inc. 2017d). The potential for pipeline leaks during operation, and the applicant-committed environmental protection measures protective of the environment, are discussed in section 3.10.1.

POTENTIAL GROUNDWATER QUALITY IMPACTS WITHIN BLOCK-CAVE ZONE

Revised Approach for Estimating Post-Closure Block-Cave Water Quality

The DEIS presented two different modeling approaches for estimating potential water quality in the block-cave zone after closure, based on two versions of a water quality model (titled the Eary 2018 and Hatch 2016 models). After receipt of public comments and further review by the Water Resources Workgroup, it became clear that the two models shown in the DEIS were misconstrued by the NEPA team as being representative of post-closure water quality in the block-cave zone. Rather, these two models were both created for a specific purpose: to estimate the load of pollutants entering the West Plant Site from the East Plant Site, during operations. These models largely calculate the same chemical load but differ in how that load is delivered to the West Plant Site. The Hatch 2016 model assumed that all oxidation products associated with the fractured ore were rinsed into the sump water, which would then enter the West Plant Site as part of the process water stream. The later Eary 2018 model assumed that all oxidation products associated with the fractured ore remain with the ore and do not report to the sump, but are instead retained in ore moisture, which would then enter the West Plant Site with the ore. In both cases, the mass of oxidation products is consistent and enters the West Plant Site, ultimately becoming one source that contributes to elevated concentrations of metals in the tailings seepage. Neither of these models are proper analogs for the physical and chemical actions that take place when the block-cave zone is reflooded after closure, and they are no longer discussed in this section.[65]

In lieu of these inappropriate estimates, different and more appropriate methods of estimating post-closure block-cave water quality were identified to disclose impacts (Williamson 2020). Oxygen is anticipated to be present in the unsaturated block-cave zone after closure, but in limited quantities. Some oxygen arrives in groundwater that must travel through overlying caved ore, either from the surrounding aquifer or percolating from the subsidence area at the surface. At the end of mining, oxygen would also be present within the fractured mineralized ore around the draw points, where ventilation actively replenishes oxygen to the extent air flow can reach into the fractured ore body. The distance air flow can penetrate is not known with any certainty, but has been estimated to be from tens to hundreds of feet.

Upon closure, the first flush of water into the block-cave zone releases residual sulfide oxidation products into solution. This first flush of water is anticipated to have poor water quality; however, as the block cave continues to reflood, the initial flush of oxidation products becomes diluted. At the same time, the remnant rock associated with the ore body that contains the most sulfide minerals becomes inundated, effectively limiting oxidation of those minerals. Over time the water quality in the block-cave zone would be anticipated to improve as more and more groundwater enters the zone.

The above mechanisms were simulated with a number of geochemical tests that were intended to replicate the flooding of the block-cave zone. Resolution Copper conducted a number of humidity cell tests to characterize the geochemistry and acid generation potential of mined rock. These are known as “kinetic” tests, as they track the changes over time in the quality of water in contact with ore or rock samples. Humidity cell tests are typically run for at least 20 weeks, and many are run longer.

After humidity cell tests were completed, Resolution Copper converted 14 of the humidity cells into saturated column tests. The saturated column tests were run for 12 weeks (MWH Americas Inc. 2013). The results for all 14 saturated column tests are shown in table 3.7.2-7 and support the conceptual description that the initial reflooding removes most of the oxidation products from oxygenated fractured ore (primarily around the draw points), and then gradually water quality improves. For all the constituents of concern (total dissolved solids, sulfate, selenium, cadmium, antimony, chromium, and copper), the results from the first week of the saturated column test (initial reflooding) are substantially greater than the last week of the humidity cell test. Concentrations then substantially decline by the final week of the saturated column test. Using sulfate as an example, the median sulfate concentration at the end of the humidity cell tests is 360 mg/L. Immediately after reflooding, the median sulfate concentration increases to 1,024 mg/L. By completion of the saturated column test after 12 weeks, the median sulfate concentration has fallen to 42 mg/L.

Uncertainty exists with these—or any—estimates decades or centuries in the future. However, the best available estimates to inform post-closure water quality in the block-cave zone are the final samples from the saturated column tests (May 24, 2010). As shown in table 3.7.2-7, the median concentrations for all constituents are lower than the Arizona numeric aquifer water quality standards. This suggests that long-term post-closure water quality in the block-cave zone may not represent an environmental concern as previously disclosed in the DEIS.

[65] While no longer used to help predict water quality in the block-cave zone after closure, as noted previously the Eary 2018 model is still an important input in the prediction of tailings seepage quality during operations.

Table 3.7.2-7. Anticipated block cave water quality based on saturated column tests

	Conductivity* (µS/cm)	Sulfate (mg/L)	Total acidity (mg/L as $CaCO_3$)	pH	Selenium (mg/L)	Cadmium (mg/L)	Antimony (mg/L)	Total Chromium (mg/L)	Copper (mg/L)
Final sample for humidity cell tests									
RES-001C (SC2, 8/25/09)	1,090	615	<5	7.05	0.001	<0.0005	<0.002	<0.05	<0.05
RES-002A (SC11, 2/10/09)	366	158	137	3.94	0.027	<0.0005	<0.002	<0.05	99.7
RES-002A (SC12, 1/12/10)	742	376	328.96	4.92	0.0055	0.0003	<0.002	<0.3	267
RES-002A (SC14, 8/25/09)	1,860	807	64.48	5.77	0.0166	0.0028	<0.002	0.02	21.2
RES-005I (SC21, 8/25/09)	333	105	107.52	3.63	0.531	0.0002	<0.002	<0.05	13
RES-006D (SC28, 8/25/09)	541	225	237.44	3.76	0.0186	0.0006	<0.002	<0.05	34.1
RES-008A (SC34, 11/17/09)	92	33	<5	–	0.0002	<0.0005	<0.002	<0.05	0.01
RES-009 (SC38, 12/9/08)	47	<10	<5	8.58	<0.0005	<0.0005	<0.002	<0.05	<0.05
RES-009 (SC39, 12/9/08)	112	<10	<5	8.78	0.0018	<0.0005	<0.002	<0.05	<0.05
RES-009E (SC44, 11/17/09)	1,750	567	481.6	–	0.0051	0.0011	<0.002	<0.05	17.3
RES-009E (SC49, 11/4/08)	1,180	668	544	4.31	0.0099	0.0082	<0.002	<0.3	364
RES-009E (SC50, 2/10/09)	919	496	345	4.21	0.0885	0.0082	<0.002	<0.05	230
RES-009E (SC52, 11/4/08)	852	345	<20	8.2	0.0039	0.0002	<0.002	<0.05	0.24
RES-009E (SC54, 1/12/10)	1,240	603	9.76	6.3	0.0025	0.0006	<0.002	0.01	3.42
Median Concentration	797	360.5	86	5.345	0.0053	0.0005	0.002	0.05	15.15
First sample for saturated column tests (3/15/10)									
RES-001C (SC2)	2,140	1,370	<5	7.28	0.0041	0.0002	<0.002	<0.05	<0.05
RES-002A (SC11)	2,200	1,580	1,360	3.26	0.0286	0.0005	<0.01	0.16	864
RES-002A (SC12)	851	477	360.32	5.04	0.009	0.0004	<0.002	0.03	387
RES-002A (SC14)	2,560	1,750	410.68	5.03	0.187	0.0089	<0.002	0.01	192
RES-005I (SC21)	730	335	313.6	3.44	0.426	0.0005	0.0217	0.04	91.3
RES-006D (SC28)	1,380	678	400.96	3.64	0.0262	0.0013	<0.002	0.02	114
RES-008A (SC34)	511	191	<5	7.7	0.0019	0.0004	<0.002	0.02	0.04
RES-009 (SC38)	203	<10	<5	8.45	0.004	<0.0005	<0.002	<0.05	0.04
RES-009 (SC39)	234	13	<5	8.36	0.0097	<0.0005	<0.002	<0.05	0.04

	Conductivity* (µS/cm)	Sulfate (mg/L)	Total acidity (mg/L as $CaCO_3$)	pH	Selenium (mg/L)	Cadmium (mg/L)	Antimony (mg/L)	Total Chromium (mg/L)	Copper (mg/L)
RES-009E (SC44)	3,940	2,010	1,710	2.57	0.0207	0.0086	<0.002	0.1	169
RES-009E (SC49)	3,310	2,490	2,250	3.5	0.0237	0.0364	<0.01	<1	1760
RES-009E (SC50)	148	49	33.4	4.72	0.0485	0.0034	<0.002	0.01	78.6
RES-009E (SC52)	2,380	1,520	<5	8.05	0.0168	0.0016	<0.002	<0.05	0.85
RES-009E (SC54)	2,430	1,460	<5	6.7	0.0104	0.0016	<0.002	<0.05	8.21
Median concentration	1,760	1,024	173.5	5.035	0.01875	0.0009	0.002	0.05	84.95
Final sample for saturated column tests (5/24/10)									
RES-001C (SC2)	1,600	1,020	<5	6.77	0.0013	<0.0005	<0.002	<0.1	0.04
RES-002A (SC11)	232	77	66.08	3.64	0.0034	<0.0005	<0.002	<0.05	2.07
RES-002A (SC12)	185	85	71.44	5.06	0.001	<0.0005	<0.002	<0.05	49.7
RES-002A (SC14)	2,250	1,580	15.36	5.56	0.0022	0.0009	<0.002	<0.1	0.49
RES-005I (SC21)	28	<10	8.84	4.46	0.0255	0.0001	<0.002	<0.05	0.07
RES-006D (SC28)	74	20	26.68	4.61	0.0039	<0.0005	<0.002	<0.05	<0.05
RES-008A (SC34)	56	<10	<5	7.55	0.0002	<0.0005	<0.002	<0.05	<0.05
RES-009 (SC38)	44	<10	<5	8.02	<0.0005	<0.0005	<0.002	<0.05	<0.05
RES-009 (SC39)	99	<10	<5	8.86	0.0036	<0.0005	<0.002	<0.05	<0.05
RES-009E (SC44)	181	63	60.48	3.8	0.0049	0.0001	<0.002	<0.05	1.02
RES-009E (SC49)	106	34	40.24	4.09	0.0013	<0.001	<0.002	<0.05	0.13
RES-009E (SC50)	148	49	33.4	4.72	0.007	0.0002	<0.002	<0.05	<0.05
RES-009E (SC52)	136	10	<5	7.79	0.0015	<0.0005	<0.002	<0.05	0.01
RES-009E (SC54)	2,330	1,350	<5	7.53	0.0009	<0.0005	<0.002	<0.1	0.11
Median concentration	142	41.5	12.1	5.31	0.00185	0.0005	0.002	0.05	0.06
Arizona numeric aquifer water quality standard†	833	250	–	–	0.05	0.005	0.006	0.1	–

Notes: All median values calculated by setting non-detections to the detection limit.

– = No data or standard.

* Conductivity is a surrogate for total dissolved solids; the general rule of thumb is that the concentration of total dissolved solids (in mg/L) is 0.6 times the conductivity measurement (in microsiemens per cm [µS/cm]).

† The standard shown for conductivity is the equivalent of the EPA secondary maximum contaminant limit of 500 mg/L for total dissolved solids, and the standard shown for sulfate represents the EPA secondary maximum contaminant limit of 250 mg/L. All other standards shown are Arizona numeric aquifer water quality standards.

However, appropriate caution needs to be taken with this conclusion. The saturated column tests represent the best estimate of post-closure water quality in the block-cave zone, but they are not perfect analogs of future conditions. First, the water-to-rock ratios in the block-cave zone may be different from those in the bench-scale saturated column tests. Second, the saturated column tests were conducted at room temperature, whereas the in-situ conditions are anticipated to have much higher temperatures. The operations block-cave modeling incorporated a correction factor to scale humidity cell test results upwards to account of the higher anticipated temperatures; no such correction is made for the results of the saturated column tests shown in table 3.7.2-7. Given these uncertainties, while encouraging, the results of the saturated column tests are not definitive.

Sources of Nitrogen for Block-Cave Water Quality

Public comments also requested clarification on how nitrate loads are handled in the block-cave water quality modeling; this was explored by the Water Resources Workgroup (Eary 2020). The primary source of nitrogen for any water leaving the block-cave zone, either as ore moisture or from pumping from the sump, is the use of ammonium nitrate-fuel oil (ANFO) explosive. These explosives produce several types of nitrogen compounds, including nitrate (NO_3) and ammonium (NH_4). Most of the nitrogen is converted to gases during explosions (95 percent); the remainder remains as residual in the ore (5 percent). All of the residual nitrogen is assumed to be leachable and enters the process either with the ore itself or from the sump (roughly 16.5 tons annually). Additional nitrogen is released from the ore during processing (roughly 10.7 tons annually), as well as added from background makeup water from the Desert Wellfield (about 16.4 tons annually). All of these sources contribute to the nitrogen load in the tailings slurry, and ultimately to the tailings seepage.

POTENTIAL FOR SUBSIDENCE LAKE DEVELOPMENT

The Groundwater Modeling Workgroup recognized that three simultaneous events would take place that suggest there could be the potential for the creation of a surface lake on Oak Flat after closure of the mine:

- The subsidence crater would develop. The base case model run indicates the subsidence area would be about 800 feet deep. Most of the sensitivity runs of the subsidence model are similar, although one sensitivity model run reached about 1,100 feet deep (Garza-Cruz and Pierce 2018).
- Groundwater levels would rebound and rise as the aquifer equilibrates after dewatering is curtailed after closure of the mine.
- Block caving would have created a hydraulic connection from the surface to the deep groundwater system and eliminated any intervening layers like the Whitetail Conglomerate that formerly were able to prevent or slow vertical groundwater flow.

In the DEIS, the Groundwater Modeling Workgroup explored the potential for a subsidence lake to form. Ultimately the Forest Service determined that the presence of a subsidence lake was remote and speculative, and as such, it would therefore be inappropriate to analyze in the EIS. For a subsidence lake to form, groundwater levels would have to rebound to an elevation greater than the bottom of the subsidence area. Table 3.7.2-8 summarizes the modeled groundwater levels for the three wells within the area of the subsidence area. The best-calibrated model indicates that after 1,000 years, groundwater levels are still at least 200 feet below the bottom of the subsidence area, and possibly as much as 650 feet below the bottom of the subsidence area. Relative positions of the subsidence area and recovering groundwater levels are shown in figure 3.7.2-4.

Table 3.7.2-8. Comparison of rebounding groundwater levels and subsidence area elevation

Well	Current Land Surface Elevation (from well schematics)	Estimated Elevation of Bottom of Subsidence Area (based on a total crater depth of 800–1,100 feet)	Estimated Water Level Elevation at End of Mining	Estimated Water Level Elevation after 1,000 Years (Best-calibrated Model)	Estimated Water Level Elevation after 1,000 Years (Uncertainty Range)	Elevation of MSD One Portal	Elevation of Never Sweat Tunnel	Elevation of Umbrella Cave
DHRES-01	4,076	3,276–2,976	−2,799	2,666	920–3,460	2,930	3,200	2,992
DHRES-02	3,976	3,176–2,876	−2,798	2,666	920–3,460	2,930	3,200	2,992
DHRES-08	4,120	3,320–3,020	−2,798	2,666	920–3,460	2,930	3,200	2,992

Note: All elevations are given in feet above mean sea level (amsl).

Public comments on the DEIS suggested that while the results shown in table 3.7.2-8 and figure 3.7.2-4 accounted for uncertainty in the subsidence modeling, they did not account for the uncertainty in the groundwater flow modeling. Further analysis was conducted to estimate the possible variability in the recovery rate of groundwater. Extrapolation of the recovery trends for the entire range of modeling suggests that after 1,000 years, groundwater elevations could range anywhere from 920 feet amsl to 3,460 feet amsl.

Most scenarios, including the best-calibrated model, suggest the subsidence lake would only occur in the far future, more than 1,000 years after cessation of mining. There is a scenario presented in table 3.7.2-8 and figure 3.7.2-4 using the upper end of the recovery range that places the groundwater elevation above the bottom of the subsidence area—the necessary condition for a subsidence lake to form. This condition is modeled to occur roughly 900 years in the future. The revised analysis in the FEIS reaches the same conclusions as those in the DEIS: while there are fundamental trends that suggest some day a subsidence crater lake could form, the time frames under all scenarios—at least 900 years in the future—make this occurrence remote and speculative, and it remains inappropriate to analyze the presence of a subsidence crater lake.

POTENTIAL FOR OTHER EXPOSURE PATHWAYS FOR BLOCK-CAVE GROUNDWATER

The Groundwater Modeling Workgroup explored the potential for exposure to block-cave groundwater at the surface other than through a subsidence lake. The Magma Mine workings connect the block-cave zone to the ground surface, and questions arose if the historic workings of the Magma Mine could be a pathway for block-cave groundwater to emerge at the surface. There is also at least one natural cave in the area (Umbrella Cave) that could represent an exposure pathway. Elevations for possible exposure points are shown in table 3.7.2-8.

Ultimately the group determined that block-cave groundwater would not rise to an elevation that would allow it to daylight through the Magma Mine workings, and thus there would be little potential for exposure to block-cave groundwater. The Groundwater Modeling Workgroup determined this based on the following rationale:

- During operations, pumping would dewater the Magma Mine workings. After dewatering ends, collected water in the Magma Mine workings would drain toward the block-cave zone, and not outward.
- The Magma Mine portal that comes to surface at the lowest elevation (MSD One Portal) daylights at an elevation of 2,930 feet amsl. At 1,000 years, this remains over 260 feet above recovered groundwater levels (best-calibrated model).
- A tunnel that drains away from the block-cave zone (Never Sweat Tunnel) intercepts the subsidence area at approximately 3,200 feet amsl. At 1,000 years, this remains over 530 feet above recovered groundwater levels (best-calibrated model).
- Umbrella Cave has an elevation of 2,992 feet amsl and remains over 320 feet above recovered groundwater levels at 1,000 years (best-calibrated model).
- The cone of depression in the aquifer created by the mine dewatering would persist for hundreds of years, creating hydraulic conditions that prevent subsurface flow away from the block-cave zone.
- As with the potential for a subsidence crater lake developing, while there are fundamental trends that suggest some day water exposure could occur through human-made or natural openings, the time frames under all scenarios—at least 900 years in the future—make this occurrence remote

and speculative, and it remains inappropriate to analyze the future exposure to block-cave water through human-made or natural openings.

The relative positions of the subsidence area, other potential exposure points, and the modeled rise of groundwater levels is shown in figure 3.7.2-4.

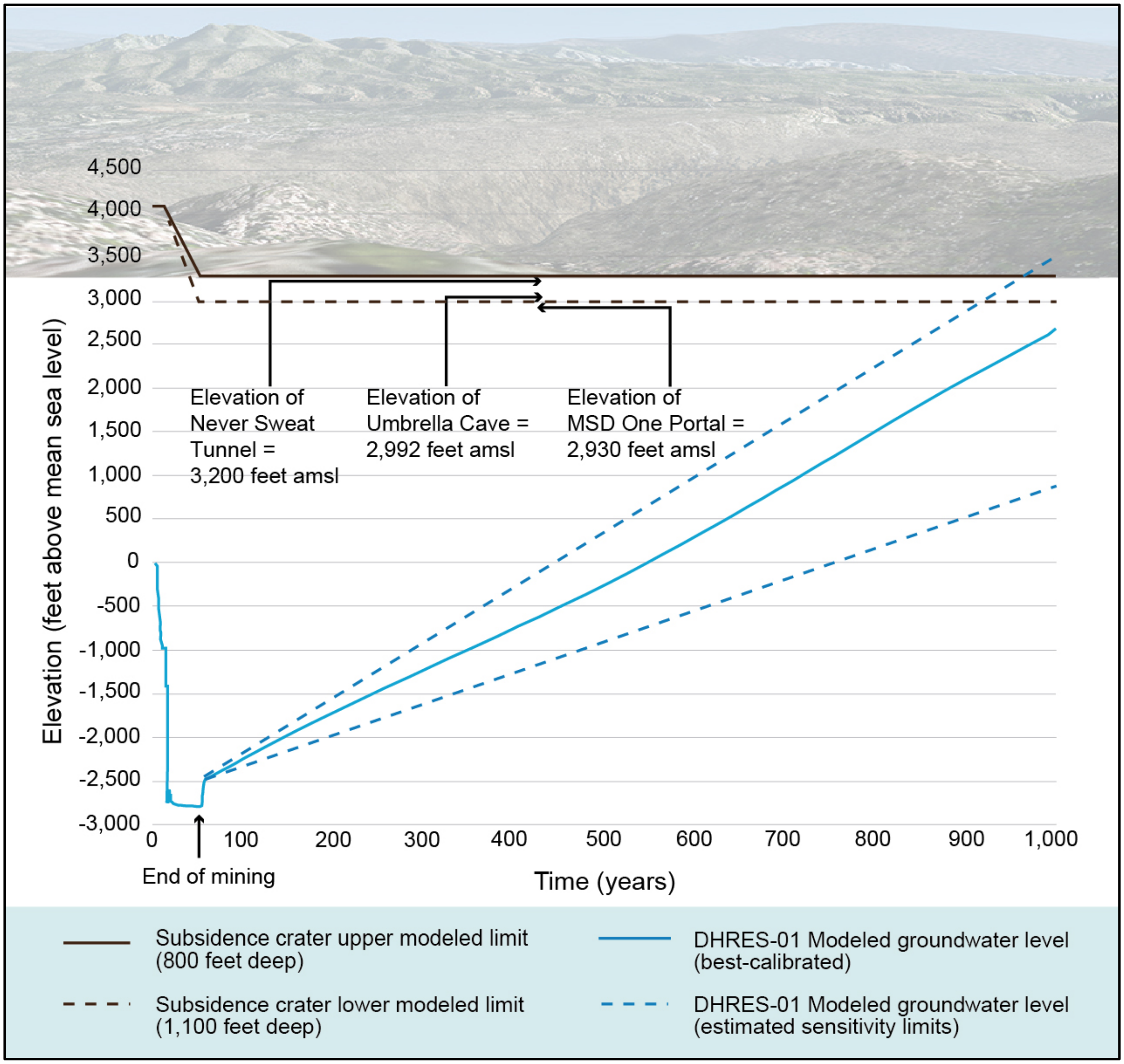


Figure 3.7.2-4. Potential for subsidence lake and other points of exposure of block-cave water

Possible Water Quality Outcomes from a Subsidence Lake

While the fundamental processes needed to create a subsidence lake are reasonably foreseeable—rebounding water levels, subsiding ground surface, fracturing of intervening geological layers—the relative elevations based on the modeling conducted does not support that these processes would come together in a way that would actually create a lake within the subsidence area.

Similarly, if a lake developed, it is not possible to predict the details that would be necessary to conduct even a rudimentary analysis of effects. For instance, the depth of the lake cannot be known with any accuracy. That single parameter would affect both the amount of inflow of native groundwater and the amount of evaporation that would occur from the lake surface, and it is the interplay of these two parameters that largely determines how constituents would concentrate in the lake and whether the ultimate water quality would be hazardous to wildlife.

Formation of a lake is speculative, but some context can be provided for the possible water quality in the subsidence lake. Water quality for the basic inputs is generally known, even if the relative amounts, how they would mix, and what evaporation would take place are not known. Representative values are shown in table 3.7.2-9, with comparison to Arizona surface water standards for wildlife. The broad conclusion that can be drawn is that if a subsidence lake were to form, a potential exists for concentrations above Arizona surface water standards, particularly copper. However, the potential also exists for water quality to be acceptable. These represent the bounds of possible outcomes.

Table 3.7.2-9. Representative values of possible subsidence lake water sources (mg/L)

Constituent	Apache Leap Tuff Groundwater (see appendix N)	Deep Groundwater (see appendix N)	Block-Cave Sump Geochemistry at Closure (see table 3.7.2-1)	Precipitation*	Surface Water Quality Standard†
Total dissolved solids	248	609	1,528	10–20	–
Sulfate	18	245	934–2,247	2.2	–
Antimony	Non-detect	Non-detect	0.0047–0.035	Non-detect	0.030
Cadmium	Non-detect	Non-detect	0.0008–0.19	Non-detect	0.00068–0.0062
Selenium	Non-detect	Non-detect	0.0051–0.5	Non-detect	0.002
Copper	0.01	0.09	0.0148–141	Non-detect	0.0023–0.0293
Nitrate	0.50	0.43	Not modeled	0.27–1.05	–
Hardness (as $CaCO_3$)	125	338	851–1,690	4	–

* Carroll (1962); Root et al. (2004); metal loads in precipitation are assumed to be insignificant for comparison.

† For comparison, the standard for Aquatic and Wildlife-Warmwater, chronic exposure is shown. Where hardness is required to calculate the standard, a range is shown. Antimony, cadmium, and copper standards are for dissolved concentrations, selenium is for total concentrations. Model data are not specific to total or dissolved fractions; for the purposes of comparison to surface water standards it can be assumed to apply to both.

POTENTIAL SURFACE WATER QUALITY IMPACTS FROM STORMWATER RUNOFF

Stormwater Controls and Potential for Discharge of Stormwater

Construction and Operation Phases

Stormwater control measures for each alternative are described in Newell and Garrett (2018d). During construction, temporary sediment and erosion controls would be implemented as required under a stormwater permit issued by ADEQ. These controls would include physical control structures as well as best management practices. Physical control structures could include diversions, berms, sediment traps, detention basins, silt fences, or straw wattles. Best management practices could include limiting vegetation removal, good housekeeping, proper material storage, and limiting ground disturbance. Stormwater control measures are generally kept in place until disturbed areas are stabilized either through revegetation or by permanent constructed facilities.

Generally speaking, during operations any precipitation or runoff that comes into contact with tailings, ore, hazardous material storage areas, or processing areas is considered "contact water." During operations contact water would be captured, contained in basins, pumped out after storm events, and recycled back into the process water stream. This type of containment would be required by both the stormwater and aquifer protection permits that would be issued for the project. Contact water would not be released to the environment at any time during operations.

There are areas of the West Plant Site and filter plant and loadout facility that are undisturbed or contain only ancillary facilities. Stormwater from these areas is considered "non-contact" stormwater. In many cases, upstream runoff would be diverted around the project facilities to prevent the stormwater from becoming contact water and would be allowed to continue flowing into downstream drainages. Non-contact stormwater would be allowed to leave the property.

The tailings storage facility generally follows the same strategy during operations. For all alternatives, runoff from upstream of the facility would be diverted around the facility to prevent any contact with tailings. For Alternatives 2, 3, 5, and 6, any precipitation falling within the facility would run into the recycled water pond, and any runoff from the external embankments would be routed to the downstream seepage collection ponds, then pumped back and recycled into the process water stream. For Alternative 4, with filtered tailings, the tailings surface is designed to minimize ponding, and all contact water would be routed to downstream seepage collection ponds. As with the other alternatives, the water from the Alternative 4 seepage collection ponds would be pumped back and recycled in the process water stream; however, with Alternative 4, the water quality running off of the PAG tailings facility may be such that it requires further treatment prior to reuse.

Closure and Post-closure Phases

With respect to stormwater, the goal upon closure is to stabilize disturbed areas, minimize long-term active management, and return as much flow as possible to the environment. This is readily accomplished at the East Plant Site, West Plant Site, and filter plant and loadout facility once facilities are demolished and removed, and the sites are revegetated. Closure details for these areas are included in sections 6.5, 6.6, 6.8, and appendix Y of the GPO (Resolution Copper 2016c).

The tailings storage facility represents a more complex closure problem, regardless of alternative. The specific goals of closing the tailings storage facility are as follows:

- Develop a stable landform
- Develop a stable vegetated cover that limits infiltration and protects surface water quality by preventing contact of stormwater with tailings
- Minimize ponded water on the closed tailings surface
- Limit access of oxygen to PAG tailings to prevent oxidation of pyrite materials (acid rock drainage)
- Protect the reclaimed surface against wind or water erosion
- Provide a growth medium for vegetation to establish and be sustained in perpetuity

Closure of the tailings facilities for Alternatives 2, 3, 5, and 6 is a long-term phased process that involves gradually reducing the size of the recycled water pond and then encapsulating the PAG tailings with NPAG tailings. Eventually the tailings embankments and top surface of the facility are given a soil cover with a thickness of at least 1 to 2 feet and revegetated. Stormwater conveyance channels and armoring would be used where appropriate to protect the reclaimed surface. Once surfaces are covered and stable, stormwater could be allowed to discharge downstream if water quality meets release criteria.

For some time after closure, the seepage collection ponds would be maintained downstream of the tailings storage facility to collect drainage from the facility. This time could vary from years to decades, depending on the alternative. There would be no discharge from the collection ponds to downstream waters, neither seepage nor stormwater that collects within the ponds. For some time the recycled water pond would still exist within the tailings facility, and during this time collected water in the seepage ponds could be pumped back to the recycled water pond for evaporation. Once the recycled water pond disappears, the seepage collection ponds are designed to be large enough to evaporate any collected seepage and stormwater. The seepage collection ponds are meant to stay in place until all water reporting to the ponds is of adequate quality to allow discharge downstream.

Closure of the filtered tailings facility (Alternative 4) is similar but simplified by the lack of any recycled water pond. Instead, all surfaces of the PAG and NPAG facilities would be given a soil cover and revegetated. Stormwater from upstream in the watershed would be diverted around the facilities in perpetuity, and once surfaces are covered and stable, stormwater from the facilities could be allowed to discharge downstream as well if water quality meets release criteria.

For some time after closure (estimated to be about 5 years), the seepage collection ponds for Alternative 4 would be maintained downstream of the tailings storage facility. The seepage collection ponds are meant to stay in place until all water reporting to the ponds is of adequate quality to allow discharge downstream. Unlike Alternatives 2, 3, 5, and 6, any excess water in the seepage collection ponds during closure cannot be pumped back to a recycled water pond; these ponds therefore could require active water treatment. In the long term, the ponds are designed to be large enough to evaporate any collected seepage and stormwater.

The potential for ponds to impact wildlife is assessed in section 3.8.4.2.

Summary of Stormwater Controls

Under normal conditions, at no point during construction, operation, closure, or post-closure would stormwater coming into contact with tailings, ore, or processing areas be allowed to discharge downstream. After closure, precipitation falling on the tailings facilities would interact with the soil cover, not tailings. The seepage collection ponds represent a long-term commitment for managing seepage and stormwater, but eventually would either become passive systems fully evaporating collected water, or would be removed after demonstrating that collected water is of adequate quality to discharge.

Stormwater mixes with collected seepage in collection ponds and some would be lost to the environment; this occurrence is incorporated into the bypass seepage mixing/loading model.

Predicted Quality of Stormwater Runoff and Potential Release Scenario

Predictions of Stormwater Runoff Quality

The quality of stormwater runoff from tailings and the soil cover can be predicted in several ways. In the aquifer protection permitting process, ADEQ often relies on a test called the synthetic precipitate leaching procedure (SPLP). This test measures contaminants in a slightly acidic water solution that has interacted with a rock or tailings sample. One drawback of relying solely on the SPLP test is that it is usually conducted only using fresh core or lab-created tailings samples that have not weathered. By contrast, in reality, precipitation could interact with embankment tailings that could have been weathering for years or decades.

Two additional methods reflect the water quality from interaction with weathered materials. As part of the geochemical characterization activities, Resolution Copper conducted a series of “barrel” tests, in which barrels of material were left exposed to natural precipitation over the course of several years.
The resulting leachate from the barrels was periodically collected and analyzed. Numerous humidity cell tests also were run for long periods of time. These tests involve periodic exposure of samples to water over many weeks, even years. An estimate of the potential runoff water quality from PAG and NPAG tailings was produced, drawing on the results of these various geochemical tests (Eary 2018g). Runoff from NPAG tailings was calculated by combining the results of 12 humidity cell tests conducted on tailings samples representing different lithologies. Potential runoff water quality from PAG tailings (applicable to Alternative 4 only) was estimated from barrel tests conducted on filtered PAG tailings (specifically Barrel #3), supplemented with results from barrel tests conducted on paste PAG tailings (specifically Barrel #1).

Resolution Copper also sampled natural runoff quality, specifically during a storm event in February 2018 in the vicinity of the Near West location (specific to Alternatives 2 and 3).

Water quality results for SPLP tests, Resolution Copper estimates of runoff quality, and natural runoff are shown in table 3.7.2-10 and compared with the surface water quality standards for the most restrictive use.[66]

All methods of estimating stormwater runoff quality suggest that both NPAG and PAG tailings may have concentrations of some constituents that are above Arizona surface water standards. As stated above, this stormwater would not be discharged to the environment at any time; the results shown in table 3.7.2-10 reinforce the need for requiring stormwater controls during operations. Post-closure runoff water quality, after the soil cover is in place and revegetated, should be similar to natural runoff water quality and concentrations above surface water quality standards would not be anticipated.

Potential Stormwater Release Scenario

Stormwater contacting tailing would not be released downstream during normal operations. However, based on public comments, we explored the possibility of a more extreme event causing release of contact stormwater during operations, focused on Alternative 6 – Skunk Camp (Preferred Alternative) (Resolution Copper 2020f).

[66] Surface water quality standards are difficult to succinctly summarize, as the standards vary by specific designated use of the water body and in some cases vary by hardness of the water. For reference, table N-5 in appendix N summarizes all surface water standards for water bodies in the area, as well as aquifer water quality standards.

Table 3.7.2-10. Predicted stormwater runoff water quality (mg/L)

	Estimated Runoff Water Quality from NPAG Tailings (Alternatives 2, 3, 5, 6)*	Estimated Runoff Water Quality from PAG Tailings (Alternative 4)*	Water Quality Measured in Natural Runoff[†]	SPLP Results for NPAG Tailings[‡]	SPLP Results for PAG Tailings[‡]	Surface Water Standard for Most Restrictive Use (Gila River or Queen Creek)	Surface Water Standard for Most Restrictive Use (Ephemeral Tributaries)
Regulated Constituents							
Antimony	0.00073	0.00062	0.00027	<0.003	<0.003	0.030	0.747
Arsenic	0.00016	**0.576**	0.0052	<0.003	<0.003	0.030	0.280
Barium	0.0128	0.208	0.0128	0.0122	0.0275	98	98
Beryllium	0.0022	**0.192**	0.0005	<0.002	<0.002	0.0053	1.867
Boron	0.0028	0.104	0.03			1	186.667
Cadmium	0.00097	**0.106**	0.000019	<0.0002	<0.0002	0.0043	0.2175
Chromium, Total[§]	0.00036	**9.107**	0.00095	<0.006	<0.006	0.011	–
Copper	**9.81**	**3,294**	0.012	<0.01	<0.01	0.0191	0.0669
Fluoride	0	**424.6**	0.13	1.25	0.61	140	140
Iron	0.177	**5,353.8**	0.0225	<0.06	<0.06	1	–
Lead	0.00026	0.**0095**	0.0001	**0.0115**	<0.003	0.0065	0.015
Manganese	0.693	**43**	0.017	0.0106	0.0313	10	130.667
Mercury				**<0.0002**	**<0.0002**	0.00001	0.005
Nickel	0.**112**	**26.39**	0.0013			0.1098	10.7379
Nitrate	0	0	3.1			3733.333	3733.333
Nitrite						233.333	233.333
Selenium	**0.0088**	**0.322**	0.00027	**<0.003**	**0.0043**	0.002	0.033
Silver	0.000006	**1.78**	0.000018	<0.005	<0.005	0.0147	0.0221
Thallium	0.00008	**0.0177**	0.000015	<0.001	<0.001	0.0072	0.075
Uranium				<0.001	<0.001	2.8	2.8
Zinc	0.171	**17.29**	0.0015	<0.01	<0.01	0.2477	2.8758
pH	**5.48**	**2.13**	7.59	6.53	6.72	6.5–9.0	6.5–9.0

	Estimated Runoff Water Quality from NPAG Tailings (Alternatives 2, 3, 5, 6)*	Estimated Runoff Water Quality from PAG Tailings (Alternative 4)*	Water Quality Measured in Natural Runoff†	SPLP Results for NPAG Tailings‡	SPLP Results for PAG Tailings‡	Surface Water Standard for Most Restrictive Use (Gila River or Queen Creek)	Surface Water Standard for Most Restrictive Use (Ephemeral Tributaries)
Constituents without Numeric Standards							
Sulfate	264	28,452	6.8	229	115	–	–
Total Dissolved Solids	–	–	–	294	186	–	–

Notes:

See appendix N, table N-5, for details regarding the water quality standards used in this table.

All values shown in milligrams per liter. Shaded cell and bolded text indicate concentrations above at least one water quality standard.

For all analyses, values below the laboratory detection limit are calculated as equal to the detection limit (except for SPLP, which are based on single samples). There are other valid methods that could be used, such as using a zero value, or more commonly, using half the detection limit. Because surface water standards for some constituents—particularly mercury—can be extremely low, it is important to use the detection limit when looking at non-detect results. To use any lower value could yield results that meet the water quality standard, even when the detection limit was actually too high to draw this conclusion.

Some water quality standards for metals are specific to total recoverable metals or dissolved metals. Predicted results are compared with standards regardless of whether the standard specifies total or dissolved.

* From Enchemica, Common Inputs Memorandum, 7/18/18, table 3-4 (Eary 2018g).

† From Enchemica, Common Inputs Memorandum, 7/18/18, table 3-2; from stormwater samples collected at Near West location (Eary 2018g).

‡ NPAG results taken from "7/7A 7C Scavenger" sample from Verberg (2007); PAG results taken from "7/7A 7C Cleaner" sample from Verberg (2007).

§ Standard shown for chromium is for hexavalent chromium, which is the most restrictive of the three chromium standards (total chromium, trivalent chromium, and hexavalent chromium).

The overall components of the stormwater controls for Alternative 6 are as follows:

- Precipitation falling on about 8,000 acres of the watershed would be diverted away from the tailings storage facility before it contacts any tailings and would be routed downstream to Dripping Spring Wash. These diversion controls are sized for the 100-year, 24-hour peak flow or volume, without assuming any auxiliary pumping of water to the recycle water pond. If the diversion controls were to fail completely or in part, the overflow would report to the tailings storage facility.
- Precipitation falling on about 7,000 acres of the watershed, including the top of the tailings storage facility itself, would report during operations to the NPAG or PAG cells and eventually be pumped into the recycle water pond. Each area of the tailings storage facility (the PAG cell, NPAG beach) is sized to hold the 72-hour Probable Maximum Flood; importantly, this sizing also assumes that no upstream diversion takes place (i.e., the diversion controls fail).
- Precipitation falling on about 1,200 acres of the watershed below the tailings embankment would be diverted away from the seepage collection pond before it contacts any tailings or seepage and would be routed downstream to Dripping Spring Wash. These diversion controls are sized for 100-year, 24-hour peak flow. If the diversion controls were to fail completely or in part, the overflow would report to the seepage collection pond.
- Precipitation falling on about 800 acres—primarily on the exposed face of the main tailings embankment—would report to the seepage collection pond. The seepage collection pond is sized to hold the operational volume, 15 feet of upset contingency, an additional 5 feet of freeboard, and the 200-year, 24-hour storm volume, without assuming any auxiliary pumping of water to the recycle water pond (i.e., pumps fail). Importantly, the seepage collection pond includes an emergency spillway, and overflow from the emergency spillway would report downstream to Dripping Spring Wash. We explored this potential for release of contact stormwater through the emergency spillway and into Dripping Spring Wash.

For this scenario to occur, the seepage collection pond would need to be not just operating at full capacity, but in an upset condition where pumps have been shut down and are still inoperable (including any redundant pumping systems), at which time a runoff event greater than the 200-year, 24-hour storm occurs. The probability of these events occurring and the anticipated outcomes are shown in table 3.7.2-11.

Table 3.7.2-11. Results of potential stormwater release scenario

Return Period of Storm Event	Annual Exceedance Probability of Storm Event	Probability of Storm Event Occurring over Life of Mine (41 years)	Scenarios Resulting in Release over Spillway	Maximum Discharge from Spillway (acre-feet)	Total Storm Volume Reporting to Gila River (acre-feet)	Release Scenarios with Concentrations above Arizona Numeric Surface Water Quality Standards*
1 in 300 years	0.33%	13%	1-day storm; full upset conditions	40	26,770	1 of 1
1 in 400 years	0.25%	10%	1-day storm, full and partial upset conditions; 7-day storm, full upset conditions	90	31,250	2 of 4

Return Period of Storm Event	Annual Exceedance Probability of Storm Event	Probability of Storm Event Occurring over Life of Mine (41 years)	Scenarios Resulting in Release over Spillway	Maximum Discharge from Spillway (acre-feet)	Total Storm Volume Reporting to Gila River (acre-feet)	Release Scenarios with Concentrations above Arizona Numeric Surface Water Quality Standards*
1 in 500 years	0.2%	8%	1-day and 7-day storms, full and partial upset conditions; 3-day storm, full upset conditions	130	36,360	4 of 7
1 in 1,000 years	0.1%	4%	1-, 3-, and 7-day storms; full and partial upset conditions	260	59,890	9 of 9

* Release scenarios include different upset conditions and flood scenarios for any given storm event; full upset conditions mean that the initial depth of water in the seepage control pond is at 15 feet prior to the storm, and partial upset conditions mean that the initial depth of water in the seepage control pond is at 5 or 10 feet prior to the storm.

For all storm events with a return period greater than 300 years, releases could occur under some operational conditions that would result in concentrations in Dripping Spring Wash greater than the Arizona numeric surface water quality standards. In all cases these concentrations are restricted to the area immediately downstream of the seepage collection pond. Due to the large amount of dilution from the contributing watershed that occurs during large storm events, all concentrations fall below standards at the confluence of Dripping Spring Wash with Silver Creek (about 6 miles downstream).

EFFECTIVENESS OF SUBAQUEOUS DEPOSITION AT PAG CELLS TO CONTROL OXYGEN INGRESS

The Resolution Copper tailings storage facility designs—with the exception of the filtered tailings facility associated with Alternative 4—all use the concept of depositing the PAG tailings below a water cover during operations in order to limit oxygen ingress and therefore control potential oxidation that would increase the dissolved metal load in tailings seepage. Some public comments question whether this technique would be feasible and effective in a climate like Arizona.

The Water Resources Workgroup undertook further investigation of this issue, including review of case studies and analog locations, and industry guidance and best practices (Enos 2020). In general, subaqueous disposal represents an industry-tested approach for managing tailings, effective at suppressing sulfide mineral oxidation and elevated metals concentrations. The key to the effectiveness of this approach hinges on maintaining a minimum water depth. The project water balance for the alternatives indicates that sufficient water would be available, but this anticipated water availability would need to be borne out during operations. The analysis also found that while there are many case examples demonstrating that water covers are effective, there are no current examples in arid environments, like the desert of the southwestern United States, that match the climate and scale of the Resolution Copper Project.

POTENTIAL FOR SEEPAGE CAUSING CHANGES IN SURFACE WATER REGIME

Public comments suggested that the addition of tailings seepage to the aquifer could result in a groundwater mound, potentially causing stream reaches that are currently ephemeral to instead become perennial. If this occurred, it would represent a new point of potential exposure to tailings seepage. This was explored by the Water Resources Workgroup. Estimates of the magnitude of seepage compared to the aquifer capacity suggest mounding will not be substantial.

- For Alternatives 2, 3, and 4, the estimated subsurface flow in the Queen Creek alluvial aquifer is about 575 acre-feet (Gregory and Bayley 2018e). The amount of tailings seepage (after seepage controls) is from 2.7 acre-feet (Alternative 3) to 20.7 acre-feet (Alternative 2). This increase (0.5 to 3.5 percent) is unlikely to fundamentally change the ephemeral nature of Queen Creek (Newell and Garrett 2018d).
- The Alternative 5 design has a pumpback system designed specifically to maintain the capacity of the aquifer to accept flow; by definition, this design ensures that groundwater levels do not rise to the land surface and become surface flow.
- For Alternative 6, the refined numeric groundwater flow modeling demonstrates directly that groundwater mounding does not occur (Montgomery and Associates Inc. 2020c).

POTENTIAL FOR IMPACT TO PUBLIC WATER SUPPLIES

Public comments raised concerns about changes in groundwater or surface water quality impacting public water supplies. Specific public waters supplies identified in our analysis include the Arizona Water Company water systems at Apache Junction, Superior, Winkelman, and Pinal Valley, and the public water supply (groundwater and surface water) in Queen Valley.

The Arizona Water Company systems for Apache Junction, Superior, and Pinal Valley are located in the East Salt River valley. There are no anticipated discharges associated with any alternatives that would impact the quality of these water supplies.

The Arizona Water Company Winkelman system—and other public water supplies—are located on the Gila River downstream from Alternative 6 – Skunk Camp. The Gila River also provides water to other downstream water users below both Alternative 5 – Peg Leg and Alternative 6 – Skunk Camp. The potential to impact these water supplies is disclosed under those alternatives. Similarly, potential impacts to Queen Valley water supplies are discussed under Alternatives 2, 3, and 4 (see "Ramifications on Downstream Water Users" section under each alternative).

These disclosures focus on the potential for discharges from the project—primarily tailings seepage—to impact downstream water supplies. Note that risks to water supplies in the event of a failure of the tailings storage facility are assessed in Section 3.10.1, Tailings and Pipeline Safety.

Alternative 2 – Near West Proposed Action

POTENTIAL WATER QUALITY IMPACTS FROM TAILINGS STORAGE FACILITY

Seepage Controls Incorporated into Design

A tailings storage facility creates seepage. Total seepage is all water that drains from the tailings storage facility by gravity. Lost seepage is seepage that is not recovered with the engineered seepage controls. Lost seepage is assumed to discharge to the environment.

The design of engineered seepage controls for each alternative has been approached in stages.
For Alternatives 2 and 3:

- Level 0: Controls that are inherent in the design of the embankment itself and required for stability, but also function to control seepage.
- Level 1: A suite of engineered seepage controls always envisioned to be part of the design, that served as the starting point for the seepage modeling.

- Levels 2–4: These represent additional layers of engineered seepage control considered during the design process in order to reduce seepage to meet water quality objectives. Some of these controls would have to be built into the facility from the start, such as low-permeability liners for the PAG tailings. Others are expected to be necessary but can be implemented if real-world observations indicate existing seepage controls are not sufficient, such as downstream grout curtains and additional seepage collection ponds.

The following describes the various engineered seepage controls assessed in the Alternative 2 alternative design, and table 3.7.2-12 summarizes how these are expected to be applied. A conceptual diagram of the seepage controls is shown in figure 3.7.2-5. The initial suite of engineered seepage controls includes blanket and finger drains, foundation treatment, and downstream seepage collection dams and pumpback wells.

- Primary seepage control measures for stability (Level 0) include blanket and finger drains built into the facility. Sand and gravel blanket drains are required beneath the cyclone sand embankment; the blanket drain was modeled as a 3-foot-thick, highly conductive layer consisting of coarse gravel that drains the embankment and conveys seepage to the seepage collection ponds downstream of the facility. Finger drains would also collect water from beneath the tailings and convey it beneath the starter dam via a series of lined channels to the seepage collection ponds. Finger drains were modeled as channels 10 feet thick by 30 feet wide, and filled with highly conductive coarse gravel, following the topography of the existing alluvial tributaries.
    - Enhancements: For Level 1 controls, the blanket drain was expanded further beneath the facility to increase seepage control, ultimately extending 200 feet upstream.
- The foundation would be treated during construction to reduce seepage and encourage flow into the drain system. Foundation treatment can include a variety of techniques such as dental concrete,[67] cut-offs, grouting, or engineered low-permeability layers such as compacted fine tailings, engineered low-permeability liners, asphalt, slurry bentonite, and/or cemented paste tailings. Specific treatments would be designed based on real-world conditions encountered during site preparation. For the purposes of the alternative design, it is assumed that engineered low-permeability layers would be used with geological units with relatively higher conductivities (Tertiary perlite, Tertiary tuff, and Precambrian Apache Group units) that underlie approximately one-third of the tailings footprint.
    - Enhancements: For Level 1 controls, the full starter PAG cell was assumed to be underlain by an engineered low-permeability layer. For Level 4 controls, this was expanded to the entire PAG cell.
- Eleven primary seepage collection dams with associated seepage collection ponds would be constructed in natural valleys downstream of the cycloned sand embankment. All alluvial soil underneath the crest of the seepage collection dams would be excavated until competent foundation material is reached. Dams are then covered on the upstream side with an engineered low-permeability layer and built with grouted cut-off walls to help intercept subsurface flow. Pumpback wells would be installed upstream of the grout curtain and would return seepage to the recycled water pond.
    - Enhancements: Under Level 1 controls, grout curtains were expanded to 100-foot depth. Under Level 2 controls, grout curtains were expanded to the bedrock ridges between seepage collection dams and any high-permeability zones.

[67] "Dental concrete" is conventional concrete that is used to shape surfaces and fill irregularities, much like filling a cavity in a tooth.

Table 3.7.2-12. Effectiveness of Alternative 2 engineered seepage controls

Seepage Control Levels and Components	Uncaptured Seepage from Facility	Source
Uncontrolled seepage from tailings facility	2,132 acre-feet/year	Groenendyk and Bayley (2018b) and Klohn Crippen Berger Ltd. (2018a)
Level 0 (seepage controls for geotechnical stability)		
- Modified centerline cyclone sand embankment - Blanket drain under embankment; finger drains	Not explicitly modeled; incorporated into Level 1 modeling	
Level 0–1		
- Blanket drain extends into facility under NPAG beach; finger drains (blanket/finger drains account for roughly 88% of seepage collected) - Seepage collection ponds with pumpback wells and cut-off walls	194 acre-feet/year	Groenendyk and Bayley (2018a)
Level 1		
- Blanket drain extends 200 feet into facility - Foundation treatment and selected areas of engineered low-permeability layers, for all areas not Gila Conglomerate - Engineered low-permeability layer for starter PAG facility - Seepage collection ponds with pumpback wells, cut-off walls, and grout curtain to 100-foot depth	Not explicitly modeled; incorporated into Level 4 modeling	N/A
Level 2		
- Grout curtain extended to target high-permeability zones and seepage pathways	Not explicitly modeled; incorporated into Level 4 modeling	N/A
Level 3		
- Add second perimeter of seepage collection ponds downstream	Not explicitly modeled; incorporated into Level 4 modeling	N/A
Level 4 (includes Levels 0 through 4)		
- Add pumpback wells, cut-off walls, and grout curtains to second perimeter of seepage collection ponds - Engineered low-permeability layer for entire PAG cell - Downgradient grout curtain extending to 100-foot depth - Additional pumpback wells in targeted areas to maximize capture	20.7 acre-feet/year†	Groenendyk and Bayley (2019)
- For comparison: fully lined facility (3,300 acres)*	792 acre-feet/year	Rowe (2012)

* See Newell and Garrett (2018d) for details of calculations; assumes 1 foot of head over liner.

† Initial estimate of post-closure seepage based on infiltration of precipitation was 17 acre-feet per year; post-closure seepage was later changed to match operational seepage of 20.7 acre-feet per year.

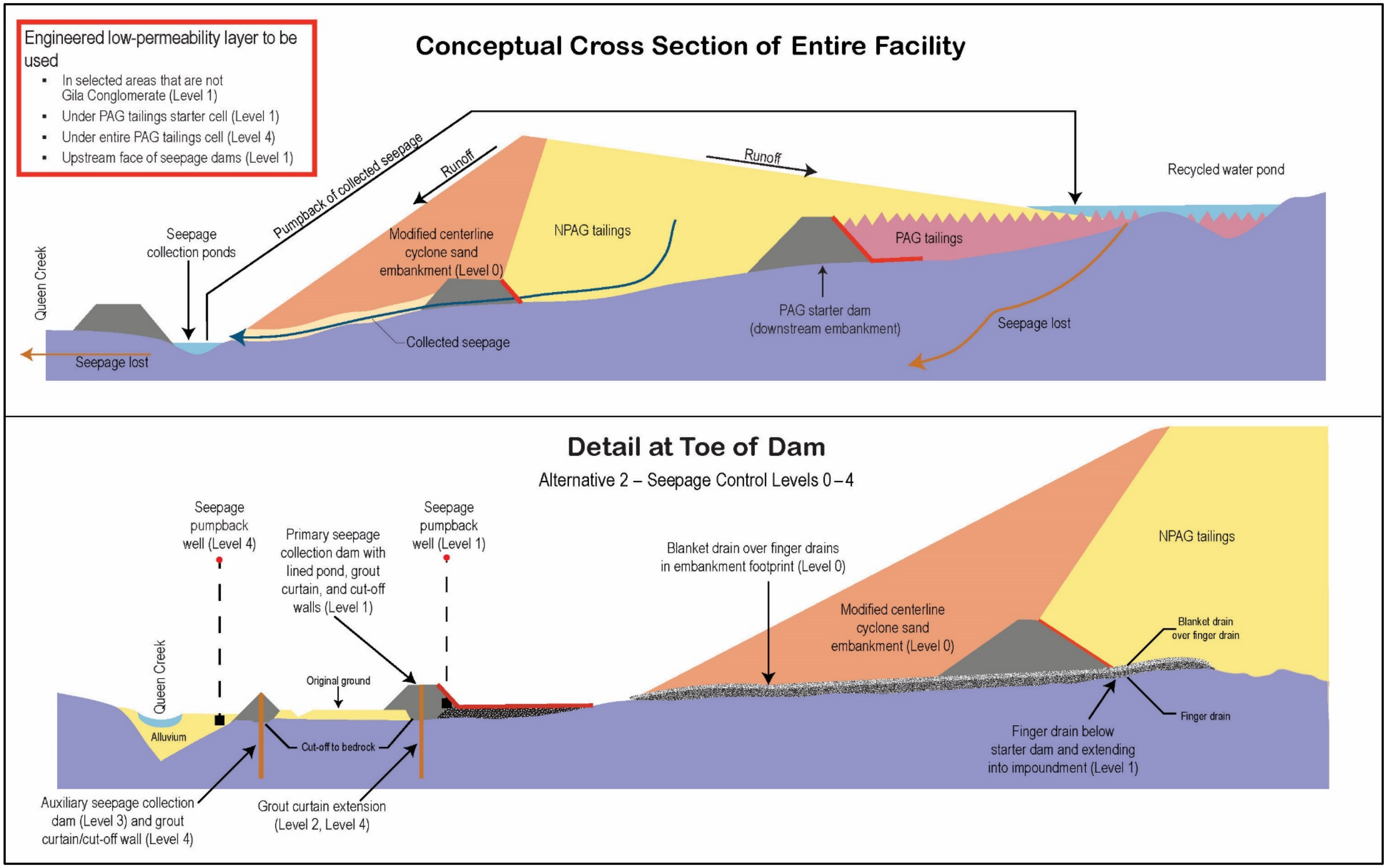


Figure 3.7.2-5. Alternative 2 seepage controls

In addition to the basic suite of engineered controls, three additional concepts were brought into the design for further seepage control:

- Five auxiliary seepage collection dams would be constructed downstream of the primary seepage collection dams (Level 3). These could be further enhanced with pumpback wells, cut-off walls, and grout curtains (Level 4).
- A 7.5-mile-long and 100-foot-deep grout curtain would be installed downgradient of the tailings facility (Level 4).
- Twenty-one auxiliary pumpback wells would be installed beyond the grout curtain with depths of approximately 200 feet, wherever deemed useful (Level 4).

Anticipated Effectiveness of Seepage Controls

Total seepage was estimated during the initial design phase using a one-dimensional, unsaturated flow model (Klohn Crippen Berger Ltd. 2018a). Total seepage estimates start with a water balance calculation of flow through the tailings during full buildout, based on assumptions about weather (precipitation and evaporation), consolidation, and area and depth of the tailings.

A three-dimensional groundwater flow model was then used to model the amount of this total seepage that would be captured by various engineered seepage controls, leaving some amount of lost seepage to enter the environment downgradient (Groenendyk and Bayley 2018b, 2019).

During operations, total seepage created by the tailings was estimated at 2,132 acre-feet per year (1,912 and 220 acre-feet per year of NPAG and PAG seepage, respectively) and lost seepage was modeled to be 194 acre-feet per year with Level 1 seepage controls, and 21 acre-feet per year with all enhanced engineered seepage controls (Level 4).

Modeling indicates the Level 4 seepage controls would reach a seepage capture efficiency of 99 percent. Most of this seepage is captured by blanket and finger drains (88 percent).

Risk of Seepage Impacting Groundwater or Surface Water Quality

Modeled results for groundwater and surface water impacts are reported by Gregory and Bayley (2019). The detailed results of the bypass seepage mixing/loading model were supplied as an Excel spreadsheet, and can be found in Garrett (2019d). Table 3.7.2-13 presents model results for all modeled chemical constituents in the first groundwater cell along Queen Creek (cell QC-3)[68] and the ultimate, final surface water cell (Queen Creek at Whitlow Ranch Dam), for model years 41, 100, and 245.[69] This provides perspective on trends and expected conditions at the end of mining and in the long term. Table 3.7.2-13 also presents Arizona water quality standards and baseline chemistry for added perspective.

Figures M-1 through M-7 in appendix M illustrate model results for seven chemical constituents of concern that either are regulated constituents that helped drive the required level of engineered seepage controls incorporated into the design (cadmium, selenium, antimony, copper) or offer other significant perspective on water quality (nitrate, total dissolved solids, sulfate). These figures depict the model results for all groundwater and surface water cells.

[68] Results are included in the modeling for several washes that would receive lost seepage (Potts and Roblas Canyon), which are upgradient from cell QC-3. It is not likely that substantial groundwater exists in these alluvial channels; these modeled results are indicative of seepage itself, rather than groundwater concentrations expected in the aquifer.

[69] Note that model year 41 represents the end of mining, the end of tailings production, and the start of facility closure.

Table 3.7.2-13. Seepage water quality modeling results for Alternative 2 (mg/L)

	Aquifer Water Quality Standard	Baseline Groundwater Quality (Well DS17-17*)	QC-3 Model Cell Year 41	QC-3 Model Cell Year 100	QC-3 Model Cell Year 245	Surface Water Standard for the Most Restrictive Use	Baseline Surface Water Quality (Whitlow Ranch Dam*)	Queen Creek at Whitlow Ranch Dam Modeled Surface Water Year 41	Queen Creek at Whitlow Ranch Dam Modeled Surface Water Year 100	Queen Creek at Whitlow Ranch Dam Modeled Surface Water Year 245
Constituents with Numeric Standards										
Antimony	0.006	0.00021	0.00026	0.00034	0.00036	0.030	0.00052	0.00054	0.00059	0.00065
Arsenic	0.05	0.0013	0.0013	0.0013	0.0014	0.030	0.00235	0.0024	0.0024	0.0024
Barium	2	0.0261	0.0263	0.0263	0.0263	98	0.0350	0.035	0.035	0.035
Beryllium	0.004	0.00100	0.00100	0.00101	0.00101	0.0053	0.0010	0.0010	0.0010	0.0010
Boron	–	0.069	0.073	0.078	0.078	1	0.057	0.059	0.062	0.066
Cadmium	0.005	0.00004	0.0001	0.0002	0.0002	0.0051‡	0.00005	0.00007	0.00015	0.00020
Chromium, Total§	0.1	0.0019	0.0022	0.0029	0.0027	0.011	0.0015	0.0016	0.0020	0.0023
Copper	–	0.00076	0.004	0.004	0.003	0.0234‡	0.00230	0.0041	0.0039	0.0045
Fluoride	4	0.529	0.56	0.57	0.56	140	0.4	0.42	0.43	0.43
Iron	–	0.045	0.0450	0.0450	0.0450	1	0.048	0.048	0.048	0.048
Lead	0.05	0.000065	0.00008	0.00009	0.00009	0.0083‡	0.00008	0.00008	0.00009	0.00010
Manganese	–	0.0049	0.011	0.028	0.025	10	0.150	0.153	0.162	0.169
Mercury	0.002	N/A	N/A	N/A	N/A	0.00001	N/A	N/A	N/A	N/A
Nickel	0.1	0.0027	0.003	0.005	0.005	0.1343‡	0.0027	0.0030	0.0041	0.0050
Nitrate	10	0.38†	0.43	0.46	0.45	3,733.333	1.900	1.93	1.94	1.97
Nitrite	1	N/A	N/A	N/A	N/A	233.333	N/A	N/A	N/A	N/A
Selenium	0.05	0.0009	0.002	0.005	0.004	0.002	0.0007	0.0012	**0.0027**	**0.0038**
Silver	–	0.000036	0.0003	0.0009	0.0007	0.0221	0.000036	0.00016	0.00049	0.00071
Thallium	0.002	0.00003	0.00006	0.00009	0.00008	0.0072	0.000030	0.00004	0.00006	0.00008
Uranium	–	N/A	N/A	N/A	N/A	2.8	N/A	N/A	N/A	N/A
Zinc	–	0.005	0.018	0.045	0.039	0.3031‡	0.0030	0.0088	0.0238	0.0353
pH	–	N/A	N/A	N/A	N/A	6.5–9.0	N/A	N/A	N/A	N/A

	Aquifer Water Quality Standard	Baseline Groundwater Quality (Well DS17-17*)	QC-3 Model Cell Year 41	QC-3 Model Cell Year 100	QC-3 Model Cell Year 245	Surface Water Standard for the Most Restrictive Use	Baseline Surface Water Quality (Whitlow Ranch Dam*)	Queen Creek at Whitlow Ranch Dam Modeled Surface Water Year 41	Queen Creek at Whitlow Ranch Dam Modeled Surface Water Year 100	Queen Creek at Whitlow Ranch Dam Modeled Surface Water Year 245
Constituents without Numeric Standards										
Sulfate	–	173	186	208	209	–	136	144	154	168
Total Dissolved Solids	**–**	**589**	**614**	**652**	**652**	**–**	**546**	**561**	**579**	**603**

Notes: N/A = not analyzed in seepage modeling

Shaded cell and bolded text indicate concentrations above water quality standard.

Model data are not specific to total or dissolved fractions; for the purposes of comparison to surface water standards it can be assumed to apply to both.

* Results shown represent median values from water quality measurements.

† No available data for well DS17-17. NO_3-N value calculated as median of three samples collected from Bear Tank and Benson Springs between November 2014 and March 2015.

‡ Standards are hardness dependent and were calculated using lowest (most stringent) hardness value recorded for Whitlow Ranch Dam (307 mg/L $CaCO_3$ on August 25, 2017); see appendix N, table N-5, for details on how these standards were selected.

§ Standard shown for chromium is for hexavalent chromium, which is the most restrictive of the three chromium standards (total chromium, trivalent chromium, and hexavalent chromium).

Modeling results for Alternative 2 indicate the following:

- Modeling estimates that engineered seepage controls can recover 99 percent of total seepage. All levels of control (Levels 0 through 4) have been applied to Alternative 2 for the purposes of estimating the effects of tailings seepage on water quality.
- For all constituents, concentrations decrease with distance from the tailings storage facility, but increase over time.
- There are no concentrations above aquifer water quality standards for the first model cell corresponding to groundwater (cell QC-3) or subsequent downgradient cells.
- Concentrations of selenium are above the surface water regulatory standard for the most restrictive use in model year 64 and onward for Queen Creek at Whitlow Ranch Dam (see appendix M, figure M-3), despite incorporation of engineered seepage controls estimated to capture 99 percent of total seepage. No other constituents are modeled to have concentrations above surface water regulatory standards. The model result is above the standard by a very small amount, and the uncertainty in the model does not allow a strict comparison. It can only be concluded that concentrations are expected to be near the standard.
- Sulfate and total dissolved solids are significant constituents in tailings seepage and can alter the potential use of downstream water resources, but do not have numeric standards. Over time, sulfate concentrations in groundwater closest to the tailings storage facility are expected to rise slightly above the 250 mg/L secondary standard, to 340 mg/L (see appendix M, figure M-1).
- Most constituents increase in concentration in groundwater and surface water above existing baseline conditions.
- The risk of not being able to meet desired seepage capture efficiencies is high. While the determination of whether water quality standards would be met is under the jurisdiction of ADEQ, the disclosure undertaken by the Forest Service suggests that the high capture efficiency required of the engineered seepage controls could make meeting water quality standards under this alternative challenging. The number and types of engineered seepage controls represent significant economic and engineering challenges.

Practicability for Additional Seepage Controls

The site-specific suite of engineered seepage controls designed for Alternative 2 is substantially more effective at controlling seepage than a fully lined facility with no other controls. The estimated loss through a full liner due to defects is 792 acre-feet per year (see Rowe (2012) and Newell and Garrett (2018d) for details of this estimate). This estimate is specifically for geomembrane as specified under Arizona BADCT; composite liners are able to reach better performance, but there are substantial logistical concerns about the ability to successfully install a full liner of any kind (see Newell and Garrett (2018d) for a summary of concerns).

Under the suite of engineered seepage controls considered (Levels 0 through 4), all parts of the foundation except those on Gila Conglomerate would already use low-permeability layers which have similar permeabilities to the Arizona BADCT specifications. The comparison to a full liner illustrates the need for layered seepage controls, particularly downstream seepage collection dams and pumpback wells, to control seepage that would be generated from within the facility, regardless of the foundation treatment.

Alternative 2 has limited ability to add further layers of seepage controls during operations. The envisioned seepage controls (Levels 0 through 4) already would extend downstream to the edge of Queen Creek. Logistically, there is little physical room to add additional controls.

RAMIFICATIONS FOR LONG-TERM CLOSURE

Post-closure Water Quality, Seepage Rates, and Closure Timing

Modeling indicates that the concentrations of constituents of concern continue to increase over time, post-closure. In addition, the estimated long-term post-closure seepage rate of 17 acre-feet per year (Gregory and Bayley 2018a) is close to the seepage rate only achieved with all Level 4 engineered seepage controls in place (20.7 acre-feet per year), including the active pumpback wells. This suggests that passive closure of the tailings storage facility may be difficult, and active management may be required.

In the alternative design, Klohn Crippen Berger Ltd. (2018a) estimated that active closure would be required up to 100 years after the end of operations. Up to 25 years after closure, the recycled water pond still is present and therefore all engineered seepage controls could remain operational, with seepage pumped back to the tailings storage facility. After 25 years, the recycled water pond is no longer present. At this time the seepage collection ponds would be expanded to maximize evaporation, and then active water management (either enhanced evaporation or treatment prior to release) would take place until the ponds could passively evaporate all incoming seepage. The sludge containing concentrated metals and salts from evaporation would eventually require cleanup and potentially off-site disposal as solid or hazardous waste; this would likely include both the accumulated solids as well as the seepage pond liner.

Financial Assurance for Closure and Post-closure Activities

Alternative 2 potentially involves long time periods of post-closure monitoring and mitigation related to stormwater or seepage water quality. This raises concern regarding the possibility of Resolution Copper going bankrupt or otherwise abandoning the property after operations have ceased. If this were to happen, the responsibility for these long-term activities would fall to the Forest Service. The Forest Service would need to have financial assurance in place to ensure adequate funds to undertake these activities for long periods of time—for decades or even longer.

The authority and mechanisms for ensuring long-term funding is discussed in section 1.5.5. The types of activities that would likely need to be funded could include the following:

- Active (such as water treatment plant) or passive (such as wetlands) water treatment systems, including design, operational maintenance, and replacement costs
- Treatment and disposal of any sludge generated by water treatment plants, or through passive evaporation
- Monitoring of water quality of seepage and downstream waters
- Maintenance and monitoring of post-closure stormwater control features
- Monitoring the water quality of stormwater runoff associated with the closure cover, to determine ability to release stormwater back to the downstream watershed

Additional financial assurance requirements for long-term maintenance and monitoring are part of the Arizona APP program:

> [T]he applicant or permittee shall demonstrate financial responsibility to cover the estimated costs to close the facility and, if necessary, to conduct postclosure monitoring and maintenance by providing to the director for approval a financial assurance mechanism or combination of mechanisms as

prescribed in rules adopted by the director or in 40 Code of Federal Regulations section 264.143 (f)(1) and (10) as of January 1, 2014. (ARS 49-243; also see Arizona Administrative Code R18-9-A203 for specific regulations and methods allowed for financial assurance)

The Arizona State Mine Inspector also has authority to require a mine reclamation plan and financial assurance for mine closure (Arizona Administrative Code Title 11, Chapter 2). The regulations for these focus primarily on surface disturbance and revegetation, rather than water quality.

A refined seepage analysis was conducted for Alternative 6 – Skunk Camp (Preferred Alternative) that provides insights into the time frames associated with long-term seepage treatment from slurry tailings facilities. Based on these estimates, draindown over time from the NPAG beach tailings would slowly decrease from over 4,000 gallons per minute at the point of mine closure, to eventually reach a steady-state of 40 to 80 gallons per minute, based solely on the amount of water allowed in by the closure cover (KCB Consultants Ltd. 2020d).

The final post-closure seepage collection pond has yet to be sized, but conceptually the potential unaided evaporation from a 10-acre pond would be about 60 acre-feet per year, equal to about 220 gallons per minute. The draindown curve indicates it might take 20–30 years for seepage reductions to reach this point. The refined seepage analysis confirms the rough estimate that active water management could be needed for several decades after closure.

POTENTIAL IMPACTS ON IMPAIRED WATERS

As noted, in the project area Queen Creek is currently considered impaired for copper. The overall estimated current copper loading on this reach of Queen Creek is 0.101 kg/day. The draft TMDL for dissolved copper estimated for this reach of Queen Creek is 0.080 kg/day; this represents the total allowable amount of dissolved copper that would not result in surface water quality standards being exceeded. Note that these calculations include Resolution Copper's current permits for the West Plant Site and East Plant Site, but no discharges from a future tailings facility. ADEQ has identified the need for more than a 20 percent reduction in dissolved copper loading in order for this reach of Queen Creek to not be impaired (Arizona Department of Environmental Quality 2017).

Seepage from Alternative 2 would represent an additional dissolved copper load to Queen Creek of 0.0227 kg/day during operations and 0.0072 kg/day post-closure (see Newell and Garrett (2018d) for calculations of pollutant loading from each alternative). Alternative 2 would increase the dissolved copper load in Queen Creek by 7 to 22 percent and would interfere with efforts to reduce dissolved copper loads to Queen Creek.

In addition to tailings seepage, an emergency release of stormwater from seepage collection ponds (a scenario discussed in detail under Alternative 6) could similarly increase the dissolved copper load in Queen Creek and would interfere with efforts to reduce dissolved copper loads to Queen Creek. Such a release has a low probability, would occur only under certain combinations of extreme storm events (300-year return period or greater) and operational upset conditions, and would be short-lived.

PREDICTED REDUCTIONS IN ASSIMILATIVE CAPACITY

The calculated reductions in assimilative capacity are shown in table 3.7.2-14. For Alternative 2, since concentrations for selenium were already predicted to be above the surface water quality standards, by definition no assimilative capacity remains for this pollutant (see table 3.7.2-14).

Table 3.7.2-14. Predicted changes in assimilative capacity more than 20 percent due to seepage entering surface waters

Alternative	Receiving Water	Remaining Assimilative Capacity After Seepage Enters Surface Water
Alternative 2	Queen Creek at Whitlow Ranch Dam	Selenium (0%); the selenium concentration is above the numeric surface water quality standard
Alternative 3	Queen Creek at Whitlow Ranch Dam	No changes in assimilative capacity greater than 20% are anticipated
Alternative 4	Queen Creek at Whitlow Ranch Dam	Selenium (0%); the selenium concentration is above the numeric surface water quality standard
Alternative 5	Gila River below Donnelly Wash	Copper (77%); Selenium (63%)
Alternative 6	Gila River below Dripping Spring Wash	Selenium (67%)

Note: For full calculations, see Newell and Garrett (2018d); this document also contains an assessment of potential changes in assimilative capacity due to reductions in stormwater runoff discussed in section 3.7.3.

FURTHER ASSESSMENT WITH LOW-FLOW CONDITIONS

The water quality model of potential surface water quality impacts in Queen Creek from Alternative 2 tailings seepage makes use of the median flow rate in Queen Creek at Whitlow Ranch Dam (estimated to be 1.43 cubic feet per second).[70] As noted in the methodology section, using median flow is a common method of estimating baseflow conditions, because it tends to exclude large flood events. Public comments on the DEIS suggested that these flow conditions do not consider the impact of tailings seepage during critical low-flow periods in Queen Creek. In response, we assessed the potential for predicted concentrations in Queen Creek to be greater than Arizona numeric surface water quality standards under low-flow conditions.

The concentration of constituents in Queen Creek is a function of the load from the tailings seepage, the background load in Queen Creek, and the available flow in Queen Creek. The approach shown in table 3.7.2-15 assumes that background concentrations in Queen Creek remain constant; therefore, when flow rates drop, the background load drops as well.[71] Meanwhile, the tailings seepage load entering Queen Creek with groundwater in the alluvial aquifer remains the same but contributes a larger percentage of the total load. This leads to increases in the overall predicted concentration. At some given magnitude of streamflow, the flow is low enough that concentrations due to the influence of the tailings seepage load may exceed the Arizona numeric surface water quality standard. The amount of time that flow in Queen Creek tends to be at or lower than this critical low flow value provides an estimate of how often water quality problems might arise.

For Alternative 2, the results from this approach suggest that the ability to meet numeric surface water quality standards would not change under low-flow conditions. Water quality modeling already predicts that selenium would reach concentrations greater than numeric surface water quality standards at median flow rates, and would reach these concentrations at low flow rates as well. For other metals, flows in Queen Creek low enough to cause concern have never been observed. The exceptions are copper and zinc; we estimate that flows fall low enough to lead to concern less than 1 percent of the time.

[70] Based on USGS stream gage 09478500 Queen Creek below Whitlow Ranch Dam, period of record roughly 2002 to 2020.

[71] Based on previous assessments of Queen Creek, some of the upstream portions of the watershed—including Oak Flat—appear to contribute the highest loads of metals (Arizona Department of Environmental Quality 2017). During EIS water quality modeling discussions, this led to suggestions that large storm flows may actually increase metal concentrations in Queen Creek, rather than dilute them. Regardless, the water quality samples upon which the low-flow analysis is based were collected at Whitlow Ranch Dam under baseflow conditions, and are anticipated to be representative of low-flow conditions when only groundwater is contributing to flow in Queen Creek.

Table 3.7.2-15. Estimated low-flow values required for predicted concentrations to be greater than standards in Queen Creek, due to Alternative 2 tailings seepage

Constituent	Background Concentration of Queen Creek (mg/L)	Maximum Predicted Concentration in Queen Creek at Whitlow Ranch Dam (mg/L)	Median Flow Rate in Queen Creek (cfs)	Estimated Annual Load from Queen Creek (kg)	Estimated Annual Load from Seepage (kg)	Arizona Numeric Surface Water Quality Standard (mg/L)	Estimated Low Flow at which Standard would be Reached (cfs)	Estimated Percent of Time Queen Creek Flow is Below Standard-Reaching Rate*
Selenium	0.0007	0.0048	1.43	0.89	5.23	0.002	N/A	N/A
Cadmium	0.00005	0.00025	1.43	0.06	0.26	0.0043	0.07	N/O
Antimony	0.00052	0.00067	1.43	0.66	0.19	0.03	0.01	N/O
Copper	0.0023	0.006	1.43	2.94	4.72	0.0191	0.31	1
Arsenic	0.0024	0.0024	1.43	3.00	–	0.03	–	–
Beryllium	0.001	0.001	1.43	1.28	–	0.0053	–	–
Chromium	0.0015	0.0026	1.43	1.91	1.40	0.011†	0.17	N/O
Lead	0.00008	0.00011	1.43	0.10	0.04	0.0065	0.01	N/O
Nickel	0.0027	0.0057	1.43	3.45	3.83	0.1098	0.04	N/O
Silver	0.000036	0.00097	1.43	0.05	1.19	0.0147	0.09	N/O
Thallium	0.00003	0.00011	1.43	0.04	0.10	0.0072	0.02	N/O
Zinc	0.003	0.0459	1.43	3.83	54.75	0.2477	0.25	<1

Notes: N/A = Not applicable, as constituent already has concentrations greater than numeric standards at median flow rates.

N/O = Not observed. Flows low enough to cause concentrations greater than numeric standards have never been observed over the period of record at this gage.

– Indicates that tailings seepage provides no or negligible load, and there is no expectation that concentrations could be greater than numeric surface water standards.

* Estimated based on USGS gage 09478500, Queen Creek below Whitlow Ranch Dam, period of record from 2002 to 2020

† Standard shown for chromium is for hexavalent chromium, which is the most restrictive of the three chromium standards (total chromium, trivalent chromium, and hexavalent chromium).

RAMIFICATIONS ON DOWNSTREAM WATER USERS

The community of Queen Valley is located just downstream of Whitlow Ranch Dam, and concerns were raised over potential impacts on both surface water and groundwater use resulting from changes in water quality.

The hydrologic connection between Queen Creek, the impoundment of water at Whitlow Ranch Dam, and water uses in Queen Valley was explored (Garrett 2020k; Montgomery and Associates Inc. 2020d).

Groundwater in Queen Valley occurs in a wedge of Tertiary basin-fill deposits and Apache Leap Tuff that is overlain by floodplain alluvium deposits to locally form an aquifer. The floodplain alluvium, reportedly up to 42 feet thick at Whitlow Ranch Dam, serves to capture and store surface water runoff, which in turn recharges the underlying deposits. The alluvium generally does not contribute to supply wells in Queen Valley.

Water flows into the Queen Valley community from a narrow bedrock gap at Whitlow Ranch Dam. This represents the discharge point for all surface water runoff from Upper Queen Creek and the Superior Basin. The dam itself, completed in 1960, has an impervious core and footing through the entire thickness of the floodplain alluvium, which forces groundwater to the surface and is the reason for the presence of perennial water behind the dam. Impounded surface water and groundwater are discharged through the dam by a 5.5-foot-diameter culvert.

Flow downstream of the dam rarely travels more than a few miles, as it is either diverted to an irrigation canal used by the Queen Valley Country Club or percolates into the alluvium and underlying rock units. The canal delivers water to a series of ponds and lakes, and for irrigation of the golf course. Seepage from the canals and ponds may also recharge the underlying aquifer.

Based on evaluation of hydrographs and pumping data, Queen Valley aquifer acts similarly to many ephemeral systems in Arizona. During dry periods, both decreased runoff and increased pumping tend to cause sustained declines in the groundwater levels and aquifer storage below Queen Valley. During wet periods, less groundwater is pumped, and surface water readily recharges the aquifer, recovering groundwater levels and aquifer storage.

Water quality changes caused by tailings seepage in both groundwater (forced to the surface at Whitlow Ranch Dam) and in surface water would reasonably migrate downstream into Queen Valley via the outflow culvert at the dam. As noted above, concentrations of selenium at Whitlow Ranch Dam are above the surface water regulatory standard for the most restrictive use. Because little dilution would occur between the dam and diversion of surface water for use in Queen Valley, these concentrations are reasonable estimates of water quality changes in Queen Valley as well.

With respect to selenium, the most-restrictive surface water quality standard used for comparison in table 3.7.2-13 is for warmwater aquatic and wildlife chronic exposure (0.002 mg/L). The surface water quality standards for the anticipated uses in Queen Valley (full or partial body contact, agricultural irrigation) are less restrictive (0.020 mg/L; see table N-5 in appendix N for more detail). Predicted selenium concentrations (0.0038 mg/L at Year 245) would not exceed these less-restrictive standards.

Surface water quality in the diversions in Queen Valley would be anticipated to change from current conditions due to the seepage from the Alternative 2 tailings storage facility. Surface water would exhibit increases in metals, sulfate, and dissolved solids. While these changes would occur, the concentrations of these constituents may not increase enough to impact the actual uses of the water, such as for irrigation.

Surface water also has a fairly direct connection to the Queen Valley aquifer and would also be anticipated to recharge groundwater in Queen Valley. Water quality changes in surface water therefore could also cause changes in groundwater quality. However, unlike the direct use of surface water, much of the groundwater recharge takes place during large storm events and substantial dilution could occur. Regardless of dilution effects, concentrations in surface water are not anticipated to be greater than aquifer water quality standards, as shown in table 3.7.2-13.

Groundwater quality in Queen Valley would be anticipated to potentially change from current conditions due to the seepage from the Alternative 2 tailings storage facility, exhibiting increases in metals, sulfate, and dissolved solids. However, such increases may not affect the actual use of the groundwater, as they do not exceed numeric aquifer water quality standards.

Alternative 3 – Near West – Ultrathickened

POTENTIAL WATER QUALITY IMPACTS FROM TAILINGS STORAGE FACILITY

Seepage Controls Incorporated into Design

The various engineered seepage controls assessed in the Alternative 3 design and how they are expected to be applied are shown in table 3.7.2-16. A conceptual diagram of the seepage controls is shown in figure 3.7.2-6. These are almost entirely identical to Alternative 2, except in Alternative 3 a low-permeability layer is used for the entire PAG cell starting with Level 1 controls.

Anticipated Effectiveness of Seepage Controls

As with Alternative 2, total seepage was estimated during the initial design phase using a one-dimensional, unsaturated flow model (Klohn Crippen Berger Ltd. 2018b), and a three-dimensional groundwater flow model was used to model the amount of total seepage that would be captured by various engineered seepage controls, leaving some amount of lost seepage to enter the environment downgradient (Groenendyk and Bayley 2018b, 2019).

During operations, total seepage created by the tailings was estimated at 728 acre-feet per year (508 and 220 acre-feet per year of NPAG and PAG seepage, respectively) and lost seepage was modeled to be 116 acre-feet per year with Level 1 seepage controls, and 2.7 acre-feet per year with all enhanced engineered seepage controls (Level 4).

Modeling indicates the Level 4 seepage controls would reach a seepage capture efficiency of 99.5 percent. Most of this is captured by blanket and finger drains (88 percent).

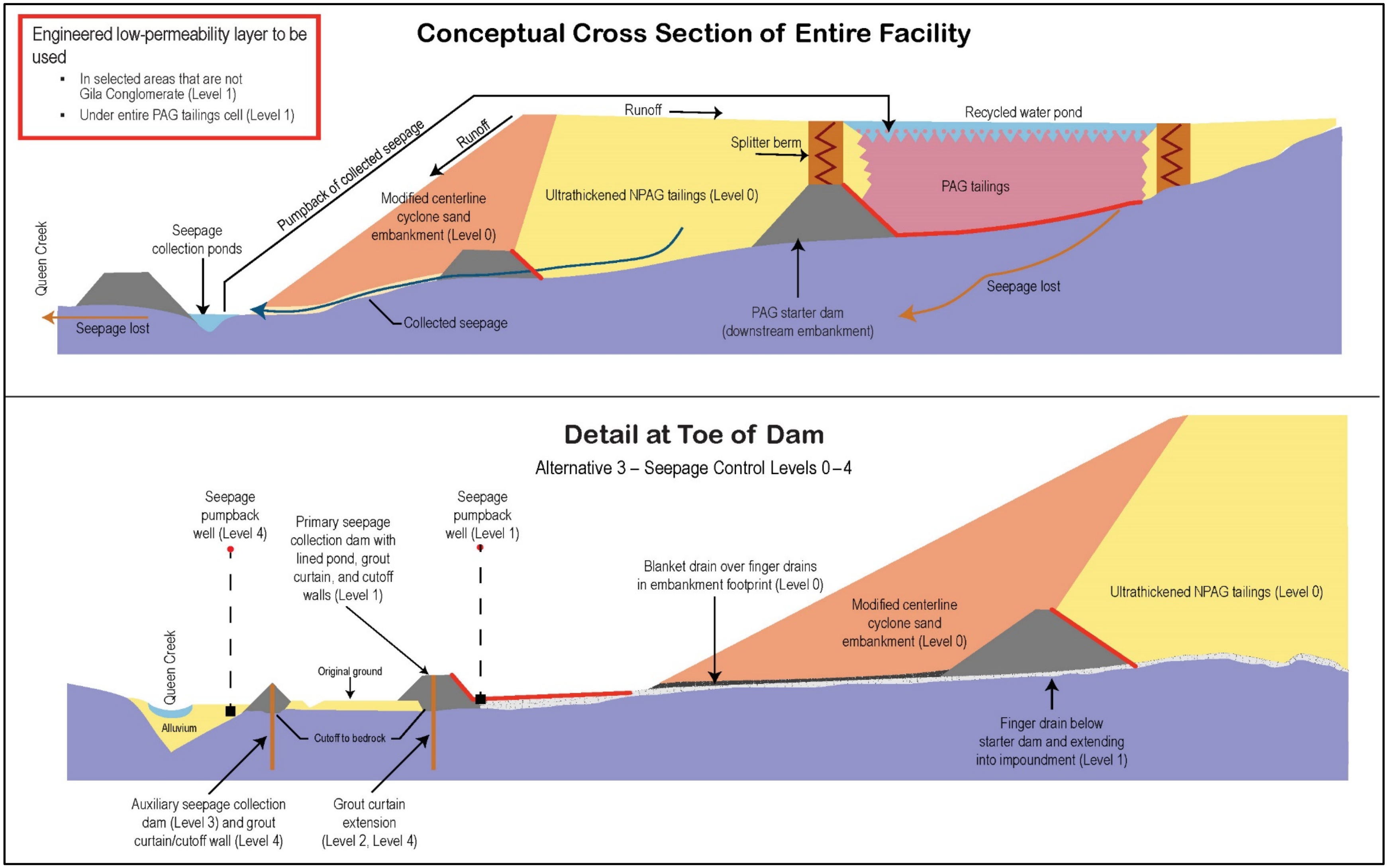


Figure 3.7.2-6. Alternative 3 seepage control

Table 3.7.2-16. Effectiveness of Alternative 3 engineered seepage controls

Seepage Control Levels and Components	Uncaptured Seepage from Facility	Source
Uncontrolled seepage from tailings facility	728 acre-feet/year	Groenendyk and Bayley (2018b) and Klohn Crippen Berger Ltd. (2018b)
Level 0 (seepage controls for geotechnical stability)		
- Modified centerline cyclone sand embankment - Blanket drain under embankment; finger drains	Not explicitly modeled; incorporated into Level 1 modeling	
Level 0-1		
- Blanket drain extends into facility under NPAG beach; finger drains (blanket/finger drains account for roughly 88% of seepage collected) - Seepage collection ponds with pumpback wells and cut-off walls	116 acre-feet/year	Groenendyk and Bayley (2018a)
Level 1		
- Foundation treatment and selected areas of engineered low-permeability layers, for all areas not Gila Conglomerate - Engineered low-permeability layer for entire PAG facility - Seepage collection ponds with pumpback wells, cut-off walls, and grout curtain to 100-foot depth	Not explicitly modeled; incorporated into Level 4 modeling	N/A
Level 2		
- Grout curtain extended to target high-permeability zones and seepage pathways	Not explicitly modeled; incorporated into Level 4 modeling	N/A
Level 3		
- Add second perimeter of seepage collection ponds downstream	Not explicitly modeled; incorporated into Level 4 modeling	N/A
Level 4 (includes Levels 0 through 4)		
- Add pumpback wells, cut-off walls, and grout curtains to second perimeter of seepage collection ponds - Downgradient grout curtain extending to 100-foot depth - Additional pumpback wells in targeted areas to maximize capture	2.7 acre-feet/year	Groenendyk and Bayley (2019)

Risk of Seepage Impacting Groundwater or Surface Water Quality

Modeled results for groundwater and surface water impacts are reported by Gregory and Bayley (2019). The detailed results of the bypass seepage mixing/loading model were supplied as an Excel spreadsheet, and can be found in Garrett (2019d). Table 3.7.2-17 presents model results for all modeled chemical constituents in the first groundwater cell along Queen Creek (cell QC-3)[72] and the ultimate, final surface water cell (Queen Creek at Whitlow Ranch Dam), for model years 41, 100, and 245. This provides perspective on trends and expected conditions at the end of mining and in the long term. Table 3.7.2-17 also presents Arizona water quality standards and baseline chemistry for added perspective.

Figures M-8 through M-14 in appendix M illustrate model results for the seven constituents of concern.

[72] Similar to Alternative 2, results are included in the modeling for several washes that would receive lost seepage (Potts and Roblas Canyons), which are upgradient from cell QC-3. It is not likely that substantial groundwater exists in these alluvial channels; these modeled results are indicative of seepage itself, rather than groundwater concentrations expected in the aquifer.

Modeling results for Alternative 3 indicate the following:

- Modeling estimates that engineered seepage controls can recover 99.5 percent of total seepage. All levels of control (Levels 0 through 4) have been applied to Alternative 3 for the purposes of estimating the effects of tailings seepage on water quality.
- For all constituents, concentrations decrease with distance from the tailings storage facility, but increase over time.
- No chemical constituent are anticipated in concentrations above groundwater or surface water standards.
- Selenium and cadmium are increased slightly above baseline conditions in groundwater and surface water (see appendix M, figures M-10 and M-11).
- The risk of not being able to meet desired seepage capture efficiencies is high. While the determination of whether water quality standards would be met is under the jurisdiction of ADEQ, the disclosure undertaken by the Forest Service suggests that the high capture efficiency required of the engineered seepage controls could make meeting water quality standards under this alternative challenging. The number and types of engineered seepage controls represent significant economic and engineering challenges.

Practicability for Additional Seepage Controls

The assessment of practicability of using a full liner, or adding extra layers of seepage controls during operations, is the same as for Alternative 2.

RAMIFICATIONS FOR LONG-TERM CLOSURE

Post-closure Water Quality, Seepage Rates, and Closure Timing

Modeling indicates that the concentrations of constituents of concern continue to increase over time, post-closure. In the alternative design, KCB (2018b) estimated that active closure would only be required up to 9 years after the end of operations. At that time, the seepage collection ponds would be expanded to maximize evaporation; passive evaporation of all incoming seepage was anticipated. The sludge of concentrated metals and salts from evaporation would eventually require cleanup and potentially off-site disposal as solid or hazardous waste; this would likely include both the accumulated solids as well as the seepage pond liner.

The final seepage modeling assumes that long-term lost seepage rates would match those during operations (2.7 acre-feet per year), which is much lower than original estimates of long-term recharge through the tailings storage facility caused by infiltration of precipitation (25 acre-feet per year (Gregory and Bayley 2018a)). This suggests that active management may be needed indefinitely post-closure.

Financial Assurance for Closure and Post-closure Activities

The regulatory framework to require financial assurance to ensure closure and post-closure activities are conducted is the same as for Alternative 2.

POTENTIAL IMPACTS ON IMPAIRED WATERS

As noted, in the project area Queen Creek is currently considered impaired for copper. The overall estimated current loading on this reach of Queen Creek is 0.101 kg/day. The draft TMDL for dissolved copper estimated for this reach of Queen Creek is 0.080 kg/day; this represents the total allowable amount of dissolved copper that would not result in surface water quality standards being exceeded. Note that these calculations include Resolution Copper's current permits for the West Plant Site and East Plant Site, but no discharges from a tailings facility. ADEQ has identified the need for more than a 20 percent reduction in dissolved copper loading in order for this reach of Queen Creek to not be impaired (Arizona Department of Environmental Quality 2017).

Seepage from Alternative 3 would represent an additional dissolved copper load to Queen Creek of 0.0018 kg/day during operations and 0.0010 kg/day post-closure (see Newell and Garrett (2018d) for calculations of pollutant loading from each alternative). Alternative 3 would increase the dissolved copper load in Queen Creek by 1 to 2 percent and would minimally interfere with efforts to reduce dissolved copper loads to Queen Creek.

As with Alternative 2, in addition to tailings seepage, an emergency release of stormwater from seepage collection ponds (a scenario discussed in detail under Alternative 6) could similarly increase the dissolved copper load in Queen Creek and would interfere with efforts to reduce dissolved copper loads to Queen Creek. Such a release has a low probability, would occur only under certain combinations of extreme storm events (300-year return period or greater) and operational upset conditions, and would be short-lived.

PREDICTED REDUCTIONS IN ASSIMILATIVE CAPACITY

The calculated reductions in assimilative capacity are shown in table 3.7.2-14. For Alternative 3, seepage is not anticipated to use up more than 20 percent of the assimilative capacity in Queen Creek.

FURTHER ASSESSMENT WITH LOW-FLOW CONDITIONS

Similar to Alternative 2, we analyzed how streamflow less than the median would potentially affect concentrations, as shown in table 3.7.2-18.

For Alternative 3, the results from this approach suggest that the ability to meet numeric surface water quality standards would not change under low-flow conditions. Except for selenium, flows in Queen Creek have never been observed low enough to cause concern. For selenium, we estimate that flows fall low enough to lead to concern less than 1 percent of the time.

RAMIFICATIONS ON DOWNSTREAM WATER USERS

Similar to Alternative 2, seepage from the Alternative 3 tailings storage facility has a potential to impact surface water and groundwater supplies in Queen Valley.

However, unlike Alternative 2, there are no anticipated concentrations of contaminants above any aquifer or surface water quality standards, as shown in table 3.7.2-17. Surface water quality in the diversions in Queen Valley may change from current conditions due to the seepage from the Alternative 3 tailings storage facility, exhibiting increases in metals, sulfate, and dissolved solids. However, such increases may not affect the actual use of the water, as they do not exceed numeric surface water quality standards.

Similarly, groundwater quality in Queen Valley may change from current conditions due to the seepage from the Alternative 3 tailings storage facility, exhibiting increases in metals, sulfate, and dissolved solids. However, such increases may not affect the actual use of the groundwater, as they do not exceed numeric aquifer water quality standards.

Table 3.7.2-17. Seepage water quality modeling results for Alternative 3 (mg/L)

	Aquifer Water Quality Standard	Baseline Groundwater Quality (Well DS17-17*)	QC-3 Model Cell Year 41	QC-3 Model Cell Year 100	QC-3 Model Cell Year 245	Surface Water Standard for Most Restrictive Use	Baseline Surface Water Quality (Whitlow Ranch Dam*)	Queen Creek at Whitlow Ranch Dam Modeled Surface Water Year 41	Queen Creek at Whitlow Ranch Dam Modeled Surface Water Year 100	Queen Creek at Whitlow Ranch Dam Modeled Surface Water Year 245
Constituents with Numeric Standards										
Antimony	0.006	0.00021	0.00021	0.00021	0.00022	0.030	0.00052	0.00052	0.00052	0.00053
Arsenic	0.05	0.0013	0.0013	0.0013	0.0013	0.030	0.00235	0.0024	0.0024	0.0024
Barium	2	0.0261	0.0261	0.0261	0.0261	98	0.035	0.035	0.035	0.035
Beryllium	0.004	0.00100	0.00100	0.00100	0.00100	0.0053	0.0010	0.0010	0.0010	0.0010
Boron	–	0.069	0.069	0.069	0.069	1	0.057	0.057	0.057	0.057
Cadmium	0.005	0.00004	0.0000	0.0000	0.0001	0.0051‡	0.00005	0.00005	0.00005	0.00006
Chromium, Total§	0.1	0.0019	0.0019	0.0019	0.0020	0.011	0.0015	0.0015	0.0015	0.0015
Copper	–	0.00076	0.001	0.001	0.001	0.0234‡	0.00230	0.0023	0.0024	0.0024
Fluoride	4	0.529	0.53	0.53	0.53	140	0.4	0.41	0.41	0.41
Iron	–	0.045	0.0450	0.0450	0.0450	1	0.048	0.048	0.048	0.048
Lead	0.05	0.000065	0.00007	0.00007	0.00007	0.0083‡	0.00008	0.00008	0.00008	0.00008
Manganese	–	0.0049	0.005	0.005	0.007	10	0.150	0.150	0.150	0.151
Mercury	0.002	N/A	N/A	N/A	N/A	0.00001	N/A	N/A	N/A	N/A
Nickel	0.1	0.0027	0.003	0.003	0.003	0.1343‡	0.0027	0.0027	0.0027	0.0028
Nitrate	10	0.38†	0.38	0.38	0.39	3,733.333	1.90	1.90	1.90	1.90
Nitrite	1	N/A	N/A	N/A	N/A	233.333	N/A	N/A	N/A	N/A
Selenium	0.05	0.0009	0.001	0.001	0.001	0.002	0.0007	0.0007	0.0007	0.0009
Silver	–	0.000036	0.0000	0.0001	0.0001	0.0221	0.000036	0.00004	0.00005	0.00007
Thallium	0.002	0.00003	0.00003	0.00003	0.00004	0.0072	0.000030	0.00003	0.00003	0.00003
Uranium	–	N/A	N/A	N/A	N/A	2.8	N/A	N/A	N/A	N/A
Zinc	–	0.005	0.005	0.006	0.008	0.3031‡	0.0030	0.0030	0.0034	0.0045
pH	–	N/A	N/A	N/A	N/A	6.5–9.0	N/A	N/A	N/A	N/A

	Aquifer Water Quality Standard	Baseline Groundwater Quality (Well DS17-17*)	QC-3 Model Cell Year 41	QC-3 Model Cell Year 100	QC-3 Model Cell Year 245	Surface Water Standard for Most Restrictive Use	Baseline Surface Water Quality (Whitlow Ranch Dam*)	Queen Creek at Whitlow Ranch Dam Modeled Surface Water Year 41	Queen Creek at Whitlow Ranch Dam Modeled Surface Water Year 100	Queen Creek at Whitlow Ranch Dam Modeled Surface Water Year 245
Constituents without Numeric Standards										
Sulfate	–	173	173	174	176	–	136	136	136	138
Total Dissolved Solids	**–**	**589**	**589**	**590**	**594**	**–**	**546**	**546**	**546**	**549**

Notes: N/A= not analyzed in seepage modeling

Model data are not specific to total or dissolved fractions; for the purposes of comparison to surface water standards it can be assumed to apply to both.

* Results shown represent median values from water quality measurements.

† No available data for well DS17-17. NO_3-N value calculated as median of three samples collected from Bear Tank and Benson Springs between November 2014 and March 2015.

‡ Standards are hardness dependent and were calculated using lowest (most stringent) hardness value recorded for Whitlow Ranch Dam (307 mg/L $CaCO_3$ on August 25, 2017); see appendix N, table N-5, for details on how these standards were selected.

§ Standard shown for chromium is for hexavalent chromium, which is the most restrictive of the three chromium standards (total chromium, trivalent chromium, and hexavalent chromium).

Table 3.7.2-18. Estimated low-flow values required for predicted concentrations to be greater than standards in Queen Creek, due to Alternative 3 tailings seepage

Constituent	Background Concentration of Queen Creek (mg/L)	Maximum Predicted Concentration in Queen Creek at Whitlow Ranch Dam (mg/L)	Median Flow Rate in Queen Creek (cfs)	Estimated Annual Load from Queen Creek (kg)	Estimated Annual Load from Seepage (kg)	Arizona Numeric Surface Water Quality Standard (mg/L)	Estimated Low Flow at which Standard would be Reached (cfs)	Estimated Percentage of Time Queen Creek Flow is Below Standard-Reaching Rate*
Selenium	0.0007	0.0009	1.43	0.89	0.26	0.002	N/A	<1
Cadmium	0.00005	0.00006	1.43	0.06	0.01	0.0043	0.07	N/O
Antimony	0.00052	0.00053	1.43	0.66	0.01	0.03	0.01	N/O
Copper	0.0023	0.0025	1.43	2.94	0.26	0.0191	0.31	N/O
Arsenic	0.0024	0.0024	1.43	3.00	–	0.03	–	–
Beryllium	0.001	0.001	1.43	1.28	–	0.0053	–	–
Chromium	0.0015	0.0016	1.43	1.91	0.13	0.011†	0.17	N/O
Lead	0.00008	0.00008	1.43	0.10	0.00	0.0065	0.01	N/O
Nickel	0.0027	0.0029	1.43	3.45	0.26	0.1098	0.04	N/O

Constituent	Background Concentration of Queen Creek (mg/L)	Maximum Predicted Concentration in Queen Creek at Whitlow Ranch Dam (mg/L)	Median Flow Rate in Queen Creek (cfs)	Estimated Annual Load from Queen Creek (kg)	Estimated Annual Load from Seepage (kg)	Arizona Numeric Surface Water Quality Standard (mg/L)	Estimated Low Flow at which Standard would be Reached (cfs)	Estimated Percentage of Time Queen Creek Flow is Below Standard-Reaching Rate*
Silver	0.000036	0.00008	1.43	0.05	0.06	0.0147	0.09	N/O
Thallium	0.00003	0.00003	1.43	0.04	–	0.0072	–	–
Zinc	0.003	0.005	1.43	3.83	2.55	0.2477	0.25	N/O

Notes:

N/O = Not observed. Flows low enough to cause concentrations greater than numeric standards have never been observed over the period of record at this gage.

– Indicates that tailings seepage provides no or negligible load, and there is no expectation that concentrations could be greater than numeric surface water standards.

* Values in this column relate to the "Estimated Low Flow at which Standard would be Reached (cfs)" column to the left. Estimated based on USGS gage 09478500, Queen Creek below Whitlow Ranch Dam, period of record from 2002 to 2020.

† Standard shown for chromium is for hexavalent chromium, which is the most restrictive of the three chromium standards (total chromium, trivalent chromium, and hexavalent chromium).

Alternative 4 – Silver King

POTENTIAL WATER QUALITY IMPACTS FROM TAILINGS STORAGE FACILITY

Seepage Controls Incorporated into Design

Alternative 4 includes the following seepage controls, similar in nature to those described for Alternative 2. A conceptual diagram of the seepage controls is shown in figure 3.7.2-7. Table 3.7.2-19 summarizes how these are expected to be applied:

- Blanket drains and/or finger drains beneath the embankment and the tailings facility (Level 0).
- Lined collection ditches and five seepage collection ponds downstream of PAG and NPAG facilities designed to cut off the alluvium (Level 1).
- Grouting of fractures in the bedrock foundation, and pumpback wells (Level 2).

Anticipated Effectiveness of Seepage Controls

For Alternative 4 – Silver King, total seepage was estimated during the initial design phase using a one-dimensional, unsaturated flow model (Klohn Crippen Berger Ltd. 2018c). Unlike Alternatives 2 and 3, there is limited information on the hydrology and geology of the proposed Silver King tailings location and constructing a similar three-dimensional steady-state flow model is not feasible. The efficiency of seepage capture was estimated instead, based on professional judgment of the design engineers and an understanding of the potential flow pathways for seepage. Based on the professional judgement of the design engineers, it is estimated that these seepage controls would capture no more than 80 percent of seepage using Level 1 controls and no more than 90 percent of seepage using Level 2 controls (Klohn Crippen Berger Ltd. 2019b).

During operations, total seepage created by the tailings was estimated at 79 acre-feet per year (77.5 and 1.9 acre-feet per year of NPAG and PAG seepage, respectively) and lost seepage was modeled to be 17 or more acre-feet per year with Level 1 seepage controls, and 9 or more acre-feet per year with all enhanced engineered seepage controls (Level 2).

Table 3.7.2-19. Effectiveness of Alternative 4 engineered seepage controls

Seepage Control Levels and Components	Uncaptured Seepage from Facility	Source
Uncontrolled seepage from tailings facility	79 acre-feet/year	Klohn Crippen Berger Ltd. (2019b)
Level 0 (seepage controls for geotechnical stability)		
- Dewatered (filtered) tailings - Compacted structural zone - Blanket drain under structural zone; finger drains	Not explicitly modeled; incorporated into Level 1 modeling	N/A
Level 1		
- Lined collection ditches and ponds in alluvial channels - Based on professional judgement, estimated to have no greater than 80% efficiency at seepage control	17 acre-feet per year or more	Klohn Crippen Berger Ltd. (2019b)
Level 2		
- Targeted grouting of fractures in foundation - Pumpback wells for seepage return - Based on professional judgment, estimated to have no greater than 90% efficiency at seepage control	9 acre-feet per year or more	Klohn Crippen Berger Ltd. (2019b)

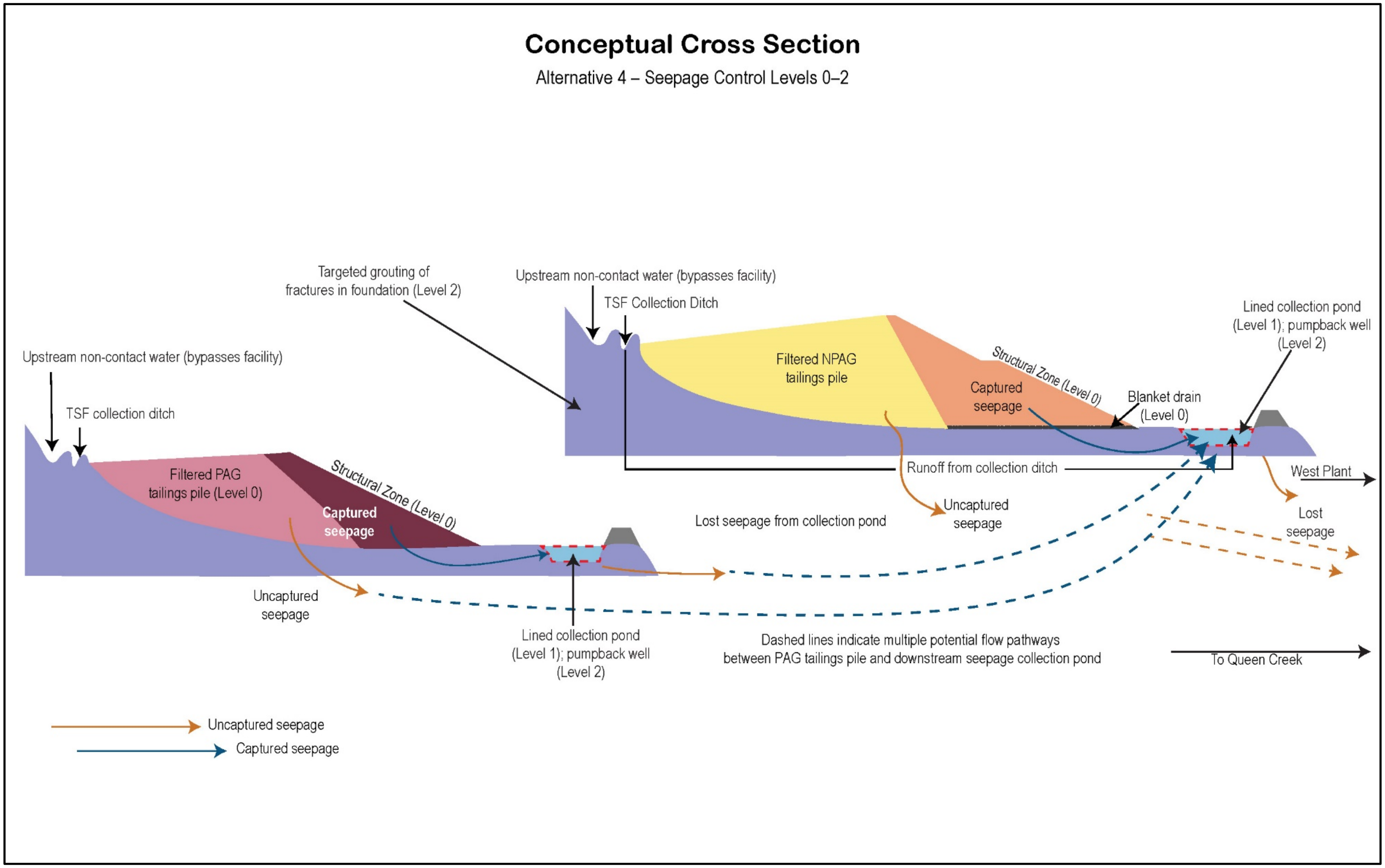


Figure 3.7.2-7. Alternative 4 seepage controls

Risk of Seepage Impacting Groundwater or Surface Water Quality

Modeled results for groundwater and surface water impacts are reported by Gregory and Bayley (2019). The detailed results of the bypass seepage mixing/loading model were supplied as an Excel spreadsheet, and can be found in Garrett (2019d). Table 3.7.2-20 presents model results for all modeled chemical constituents in the first groundwater cell along Queen Creek (cell QC-1)[73] and the ultimate surface water cell (Queen Creek at Whitlow Ranch Dam), for model years 41, 100, and 245. This provides perspective on trends and expected conditions at the end of mining and in the long term. Table 3.7.2-20 also presents Arizona water quality standards and baseline chemistry for added perspective.

Figures M-15 through M-21 in appendix M illustrate model results for the seven constituents of concern.

Modeling results for Alternative 4 indicate the following:

- The model results rely upon the 90 percent estimated efficiency of engineered seepage controls, which is not based on technical analysis (unlike Alternatives 2, 3, 5, and 6) but on professional judgment.
- For all constituents, concentrations decrease with distance from the tailings storage facility, but increase over time.
- There are no concentrations above aquifer water quality standards for the first model cell corresponding to groundwater (cell QC-1) or subsequent downgradient cells. Note that although Gregory and Bayley (2019) report that concentrations are above groundwater standards for Alternative 4, their conclusion is based upon the interpretation of first groundwater occurring in the alluvial channels very close to the tailings storage facility. As noted above, it is not likely that groundwater actually occurs until further downgradient, near Queen Creek.
- Concentrations of selenium are above the surface water regulatory standard for the most restrictive use in model years 59 and onward for Queen Creek at Whitlow Ranch Dam (see appendix M, figure M-17), despite incorporation of engineered seepage controls estimated to capture 90 percent of total seepage. No other constituents are modeled to have concentrations above surface water regulatory standards. The model result is above the standard by a very small amount, and the uncertainty in the model does not allow a strict comparison. It can only be concluded that concentrations are expected to be near the standard.
- Sulfate and total dissolved solids are significant constituents in tailings seepage and can alter the potential use of downstream water resources, but do not have numeric standards. Over time, sulfate concentrations in groundwater closest to the tailings storage facility are expected to rise slightly above the 250 mg/L secondary standard, to 284 mg/L (see appendix M, figure M-15).
- Most constituents increase in concentration in groundwater and surface water above existing baseline conditions.
- Of all the alternatives, Alternative 4 is the only one where seepage control effectiveness was not able to be modeled; instead, this alternative relies on professional engineering judgment for the effectiveness of the seepage controls. Additional controls could be needed; the practicability of this is described in the following section.

[73] Results are included in the modeling for several washes that would receive lost seepage (Happy Camp Wash East and West, Silver King Wash, Potts Canyon), which are upgradient from cell QC-1. It is not likely that substantial groundwater exists in these alluvial channels; these modeled results are indicative of seepage itself, rather than groundwater concentrations expected in the aquifer.

Practicability for Additional Seepage Controls

The amount of seepage without engineered controls is considerably less for Alternative 4, compared with the other alternatives, with only 79 acre-feet per year. The estimated loss through a full liner is about 550 acre-feet per year for a 2,300-acre facility. This estimate is specifically for a geomembrane as specified under Arizona BADCT; composite liners are able to reach better performance, but there are substantial logistical concerns about the ability to successfully install a full liner of any kind, and the terrain at Alternative 4 was specifically considered for feasibility (see Newell and Garrett (2018d) for a summary of concerns).

Unlike Alternatives 2 and 3, Alternative 4 has more ability to add further layers of seepage control during operations. For instance, there is room to install additional downstream seepage collection ponds with cut-off walls and pumpback wells, in Silver King Wash and Happy Camp Wash. The greater distance downstream to Queen Creek allows more flexibility during operations for this location, compared with Alternatives 2 and 3.

RAMIFICATIONS FOR LONG-TERM CLOSURE

Post-closure Water Quality, Seepage Rates, and Closure Timing

Modeling indicates that the concentrations of constituents of concern continue to increase over time, post-closure. Post-closure seepage rates are estimated as 15.2 to 31.9 acre-feet per year (Wickham 2018).

In the alternative design, Klohn Crippen Berger Ltd. (2018c) estimated that active closure would be required for 5 years after the end of operations. During this time, reclamation of the exposed tailings would be in progress, and the need to retain stormwater in the collection ponds requires more capacity than the collection ponds can passively evaporate and may require active treatment. Once stormwater can again be released downstream, after the tailings surface has been reclaimed with a stable closure cover, the collection ponds would be able to passively evaporate collected water. The sludge of concentrated metals and salts from evaporation would eventually require cleanup and potentially off-site disposal as solid or hazardous waste; this would likely include both the accumulated solids as well as the seepage pond liner.

Financial Assurance for Closure and Post-closure Activities

The regulatory framework to require financial assurance to ensure closure and post-closure activities are conducted is the same as for Alternatives 2 and 3.

POTENTIAL IMPACTS ON IMPAIRED WATERS

As noted, in the project area Queen Creek is currently considered impaired for copper. The overall estimated current loading on this reach of Queen Creek is 0.101 kg/day. The draft TMDL for dissolved copper estimated for this reach of Queen Creek is 0.080 kg/day; this represents the total allowable amount of dissolved copper that would not result in surface water quality standards being exceeded. Note that these calculations include Resolution Copper's current permits for the West Plant Site and East Plant Site, but no discharges from a tailings facility. ADEQ has identified the need for more than a 20 percent reduction in dissolved copper loading in order for this reach of Queen Creek to not be impaired (Arizona Department of Environmental Quality 2017).

Seepage from Alternative 4 would represent an additional dissolved copper load to Queen Creek of 0.0116 kg/day during operations and 0.0217 kg/day post-closure (see Newell and Garrett (2018d) for calculations of pollutant loading from each alternative). Alternative 4 would increase the dissolved copper load in Queen Creek by 11 to 21 percent and would interfere with efforts to reduce dissolved copper loads to Queen Creek.

As with Alternatives 2 and 3, in addition to tailings seepage, an emergency release of stormwater from seepage collection ponds (a scenario discussed in detail under Alternative 6) could similarly increase the dissolved copper load in Queen Creek and would interfere with efforts to reduce dissolved copper loads to Queen Creek. Such a release has a low probability, would occur only under certain combinations of extreme storm events (300-year return period or greater) and operational upset conditions, and would be short-lived.

PREDICTED REDUCTIONS IN ASSIMILATIVE CAPACITY

The calculated reductions in assimilative capacity are shown in Table 3.7.2-14. For Alternative 4, since concentrations for selenium were already predicted to be above the surface water quality standards, by definition no assimilative capacity remains for this pollutant.

FURTHER ASSESSMENT WITH LOW-FLOW CONDITIONS

Similar to Alternatives 2 and 3, we analyzed how streamflow less than the median would potentially affect concentrations, as shown in table 3.7.2-21.

For Alternative 4, the results from this approach suggest that the ability to meet surface water quality standards would not change under low-flow conditions. Water quality modeling already predicts that selenium would reach concentrations greater than numeric surface water quality standards at median flow rates, and would reach these concentrations at low flow rates as well. For other metals, flows in Queen Creek have never been observed low enough to cause concern. The exceptions are copper and zinc; we estimate that flows fall low enough to lead to concern less than 1 percent of the time.

RAMIFICATIONS ON DOWNSTREAM WATER USERS

The ramifications of seepage from the Alternative 4 tailings storage facility on surface water and groundwater supplies in Queen Valley is nearly identical to Alternative 2.

Concentrations of selenium at Whitlow Ranch Dam are above the surface water regulatory standard for the most restrictive use; as little dilution would occur between the dam and diversion of surface water for use in Queen Valley, these concentrations are reasonable estimates of water quality changes in Queen Valley as well. With respect to selenium, the most-restrictive surface water quality standard used for comparison in table 3.7.2-20 is for warmwater aquatic and wildlife chronic exposure (0.002 mg/L). The surface water quality standards for the anticipated uses in Queen Valley (full or partial body contact, agricultural irrigation) are less restrictive (0.020 mg/L; see table N-5 in appendix N for more detail). Predicted selenium concentrations (0.0046 mg/L at Year 245) would not exceed these less-restrictive standards.

Surface water quality in the diversions in Queen Valley would be anticipated to change from current conditions due to the seepage from the Alternative 4 tailings storage facility. Surface water would exhibit increases in metals, sulfate, and dissolved solids. While these changes would occur, the concentrations of these constituents may not increase high enough to impact the actual uses of the water, such as for irrigation.

None of the anticipated concentrations at Whitlow Ranch Dam are greater than aquifer water quality standards, as shown in table 3.7.2-20. Groundwater quality in Queen Valley would be anticipated to potentially change from current conditions due to the seepage from the Alternative 4 tailings storage facility, exhibiting increases in metals, sulfate, and dissolved solids. However, such increases may not affect the actual use of the groundwater, as they do not exceed numeric aquifer water quality standards.

Table 3.7.2-20. Seepage water quality modeling results for Alternative 4 (mg/L)

	Aquifer Water Quality Standard	Baseline Groundwater Quality (Well DS17-17*)	QC-3 Model Cell Year 41	QC-3 Model Cell Year 100	QC-3 Model Cell Year 245	Surface Water Standard for Most Restrictive Use	Baseline Surface Water Quality (Whitlow Ranch Dam*)	Queen Creek at Whitlow Ranch Dam Modeled Surface Water Year 41	Queen Creek at Whitlow Ranch Dam Modeled Surface Water Year 100	Queen Creek at Whitlow Ranch Dam Modeled Surface Water Year 245
Constituents with Numeric Standards										
Antimony	0.006	0.00021	0.00022	0.00052	0.00074	0.030	0.00052	0.00052	0.00068	0.00080
Arsenic	0.05	0.0013	0.0013	0.0016	0.0018	0.030	0.00235	0.0024	0.0025	0.0026
Barium	2	0.0261	0.0263	0.0263	0.0264	98	0.0350	0.035	0.035	0.035
Beryllium	0.004	0.00100	0.00102	0.00102	0.00104	0.0053	0.0010	0.0010	0.0010	0.0010
Boron	–	0.069	0.069	0.082	0.091	1	0.057	0.057	0.064	0.069
Cadmium	0.005	0.00004	0.0000	0.0003	0.0004	0.0051‡	0.00005	0.00005	0.00016	0.00023
Chromium, Total§	0.1	0.0019	0.0019	0.0026	0.0030	0.011	0.0015	0.0015	0.0019	0.0021
Copper	–	0.00076	0.003	0.004	0.006	0.0234‡	0.00230	0.0035	0.0038	0.0049
Fluoride	4	0.529	0.53	0.56	0.58	140	0.4	0.41	0.42	0.43
Iron	–	0.045	0.0450	0.0450	0.0450	1	0.048	0.048	0.048	0.048
Lead	0.05	0.000065	0.00007	0.00012	0.00015	0.0083‡	0.00008	0.00008	0.00010	0.00012
Manganese	–	0.0049	0.010	0.060	0.088	10	0.150	0.153	0.178	0.194
Mercury	0.002	N/A	N/A	N/A	N/A	0.00001	N/A	N/A	N/A	N/A
Nickel	0.1	0.0027	0.004	0.007	0.009	0.1343‡	0.0027	0.0031	0.0047	0.0060
Nitrate	10	0.38†	0.40	0.40	0.42	3,733.333	1.90	1.91	1.91	1.92
Nitrite	1	N/A	N/A	N/A	N/A	233.333	N/A	N/A	N/A	N/A
Selenium	0.05	0.0009	0.001	0.006	0.008	0.002	0.0007	0.0007	**0.0031**	**0.0046**
Silver	–	0.000036	0.0000	0.0009	0.0014	0.0221	0.000036	0.00004	0.0005	0.00074
Thallium	0.002	0.00003	0.00003	0.00009	0.00012	0.0072	0.000030	0.00003	0.00006	0.00008
Uranium	–	N/A	N/A	N/A	N/A	2.8	N/A	N/A	N/A	N/A
Zinc	–	0.005	0.006	0.053	0.081	0.3031‡	0.0030	0.0036	0.0281	0.0428
pH	–	N/A	N/A	N/A	N/A	6.5–9.0	N/A	N/A	N/A	N/A

	Aquifer Water Quality Standard	Baseline Groundwater Quality (Well DS17-17*)	QC-3 Model Cell Year 41	QC-3 Model Cell Year 100	QC-3 Model Cell Year 245	Surface Water Standard for Most Restrictive Use	Baseline Surface Water Quality (Whitlow Ranch Dam*)	Queen Creek at Whitlow Ranch Dam Modeled Surface Water Year 41	Queen Creek at Whitlow Ranch Dam Modeled Surface Water Year 100	Queen Creek at Whitlow Ranch Dam Modeled Surface Water Year 245
Constituents without Numeric Standards										
Sulfate	–	173	175	212	241	–	136	137	156	172
Total Dissolved Solids	**–**	**589**	**592**	**647**	**688**	**–**	**546**	**547**	**576**	**598**

Notes: N/A= not analyzed in seepage modeling

Shaded cell and bolded text indicate concentrations above water quality standard.

Model data are not specific to total or dissolved fractions; for the purposes of comparison to surface water standards it can be assumed to apply to both.

* Results shown represent median values from water quality measurements.

† No available data for well DS17-17. NO3-N value calculated as median of three samples collected from Bear Tank and Benson Springs between November 2014 and March 2015.

‡ Standards are hardness dependent and were calculated using lowest (most stringent) hardness value recorded for Whitlow Ranch Dam (307 mg/L $CaCO_3$ on August 25, 2017); see appendix N, table N-5, for details on how these standards were selected.

§ Standard shown for chromium is for hexavalent chromium, which is the most restrictive of the three chromium standards (total chromium, trivalent chromium, and hexavalent chromium).

Table 3.7.2-21. Estimated low-flow values required for predicted concentrations to be greater than standards in Queen Creek, due to Alternative 4 tailings seepage

Constituent	Background Concentration of Queen Creek (mg/L)	Maximum Predicted Concentration in Queen Creek at Whitlow Ranch Dam (mg/L)	Median Flow Rate in Queen Creek (cfs)	Estimated Annual Load from Queen Creek (kg)	Estimated Annual Load from Seepage (kg)	Arizona Numeric Surface Water Quality Standard (mg/L)	Estimated Low Flow at which Standard would be Reached (cfs)	Estimated Percent of Time Queen Creek Flow is Below Standard-Reaching Rate*
Selenium	0.0007	0.0046	1.43	0.89	4.98	0.002	N/A	N/A
Cadmium	0.00005	0.00023	1.43	0.06	0.23	0.0043	0.06	N/O
Antimony	0.00052	0.0008	1.43	0.66	0.36	0.03	0.01	N/O
Copper	0.0023	0.0049	1.43	2.94	3.32	0.0191	0.22	<1
Arsenic	0.0024	0.0026	1.43	3.00	0.32	0.03	0.01	N/O
Beryllium	0.001	0.001	1.43	1.28	–	0.0053	–	–
Chromium	0.0015	0.0021	1.43	1.91	0.77	0.011†	0.09	N/O
Lead	0.00008	0.00012	1.43	0.10	0.05	0.0065	0.01	N/O
Nickel	0.0027	0.006	1.43	3.45	4.21	0.1098	0.04	N/O

Constituent	Background Concentration of Queen Creek (mg/L)	Maximum Predicted Concentration in Queen Creek at Whitlow Ranch Dam (mg/L)	Median Flow Rate in Queen Creek (cfs)	Estimated Annual Load from Queen Creek (kg)	Estimated Annual Load from Seepage (kg)	Arizona Numeric Surface Water Quality Standard (mg/L)	Estimated Low Flow at which Standard would be Reached (cfs)	Estimated Percent of Time Queen Creek Flow is Below Standard-Reaching Rate*
Silver	0.000036	0.00074	1.43	0.05	0.90	0.0147	0.07	N/O
Thallium	0.00003	0.00008	1.43	0.04	0.06	0.0072	0.01	N/O
Zinc	0.003	0.0428	1.43	3.83	50.79	0.2477	0.23	<1

Notes:

N/A = Not applicable, as constituent already has concentrations greater than numeric standards at median flow rates.

N/O= Not observed. Flows low enough to cause concentrations greater than numeric standards have never been observed over the period of record at this gage.

– Indicates that tailings seepage provides no or negligible load, and there is no expectation that concentrations could be greater than numeric surface water standards.

* Values in this column relate to the “Estimated Low Flow at which Standard would be Reached (cfs)” column to the left. Estimated based on USGS gage 09478500, Queen Creek below Whitlow Ranch Dam, period of record from 2002 to 2020.

† Standard shown for chromium is for hexavalent chromium, which is the most restrictive of the three chromium standards (total chromium, trivalent chromium, and hexavalent chromium).

Alternative 5 – Peg Leg

POTENTIAL WATER QUALITY IMPACTS FROM TAILINGS STORAGE FACILITY

Seepage Controls Incorporated into Design

Alternative 5 includes the following seepage controls, similar in nature to those described for Alternative 2. A conceptual diagram of the seepage controls is shown in figure 3.7.2-8. Table 3.7.2-22 summarizes how these are expected to be applied:

- Blanket drains beneath the embankment (Level 0)
- Lined collection ditches and six seepage collection ponds (Level 1)
- A geomembrane (HDPE) over 300 acres where the initial recycled water pond would be, in order to maintain operational control of tailings deposition (Level 1)
- An engineered low-permeability layer under the entire separate PAG cell (Level 1); under Level 2 controls this would be upgraded to a full synthetic liner and additional foundation preparation to remove material down to bedrock
- A pumpback well system (Level 1)
- Use of thin-lift deposition in Year 7 once adequate room becomes available (Level 2)

Anticipated Effectiveness of Seepage Controls

For Alternative 5, total seepage estimates are based on an “Order of Magnitude” water balance estimated using a two-dimensional finite element model (SLIDE V7.0) (Golder Associates Inc. 2018a).

The amount of lost seepage for Alternative 5 is calculated in a different manner than other alternatives. Much of the foundation consists of a deep alluvial aquifer associated with Donnelly Wash, which results in substantial seepage losses even with engineered seepage controls built into the facility. Therefore, a downstream pumpback system is a key component of the engineered seepage controls. The amount of flow the alluvial aquifer is able to handle was estimated and a downstream pumpback well system is expected to remove enough water to maintain the aquifer at equilibrium.

During operations, total seepage created by the tailings was estimated at 3,930 acre-feet per year (2,660 and 1,270 acre-feet per year of NPAG and PAG seepage, respectively) and lost seepage was modeled to be 1,317 acre-feet per year with Level 1 seepage controls, and 261 acre-feet per year with all enhanced engineered seepage controls (Level 2).

Modeling indicates the Level 2 seepage controls would reach a seepage capture efficiency of 84 percent of the seepage. It is important to note that the pumpback well system is adjusted under Level 2 and pumpage is reduced to only what is needed to control water quality; substantial additional pumping could be undertaken if needed at this location.

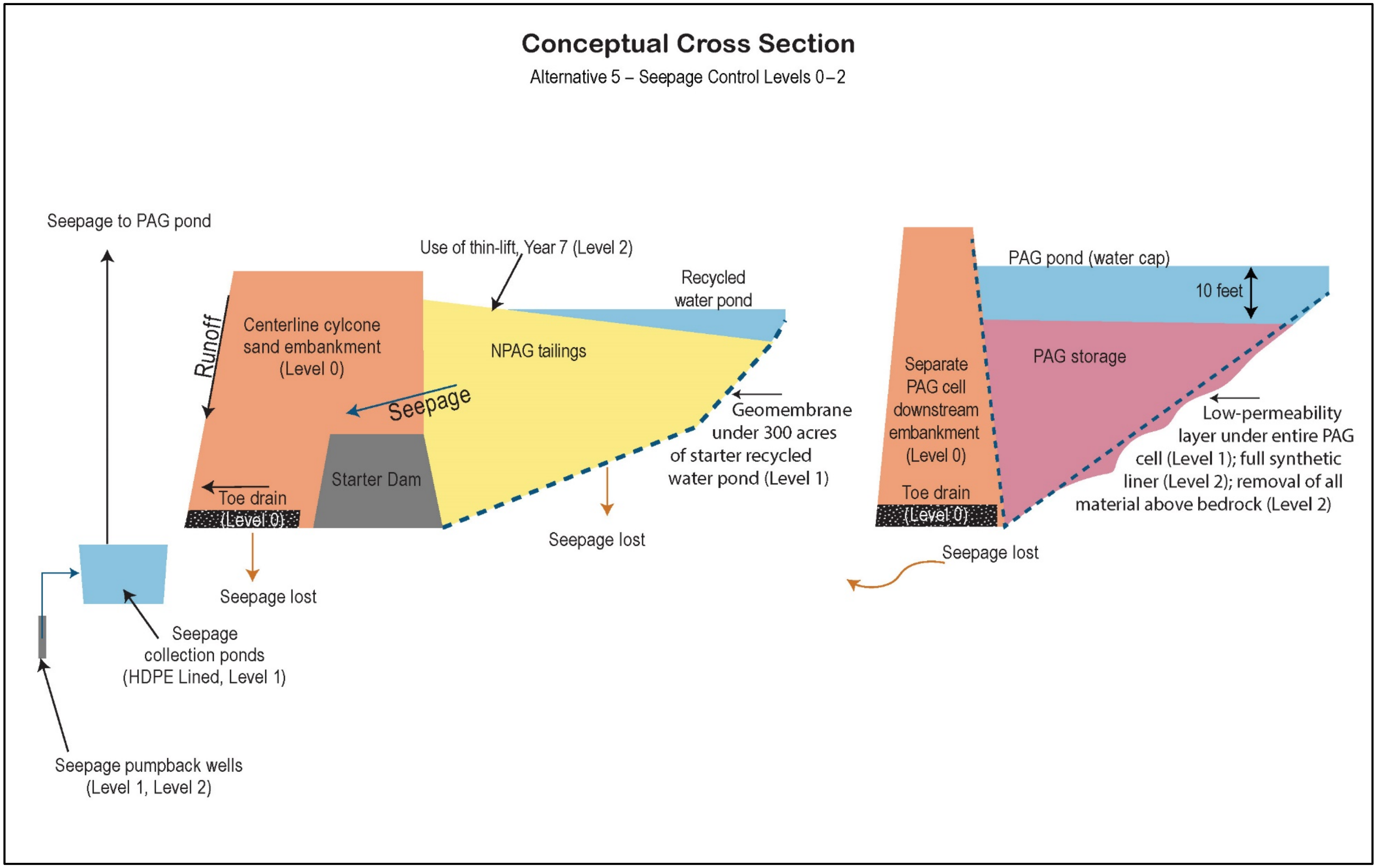


Figure 3.7.2-8. Alternative 5 seepage controls

Table 3.7.2-22. Effectiveness of Alternative 5 engineered seepage controls

Seepage Control Levels and Components	Uncaptured Seepage from Facility	Source
Uncontrolled seepage from tailings facility	3,930 acre-feet/year	Klohn Crippen Berger Ltd. (2019d)
Level 0 (seepage controls for geotechnical stability)		
- Centerline cyclone sand embankment - Blanket drain under embankment - Separate PAG and NPAG cells	Not explicitly modeled; incorporated into Level 1 modeling	N/A
Level 1		
- Lined seepage collection ditches and ponds - Finger drains under facility along natural drainages - 300 acres of geomembrane (HDPE) underneath recycled water pond - Engineered low-permeability layer under entire PAG cell - Pumpback well system to control downgradient flow	1,317 acre-feet per year	Klohn Crippen Berger Ltd. (2019d)
Level 2		
- Full synthetic liner below entire PAG cell - Removal of all material above bedrock below PAG cell - Thin-lift deposition to start in year 7 (requires sufficient room) - Adjustment to pumpback well system, reducing pumping to just amount necessary to control water quality	261 acre-feet per year	Kidner and Pilz (2019) and Klohn Crippen Berger Ltd. (2019d)

Risk of Seepage Impacting Groundwater or Surface Water Quality

Modeled results for groundwater and surface water impacts are reported by Gregory and Bayley (2019). The detailed results of the bypass seepage mixing/loading model were supplied as an Excel spreadsheet, and can be found in Garrett (2019d). Table 3.7.2-23 presents model results for all modeled chemical constituents for cells in the first groundwater cell along Donnelly Wash (cell DW-2) and the ultimate surface water cell (Gila River below Donnelly Wash), for model years 41, 100, and 245. This provides perspective on trends and expected conditions at the end of mining and in the long term. Table 3.7.2-23 also presents Arizona water quality standards and baseline chemistry for added perspective.

Figures M-22 through M-28 in appendix M illustrate model results for the seven constituents of concern.

Modeling results for Alternative 5 indicate the following:

- Modeling estimates that engineered seepage controls can recover 84 percent of total seepage. All levels of control (Levels 0 through 2) have been applied to Alternative 5 for the purposes of estimating the effects of tailings seepage on water quality.
- For all constituents, concentrations decrease with distance from the tailings storage facility, but increase over time.
- No chemical constituent are anticipated in concentrations above groundwater or surface water standards. Nitrate is present in concentrations above aquifer water quality standards, but this is due to background nitrate concentrations and not seepage from the facility. Note also that in year 245, selenium just reaches the aquifer water quality standard but is not above it.
- Sulfate and total dissolved solids are significant constituents in tailings seepage and can alter the potential use of downstream water resources, but do not have numeric standards. Over time, sulfate concentrations in groundwater closest to the tailings storage facility are expected to rise

substantially above the 250 mg/L secondary standard to 594 mg/L (see appendix M, figure M-22).

- Most constituents increase in concentration in groundwater and surface water above existing baseline conditions.
- The practicability of adding seepage controls during operations is assessed in the following section.

Practicability for Additional Seepage Controls

The site-specific suite of engineered seepage controls designed for Alternative 5 is substantially more effective at controlling seepage than a fully lined facility with no other controls. The estimated loss through a full liner is about 1,400 acre-feet per year for a 5,900-acre facility (see Rowe (2012) and Newell and Garrett (2018d) for details of this estimate). This estimate is specifically for an engineered low-permeability liner as specified under Arizona BADCT; composite liners are able to reach better performance, but there are substantial logistical concerns about the ability to successfully install a full liner of any kind (see Newell and Garrett (2018d) for a summary of concerns).

Under the suite of engineered seepage controls considered (Levels 0 through 2), the entire PAG cell and about 300 acres of the NPAG facility would already use low-permeability layers which have similar permeabilities to the Arizona BADCT specifications. The comparison with a full liner illustrates the need for layered seepage controls, particularly downstream seepage collection dams and pumpback wells, to control seepage that would be generated from within the facility regardless of the foundation treatment.

Alternative 5 has substantial flexibility for adding other layers of seepage controls during operation as needed. The pumpback system for Level 2 seepage controls is not assumed to be operating at full capacity, and this would be an efficient way of increasing seepage capture as needed. The distance downstream to the Gila River offers opportunities for modified or expanded pumpback systems or physical barriers (grout curtains).

RAMIFICATIONS FOR LONG-TERM CLOSURE

Post-closure Water Quality, Seepage Rates, and Closure Timing

Modeling indicates that the concentrations of constituents of concern continue to increase over time, post-closure. Post-closure seepage rates are estimated to be 261 acre-feet per year (Kidner and Pilz 2019).

In the alternative design, Kidner and Pilz (2019) estimated during closure the facility would gradually drain down. The seepage collection ponds would remain in place and passively evaporate seepage, and the seepage extraction wells downstream would remain in place to control seepage as long as necessary. This time frame is estimated from 100 to 150 years (Kidner and Pilz 2019). Once the collection ponds can be closed, the closure plans call for encapsulating the accumulated sludge in the geomembrane and backfilling with soil to grade.

A refined seepage analysis was conducted for Alternative 6 – Skunk Camp (Preferred Alternative) that provides insights into the time frames associated with long-term seepage treatment from slurry tailings facilities. Based on these estimates, draindown over time from the NPAG beach tailings would slowly decrease from over 4,000 gallons per minute at the point of mine closure, to eventually reach a steady-state of 40 to 80 gallons per minute, based solely on the amount of water allowed in by the closure cover (KCB Consultants Ltd. 2020d).

The final post-closure seepage collection pond has yet to be sized, but conceptually the potential unaided evaporation from a 10-acre pond would be about 60 acre-feet per year, equal to about 220 gallons per minute. The draindown curve indicates it might take 20–30 years for seepage to reduce to reach this point. The refined seepage analysis confirms the rough estimate that active water management could be needed for several decades after closure.

Financial Assurance for Closure and Post-closure Activities

The regulatory framework under the State of Arizona to require financial assurance for long-term closure activities is the same as described for Alternative 2. However, for the tailings facility, financial assurance requirements would be required by BLM, not the Forest Service.

Like the Forest Service, BLM also has regulatory authority to require financial assurance for closure activities, contained in their surface management regulations (43 CFR Subpart 3809). BLM considers that the financial assurance must cover the estimated cost as if BLM were hiring a third-party contractor to perform reclamation of an operation after the mine has been abandoned. The financial assurance must include construction and maintenance costs for any treatment facilities necessary to meet Federal and State environmental standards.

POTENTIAL IMPACTS ON IMPAIRED WATERS

Any discharges from Alternative 5 are downstream of any impaired waters.

PREDICTED REDUCTIONS IN ASSIMILATIVE CAPACITY

The calculated reductions in assimilative capacity are shown in table 3.7.2-14. For Alternative 5, the discharge of seepage into the Gila River uses more than 20 percent of the assimilative capacity for copper and selenium.

FURTHER ASSESSMENT WITH LOW-FLOW CONDITIONS

The water quality model of potential surface water quality impacts in the Gila River from Alternative 5 tailings seepage makes use of the median flow rate in the Gila River (estimated to be 241 cubic feet per second at Donnelly Wash).[74] As noted in the methodology section, using median flow is a common method of estimating baseflow conditions, because it tends to exclude large flood events. Public comments on the DEIS suggested that these flow conditions do not consider the impact of tailings seepage during critical low-flow periods in the Gila River. In response, we assessed the potential for predicted concentrations in the Gila River to be greater than Arizona numeric surface water quality standards under low-flow conditions.

The concentration of constituents in the Gila River is a function of the load from the tailings seepage after mixing with groundwater in the Donnelly Wash aquifer, the background load in the Gila River, and the available flow in the Gila River. The approach shown in table 3.7.2-24 assumes that background concentrations in the Gila River remain constant; therefore, when flow rates drop, the background load drops as well. Meanwhile, the tailings seepage load entering the Gila River with groundwater from the Donnelly Wash alluvial aquifer remains the same but contributes a larger percentage of the total load.

[74] For Alternative 5, there are no stream gages on the Gila River close to Donnelly Wash. The flow rate was interpolated based on flow data from the two USGS gaging stations closest to Donnelly Wash: station 09474000, located along the Gila River approximately 14 miles upstream from Donnelly Wash at Kelvin, Arizona; and station 09475500, located at the Florence-Casa Grande Canal approximately 6 miles downstream from Donnelly Wash, near Florence, Arizona. Daily flow measurements from the two stations were used to estimate the median flow rate for the Gila River at Donnelly Wash, using a spatially weighted average based on distance from each stream gage. The period of record used was from 2003 to the end of September 2017 (Gregory and Bayley 2018c).

This leads to increases in the overall predicted concentration. At some given magnitude of streamflow, the flow is low enough that concentrations due to the influence of the tailings seepage load may exceed the Arizona numeric surface water quality standard. The amount of time that flow in the Gila River tends to be at or lower than this critical low-flow value provides an estimate of how often water quality problems might arise.

For Alternative 5, the results from this approach suggest that a number of metals could reach concentrations greater than numeric surface water quality standards at lower flow rates, with selenium and copper having the greatest risk. Based on flow data for the Gila River, we estimate that flows fall low enough to lead to these conditions about 28 percent of the time.

RAMIFICATIONS ON DOWNSTREAM WATER USERS

Seepage from the Alternative 5 tailings storage facility would affect both groundwater downgradient in the Donnelly Wash alluvial aquifer, as well as surface water in the Gila River, which likely has some level of groundwater contribution from Donnelly Wash. Concerns were raised over the potential impacts to downstream water supplies, whether directly using water from the Gila River or relying on groundwater wells along the river floodplain in close connection with surface water. Specific water supplies of concern include Hayden, Kearny, Winkelman, and agricultural diversions for the San Carlos Irrigation and Drainage District.

Unlike Alternatives 2 and 4, there are no anticipated concentrations of contaminants in the Gila River due to the tailings seepage above any aquifer or surface water quality standards, as shown in table 3.7.2-23. Some dilution would be anticipated to occur downstream as well, due to contributions from other tributaries or groundwater inflows. The anticipated increases in concentrations above baseline surface water quality are relatively small, compared with the increases anticipated in Queen Creek with Alternatives 2, 3, and 4. Low-flow conditions, occurring about 28 percent of the time, would tend to increase concentrations for selenium and copper to concentrations above the most stringent surface water quality standards. Surface water quality in any diversions along the Gila River would be anticipated to change from current conditions due to the seepage from the Alternative 5 tailings storage facility, exhibiting increases in metals, sulfate, and dissolved solids. Whether such increases affect the use of the water downstream would depend on the specific use and potential dilution. Regardless, the risk of impacting downstream water users due to degraded water quality increases under low-flow conditions.

Any groundwater wells in close hydraulic connection with the Gila River would be anticipated to potentially change from current conditions due to the seepage from the Alternative 5 tailings storage facility, exhibiting increases in metals, sulfate, and dissolved solids. However, such increases may not affect the actual use of the groundwater, as they do not exceed numeric aquifer water quality standards.

Table 3.7.2-23. Seepage water quality modeling results for Alternative 5 (mg/L)

	Aquifer Water Quality Standard	Baseline Groundwater Quality (Tea Cup Well*)	DW-2 Model Cell Year 41	DW-2 Model Cell Year 100	DW-2 Model Cell Year 245	Surface Water Standard for Most Restrictive Use	Baseline Surface Water Quality (Gila River below Donnelly Wash[†])	Gila River below Donnelly Wash Modeled Surface Water Year 41	Gila River below Donnelly Wash Modeled Surface Water Year 100	Gila River below Donnelly Wash Modeled Surface Water Year 245
Constituents with Numeric Standards										
Antimony	0.006	0.00003	0.00003	0.00044	0.00214	0.030	0.00023	0.00023	0.00023	0.00025
Arsenic	0.05	0.0021	0.0021	0.0022	0.0032	0.030	0.00889	0.0089	0.0089	0.0089
Barium	2	0.0428	0.0428	0.0442	0.0483	98	0.0826	0.083	0.083	0.083
Beryllium	0.004	0.0010	0.00100	0.00104	0.00202	0.0053	0.0017	0.0017	0.0017	0.0017
Boron	–	0.082	0.082	0.112	0.205	1	0.190	0.190	0.190	0.191
Cadmium	0.005	0.00004	0.0000	0.0006	0.0026	0.0049[‡]	0.00006	0.00006	0.00006	0.00009
Chromium, Total[¶]	0.1	0.0019	0.0019	0.0050	0.0137	0.011	0.0020	0.0020	0.0020	0.0021
Copper	–	0.00330	0.003	0.034	1.035	0.0222[‡]	0.00408	0.0041	0.0041	0.0099
Fluoride	4	0.68	0.68	0.90	1.71	140	0.987	0.99	0.99	1.00
Iron	–	0.045	0.0450	0.0452	0.0470	1	0.056	0.056	0.056	0.056
Lead	0.05	0.002630	0.00263	0.00274	0.00321	0.0078[‡]	0.00015	0.00015	0.00015	0.00016
Manganese	–	0.0049	0.005	0.075	0.580	10	0.028	0.028	0.028	0.033
Mercury	0.002	N/A	N/A	N/A	N/A	0.00001	N/A	N/A	N/A	N/A
Nickel	0.1	0.0027	0.003	0.012	0.085	0.1280[‡]	0.0023	0.0023	0.0023	0.0030
Nitrate	10	**15.20[§]**	**15.26**	**15.53**	**16.34**	3,733.333	0.091	0.09	0.09	0.11
Nitrite	1	N/A	N/A	N/A	N/A	233.333	N/A	N/A	N/A	N/A
Selenium	0.05	0.0011	0.001	0.013	0.050	0.002	0.0004	0.0004	0.0004	0.0010
Silver	–	0.000036	0.0000	0.0026	0.0100	0.0201	0.000061	0.00006	0.00006	0.00018
Thallium	0.002	0.00003	0.00003	0.00024	0.00073	0.0072	0.000080	0.00008	0.00008	0.00009
Uranium	–	N/A	N/A	N/A	N/A	2.8	N/A	N/A	N/A	N/A
Zinc	–	0.016	0.016	0.132	0.560	0.2888[‡]	0.0050	0.0050	0.0050	0.0109
pH	–	N/A	N/A	N/A	N/A	6.5–9.0	N/A	N/A	N/A	N/A

	Aquifer Water Quality Standard	Baseline Groundwater Quality (Tea Cup Well*)	DW-2 Model Cell Year 41	DW-2 Model Cell Year 100	DW-2 Model Cell Year 245	Surface Water Standard for Most Restrictive Use	Baseline Surface Water Quality (Gila River below Donnelly Wash†)	Gila River below Donnelly Wash Modeled Surface Water Year 41	Gila River below Donnelly Wash Modeled Surface Water Year 100	Gila River below Donnelly Wash Modeled Surface Water Year 245
Constituents without Numeric Standards										
Sulfate	–	59	59	138	594	–	159	159	159	164
Total Dissolved Solids	**–**	**523**	**523**	**648**	**1,338**	**–**	**776**	**776**	**776**	**783**

Notes: N/A= not analyzed in seepage modeling

Shaded cell and bolded text indicate concentrations above water quality standard.

Model data are not specific to total or dissolved fractions; for the purposes of comparison to surface water standards it can be assumed to apply to both.

* Assumed concentrations are based on single sample collected on September 27, 2017, and are therefore approximate.

† Assumed concentrations are based on single sample collected on November 13, 2018, and are therefore approximate.

‡ Standards are hardness dependent and were calculated using a hardness value of 290 mg/L $CaCO_3$ (from sample collected on November 13, 2018); see appendix N, table N-5 for details on how these standards were selected.

§ NO_3-N concentration shown is above its standard; additional water quality monitoring is required to determine whether value is representative of aquifer water quality or due to localized contamination.

⁋ Standard shown for chromium is for hexavalent chromium, which is the most restrictive of the three chromium standards (total chromium, trivalent chromium, and hexavalent chromium)

Table 3.7.2-24. Estimated low-flow values required for predicted concentrations to be greater than standards in the Gila River, due to Alternative 5 tailings seepage

Constituent	Background Concentration of Gila River (mg/L)	Maximum Predicted Concentration in Gila River below Donnelly Wash (mg/L)	Median Flow Rate in Gila River (cfs)	Estimated Annual Load from Gila River (kg)	Estimated Annual Load from Seepage (kg)	Arizona Numeric Surface Water Quality Standard (mg/L)	Estimated Low Flow at which Standard would be Reached (cfs)	Estimated Percent of Time Gila River Flow is Below Standard-Reaching Rate*
Selenium	0.0004	0.001	241	86	129	0.002	90.2	27
Cadmium	0.00006	0.00009	241	13	6	0.0043	1.7	7
Antimony	0.00023	0.00025	241	49	4	0.03	0.2	3
Copper	0.00408	0.0099	241	876	1,250	0.0191	93.2	28
Arsenic	0.00889	0.0089	241	1,909	2	0.03	0.1	3
Beryllium	0.0017	0.0017	241	365	–	0.0053	–	–
Chromium	0.002	0.0021	241	429	21	0.011†	2.7	7

Constituent	Background Concentration of Gila River (mg/L)	Maximum Predicted Concentration in Gila River below Donnelly Wash (mg/L)	Median Flow Rate in Gila River (cfs)	Estimated Annual Load from Gila River (kg)	Estimated Annual Load from Seepage (kg)	Arizona Numeric Surface Water Quality Standard (mg/L)	Estimated Low Flow at which Standard would be Reached (cfs)	Estimated Percent of Time Gila River Flow is Below Standard-Reaching Rate*
Lead	0.00015	0.00015	241	32	–	0.0065	–	–
Nickel	0.0023	0.003	241	494	150	0.1098	1.6	6
Silver	0.000061	0.00018	241	13	26	0.0147	2.0	7
Thallium	0.00008	0.00009	241	17	2	0.0072	0.3	4
Zinc	0.005	0.0109	241	1,074	1,267	0.2477	5.8	10

Note:

– Indicates that tailings seepage provides no or negligible load, and there is no expectation that concentrations could be greater than numeric surface water standards.

* Values in this column relate to the “Estimated Low Flow at which Standard would be Reached (cfs)” column to the left. Estimated based on USGS gage 09474000, Gila River at Kelvin, period of record from 2003 to 2017.

† Standard shown for chromium is for hexavalent chromium, which is the most restrictive of the three chromium standards (total chromium, trivalent chromium, and hexavalent chromium).

Alternative 6 – Skunk Camp

POTENTIAL WATER QUALITY IMPACTS FROM TAILINGS STORAGE FACILITY

Seepage Controls Incorporated into Design

Alternative 6 includes the following seepage controls, similar in nature to those described for Alternative 2. A conceptual diagram of the seepage controls is shown in figure 3.7.2-9. Table 3.7.2-25 summarizes how these are expected to be applied:

- Blanket drains beneath the embankment (Level 0), extending farther under the facility under Level 1 controls.
- A low-permeability layer under the entire separate PAG cell (Level 1).
- A single downstream seepage collection pond with grout curtains and a pumpback well system (Level 1). Under Level 2 the grout curtain and wells are deepened, and then under Level 3 they are deepened again.

Anticipated Effectiveness of Seepage Controls

For Alternative 6, total seepage estimates are based on two-dimensional steady-state finite element model (SEEP/W) (Klohn Crippen Berger Ltd. 2019c). The amount of lost seepage for Alternative 6 is estimated in two ways, both derived from the two-dimensional model. One estimate of lost seepage is the difference between the modeled seepage from the NPAG and PAG facilities, minus the amount of seepage modeled to be collected in the downstream seepage collection pond. A second estimate is derived directly from the modeled flux of water downstream of the seepage collection pond.

During operations, total seepage created by the tailings was estimated at 1,870 acre-feet per year (1,820 and 50 acre-feet per year of NPAG and PAG seepage, respectively) and lost seepage was modeled to be 580 to 660 acre-feet per year with Level 1 seepage controls, 270 to 370 acre-feet per year with Level 2 enhancements to the grout curtains and wells, and 200 to 260 acre-feet per year with all Level 3 enhancements.

Table 3.7.2-25. Effectiveness of Alternative 6 engineered seepage controls

Seepage Control Levels and Components	Uncaptured Seepage from Facility	Source
Uncontrolled seepage from tailings facility	1,870 acre-feet/year	Klohn Crippen Berger Ltd. (2019c)
Level 0 (seepage controls for geotechnical stability)		
- Centerline cyclone sand embankment - Blanket drain under embankment - Separate PAG and NPAG cells	Not explicitly modeled; incorporated into Level 1 modeling	N/A
Level 1		
- Blanket drain extends 100–200 feet underneath impoundment - Engineered low-permeability layer under entire PAG cell - Seepage collection ponds, with cut-offs, grout curtains, and pumpback wells; grout curtains extend to 70 feet (estimated base of alluvium); pumpback wells extend to 20 feet	580 to 660 acre-feet per year	Klohn Crippen Berger Ltd. (2019c)

Seepage Control Levels and Components		Uncaptured Seepage from Facility	Source
Level 2			
-	Grout curtains extended to 100 feet (estimated base of Gila Conglomerate); pumpback wells extend to 70 feet	270 to 370 acre-feet per year	Klohn Crippen Berger Ltd. (2019c)
Level 3			
-	Pumpback wells extend to 100 feet	70 to 180 acre-feet per year	Klohn Crippen Berger Ltd. (2019c)

Risk of Seepage Impacting Groundwater or Surface Water Quality

As noted in section 3.7.2.2, additional modeling was conducted to estimate impacts to water quality from tailings seepage for Alternative 6, taking advantage of new field information collected at this location. The new modeling is a refinement of the modeling conducted for the DEIS, using similar inputs but different modeling techniques. Specifically, a numerical groundwater flow model (referred to here as the "FEIS water quality model") was used instead of a mixing cell model (referred to here as the "DEIS water quality model"). Both techniques are valid, and results from both are disclosed here.

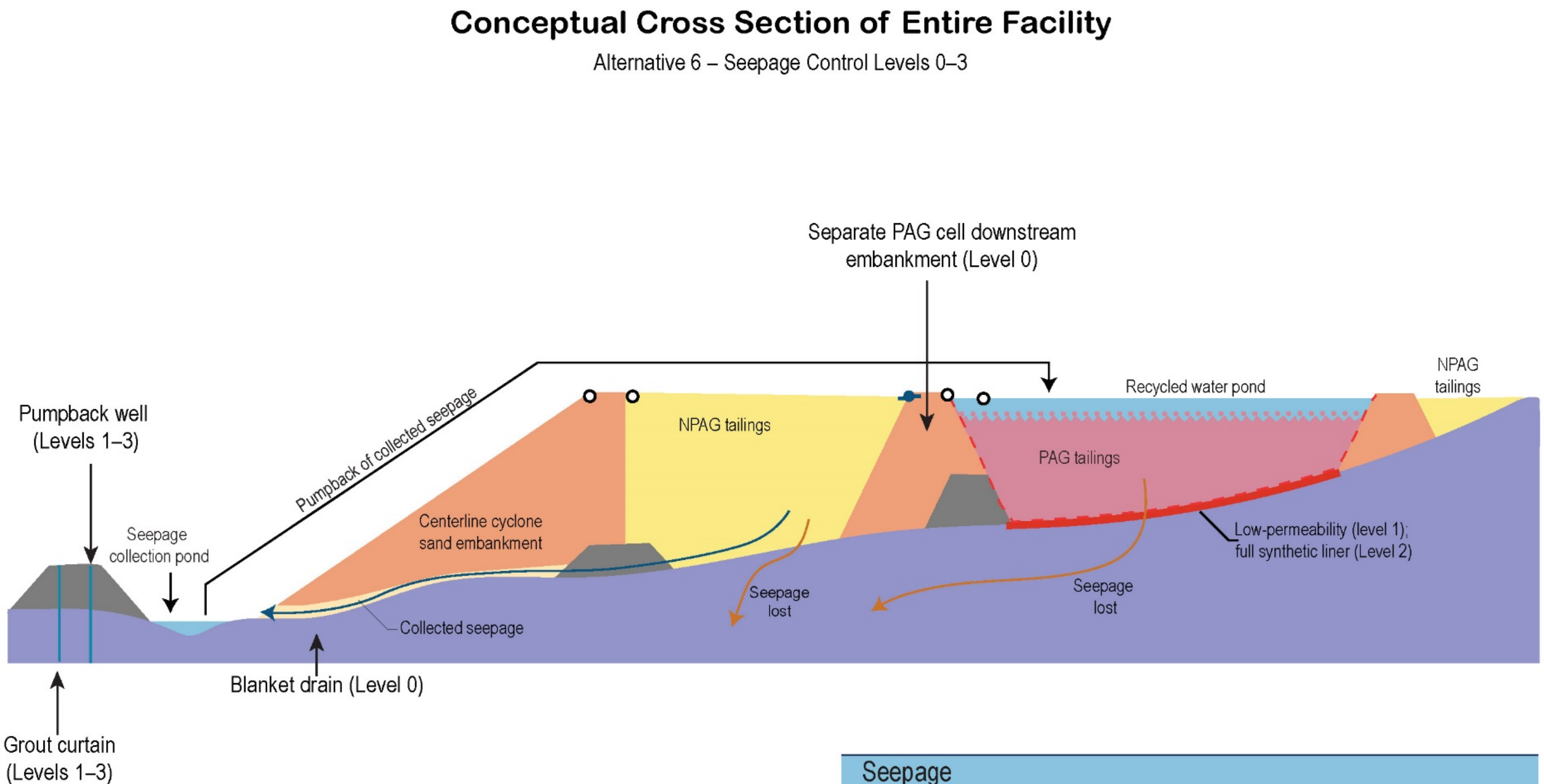
DEIS Water Quality Model

Modeled results for groundwater and surface water impacts based on the DEIS water quality model are reported by Gregory and Bayley (2019). The detailed results of the DEIS water quality model were supplied as an Excel spreadsheet and can be found in Garrett (2019d). Table 3.7.2-26 presents model results for all modeled chemical constituents in the first groundwater cell (cell DS-1) and the ultimate surface water cell (Gila River below Dripping Spring Wash), for model years 41, 100, and 245. This provides perspective on trends and expected conditions at the end of mining and in the long term. Table 3.7.2-26 also presents Arizona water quality standards and baseline chemistry for added perspective.

Figures M-29 through M-35 in appendix M illustrate the DEIS water quality model results for the seven constituents of concern.

Modeling results for Alternative 6 using the DEIS water quality model indicate the following:

- Modeling estimates that engineered seepage controls can recover 90 percent of total seepage. All levels of control (Levels 0 through 3) have been applied to Alternative 6 for the purposes of estimating the effects of tailings seepage on water quality.
- For all constituents, concentrations decrease with distance from the tailings storage facility, but increase over time.
- No chemical constituents are anticipated in concentrations above groundwater or surface water standards.
- Sulfate and total dissolved solids are significant constituents in tailings seepage and can alter the potential use of downstream water resources, but do not have numeric standards. Over time, sulfate concentrations in groundwater closest to the tailings storage facility are expected to rise slightly above the 250 mg/L secondary standard, to 385 mg/L (see appendix M, figure M-29).
- Most constituents increase in concentration in groundwater and surface water above existing baseline conditions.
- The practicability of adding seepage controls during operations is assessed in the following section.



Seepage Control Level	Grout Curtain/Cut-off	PumpBack Well
1	Depth of 70 feet	Depth of 20 feet
2	Depth of 100 feet	Depth of 70 feet
3	Depth of 100 feet	Depth of 100 feet

Figure 3.7.2-9. Alternative 6 seepage control

Table 3.7.2-26. Seepage water quality modeling results for Alternative 6 from DEIS water quality model (mg/L)

	Aquifer Water Quality Standard	Baseline Groundwater Quality (Skunk Camp Well*)	DS-1 Model Cell Year 41	DS-1 Model Cell Year 100	DS-1 Model Cell Year 245	Surface Water Standard for Most Restrictive Use	Baseline Surface Water Quality (Gila River below Dripping Spring Wash*)	Gila River below Dripping Spring Wash Modeled Surface Water Year 41	Gila River below Dripping Spring Wash Modeled Surface Water Year 100	Gila River below Dripping Spring Wash Modeled Surface Water Year 245
Constituents with Numeric Standards										
Antimony	0.006	0.00023	0.00091	0.00128	0.00162	0.030	0.00023	0.00024	0.00025	0.00025
Arsenic	0.05	0.0003	0.0003	0.0005	0.0011	0.030	0.00861	0.0086	0.0086	0.0086
Barium	2	0.0038	0.0073	0.0081	0.0078	98	0.0749	0.075	0.075	0.075
Beryllium	0.004	0.0017	0.00171	0.00171	0.00171	0.0053	0.0017	0.0017	0.0017	0.0017
Boron	–	0.026	0.076	0.100	0.109	1	0.196	0.197	0.197	0.197
Cadmium	0.005	0.00006	0.0011	0.0015	0.0014	0.0043[†]	0.00006	0.00008	0.00009	0.00009
Chromium, Total[‡]	0.1	0.0020	0.0077	0.0098	0.0087	0.011	0.0020	0.0021	0.0021	0.0021
Copper	–	0.00165	0.038	0.051	0.044	0.0191[†]	0.00207	0.0026	0.0029	0.0028
Fluoride	4	0.232	0.78	0.96	0.87	140	1.0	1.04	1.04	1.04
Iron	–	0.056	0.0563	0.0564	0.0564	1	0.071	0.071	0.071	0.071
Lead	0.05	0.000140	0.00031	0.00040	0.00045	0.0065[†]	0.00014	0.00014	0.00014	0.00015
Manganese	–	0.0034	0.122	0.170	0.156	10	0.029	0.031	0.032	0.032
Mercury	0.002	N/A	N/A	N/A	N/A	0.00001	N/A	N/A	N/A	N/A
Nickel	0.1	0.0023	0.015	0.020	0.022	0.1098[†]	0.0023	0.0025	0.0026	0.0026
Nitrate	10	1.34	1.82	1.95	1.91	3,733.333	0.305	0.31	0.32	0.31
Nitrite	1	N/A	N/A	N/A	N/A	233.333	N/A	N/A	N/A	N/A
Selenium	0.05	0.0004	0.022	0.030	0.028	0.002	0.0004	0.0007	0.0009	0.0009
Silver	–	0.000061	0.0050	0.0069	0.0059	0.0147	0.000061	0.00014	0.00018	0.00016
Thallium	0.002	0.00008	0.00042	0.00053	0.00047	0.0072	0.000080	0.00009	0.00009	0.00009
Uranium	–	N/A	N/A	N/A	N/A	2.8	N/A	N/A	N/A	N/A
Zinc	–	0.224	0.445	0.538	0.518	0.2477[†]	0.0050	0.0085	0.0103	0.0099
pH	–	N/A	N/A	N/A	N/A	6.5–9.0	N/A	N/A	N/A	N/A

	Aquifer Water Quality Standard	Baseline Groundwater Quality (Skunk Camp Well*)	DS-1 Model Cell Year 41	DS-1 Model Cell Year 100	DS-1 Model Cell Year 245	Surface Water Standard for Most Restrictive Use	Baseline Surface Water Quality (Gila River below Dripping Spring Wash*)	Gila River below Dripping Spring Wash Modeled Surface Water Year 41	Gila River below Dripping Spring Wash Modeled Surface Water Year 100	Gila River below Dripping Spring Wash Modeled Surface Water Year 245
Constituents without Numeric Standards										
Sulfate	–	54	196	365	385	–	100	102	105	105
Total Dissolved Solids	**–**	**327**	**575**	**830**	**846**	**–**	**702**	**706**	**710**	**711**

Notes: N/A = not analyzed in seepage modeling

Model data are not specific to total or dissolved fractions; for the purposes of comparison to surface water standards it can be assumed to apply to both.

* Assumed concentrations are based on single sample collected on November 9, 2018, and are therefore approximate.

† Standards are hardness dependent and were calculated using a hardness value of 242 mg/L $CaCO_3$ (from sample collected on November 9, 2018); see appendix N, table N-5, for details on how these standards were selected.

‡ Standard shown for chromium is for hexavalent chromium, which is the most restrictive of the three chromium standards (total chromium, trivalent chromium, and hexavalent chromium).

Field Investigations between DEIS and FEIS

The full suite of field investigations conducted at the Skunk Camp location between the DEIS and FEIS are described in section 3.2. The additional site investigations generally confirmed and did not fundamentally alter the understanding of the geology or hydrology of the location. The outcomes and their comparison to the DEIS water quality model and the FEIS water quality model are shown in table 3.7.2-27. Both the DEIS and FEIS water quality models assess the flow through the alluvium as the primary mechanism by which tailings seepage reaches downstream surface waters. Though using different modeling techniques, the depth and hydraulic conductivity of the alluvium in each model are similar in magnitude and conform with the observations made in the field.

Table 3.7.2-27. Comparison of field investigations and water quality modeling at Skunk Camp location

Parameter	Initial Pre-DEIS Field Investigations*	DEIS Water Quality Model Assumptions†	Post-DEIS Field Investigations‡	FEIS Water Quality Model Assumptions§
Thickness of Quaternary alluvial deposits	Less than 150 feet	Not explicitly stated	11 to 76 feet	Variable; up to 100 feet
Thickness of Gila Conglomerate	Greater than 2,900 feet	Not explicitly stated	Greater than 1,500 feet	Variable; up to 2,000 feet
Depth to groundwater	70 to 180 feet	Not explicitly stated	70 to 560 feet	Not explicitly stated
Saturated thickness of alluvium	0 to 80 feet (calculated from above data)	7 to 28 feet (calculated using Darcy's law)	Alluvium mostly unsaturated	Not explicitly stated
Hydraulic conductivity of alluvium	Not reported	500 feet/day	5.4 to 496 feet per day, geometric mean of 28.9 feet per day	Variable; geometric mean of 24 feet/day
Hydraulic conductivity of Gila Conglomerate	Not reported	Flow through Gila Conglomerate not modeled	0.005 to 2.7 feet per day, geometric mean of 0.5 foot per day	Variable; geometric mean of 0.3 foot/day

* Fleming, Shelley, et al. (2018)

† Gregory and Bayley (2018d)

‡ KCB Consultants Ltd. (2019); Montgomery and Associates Inc. (2020a); Montgomery and Associates Inc. (2020g)

§ Montgomery and Associates Inc. (2020a); Montgomery and Associates Inc. (2020c)

FEIS Water Quality Model

Modeled results for groundwater and surface water impacts based on the FEIS water quality model are reported by Montgomery and Associates (2020c). The numerical groundwater flow model takes a different approach to estimating the potential for concentrations in the Gila River to be greater than numeric surface water quality standards. Rather than mix groundwater impacted by tailings seepage with surface water flowing in the Gila River, predicted concentrations in the aquifer just upgradient from the Gila River are compared with both numeric aquifer and numeric surface water quality standards. By demonstrating that the groundwater itself does not contain concentrations over the standard, the model also demonstrates that surface water—once mixed with that groundwater—would also not contain concentrations over the standards.

Table 3.7.2-28 presents model results for all modeled chemical constituents in the aquifer at two locations for approximate model years 41, 100, and 245: at a likely future groundwater point of compliance about one mile downgradient from the tailings storage facility, and just upgradient from the Gila River. Based on these results, concentrations increase in the aquifer just downgradient from the tailing storage facility, but virtually no load is delivered by tailings seepage as far as the Gila River, and no concentrations rise above numeric water quality standards for either groundwater or surface water.

There are likely three primary reasons why the refined FEIS water quality model has different results from the DEIS water quality model.

- The first reason the FEIS water quality model predicts lower concentrations downgradient is that the anticipated seepage from the tailings facility itself was remodeled, including both the anticipated draindown over time from the entrained water and the long-term post-closure seepage allowed by the closure cover (KCB Consultants Ltd. 2020d). The DEIS water quality model assumed a long-term seepage of 160 gallons per minute after closure (Gregory and Bayley 2018d). The refined estimates for the FEIS water quality model range from 40 to 80 gallons per minute after closure (KCB Consultants Ltd. 2020d).
- The second reason the FEIS water quality model predicts lower concentrations downgradient is that the seepage controls were directly modeled as part of the seepage transport; for the DEIS water quality model, only the minimum tailings seepage controls and design elements necessary for geotechnical stability were incorporated into the modeling (Gregory and Bayley 2018d).
- The third reason the FEIS water quality model predicts lower concentrations downgradient is that the flow modeling itself is a more sophisticated representation of the flow through the aquifer system that is available for dilution. Specific concerns were raised in public comments about the amount of data available for the downgradient portions of Dripping Spring Wash between the tailings storage facility and the Gila River. The refined modeling incorporates groundwater-level measurements from 26 site-specific wells, seven of which are located downstream of the tailings storage facility embankment. Flow is modeled through both the alluvial aquifer and the Gila Conglomerate, using unit-specific hydraulic conductivities based on field tests. This represents flow through the physical system more realistically than the DEIS water quality model, with flow amounts constrained by verified aquifer properties.

In summary, the DEIS water quality modeling results were specifically noted by the modelers as likely overestimating water quality impacts, and the FEIS water quality model represents a more realistic attempt at predicting water quality outcomes.

The FEIS water quality model was prepared by Resolution Copper in response to discussions with the Water Resources Workgroup. The resulting model was then vetted by the groundwater professionals working on behalf of the Tonto National Forest (Walser 2020c). That review notes a number of aspects of the FEIS water quality model that would need to be explored to reduce uncertainty to the point that the model could be solely relied upon for the EIS analysis. In light of this, the reviewers caution that the FEIS water quality model should be regarded as a screening method with certain limitations, and suggest using it in conjunction with the DEIS water quality model (Walser 2020c).

After consideration of the uncertainties and concerns raised, we chose to adopt this approach, and chose to disclose the results of both the DEIS water quality model and the FEIS water quality model in the FEIS.

The CEQ regulations in effect for this NEPA analysis identify the need for scientific integrity in the process: “Agencies shall insure the professional integrity, including scientific integrity, of the discussions and analyses in environmental impact statements” (40 CFR 1502.24). Where incomplete or unavailable information the focus in the EIS is on information “essential to a reasoned choice among alternatives” (40 CFR 1502.22). As detailed in table 3.7.2-27, the field investigations at the Skunk Camp tailings storage facility location after publication of the DEIS largely confirmed what was assumed for the DEIS. Additionally, after full review and consideration of comments received on the DEIS (as detailed in appendix R), we found no comments that invalidated the use of the DEIS water quality model. The DEIS water quality model remains a valid approach for disclosing anticipated water quality impacts from the Resolution Copper Project, and a valid approach for evaluating the differences among alternatives.

The FEIS water quality model—with full consideration of the uncertainties described by the Water Resources Workgroup (Walser 2020c)—is a supplement to the DEIS water quality analysis. It reflects a different modeling approach that is more sophisticated and more precise. The FEIS water quality model can take into account greater variability in the hydrogeologic framework, provide better resolution on the timing and location of water quality impacts, and can better model both the seepage from the tailings storage facility and the seepage control measures (such as the pumpback system). This makes it a more sophisticated tool, but not necessarily a more accurate tool. The Water Resources Workgroup review of the uncertainties of the FEIS water quality model conforms with the requirement for scientific integrity. The choice to reflect the uncertainties of the FEIS water quality model by using it as a supplement to the still-valid DEIS water quality model also adheres with the requirement for scientific integrity.

In any case, it should be noted that the results of both models are also largely consistent and do not change the disclosure of impacts between alternatives:

- Neither model indicates that concentrations will rise above numeric surface water quality standards in the nearest downstream perennial water (the Gila River),
- Neither model indicates that concentrations will rise above Arizona aquifer water quality standards in the downgradient aquifer beyond the immediate vicinity of the tailings storage facility.

Figures M-36 through M-42 in appendix M illustrate the FEIS water quality model results for the seven constituents of concern.

Modeling results for Alternative 6 using the FEIS water quality model indicate the following:

- Modeling estimates that engineered seepage controls recover roughly 24 percent of seepage. Wells have a capture efficiency of about 40 percent (i.e., 40 percent of the water is seepage and the rest is native groundwater), whereas finger drains have a capture efficiency of about 83 percent (Montgomery and Associates Inc. 2020c).
- For all constituents, concentrations decrease with distance from the tailings storage facility, but increase over time. However, while numerically increasing, the tailings seepage load is almost non-detectable by the time it reaches the Gila River. No chemical constituents are anticipated in concentrations above numeric groundwater or surface water standards in the aquifer just upgradient of the Gila River. Concentrations above aquifer water quality standards are only anticipated within about 1 mile of the toe of the tailings storage facility.

Practicability for Additional Seepage Controls

The site-specific suite of engineered seepage controls designed for Alternative 6 is substantially more effective at controlling seepage than a fully lined facility with no other controls. The estimated loss through a full liner is about 960 acre-feet per year for a 4,000-acre facility (see Rowe (2012) and Newell and Garrett (2018d) for details of this estimate). This estimate is specifically for an engineered low-permeability liner as specified under Arizona BADCT; composite liners are able to reach better performance, but there are substantial logistical concerns about the ability to successfully install a full liner of any kind (see Newell and Garrett (2018d) for a summary of concerns).

Under the suite of engineered seepage controls considered (Levels 0 through 2), the entire PAG cell would already use low-permeability layers which have similar permeabilities to the Arizona BADCT specifications. The comparison to a full liner illustrates the need for layered seepage controls, particularly downstream seepage collection dams and pumpback wells, to control seepage that would be generated from within the facility, regardless of the foundation treatment.

Like Alternative 5, Alternative 6 has substantial flexibility for adding other layers of seepage controls during operations as needed. The distance downstream to the Gila River offers opportunities for modified or expanded pumpback systems or physical barriers (grout curtains).

The refined FEIS water quality modeling of seepage controls suggests they would be highly effective at maintaining aquifer water quality.

RAMIFICATIONS FOR LONG-TERM CLOSURE

Post-closure Water Quality, Seepage Rates, and Closure Timing

Modeling indicates that the concentrations of constituents of concern continues to increase over time, post-closure. Post-closure seepage rates are estimated to be 200 to 260 acre-feet per year (Klohn Crippen Berger Ltd. 2019c). In the alternative design, Klohn Crippen Berger Ltd. (2018d) estimated that active closure would be required up to 20 years after the end of operations. Up to 5 years after closure, the recycled water pond still is present and therefore all engineered seepage controls could remain operational, with seepage pumped back to the tailings storage facility. After 5 years, the recycled water pond is no longer present. At this time, the seepage collection ponds would be expanded to maximize evaporation, and then active water management (either enhanced evaporation or treatment for release) would take place until the ponds could passively evaporate all incoming seepage (estimated at 20 years). The sludge of concentrated metals and salts from evaporation would eventually require cleanup and potentially off-site disposal as solid or hazardous waste; this would likely include both the accumulated solids as well as the seepage pond liner.

A refined seepage analysis was conducted for Alternative 6 that provides insights into the time frames associated with long-term seepage treatment. Based on these estimates, draindown over time from the NPAG beach tailings would slowly decrease from over 4,000 gallons per minute at the point of mine closure, to eventually reach a steady-state of 40 to 80 gallons per minute, based solely on the amount of water allowed in by the closure cover (KCB Consultants Ltd. 2020d).

The final post-closure seepage collection pond has yet to be sized, but conceptually the potential unaided evaporation from a 10-acre pond would be about 60 acre-feet per year, equal to about 220 gallons per minute. The draindown curve indicates it might take 20–30 years for seepage to reduce to reach this point. The refined seepage analysis confirms the rough estimate that active water management could be needed for several decades after closure.

A further post-closure issue raised by the Water Resources Workgroup is the potential for a large release of poor-quality groundwater downgradient when the grout curtain at the seepage collection pond is breached or removed. Resolution Copper provided clarification of the anticipated effects, based on the FEIS water quality model for Alternative 6. The modeling demonstrates no change in concentrations with and without the grout curtain in place (Resolution Copper 2020d).

Financial Assurance for Closure and Post-closure Activities

The regulatory framework under the State of Arizona to require financial assurance for long-term closure activities is the same as described for Alternative 2. However, Alternative 6 differs from the other alternatives because the tailings facility would not be located on lands managed by the Forest Service (Alternatives 2, 3, and 4) or BLM (Alternative 5). For Alternative 6, the Federal financial assurance mechanisms would not be applicable.

POTENTIAL IMPACTS ON IMPAIRED WATERS

As noted, the Gila River between the San Pedro River and Mineral Creek is currently considered impaired for suspended sediment concentrations. Given the stormwater controls put in place during operation and the long-term reclamation after closure, it is unlikely that Alternative 6 would contribute to suspended sediment in the Gila River.

PREDICTED REDUCTIONS IN ASSIMILATIVE CAPACITY

The calculated reductions in assimilative capacity are shown in table 3.7.2-14. For Alternative 6, the discharge of seepage into the Gila River uses more than 20 percent of the assimilative capacity for selenium.

FURTHER ASSESSMENT WITH LOW-FLOW CONDITIONS

The DEIS water quality model of potential surface water quality impacts in the Gila River from Alternative 6 tailings seepage makes use of the median flow rate in the Gila River (estimated to be 272 cubic feet per second at Dripping Spring Wash).[75] As noted in the methodology section, using median flow is a common method of estimating baseflow conditions, because it tends to exclude large flood events. Public comments on the DEIS suggested that these flow conditions do not consider the impact of tailings seepage during critical low-flow periods in the Gila River. In response, we assessed the potential for predicted concentrations in the Gila River to be greater than Arizona numeric surface water quality standards under low-flow conditions.

The concentration of constituents in the Gila River is a function of the load from the tailings seepage after mixing with groundwater in the Dripping Spring Wash aquifer, the background load in the Gila River, and the available flow in the Gila River. The approach shown in table 3.7.2-29 assumes that background concentrations in the Gila River remain constant; therefore, when flow rates drop, the background load drops as well. Meanwhile, the tailings seepage load entering the Gila River with groundwater from the Dripping Spring Wash alluvial aquifer remains the same but contributes a larger percentage of the total load. This leads to increases in the overall predicted concentration. At some given magnitude of streamflow, the flow is low enough that concentrations due to the influence of the tailings seepage load may exceed the Arizona numeric surface water quality standard. The amount of time that flow in the Gila River tends to be at or lower than this critical low-flow value provides an estimate of how often water quality problems might arise.

For Alternative 6, the results from the DEIS water quality model suggest that a number of metals could reach concentrations greater than numeric surface water quality standards at lower flows, with selenium having the greatest risk. Based on flow data for the Gila River, we estimate that flows fall low enough to lead to these conditions about 28 percent of the time. Other metals would require even lower flows to

[75] As with Alternative 5, there are no stream gages at Dripping Spring Wash. The median flow rate in the Gila River at Dripping Spring Wash was estimated using flow rate measurements from USGS stream gage 9469500, Gila River below Coolidge Dam, located 18 miles upstream from the confluence; and station 9474000 Gila River at Kelvin, located 25 miles downstream from the confluence. The median flow was estimated as a spatially weighted average based on distance from each station. The period of record from 1968 to 2018 was used for the calculations.

reach concentrations greater than numeric surface water quality standards; these include cadmium (flows fall low enough about 14 percent of the time); copper (21 percent); chromium (16 percent); silver (15 percent); and zinc (19 percent).

The results from the FEIS water quality model for Alternative 6 indicate that tailings seepage would not cause concentrations greater than surface water standards under any flow conditions. This is because the groundwater entering the Gila River is, itself, predicted to have no concentrations greater than numeric surface water standards.

RAMIFICATIONS ON DOWNSTREAM WATER USERS

Similar to Alternative 5, seepage from the Alternative 6 tailings storage facility would affect both groundwater downgradient in the Dripping Spring Wash alluvial aquifer, as well as surface water in the Gila River, which likely has some level of groundwater contribution from Dripping Spring Wash. Concerns were raised over the potential impacts to downstream water supplies, including the Gila River as a direct source of water, and groundwater wells along the river floodplain in close connection with surface water. Specific water supplies of concern include Hayden, Kearny, Winkelman, and agricultural diversions for the San Carlos Irrigation and Drainage District.

As with Alternative 5, there are no anticipated concentrations of contaminants in the Gila River due to the tailings seepage above any aquifer or surface water quality standards, as shown in table 3.7.2-26. Some dilution would be anticipated to occur downstream as well, due to contributions from other tributaries or groundwater inflows, notably the substantial inflow from the San Pedro River. Under the DEIS water quality modeling, the anticipated increases in concentrations above baseline surface water quality are relatively small, compared with the increases anticipated in Queen Creek with Alternatives 2, 3, and 4, but low-flow conditions can increase the risk of concentrations above numeric surface water quality standards. The refined water quality modeling for the FEIS indicates that any changes in surface water quality would be unlikely.

Similarly, any groundwater wells in close hydraulic connection with the Gila River would be anticipated to have no change in water quality based on the refined FEIS water quality modeling.

Table 3.7.2-28. Seepage water quality modeling results for Alternative 6 from FEIS water quality model (mg/L)

	Aquifer Water Quality Standard	Aquifer about 1 mile Downgradient from toe of tailings Year 41	Aquifer about 1 mile Downgradient from toe of tailings Year 100	Aquifer about 1 mile Downgradient from toe of tailings Year 245	Aquifer Just Upgradient from Gila River Year 41	Aquifer Just Upgradient from Gila River Year 100	Aquifer Just Upgradient from Gila River Year 245	Surface Water Standard for Most Restrictive Use
Constituents with Numeric Standards								
Antimony	0.006	0.00051	0.00169	0.00168	0.00027	0.00027	0.00027	0.030
Arsenic	0.05	0.00074	0.00077	0.00077	0.00634	0.00634	0.00634	0.030
Barium	2	0.0246	0.0300	0.0299	0.0688	0.0688	0.0688	98
Boron	–	–	–	–	0.199	0.199	0.199	1
Cadmium	0.005	0.000442	0.002081	0.002058	0.000061	0.000061	0.000061	0.0043†
Chromium, Total*	0.1	0.005	0.014	0.014	0.002	0.002	0.002	0.011
Copper	–	–	–	–	0.00752	0.00752	0.00752	0.0191†
Fluoride	4	0.444	1.287	1.275	0.976	0.976	0.976	140
Iron	–	–	–	–	0.042	0.042	0.042	1
Lead	0.05	0.00038	0.00066	0.00066	0.00097	0.00097	0.00097	0.0065†
Manganese	–	–	–	–	0.0846	0.0846	0.0846	10
Nickel	0.1	0.0071	0.0269	0.0266	0.0045	0.0045	0.0045	0.1098†
Nitrate	10	2.9	3.8	3.8	0.311	0.311	0.311	3,733.333
Selenium	0.05	0.0083	0.0419	0.0415	0.0007	0.0007	0.0007	0.002
Silver	–	–	–	–	0.000061	0.000061	0.000061	0.0147
Thallium	0.002	0.00023	0.00085	0.00084	0.00008	0.00008	0.00008	0.0072
Zinc	–	–	–	–	0.13	0.13	0.13	0.2477†
Constituents without Numeric Standards								
Sulfate	–	81.1	342.1	338.4	133.1	133.1	133.1	–

	Aquifer Water Quality Standard	Aquifer about 1 mile Downgradient from toe of tailings Year 41	Aquifer about 1 mile Downgradient from toe of tailings Year 100	Aquifer about 1 mile Downgradient from toe of tailings Year 245	Aquifer Just Upgradient from Gila River Year 41	Aquifer Just Upgradient from Gila River Year 100	Aquifer Just Upgradient from Gila River Year 245	Surface Water Standard for Most Restrictive Use
Total Dissolved Solids	–	418	860	853	597	597	597	–

Note: Model data are not specific to total or dissolved fractions; for the purposes of comparison to surface water standards it can be assumed to apply to both. Also note that review of the FEIS water quality model cautions that results should be viewed primarily as a screening tool, rather than strictly quantitative, due to model uncertainties.

For the FEIS model, assumed concentrations in the aquifer just upgradient from the Gila River are based on samples from the Gila River

† Standards are hardness dependent and were calculated using a hardness value of 242 mg/L $CaCO_3$ (from sample collected on November 9, 2018); see appendix N, table N-5, for details on how these standards were selected

* Standard shown for chromium is for hexavalent chromium, which is the most restrictive of the three chromium standards (total chromium, trivalent chromium, and hexavalent chromium).

Table 3.7.2-29. Estimated low-flow values required for predicted concentrations to be greater than standards in the Gila River, due to Alternative 6 tailings seepage (DEIS water quality model)

Constituent	Background Concentration of Gila River (mg/L)	Maximum Predicted Concentration in Gila River below Dripping Spring Wash (mg/L)	Median Flow Rate in Gila River (cfs)	Estimated Annual Load from Gila River (kg)	Estimated Annual Load from Seepage (kg)	Arizona Numeric Surface Water Quality Standard (mg/L)	Estimated Low Flow at which Standard would be Reached (cfs)	Estimated Percent of Time Gila River Flow is Below Standard-Reaching Rate*
Selenium	0.0004	0.0009	272	97	121	0.002	85.0	28%
Cadmium	0.00006	0.00009	272	15	7	0.0043	1.9	14
Antimony	0.00023	0.00025	272	56	5	0.03	0.2	<1
Copper	0.00207	0.0029	272	502	201	0.0191	13.3	21
Arsenic	0.0086	0.0086	272	2,088	–	0.03	–	–
Beryllium	0.0017	0.0017	272	413	–	0.0053	–	–
Chromium	0.002	0.0021	272	486	24	0.011†	3.0	16
Lead	0.00014	0.00015	272	34	2	0.0065	0.4	<1
Nickel	0.0023	0.0026	272	558	73	0.1098	0.8	3
Silver	0.00006	0.00018	272	15	29	0.0147	2.2	15
Thallium	0.00008	0.00008	272	19	–	0.0072	–	–
Zinc	0.005	0.0105	272	1,214	1,335	0.2477	6.2	19

Note:

– Indicates that tailings seepage provides no or negligible load, and there is no expectation that concentrations could be greater than numeric surface water standards.

* Values in this column relate to the “Estimated Low Flow at which Standard would be Reached (cfs)” column to the left. Estimated based on USGS gage 09469500, Gila River below Coolidge Dam, period of record from 1968 to 2018.

* Standard shown for chromium is for hexavalent chromium, which is the most restrictive of the three chromium standards (total chromium, trivalent chromium, and hexavalent chromium).

Other Water Quality Concerns

PERSISTENCE OF PROCESSING CHEMICALS IN TAILINGS

In order to extract concentrated copper and molybdenum using flotation, Resolution Copper would add a series of substances or reagents during processing. If these substances were to persist in the processing water, they have the potential to be released to the environment along with seepage from the tailings storage facilities. Six reagents expected to be used in the processing facility were analyzed (Hudson 2018):

- AERO 8989. This substance renders the copper minerals hydrophobic, causing them to attach to air bubbles blown into the flotation tank. The copper-molybdenum concentrate froth then floats to the top of the tank and is skimmed off. The majority of the AERO 8989 exits the process with the copper-molybdenum concentrate. This concentrate gets thickened and separated into copper concentrate and molybdenum concentrate and sent off-site for additional processing. Water recovered from the concentrate thickeners is recycled back to the processing plant. While some small amounts may persist in the tailings stream, there is no pathway for a substantial release of AERO 8989 to the environment.
- Diesel. Diesel acts similarly to AERO 8989 but for molybdenum minerals. Water recovered from the concentrate thickeners is recycled back to the processing plant. As with AERO 8989, while some small amounts may persist in the tailings stream, there is no pathway for a substantial release of diesel to the environment.
- Sodium isopropyl xanthate (SIPX) acts similarly to AERO 8989 and diesel but attaches to pyrite and sulfide minerals and renders them hydrophobic. SIPX is used later in the process, after copper and molybdenum concentrates have been removed, in order to separate the PAG and NPAG tailings streams. The majority of this reagent would enter the tailings storage facility with the PAG tailings stream.

  Any water recovered in the recycled water pond would potentially contain SIPX and would be recycled back to the processing plant. Some SIPX remains entrained with the PAG tailings and therefore has the potential to contribute to seepage water quality. The breakdown of SIPX yields xanthate and carbon disulfide as two major byproducts. Xanthate decomposes as well as adsorbs; depending on the temperature the half-life can range from less than 1 hour to almost 4 months (Eary 2018h). At the concentrations being considered and the likely temperatures, xanthate is unlikely to survive long enough to be detectable in any lost seepage.

  Most of the carbon disulfide generated is expected to be volatilized as tailings pass through the spigots and are deposited in the facility; in the atmosphere carbon disulfide decomposes to carbonyl sulfide, carbon monoxide, and sulfur dioxide. The carbon disulfide that remains decomposes with a half-life ranging from roughly 6 months to 1 year. Given that the transit times for seepage to reach aquifers is estimated in the range of decades (Groenendyk and Bayley 2018a), carbon disulfide is unlikely to survive long enough to be detectable in any lost seepage.
- Methyl isobutyl carbinol (MIBC). MIBC is used to lower the surface tension of the water, thus strengthening the air bubbles in the flotation tank. MIBC is used during concentration of copper and molybdenum and during separation of the PAG and NPAG tailings streams. Most MIBC would volatize, and the MIBC that remains degrades relatively quickly, at about 14 percent per day (Hudson 2018). MIBC is unlikely to survive long enough to be detectable in any lost seepage.
- Sodium hydrogen sulfide. This substance is used to separate copper from molybdenum concentrate by causing copper minerals to sink, while molybdenum concentrate remains in flotation. Water recovered from the concentrate thickeners is recycled back to the processing

plant. There is no pathway for a substantial release of sodium hydrogen sulfide to the environment.

- Magnafloc 155. This substance is a flocculant, used to cause particles to combine into large groups and therefore settle more readily. This substance would be present in the PAG and NPAG tailings streams and in the copper and molybdenum concentrates. Specific information on the degradation of Magnafloc 155 is lacking. Some evidence exists that exposure to sunlight and physical processing are both likely to cause degradation. The potential for Magnafloc 155 to persist in tailings seepage is unclear, but as the purpose of using Magnafloc is to bind with solid particles it would not be expected to have substantial mobility.

TECHNOLOGICALLY ENHANCED NATURALLY OCCURRING RADIOACTIVE MATERIALS (TENORM)

The potential for the occurrence of natural radioactive materials in the ore deposit, the potential to concentrate those materials during processing, and the potential for these materials to affect tailings seepage were raised as potential concerns for the project. This topic was investigated by Resolution Copper (Duke 2019b), and further analyzed by the Forest Service for the EIS. Full details of the analysis are contained in Newell and Garrett (2018d) and are summarized here.

Radioactive materials such as uranium, thorium, and radium occur naturally in the earth's crust and soil. In some cases, these materials can be concentrated by mining processes, leading to a concern that technologically enhanced naturally occurring radioactive materials (TENORM) could result in water quality concerns in seepage from the tailings storage facility.

The potential for this problem to occur was assessed based on analysis conducted on 5,987 samples of Resolution copper ore from 137 exploration boreholes, master ore composites, laboratory-simulated tailings samples, and background groundwater quality samples. When compared with common background levels, review of existing information at the site does not suggest the strong presence of naturally occurring radioactive materials above typical concentrations, although a small percentage (2 to 6 percent) of samples have exhibited concentrations above thresholds of concern.

Several past examples of TENORM have been documented in the vicinity of the project, including at the Magma Mine, Pinto Valley, and the Ray Mine. However, all of these were associated with acidic leaching and electrowinning. The Resolution Copper Project does not include any heap leaching, solvent extraction-electrowinning, or recycling of raffinate. The processes that historically have been documented with problems would not occur as part of this project.

With respect to the processing (flotation) that would be used during the Resolution Copper Project, site-specific locked-cycle testing has simulated the effect of processing to potentially concentrate radioactive materials, and no concentrations are above any thresholds of concern for uranium, radium, and gross alpha activity.

PRESENCE OF ASBESTIFORM MINERALS

Similar to radioactive materials, the potential for asbestiform minerals to occur in the Resolution ore deposit and eventually end up in the tailings facility was raised as a possible concern. Resolution Copper investigated the overall occurrence of these minerals (Duke 2019a).

Asbestos is present in trace to minor amounts in the Resolution ore and development rock as fibrous forms of the amphibole minerals tremolite and actinolite, primarily tremolite. The general threshold for asbestos-containing material is more than 1 percent asbestos as determined by polarized light microscopy (40 CFR 61.141).

Abundances of tremolite and actinolite in the ore body were assessed from 992 samples from 110 exploration boreholes. Tremolite is consistently present (90 percent of samples), with the highest concentrations generally associated with skarn rock units. Abundance ranged from less than 0.01 to 24.24 percent by weight, with a mean of 0.27 percent by weight.

Resolution Copper has conducted two additional targeted studies. In 2006, 34 samples of development rock were submitted for bulk asbestos analysis. Of these, 85 percent of the samples did not contain detectable asbestiform minerals. All samples with detectable asbestiform minerals were associated with skarn rock units. In 2007, 53 samples specific to skarn rock units were submitted for bulk asbestos analysis. Of these, 66 percent of the samples did not contain detectable asbestiform minerals; the remaining abundances ranged from 0.5 to 4.0 percent by weight.

These analyses indicate that asbestiform minerals are present in the ore deposit, but on average the percentage is below the threshold for concern. However, the block caving is not conducted on the ore deposit as a whole, but panel by panel. When viewed on a panel-by-panel basis, overall asbestiform minerals are not anticipated to exceed 0.1 percent by weight.

CHEMICAL DUST SUPPRESSANTS

Public comments raised concerns over the potential water quality impacts from the use of chemical dust suppressants. Past environmental problems have focused on inadvertent contamination caused by reuse of materials like motor oil (Piechota et al. 2004).

Resolution Copper has identified that in addition to water, they may use polymers for dust suppression (Resolution Copper 2016c). Field experiments have been conducted in Arizona and Nevada to review the potential for commonly used chemical dust suppressants—including polymers—to cause water quality issues (Irwin et al. 2008). Products were tested for surface runoff impacts (potential surface water quality impacts) and vertical leaching impacts (potential groundwater quality impacts).

Generally speaking, few water quality issues were observed experimentally with the polymer product. The primary impact in surface runoff was total suspended solids, which was equated to the product's ability to bind soil together into larger clumps. The researchers noted that overland runoff would likely allow those dirt clumps to settle out before reaching water bodies. No water quality issues were noted with the vertical leaching tests.

Cumulative Effects

Full details of the cumulative effects analysis can be found in chapter 4. The following represents a summary of the cumulative impacts resulting from the project-related impacts described in Section 3.7.2.4, Environmental Consequences, that are associated with groundwater or surface water quality, when combined with other reasonably foreseeable future actions.

The following actions were determined through the cumulative effects analysis process to be reasonably foreseeable, and have impacts that likely overlap in space and time with impacts from the Resolution Copper Project:

- Ray Land Exchange and Proposed Plan Amendment
- Ripsey Wash Tailings Project

The cumulative effects analysis area for groundwater and surface water quality consists of the watersheds for upper Queen Creek (headwaters to Whitlow Ranch Dam), Dripping Spring Wash, Donnelly Wash, and the Gila River between Dripping Spring Wash to the Ashurst-Hayden Diversion Dam near Florence.

The effects on surface water quality generally would be confined to the watersheds within which the project is located. In most cases, the point at which groundwater quality impacts would merge with impacts from other projects is where groundwater is expressed at the surface, specifically Queen Creek (Alternatives 2, 3, and 4) and the Gila River (Alternatives 5 and 6). The metric used to quantify the cumulative impacts to groundwater and surface water quality is the addition of pollutants to the same groundwater basin, aquifer, or surface water (concentration or tonnage for specific pollutants). Pollutants from multiple sources accumulate on a watershed scale and affect the ability for downstream waters to meet beneficial uses and surface water quality standards. Similarly, pollutants from multiple sources accumulate in an aquifer and affect the ability to meet beneficial uses and aquifer water quality standards. In both cases, accumulated pollutant loads can affect water supplies, wildlife, livestock, and the availability of water supplies for future development or generations.

Both reasonably foreseeable future actions have the potential to be cumulative with Resolution Copper Project impacts on the Gila River.

- Ray Land Exchange parcels. Since no mine plans have been prepared to date, it is unknown whether there would be pollutant discharges from the activities associated with the Ray Land Exchange. The distance suggests that overlap of discharges into the same groundwater systems that could be impacted by the Resolution Copper Project is unlikely to occur, or if it does, is unlikely to be substantial. The watershed divide suggests that surface water quality impacts, including those from stormwater runoff, could eventually enter the Gila River. If this is the case, they would be cumulative with increased pollutant loads associated with either Alternative 5 – Peg Leg, which would enter the Gila River via tailings seepage downstream from the Ray Land Exchange parcels, or with Alternative 6 – Skunk Camp, which is located upstream from the Ray Land Exchange parcels.

  Ripsey Wash Tailings Project. The Ripsey Wash tailings storage facility would generate tailings seepage that would likely enter the Gila River as well (upstream from Alternative 5 and downstream from Alternative 6). Based on disclosures from the permitting process, anticipated tailings seepage water quality appears to meet numeric Arizona aquifer water quality standards; however, the seepage still has substantially high concentrations of sulfate (greater than 2,000 mg/L) and dissolved solids (greater than 3,200 mg/L). These would contribute to pollutant loads in the Gila River. The overall pollutant load (tons per year) cannot be estimated without better information on anticipated flow rates. The potential for cumulative impacts is greatest after closure, as during operations a pumpback system would be employed to control seepage impacts.

Mitigation Effectiveness

Mitigation Identifier and Title	Authority to Require
FS-SV-03: Revised Reclamation and Closure Plans	Required – Forest Service
FS-PH-03: Skunk Camp Pipeline Protection and Integrity Plan	Required – Forest Service
RC-WR-03: Skunk Camp Water Quality Monitoring Plan	Voluntary – Resolution Copper

We developed a robust monitoring and mitigation strategy to avoid, minimize, rectify, reduce, or compensate for resource impacts that have been identified during the process of preparing this EIS. Appendix J contains descriptions of mitigation measures that are being required by the Forest Service and mitigation measures voluntarily brought forward and committed to by Resolution Copper. Appendix J also contains descriptions of monitoring that would be needed to identify potential impacts and mitigation effectiveness.

This section contains an assessment of the effectiveness of design features associated with mitigation and monitoring measures found in appendix J that are applicable to groundwater and surface water quality. See appendix J for full descriptions of each measure noted below.

MITIGATION EFFECTIVENESS AND IMPACTS OF REQUIRED MITIGATION MEASURES APPLICABLE TO GROUNDWATER AND SURFACE WATER QUALITY

Appendix J contains mitigation and monitoring measures being required by the Forest Service under its regulatory authority or because these measures are required by other regulatory processes (such as the PA or Biological Opinion). These measures are assumed to occur, and their effectiveness and impacts are disclosed here. The unavoidable adverse impacts disclosed below take the effectiveness of these mitigations into account.

Revised Reclamation and Closure Plans (FS-SV-03). Implementing reclamation and closure plans ensure that post-closure landscape is successfully revegetated to the extent practicable, and that the landforms are stable and safe. This measure is effective at partially replacing habitat and vegetation over the long term within the footprint of all mine components, reducing long-term effects on surface water quality from erosion, and improving long-term resilience and safety of the tailings storage facility. Proper design and installation of the closure cover would be effective at minimizing infiltration of precipitation into the facility, allowing seepage to reduce over the long term and reducing impacts to groundwater quality.

Skunk Camp Pipeline Protection and Integrity Plan (FS-PH-03). Implementing design and construction measures meant to mitigate specific potential failure modes ensures that the pipelines will be resilient and secure. Operational and maintenance measures ensure that problems are identified as they arise and that appropriate remedies are taken. These actions would be effective at reducing the risk of pipeline ruptures and inadvertent spills, which also reduces potential risk to groundwater and surface water quality.

MITIGATION EFFECTIVENESS AND IMPACTS OF VOLUNTARY MITIGATION MEASURES APPLICABLE TO GROUNDWATER AND SURFACE WATER QUALITY

Appendix J contains mitigation and monitoring measures brought forward voluntarily by Resolution Copper and committed to in correspondence with the Forest Service. These measures are assumed to occur but are not guaranteed to occur. Their effectiveness and impacts if they were to occur are disclosed here; however, the unavoidable adverse impacts disclosed below do not take the effectiveness of these mitigations into account.

Skunk Camp Water Quality Monitoring Plan (RC-WR-03). While voluntary at this point, it is likely that at least portions of the water quality monitoring plan for the Skunk Camp tailings storage facility would be required under the APP obtained from ADEQ. Monitoring would not be effective at preventing water quality impacts from seepage, but would be effective at identifying deviations from anticipated concentrations or potential failure or ineffectiveness of seepage control measures, which in the long term would be protective of groundwater quality.

OTHER POTENTIAL FUTURE MITIGATION MEASURES APPLICABLE TO GROUNDWATER AND SURFACE WATER QUALITY

Appendix J contains several other potential future mitigation measures that the Forest Service is disclosing as potentially useful in mitigating adverse effects, but for which there is no authority to require.

There is no expectation that these measures would occur, and therefore the effectiveness is not considered in the EIS.

Create and maintain public information repository (PF-WR-01). Maintaining a central location for monitoring data would allow the public to have access to reports submitted to regulatory agencies as conditions of permits. This would be beneficial for transparency, but overall would not reduce potential water quality impacts.

UNAVOIDABLE ADVERSE IMPACTS

The applicant-committed environmental protection measures for stormwater control would effectively eliminate any runoff in contact with ore or tailings. There are no anticipated unavoidable adverse effects associated with the quality of stormwater runoff under normal operating conditions, but under certain upset conditions and extreme storm events discharges from the seepage collection pond could occur, resulting in concentrations of contaminants in downstream waters above numeric water quality standards, though only for a certain distance until watershed flows dilute the discharge.

Seepage from the tailings storage facilities has several unavoidable adverse effects. In all cases, the tailings seepage adds a pollutant load to the downstream environment, including downstream aquifers and downstream surface waters where groundwater eventually daylights. The overall impact of this seepage varies by alternative. Alternatives 2, 3, and 4 all have anticipated impacts on water quality or have a high risk to water quality because of the extreme seepage control measures that must be implemented, and the relative inflexibility of adding more measures as needed, given the proximity to Queen Creek.

Alternatives 5 and 6 are located at the head of larger alluvial aquifers with some distance downstream before the first perennial water (the Gila River). Adverse effects are not anticipated from these alternatives. These two locations offer more flexibility for responding to potential problems using additional seepage controls if needed.

For all alternatives, some level of reduction in assimilative capacity of downstream waters (Queen Creek, Gila River) is unavoidable. For Alternatives 2, 3, and 4, discharge of additional contaminant load to designated impaired waters is also unavoidable.

Other Required Disclosures

SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

The use of the alternative sites for tailings storage represents a short-term use, with disposal happening over the operational life of the mine. However, the seepage from the tailings facilities would continue for much longer, with potential management anticipated being required over 100 years in some cases. While seepage persists, the long-term productivity of the downstream aquifers and surface waters could be impaired for some alternatives.

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

The potential impacts on water quality from tailings seepage would cause an irretrievable commitment of water resources downstream of the tailings storage facility, lasting as long as seepage continued. Eventually the seepage amount and pollutant load would decline, and water quality conditions would return to a natural state. This may take over 100 years to achieve in some instances.

While long lived, the impacts on water quality would not be irreversible, and would eventually end as the seepage and pollutant load declined.

3.7.3 Surface Water Quantity

3.7.3.1 Introduction

Perennial streams and springs are relatively rare in the area but do exist (see discussion in Section 3.7.1, Groundwater Quantity and Groundwater-Dependent Ecosystems). For the most part, surface waters in the area consist of dry washes or ephemeral channels that flow only in response to moderate- to high-intensity rainfall events. Water that flows in these washes and streams due to runoff from rainfall events reflects conditions in the upstream watershed—the geographic area that contributes to flow in the stream—and these flows could change if the upstream watershed changes.

The project would cause two major changes to these watersheds. Once the subsidence area develops at the surface, precipitation falling within this area would no longer report to the downstream stream network, potentially reducing runoff reaching both Devil's Canyon and Queen Creek.

In addition to the loss of runoff from the subsidence area, precipitation falling on or within the tailings storage facility would also be unavailable to downstream washes. All the tailings alternatives are designed to allow any runoff from upstream in the watershed to flow around the facility and continue flowing downstream. However, for the slurry tailings facilities (Alternatives 2, 3, 5, and 6), the top of the tailings facility is managed as a pond to allow process water to be recycled. Any rain falling within the bounds of a slurry facility, including the seepage recovery ponds at the downstream toe of the tailings embankment, is retained and recycled.

Alternative 4 – Silver King is the sole filtered tailings alternative and is different from the slurry alternatives. Filtered tailings must be managed to shed, not retain, water. However, because rain that sheds off the filtered tailings has contacted tailings, it must be collected downstream and not released to the environment during operations. The overall result for the filtered tailings alternative is the same as for the slurry alternatives—less surface water reporting downstream.

This section analyzes the reduction in streamflow caused by each of the alternatives, in terms of both total volume and peak flows during flood events. This section also analyzes the impacts that would be expected on sediment yields and stream geomorphology, impacts on water quality from sediment changes, impacts on jurisdictional waters of the U.S. (related to the CWA Section 404 program), impacts on floodplains, and impacts on wetlands (related to Executive Order (EO) 11990). Some aspects of the analysis are briefly summarized in this section. Additional details not included are captured in the project record (Newell and Garrett 2018d).

Changes from the DEIS

Overall, we received few public comments specific to the analysis of surface water quantity impacts, resulting in minimal changes. As with all resources, Alternatives 5 and 6 no longer have alternative pipeline routes to reach the tailings storage facility. Each alternative now has one pipeline route, described in Chapter 2. Additionally, we revised the Alternative 6 pipeline route, primarily to address potential impacts to habitat and resources along Mineral Creek. These changes had no impact on the surface water quantity analysis, since runoff is not captured or detained by pipeline areas as it is for the subsidence area and tailings storage facility.

The analysis of potential impacts to geomorphology (erosion and sedimentation) remains the same as described in the DEIS. However, we added a refined geomorphology analysis using different methodologies that is specific to the Preferred Alternative (Alternative 6). We completed further work on the delineations of jurisdictional waters of the U.S., conducted to support the CWA Section 404 permit and added these details.

We also added discussion of potential impacts on downstream surface water rights. Note that analysis of potential impacts to groundwater rights are analyzed in section 3.7.1.

New mitigation measures were brought forward to directly address surface water impacts, including the direct replacement of water in Queen Creek. These are analyzed in the “Mitigation Effectiveness” discussion in this section. The cumulative effects analysis was revised for the FEIS to better quantify impacts and is described in detail in chapter 4 and summarized in this section.

3.7.3.2 Analysis Methodology, Assumptions, and Uncertain and Unknown Information

Analysis Area

The analysis area for surface water quantity includes the Queen Creek, Devil’s Canyon, Dripping Spring Wash, and Donnelley Wash drainages: all of these watercourses are tributaries of the Gila River. The primary focus of the analysis is on waters downstream of areas that would be directly impacted by the mine, including by the subsidence area. Since the entire watershed affects flow in these areas, the analysis area also includes the larger watershed of these channels, as shown on figure 3.7.3-1. Specific analysis locations used to assess changes in streamflow are also shown on figure 3.7.3-1.

Approach

Two separate modeling approaches were used to assess how the subsidence area and tailings storage facilities would affect runoff. Flood flows are often characterized by the “return period,” i.e., a 2-year or 20-year flood event, which is just another way of expressing the probability of an event occurring. For example, a 2-year event has a 50 percent chance of occurring for any given storm, and a 20-year event has a 5 percent chance of occurring for any given storm. An approach developed by the USGS was used to analyze how reduced watershed area would affect peak flood flows with different return periods (Lehman 2017, 2018).

In addition to changes to individual flood events, the loss of watershed area also would affect the overall volume of water flowing through a wash and available to wildlife, vegetation, and surface water users. A “monthly water balance” modeling approach was used to assess reductions in the overall volumes of water available to the natural system due to the subsidence area and the tailings storage facilities (BGC Engineering USA Inc. 2018c). Prior to use, the monthly water balance model was first calibrated using data from Pinto Creek. The modelers found Devil’s Canyon, Queen Creek, and Dripping Spring Wash watersheds to be similar in nature to Pinto Creek, but note that Donnelly Wash is substantially different (less-steep gradient), which may introduce some uncertainty into the modeling (BGC Engineering USA Inc. 2018c). For a further overview of these two modeling approaches, and for additional citations for further information, see Newell and Garrett (2018d).

For much of the project area, 100-year floodplains have not been mapped, but have been estimated based on available geological mapping (Newell and Garrett 2018d).

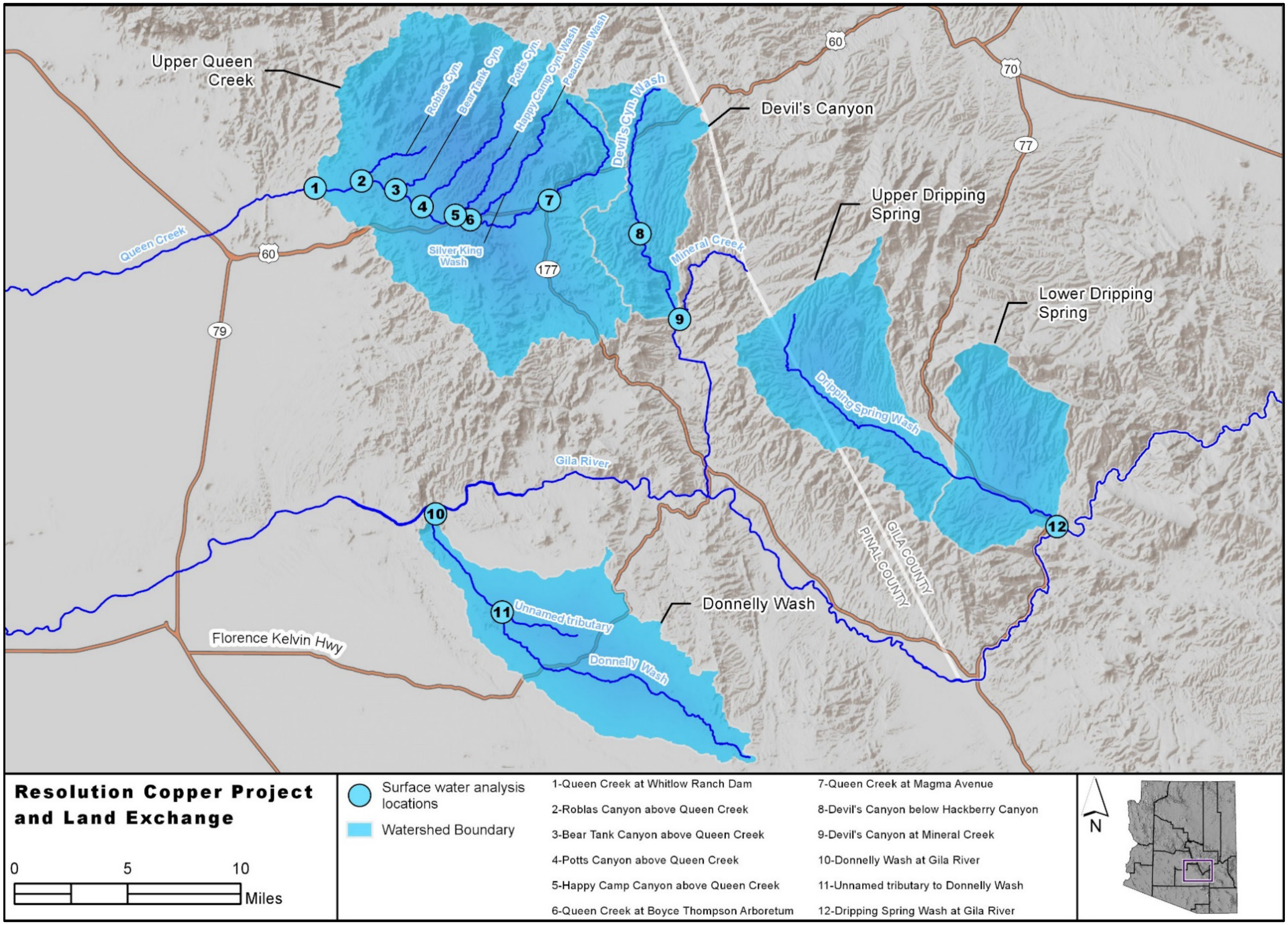


Figure 3.7.3-1. Surface water quantity analysis area

3.7.3.3 Affected Environment

Relevant Laws, Regulations, Policies, and Plans

A number of laws, regulations, and policies are pertinent to surface water quantity and are summarized in Newell and Garrett (2018d). Two of these are worth noting here.

As discussed in section 1.5.3, the USACE would rely on this EIS to support issuance of a permit under Section 404 of the CWA, which regulates dredge and fill within waters of the U.S. Part of the USACE permitting responsibility would be to identify jurisdictional waters of the U.S., identify which alternative represents the least environmentally damaging practicable alternative, and to require adequate mitigation to compensate for impacts on waters of the U.S. This section summarizes the potentially jurisdictional waters associated with each alternative, and considers the mitigation proposed to compensate for impacts on waters of the U.S.

In Arizona, jurisdictional waters of the U.S. often include both ephemeral washes and wetlands areas. Both types of jurisdictional waters are defined by specific technical guidance from the USACE. The Forest Service also considers wetlands under EO 11990, which directs Federal agencies to minimize the destruction, loss, or degradation of wetlands and to preserve and enhance the natural and beneficial value of wetlands in carrying out programs that affect land use. Wetlands considered under EO 11990 are not strictly defined and differ from the jurisdictional waters considered for a 404 permit. This section separately considers wetlands under EO 11990, relying on the National Wetlands Inventory as a data source.

DOCUMENTATION SPECIFIC TO CLEAN WATER ACT SECTION 404 PERMIT ISSUANCE

Issuance of a permit under Section 404 of the CWA requires submittal of a permit application and supporting documentation to the USACE. Fundamental to those regulations is the principle that dredged or fill material cannot be discharged into the aquatic ecosystem unless it can be demonstrated that there is no less environmentally damaging practicable alternative that achieves an applicant’s project purpose. In other words, only the least environmentally damaging practicable alternative can be permitted (40 CFR 230.10(a)).

The 404 permitting process requires that the permittee know the extent of any drainages that are considered jurisdictional waters of the U.S. This information is obtainable with either an Approved Jurisdictional Determination from the USACE, or a Preliminary Jurisdictional Determination. A Preliminary Jurisdictional Determination is a non-binding indication of the presence of waters of the U.S. on a parcel and is advisory in nature. Several jurisdictional determinations are pertinent to the project:

- U.S. Army Corps of Engineers (2012a) and U.S. Army Corps of Engineers (2015). These documents are both Approved Jurisdictional Determinations that indicate absence of jurisdiction within the Queen Creek watershed above Whitlow Ranch Dam.
- U.S. Army Corps of Engineers (2020a). This document is an Approved Jurisdictional Determination that indicates absence of jurisdiction for portions of the Alternative 6 pipeline corridor that occur within the Queen Creek watershed above Whitlow Ranch Dam.
- U.S. Army Corps of Engineers (2020b). This document is a Preliminary Jurisdictional Determination for portions of the Alternative 6 pipeline corridor, and for the Alternative 6 tailings storage facility, that occur within the Dripping Spring Wash watershed.

In addition to drainage channels, “special aquatic sites” are another type of feature that can be regulated under Section 404 of the CWA. Special aquatic sites are geographic areas possessing special ecological characteristics of productivity, habitat, wildlife protection, or other important and easily disrupted ecological values. These areas are generally recognized as significantly influencing or positively contributing to the general overall environmental health or vitality of the entire ecosystem of a region (40 CFR 230.3(m)). These include such features as sanctuaries and refuges, wetlands, mud flats, vegetated shallows, and riffle and pool complexes (40 CFR 230.41-45). As noted above, wetlands considered under EO 11990—which are disclosed in this section—differ from the jurisdictional waters considered for a 404 permit, and also differ from special aquatic sites. No special aquatic sites as defined under the CWA were identified within the footprint of the facilities during the jurisdictional determinations listed above.

The 404 permitting process includes submittal of a document called a “404(b)1 alternatives analysis.” The purpose of the 404(b)1 alternatives analysis is to identify the least environmentally damaging practicable alternative. To determine the least environmentally damaging practicable alternative, each practicable alternative for the proposed mine must be fully analyzed in the 404(b)1 alternatives analysis to assess the relative magnitude of project impacts, including direct, secondary, and cumulative impacts.

Most of the impacts considered under the USACE process are identical to those considered in this EIS, describing physical effects on the environment caused by the mine. However, some impacts considered under the USACE process are specific only to that permitting process, which may have a different scope of analysis. For example, the analysis in sections 3.7.1 and 3.7.3 of this EIS considers the overall physical impacts on streams and the riparian ecosystems associated with streams, but in doing so does not look at acreage as a measure of impact. In contrast, the calculation of the exact acreage of impacts on jurisdictional waters (both direct and indirect) is a very specific requirement of the 404(b)1 alternatives analysis.

Because of these differences, the 404(b)1 alternatives analysis is a document strongly related to the EIS, but also separate. The 404(b)1 alternatives analysis submitted to the USACE by Resolution Copper for the preferred alternative and approved by the USACE is attached to the EIS as appendix C.

An additional requirement of the USACE process is for compensatory mitigation to offset the impacts on jurisdictional waters. Similar to the 404(b)1 alternatives analysis, this mitigation is pertinent to both the EIS and the USACE process but is handled differently in each. In the EIS, the focus is on whether mitigation would be effective at addressing impacts of any resources, and if so, what residual impacts would remain. This is often a qualitative assessment. For the USACE process, the calculations of the amount of mitigation required are quantitative and formulaic with specific acreage multipliers used for different types of impacts. The conceptual compensatory mitigation plan submitted to the USACE by Resolution Copper for the preferred alternative and approved by the USACE is attached to the EIS as appendix D.

The effectiveness of the conceptual mitigation is assessed in this section of the EIS in a manner similar to other resources and does not reflect USACE calculations or analysis.

Primary Legal Authorities and Technical Guidance Relevant to the Surface Water Quantity Analysis

- Clean Water Act (Section 404)
- Executive Order 11988—Occupancy and modification of floodplains; Executive Order 11990—Destruction, loss, or degradation of wetlands
- Pinal County Floodplain Management Ordinance

Existing Conditions and Ongoing Trends

REGIONAL HYDROLOGIC SETTING

The analysis area includes the Queen Creek, Devil's Canyon, Dripping Spring Wash, and Donnelly Wash drainages: all of these watercourses are tributaries of the Gila River, as shown in figure 3.7.3-1. Watershed characteristics of these drainages are summarized in table 3.7.3-1.

Table 3.7.3-1. Watershed characteristics

Watershed	Minimum Elevation (feet amsl)	Maximum Elevation (feet amsl)	Mean Elevation (feet amsl)	Average Slope (percent)	Area (square miles)
Devil's Canyon	2,240	5,610	4,240	36	36
Dripping Spring Wash	2,025	7,645	3,670	33	117
Queen Creek	2,135	5,610	3,225	31	143
Donnelly Wash	1,615	3,900	2,900	7	60

Note: Watershed characteristics derived from USGS StreamStats application (U.S. Geological Survey 2018c)

QUEEN CREEK AND DEVIL'S CANYON WATERSHEDS (SUBSIDENCE AREA AND ALTERNATIVES 2, 3, AND 4)

The western part of the analysis area is drained by Queen Creek, which arises in the highlands around the Pinal Mountains and flows past Oak Flat and through the town of Superior. Queen Creek ultimately flows to Whitlow Ranch Dam, about 11 miles west of Superior. The dam is an ungated flood risk–management structure that was constructed in 1960 to reduce the risk of downstream flood damage to farmland and the communities of Chandler, Gilbert, Queen Creek, and Florence Junction. The dam includes a diversion structure to satisfy local water rights.

As discussed in Section 3.7.1, Groundwater Quantity and Groundwater-Dependent Ecosystems, Queen Creek is primarily ephemeral but exhibits perennial flow downstream of the town of Superior wastewater treatment plant, both from effluent and groundwater discharges from a nearby mine pit.

The ore body is located approximately 4,500–7,000 feet beneath Oak Flat in the upper Queen Creek basin. Devil's Canyon is located to the immediate east of Oak Flat with its headwaters located north of U.S. 60. Devil's Canyon cuts through the Apache Leap Tuff, forming a steep-sided canyon that flows in a southerly direction for approximately 9 miles. Devil's Canyon discharges into the reservoir of Big Box Dam. Mineral Creek, to the immediate east of Devil's Canyon, also discharges into the reservoir. Big Box Dam was constructed to divert flows from Devil's Canyon and Mineral Creek around the Ray Mine and into the Gila River. As discussed in section 3.7.1, much of upper Devil's Canyon is ephemeral, where runoff is driven by rainfall events. However, there are several perennial reaches that are sustained either by shallow, recharged groundwater systems or a regional groundwater system that discharges to the surface via seeps and springs.

The subsidence area would affect portions of the watershed for Queen Creek and Devil's Canyon, and the tailings storage facilities for Alternatives 2, 3, and 4 would affect tributaries to Queen Creek.

GILA RIVER WATERSHED (ALTERNATIVES 5 AND 6)

Alternative 5 – Peg Leg would impact Donnelly Wash, which flows north to join the Gila River downstream of Mineral Creek. Donnelly Wash flows through an alluvial valley and has more gentle slope gradients, compared with the other watersheds. The main stem channel of Donnelly Wash is entirely ephemeral, with no known perennial reaches.

Alternative 6 – Skunk Camp would impact Dripping Spring Wash. Dripping Spring Wash is located in the eastern part of the analysis area. Dripping Spring Wash flows to the southeast for approximately 18 miles before discharging into the Gila River downstream of the Coolidge Dam. The main stem channel of Dripping Spring Wash is entirely ephemeral, with no known perennial reaches.

Both Alternatives 5 and 6 would also affect flow to the Gila River itself, which is perennial between Coolidge Dam and Florence.

CLIMATE CONDITIONS

The climate of the project area is generally arid to semi-arid. Topography influences the spatial distribution of precipitation, being lowest in the valley bottoms (average annual totals of approximately 13 inches in the vicinity of Whitlow Ranch Dam), and greatest in the upper elevations of the Queen Creek watershed (26 inches). There are two separate rainfall seasons. The first occurs during the winter from November through March, when the area is subjected to occasional storms from the Pacific Ocean. The second rainfall period occurs during the July and August "monsoon" period when Arizona is subjected to widespread thunderstorm activity whose moisture supply originates in the Gulf of Mexico and Pacific Ocean.

Precipitation typically occurs as high-intensity, short-duration storms during the summer monsoon, and longer term storms of more moderate intensity that occur during the winter months. Summer storms, coupled with relatively impervious land surfaces, sparse vegetation, and steep topographic gradients, result in rapid increases in streamflow. Winter rains tend to produce runoff events of longer duration and with higher maximum flows than summer rains. This is a result of higher rainfall totals and wetter antecedent moisture conditions that tend to prevail in the winter months due to a significantly lower evapotranspiration demand. These wetter conditions result in less near-surface storage capacity in the winter and a larger proportion of any given rain event runs off rather than infiltrating. Regional gaging stations indicate that a majority of runoff occurs during the winter months (December to March) when evaporation rates are at a minimum.

ONGOING CLIMATIC TRENDS AFFECTING WATER BALANCE

Climate trends suggest that runoff could decrease in the future due to increased temperatures and reduced precipitation. Average temperatures in Arizona have increased about 2°F in the last century (U.S. Environmental Protection Agency 2016). In the Lower Colorado River basin, the annual mean and minimum temperature have increased 1.8°F–3.6°F for the time period 1900–2002, and data suggest that spring minimum temperatures for the same time period have increased 3.6°F–7.2°F (Dugan 2018).

Annual average temperatures are projected to rise by 5.5°F to 9.5°F by 2070–2099, with continued growth in global emissions (Melillo et al. 2014).

While future projected temperature increases are anticipated to change mean annual precipitation to a small degree, the majority of changes to annual flow in the Lower Colorado River basin are related to changes in runoff timing. Increased temperatures are expected to diminish the accumulation of snow and the availability of snowmelt, with the most substantial decreases in accumulation occurring in lower elevation portions of the basin where cool season temperatures are most sensitive to warming (Dugan 2018).

Most precipitation falling within the watershed either evaporates or is transpired by vegetation, either from shallow surface soils (approximately 96 percent of precipitation) or along stream drainages and areas where the groundwater is relatively close to the surface and directly available to trees and shrubs (approximately 1 percent of precipitation). The remainder recharges to groundwater or leaves the basin as surface runoff (Montgomery and Associates Inc. 2018).[76]

3.7.3.4 Environmental Consequences of Implementation of the Proposed Mine Plan and Alternatives

Alternative 1 – No Action

Under the no action alternative, impacts on surface water runoff from the Resolution Copper Project and associated activities would not occur. However, impacts on a number of springs because of groundwater drawdown would occur under the no action alternative, as analyzed and discussed in section 3.7.1.

Table 3.7.3-2 summarizes locations where changes in average monthly and annual streamflow quantity were quantified for each the identified alternatives (BGC Engineering USA Inc. 2018c). Potential changes in streamflow have also been quantified for peak instantaneous flood flows and flows with durations of 1, 3, 7, 15, and 30 days (Lehman 2017, 2018). These changes in streamflow discharge-duration-frequency were assessed for annual exceedance probability (AEP) at 50, 20, 10, 4, 2, 1, 0.5, and 0.2 percent levels.

Streamflow discharge-duration-frequency analysis provides a detailed look at the dynamics of a stream under many conditions, and the full comparison is available for review (Newell and Garrett 2018d). For purposes of comparison in the EIS, two values from the discharge-duration-frequency analysis were selected to represent impacts at each location. The values selected are those that represent the peak instantaneous and the 30-day stream flows, each with a 50 percent probability of exceedance. The return period was selected because it represents flows that happen with relative frequency. The short duration (peak instantaneous streamflow) was selected to represent short, intense ephemeral flows that occur, typical of monsoon events. The long duration (30-day streamflow) was selected to represent streamflow occurring over longer periods but at lesser volume, more typical of conditions affected by baseflow.

The locations analyzed by BGC Engineering USA Inc. (2018c) and Lehman (2017, 2018) differ slightly—coincident analysis locations are identified in italic font in table 3.7.3-2.

[76] These percentages were calculated specifically for the Queen Creek watershed but in general would expect to be similar to the other watersheds in the analysis area, which are at similar elevations, with similar climate, and similar topography.

Table 3.7.3-2. Watershed locations where changes in streamflow for the project EIS action alternatives were analyzed

Location	Drainage Area (square miles)	Action Alternative
Devil's Canyon – downstream of confluence with Hackberry Canyon, roughly DC-8.1C.	19.0	All
Devil's Canyon – confluence with Mineral Creek	35.8	All
Queen Creek – at Magma Avenue Bridge	10.4	All
Queen Creek – at Boyce Thompson Arboretum	27.9	All
Queen Creek – Upstream of Whitlow Ranch Dam	143.0	All
Potts Canyon* – confluence with Queen Creek	18.1	Alternative 4
Happy Canyon* – confluence with Queen Creek	4.2	
Silver King Wash* – confluence with Queen Creek	6.7	
Roblas Canyon† – confluence with Queen Creek	10.2	Alternative 2, Alternative 3
Bear Tank Canyon† – confluence with Queen Creek	4.9	
Unnamed Wash – confluence with Gila River	7.1	Alternative 5
Donnelly Wash – confluence with Gila River	59.9	
Gila River at Donnelly Wash	18,011	Alternative 5
Dripping Spring Wash – confluence with Gila River	117	Alternative 6
Gila River at Dripping Spring Wash	12,866	Alternative 6

Note: See process memorandum for more information on differences between analysis points (Newell and Garrett 2018d).

* Northern tributary impacted by Alternative 4 tailings storage facility.

† Northern tributary impacted by Alternative 2 and Alternative 3 tailings storage facility.

The total area of watershed removed from the system of each of the alternatives is summarized in table 3.7.3-3. These footprints reference the total watershed area where water losses would occur, either due to contact water being collected (tailings storage facilities or West Plant Site) or from the subsidence area.

Table 3.7.3-3. Watershed area lost for each mine component

Mine Component	Area of Watershed Lost (square miles)
Subsidence area – Queen Creek	1.76
Subsidence area – Devil's Canyon	0.94
West Plant Site	1.40
Near West tailings storage facility – Alternatives 2 and 3	6.90
Silver King tailings storage facility – Alternative 4	6.32
Peg Leg tailings storage facility – Alternative 5	11.88
Skunk Camp tailings storage facility – Alternative 6	12.15

Impacts Common to All Action Alternatives

EFFECTS OF THE LAND EXCHANGE

The land exchange would have effects on surface water quantity.

The Oak Flat Federal Parcel would leave Forest Service jurisdiction. Several surface waters are located on the Oak Flat Federal Parcel, including Rancho Rio Canyon, Oak Flat Wash, and Number 9 Wash, and the parcel also is a portion of the watershed feeding both Queen Creek and Devil's Canyon. The role of the Tonto National Forest under its primary authorities in the Organic Administration Act, Locatable Regulations (36 CFR 228 Subpart A), and Multiple-Use Mining Act is to ensure that mining activities minimize adverse environmental effects on NFS surface resources; this includes these surface waters. The removal of the Oak Flat Federal Parcel from Forest Service jurisdiction negates the ability of the Tonto National Forest to regulate effects on these resources.

The offered lands parcels would enter either Forest Service or BLM jurisdiction. A number of ephemeral washes and perennial water features are located on these lands:

- Tangle Creek. Tangle Creek is an intermittent or perennial tributary to the Verde River and bisects the parcel. It includes associated riparian habitat with mature hackberry, mesquite, ash, and sycamore trees.
- Turkey Creek. Features of the Turkey Creek Parcel include Turkey Creek, which is an intermittent or perennial tributary to Tonto Creek and eventually to the Salt River at Roosevelt Lake. Riparian vegetation occurs along Turkey Creek with cottonwood, locus, sycamore, and oak trees.
- Cave Creek. Features of the Cave Creek Parcel include Cave Creek, an ephemeral to intermittent tributary to the Agua Fria River, with some perennial reaches in the vicinity of the parcel.
- East Clear Creek. Features of the East Clear Creek Parcel include East Clear Creek, a substantial perennial tributary to the Little Colorado River. Riparian vegetation occurs along East Clear Creek, including boxelder, cottonwood, willow, and alder trees.
- Lower San Pedro River. Features of the Lower San Pedro River Parcel include the San Pedro River and several large ephemeral tributaries (Cooper, Mammoth, and Turtle Washes). The San Pedro River itself is ephemeral to intermittent along the 10-mile reach that runs through the parcel; some perennial surface water is supported by an uncapped artesian well. The San Pedro is one of the few remaining free-flowing rivers in the Southwest and it is recognized as one of the more important riparian habitats in the Sonoran and Chihuahuan Deserts. The riparian corridor in the parcel includes more than 800 acres of mesquite woodlands that also features a spring-fed wetland.
- Appleton Ranch. The Appleton Ranch Parcels are located along ephemeral tributaries to the Babocomari River (Post, Vaughn, and O'Donnell Canyons). Woody vegetation is present along watercourses as mesquite bosques, with very limited stands of cottonwood and desert willow.
- Small ephemeral washes and unnamed drainages are associated with the Apache Leap South Parcel or the Dripping Springs Parcel.

Specific management of surface water resources on the offered lands would be determined by the agencies, but in general when the offered lands enter Federal jurisdiction, these surface waters would be afforded a level of protection they currently do not have under private ownership.

EFFECTS OF FOREST PLAN AMENDMENT

The Tonto National Forest Land and Resource Management Plan (1985b) provides guidance for management of lands and activities within the Tonto National Forest. It accomplishes this by establishing a mission, goals, objectives, and standards and guidelines. Missions, goals, and objectives are applicable on a forest-wide basis. Standards and guidelines are either applicable on a forest-wide basis or by specific management area.

A review of all components of the 1985 forest plan was conducted to identify the need for amendment due to the effects of the project, including both the land exchange and the proposed mine plan (Shin 2020). A number of standards and guidelines (22) were identified applicable to management of surface water resources. None of these standards and guidelines were found to require amendment because of the proposed project, on either a forest-wide or management area–specific basis. For additional details on specific rationale, see Shin (2020).

EFFECTS OF COMPENSATORY MITIGATION LANDS

None of the activities proposed on the compensatory mitigation lands would capture or detain stormwater runoff; no impacts on surface water quantity are anticipated.

EFFECTS OF RECREATION MITIGATION LANDS

The recreation mitigation lands are not anticipated to affect surface water quantity. None of the activities associated with the recreation mitigation lands are expected to capture or detain stormwater runoff.

SUMMARY OF APPLICANT-COMMITTED ENVIRONMENTAL PROTECTION MEASURES

A number of environmental protection measures are incorporated into the design of the project that would act to reduce potential impacts on surface water quantity. These are non-discretionary measures, and their effects are accounted for in the analysis of environmental consequences.

In the GPO, Resolution Copper has committed to various measures to reduce impacts on surface water quantity:

- To the extent practicable, stormwater flows upgradient of the facilities would be diverted around the disturbed areas and returned to the natural drainage system;
- As much water as possible would be recycled for reuse;
- Permanent diversion channels would be designed for operations and closure; and
- Runoff from roads, buildings, and other structures would be handled through best management practices, including sediment traps, settling ponds, berms, sediment filter fabric, wattles, etc.

IMPACTS ON SURFACE RUNOFF AND STREAMFLOW

The proposed block caving mining operation would result in the formation of a subsidence area at the surface. This subsidence area is estimated to cover an area of 2.7 square miles within the Queen Creek and Devil's Canyon watersheds. Once fully formed, precipitation within the subsidence area footprint would not be expected to report as runoff to either Queen Creek or Devil's Canyon, resulting in a decrease in streamflow in both drainages. Tables 3.7.3-4 and 3.7.3-5 summarize expected changes in average monthly streamflow at two locations on Devil's Canyon and three locations on Queen Creek. These tables also show the peak instantaneous and 30-day (50 percent exceedance) stream flows for Queen Creek at Magma Avenue and for Devil's Canyon at Mineral Creek. Note that tables 3.7.3-4 and 3.7.3-5 only reflect streamflow losses from mine components common to all action alternatives, like the subsidence area and the West Plant Site. Additional losses occur under Alternatives 2, 3, and 4, shown later in this section.

Table 3.7.3-4. Estimated changes in average monthly streamflow and peak flood flows common to all action alternatives – Devil's Canyon

Month	DC-8.1C			Mineral Creek Confluence		
	Existing (cfs)	Proposed (cfs)	Decrease (%)	Existing (cfs)	Proposed (cfs)	Decrease (%)
January	13.73	13.01	−5.3	21.97	21.25	−3.3
February	11.23	10.61	−5.6	17.33	16.71	−3.6
March	6.60	6.25	−5.3	10.38	10.04	−3.4
April	1.64	1.56	−5.1	2.47	2.38	−3.4
May	0.48	0.45	−5.4	0.73	0.71	−3.5
June	0.17	0.17	−5.3	0.27	0.26	−3.4
July	0.53	0.48	−8.2	0.84	0.79	−5.2
August	1.36	1.27	−7.2	2.18	2.09	−4.5
September	1.18	1.09	−7.5	1.98	1.89	−4.5
October	1.04	0.97	−6.5	1.75	1.68	−3.9
November	1.96	1.84	−5.9	3.22	3.11	−3.6
December	5.32	5.04	−5.4	8.48	8.19	−3.4
Average	3.74	3.53	−5.6	5.92	5.71	−3.5
Peak instantaneous streamflow (50% exceedance)	–	–	–	666	657	−1.4
30-day streamflow (50% exceedance)	–	–	–	13.9	13.6	−2.2

Sources: BGC Engineering (2018c); Lehman (2018)

Notes: Numbers have been rounded for presentation.

cfs = cubic feet per second

Table 3.7.3-5. Estimated changes in average monthly streamflow and peak flood flows common to all action alternatives – Queen Creek

Month	Queen Creek at Magma Avenue			Queen Creek at Boyce Thompson Arboretum			Queen Creek above Whitlow Ranch Dam		
	Existing (cfs)	Proposed (cfs)	Decrease (%)	Existing (cfs)	Proposed (cfs)	Decrease (%)	Existing (cfs)	Proposed (cfs)	Decrease (%)
January	5.63	4.61	−18.2	6.54	5.66	−13.4	23.90	23.02	−3.7
February	4.75	3.86	−18.6	5.50	4.75	−13.7	21.14	20.39	−3.6
March	2.61	2.12	−18.8	3.07	2.66	−13.5	12.11	11.69	−3.4
April	0.68	0.56	−17.8	0.81	0.71	−12.8	2.83	2.73	−3.7
May	0.20	0.16	−18.4	0.24	0.20	−13.4	0.87	0.84	−3.6
June	0.07	0.06	−18.5	0.08	0.07	−13.3	0.32	0.31	−3.5
July	0.31	0.25	−20.2	0.38	0.32	−14.3	1.50	1.44	−3.6
August	0.74	0.59	−19.6	0.98	0.84	−13.5	3.64	3.51	−3.6
September	0.64	0.51	−19.7	0.81	0.70	−13.6	3.27	3.16	−3.4
October	0.49	0.39	−19.5	0.63	0.54	−13.4	2.60	2.52	−3.2
November	0.83	0.67	−19.4	1.12	0.97	−13.0	5.07	4.93	−3.2
December	2.17	1.76	−18.6	2.68	2.33	−13.2	10.94	10.59	−2.9
Average	1.58	1.28	−18.6	1.89	1.63	−13.4	7.28	7.03	−3.5
Peak instantaneous streamflow (50% exceedance)	356	316	−11.2	–	–	–	–	–	–
30-day streamflow (50% exceedance)	4.4	3.9	−20.4	–	–	–	–	–	–

Sources: BGC Engineering (2018c); Lehman (2018)

Notes: Impacts shown are solely for effects from the subsidence area and West Plant Site. Combined impacts from the tailings storage facilities for Alternatives 2 and 3 (affecting Queen Creek above Whitlow Ranch Dam) and Alternative 4 (affecting Queen Creek at Boyce Thompson Arboretum and Queen Creek above Whitlow Ranch Dam) are detailed later in this section.

Numbers have been rounded for presentation.

cfs = cubic feet per second

Stormwater runoff in ephemeral drainages also is an important mechanism for recharge of water to aquifers. In central Arizona, these stream channels often comprise highly porous alluvial materials, allowing ready capture of runoff and storage. Water stored in near-channel alluvium typically is transpired by vegetation, sustains baseflow in intermittent or perennial streams, or infiltrates to underlying aquifers. The overall capture of stormwater within the facility and resulting reduction of downstream storm flows during operations would impact aquifer recharge to some extent.

IMPACTS ON SEDIMENT YIELDS AND GEOMORPHOLOGY OF STREAMS

Physical changes to watersheds can affect not just runoff, but also the sediment those flows carry downstream. One of the major functions of a stream is to transport sediment. All of the stream systems immediately downstream of project components are ephemeral in nature and only flow in response to precipitation. Ephemeral channels or washes have a cyclical pattern of infill and erosion. In this pattern, sediment movement usually occurs as pulses associated with flood events that push large amounts of coarse sediment through the system (Levick et al. 2008). The long-term stability of the downstream channel is based on the equilibrium between erosion and deposition of sediment delivered to the system. When that delivery system is disrupted or altered, changes to stream aggradation (the rising of the grade of a streambed) and scour (the erosive removal of sediment from a streambed) can occur until the system reaches equilibrium once again.

The beds of the downstream channels consist mostly of unsorted, unconsolidated sands, gravels, and cobbles. On smaller tributary washes higher in the watershed, particularly around the Near West (Alternatives 2 and 3) and Silver King (Alternative 4) sites, these sediments may be relatively shallow. Farther downstream, in Queen Creek (Alternatives 2, 3, and 4), Donnelly Wash (Alternative 5), or Dripping Spring Wash (Alternative 6), channels are often quite wide and sediments quite deep (Hart 2016).

All of these ephemeral washes are sediment transport–limited systems. This means that there is more sediment in the system than stormwater can transport. This is common in ephemeral streams due to the flashy (i.e., short duration) nature of flows. Flashy flows emanating from large precipitation events pick up sediment in a pulse of water and then deposit it quickly as flows recede.

Stormflows are expected to change both in the amount of flow and the magnitude of peak flows. For Queen Creek, a reduction in storm flow volume of roughly 19 percent is anticipated at Magma Avenue Bridge (all alternatives), dropping to 4 to 9 percent at Whitlow Ranch Dam (varies by alternative). These changes may result in both a reduced sediment supply to Queen Creek from impacted tributaries and less bedload transport in Queen Creek due to reduced tractive forces.

The potential reduction in sediment supply is not considered a significant impact because the system is sediment-transport limited. With respect to reduced sediment transport, such a reduction would be well within the natural variability of the system, as is evident from the historical data. The existing system already experiences significant variability in the potential for sediment transport for individual flood events. For example, the 2-year return period (50 percent annual probability) flood in Queen Creek for existing conditions is 1,280 cubic feet per second (cfs), compared with 15,830 cfs during a 100-year return period (1 percent annual probability) flood. That difference in peak flow is greater than an order of magnitude. Where the creek's banks are composed of alluvium, an expected response to reduced peak flows might be a slight narrowing of the channel width proportional to the magnitude of the predicted flow reduction.

Additionally, these systems do not frequently flow. Therefore, any adjustments to the channel geometry would be very slow to occur and difficult to detect. There are two GDEs present along Queen Creek, between km 17.4 and 15.6, and at Whitlow Ranch Dam.[77] Both of these systems are adapted to heavy sediment loads occurring now in ephemeral systems and their function would not be impacted.

Impacts are slightly greater for Donnelly Wash (Alternative 5), with reduction in storm flow volume of roughly 21 percent at the confluence with the Gila River. Reductions in flows in Dripping Spring Wash (Alternative 6) are roughly 13 percent at the confluence with the Gila River. These changes may result in both a reduced sediment supply to Donnelly Wash and Dripping Spring Wash from impacted tributaries and less bedload transport due to reduced tractive forces. As with Queen Creek, the potential reduction in sediment supply is not considered a significant impact for a sediment transport–limited system. No GDEs or aquatic habitat have been identified along either Donnelly Wash or Dripping Spring Wash. Tributaries upstream of the main stems of Queen Creek, Donnelly Wash, and Dripping Spring Wash exhibit greater changes; no aquatic habitat or GDEs exist in any of these tributaries.

After publication of the DEIS, an additional analysis of potential geomorphological changes was conducted for the Preferred Alternative (Alternative 6), using techniques specifically mentioned in public comments (Garrett 2020a; JE Fuller 2020). The additional analysis looked at seven segments of Dripping Spring Wash and assessed their characteristics for slope and bed material. The analysis reached similar conclusions as described above, that the reduction in stormflow caused by the stormwater controls of the tailings storage facility was unlikely to change the fundamental nature of the downstream channels.

However, the additional analysis also found that the detention of sediment by the stormwater controls, during operations, had the potential to result in scour downstream of the facility, and recommended that engineered erosion countermeasures be implemented in the tailings storage facility design to mitigate potential erosion (JE Fuller 2020).

IMPACTS ON WATER QUALITY FROM SEDIMENT CHANGES

Ground disturbance and removal of vegetation can increase sediment movement into downstream waters and affect water quality and aquatic habitat. Water quality is often characterized by the measurement of the amount of sediment per given amount of water (also known as the sediment concentration).

As described in detail in section 3.7.2, during operations, stormwater controls would be in place for all major project components (West Plant Site, East Plant Site, tailings facilities, filter plant and loadout facility) to prevent stormwater that contacts tailings materials or processing areas from being discharged downstream. This prevents stormwater from moving downstream but also prevents any increases in sediment concentration from the disturbed areas. The remaining flows in the undisturbed part of the watershed would continue to move sediment at the concentrations found under normal conditions.

The design storm event selected for sizing the stormwater management facilities at the East Plant Site, West Plant Site, and filter plant and loadout facility is the 100-year, 24-hour storm event, which Resolution Copper selected based on recommendations from the ADEQ Arizona Mining Guidance Manual BADCT (Arizona Department of Environmental Quality 2004; Resolution Copper 2016c). Note that tailings storage facilities themselves use much larger events in the design of their embankments, as discussed in section 3.10.1.

After closure and all reclamation has occurred, these stormwater controls would no longer be in place for most project components. Long-term revegetation is expected to be effective, and the reclaimed landforms stable without excessive erosion (see Section 3.3, Soils and Vegetation). Even with successful

[77] Kilometers are referenced here because many of the stream descriptions used by Resolution Copper reference the distance upstream of the confluence, measured in kilometers. For instance, spring “DC-8.4W” is located 8.4 km upstream of the mouth of Devil’s Canyon, on the west side of the drainage.

reclamation and revegetation, these areas would not return to pre-disturbance conditions; however, they would still meet a level of functioning condition as specified by the Forest Service. If desired long-term stability or revegetation conditions are not met, then financial assurance or bonds would not be released, and the Forest Service could maintain stormwater controls until revegetation is successful at stabilizing the disturbed ground surface. The long-term expectation is for most disturbed areas to return to the watershed in a condition without excess erosion or excess delivery of sediment.

Linear features, such as pipeline corridors, roads, and power line corridors, also result in ground disturbance but would not have operational stormwater controls in place to contain all runoff. Instead, stormwater permitting requirements under the AZPDES require that active stormwater controls remain in place until adequate site stabilization has occurred to minimize soil loss. Active stormwater controls typically are temporary measures that are designed and applied in a way specific to each location in order to prevent sediment movement into nearby water courses. Active controls require maintenance and eventually are removed once site stabilization has taken place. Active stormwater controls could include such items as silt fences, straw bales or rolls, dikes, sediment traps, or water bars; stabilization techniques could include such items as reseeding, soil treatment, or hardscaping. Provided adequate stormwater controls and best management practices are used, impacts from linear disturbance are generally minimal, since the amount of disturbance reporting to any one wash is relatively limited.

Stormwater and erosion controls applicable to each alternative are summarized in Newell and Garrett (2018d).

Alternative 2 – Near West Proposed Action

IMPACTS ON SURFACE RUNOFF AND STREAMFLOW

Changes in runoff from the subsidence area and West Plant Site would reduce average flows in Queen Creek at Whitlow Ranch Dam by about 4 percent; these losses in combination with additional changes caused by the tailings facility for Alternative 2 would reduce average flows by about 7 percent. As well as impacting flows in Queen Creek, Alternative 2 would impact flows in Roblas Canyon, Bear Tank Canyon, and Potts Canyon. Estimated changes in average monthly streamflow for these drainages are presented in table 3.7.3-6. All streamflow in Bear Tank Canyon would either be diverted into Potts Canyon or captured within the tailings storage facility footprint, resulting in a total loss of surficial runoff at the canyon’s mouth. Surface runoff diverted into Potts Canyon results in a slight increase in streamflow for this watershed.

Table 3.7.3-6 also shows the peak instantaneous and 30-day (50 percent exceedance) stream flows for Queen Creek at Whitlow Ranch Dam. In percentages, changes in peak flows are similar to changes in average streamflow, with reductions from 3 to 7 percent.

POTENTIAL IMPACT ON SURFACE WATER RIGHTS FROM RUNOFF REDUCTION

As discussed in section 3.7.1, Arizona law allows for the right to appropriate and use surface water, generally based on a “first in time, first in right” basis. ADWR administers this function, which maintains databases of water right filings, reviews applications and claims, and when appropriate issues permits and certificates of water right. However, water right filings can be made on the same surface water by multiple parties. At this time, almost all Arizona surface waters are over-appropriated with no clear prioritization of overlapping water rights.

To remedy these issues, a legal proceeding called the General Stream Adjudication of the Gila River is being undertaken through the Arizona court system. The goals of the adjudication include clarifying the validity and priority of surface water rights. The adjudication has been underway for several decades.

While progress has been made, many issues remain unresolved, including any prioritization or validation of water rights in the analysis area.

Alternative 2 would result in surface flow reductions in Queen Creek. The hydrologic connection between Queen Creek, the impoundment of water at Whitlow Ranch Dam, and water uses in Queen Valley was explored (Garrett 2020k; Montgomery and Associates Inc. 2020d). Stormwater reductions caused by the subsidence area and the tailings storage facility have the potential to reduce baseflow from Whitlow Ranch Dam, possibly impacting water right holders in Queen Valley where surface water is used for irrigation and amenities.

The Forest Service analysis identified and disclosed possible loss of surface water. However, the impact on any surface water rights from a legal or regulatory standpoint cannot yet be determined due to the ongoing adjudication.

A further consideration is the manner in which surface water reductions occur. With respect to the tailings stormwater controls, sequestration and control of stormwater from development in upland areas typically is not considered under the General Stream Adjudication, with exceptions for such diversions in active channels such as stock tanks. This leads to the same situation: while physical impacts to surface flow can be disclosed, impact to any surface water rights from a legal or regulatory standpoint cannot be determined unless stormwater controls are considered to be appropriate for consideration under the General Stream Adjudication or other water rights proceeding.

Note that mitigation is now proposed to offset the reductions in flow caused by the subsidence area, if not the tailings storage facility. Further discussion is provided in the "Mitigation Effectiveness" section below.

IMPACTS ON JURISDICTIONAL WATERS OF THE U.S. (RELATED TO CLEAN WATER ACT SECTION 404 PERMIT)

Section 404 of the CWA requires issuance of a permit for discharge of dredged or fill material within jurisdictional waters of the U.S. Waters of the U.S. generally consist of aquatic features such as streams/washes and wetlands. The determination of what aquatic features are considered jurisdictional is made by the USACE.

In 2012 and 2015, the USACE issued determinations that no jurisdictional waters exist within substantial portions of the Queen Creek watershed upstream of Whitlow Ranch Dam, which includes the footprint of Alternative 2 (U.S. Army Corps of Engineers 2012a, 2015). Therefore, no jurisdictional waters would be impacted by Alternative 2.

IMPACTS ON FLOODPLAINS (RELATED TO EXECUTIVE ORDER 11988)

Mapped floodplains for Alternative 2 total 8.5 acres, where the eastern boundary of the West Plant Site overlaps the floodplain of a tributary to Queen Creek. Further information on floodplain acreages, including mapping coverage, is included in Newell and Garrett (2018d).

IMPACTS ON WETLANDS (RELATED TO EXECUTIVE ORDER 11990)

As previously noted, assessing wetlands under EO 11990 is different from assessing jurisdictional waters under a CWA Section 404 permit. For the analysis in this section, the FWS National Wetlands Inventory is used to identify potential wetlands. Details of the wetlands identified from the National Wetlands Inventory are found in Newell and Garrett (2018d). Wetlands affected include

- xeroriparian vegetation along ephemeral washes (151.7 acres),

- stock tanks (5.4 acres), and
- wetlands largely along Queen Creek (5.6 acre).

Alternative 3 – Near West – ultrathickened

Alternatives 2 and 3 have almost identical footprints; therefore, all streamflow impacts are the same as summarized in table 3.7.3-6. Impacts on potentially jurisdictional waters, floodplains, and wetlands would also be identical to Alternative 2.

Alternative 4 – Silver King

IMPACTS ON SURFACE RUNOFF AND STREAMFLOW

Changes in runoff from the subsidence area and West Plant Site would reduce average flows in Queen Creek at Whitlow Ranch Dam by about 4 percent; these losses, combined with additional changes caused by the tailings facility for Alternative 4, would reduce average flows by about 9 percent. Alternative 4 also impacts flows at Boyce Thompson Arboretum, reducing average flows by about 20 percent. Additional flow losses would also occur under Alternative 4, with the proposed tailings storage facility impacting flows in Happy Canyon, Silver King Wash, and Potts Canyon. Estimated changes in average monthly streamflow are presented in table 3.7.3-7 (Queen Creek) and table 3.7.3-8 (northern tributaries). Whereas the tailings storage facility disturbance footprint within Silver King Wash is 0.21 square mile, portions of the Potts Canyon and Happy Canyon watersheds are diverted into Silver King Wash. As a result, the overall impact on streamflow in this wash is only 0.5 percent on average.

Table 3.7.3-7 also shows the peak instantaneous and 30-day (50 percent exceedance) stream flows for Queen Creek at Whitlow Ranch Dam. In percentages, changes in peak flows are similar to changes in average streamflow, with reductions from 3 to 7 percent.

POTENTIAL IMPACT ON SURFACE WATER RIGHTS FROM RUNOFF REDUCTION

These potential impacts would be identical to those described for Alternatives 2 and 3.

IMPACTS ON JURISDICTIONAL WATERS OF THE U.S. (RELATED TO CLEAN WATER ACT SECTION 404 PERMIT)

As with Alternatives 2 and 3, the USACE issued determinations that no jurisdictional waters exist within substantial portions of the Queen Creek watershed upstream of Whitlow Ranch Dam, which includes the footprints of these alternatives. Therefore, no jurisdictional waters would be impacted by Alternative 4.

Table 3.7.3-6. Estimated changes in average monthly streamflow and peak flood flows for Queen Creek and northern tributaries – Alternative 2

Month	Queen Creek above Whitlow Ranch Dam*			Roblas Canyon			Bear Tank Canyon			Potts Canyon		
	Existing (cfs)	Proposed (cfs)	Decrease (%)	Existing (cfs)	Proposed (cfs)	Decrease (%)	Existing (cfs)	Proposed (cfs)	Decrease (%)	Existing (cfs)	Proposed (cfs)	Increase (%)
January	23.90	22.29	−6.8	2.91	2.70	−7.1	1.20	0.0	−100	8.19	8.55	+4.5
February	21.14	19.80	−6.3	2.38	2.22	−6.7	0.96	0.0	−100	6.81	7.11	+4.4
March	12.11	11.33	−6.4	1.37	1.27	−7.6	0.54	0.0	−100	3.64	3.80	+4.6
April	2.83	2.64	−6.7	0.32	0.30	−7.9	0.13	0.0	−100	1.01	1.05	+3.9
May	0.87	0.81	−6.4	0.10	0.09	−7.4	0.04	0.0	−100	0.29	0.30	+4.2
June	0.32	0.30	−6.5	0.04	0.03	−7.5	0.01	0.0	−100	0.10	0.11	+4.3
July	1.50	1.39	−7.3	0.19	0.17	−9.5	0.08	0.0	−100	0.45	0.48	+4.7
August	3.64	3.40	−6.7	0.40	0.37	−7.7	0.17	0.0	−100	1.19	1.24	+4.5
September	3.27	3.05	−6.5	0.38	0.35	−8.3	0.15	0.0	−100	1.04	1.09	+4.3
October	2.60	2.43	−6.4	0.29	0.26	−8.5	0.12	0.0	−100	0.78	0.81	+4.4
November	5.07	4.76	−6.2	0.58	0.53	−8.7	0.25	0.0	−100	1.41	1.47	+4.7
December	10.94	10.23	−6.5	1.25	1.14	−8.7	0.52	0.0	−100	3.34	3.48	+4.3
Average	7.28	6.81	−6.5	0.84	0.78	−7.5	0.35	0.0	−100	2.33	2.44	+4.4
Peak instantaneous streamflow (50 percent exceedance)	1,280	1,238	−3.3	–	–	–	–	–	–	–	–	–
30-day streamflow (50 percent exceedance)	34.8	32.4	−6.9	–	–	–	–	–	–	–	–	–

Sources: BGC Engineering (2018c); Lehman (2018)

Note: Numbers have been rounded for presentation.

* Calculations reflect the combined effects of subsidence, West Plant Site, and Alternative 2 tailings storage facility.

Table 3.7.3-7. Estimated changes in average monthly streamflow and peak flood flows for Queen Creek – Alternative 4

Month	Queen Creek at Boyce Thompson Arboretum			Queen Creek above Whitlow Ranch Dam		
	Existing (cfs)	Proposed (cfs)	Decrease (%)	Existing (cfs)	Proposed (cfs)	Decrease (%)
January	6.54	5.24	−19.8	23.90	21.66	−9.4
February	5.50	4.40	−20.0	21.14	19.25	−8.9
March	3.07	2.46	−19.9	12.11	11.08	−8.5
April	0.81	0.66	−18.8	2.83	2.57	−9.3
May	0.24	0.19	−19.7	0.87	0.79	−9.1
June	0.08	0.07	−19.6	0.32	0.29	−8.9
July	0.38	0.30	−21.3	1.50	1.36	−9.0
August	0.98	0.77	−20.7	3.64	3.29	−9.6
September	0.81	0.64	−20.4	3.27	2.98	−8.8
October	0.63	0.50	−20.2	2.60	2.38	−8.4
November	1.12	0.89	−20.3	5.07	4.68	−7.9
December	2.68	2.15	−19.7	10.94	10.03	−8.4
Average	1.89	1.51	−19.9	7.28	6.64	−8.9
Peak instantaneous streamflow (50% exceedance)	–	–	–	1,280	1,239	−3.2
30-day streamflow (50% exceedance)	–	–	–	34.8	32.4	−6.9

Sources: BGC Engineering (2018c); Lehman (2018)

Notes: Numbers have been rounded for presentation. Calculations reflect the combined effects of subsidence, West Plant Site, and Alternative 4 tailings storage facility.

Table 3.7.3-8. Estimated changes in average monthly streamflow and peak flood flows for Queen Creek tributaries – Alternative 4

Month	Silver King Wash			Happy Canyon			Potts Canyon		
	Existing (cfs)	Proposed (cfs)	Change (%)	Existing (cfs)	Proposed (cfs)	Decrease (%)	Existing (cfs)	Proposed (cfs)	Decrease (%)
January	3.23	3.23	−0.2	0.99	0.44	−55.3	8.19	6.49	−20.7
February	2.68	2.66	−0.6	0.84	0.38	−54.1	6.81	5.39	−20.7
March	1.48	1.48	−0.3	0.52	0.26	−50.6	3.64	2.88	−20.8
April	0.41	0.41	0.7	0.11	0.05	−58.0	1.01	0.82	−19.4
May	0.12	0.12	0.0	0.03	0.01	−57.1	0.29	0.23	−20.3
June	0.04	0.04	−0.1	0.01	0.01	−53.8	0.10	0.08	−20.4
July	0.19	0.19	−0.8	0.07	0.03	−51.5	0.45	0.36	−21.8
August	0.47	0.47	−1.4	0.18	0.09	−49.9	1.19	0.92	−22.6
September	0.41	0.41	−0.5	0.14	0.07	−51.4	1.04	0.83	−21.0
October	0.31	0.31	−0.9	0.11	0.05	−50.1	0.78	0.61	−21.4
November	0.53	0.53	−1.6	0.23	0.13	−45.1	1.41	1.10	−21.9
December	1.31	1.30	−0.7	0.46	0.23	−49.7	3.34	2.64	−20.8
Average	0.93	0.92	−0.5	0.31	0.15	−52.5	2.33	1.85	−20.9

Source: BGC Engineering (2018c)

Note: Numbers have been rounded for presentation.

IMPACTS ON FLOODPLAINS (RELATED TO EXECUTIVE ORDER 11988)

Floodplain impacts for Alternative 4 are identical to those for Alternatives 2 and 3. Further information on floodplain acreages, including mapping coverage, is included in Newell and Garrett (2018d).

IMPACTS ON WETLANDS (RELATED TO EXECUTIVE ORDER 11990)

As previously noted, assessing wetlands under EO 11990 is different from assessing jurisdictional waters under a CWA Section 404 permit. For the analysis in this section, the FWS National Wetlands Inventory is used to identify potential wetlands. Details of the wetlands identified from the National Wetlands Inventory are found in Newell and Garrett (2018d). Wetlands affected include

- xeroriparian vegetation along ephemeral washes (164.5 acres),
- stock tanks (5.3 acres), and
- a wetlands largely along Queen Creek (5.6 acre).

Alternative 5 – Peg Leg

IMPACTS ON SURFACE RUNOFF AND STREAMFLOW

Streamflow at the mouth of Donnelly Wash and a smaller tributary to the immediate north (herein called "unnamed wash") would be impacted by the Alternative 5 tailings storage facility footprint. Estimated changes in average monthly streamflow are presented in table 3.7.3-9.

Average monthly stream flows for the Gila River are based on USGS gage 09474000, "Gila River at Kelvin, AZ." Streamflow records for this gage extend as far back as 1911. Monthly values reported in table 3.7.3-9 are averages for the 1981–2016 period. This USGS gage is located approximately 15 miles upstream of the Donnelly Wash confluence.

This table also shows the peak instantaneous and 30-day (50 percent exceedance) stream flows for Donnelly Wash. Potential changes in streamflow discharge-duration-frequency for the Gila River have not been estimated for two reasons:

- The upstream Coolidge/San Carlos Reservoir regulates flow, making it difficult to conduct a flood frequency analysis (Lehman 2018); and
- The total drainage area reductions are very small (<0.1 percent) for the Peg Leg alternative.

POTENTIAL IMPACT ON SURFACE WATER RIGHTS FROM RUNOFF REDUCTION

Alternative 5 would result in surface flow reductions in the Gila River, however negligible (0.2 percent). While theoretically possible, it is unlikely this level of reduction would impact downstream surface water right holders in any measurable way, including water delivered to the San Carlos Irrigation and Drainage District.

Regardless of whether a measurable impact would occur, the conclusions remain similar to those for Alternatives 2, 3, and 4. The Forest Service analysis identified and disclosed possible surface water loss. However, the impact on any surface water rights from a legal or regulatory standpoint cannot yet be determined due to the ongoing adjudication, and due to the fact that sequestration and control of stormwater from development in upland areas typically is not considered under the General Stream Adjudication.

Table 3.7.3-9. Estimated changes in average monthly streamflow and peak flood flows for Donnelly Wash, Unnamed Wash, and Gila River – Alternative 5

Month	Donnelly Wash at Mouth			Unnamed Wash at Mouth			Gila River at Donnelly Wash		
	Existing (cfs)	Proposed (cfs)	Decrease (%)	Existing (cfs)	Proposed (cfs)	Decrease (%)	Existing (cfs)	Proposed (cfs)	Decrease (%)
January	13.19	10.23	−22.5	1.18	0.87	−26.1	746	743.2	−0.4
February	9.26	7.14	−22.9	0.82	0.60	−26.7	554	551.3	−0.4
March	5.27	4.09	−22.3	0.55	0.43	−22.0	852	850.3	−0.2
April	1.31	1.03	−21.0	0.13	0.10	−22.5	609	608.4	0.0
May	0.34	0.25	−24.8	0.03	0.02	−26.3	536	536.1	0.0
June	0.14	0.11	−22.7	0.01	0.01	−24.1	636	636.3	0.0
July	0.66	0.55	−15.8	0.05	0.04	−21.9	744	743.9	0.0
August	2.32	1.92	−17.2	0.19	0.14	−22.3	720	719.1	−0.1
September	1.49	1.21	−19.3	0.16	0.13	−18.9	345	344.5	−0.1
October	2.10	1.66	−20.9	0.22	0.18	−20.5	252	251.2	−0.2
November	3.13	2.53	−19.3	0.27	0.21	−23.0	61	60.5	−1.1
December	5.30	4.29	−19.1	0.54	0.43	−19.6	245	243.4	−0.5
Average	3.69	2.90	−21.3	0.34	0.26	−23.7	526	525.0	−0.2
Peak instantaneous streamflow (50 percent exceedance)	866	784	−9.5	–	–	–	–	–	–
30-day streamflow (50 percent exceedance)	10.9	8.9	−18.4	–	–	–	–	–	–

Sources: BGC Engineering (2018c); Lehman (2018)

Notes: Numbers have been rounded for presentation.

Some uncertainty has been noted for the monthly water balance model as used on Donnelly Wash, due to the difference in watershed characteristics, compared with Pinto Creek, which was used to calibrate the model.

IMPACTS ON JURISDICTIONAL WATERS OF THE U.S. (RELATED TO CLEAN WATER ACT SECTION 404 PERMIT)

Unlike locations within the Queen Creek watershed or the Dripping Spring Wash watershed, the USACE has not made any determination on potentially jurisdictional waters for the Peg Leg location. However, based on discussions between the USACE and the Forest Service, it is believed that washes within the Donnelly Wash watershed would be considered jurisdictional waters of the U.S. and would be subject to permitting under Section 404 of the CWA.

It is estimated that approximately 759,064 linear feet of potentially jurisdictional waters are located within the footprint of the Alternative 5 tailings storage facility, potentially impacting 182.5 acres of waters of the U.S. (WestLand Resources Inc. 2018c). No potentially jurisdictional wetlands were noted within the footprint of Alternative 5 during field surveys. The USACE also considers indirect impacts from the "dewatering" of downgradient reaches through upgradient fills; these have not been estimated. Indirect impacts are generally considered to extend from the point of fill down to the confluence with the next substantial drainage.

IMPACTS ON FLOODPLAINS (RELATED TO EXECUTIVE ORDER 11988)

Mapped floodplains affected by Alternative 5 total 179 acres. The 8.5 acres where the eastern boundary of the West Plant Site overlaps the floodplain of a tributary to Queen Creek is the same as Alternatives 2, 3, and 4. The additional 170 acres are associated with the tailings storage facility and the tailings pipeline corridor. For the tailings storage facility, these floodplains are associated with Donnelly Wash and an unnamed tributary wash. For the tailings pipeline corridor, these floodplains are associated with the Gila River and Walnut Canyon. Further information on floodplain acreages, including mapping coverage, is included in Newell and Garrett (2018d).

IMPACTS ON WETLANDS (RELATED TO EXECUTIVE ORDER 11990)

As previously noted, assessing wetlands under EO 11990 is different from assessing jurisdictional waters under a CWA Section 404 permit. For the analysis in this section, the FWS National Wetlands Inventory is used to identify potential wetlands. Details of the wetlands identified from the National Wetlands Inventory are found in Newell and Garrett (2018d). Wetlands affected include

- xeroriparian vegetation along ephemeral washes (266.8 acres),
- wetlands largely associated with Queen Creek (6.3 acres),
- wetlands largely associated with the Gila River (6.7 acres), and
- stock tanks (11.2 acres).

Alternative 6 – Skunk Camp

IMPACTS ON SURFACE RUNOFF AND STREAMFLOW

Streamflow at the mouth of Dripping Spring Wash would be impacted both by the Alternative 6 tailings storage facility footprint and the northern diversion channels, which divert water into the Mineral Creek watershed. Estimated changes in average monthly streamflow are presented in table 3.7.3-10.

Average monthly stream flows for the Gila River are based on USGS gage 09469500, "Gila River below Coolidge Dam, AZ." Streamflow records for this gage extend as far back as 1899. Monthly values reported in table 3.7.3-10 are averages for the 1981–2016 period. This USGS gage is located approximately 20 miles upstream of the Dripping Spring Wash confluence.

Table 3.7.3-10. Estimated changes in average monthly streamflow and peak flood flows for Dripping Spring Wash and Gila River – Alternative 6

Month	Dripping Spring Wash at Mouth			Gila River at Dripping Spring Wash Confluence			Gila River at Donnelly Wash Confluence		
	Existing (cfs)	Proposed (cfs)	Decrease (%)	Existing (cfs)	Proposed (cfs)	Decrease (%)	Existing (cfs)	Proposed (cfs)	Decrease (%)
January	43.66	35.06	−12.8	436	427.9	−2.0	746	740.9	−0.7
February	31.65	25.08	−13.5	384	377.5	−1.7	554	549.4	−0.8
March	16.89	13.34	−13.6	701	697.7	−0.5	852	849.3	−0.3
April	4.12	3.27	−13.4	562	561.1	−0.2	809	608.1	−0.1
May	1.11	0.87	−13.9	536	535.8	0.0	536	536.0	0.0
June	0.46	0.36	−13.5	642	642.0	0.0	636	636.3	0.0
July	1.44	1.16	−12.4	687	686.4	0.0	744	743.8	0.0
August	3.84	3.10	−12.5	602	601.3	−0.1	720	719.1	−0.1
September	3.27	2.63	−12.6	288	287.7	−0.2	345	344.4	−0.1
October	4.63	3.87	−10.6	153	152.7	−0.5	252	251.2	−0.2
November	7.92	6.44	−12.1	33	32.0	−4.4	61	60.2	−1.6
December	16.17	12.96	−12.9	179	175.5	−1.8	245	242.5	−0.9
Average	11.18	8.94	−12.9	435	432.5	−0.5	526	524.4	−0.3
Peak instantaneous streamflow (50% exceedance)	1,168	1,114	−4.7	–	–	–	–	–	–
30-day streamflow (50% exceedance)	36.2	32.7	−9.7	–	–	–	–	–	–

Sources: BGC Engineering (2018c); Lehman (2018)

Note: Numbers have been rounded for presentation.

Table 3.7.3-10 also shows the peak instantaneous and 30-day (50 percent exceedance) stream flows for Donnelly Wash. As with Alternative 5, potential changes in streamflow discharge-duration-frequency for the Gila River were not estimated.

POTENTIAL IMPACT ON SURFACE WATER RIGHTS FROM RUNOFF REDUCTION

Alternative 6 would result in surface flow reductions in the Gila River, however negligible (0.3 percent at Donnelly Wash). While theoretically possible, it is unlikely this level of reduction would impact downstream surface water right holders in any measurable way, including water delivered to the San Carlos Irrigation and Drainage District.

Regardless of whether a measurable impact would occur, the conclusions remain similar to those for other alternatives. The Forest Service analysis identifies and discloses possible loss of surface water. However, the impact on any surface water rights from a legal or regulatory standpoint cannot yet be determined due to the ongoing adjudication, and due to the fact that sequestration and control of stormwater from development in upland areas typically is not considered under the General Stream Adjudication.

IMPACTS ON JURISDICTIONAL WATERS OF THE U.S. (RELATED TO CLEAN WATER ACT SECTION 404 PERMIT)

Based on the Preliminary Jurisdictional Determination for Alternative 6 (U.S. Army Corps of Engineers 2020b), the impacts on jurisdictional waters for the Alternative 6 location were evaluated in the 404(b)1 alternatives analysis, which is appendix C of the FEIS. The estimated total impacts to waters of the U.S. from the tailings storage facility footprint, pipeline corridor, and associated facilities is 188.3 acres. Of these, 129.2 acres are anticipated to be direct permanent impacts resulting from ground disturbance during construction. Another 15.7 acres of mostly temporary impacts would occur with the pipeline and access road. In addition to direct disturbance, another 43.4 acres of permanent impacts are anticipated from the loss of surface runoff to ephemeral drainages downstream of the tailings storage facility.

IMPACTS ON FLOODPLAINS (RELATED TO EXECUTIVE ORDER 11988)

Mapped floodplains affected by Alternative 6 total 786 acres. The 8.5 acres where the eastern boundary of the West Plant Site overlaps the floodplain of a tributary to Queen Creek is the same as the other alternatives. The additional 777 acres are associated with the tailings storage facility and the tailings pipeline corridor. For the tailings storage facility, 757 acres of floodplains are associated with Dripping Spring Wash and tributaries, including Stone Cabin Wash and Skunk Camp Wash.

For the collocated powerline and tailings pipeline corridor, 20 acres of floodplains are associated with tributaries to Mineral Creek, including Lyons Fork and Cedar Creek. In these areas the pipeline would be buried and unlikely to impact flood flows. Further information on floodplain acreages, including mapping coverage, is included in Newell and Garrett (2018d).

IMPACTS ON WETLANDS (RELATED TO EXECUTIVE ORDER 11990)

As previously noted, assessing wetlands under EO 11990 is different from assessing jurisdictional waters under a CWA Section 404 permit. For the analysis in this section, the FWS National Wetlands Inventory is used to identify potential wetlands. Details of the wetlands identified from the National Wetlands Inventory are found in Newell and Garrett (2018d). Wetlands affected include

- xeroriparian vegetation along ephemeral washes (234.0 acres),
- stock tanks (11.3 acres), and
- wetlands largely associated with Queen Creek (5.6 acres).

Cumulative Effects

Full details of the cumulative effects analysis can be found in chapter 4. The following represents a summary of the cumulative impacts resulting from the project-related impacts described in Section 3.7.3.4, Environmental Consequences, that are associated with surface water quantity, when combined with other reasonably foreseeable future actions.

The following actions were determined through the cumulative effects analysis process to be reasonably foreseeable, and have impacts that likely overlap in space and time with impacts from the Resolution Copper Project:

- LEN Range Improvements
- Ray Land Exchange and Proposed Plan Amendment
- Ripsey Wash Tailings Project

The cumulative effects analysis area for surface water quantity are the watersheds within which the project is located. The metric used to quantify the cumulative impacts to surface water quantity is the reductions in streamflow, preferably in annual volume, within the same watershed [acre-feet or percent reduction from baseline conditions]; in lieu of flow estimates, acreage of watershed from which stormwater would no longer flow downstream [acres]. Flow reductions across a watershed accumulate and affect the overall amount of water available to downstream users, aquatic habitat, and riparian areas.

The three reasonably foreseeable future actions above, combined with the Resolution Copper Project, represent about 29,000 acres of the 591,000-acre cumulative effects analysis area, or about 5 percent. Most of this acreage is associated with mining projects, like the Resolution Copper Project, and it is reasonable to assume that reductions in storm flow could be caused by eliminating runoff of contact stormwater. Much of the combined disturbed area falls within the Gila River watershed, and cumulative reductions in surface flow would be most noticeable in that water body.

Mitigation Effectiveness

Mitigation Identifier and Title	Authority to Require
FS-SV-03: Revised Reclamation and Closure Plans	Required – Forest Service
FS-WR-02: 404 Compensatory Mitigation Plan	Required – U.S. Army Corps of Engineers
FS-WR-04: Replacement of water in Queen Creek	Required – Forest Service

We developed a robust monitoring and mitigation strategy to avoid, minimize, rectify, reduce, or compensate for resource impacts that have been identified during the process of preparing this EIS. Appendix J contains descriptions of mitigation measures that are being required by the Forest Service and mitigation measures voluntarily brought forward and committed to by Resolution Copper. Appendix J also contains descriptions of monitoring that would be needed to identify potential impacts and mitigation effectiveness.

This section contains an assessment of the effectiveness of design features associated with mitigation and monitoring measures found in appendix J that are applicable to surface water quantity. See appendix J for full descriptions of each measure noted below.

MITIGATION EFFECTIVENESS AND IMPACTS OF REQUIRED MITIGATION MEASURES APPLICABLE TO SURFACE WATER QUANTITY

Appendix J contains mitigation and monitoring measures being required by the Forest Service under its regulatory authority or because these measures are required by other regulatory processes (such as the PA or Biological Opinion). These measures are assumed to occur, and their effectiveness and impacts are disclosed here. The unavoidable adverse impacts disclosed below take the effectiveness of these mitigations into account.

Revised Reclamation and Closure Plans (FS-SV-03). Implementing reclamation and closure plans ensure that the post-closure landscape is successfully revegetated to the extent practicable, and that the landforms are stable and safe. This measure is effective at partially replacing habitat and vegetation over the long-term within the footprint of all mine components, reducing long-term effects on surface water quality from erosion, improving long-term resilience and safety of the tailings storage facility, and allowing water to return from reclaimed areas to downstream watersheds.

Clean Water Act Section 404 Compensatory Mitigation Plan (FS-WR-02). The compensatory mitigation parcels would offer conservation of riparian habitat, as well as overall improvement in the health and stability of riparian habitats, by minimizing invasive non-native species and returning conditions to a more natural state. This measure would be effective at replacing xeroriparian habitat lost within the project footprint. Upon approval by the USACE, this compensatory mitigation is considered to be effective at mitigating any impacts to waters of the U.S. resulting from the proposed project.

Replacement of water in Queen Creek (FS-WR-04). This measure would replace the storm runoff in Queen Creek that otherwise would be lost to the subsidence area. It would be highly effective at minimizing the effects felt in Queen Creek caused by reduction in the watershed area, specifically impacts to surface water quantity and riparian habitat. Note that other stormwater losses would still occur under Alternatives 2, 3, and 4.

MITIGATION EFFECTIVENESS AND IMPACTS OF VOLUNTARY MITIGATION MEASURES APPLICABLE TO SURFACE WATER QUANTITY

Appendix J contains mitigation and monitoring measures brought forward voluntarily by Resolution Copper and committed to in correspondence with the Forest Service. These measures are assumed to occur but are not guaranteed to occur. Their effectiveness and impacts if they were to occur are disclosed here; however, the unavoidable adverse impacts disclosed below do not take the effectiveness of these mitigations into account. No additional mitigation measures were voluntarily brought forward for surface water quantity.

OTHER POTENTIAL FUTURE MITIGATION MEASURES APPLICABLE TO SURFACE WATER QUANTITY

Appendix J contains several other potential future mitigation measures that the Forest Service is disclosing as potentially useful in mitigating adverse effects, but for which there is no authority to require. There is no expectation that these measures would occur, and therefore the effectiveness is not considered in the EIS.

Divert existing flows across the subsidence area to preserve downstream flows (PF-WR-02). The possibility of maintaining storm runoff in Devil's Canyon that otherwise would be lost to the subsidence area would offer benefits to downstream riparian habitat and stormwater flows.

UNAVOIDABLE ADVERSE IMPACTS

The primary impact described in the analysis (in this section, as well as section 3.7.1) is the loss of surface water flow to riparian areas (including xeroriparian vegetation along ephemeral washes) and loss of surface flow to any GDEs that are associated with these drainages. The conceptual mitigation proposed under the CWA would not be effective at avoiding, minimizing, rectifying, or reducing these impacts. Rather, the proposed conceptual mitigation would be effective at offsetting impacts caused by reduced surface water flows by replacing riparian function far upstream or downstream of project impacts.

As the subsidence area is unavoidable, the loss of runoff to the watershed due to the subsidence area is also unavoidable, as are any effects on GDEs from reduced annual flows. Return of water to Queen Creek would be highly effective at eliminating impacts from this water loss, though this mitigation is voluntary and not guaranteed to occur. The loss of water to the watershed due to the tailings facility (during operations, prior to successful reclamation) is unavoidable as well, due to water management and water quality requirements. Direct impacts on wetlands, stock tanks, and ephemeral drainages from surface disturbance are also unavoidable.

Other Required Disclosures

SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

Desert washes, stock tanks, and wetland areas in the footprint of the subsidence area and tailings storage facility would be permanently impacted. In the short term, over the operational life of the mine, precipitation would be lost to the watershed. In the long term, most precipitation falling at the tailings facility would return to the watershed after closure and successful reclamation. There would be a permanent reduction in the quantity of surface water entering drainages as a result of capture of runoff by the subsidence area.

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

With respect to surface water flows from the project area, all action alternatives would result in both irreversible and irretrievable commitment of surface water resources. Irreversible commitment of surface water flows would result from the permanent reduction in stormwater flows into downstream drainages from the subsidence area. Changes to wetlands, stock tanks, and ephemeral drainages caused by surface disturbance would also be irreversible. Irretrievable commitment of surface water resources would be associated with additional temporary diversion, storage, and use of stormwater during active mining, but would be restored to the watershed after closure and reclamation.

3.8 Wildlife and Special Status Wildlife Species

3.8.1 Introduction

This section documents and analyzes the occurrence and distribution of wildlife species within the analysis area, including wildlife movement corridors, general wildlife, and special status wildlife species. Special status wildlife species are those listed under the ESA, and Tonto National Forest Sensitive species, as well as BLM Sensitive species, migratory birds, other species that are afforded protection within the analysis area, and species that AGFD focuses on for conservation efforts. A description of vegetation communities that serve as habitat are included in Section 3.3, Soils, Vegetation, and Reclamation.

Overview

Many species—including birds, amphibians, fish, and mammals—rely in some way on the habitat that could be impacted by the proposed action or alternatives. This habitat is important for forage, mating, protective cover, nesting and denning, and travel. Some species in the area have special protection, such as under the Endangered Species Act or the Migratory Bird Treaty Act, and other species have been given special status by the Forest Service. Wildlife impacts can occur not just from habitat loss and fragmentation, but also from artificial lighting, noise, vibration, traffic, loss of water sources, or changes in air or water quality or quantity.

This section includes descriptions of the affected environment, including the occurrence and distribution of general wildlife and game species, descriptions of special habitat areas (such as important bird areas, caves, and springs), wildlife connectivity across the larger landscape, special status wildlife species, and management indicator species (which are a specific Forest Service concern). Impacts analyzed include general impacts on wildlife occurring from construction, operation, and reclamation and closure, additional impacts that are specific to wildlife groups (mammals, birds, reptiles, amphibians, and invertebrates), and impacts on special status wildlife species. Some aspects of the analysis are briefly summarized in this section. Additional details not included are captured in the project record (Newell 2018j), Biological Assessment (SWCA Environmental Consultants 2020a), and Biological Evaluation (U.S. Forest Service 2020a).

3.8.1.1 Changes from the DEIS

The FEIS contains numerous changes to wildlife analysis in response to comments received on the DEIS. The DEIS considered alternative pipeline routes to reach the tailings storage facility for Alternatives 5 and 6. The FEIS describes one pipeline route each for Alternatives 5 and 6. Additionally, we revised the Alternative 6 pipeline route, primarily to address potential impacts to habitat and resources along Mineral Creek. As a result of these changes, all calculations of acreage impacts used in the analysis have changed. This includes those calculations found in the reference materials (Newell 2018j; SWCA Environmental Consultants 2020a; U.S. Forest Service 2020a). Analysis also includes any potential effects related to compensatory mitigation lands brought forward as part of the CWA Section 404 permitting process.

Since publication of the DEIS, we initiated and concluded Section 7 consultation with the FWS under the ESA. Appendix P to the FEIS includes the final Biological Opinion. Appendix P also contains conclusions of impacts to threatened and endangered species and any designated or proposed critical habitat.

With respect to impacts on wildlife resources, we conducted additional analysis on effects on migratory birds, special habitat areas, wildlife connectivity, and a number of indirect effects on species from nearby mining activities. We also considered new sources of information for species occurrence submitted as part of comments on the DEIS. These included a number of camera studies conducted on and around Oak Flat.

We developed numerous new applicant-committed environmental protection measures as part of Section 7 consultation and incorporated them into the analysis. New mitigation measures were brought forward to directly address wildlife impacts, including measures developed by Resolution Copper in consultation with AGFD. These are analyzed in the "Mitigation Effectiveness" discussion in this section. Cumulative effects analysis was revised for the FEIS to better quantify impacts. The analysis is described in detail in chapter 4 and summarized in this section.

3.8.2 Analysis Methodology, Assumptions, and Uncertain and Unknown Information

3.8.2.1 Analysis Area

The analysis area covers the project footprint plus a 1-mile buffer and areas along Queen Creek and Devil's Canyon where groundwater drawdown or reductions in surface water could change habitat (figure 3.8.2-1). Direct disturbance of the land and vegetation caused much of the impact on species and habitat. We determined the 1-mile buffer and areas of Queen Creek and Devil's Canyon by using the areas where the noise analyses, water analyses (i.e., groundwater and surface water quantity/quality analyses), fugitive dust distance affecting air quality, and noxious weed introduction and spread (Foxcroft et al. 2007) indicate the potential for impacts. The buffer for the compensatory mitigation parcels was set at 0.25 mile to account for all direct and indirect impacts for the proposed activities.

According to the air quality analysis, ambient air quality standards would be achieved at the project footprint boundaries; therefore, any potential air quality impacts are encompassed within the 1-mile buffer. The noise modeling shows that for all action alternatives, noise levels at 1 mile would be at or below the level of normal human conversation; as such, the 1-mile buffer is sufficient to address potential impacts from noise-producing activities. We also expect light associated with project construction and facilities to increase night-sky brightness from 1 to 9 percent on average (Dark Sky Partners LLC 2018). Light impacts would occur across the landscape but available research suggests any substantial impacts would occur within the 1-mile buffer (Newell 2018j). Species' movement corridors include areas outside the 1-mile buffer; we address potential impacts on those corridors at a landscape level.

AGFD is a cooperating agency and made species records and other information available to the Forest Service for use in the analysis. AGFD searched for records within the project footprint plus a 5-mile buffer; this information was used to determine the likelihood of occurrence of each species. This search area is greater than the analysis area and thus errs on the side of including more species records rather than fewer. This larger 5-mile buffer is clearly noted when it has been used (Newell 2018j).

The temporal parameters for this analysis involved the time frames for (1) construction: mine years 1 through 9, (2) operation: mine years 6 through 46, and (3) post-closure/reclamation: mine years 46 through 51 to 56, plus any additional years that are identified in other resource analysis (e.g., the groundwater analysis used to inform this section predicts out to 200 years). Construction activities would overlap operations activities for approximately 6 years.

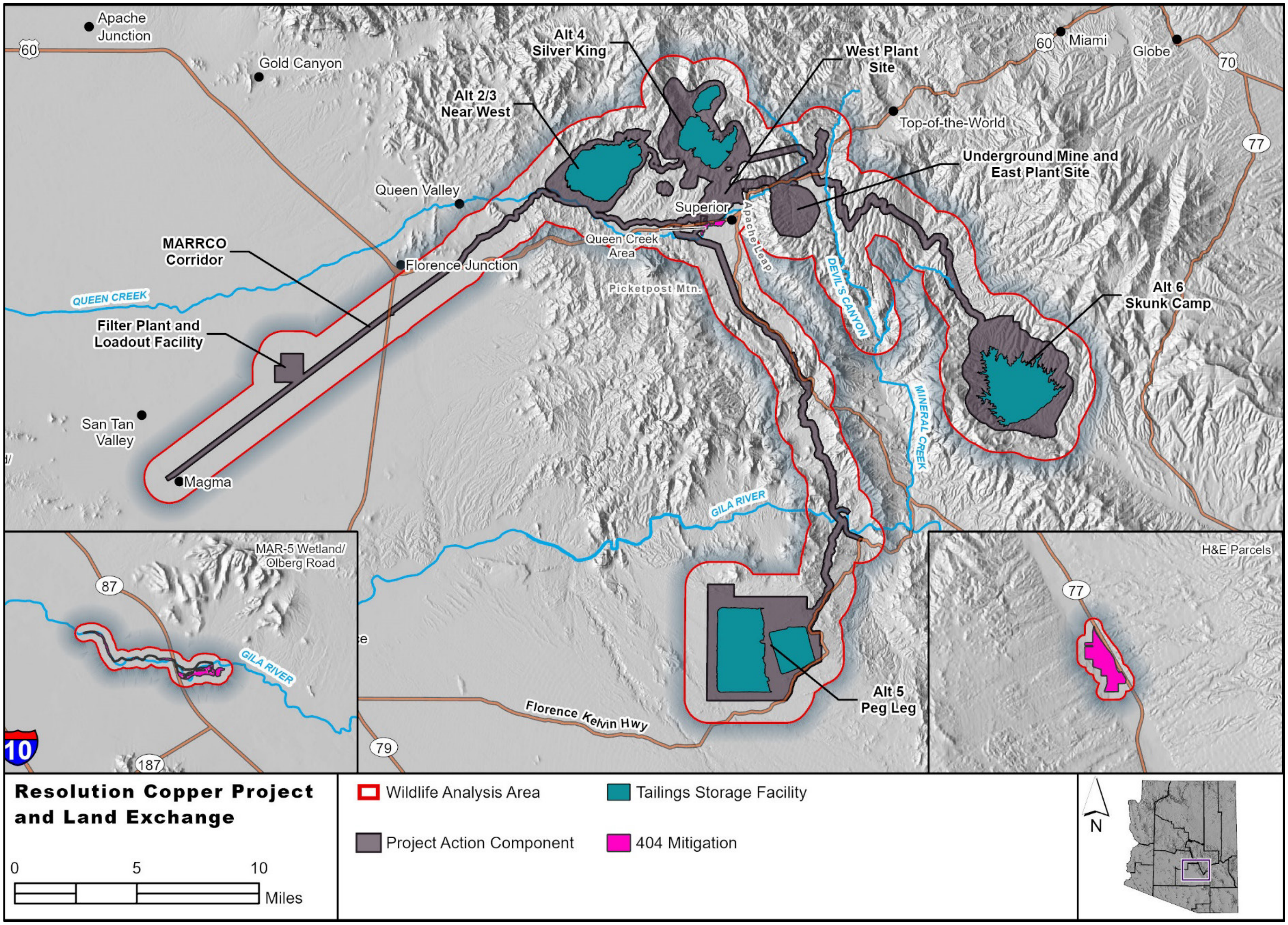


Figure 3.8.2-1. Wildlife analysis area

3.8.2.2 Analysis Methodology

The goal of this analysis is to identify the potential impacts on wildlife and special status wildlife species and their habitats, from all activities associated with each project alternative. Several elements constitute the core of this analysis: (1) the factors for analysis identified during the NEPA scoping process, (2) survey and records data provided as part of this project, and (3) a scientific examination using current literature on species and how environmental changes (human or natural) affect species and their habitat.

Additional information and details, including analysis methods, species accounts, occurrence records, etc., on wildlife resources discussed in this section can be found in the background documentation (see appendix A in Newell (2018j)). The uncertainties and unknown information, as well as assumptions, of this analysis include (1) limitations in the use of GIS data (e.g., mapping data may have inaccuracies and calculations could be an over- or underestimation); (2) lack of current scientific data on how certain environmental changes affect species; and (3) reliance on other resource analyses also furthers the assumptions, uncertainties, and unknown information stated in those sections into this analysis.

3.8.3 Affected Environment

3.8.3.1 Relevant Laws, Regulations, Policies, and Plans

The primary Federal, State, and local policies, regulations, and guidelines used to analyze potential impacts on wildlife in the project analysis area are shown in the accompanying text box and further detailed in Newell (2018j).

Primary Legal Authorities and Technical Guidance Relevant to the Wildlife Effects Analysis

- Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.)
- Migratory Bird Treaty Act of 1918, as amended (16 U.S.C. 703–711)
- National Forest Management Act implementing regulations (36 CFR 219.19(a)(1))
- Bald and Golden Eagle Protection Act of 1940, as amended (16 U.S.C. 668–668c)
- Bureau of Land Management – Phoenix Resource Management Plan, Las Cienegas National Conservation Area Resource Management Plan, and San Pedro Riparian National Conservation Area Resource Management Plan
- Arizona Game and Fish Department determinations of Species of Greatest Conservation Need (SGCN) occurring within the wildlife analysis area

3.8.3.2 Existing Conditions and Ongoing Trends

General Wildlife

A wide variety of general wildlife and associated habitats is found in or within 5 miles of the analysis area of all action alternatives. Section 3.3, Soils, Vegetation, and Reclamation, describes the associated habitats. Many of the non-game wildlife species are considered by AGFD to be Species of Greatest Conservation Need (SGCN).[78] These species mostly overlap species with Federal special status (ESA,

[78] Species of Greatest Conservation Need is a designation used by AGFD, as a means to focus planning and conservation efforts, particularly in the State Wildlife Action Plan.

Tonto National Forest, or BLM) and are included under the "Special Status Wildlife Species" section. Several SGCN species that do not otherwise overlap Federal special status wildlife species are also included in the "Special Status Wildlife Species" section. We used biological surveys, as well as observations pulled from the AGFD's Heritage Data Management System data, to determine which SGCN species have occurrence records within 5 miles of the action alternatives. We then evaluated SGCN for their likelihood of occurrence within 5 miles of Alternatives 2 and 3 (41 known to occur, 6 possible to occur); Alternative 4 (41 known to occur, 6 possible to occur); Alternative 5 (45 known to occur, 9 possible to occur); and Alternative 6 (45 known to occur, 11 possible to occur) (Newell 2018j). These were further refined for the FEIS to address species within 1 mile of project features (see section 3.8.4 and table 3.8.4-2 later in this section).

Game Species

A wide variety of Species of Economic and Recreational Importance (SERI), game species, and associated habitat occur within 5 miles of the action alternatives and are primarily addressed in the "Recreation" and "Socioeconomics" resource sections of this chapter. Section 3.3, Soils, Vegetation, and Reclamation, shows the associated habitats. The footprint of the analysis area is located within AGFD's Game Management Unit (GMU) 24A and 24B, where nine game species are present. Those species include Gambel's quail (*Callipepla gambelii*), javelina (*Pecari tajacu*), cottontail (*Sylvilagus* spp.), mule deer (*Odocoileus hemionus*), white-tailed deer (*Odocoileus virginianus*), black bear (*Ursus americanus*), mountain lion (*Puma concolor*), bighorn sheep (*Ovis canadensis*), and tree squirrel (*Sciurus* spp.). Elk (*Cervus canadensis*) is also present in GMU 24A, but not in the portion of the GMU near or within the analysis area. Additionally, there are 10 SERI species with predicted occurrences within 5 miles of the project footprint. These species include mule deer, white-tailed deer, javelina, elk, black bear, mountain lion, Gambel's quail, mourning dove (*Zenaida macroura*), white-winged dove (*Zenaida asiatica*), and band-tailed pigeon (*Patagioenas fasciata*).

Special Habitat Areas

Special habitat areas include wildlife waters; Important Bird Areas; caves, mines, and karst features; and springs (figure 3.8.3-1). More information on caves/mines/karst features and springs is available in the "Geology, Minerals, and Subsidence" and "Groundwater Quantity and Groundwater-Dependent Ecosystems" sections of this chapter, respectively, and the habitats are described by biotic community in the "Soils and Vegetation" section. The Boyce Thompson Arboretum/Arnett-Queen Creeks Important Bird Area is located within 5 miles of the action alternatives but is only within the footprint of the pipeline corridor associated with Alternative 5 (see figure 3.8.3-1).

There are 15 wildlife waters (waters built or improved specifically for wildlife such as stock tanks and wildlife guzzlers) within 5 miles of the project footprint. Of these 15 wildlife waters, three would be within the project footprint. These wildlife waters include the Benson Spring, which would be within the footprint of the tailings facility for Alternatives 2 and 3; and Silver King, which would be within the tailings facility area for Alternative 4. Additionally, the Superior #1 wildlife water would be within the analysis area for Alternative 5.

Caves, abandoned mines, and karst features in the analysis area may provide suitable roosting habitat for bat species. There are four caves, two mines, and four karst features within 5 miles of the project footprint. Only one of these, the Bomboy Mine, is within the project footprint. It is located within the footprint of the proposed tailings facility for Alternatives 2 and 3 (see figure 3.8.3-1). All of the remaining features are within 5 miles of all action alternatives and include the Umbrella Cave and the Superior High School Cave. Some of these features have been closed, and bat gates have been installed to allow bat use of the features.

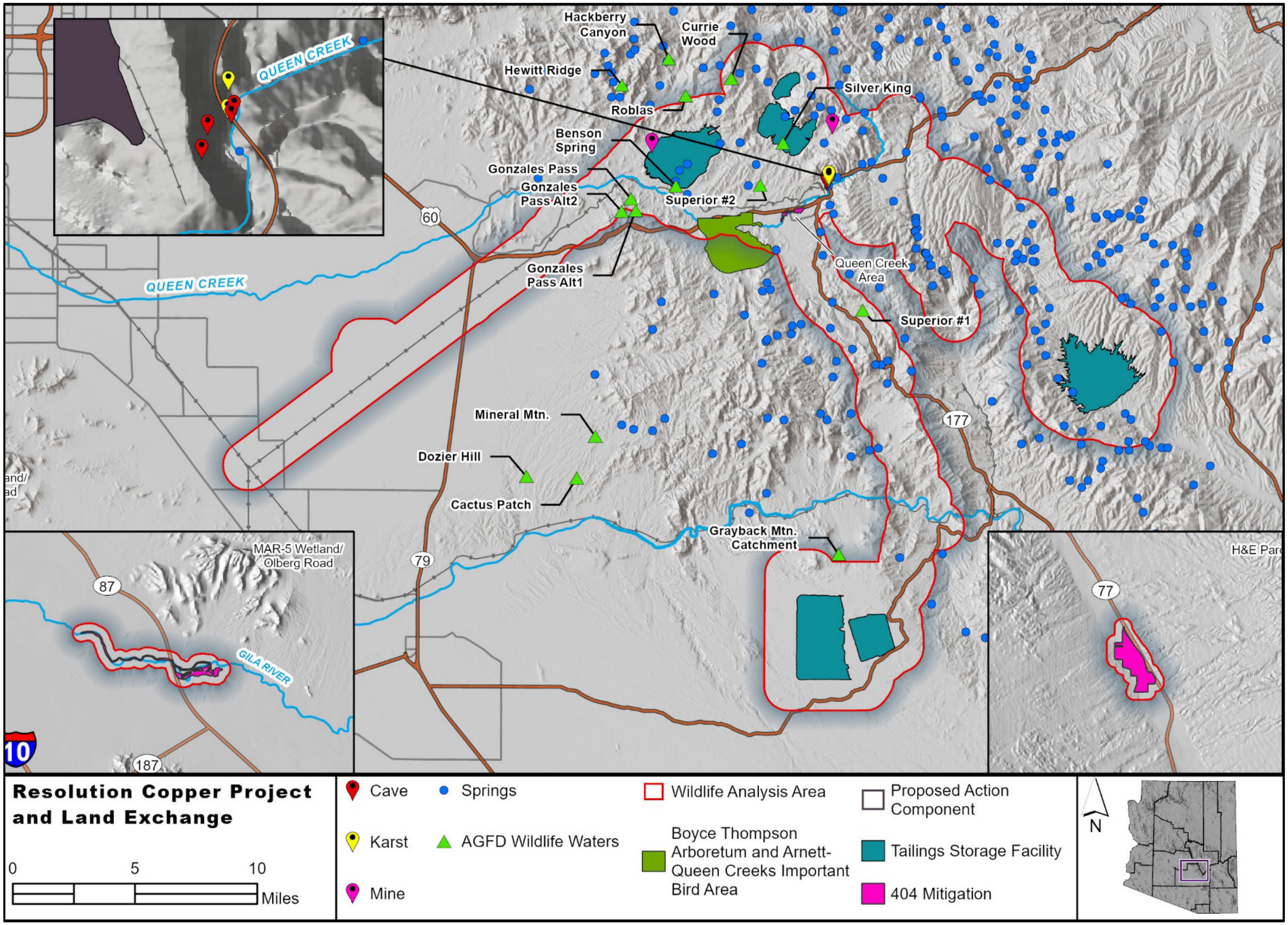


Figure 3.8.3-1. Special habitat areas, caves, mines, springs, and karst features

There are 103 springs mapped within 1 mile of the project footprint, a portion of the 338 total springs within 5 miles of the project footprint (see figure 3.8.3-1). This includes 24 springs and several stream segments that are considered to be groundwater dependent with the potential to be impacted by the project (see table 3.7.1-2). The specific list of GDEs, including springs, perennial waters, and riparian areas that are believed to have a connection to regional aquifers and could potentially be impacted by the action alternatives is the focus of the "Groundwater Quantity and Groundwater-Dependent Ecosystems" section of this chapter. Unlike the subset of springs analyzed in the "Groundwater Quantity and Groundwater-Dependent Ecosystems" section, the vast majority of springs shown in figure 3.8.3-1 were identified from available databases or literature sources and may or may not be physically present on the landscape, or they represent local seeps or springs without persistent water or a connection to regional aquifers.
The wider springs inventory is included in this section because these water sources are still important to wildlife; however, many of these springs would not be impacted by project activities unless directly within the project footprint.

Wildlife Connectivity

Through resource management planning in recent years, agencies, organizations, stakeholders, academia, private citizens, and non-profit organizations all aided in identifying the important wildlife movement corridors throughout the state. During the development of the 2006 "Arizona's Wildlife Linkages Assessment" (Arizona Wildlife Linkages Workgroup 2006) and the 2013 "Pinal County Wildlife Connectivity Assessment: Report on Stakeholder Input" (Arizona Game and Fish Department 2013), stakeholders identified numerous wildlife movement corridors, as well as natural topographic features such as canyons and washes that are used as animal movement corridors, as important to the conservation of species and their populations. Other researchers further analyzed and modeled some of these animal movement corridors to refine the best biological corridors (Beier et al. 2007). Continuing development throughout the region has reduced available space for wildlife and increased barriers to wildlife connectivity and movement.

Habitat block areas were identified statewide as areas important for wildlife movement and landscape-scale connectivity. Habitat blocks are defined as "a relatively large and unfragmented area of land capable of sustaining healthy populations of wildlife into the foreseeable future" (Arizona Game and Fish Department 2013). Category 1 blocks are the most intact and have no measurable human modification; Category 2 blocks are intact but may have some feature running through (Perkl 2013). Figure 3.8.3-2 depicts details of wildlife movement corridors within the vicinity of the analysis area and their geographical placement in the surrounding region. Figure 3.8.3-3 depicts landscape integrity in the vicinity of the analysis area. Additional detail can be found in the background documentation (see the "Wildlife Connectivity" section in Newell (2018j)).

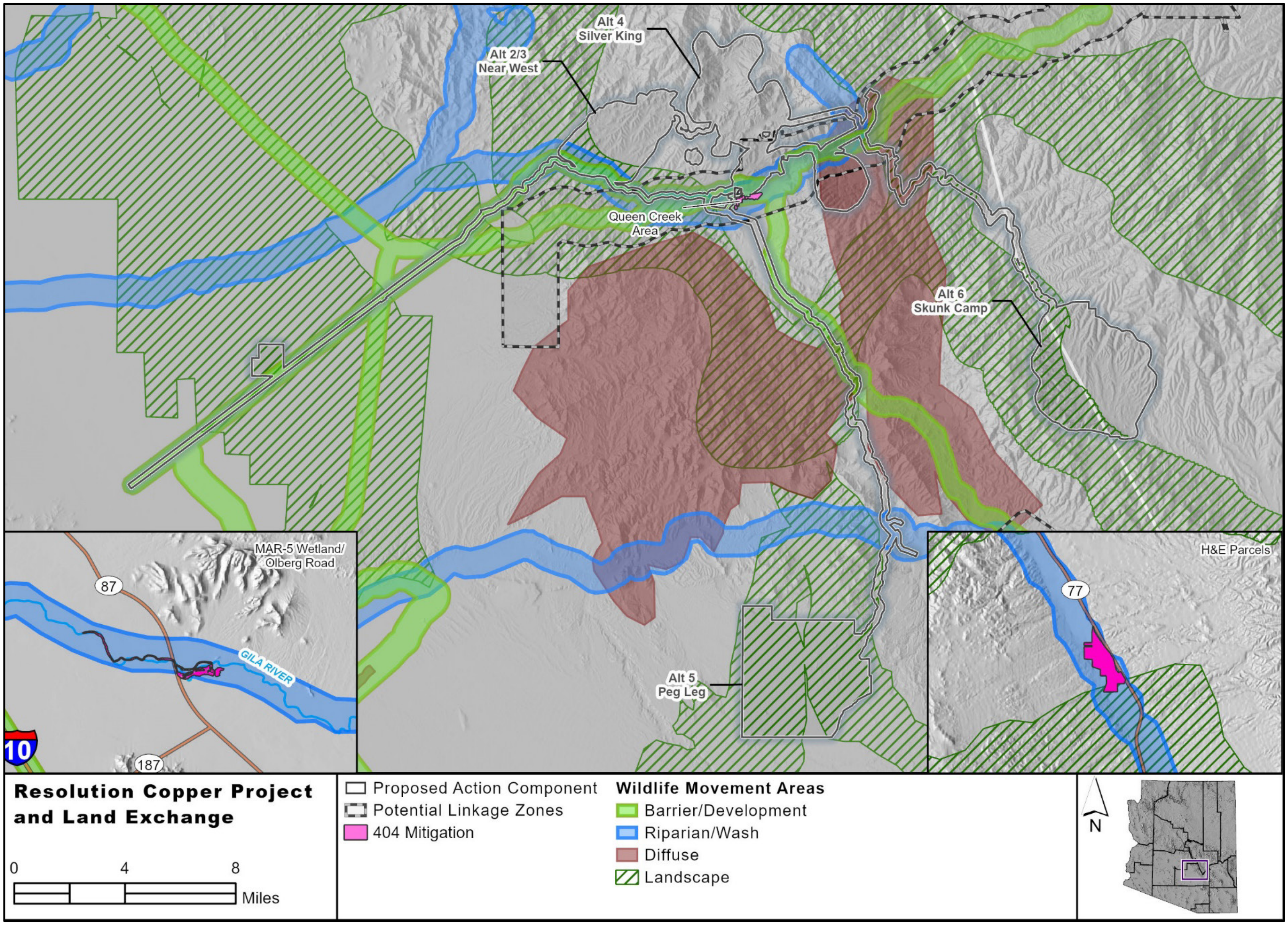


Figure 3.8.3-2. Wildlife movement areas

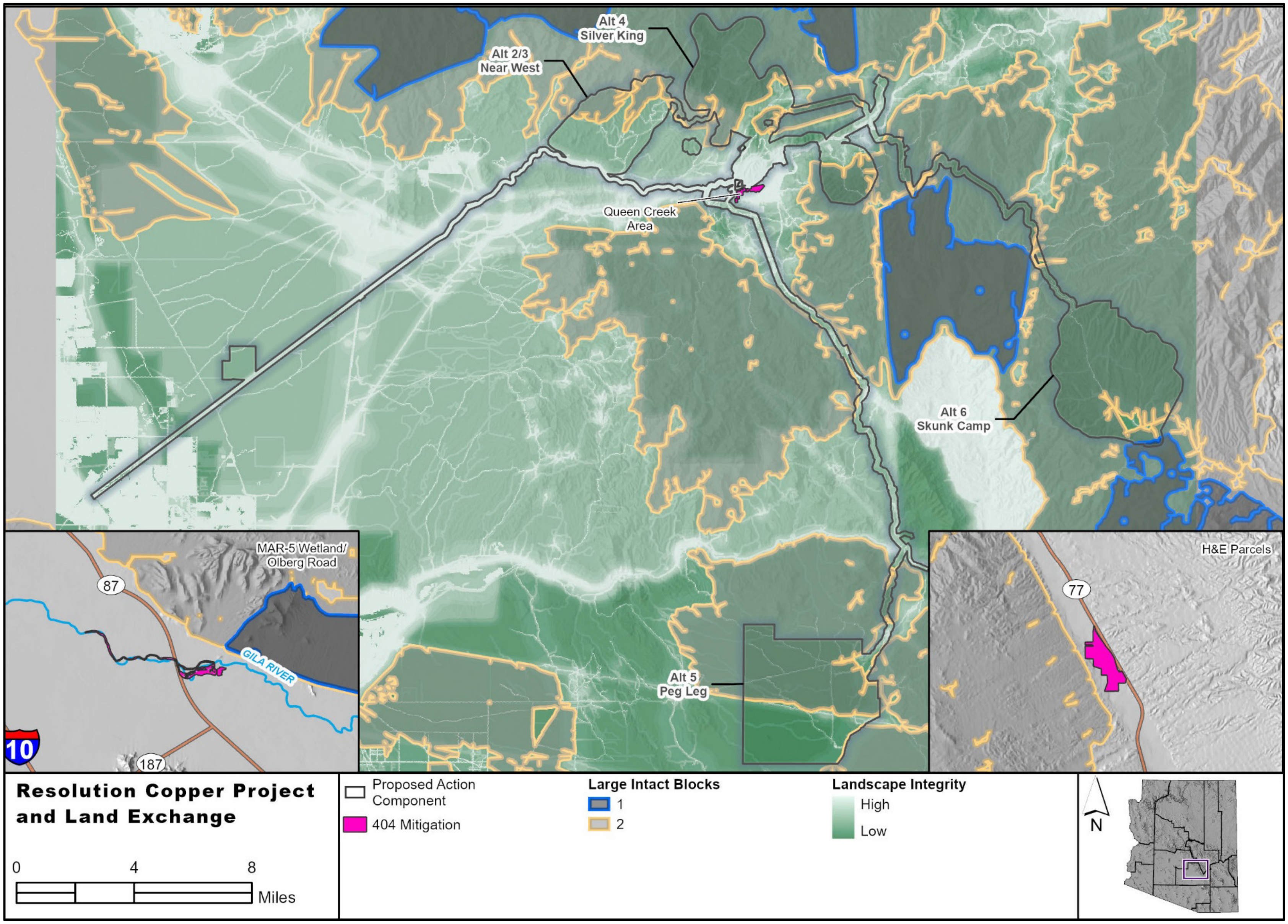


Figure 3.8.3-3. Landscape integrity

Special Status Wildlife Species

For each action alternative, Federal and State special status wildlife species lists were analyzed, including the following:

- Federal
    - Endangered Species Act wildlife species listed in Pinal and Gila Counties
    - Migratory Bird Treaty Act (MBTA) species
    - Bald and Golden Eagle Protection Act (BGEPA) species
    - Tonto National Forest
        - Sensitive species
        - Migratory Bird Species of Concern
        - Management indicator species (MIS)
        - Other Species of Interest (OSI)
    - Bureau of Land Management
        - Sensitive species for the Gila District Office
- State
    - Arizona Game and Fish Department
        - Species of Greatest Conservation Need, if they had other status listings; two SGCN-only species were addressed at the request of the cooperating agency.

Additional detail regarding which species are known to occur or may possibly occur in the analysis area can be found in the background documentation (see table 2 in Newell (2018j)).

Compensatory Mitigation Lands

Permitting under Section 404 of the CWA will require some level of compensatory mitigation to offset direct and indirect impacts to waters of the U.S. The compensatory mitigation package approved by the USACE is included as appendix D of the FEIS. The following suite of off-site mitigation is considered part of the proposed project analyzed in this section (see figure 3.8.2-1).

- MAR-5 Wetland/Olberg Road. The conceptual mitigation strategy consists of exotic tree species (principally tamarisk [*Tamarix* spp.]) removal and control, combined with native plant species reseeding, to allow for the establishment and maintenance of a riparian habitat dominated by native tree species. Tamarisk removal and seeding for native species at the upstream Olberg Road site would remove the major seed source for invasive tamarisk for the adjacent, downstream MAR-5 discharge area. Proposed mitigation activities for the MAR-5 site include continued scheduled CAP water discharges, limited tamarisk removal and control, and seeding of native plant species. Mitigation activities at the Olberg Road site consist of tamarisk removal and control within the entire 23-acre site, followed by seeding of native plant species. Exotic tree species removal and control, combined with seeding of native plant species, would allow for the establishment and maintenance of a riparian habitat dominated by native tree species at both sites and would eliminate a large, local source of exotic tree species seed from that section of the Gila River. Exotic species removal would occur outside of the yellow-billed cuckoo breeding season and southwestern willow flycatcher breeding season (May 1–September 30) at both mitigation sites. No critical habitat is located on the sites.

- Queen Creek. This site is located downstream of the town of Superior, along Queen Creek. Conceptual mitigation elements include the removal of tamarisk to allow riparian vegetation to return to its historic composition and structure and promote more natural stream functions, and establishment of a conservation easement covering approximately 79 acres along 1.8 miles of Queen Creek to restrict future development of the site and provide protected riparian and wildlife habitat.

  Proposed mitigation activities for the Queen Creek site would include ecological improvements to the riparian habitat. Within the xeroriparian corridor, limited removal of sparsely populated tamarisk and other invasive species would occur, followed by planting and seeding of native plant species. In portions of the site where there are anthropogenic disturbances, selective debris would be removed while avoiding disturbance to existing mature woody vegetation; seeding of native plant species would follow. The remaining portions of the mitigation site would be preserved, providing protection to riparian and wildlife habitat. Exotic species and debris removal would occur outside of the yellow-billed cuckoo and southwestern willow flycatcher breeding seasons (May 1–September 30).

  H&E Farm. The H&E Farm is a 500-acre property owned by The Nature Conservancy. Proposed mitigation activities include earthwork to reconnect historic tributaries. Earthwork would reestablish the San Pedro River's access to its river right floodplain and terrace and enhance the wetland features present in the area. Compacted soils across the site on the terraces are causing earth fissures and sinkholes on the parcel, which will continue if no intervention occurs. The use of grading in the south end of the parcel to create alluvial fans is proposed to provide tree growth potential, which would be similar to what exists on the other side of the San Pedro River off-parcel. Planting and seeding native species is planned to restore a more native vegetation community along the bank of the river. The intent is to mirror previous mitigation strategies implemented by The Nature Conservancy as well as ongoing mitigation at the AGFD Lower San Pedro Wildlife Area that is contiguous to the western and northern boundaries of the H&E Farm parcel. Mitigation activities would occur outside of the yellow-billed cuckoo and southwestern willow flycatcher breeding seasons (May 1–September 30). Yellow-billed cuckoo critical habitat is present within areas where no earthwork or vegetation removal is planned.

Management Indicator Species

The Forest Service is required to maintain viable populations of native and desired non-native species by evaluating a project's effects on selected MIS as set forth in the National Forest Management Act. Management indicator species are defined as follows: "Plant and animal species, communities, or special habitats selected for emphasis in planning, and which are monitored during forest plan implementation in order to assess the effects of management activities on their populations and the populations of other species with similar habitat needs which they may represent" (FSM 2620.5) (U.S. Forest Service 1991).

In order to meet the National Forest Management Act requirement to maintain viable populations of native and desired non-native species, MIS were selected based on a variety of criteria. In general, MIS were selected to serve as barometers of management effects on other species with similar habitat requirements. The Tonto National Forest has 30 MIS, which consist mostly of birds, to represent 30 habitat features (see table 3 in Newell (2018j)). Section 3.8.4 represents an analysis of current habitat and population trends of each MIS population within the Tonto National Forest, conducted as an interpretation of changes in populations and habitat trends since implementation of the 1985 forest plan for potential effects on MIS resulting from implementation of Tonto National Forest–approved projects. A forest-wide assessment titled "Tonto National Forest Management Indicator Species Status Report"

(Klein et al. 2005) summarizes current knowledge of population and habitat trends for MIS on the Tonto National Forest.

Habitats for a number of the Tonto National Forest MIS occur in the project area. As most MIS are not rare species, it is assumed that some individuals of each MIS associated with the habitat types in the project area are also present. Additionally, we expect that individuals of MIS associated with habitat not known to be present within the project area have the potential to occur.

Additional detail regarding which MIS species are associated with each vegetation type or series, species trends, total acres on Tonto National Forest, and acres within the analysis area can be found in the background documentation (see table 3 in Newell (2018j)).

3.8.4 Environmental Consequences of Implementation of the Proposed Mine Plan and Alternatives

3.8.4.1 Alternative 1 – No Action Alternative

Under the no action alternative, the proposed project would not be constructed and potential impacts on wildlife resources (species and habitat) would not occur. Impacts on wildlife resources from existing disturbances (e.g., recreation, livestock grazing, mining and development, wildfires) would continue.

3.8.4.2 Impacts Common to All Action Alternatives

Effects of the Land Exchange

The selected Oak Flat Federal Parcel would leave Forest Service jurisdiction. The role of the Tonto National Forest under its primary authorities in the Organic Administration Act, Locatable Regulations (36 CFR 228 Subpart A), and Multiple-Use Mining Act is to ensure that mining activities minimize adverse environmental effects on NFS surface resources; this includes effects on the wildlife resources that may occur on the Oak Flat Federal Parcel. The removal of the Oak Flat Federal Parcel from Forest Service jurisdiction negates the ability of the Tonto National Forest to regulate effects on these resources or manage them to achieve desired conditions.

The offered lands would come under Federal jurisdiction. Specific management of the wildlife resources of those parcels would be determined by the agencies to meet desired conditions or support appropriate land uses. In general, these parcels contain a variety of ecosystems similar to those that support wildlife species in the analysis area, including riparian, xeroriparian, semi-desert grassland, and desert ecosystems, that would come under Federal jurisdiction.

Effects of Forest Plan Amendment

The Tonto National Forest Land and Resource Management Plan (1985b) provides guidance for management of lands and activities within the Tonto National Forest. It accomplishes this by establishing a mission, goals, objectives, and standards and guidelines. Missions, goals, and objectives are applicable on a forest-wide basis. Standards and guidelines are either applicable on a forest-wide basis or by specific management area.

A review of all components of the 1985 forest plan was conducted to identify the need for amendment due to the effects of the project, including both the land exchange and the proposed mine plan (Shin 2020). Of all resources, wildlife have the greatest number of standards and guidelines identified in the forest plan for consideration (37). None of these standards and guidelines were found to require amendment to the proposed project, either on a forest-wide or management area-specific basis. For additional details on specific rationale, see Shin (2020).

Effects of Compensatory Mitigation Parcels

Potential impacts to wildlife and special status species from the compensatory mitigation parcel activities primarily would be beneficial under all action alternatives. Included would be habitat protection and improvement, as well as improving wildlife connectivity by protecting habitat blocks. Some temporary impacts associated with vegetation management and other activities could affect species through habitat modification and loss, increased noise levels, presence of workers and equipment, increased dust, and other impacts similar to those described above in Impacts Common to All Action Alternatives, below in Additional Impacts Specific to Wildlife Groups, as well as in the Biological Evaluation and Biological Assessment (SWCA Environmental Consultants 2020a; U.S. Forest Service 2020a).

Effects of Recreation Mitigation Lands

The recreation mitigation lands are anticipated to have beneficial impacts to wildlife and special status species by reducing the haphazard development of unauthorized trails, therefore limiting further degradation of habitat important to wildlife and special status species.

Summary of Applicant-Committed Environmental Protection Measures

A number of environmental protection measures are incorporated into the design of the project that would act to reduce potential impacts on wildlife. These are non-discretionary measures and their effects are accounted for in the analysis of environmental consequences.

In the GPO and in the Biological Opinion, Resolution Copper has committed to a variety of measures to reduce potential impacts on wildlife, including those outlined in Appendix P.

- In order to minimize the potential risk for bird collisions with transmission lines, the lines and structures would be designed in accordance with Reducing Avian Collision with Power Lines (Avian Power Line Interaction Committee 2012). Line marking devices, i.e., flight diverters, would be placed at the proposed crossings of Queen Creek, Devil's Canyon, and Mineral Creek, especially in areas where there is suitable habitat for the yellow-billed cuckoo.
- Resolution Copper prepared a Noxious Weed and Invasive Species Management Plan on National Forest System Lands (Resolution Copper 2019). Resolution Copper further agreed to prepare reports 2 years after construction begins and every 5 years during operations. These reports will update the Tonto National Forest and FWS on surveys, control, and activities related to noxious and invasive weed management.
- Some additional non-lethal harassment and scare devices to deter and disperse wildlife from the PAG tailings, non-contact and contact stormwater catchment basins, and process water ponds may also be considered and could include the following:
    - Plastic ball covers, vehicle lights and horns, motion-sensor lights, flags, perch deterrents, shell crackers, bird bangers, screamers, distress cries/electronic noise systems, bird scare balloons, propane cannons, and mylar scare tape.
    - A bird hazing protocol would be developed for Resolution Copper employees and would include a combination of harassment techniques. Additional hazing techniques may be adjusted or added as necessary based on field observations and ongoing research efforts. The protocol would include an inspection schedule, acceptable harassment techniques, a field

log procedure, and incident reporting procedures. Resolution Copper staff responsible for implementing the bird hazing program would be trained on the protocol prior to its initiation.

- Vegetation growth within the contact and non-contact stormwater catchment basins and process water ponds would be monitored and periodically removed as often as necessary to further discourage the presence of wading birds.

Partially in response to public comments on the DEIS and further review by the Forest Service, Resolution Copper submitted a revised draft wildlife management plan (Resolution Copper 2020j). A number of specific mitigation measures were developed to respond to impacts disclosed during the NEPA process. These new mitigation measures were incorporated into the revised plan; those new requirements of the plan are discussed in the “Mitigation Effectiveness” section.

Other applicant-committed environmental protection measures by Resolution Copper to reduce impacts on wildlife include measures adapted from previous investigations on the Tonto National Forest:

- Conducting pre-construction surveys for Sonoran desert tortoise (*Gopherus morafkai*) and Gila monster (*Heloderma suspectum*) before surface ground-disturbing activities start. A biological monitor would monitor for Sonoran desert tortoise and Gila monster during construction activities. The monitor would flag Sonoran desert tortoise and Gila monster shelter sites/burrows. These flagged areas would be inspected, and any Gila monsters and tortoises discovered would be relocated outside of project activity areas.
- Informing project crews of the potential to encounter Sonoran desert tortoise and Gila monster within the surface project area. Work crews would be instructed to check below equipment prior to moving, and to cover and/or backfill holes that could potentially entrap these species. If these species are observed, work crews would stop work until the biological monitor has relocated these species out of harm’s way.
- Establishing tortoise crossings, as needed and applicable, for concentrate and tailings pipeline corridors, as well as the railroad tracks within the MARRCO corridor within areas containing suitable habitat.
- Developing a site-specific wildlife mitigation plan in coordination with AGFD, FWS, and Forest Service biologists to address construction-related actions. Intent is to avoid, minimize, and mitigate impacts on special status species (e.g., timing of construction, species relocations, etc.). This was completed with the preparation of the draft revised wildlife management plan that was prepared in collaboration with AGFD (Resolution Copper 2020j).
- Ensuring all ground-disturbing activities associated with the tailings pipeline and power line work near Mineral Creek and Gila chub designated critical habitat occurs outside the ordinary high-water mark and designated critical habitat.
- Using trenchless/non-surface impact methods (such as horizontal drilling or micro-tunneling) in areas where project facilities intersect Mineral Creek, to avoid surface disturbance within the ordinary high-water mark and designated critical habitat.
- Clearly defining the perimeter of the construction footprint with flagging or other appropriate markers to restrict heavy equipment use and other surface-disturbing activities to areas within the construction footprint. The biological monitor will be present at all times during construction and help ensure that construction activities and equipment remain within designated limits and outside the ordinary high-water mark and designated critical habitat.
- Developing a SWPPP to reduce potential project-related increases in sedimentation to Mineral Creek.

- In areas where surveys have detected the presence of yellow-billed cuckoo, avoiding closure and reclamation activities within 500 feet of the ordinary high-water mark of Mineral Creek from May 1 through September 30, to remain outside the breeding season for the species.
- Ensuring a qualified biological monitor is present in work areas that contain suitable habitat for the southwestern willow flycatcher and yellow-billed cuckoo along Mineral Creek during all surface-disturbing activities between May and September each year.
- Conducting annual yellow-billed cuckoo surveys in Devil's Canyon and Mineral Creek immediately upstream and downstream of disturbance areas and crossings. Annual surveys will begin 2 years prior to surface-disturbing activities. Surveys will continue until pipeline construction has been completed, including reclamation of temporary construction disturbance.
- In areas where surveys have detected the presence of yellow-billed cuckoo, avoiding vegetation clearing and ground-disturbing activities associated with pipeline construction within 500 feet of the ordinary high-water mark of Mineral Creek from May 1 through September 30, to remain outside the breeding season for yellow-billed cuckoo and to prevent direct effects on the species (injuries or fatalities to adults, eggs, or young).
- Avoiding when possible large trees (greater than 12 inches in diameter), including Fremont cottonwood (*Populus fremontii*) and willow species (*Salix* spp.), as well as dense stands of vegetation.
- Cutting riparian trees to ground level when they are removed. When possible, root masses will be left intact to help stabilize soils and provide opportunities for regrowth through adventitious shoots (e.g., in the case of willows).
- Conducting yellow-billed cuckoo surveys every 5 years during mine operations in Devil's Canyon and Mineral Creek in potentially suitable habitats immediately upstream and downstream of project areas (crossings) to monitor cuckoo presence in the area and prevent/minimize direct effects on cuckoos.
- In areas where surveys show the presence of possible, probable, or confirmed breeding of yellow-billed cuckoos, avoiding large-scale, major noise-producing activities within 500 feet of the ordinary high-water mark of Mineral Creek to the extent possible (e.g., maintenance activities associated with pipeline replacement and cleaning that may affect cuckoo habitat during the breeding season (May 1 to September 30, annually)).

SRP has provided additional details on operations and maintenance activities along power lines, including vegetation maintenance, as described in a supplement to the biological assessment (SWCA Environmental Consultants 2020c). Many of these measures are specific to Arizona hedgehog cactus and focus on surveys, marking, and avoidance, both during vegetation maintenance and line maintenance work.

General Construction Impacts

The primary construction-related impacts to wildlife groups would be from habitat loss and habitat fragmentation from project facilities.

Potential construction-related impacts from all action alternatives common to all wildlife groups—including amphibians, birds, fish, invertebrates, mammals, reptiles; special status wildlife species; game species including SERI; and general wildlife—would involve the loss, degradation, and/or fragmentation of breeding, rearing, foraging, and dispersal habitats; collisions with and crushing by construction vehicles; loss of burrowing animals in burrows in areas where grading would occur; increased invasive and noxious weed establishment and spread; increased edges of vegetation blocks; increased smells associated with construction activities that could affect part(s) of the life cycle or habitat use by species that use olfactory inputs; and impacts from increased noise/vibration levels. Proposed construction activities would include the loss, degradation, and fragmentation of habitat for wildlife and special status wildlife species during ground-clearing activities. Ground-clearing activities include construction of access roads, pipeline corridors, tailings facilities, and other project facilities. Construction activities would also affect adjacent habitats and connectivity between habitats as project features would create barriers to wildlife movement and dispersal.

Ground disturbance associated with construction activities may increase the potential for the introduction and colonization of disturbed areas by noxious and invasive plant species. This may lead to changes in vegetation communities and thus habitat for wildlife, including a possible shift over time to more wildfire-adapted non-native vegetation. These potential changes would impact species as habitat is modified and degraded and could decrease suitability of areas to support breeding, rearing, foraging, and dispersal of wildlife and special status wildlife species.

Temporary impacts associated with the presence of workers and equipment may cause species to avoid using work areas or adjacent habitats during construction activities. Some construction activities would overlap operations for approximately 6 years, during which noise- and vibration-producing activities would be ongoing. Potential impacts related to noise and vibration would be temporary and would diminish with the completion of construction activities.

Noise and vibration associated with construction activities may temporarily change behavior; disrupt breeding, sheltering, and foraging activities; and change habitat use patterns for some species. Many wildlife species rely on meaningful sounds for communication, navigation, finding food, and to avoid danger (Federal Highway Administration 2004). These impacts would be greatest for those species that rely on meaningful sounds. Some individuals would likely move away from the source(s) of the noise/vibration to adjacent or nearby habitats, which may alter or affect competition for resources within these areas. Species that use vibrational communication systems would also be affected by increases in ground-borne vibrations through substrates and soils. These impacts would occur for all action alternatives near any blasting and heavy machinery operations.

Noise/vibration and other disturbances may also lead to increased stress on individuals and disruption of breeding, sheltering, and foraging activities, thus impacting their overall fitness due to increased metabolic expenditures. These effects would be temporary and of short duration and would diminish with the completion of construction activities. Some species could see impacts on local populations in the action area, but no regional population level impacts are likely.

Additional noise and vibration impacts may include decreased immune response, hearing damage, diminished intraspecific communication, increased predation risk, and reduced reproductive success (NoiseQuest 2011; Pater et al. 2009; Sadlowski 2011). These effects would be temporary and of short duration and would diminish with the completion of construction activities. Some species could see impacts on local populations in the action area, but no regional population level impacts are likely.

The proposed project would increase the amount of edge habitat along areas to be disturbed, especially along linear features such as pipeline corridors, electrical distribution lines, and access roads. Effects from increased amounts of edge would include decreased habitat block size. Decreased habitat block size may negatively impact those species that require large blocks of contiguous habitat and benefit other species that use edge habitats or have more general habitat requirements. This could locally reduce reproductive success, increase predation, reduce prey populations, and change habitat use by those species. In areas where there is higher vegetation density, the potential impacts from habitat fragmentation and edge effects would be greatest.

Artificial lighting associated with the construction phase of the proposed project is less defined but is assumed to be less intense that associated with the operations phase, and to vary in location and intensity through the 1- to 9-year time period. Specific impacts would be similar to those described in the "General Operations Impacts" section; impacts on species groups are discussed in subsequent sections.

For species that utilize olfactory inputs to trigger part of their life cycle or habitat use, potential impacts from smells associated with construction activities could occur under all action alternatives. These potential impacts would be greatest for species that rely heavily on olfactory communication or cues.

General Operations Impacts

Potential impacts on wildlife and special status wildlife species during the operations phase of all action alternatives would be associated with subsidence; potential reduction in surface water flows and groundwater availability to support riparian habitats; habitat changes from ongoing noxious and invasive weed establishment and spread; and the ongoing presence of workers and equipment.

During the operations phase of the proposed mine, there would be impacts on wildlife and special status wildlife species from subsidence. Subsidence of the ground surface is anticipated to occur at approximately 6 years after initiation of mining activities and is anticipated to continue until 41 years after initiation of mining activities (see Section 3.2, Geology, Minerals, and Subsidence).

Within the cave limit, the development of a subsidence area would change the slope, aspect, surface water flow direction and rate; surface elevation; and would impact habitat on approximately 1,342 acres. This could lead to mortality of wildlife species individuals within the subsidence area during caving/fracture events. Within the fracture limit (1,598 acres) the potential impacts would be similar to the cave limit; however, the intensity would be decreased as this area would have reduced surface impacts.
The continuous subsidence limit (1,757 acres) would have limited potential for localized impacts on vegetation communities as it would have minimal surface impacts. The entire subsidence area would be fenced for public safety and would remove the subsidence area as habitat for some wildlife and special status wildlife species. Smaller species and avian species would be able to use the subsidence area as habitat.

Potential water usage associated with operation of all action alternatives would reduce water in the regional aquifer and may reduce surface water and groundwater levels downstream of the mine in Devil's Canyon and Queen Creek. Surface water amounts would be reduced, and timing/persistence of surface water would decrease. These potential decreases in groundwater and surface water would occur over a long period of time but could cause changes in riparian vegetation extent or health, and the potential reduction in streamflow could impact species that use these riparian areas during portions of their life cycle. Potential impacts may reduce or remove available habitat for wildlife and special status wildlife species and impact individuals in localized areas along Devil's Canyon and Queen Creek, or around springs. A reduction in spring and riparian habitats may require species in the area to travel farther to find water, thus impacting their overall fitness due to increased metabolic expenditures. Section 3.7.3.4 addresses potential changes to water availability.

The proposed water usage associated with the project is not anticipated to affect flow regimes or riparian habitat along the Gila River (see section 3.7.1 for a more detailed discussion of impacts on GDEs and riparian areas).

We do not anticipate any impacts on wildlife or special status wildlife species from water quality impacts at any of the tailings locations during operations, as any stormwater that comes in contact with the tailings piles would be contained in the tailings facilities or in seepage ponds downstream. Water quality modeling for the proposed project indicates that water quality at the tailings pile area would not exceed any water quality standards for wildlife species (Newell and Garrett 2018d). It is possible that avian species could use the seepage ponds. We expect concentrations of some constituents in the seepage ponds to be above chronic exposure limits and some acute exposure limits from some constituents under all action alternatives (cadmium, copper, nickel, selenium, zinc, and silver). This could lead to short- and long-term impacts on some avian species if they are exposed to water from the seepage ponds; the potential to impact these species would be greatest if they were exposed over an extended period of time. See the "Screening of Geochemistry Predictions for Effects on Wildlife Process Memorandum" for more information (Newell 2018j).

Potential impacts on wildlife and special status wildlife species habitat from increased noxious and invasive weed establishment and spread would be similar in nature to those described above for construction; however, as ground-disturbing activities would be reduced during operations, the magnitude of potential impacts would be reduced.

Potential impacts on wildlife and special status wildlife species from the presence of workers and equipment would be similar in nature to those described above for construction. However, the magnitude of impacts would be reduced as the numbers of workers and equipment would be less than during the construction phase.

Lighting associated with the operations phase of the proposed project may lead to changes in the interaction between pollinators and some plant species (Bennie et al. 2016). This may lead to decreases in forage resources for some species. Light may attract insects and increase the density of forage for some insectivorous bat species. These impacts would be greatest near light sources and would decrease with distance from the sources.

Artificial lighting associated with the operations phase of the proposed project would increase overall brightness in the night sky by 1 percent to 9 percent; therefore, impacts on wildlife species may occur. However, these impacts are not well understood or researched in current literature since much of the literature focuses on non-LED lights. Additionally, the potential impacts, if realized, would be associated within localized areas around the direct vicinity of the main operations areas, i.e., where the most lights are concentrated to increase overall night-sky brightness. The potential impacts from light would reduce with distance from the light source and could lead to localized changes in migration or dispersal behavior, including species avoiding the lighted area. It is likely that species would be avoiding the lit areas for multiple reasons, such as loss or degradation of habitat and human presence. Specific impacts on species groups are provided in subsequent sections.

For species that use olfactory inputs to trigger part of their life cycle or habitat use, potential impacts from smells associated with operations and maintenance activities could occur under operations for all action alternatives. These potential impacts would be greatest for species that rely heavily on olfactory communication or cues.

General Closure and Reclamation Impacts

Closure and reclamation activities would increase vegetative cover in areas of project-related disturbance to some extent, depending on reclamation success (discussed in more detail in Section 3.3, Soils, Vegetation, and Reclamation). Within reclaimed/revegetated areas there would be a greater potential for an improvement in habitat conditions from the increase in vegetative cover, native vegetative cover, and a reduction in soil erosion potential. While vegetative cover would likely increase, there are constraints that make it unlikely to fully meet desired conditions for the landscape, or for pre-project conditions to be achieved through reclamation/revegetation activities. Wildlife and special status wildlife species habitat in these areas would not return to pre-project conditions.

Additional Impacts Specific to Wildlife Groups

Impacts to specific wildlife species groups, special habitat areas, and wildlife connectivity would include those described above in Impacts Common to All Action Alternatives, as well as those found in Newell (2018j). Additional impacts that are specific to wildlife species groups, special habitat areas, and wildlife connectivity are given below. Further information for ESA-listed species can be found in the Biological Assessment (SWCA Environmental Consultants 2020a) and for other species status species in the Forest Service Biological Evaluation (U.S. Forest Service 2020a).

MAMMALS

Small mammals that shelter underground would be susceptible to being crushed or struck by construction equipment.

Artificial night lighting can increase the risk of predation and decrease food consumption for small, herbivorous, nocturnal mammals. Circadian rhythm and melatonin production in mammals are likely affected by artificial night lighting. Increased artificial night lighting may also increase roadkill and disrupt mammalian dispersal movements and wildlife corridor use (Beier 2006).

Bats

Bat species could experience effects from removal of foraging habitat, wintering habitat, and impacts on roosts and breeding activities by noise and vibration from blasting activities (Siemers and Schaub 2011).

Potential impacts to bat foraging and other habitat would occur where ground disturbance could remove nectar-producing plants and other food sources. In areas where springs and other waters may be impacted by variations in groundwater levels, changes to water bodies and springs could reduce foraging habitat and insect populations that are food sources for some bat species.

Bat species are nocturnal and reliant on echolocation. As such, project-related light and noise could impact bats. Project-related light may attract insects and increase the density of forage for some insectivorous bat species. These impacts would be greatest near light sources and would decrease with distance from the sources. The proposed use of LED lights may affect slower-flying species, like cave myotis (*Myotis velifer*), more than fast-flying species—like Brazilian free-tailed bats (*Tadarida brasiliensis*), California leaf-nosed bat (*Macrotus californicus*), and spotted bat (*Euderma maculatum*) (Stone et al. 2012). The increased artificial lighting at night may result in a lower food intake for some bat species and possibly lower reproductive success for some species of aerial-hawking bats (i.e., prey is pursued and caught in flight). Conversely, there is the potential that increased artificial night lighting may be beneficial to some bat species, for at least some aspects of their natural history (Fenton and Morris 1976). Moth capture rate may increase since the moth’s bat detection system is turned off in light (Frank 2006; Rydell 2006).

Potential impacts on bat species in roosts from noise and vibration may include causing adult bats to leave maternity roosts during daytime hours. This could lead to infant bats being dropped or knocked to the ground, resulting in mortalities as well as impacting their overall fitness due to increased metabolic expenditures. These impacts would be localized and would be greatest near sources of noise and/or vibration and would decrease as distance from the source(s) decreases. The Bomboy Mine is the only known mine, cave, or karst feature within the project footprint and it is within the proposed tailings facility only for Alternatives 2 and 3 (see figure 3.8.3-1).

BIRDS (INCLUDING MIGRATORY SPECIES)

All action alternatives may impact special status bird species. This includes species covered by the MBTA, that provides Federal protection to all migratory birds, including nests and eggs. Under this act, it is unlawful to take, kill, or possess migratory birds.

Potential impacts to birds would be greatest for species and individuals that breed in the project area and reduced for species and individuals that use the project and analysis areas only during migration or as wintering habitat. Additional information on the potential for species occurrence is given in Newell (2018j). Additional impacts to habitats such as springs and riparian areas as well as Important Bird Areas are considered under “Special Habitat Areas” and “Wildlife Connectivity” below.

Potential impacts on birds would include those described above under Impacts Common to All Action Alternatives, as well as those from temporary disturbance related to noise as well as changes to habitat use. Noise and vibration associated with construction activities may temporarily change habitat use patterns for some species. Many bird species rely on meaningful sounds for communication, navigation, finding food, and to avoid danger (Federal Highway Administration 2004). Some individuals likely would move away from the source(s) of the noise/vibration to adjacent or nearby habitats, which may alter or affect competition for resources within these areas. Noise/vibration and other disturbances may also increase stress on individuals, impacting their overall fitness due to increased metabolic expenditures.

Additional noise and vibration impacts to bird species may include decreased immune response, hearing damage, diminished intraspecific communication, increased predation risk, and reduced reproductive success (NoiseQuest 2011; Pater et al. 2009; Sadlowski 2011). These effects would be temporary and of short duration and would diminish with the completion of construction activities. Some species could see impacts on local populations in the analysis area, but no regional population level impacts are likely.

Changes to behavior could include increased alertness, turning toward the disturbance, fleeing the disturbance, changes in activity patterns, and nest abandonment. Raptors could be especially susceptible to noise disturbance early in the breeding season, through nest abandonment and reduction in overall success. These potential impacts would be greatest near sources of disturbance and would decrease with distance from the source. These potential impacts would occur primarily during construction activities and would decrease in frequency and intensity during operations.

Potential impacts from operations and maintenance would be from potential electrocution of birds and from striking electrical distribution lines. While some individuals could be impacted, these impacts would be minor and long term and unlikely to reach population levels. Small and mobile bird species would be anticipated to have a very low potential for collisions. The presence of electrical distribution poles would provide perches (for perching and foraging) as well as nesting habitat for some species and could increase impacts on prey species nearby. Unintentional take from these impacts would not significantly impact local, regional, or overall populations of migratory birds.

The increased amount of edge habitat created by the proposed project would allow for an increase in species potential for nest parasitism and depredation due to increased diversity of species and less nest concealment in the edge habitat (Paton 1994; Winter et al. 2000). Other species that use edge habitats or have more general habitat requirements would benefit from the increased amount of edge habitat. In areas where there is higher vegetation density, the potential impacts from habitat fragmentation and edge effects would be greatest. This would change the species composition near project facilities and impact species that use larger blocks of habitat, as they would be subject to increased predation and potential for nest parasitism. Unintentional take from these impacts would not significantly impact local, regional, or overall populations of migratory birds. These impacts are addressed above in “General Construction Impacts.”

Impacts on migrating birds from artificial light increases at night can range from death or injury from collisions with structures, to reduced energy stores due to delays or altered routes, and delayed arrival at breeding grounds (Gauthreaux Jr. and Belser 2006). Unintentional take from these impacts could occur to individual birds near areas with artificial light but would be unlikely to significantly impact local, regional, or overall populations of migratory birds.

For all impacts on migratory birds from construction, operations, and maintenance activities of each alternative, unintentional take would likely impact individual birds and local migratory bird populations, yet would vary by species due to life history traits and habitat use. Potential population-level impacts would likely be greater for species that breed in the analysis area and less for species that use the area only during migration or as wintering habitat. However, impacts on regional and overall migratory bird populations would likely be negligible. The potential acreages of impacts on migratory bird priority habitats are provided in table 3.8.4-2 later in this section. Additionally, the Boyce Thompson Important Bird Area (see figure 3.8.3-1 and the "Special Habitat Areas" section below) is located within the analysis area and the project footprint of Alternative 5.

FISH

Additional impacts on fish species include mortality from loss or modification of habitat due to changes in surface water levels or flows, including changes due to changes in groundwater elevation and contribution to surface flows. These impacts would occur for all action alternatives and would have the greatest potential to impact fish species along areas of Devil's Canyon and Queen Creek that currently have surface flows. Any impacts would be to non-native fish populations as no native fish are known to occur in sections of Devil's Canyon and Queen Creek that have surface flows. This is not anticipated to impact habitat for longfin dace (*Agosia chrysogaster*) and other species in Mineral Creek (WestLand Resources Inc. 2018a) as no reductions in flows from the proposed project are anticipated.

Artificial light increases at night are not likely to impact fish since lighting is unlikely to increase in the analysis area near their habitats; however, the exact project lighting layout is not yet known. Potential impacts on fish from artificial light could include breakdowns in niche portioning, changes in migratory patterns, temporary blindness, alternations of predator–prey relations, and changes to foraging behavior (Nightingale et al. 2006).

REPTILES

Reptile species that shelter underground would be susceptible to being crushed by construction equipment. Construction-related trash may attract reptile predators such as ravens (*Corvus corax*) and other predators. The presence of the electrical distribution lines and poles could provide perching and nesting habitat for ravens and other species, which may increase raven and other reptile predator numbers along electrical distribution lines. Knowledge of potential negative effects from artificial light on most reptile species, other than sea turtles, is limited and somewhat speculative. Potential impacts include an extended photoperiod, which can also be positive for some species like geckos and possibly the Bezy's night lizard (*Xantusia bezyi*) (Perry and Fisher 2006).

AMPHIBIANS

Amphibian species, including lowland leopard frog (*Lithobates yavapaiensis*), would also be affected by changes to water quality and quantity. These impacts would occur for all action alternatives and would have the greatest potential to impact amphibian species along areas of Devil's Canyon and Queen Creek that currently have perennial surface flows that would be reduced by changes in runoff or groundwater contribution. Artificial light increases at night are not likely to impact amphibians since lighting is unlikely to increase in the analysis area near their habitats; however, the exact project lighting layout is not yet known. Possible impacts could include changes to predator–prey relationships, changes in reproduction, and inter-specific (between different species) competition and intra-specific (between individuals of same species) competition for prey (Buchanan 2006).

INVERTEBRATES

Potential impacts on invertebrates from the proposed project would include those described earlier in this section as "Impacts Common to All Action Alternatives." Aquatic invertebrate species would also be affected by changes to water quality and quantity. These impacts would occur for all action alternatives and would have the greatest potential to impact aquatic invertebrate species along areas of Devil's Canyon and Queen Creek that currently have surface flows. Invertebrates that use vibrational communication systems would also be affected by increases in ground-borne vibrations through substrates and soils. These impacts would occur for all action alternatives near any blasting and heavy machinery operations. Artificial light at night may lead to changes in the interaction between pollinators and some plant species, such as cacti (Bennie et al. 2016). This may lead to decreases in forage resources for some species in all groups. In addition, artificial light may increase moth (Order Lepidoptera) predation by bats and birds (Frank 2006).

Special Habitat Areas

The proposed project could impact special habitat areas, including wildlife waters; Important Bird Areas; caves, mines, and karst features; riparian areas; and springs. These areas are ecologically important habitats for many species that use the analysis area.

Of the 15 wildlife waters within 5 miles of the project area, three would be within the project footprint of the different alternatives. These wildlife waters are Benson Spring, which would be within the footprint of the tailings facility for Alternatives 2 and 3; Silver King, which would be within the tailings facility area for Alternative 4; and Superior #1 wildlife water, within the analysis area of Alternative 5. Loss of these three wildlife waters may require species in the area to travel farther to find water, thus impacting their overall fitness due to increased metabolic expenditures.

The Boyce Thompson Arboretum/Arnett-Queen Creeks Important Bird Area is located within 5 miles of the action alternatives but is only within the footprint of the pipeline corridor associated with Alternative 5 (see figure 3.8.3-1). Potential impacts would include ground disturbance as well as habitat modification and loss within the pipeline corridor. As the area to be disturbed would be a small portion of the Important Bird Area, it would not significantly contribute to a measurable decline in bird populations associated with the Important Bird Area.

The Bomboy Mine is the only cave, mine, or karst feature located within the project footprint, i.e., the proposed tailings facility for Alternatives 2 and 3 (see figure 3.8.3-1). Some of these features were closed and bat gates were installed to allow bats use of the features. Impacts to the Bomboy Mine could impact bat species. These potential impacts are addressed above under "Additional Impacts Specific to Wildlife Groups."

There are 24 springs mapped that could potentially be impacted by the proposed project (see table 3.7.1-2 and figure 3.8.3-1). For those springs that would potentially be impacted by groundwater drawdown or direct disturbance (see table 3.7.1-3 and figure 3.7.1-9), flow could be greatly reduced or lost entirely. Surface water amounts would be reduced, and timing/persistence of surface water would decrease. These potential decreases in groundwater and surface water would occur over a long period of time but could cause changes in spring size and timing/persistence. Potential impacts may reduce or remove available habitat for wildlife and special status wildlife species and impact individuals in localized areas around springs. A reduction in spring habitats may require species in the area to travel farther to find water, thus impacting their overall fitness due to increased metabolic expenditures. Potential impacts to riparian habitats (see table 3.3.4-3) and species that use them) would be similar to those described for springs.

Note that mitigation implementation would replace water for springs or streams impacted by dewatering, potentially alleviating some of the impacts described above. However, analysis of this mitigation (see “Mitigation Effectiveness” in section 3.7.1) recognizes that the natural characteristic of these waters would be compromised, even if the water is replaced.

Wildlife Connectivity

Impacts on animal movement corridors from any of the action alternatives would include direct effects due to a long-term loss of movement habitat, and a reduction in landscape and habitat connectivity in landscape, diffuse, and riparian/wash wildlife movement areas from construction and mining activities and/or the construction of project facilities within those movement areas (see figures 3.8.3-2 and 3.8.3-3). There would be a loss of long-term movement habitat along pipeline corridors since vegetation would be expected to eventually reestablish in the disturbed areas but would be unlikely to return to pre-construction conditions.

Additional potential effects would include changes in wildlife movement due to habitat fragmentation; changes to predator–prey relationships; and changes to gene flow and a potential reduction in biodiversity from habitat loss and creation of barriers to movement.

Project activities could potentially change predator–prey interactions and would increase the degree of habitat fragmentation within the species’ ranges, which in turn can disrupt localized and long-distance dispersal and migration events. In addition, increased human presence in the region from mining activities would lead to temporary disturbances of individual species, affecting movement patterns.

Furthermore, potential indirect impacts on gene flow and reduction in biodiversity could occur from any of the action alternatives due to the loss of habitat and creation of barriers to movement from project facilities and activities in the project area. However, these impacts would be temporary and insignificant since these biological processes related to biodiversity occur over multi-generational time periods, which are typically longer for most species than the proposed life of the mine (Brown Jr. and Gibson 1983; Slatkin 1987). Other measures, including habitat disturbance and impacts to habitat blocks, are presented to provide a potential measure of expected impacts and to provide information to allow for a decision between alternatives. Potential impacts to biodiversity would likely be limited to impacts at the local level for most species and would not be significant at the population level. Some of these alternatives would result in minor impacts, with others resulting in major impacts. Potential impacts on habitat blocks within the project footprint are given in table 3.8.4-1 and are broken out by alternative and project component to provide a quantitative review of potential barriers to wildlife connectivity that could impact biodiversity and wildlife connectivity.

Activities on compensatory mitigation parcels would improve wildlife connectivity by protecting habitat blocks.

Table 3.8.4-1. Acres of habitat blocks potentially affected for all action alternatives

Alternative	Alternative Component	Habitat Block 1 Acres Affected	Habitat Block 2 Acres Affected
2	East Plant Site/Subsidence areas	–	1,226
2	Near West fence line	–	487
2	Tailings facility	–	789

Alternative	Alternative Component	Habitat Block 1 Acres Affected	Habitat Block 2 Acres Affected
2	Near West tailings corridor	–	56
2	West Plant Site	–	20
3	East Plant Site/Subsidence areas	–	1,226
3	Fence and tailings storage facility	–	1,275
3	Near West fence line	–	457
3	Tailings facility	–	819
3	Near West tailings corridor	–	56
3	West Plant Site	–	20
4	East Plant Site/Subsidence areas	–	1,226
4	Silver King tailings corridor	–	24
4	Silver King fence line	–	2,880
4	Tailings facility	–	1,849
4	West Plant Site	–	20
5	Peg Leg tailings corridor	–	118
5	East Plant Site/Subsidence areas	–	1,226
5	Peg Leg fence line	–	2,843
5	Tailings facility	–	3,264
5	West Plant Site	–	20
6	Access roads	--	1
6	Skunk Camp tailings corridor	--	692
6	Skunk Camp transmission line corridor	--	320
6	Skunk Camp fence line	--	5,397
6	East Plant Site/Subsidence areas	–	1,226
6	Tailings facility	–	3,757
6	West Plant Site	–	20

Source: Morey (2018a)

Potential Wildlife Exposure to Water Ponds

The project design includes numerous water features that could potentially expose wildlife, notably birds, to process water. These potential exposure points include stormwater ponds, the tailings storage facility recycle pond, the tailings storage facility seepage collection ponds, and process ponds at the West Plant Site.

STORMWATER PONDS

Stormwater controls for the mine facilities are described in detail in section 3.7.2, and are designed to detain all water that contacts ore, tailings, ore processing areas. During operations, contact water would be captured, contained in basins, pumped out after storm events, and recycled back into the process water stream. This type of containment would be required by both the stormwater and aquifer protection permits that would be issued for the project. While there are stormwater retention areas that would temporarily provide wildlife exposure points, these would be transitory in nature and would only exist until stormwater is pumped back into the process circuit. The applicant-committed environmental protection measures include hazing protocols to deter birds and wildlife from accessing these areas.

Section 3.7.2 also analyzes in detail the potential for contact stormwater to be released to the environment during low-probability events (i.e., the 300-year storm or greater), using the Alternative 6 – Skunk Camp (Preferred Alternative) as an example. This scenario would result in stormwater having contacted the tailings embankment being released over the spillway of the seepage collection pond. Estimates of water quality in this event indicate that the concentrations of some constituents may be higher than Arizona surface water quality standards for wildlife, depending on the hydrologic conditions being analyzed, indicating that some impact to wildlife potentially could occur. This potential for wildlife impacts would persist for a limited distance downstream. By the time runoff reaches 5 to 6 miles downstream, concentrations would be less than standards due to other watershed runoff.

Overall, the stormwater release scenario does represent a potential exposure point for wildlife. However, the impact to wildlife is limited by

- the low probability of these releases occurring. There is a 13 percent probability of the 300-year event occurring during the operational life of the mine;
- the limited duration of the exposure. These storm events are most likely related to winter frontal storms or tropical storms, and the events themselves could last for several days. In all cases the downstream channels below the tailings storage facilities are ephemeral alluvial channels and stormwater would not be anticipated to persist for long after the storm event ends; and
- the point of exposure being solely along the ephemeral channel, and would be over only a limited distance and area downstream.

TAILINGS STORAGE FACILITY RECYCLE POND (ALTERNATIVES 2, 3, 5, AND 6)

With the exception of Alternative 4, all tailings storage facilities have some manner of recycled water pond on the surface of the facility. These ponds serve as a water cap for the PAG tailings to prevent exposure to oxygen, and also serve as a collection point from which water is recycled back into the process stream.

The recycled water ponds represent relatively large areas with persistent water, which is an attractant to wildlife. Given the industrial nature of an active tailings storage facility, including the inaccessibility of the ponds on the top of the facility, this potential exposure is likely limited solely to birds.

Table 3.7.2-9 contains several estimates of water quality that would be roughly representative of water in the recycled water pond, due to exposure of process water to NPAG or PAG tailings. These ponds would likely have some constituents with concentrations above Arizona surface water quality standards for wildlife, indicating that some impact to wildlife could potentially occur. The applicant-committed environmental protection measures include hazing protocols to deter birds and wildlife from accessing these areas.

Overall, there is some risk to wildlife from exposure to the tailings recycle ponds, but that risk is mitigated during operations by active deterrents. After closure, the tailings recycle ponds cease to exist.

TAILINGS STORAGE FACILITY SEEPAGE COLLECTION PONDS

Downstream from the toe of each tailings storage facility are seepage collection ponds, though these differ in design and function between alternatives. During operations, these seepage collection ponds are meant as a temporary holding location for seepage, which is actively pumped back into the tailings water recycle pond. As with the stormwater ponds, the applicant-committed environmental protection measures include hazing protocols to deter birds and wildlife from accessing these areas.

After closure, the downstream seepage collection ponds would persist for many years or decades while draindown of entrained tailings water occurs. Because the tailings water recycle ponds cease to exist after closure, the seepage collected downstream must either be actively treated and released, or contained. The ponds are designed to have sufficient surface area after closure to allow evaporation of seepage and stormwater, but over time water quality would be anticipated to worsen and would be anticipated to be dangerous to wildlife. The applicant-committed environmental protection measures include hazing protocols to deter birds and wildlife from accessing these areas in order to protect wildlife from the seepage collection ponds.

PROCESS PONDS AT WEST PLANT SITE

Uncovered process ponds at the West Plant Site also would represent potential exposure to poor water quality for wildlife species, primarily birds. This exposure would be limited to operations. The applicant-committed environmental protection measures include hazing protocols to deter birds and wildlife from accessing these areas.

POTENTIAL TAILINGS FAILURE

Section 3.10.1 assesses the design of the tailings storage facility, whether it meets state, Federal, and industry-standard design criteria, the probability of a tailings storage facility failure, and the downstream consequences if one were to occur. These downstream consequences include potential exposure of poor-quality water to wildlife. The impacts described—if such a failure were to occur—include direct removal or burying of habitat, destruction of riparian and aquatic habitat, immediate impact to aquatic species related to concentrations of contaminants greater than acute surface water quality standards for wildlife, and longer persistent effects of contamination from tailings exposure.

While these impacts were disclosed in section 3.10.1, this is a low-probability, high-consequence event. The risk of embankment failure for all alternatives would be minimized by required adherence to Federal and State of Arizona design standards and by applicant-committed environmental protection measures.

Differences Between Alternatives 2 through 6

Potential impacts on wildlife species from the action alternatives would generally be as described earlier in this section. Table 3.8.4-2 presents special status wildlife species that potentially occur within the analysis area of each action alternative. These impacts are discussed more in the next section, "Impacts on Special Status Wildlife Species."

Table 3.8.4-3 provides the MIS species trends for vegetation types, total acres of vegetation types on Tonto National Forest, and acres of vegetation types associated within the footprint of each action alternative. These acres were derived using the vegetation types and the project footprint.

The incremental increase in impacts to MIS vegetation types from implementation of all action alternatives would not be expected to result in detectable population-level impacts to MIS or alter the existing forest-wide trends for MIS. The largest percent reduction in MIS vegetation types would be 2.4 percent change in the semidesert grassland community under Alternative 6 (see table 3.8.4-3). Areas outside the project area but within the action area would be expected to experience indirect effects on habitat that are described in "Impacts Common to All Action Alternatives," above.

Table 3.8.4-2. Acres of modeled habitat within the analysis area for special status wildlife species that potentially would be impacted under each action alternative

Common Name (*Scientific Name*)	Status	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Amphibians						
Lowland leopard frog (*Lithobates yavapaiensis*)	TNF: S AGFD: SGCN 1A	49,599	49,599	51,668	87,776	72,529
Birds						
Western burrowing owl (*Athene cunicularia hypugaea*)	BLM: S AGFD: SGCN 1B MBTA: Yes	27,432	27,432	27,119	27,153	27,119
Golden eagle (*Aquila chrysaetos*)	TNF: MBSC AGFD: SGCN 1B MBTA: Yes BGEPA: Yes	54,258	54,258	56,297	86,609	77,158
Juniper titmouse (*Baeolophus ridgwayi*)	TNF: MBSC AGFD: SGCN 1C MBTA: Yes	25,679	25,679	34,369	30,204	95,850
Ferruginous hawk (*Buteo regalis*)	BLM: S AGFD: SGCN 1B MBTA: Yes	13,022	13,022	16,374	12,874	28,000
Swainson's hawk (*Buteo swainsoni*)	TNF: MBSC AGFD: SGCN 1C MBTA: Yes	4,935	4,935	8,285	4,785	20,009
Common black hawk (*Buteogallus anthracinus*)	TNF: MBSC AGFD: SGCN 1C MBTA: Yes	24,193	24,193	21,357	24,063	27,231
Costa's hummingbird (*Calypte costae*)	TNF: MBSC AGFD: SGCN 1C MBTA: Yes	72,740	72,740	74,779	110,888	95,769
Northern beardless-tyrannulet (*Camptostoma imberbe*)*	TNF: MBSC AGFD: N/A MBTA: Yes	73,0244	73,024	75,065	111,202	95,943
Western yellow-billed cuckoo (Distinct Population Segment) (*Coccyzus americanus*)	ESA: T (All Arizona counties) TNF: MBSC AGFD: SGCN 1A MBTA: Yes	9,492	9,492	9,492	17,415	11,846

Common Name (*Scientific Name*)	Status	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Gilded flicker (*Colaptes chrysoides*)	TNF: MBSC AGFD: SGCN 1B MBTA: Yes BLM: S	67,159	67,159	68,637	105,306	86,363
Olive-sided flycatcher (*Contopus cooperi*)*	TNF: MBSC AGFD: SGCN 1C MBTA: Yes	73,0244	73,024	75,065	111,202	95,943
Broad-billed hummingbird (*Cynanthus latirostris*)	AGFD: SGCN 1B MBTA: Yes BLM: S	63,257	63,257	65,296	101,405	86,157
Cordilleran flycatcher (*Empidonax occidentalis*)	TNF: MBSC AGFD: SGCN 1C MBTA: Yes	0	0	0	0	21,629
Southwestern willow flycatcher (*Empidonax traillii extimus*)	ESA: E (All AZ counties except Navajo) AGFD: SGCN 1A MBTA: Yes BLM: S	15,369	15,369	15,927	33,560	41,818
Gray flycatcher (*Empidonax wrightii*)	TNF: MBSC AGFD: SGCN 1C MBTA: Yes	17,661	17,661	16,782	31,128	26,026
Prairie falcon (*Falco mexicanus*)	TNF: MBSC AGFD: SGCN 1C MBTA: Yes	73,024	73,024	75,065	111,202	95,943
American peregrine falcon (*Falco peregrinus anatum*)	TNF: S, MBSC AGFD: SGCN 1A MBTA: Yes	72,967	72,967	75,006	111,115	95,867
MacGillivray's warbler (*Geothlypis tolmiei*)*	TNF: MBSC AGFD: SGCN 1B MBTA: Yes	72,967	72,967	75,004	111,115	95,867
Pinyon jay (*Gymnorhinus cyanocephalus*)*	TNF: MBSC AGFD: SGCN 1B MBTA: Yes	455	455	514	455	798
Bald eagle (*Haliaeetus leucocephalus*)	TNF: MBSC AGFD: SGCN 1A MBTA: Yes BGEPA: Yes	64,751	64,751	65,557	74,618	86,474

Common Name (*Scientific Name*)	**Status**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 6**
Lewis's woodpecker (*Melanerpes lewis*)*	TNF: MBSC AGFD: SGCN 1C MBTA: Yes	72,967	72,967	75,004	111,115	95,867
Gila woodpecker (*Melanerpes uropygialis*)	TNF: MBSC AGFD: SGCN 1B MBTA: Yes	70,743	70,743	12,782	108,890	93,643
Canyon towhee (*Melozone fusca*)	TNF: MBSC MBTA: Yes	73,024	73,024	75,065	111,202	95,943
Elf owl (*Micrathene whitneyi*)	TNF: MBSC AGFD: SGCN 1C MBTA: Yes	70,005	70,005	71,144	107,252	92,080
Lucy's warbler (*Oreothlypis luciae*)	TNF: MBSC AGFD: SGCN 1C MBTA: Yes	72,947	72,947	75,005	111,115	95,867
Phainopepla (*Phainopepla nitens*)*	TNF: MBSC AGFD: SGCN 1C MBTA: Yes	72,947	72,947	75,005	111,115	95,867
Desert purple martin (*Progne subis hesperia*)	TNF: MBSC AGFD: SGCN 1B MBTA: Yes	72,967	72,967	75,006	111,115	95,867
Black-throated gray warbler (*Setophaga nigrescens*)	TNF: MBSC AGFD: SGCN 1C MBTA: Yes	73,024	73,024	75,065	111,202	95,943
Yellow warbler (*Setophaga petechia*)	TNF: MBSC AGFD: SGCN 1B MBTA: Yes	57,685	57,685	58,481	65,430	60,300
Red-naped sapsucker (*Sphyrapicus nuchalis*)	TNF: MBSC AGFD: SGCN 1C MBTA: Yes	22,682	22,682	29,890	31,123	51,833
Black-chinned sparrow (*Spizella atrogularis*)	TNF: MBSC AGFD: SGCN 1C MBTA: Yes	25,679	25,679	34,369	30,204	54,659
Bendire's thrasher (*Toxostoma bendirei*)*	TNF: MBSC AGFD: SGCN 1C MBTA: Yes	72,967	72,967	75,008	111,115	95,867
Arizona Bell's vireo (*Vireo bellii arizonae*)	TNF: MBSC AGFD: SGCN 1B MBTA: Yes	64,627	64,627	66,666	100,550	87,527

Common Name (*Scientific Name*)	Status	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Gray vireo (*Vireo vicinior*)	TNF: MBSC AGFD: SGCN 1C MBTA: Yes	27,903	27,903	34,819	30,204	54,659
Fish						
Gila longfin dace (*Agosia chrysogaster*)	AGFD: SGCN 1B	12,021	12,021	12,021	21,296	18,703
Gila chub (*Gila intermedia*)	ESA: E (Cochise, Coconino, Gila, Graham, Greenlee, Pima, Pinal, Santa Cruz, and Yavapai Counties) BLM: S AGFD: SGCN 1A	191	191	191	170	431
Insects						
Monarch butterfly (*Danaus plexippus* pop. 1)*	TNF: OSI BLM: S	73,024	73,024	75,065	111,202	95,943
Mammals						
Pale Townsend's big-eared bat (*Corynorhinus townsendii pallescens*)	TNF: S AGFD: SGCN 1B	72,967	72,967	75,008	111,115	95,867
Spotted bat (*Euderma maculatum*)	TNF: S AGFD: SGCN 1B	72,967	72,967	75,008	111,115	95,867
Greater western mastiff bat (*Eumops perotis californicus*)	BLM: S AGFD: SGCN 1B	72,967	72,967	75,008	111,115	95,867
Western red bat (*Lasiurus blossevillii*)	TNF: S AGFD: SGCN 1B	41,856	41,856	44,425	49,745	48,330
Lesser long-nosed bat (*Leptonycteris curasoae yerbabuenae*)	BLM: S AGFD: SGCN 1A	72,967	72,967	75,008	111,115	80,123
California leaf-nosed bat (*Macrotus californicus*)	AGFD: SGCN 1B	72,667	72,667	74,145	110,815	96,036
Cave myotis (*Myotis velifer*)	BLM: S AGFD: SGCN 1B	72,967	72,967	75,008	111,115	95,867
Brazilian free-tailed bat (*Tadarida brasiliensis*)†	SGCN 1B	72,967	72,967	75,008	111,115	95,867

Common Name (*Scientific Name*)	Status	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Reptiles						
Sonoran Desert tortoise (*Gopherus morafkai*)	TNF: S AGFD: SGCN 1A BLM: S	71,308	71,308	43,346	109,455	94,381
Bezy's night lizard (*Xantusia bezyi*)	TNF: S AGFD: SGCN 1B	33,673	33,673	38,134	44,978	59,069

Source: Based on electronic data received from AGFD; see Newell (2018j)

Status Definitions

Tonto National Forest (TNF):

S = Sensitive. Species identified by a Regional Forester for which population viability is a concern, as evidenced by: a) significant current or predicted downward trends in population number or density; b) significant current or predicted downward trends in habitat capability that would reduce a species' existing distribution.

OSI = Other Species of Interest. A plant or animal that was included in the analysis for which there are concerns about potential impacts in the region.

MBSC = Migratory Bird Species of Concern

Endangered Species Act (ESA):

E = Endangered. Endangered species are those in imminent jeopardy of extinction. The ESA specifically prohibits the take of a species listed as endangered. Take is defined by the ESA as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to engage in any such conduct.

T = Threatened. Threatened species are those that are likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

Arizona Game and Fish Department (AGFD):

SGCN 1A = Species of Greatest Conservation Need Tier 1A; Species for which the AGFD has entered into an agreement or has legal or other contractual obligations or warrants the protection of a closed season.

SGCN 1B = Species of Greatest Conservation Need Tier 1B; Vulnerable species.

SGCN 1C = Species of Greatest Conservation Need Tier 1C; Species for which insufficient information is available to fully assess the vulnerabilities and therefore need to be watched for signs of stress.

Bureau of Land Management (BLM):

S = Sensitive. Species that could easily become endangered or extinct in the state.

* AGFD was unable to provide GIS habitat data for this species so analysis was conducted based on available data about species' habitat requirements.

† Not all SGCN-listed species are addressed as part of this analysis; however, this species was added to the analysis at the request of the AGFD, a cooperating agency.

Table 3.8.4-3. Tonto National Forest vegetation type, trends, and acreages for management indicator species

Vegetation Type	Acres on Tonto National Forest	1985–2005 Vegetation Trend	Alternative 2 acres (% change)	Alternative 3 acres (% change)	Alternative 4 acres (% change)	Alternative 5 acres (% change)	Alternative 6 acres (% change)
Ponderosa pine/ Mixed conifer	283,204	Static	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Pinyon/Juniper (woodland)	1,155,722	Static	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Interior chaparral	265,480	Static	1,237.3 (0.5)	1,237.3 (0.5)	1,364.0 (0.5)	1,242.4 (0.5)	1,848.0 (0.7)
Desert grassland	316,894	Upward/ Static	92.1 (0.03)	92.1 (0.03)	1.410.4 (0.4)	108.6 (0.03)	7,329.4 (2.3)
Desert communities	774,220	Downward/ Static	7,827.5 (1.0)	7,827.5 (1.0)	6,954.0 (0.8)	14,740.3 (1.9)	4,120.5 (0.5)
Riparian (low elevation)	31,147	No change	57.9 (0.2)	57.9 (0.1)	84.7 (0.3)	82.6 (0.3)	43.6 (0.1)
Riparian (more than 3,500 feet elevation)	10,232	No change	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Aquatic	29,000	Not applicable*	14.7 (0.05)	14.7 (0.05)	14.7 (0.05)	14.7 (0.05)	14.7 (0.05)

Source: Data used for these calculations were a crosswalk between the Forest Service Potential Natural Vegetation metadata and the SWReGAP vegetation metadata.

* Vegetation trend not applicable, but see also analysis of aquatic trends in Devil's Canyon (Garrett 2019f), which indicates static trends in Devil's Canyon between roughly 2003 and 2017.

Impacts on Special Status Wildlife Species

ENDANGERED SPECIES ACT–LISTED WILDLIFE SPECIES

Yellow-billed Cuckoo (*Coccyzus americanus*)

The yellow-billed cuckoo, listed as threatened with designated critical habitat for the western distinct population segment, has the potential to occur within the analysis area for all action alternatives along Devil's Canyon and Mineral Creek north of the existing Ray Mine. The species may also occur where the Alternative 5 pipeline route would cross the Gila River. Proposed critical habitat for yellow-billed cuckoo is present at the proposed pipeline corridor crossing of the Gila River in the project footprint and at Mineral Creek for Alternative 6 (figure 3.8.4-1).

Potential impacts on the species include a loss or modification of habitat under all action alternatives along Devil's Canyon and Mineral Creek (downstream of Devil's Canyon) north of the existing Ray Mine. These potential impacts include changes to riparian habitat from reduced surface flows due to the upstream watershed decreasing in size as well as potential reductions in inputs of groundwater from project-related pumping. Potential habitat changes include loss of riparian habitat and a conversion of habitat to a drier, xeroriparian habitat. This could cause habitat to become unsuitable for nesting by the species.

Under Alternative 5, habitat for the yellow-billed cuckoo and proposed critical habitat would be removed as needed where the proposed pipeline routes would cross the Gila River. Potential impacts on habitat and proposed critical habitat would occur on up to 17.9 acres of the 2,232.1 acres of proposed critical habitat within the analysis area. Under Alternative 6, the proposed pipeline and transmission line corridor would cross critical habitat at Mineral Creek. However, the transmission line would span critical habitat with no towers, ground disturbance, or new roads. The pipeline would be constructed by using a trenchless crossing underneath critical habitat at Mineral Creek to avoid ground disturbance in critical habitat. Thus, there would be no ground disturbance in habitat for the species under Alternative 6.

The physical or biological features essential to the conservation of the species include the following (U.S. Fish and Wildlife Service 2020b):

- riparian woodlands, mesquite woodlands (mesquite-thorn-forest), and Madrean evergreen woodland drainages;
- prey base consisting of large insect fauna (for example, cicadas, caterpillars, katydids, grasshoppers, large beetles, dragonflies, moth larvae, spiders), lizards, and frogs for adults and young in breeding areas during the nesting season and in post-breeding dispersal areas; and
- hydrologic processes, in natural or altered systems, that provide for maintaining and regenerating breeding habitat.

The proposed removal of vegetation and impacts from workers and equipment being present could lead to avoidance of the disturbed area and vicinity by the species. In addition, potential impacts on proposed critical habitat include removal of riparian woodlands, including potentially suitable nesting, foraging, and dispersal habitat and a corresponding localized reduction in the prey base for the species.

A detailed analysis of potential impacts on yellow-billed cuckoo and proposed critical habitat from the preferred alternative is included in the Biological Assessment (SWCA Environmental Consultants 2020a) and was also conducted through consultation with the FWS. The resulting Biological Opinion found that the project may affect, but is not likely to adversely affect the yellow-billed cuckoo or yellow-billed cuckoo designated critical habitat (U.S. Fish and Wildlife Service 2020b).

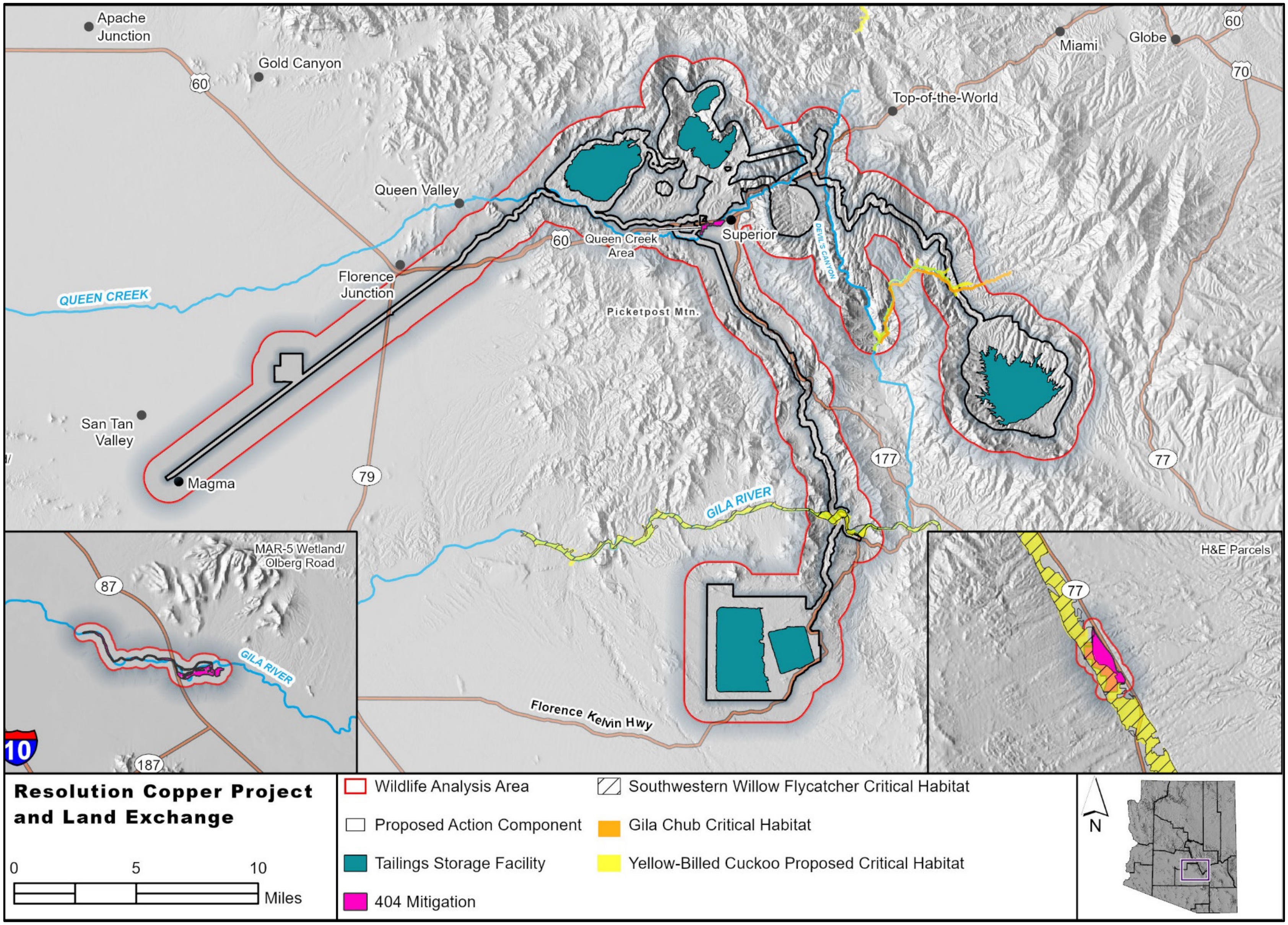


Figure 3.8.4-1. Critical habitats

Southwestern Willow Flycatcher (*Empidonax traillii extimus*)

The southwestern willow flycatcher is listed as endangered with designated critical habitat and has the potential to occur within the analysis area where the Alternative 5 pipeline would cross the Gila River. Designated critical habitat for the species is present at the proposed pipeline corridor crossing of the Gila River in the project footprint (see figure 3.8.4-1).

Under Alternative 5, habitat for the southwestern willow flycatcher and designated critical habitat would be removed where the proposed pipeline route would cross the Gila River. Potential impacts on habitat and proposed critical habitat would occur on up to 12.8 acres of the 2,234.0 acres of designated critical habitat within the analysis area. The primary constituent elements (PCEs) for southwestern willow flycatcher critical habitat include the following (U.S. Fish and Wildlife Service 2013):

- Primary Constituent Element 1—Riparian vegetation. Riparian habitat along a dynamic river or lakeside, in a natural or manmade successional environment (for nesting, foraging, migration, dispersal, and shelter) that comprises trees and shrubs and some combination of:
  - Dense riparian vegetation with thickets of trees and shrubs that can range in height from about 2 to 30 m (about 6–98 feet). Lower stature thickets (2–4 m or 6–13 feet tall) are found at higher elevation riparian forests, and tall-stature thickets are found at middle- and lower elevation riparian forests; and/or
  - Areas of dense riparian foliage at least from ground level up to approximately 4 m (13 feet) aboveground or dense foliage only at the shrub or tree level as a low, dense canopy; and/or
  - Sites for nesting that contain a dense (about 50–100 percent) tree or shrub (or both) canopy; and/or
  - Dense patches of riparian forests that are interspersed with small openings of open water or marsh or areas with shorter and sparser vegetation that creates a variety of habitat that is not uniformly dense. Patch size may be as small as 0.1 hectare (0.25 acre) or as large as 70 hectares (175 acres).
- Primary Constituent Element 2—Insect prey populations. A variety of insect prey populations found within or adjacent to riparian floodplains or moist environments, which can include flying ants, wasps, and bees (Hymenoptera); dragonflies (Odonata); flies (Diptera); true bugs (Hemiptera); beetles (Coleoptera); butterflies, moths, and caterpillars (Lepidoptera); and spittlebugs (Homoptera).

The proposed removal of vegetation and impacts from workers and equipment being present could lead to avoidance of the disturbed area and vicinity by the species. In addition, potential impacts on critical habitat could include removal of riparian vegetation, including potentially suitable nesting, foraging, and dispersal habitats and a corresponding localized reduction in insect prey populations used by the species.

A detailed analysis of potential impacts on southwestern willow flycatcher and critical habitat from the preferred alternative is included in the Biological Assessment (SWCA Environmental Consultants 2020a) and was also conducted through consultation with the FWS. The resulting Biological Opinion concurred that the project may affect, but is not likely to adversely affect the southwestern willow flycatcher or southwestern willow flycatcher critical habitat (U.S. Fish and Wildlife Service 2020b).

Gila Chub (*Gila intermedia*)

Designated critical habitat for the Gila chub is found along Mineral Creek above the confluence with Devil's Canyon. The PCEs for Gila chub critical habitat include the following (U.S. Fish and Wildlife Service 2005):

- Perennial pools, areas of higher velocity between pool areas, and areas of shallow water among plants or eddies all found in small segments of headwaters, springs, or cienegas of smaller tributaries.
- Water temperatures for spawning ranging from 20 degrees Celsius (°C) to 26.5°C with sufficient dissolved oxygen, nutrients, and any other water-related characteristics needed.
- Water quality with reduced levels of contaminants or any other water quality characteristics, including excessive levels of sediments, adverse to Gila chub health.
- Food base consisting of invertebrates, filamentous (threadlike) algae, and insects.
- Sufficient cover consisting of downed logs in the water channel, submerged aquatic vegetation, submerged large tree root wads, undercut banks with sufficient overhanging vegetation, large rocks and boulders with overhangs.
- Habitat devoid of nonnative aquatic species detrimental to Gila chub or habitat in which detrimental nonnatives are kept at a level which allows Gila chub to continue to survive and reproduce. For example, the Muleshoe Preserve Gila chub and the Sabino Canyon Gila chub populations are devoid of nonnative aquatic species. The O'Donnell Canyon Gila chub population has continued to survive and reproduce despite the current level of nonnative aquatic species present.
- Streams that maintain a natural unregulated flow pattern, including periodic natural flooding. An example is Sabino Canyon that has experienced major floods. If flows are modified, then the stream should retain a natural flow pattern that demonstrates an ability to support Gila chub.
- 300-foot riparian zone adjacent to each side of the stream.

The AGFD surveyed this area and found Gila chub in Mineral Creek in 2000; however, additional surveys in 2002, 2006, 2007, 2009, and 2013 found no Gila chub. Therefore, AGFD assumed the creek to be fishless in 2007 (Robinson 2007; Robinson et al. 2010). Additionally, WestLand Resources surveyed Mineral Creek in 2017 but did not find any Gila chub (WestLand Resources Inc. 2018a). However, surveys did not cover the entire reach of the creek. Thus, it is possible that the species is present in Mineral Creek, and the analysis assumes that it is present. The species could be affected by potential impacts on surface and groundwater that could reduce perennial pools. However, groundwater modeling for the action alternatives does not indicate that impacts from groundwater drawdown would significantly impact Mineral Creek in the area of designated critical habitat.

Potential impacts on Gila chub would include habitat modification and potential changes to water quality. The transmission line will span the habitat along Mineral Creek under Alternative 6 with no disturbance within the ordinary high-water mark or within designated critical habitat. The pipeline will avoid disturbance within the ordinary high-water mark or within designated critical habitat by using a trenchless crossing under Mineral Creek for Alternative 6.

Potential impacts on designated critical habitat include reduction of perennial pools. However, groundwater modeling for the action alternatives does not indicate that impacts from groundwater drawdown would significantly impact Mineral Creek in the area of designated critical habitat.

A detailed analysis of potential impacts on Gila chub and designated critical habitat from the preferred alternative is included in the Biological Assessment (SWCA Environmental Consultants 2020a) and was also conducted through consultation with the FWS. The resulting Biological Opinion concurred that the project may affect, but is not likely to adversely affect the Gila chub or Gila chub critical habitat (U.S. Fish and Wildlife Service 2020b).

Northern Mexican Gartersnake (*Thamnophis eques megalops*)

The northern Mexican gartersnake is listed as Threatened, with proposed critical habitat. The only place in the analysis area where the species may occur is at the H&E Farm compensatory mitigation parcel, where a conservation easement would be placed. The analysis area does not include proposed critical habitat for the species.

The establishment of a conservation easement and contribution of funds would provide beneficial effects on the northern Mexican gartersnake by having a portion of suitable habitat for the species and its native prey preserved in perpetuity. Mitigation activities would be split into three areas each with specific planned mitigation activities. Earthwork is planned in upland areas of the parcel, planting and reseeding is planned for areas along the channel, and no restoration activities are planned for riparian areas (see chapter 2 for details). Work would not occur during flycatcher and cuckoo breeding seasons (May 1–September 30).

Proposed earthwork at the H&E parcels would be limited to highly disturbed, upland areas away from the current San Pedro River channel. This species would be unlikely to use such areas for hunting, basking, dispersal, or hibernation. Thus, individual gartersnakes would not be expected to be injured or killed as a result of restoration activities at the H&E parcels. Any northern Mexican gartersnake that occurs within the H&E parcels or surrounding action area during restoration activities could experience minor behavior changes from increased noise, disturbance, or human presence resulting from restoration activities (earthwork in upland areas, planting and reseeding elsewhere). Individual snakes would be expected to move away from restoration activities toward adjacent areas of suitable habitat temporarily until project activities ceased.

A detailed analysis of potential impacts on northern Mexican gartersnake from the preferred alternative is included in the Biological Assessment (SWCA Environmental Consultants 2020a) and was also conducted through consultation with the FWS. The resulting Biological Opinion concurred that the project may affect, but is not likely to adversely affect the northern Mexican gartersnake (U.S. Fish and Wildlife Service 2020b).

TONTO NATIONAL FOREST SENSITIVE WILDLIFE SPECIES

Potential impacts on Tonto National Forest Sensitive wildlife species would be as described earlier in this section in "Impacts Common to All Action Alternatives." The acres of potential impacts on modeled habitat for these species is given in table 3.8.4-2. The project-related disturbance would decrease available habitat for these species. However, given that the proposed project would impact a small portion of the overall habitat in the project vicinity for these species under all action alternatives, the proposed project may adversely impact individuals, but is not likely to result in a loss of viability in the analysis area or cause a trend toward federal listing of these species as threatened or endangered. Additional details regarding likelihood of occurrence and potential impacts for specific species are included in Newell (2018j) and the Forest Service Biological Evaluation (U.S. Forest Service 2020a).

BLM SENSITIVE SPECIES

Potential impacts on BLM Sensitive Species would be as described earlier in this section in "Impacts Common to All Action Alternatives." The acres of potential impacts on modeled habitat for these species is given in table 3.8.4-2. The project-related disturbance would decrease available habitat for these species. However, given that the proposed project would impact a small portion of the overall habitat in the project vicinity for these species under all action alternatives, the proposed project may adversely impact individuals, but is not likely to result in a loss of viability in the analysis area or cause a trend toward federal listing of these species as threatened or endangered. Additional detail regarding specific species impacts is included in Newell (2018j) and the Forest Service Biological Evaluation (U.S. Forest Service 2020a).

3.8.4.3 Cumulative Effects

Full details of the cumulative effects analysis can be found in chapter 4. The following represents a summary of the cumulative impacts resulting from the project-related impacts described in Section 3.8.4, Environmental Consequences, that are associated with wildlife, when combined with other reasonably foreseeable future actions.

The following actions were determined through the cumulative effects analysis process to be reasonably foreseeable, and have impacts that likely overlap in space and time with impacts from the Resolution Copper Project:

- ADOT Vegetation Treatment
- Apache-Sitgreaves National Forests Public Motorized Travel Management Plan
- APS Herbicide Use within Authorized Power Line ROWs on NFS lands
- Drake Limestone Quarry Expansion
- LEN Range Improvements
- Pine Creek Mining River Bend Placer Project
- Pinto Valley Mine Expansion
- Ray Land Exchange and Proposed Plan Amendment
- Ripsey Wash Tailings Project
- Silver Bar Mining Regional Landfill and Cottonwood Canyon Road
- South Mesa Abandoned Mines
- Tonto National Forest Travel Management Plan
- Verde Connect

The loss of habitat in the project footprint contributes to changes in landscape-scale habitat blocks. The cumulative effects analysis area for wildlife consists of the larger landscape of the Arizona transition zone (an ecoregion that roughly extends from the Mogollon Rim/Colorado Plateau to the desert valleys). The metrics used to quantify cumulative impacts to wildlife resources are (1) the acreage of physical disturbance in each vegetation community, representing loss of habitat for wildlife species, (2) any critical or special habitat within the cumulative effects area, and (3) loss of groundwater dependent ecosystems (GDEs).

- Loss of habitat. The cumulative effects analysis area for wildlife resources is approximately 11,799,000 acres; this represents one of the largest cumulative effects analysis areas, due to the range over which wildlife species can occur and the continuity of habitat types.
  The 13 reasonably foreseeable future actions above, combined with the Resolution Copper Project, represent about 3,223,000 acres of the 11.8 million-acre cumulative effects analysis area, or about 27.3 percent. This represents the amount of habitat within the area that could be disturbed. Much of this disturbance area is related to the Tonto National Forest Travel Management Plan, for which changes in road use could potentially disturb habitat through noise or activity. The largest impacts are on the Semidesert Grassland vegetation type (impact to 668,000 acres), Upland Sonoran Desertscrub vegetation type (impact to 638,000 acres), and Pinyon-Juniper vegetation type (impact to 622,000 acres).
- Critical habitats. The 13 reasonably foreseeable future actions above, combined with the Resolution Copper Project, represent 860,000 acres of disturbance to critical habitat with the wildlife cumulative effects analysis area. The greatest impact would be to Mexican spotted owl critical habitat, with a total of approximately 836,000 acres of disturbance. Much of this disturbance is related to the Tonto National Forest Travel Management Plan, for which changes in road use could potentially disturb habitat through noise or activity. The second greatest impact would be to the southwestern willow flycatcher critical habitat, with a total of approximately 17,300 acres of disturbance. Note that these acreages represent any disturbance within the cumulative effects analysis area, not just where the footprints of the Resolution Copper Project and reasonably foreseeable actions overlap. This is because wildlife is mobile and can be impacted by multiple disturbed areas. However, this assumption does not hold true for critical habitat. Critical habitat is specific to a single species, and it is necessary to note that the Resolution Copper Project solely impacts Gila chub critical habitat. Based on the metrics chosen, the analysis suggests that impacts to other critical habitats—such as for Mexican spotted owl, Chiricahua leopard frog, and razorback sucker—occur within the cumulative effects analysis area. The Resolution Copper Project would not impact these species, however, and these other impacts do not represent cumulative effects.
- Groundwater-dependent ecosystems. With respect to GDEs, out of the 13 RFFAs listed above, only the Ray Land Exchange and Proposed Plan Amendment action is potentially located within the same aquifer as the Resolution Copper Project. As described for the groundwater quantity cumulative effects analysis, any overlap in groundwater drawdown is unlikely to occur, or if it does, is unlikely to be substantial. No cumulative effects on GDEs are anticipated.

3.8.4.4 Mitigation Effectiveness

Mitigation Identifier and Title	Authority to Require
FS-SV-03: Revised Reclamation and Closure Plans	Required – Forest Service
FS-WR-01: GDEs and water well mitigation	Required – Forest Service
FS-WR-04: Replacement of water in Queen Creek	Required – Forest Service
FS-WI-01: New mitigation aspects of Revised Wildlife Management Plan	Required – Forest Service
FS-WI-02: Reptile and Sonoran Desert Tortoise	Required – Forest Service
FS-WI-03: Mitigation of loss of abandoned mine or cave habitat for bats	Required – Forest Service

Mitigation Identifier and Title	Authority to Require
FS-WI-04: Maintain or replace access to stock tanks and Arizona Game and Fish Department wildlife waters	Required – Forest Service

We developed a robust monitoring and mitigation strategy to avoid, minimize, rectify, reduce, or compensate for resource impacts that have been identified during the process of preparing this EIS. Appendix J contains descriptions of mitigation measures that are being required by the Forest Service and mitigation measures voluntarily brought forward and committed to by Resolution Copper. Appendix J also contains descriptions of monitoring that would be needed to identify potential impacts and mitigation effectiveness.

This section contains an assessment of the effectiveness of design features associated with mitigation and monitoring measures found in appendix J that are applicable to wildlife. See appendix J for full descriptions of each measure noted below.

Mitigation Effectiveness and Impacts of Required Mitigation Measures Applicable to Wildlife

Appendix J contains mitigation and monitoring measures being required by the Forest Service under its regulatory authority or because these measures are required by other regulatory processes (such as the PA or Biological Opinion). These measures are assumed to occur, and their effectiveness and impacts are disclosed here. The unavoidable adverse impacts disclosed below take the effectiveness of these mitigations into account.

Revised Reclamation and Closure Plans (FS-SV-03). Implementing reclamation and closure plans ensure that post-closure landscape is successfully revegetated to the extent practicable, and that the landforms are stable and safe. This measure is effective at partially replacing habitat and vegetation for wildlife over the long term within the footprint of all mine components, reducing long-term effects on surface water quality from erosion, and improving long-term resilience and safety of the tailings storage facility.

GDE and water well mitigation (FS-WR-01). This measure would replace water sources for any riparian areas associated with springs or perennial streams (groundwater-dependent ecosystems) impacted by drawdown from the mine dewatering and block caving. Though this measure could change the overall natural character of riparian areas, it would be effective at preserving riparian vegetation and aquatic habitats available for wildlife.

Replacement of water in Queen Creek (FS-WR-04). This measure would replace the storm runoff in Queen Creek that otherwise would be lost to the subsidence area. It would be highly effective at minimizing the effects felt in Queen Creek caused by reduction in the watershed area, specifically impacts to surface water quantity and riparian habitat, which would prevent impacts to wildlife using this habitat. Note that other stormwater losses would still occur under Alternatives 2, 3, and 4.

New Mitigation Aspects of Revised Wildlife Management Plan (FS-WI-01). Adherence to the revised wildlife management plan will reduce effects on habitat and to individuals of species. The measure would be effective at reducing direct impacts to wildlife species, though it would not prevent the large-scale loss of habitat within the mine footprint. New mitigation measures incorporated in response to disclosed impacts include additional mitigation that would be effective at reducing impacts from lighting, seasonally restricting work within riparian habitat to protect avian species, minimizing harm to wildlife by using hazing protocols, minimizing harm to birds by using flight diverters on power lines over riparian habitat, minimizing impacts on raptors, migratory birds, or breeding birds by conducting preconstruction surveys, and reducing impacts to kit fox by conducting surveys and limiting potential for trapping or injury.

Reptile and Sonoran Desert Tortoise (FS-WI-02). These measures, when necessary, would be effective at preventing impacts to individual species from construction and ground disturbance.

Mitigation of loss of abandoned mine or cave habitat for bats (FS-WI-03). These measures, when necessary, would be effective at preventing impacts to bats through protection of both known roosting sites and habitat.

Maintain or replace access to stock tanks and Arizona Game and Fish Department wildlife waters (FS-WI-04). Maintaining access to stock tanks and wildlife water structures would ensure that these water sources are available for wildlife, preventing additional impacts to species from disruption of available water.

Mitigation Effectiveness and Impacts of Voluntary Mitigation Measures Applicable to Wildlife

Appendix J contains mitigation and monitoring measures brought forward voluntarily by Resolution Copper and committed to in correspondence with the Forest Service. These measures are assumed to occur but are not guaranteed to occur. Their effectiveness and impacts if they were to occur are disclosed here; however, the unavoidable adverse impacts disclosed below do not take the effectiveness of these mitigations into account. No additional mitigation measures were voluntarily brought forward for wildlife resources.

Other Potential Future Mitigation Measures Applicable to Wildlife

Appendix J contains several other potential future mitigation measures that the Forest Service is disclosing as potentially useful in mitigating adverse effects, but for which there is no authority to require. There is no expectation that these measures would occur, and therefore the effectiveness is not considered in the EIS.

Divert existing flows across the subsidence area to preserve downstream flows (PF-WR-02). The possibility of maintaining storm runoff in Devil's Canyon that otherwise would be lost to the subsidence area would offer benefits to downstream riparian habitat and wildlife using that habitat.

Voluntary achievement of "no net loss" of habitat (PF-WI-01). The acquisition of additional open space within the region would offer direct benefits to habitat, wildlife, and recreation.

Purchase lands in the "Preserve" (PF-RC-01). The acquisition of additional open space within the region would offer direct benefits to habitat, wildlife, and recreation.

Unavoidable Adverse Impacts

Biological resources would be impacted by direct surface disturbance, noise, vibration, light, dust, air pollutants, and traffic. Adverse impacts that cannot be avoided or completely mitigated include changes in cover, changes in foraging efficiency and success, changes in reproductive success, changes in growth rates of young, changes in predator–prey relationships, increased movement, habitat fragmentation and disruption of dispersal and migration patterns through animal movement corridors, and increased roadkill.

3.8.4.5 Other Required Disclosures

Short-Term Uses and Long-Term Productivity

Impacts on wildlife and wildlife habitat would primarily be short term and would include destruction of habitat for mine construction, disturbance from mining and associated activities, and direct mortality from increased mine-related vehicle traffic. Disturbance and direct mortality would cease at mine closure, and reclamation would eventually allow wildlife habitat to reestablish itself. However, this could take many decades or longer. Portions of the tailings storage facility landform may never return to pre-mining conditions, and the effects of reduced quality of habitat would be long term or permanent. Impacts on wildlife and aquatic habitat due to drawdown that affects streams and springs would represent a permanent loss in productivity.

Irreversible and Irretrievable Commitment of Resources

The direct loss of productivity of thousands of acres of various habitat from the project components would result in both irreversible and irretrievable commitment of the resources that these areas provide for wildlife (i.e., breeding, foraging, wintering, and roosting habitat; animal movement corridors, etc.). Some habitat could reestablish after closure, which would represent an irretrievable commitment of resources, but portions of the tailings storage facility landform may never return to pre-mining conditions, and the effects of reduced quality of habitat would likely be irreversible.

3.9 Recreation

3.9.1 Introduction

Overview

The lands around Superior, Arizona, and in particular the Oak Flat area above and directly east of the Apache Leap escarpment, have for decades been a popular recreation destination for camping, hiking, rock climbing, OHV driving, and other pursuits. Development of the project, along with pipelines, power lines, and other associated infrastructure, and a large, permanent tailings storage facility in the general vicinity of the mine, would inevitably result in the loss of some of the area's natural features and recreational opportunities. Some recreational opportunities would be permanently lost, while others would be displaced to other parts of the state. This section of the EIS is an effort to quantify, when possible, these anticipated changes.

Local, State, and Federal agencies provide opportunities for recreation throughout and adjacent to the project area. Recreation activities range from individual, casual, and dispersed use to organized, permitted events and designated recreation sites, for both motorized and nonmotorized recreation. Typical recreation in the project area includes driving for pleasure/vehicle touring, OHV use, hiking, rock climbing (including technical climbing and bouldering), camping, wildlife viewing and bird watching, horseback riding, mountain biking, and hunting (bird, small game, and big game).

One specific recreation concern has been the land exchange, and the subsequent loss of the Oak Flat Campground. Resolution Copper would keep the campground open as long as it is safe to do so (this is required by PL 113-291), but eventually this area would be closed to public access. Another specific recreation concern is the loss of recreation opportunities and access from the large acreage of the tailings storage facility on Federal land, which for the duration of the mine operations would be closed to all non-mining uses and displace recreation to other locations.

This section discusses the general recreation setting and opportunities, special use activities, management for recreation (Forest Service, BLM, and Arizona State lands), hunting, recreation sites, and recreation opportunities specific to the project footprint, including motorized routes and rock climbing.

3.9.1.1 Changes from the DEIS

We have made numerous changes to the recreation analysis in response to comments received on the DEIS. Alternatives 5 and 6 now have only a single pipeline route to reach the tailings storage facility, as described in chapter 2. Additionally, we revised the Alternative 6 pipeline route, primarily to address potential impacts to habitat and resources along Mineral Creek. As a result of these changes, we updated all calculations of acreage impacts used in the analysis.

We have expanded our analysis of impacts to the Arizona National Scenic Trail, to include impacts to the user experience due to the construction of pipelines that would intersect the trail, and added more details from the Arizona Trail Comprehensive Plan. We have included more detail on recreational use of BLM lands near Alternative 5, and the impacts expected on those lands. We also added more climbing area details to this section.

We have added a new section to disclose the effects of an overall loss in Federal land base on recreation users, including the displacement of recreation to other areas. We have also expanded our analysis of hunting impacts, relying on information provided by AGFD to better identify the significance of lands that would be lost to hunters.

The cumulative effects analysis has been revised for the FEIS to better quantify impacts and is described in detail in chapter 4 and summarized in this section. Any mitigations developed between the DEIS and FEIS are summarized in appendix J and if applicable to recreation, are analyzed for effectiveness in this section.

3.9.2 Analysis Methodology, Assumptions, and Uncertain and Unknown Information

3.9.2.1 Analysis Area

The spatial analysis area for potential direct and indirect effects on recreation resources includes the following: the East Plant Site and subsidence area, West Plant Site, MARRCO corridor, filter plant and loadout facility, tailings storage facility, transmission line corridors, pipeline corridors, the Silver King alternative (Alternative 4) and proposed pipelines and emergency slurry ponds, the Peg Leg alternative and proposed pipeline (Alternative 5), and the Skunk Camp alternative and proposed pipeline (Alternative 6). The analysis area for potential indirect and cumulative effects also extends to Management Area (MA) 2F of the Globe Ranger District of the Tonto National Forest; Passages 15, 16, 17, and 18 of the Arizona National Scenic Trail; and Game Management Units (GMUs) 24A, 24B, and 37B, as shown in figure 3.9.2-1. The temporal analysis area for direct and indirect effects is divided into three general phases: construction (mine life years 1 through 9), operations (years 6 through 45), and closure/reclamation (years 46 through 51 to 56).

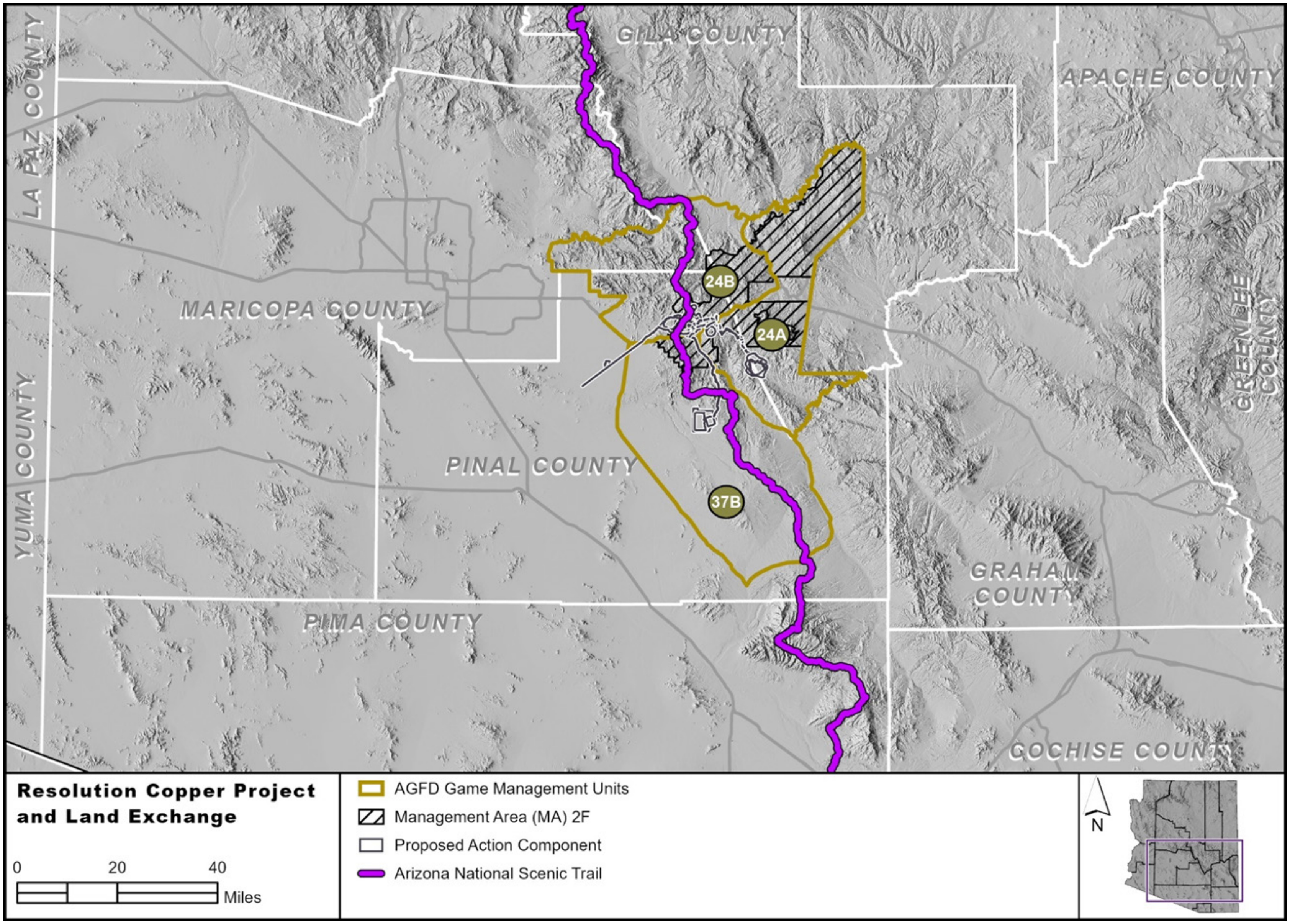


Figure 3.9.2-1. Recreation analysis area

3.9.2.2 Methodology

Recreation activities are interrelated and connected to other natural and social resources and resource uses. Therefore, changes to other resources (e.g., access or scenic resources) can affect recreational opportunities and use. In the following analysis we discuss actions that would alter or change the recreation settings in the analysis area or that could affect the capacity of that landscape setting to provide certain recreational opportunities. We quantify effects where possible.

Short-term impacts would primarily be associated with the construction of project infrastructure, would last as long as a particular construction activity, and would largely cease after roughly mine year 9. Long-term impacts would primarily be associated with mine operation, closure, reclamation, and post-closure, and depending on the impact, could last from mine year 9 to perpetuity.

3.9.3 Affected Environment

3.9.3.1 Relevant Laws, Regulations, Policies, and Plans

A complete listing and brief description of the legal authorities, reference documents, and agency guidance used in this recreation effects analysis may be reviewed in Newell (2018e).

Primary Legal Authorities and Technical Guidance Relevant to the Recreation Effects Analysis

- Secretarial Order 3373
- Multiple-Use Sustained-Yield Act of 1960, as amended (16 U.S.C. 528)
- Wilderness Act of 1964 (16 U.S.C. 1131–1136), as amended by the Arizona Wilderness Act of 1984
- National Trails System Act of 1968 (PL 90-543; 16 U.S.C. 1244(a)), as amended by the Arizona National Scenic Trail Act
- National Forest Management Act of 1976 (16 U.S.C. 1600)
- Tonto National Forest Land and Resource Management Plan
- Arizona National Scenic Trail Draft Comprehensive Plan
- Public Land Order 1229

3.9.3.2 Existing Conditions and Ongoing Trends

General Setting

Major recreational attractions in the analysis area include the Apache Leap escarpment, Oak Flat, Picketpost Mountain, Boyce Thompson Arboretum, Arizona Trail, Queen Creek Canyon, Devil’s Canyon (aka Ga’an Canyon), Hewitt Station Road, Reavis Canyon, Gila River, and Dripping Spring Mountains. A number of developed and dispersed campgrounds, day-use areas, trailheads, roads, and trails exist for both motorized and nonmotorized recreational use in the analysis area. With private funding from multiple sources, the Tonto Recreation Alliance maintains the Hewitt Station OHV trails in cooperation with the Forest Service. Dispersed and developed recreation in the analysis area is managed by the Forest Service, BLM, State of Arizona, Gila County, and Pinal County. Tonto National Forest lands (Globe

Ranger District) dominate the northern portion of the analysis area, and BLM lands (Tucson Field Office) dominate the southern portion of the analysis area (figure 3.9.3-1).

Oak Flat Campground has been used as a campground for many decades, officially gaining designation in 1955 by President Eisenhower under Public Land Order 1229. As acknowledged in sections 3.12 and 3.14, human use of the Oak Flat area extends well beyond recent decades. Rock climbing was first pursued in the Oak Flat area in the 1960s and early 1970s (Karabin Jr. 1996).

NFS roads are located throughout the analysis area. Tonto National Forest is currently preparing a draft Supplemental EIS in compliance with the Final Travel Management Rule, which requires that all NFS lands designate roads, trails, and areas for motor vehicle travel. This would restrict off-road motor vehicle use and designate roads and motorized trails open to the public, in addition to designating OHV areas, big-game harvesting retrieval rules, fuelwood collection rules, and dispersed camping rules (U.S. Forest Service 2016f). NFS roads will be shown on the Tonto National Forest Motor Vehicle Use Map. The Motor Vehicle Use Map is anticipated to be released to the public once the final Supplemental EIS is released and the final ROD has been signed by the Forest Supervisor.

The Gila-Pinal Scenic Road is a designated Scenic Byway, running along U.S. 60 from Superior to Miami, Arizona. ADOT designated the Gila-Pinal Scenic Road as a scenic road on June 20, 1986. The route travels throughout the Sonoran Desert life zone at the desert floor and moves upward through four biotic communities. Riparian woodlands are found along the many features such as Queen Creek, Arnett Creek, and Pinto Creek (America's Scenic Byways 2018).

The Legends of Superior Trails system (LOST) is located along U.S. 60, providing a connection from the Arizona Trail to Superior. LOST is a joint project between multiple public and private partners, including the Town of Superior, Tonto National Forest, and Resolution Copper. A portion of LOST is on lands owned by Resolution Copper. LOST is 6 miles long (with a few short side trails) and includes interpretive signage along the route (U.S. Forest Service 2013a).

Pinal County has proposed features and designations in its 2007 Open Space and Trails Master Plan, some of which would occur within the analysis area. OHV trails, trail corridors, as well as planned or proposed open space designations are intended to provide recreation opportunity and connectivity throughout Pinal County. In addition, a local user group (Recreation Users Group or RUG) has proposed a motorized and nonmotorized trail plan that coincides with part of the analysis area; this plan features new trailheads, motorized roads, motorized trails, and nonmotorized trails (see yellow nonmotorized lines and white motorized lines in figure 3.9.3-2).

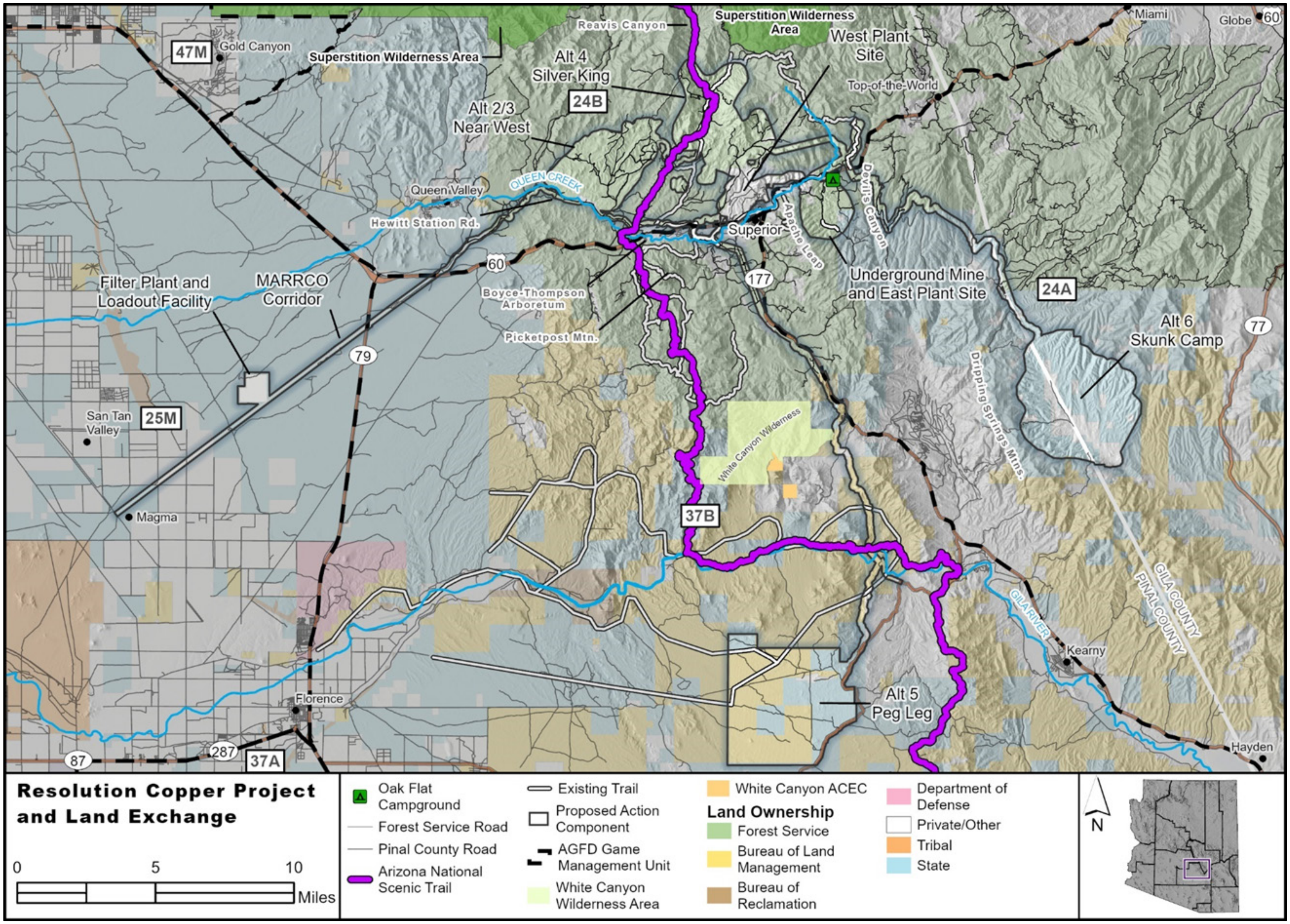


Figure 3.9.3-1. Existing recreation setting overview

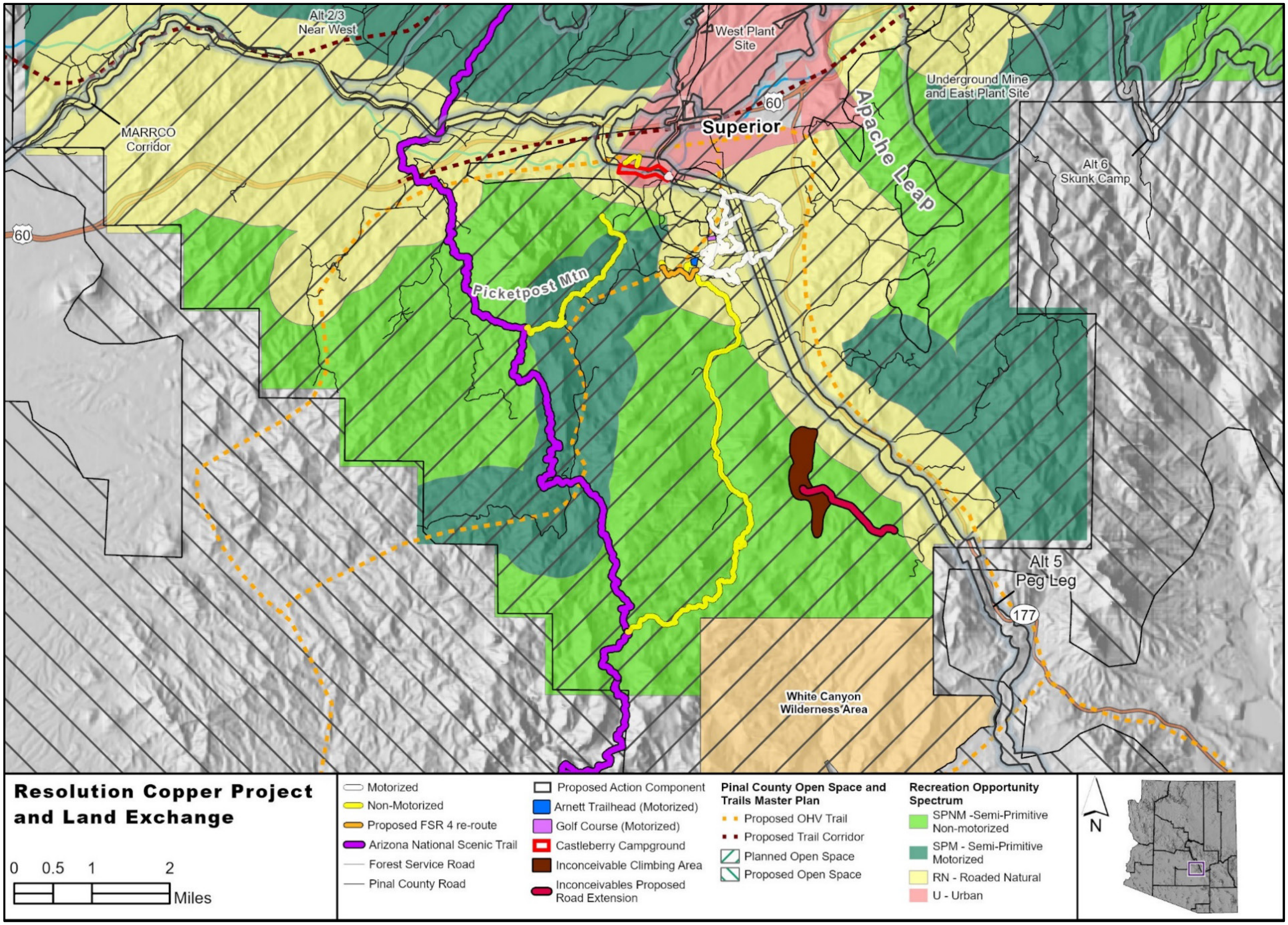


Figure 3.9.3-2. Proposed recreation setting overview

Special Use Activities

The Tonto National Forest manages its special use permit pursuant to 36 CFR 251, and the analysis area is used by a number of permitted recreation and commercial special use activities. Recreation events are commercial activities requiring temporary, authorized use of NFS land. Commercial activities may consist of outfitter and guide services, filming, photography, or campground management. Commercial activity on Tonto National Forest lands occurs when an entry or participation fee is charged by the applicant, and the primary purpose is the sale of a good or service. Most of these applicants offer guided tours that provide the safety, knowledge, and experience of qualified guides with quality equipment, while others provide in-demand equipment and basic instruction for visitors to explore on their own. Activities include hiking, camping, climbing, canyoneering, horseback riding, jeep tours, motorcycle riding, utility task vehicle (UTV), OHV, and ATV tours, road biking, and mountain biking. Each company follows strict operating procedures, safety practices, and Forest Service regulations to protect the environment. Additionally, group recreation events may also require a special use permit (U.S. Forest Service 2013b).

Recreation Opportunity Spectrum

The recreation setting varies on the Tonto National Forest lands throughout the analysis area, illustrated by the different recreation opportunity spectrum (ROS) classifications that occur within the analysis area: semiprimitive nonmotorized, semiprimitive motorized, roaded natural, and urban. Table 3.9.3-1 and figure 3.9.3-3 give an overview of the ROS in the analysis area.

Table 3.9.3-1. Recreation opportunity spectrum acreages

ROS Class	Acres in the Analysis Area
Semiprimitive nonmotorized	5,576
Semiprimitive motorized	21,226
Roaded natural	10,213
Urban	10,180

Note: Acreages may not total due to rounding and/or unclassified lands; acreages that are common to alternatives are not double-counted.

BLM Recreation Management

The BLM currently uses an outcomes-focused recreation management framework that focuses on targeted outcomes gained from visitors engaging in recreational experiences (see BLM Handbook H-8320-1, “Planning for Recreation and Visitor Services” (Bureau of Land Management 2014)). The BLM-managed public lands provide visitors with a wide variety of outdoor recreation opportunities (activities and settings) to attain desired experiences and personal benefits. Public lands are designated as a Special Recreation Management Area (SRMA) or Extensive Recreation Management Area (ERMA). ERMAs constitute all public lands outside specially or administratively designated areas (e.g., National Land Conservation System units or ACECs, respectively), typically areas where recreation is non-specialized, dispersed, and does not require intensive management. Recreational activities are typically subject to fewer restrictions in ERMAs. There are no SRMAs in the analysis area; the nearest SRMA is the Gila River SRMA, 10 miles to the east. All BLM-managed lands within the analysis area are managed as ERMAs, but are heavily used by both motorized and nonmotorized recreation. The BLM manages approximately 33 miles of the Arizona Trail in the analysis area (see figure 3.9.3-4).

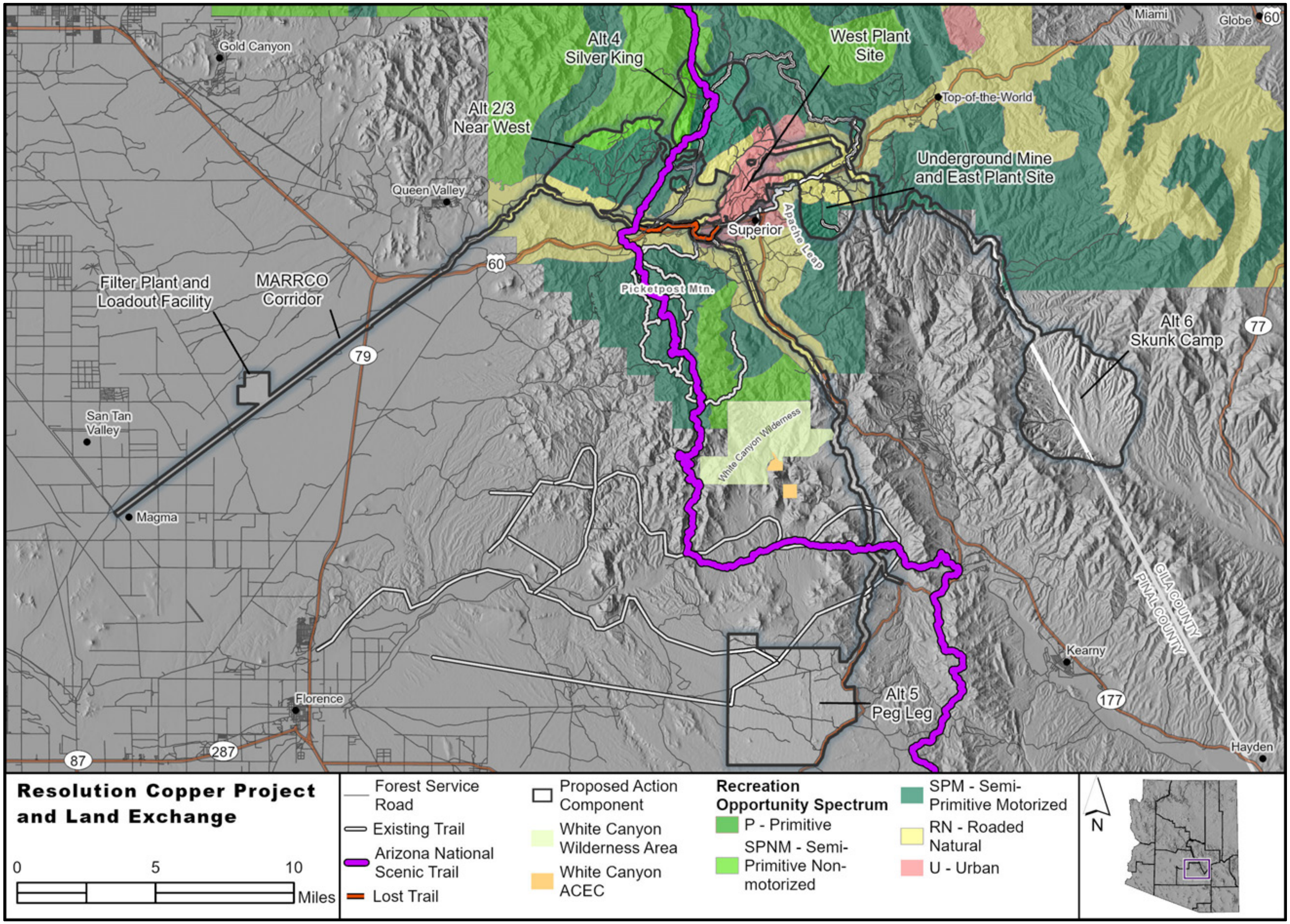


Figure 3.9.3-3. Existing recreation opportunity overview

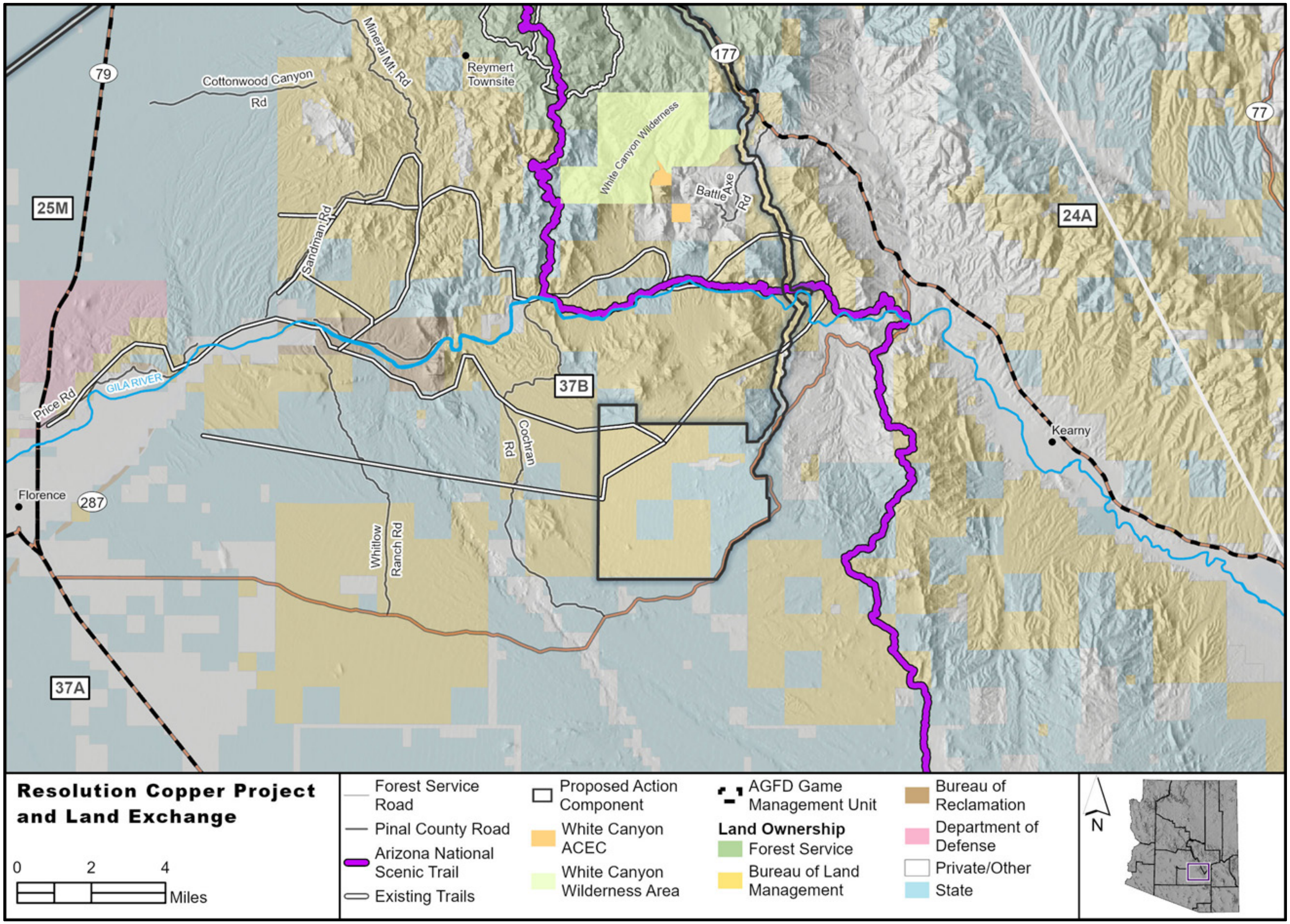


Figure 3.9.3-4. Primary roads affected by Alternative 5 – Peg Leg

Similar to the Forest Service, special recreation permits are another tool the BLM uses to manage recreational use of public lands. Special recreation permits are authorizations that allow for commercial, competitive, and group recreation uses of BLM-managed public lands and related waters. BLM administers commercial, competitive, and organized group recreational uses in accordance with Special Recreation Permits issued under 43 CFR 2930. There are several permitted commercial recreational uses in the analysis area, including but not limited to overnight trips, hunting outfitters, and OHV rallies.

BLM routes are located within the analysis area. The conditions and frequency of use of these routes are similar to those described for NFS routes. Some fall within the BLM's Middle Gila Canyons travel management area, which attracts heavy recreational use for OHV riding and other activities. The area consists of the BLM lands north of the Florence-Kelvin Highway and south of U.S. 60, between SR 78 and SR 177. This popular OHV area includes technical OHV trails valued for their challenging terrain. A transportation and travel management plan was completed in November 2010. The plan identified the existing network of primitive roads and trails in the area, including the main public land access routes.

The BLM Tucson Field Office is currently preparing a draft travel management plan to designate roads, trails, and areas for motor vehicle travel (i.e., open, limited, or closed). Unlike the Tonto National Forest lands, BLM lands in the analysis area have not been inventoried for recreation settings. However, the area includes similar settings as found on the Tonto National Forest.

In 1988, the BLM designated the White Canyon ACEC, further delineated in 1998 for the area's outstanding scenic, wildlife, and cultural values after the approximately 320-acre, noncontiguous area was recommended "not suitable" for wilderness designation in the Phoenix Wilderness Final Environmental Impact Statement (Bureau of Land Management 1986c). In 1990, Congress designated the White Canyon Wilderness, comprising 5,800 acres and including the same qualities recognized in the ACEC.

Primitive-like existing conditions are found in the White Canyon Wilderness area, Semi-primitive Non-Motorized–like existing conditions are found in the areas away from the roads, Semi-Primitive Motorized-like settings exist along the primitive road network, and Rural-like existing conditions are found in the developed areas along county roads. Most of the BLM lands in the area are characterized by a Semi-Primitive Motorized existing condition. As previously stated, BLM lands have not been inventoried. Therefore, these are not classifications (i.e., management prescriptions), but rather are existing conditions described using ROS setting descriptions.

State Trust Land

Arizona State Trust land is present throughout portions of the analysis area. ASLD lands are not public lands; they are lands managed by ASLD to generate revenue for State purposes. However, recreational uses are allowed by permit and are open to hunting and fishing with a valid license. Recreation (such as hiking, camping, or motorized travel) may be allowed with a recreational permit available through the ASLD. However, some trails (such as the Arizona Trail) are available for public use without a permit.

Hunting

Hunting opportunities are available on all public lands, including lands managed by the ASLD. The lands included are also within the GMUs as identified by the AGFD as 24A, 24B, and 37B. A valid hunting license is required on all public lands as well as those managed by ASLD. Currently, hunting opportunities within the vicinity of the project area in GMUs 24A, 24B, and 37B include: six out of Arizona's 10 big-game species (mule deer, white-tailed deer, javelina, mountain lion, black bear, and bighorn sheep), small game (cottontail, jackrabbit, Gambel's quail, scaled quail), migratory game birds (mourning dove, white-winged dove, and band-tailed pigeon) and fur-bearing or predatory mammals (e.g., coyote and bobcat). Species such as these are considered Species of Economic and Recreational

Importance (SERI) to AGFD and citizens of Arizona (Arizona Game and Fish Department 2012). Several of these species currently occupy habitat that has 100 percent overlap with the proposed project area, including the tailings storage facility alternatives, tailings pipeline corridors, and/or new power lines. The majority of the proposed project area is located within GMU 24B. The Near West tailings storage facility (Alternatives 2 or 3) and Silver King tailings storage facility (Alternative 4) are located in GMU 24B; the East Plant Site and Skunk Camp tailings storage facility (Alternative 6) locations are in GMU 24A; and the Peg Leg tailings storage facility (Alternative 5) location is in GMU 37B. Several proposed mine features either currently exist, or would be located exclusively on private lands, or are linear features (pipelines or power lines) in all three GMUs.

Based on "values" mapping conducted by AGFD, a moderate to high number of participants (hunters) found portions of the Near West tailings storage facility (Alternative 2 or 3) west of Superior (GMU 24B) to be of high value for hunting mule deer, white-tailed deer, javelina, quail, dove, and predators. In the area of the Silver King tailings storage facility (Alternative 4) (GMU 24B), a moderate to high number of participants valued the area for mule deer and predator hunting; but a low to moderate number of participants valued it for javelina, quail, and dove hunting. As elevations increase to the north and east in the Montana and Peachville Mountain areas near Silver King, more hunters highly valued the area for white-tailed deer hunting. The area of the Peg Leg tailings storage facility (Alternative 5) in GMU 37B is highly valued by a high to moderate number of participants for quail, javelina, and predator hunting; and by moderate to low number of participants for dove, mule deer, and white-tailed deer hunting. The area of the East Plant Site in GMU 24A is highly valued by a moderate to high number of participants for quail and predator hunting; and a low to moderate number of participants for dove, javelina, mule deer, and white-tailed deer. The area of the Skunk Camp tailings storage facility (Alternative 6) in GMU 24A is highly valued by a high number of participants for quail hunting, but a low number for dove hunting. A moderate number highly value the area for white-tailed deer, mule deer, and javelina hunting; and a low number of participants for predator hunting (Arizona Game and Fish Department 2018b, 2018c, 2018d). Hunting primarily occurs in the fall and winter.

There are 10 SERI species with predicted occurrences within 5 miles of the project footprint. These species include mule deer, white-tailed deer, javelina, elk, black bear, mountain lion, Gambel's quail, mourning dove, white-winged dove, and band-tailed pigeon.

Birding

The recreation analysis area includes high-quality options for birding and bird watching, including an Audubon Society-designated Arizona Important Bird Area centered at Boyce Thompson Arboretum/ Arnett and Queen Creeks. Other areas that offer unique habitat and forage for migrant, resident, and vagrant birds are located in the analysis area including Oak Flat, Queen Creek Canyon, Apache Leap, and Telegraph Canyon. Local and national birding events use the analysis area during all birding seasons, peaking in the spring and at annual bird counts such as the Christmas Day Bird Count.

Recreation Sites

ARIZONA NATIONAL SCENIC TRAIL

The Arizona Trail, which is more than 800 miles long, was designated a national scenic trail in a 2009 amendment to the 1968 National Trails System Act (Arizona Trail Association 2018). The National Trails System Act of 1968, as amended, establishes national scenic trails to provide maximum outdoor recreation potential and for the conservation and enjoyment of scenic, historic, natural, or cultural qualities of the areas which they traverse. The Arizona Trail is a primarily primitive, nonmotorized long-distance route that preserves and showcases the unique and diverse scenic, natural, historic, and cultural treasures of Arizona and our nation. The Arizona Trail experience provides opportunities for quality recreation, self-reliance, and discovery within a corridor of open space defined by the spectacular natural landscapes of the state (U.S. Forest Service 2018c).

The Arizona Trail is administered by the Forest Service in cooperation with other Federal agencies. The Forest Service is developing a comprehensive management plan for the Arizona Trail that establishes a 0.5-mile trail management corridor extending from the trail centerline (total 1-mile-wide corridor) for the entire length of the trail. The management corridor is critical to the nature and purpose of the trail, and management plans for lands within the trail corridor will be developed or updated by the respective agencies after the Forest Service completes its comprehensive management plan.

Four trail "passages" are located within the analysis area, stretching from the Tortilla Mountains in the south to the Superstition Mountains in the north (see figure 3.9.3-1). The four passages of the Arizona Trail total approximately 84 miles of trail through the analysis area. These are Passage 15 – Tortilla Mountains; Passage 16 – Gila River Canyons; Passage 17 – Alamo Canyon; and Passage 18 – Reavis Canyon.

APACHE LEAP SPECIAL MANAGEMENT AREA

The Apache Leap SMA was established in 2017 (U.S. Forest Service 2017c) and straddles the Apache Leap escarpment, covering 839 acres (figure 3.9.3-5). This escarpment of cliffs and hoodoos visually dominates the eastern skyline from the basin below creating a scenic backdrop for the town of Superior and adjacent highways. The escarpment's eastern slopes include numerous drainages and canyons that lead to the Oak Flat area, located approximately 2 air miles away. The area offers dispersed recreation opportunities that emphasize nonmotorized and nature-based activities in a predominantly undeveloped setting.

The area was set aside in recognition of its unique natural and scenic character; for its bounty of life-sustaining natural resources, which include acorns, medicinal and other edible plants, wild game, and water; and as a place of religious and cultural importance to the Apache people.

No mining activities are proposed within the SMA. However, authorized activities under PL 113-291 include installing seismic monitoring equipment, as well as signage and other public safety notices, and operating an underground tunnel and associated workings between the East Plant Site and West Plant Site, which would extend beneath the Apache Leap escarpment.

OAK FLAT CAMPGROUND

The Tonto National Forest manages the Oak Flat Campground, which provides approximately 20 campsites (available first come, first served) and two vault toilets (U.S. Forest Service 2018d). The campground is situated along the Gila-Pinal Scenic Road in the rolling hills near Devil's Canyon (figure 3.9.3-6) and hosts a large stand of mature oak trees that provide natural shade. The surrounding area is known for its numerous recreational bouldering opportunities. Families and individuals like to come to this site for its natural desert beauty and rock climbing. Oak Flat Campground is also an important birding destination and considered an eBird "hotspot," with approximately 183 different species reported by birders to eBird (Arizona Game and Fish Department 2018e). Oak Flat is a unique recreation setting for not only Tonto National Forest but the entire state of Arizona. Multi-year camera studies conducted from 2011 to 2019 indicated over 5,000 observances of users in various areas of Oak Flat (Featherstone and Alexander 2019; Featherstone et al. 2012).

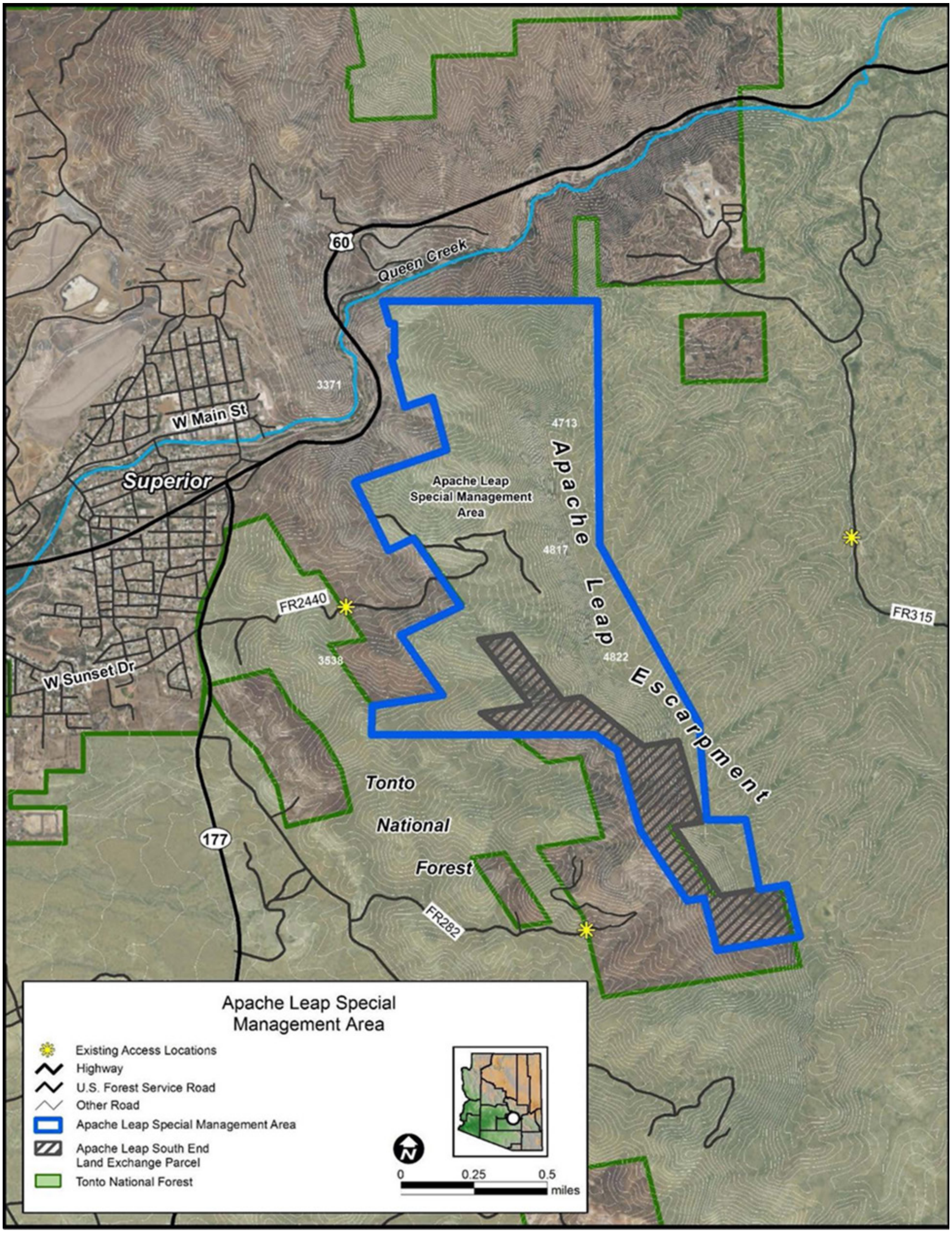


Figure 3.9.3-5. Overview of Apache Leap Special Management Area

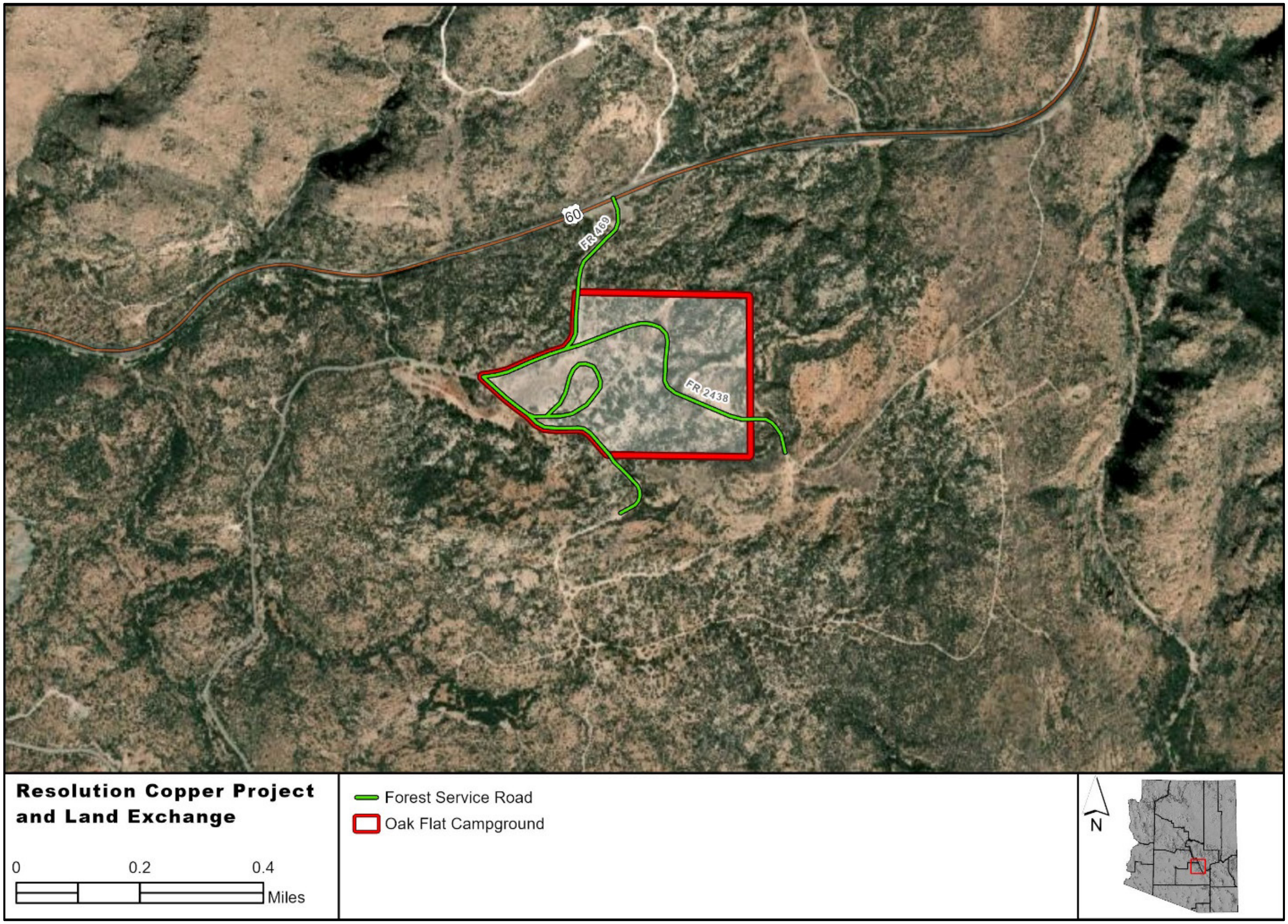


Figure 3.9.3-6. Location of Oak Flat Campground

Mine Area and Associated Infrastructure

MOTORIZED ROUTES

The analysis area comprises portions of both the Mesa and Globe Ranger Districts. Generally, recreation opportunities in these areas are the same, ranging in elevation from a low point of approximately 1,500 feet along the western boundary of the analysis area (the terminus of the MARRCO corridor) up to the high point of the analysis area, King's Crown Peak (north of the East Plant Site) at approximately 5,500 feet. Commonly used NFS roads within the analysis area are described here (see also figure 3.9.3-1).

NFS Road 2440—NFS Road 2440, also known as the Cross Canyon Road, extends approximately 1.75 miles from SR 177 on the east side of Superior, Arizona, into the western portion of the Apache Leap SMA. The road is gated at its junction with private land approximately 0.5 mile from SR 177. Public users park at this gate and walk the roadbed, through the private land parcel owned by Resolution Copper, for the remaining 1.25 miles to enter the western portion of the Apache Leap SMA. From various points along this route, users leave the roadway and travel overland farther into the Apache Leap SMA for dispersed recreation opportunities.

Resolution Copper holds a permit for the use of NFS Road 2440 to access two groundwater monitoring wells (MB-03 and QC-04) within the Apache Leap SMA, as permitted by the Resolution Copper pre-feasibility plan (U.S. Forest Service 2010b). Resolution Copper conducts minimal maintenance on the road to provide the level of access necessary to collect monitoring data and maintain the wells.

NFS Road 282—NFS Road 282 extends approximately 1.75 miles from SR 177 toward the southwestern portion of the Apache Leap SMA. The road is gated at its junction with private land. Users park vehicles at this gate and access the southwestern portion of the Apache Leap SMA on undesignated user-created routes that cross private lands.

U.S. 60/Queen Creek Corridor—Users access the northern and northwestern portion of the Apache Leap SMA from several undesignated nonmotorized access routes that originate along U.S. 60 east of Superior, Arizona. Users navigate the steep slopes to climb out of the Queen Creek drainage and can also access the Apache Leap SMA to the south via undesignated trails. Access from these points requires users to cross private (owned by Resolution Copper) lands to enter the area. Scenic driving is also common along this corridor, which is designated as the Gila-Pinal Scenic Road.

NFS Road 315—NFS Road 315 is the primary access into Oak Flat and the Oak Flat Campground. Several undesignated parking areas along NFS Road 315 provide access to the eastern portion of the Apache Leap SMA. Users travel overland on multiple, nonmotorized undesignated user-created routes to the top of the Apache Leap escarpment. These routes provide the primary access for rock climbing in the Apache Leap area, as well as Lower Devil's Canyon, Hackberry Canyon, and the Refuge.

NFS Road 357/NFS Road 650 (aka Hewitt Station Road/Happy Camp Road)—NFS Road 357 and NFS Road 650 are the primary access to the Tonto National Forest lands north of Superior and south of the Superstition Wilderness. These routes are often combined with other nearby routes to form a loop, popular for OHV users; however, access via NFS Road 357 has been restricted by gated entry at the private property boundary. These routes also provide the primary access to the Arizona Trail, and lead to trailheads to the popular Roger's and Reavis Canyon trails.

NFS Road 342—NFS Road 342 is a popular OHV route that may also be used in conjunction with NFS Road 650 for a loop route accessed from U.S. 60 (see figure 3.9.3-1).

In addition, the BLM routes of Mineral Mountain Road, Reymert Townsite Road, Cottonwood Canyon Road, Sandman Road, Price Road, Battle Axe Road, Whitlow Ranch Road, and Cochran Road are located in the analysis area.

ROCK CLIMBING

The analysis area includes unique geological features that offer bouldering as well as technical, sport, traditional (“trad”), and top-rope rock climbing opportunities (Karabin Jr. 1996; Oliver 2017). Before 2004, the public could drive vehicles and park unimpeded along the Magma Mine Road and the area that is now the East Plant Site to access climbing areas in Oak Flat and Apache Leap. A portion of this area is now closed to public access due to safety concerns; however, limited parking is still available along the Magma Mine Road near Euro Dog Valley, the Mine Area, and Apache Leap. Resolution Copper has been working with local climbing groups since 2004 to establish legal access to their private lands that would still be available for climbing. A final agreement was signed that keeps the Pond and Atlantis climbing areas, which are on Resolution Copper–owned property, perpetually open for public use. Figure 3.9.3-7 illustrates the known climbing opportunities in the analysis area. Tam O’Shanter Peak and the Homestead are nearby climbing areas.

The Homestead

The Homestead is an area offering sport climbing on limestone cliffs in remote, scenic high desert within a 2-hour drive from Phoenix and Tucson. The canyon and the climbing routes are on BLM-administered land, and on private property owned by the Access Fund. The area is in a canyon with over 250 sport climbs on 12 limestone walls on both sides, accessed by primitive foot trails. Land ownership in the area is intermingled BLM, State Trust land, and private property, including property owned by the Access Fund. Public use of State Trust land requires a recreational permit from the ASLD. The private property beyond the Access Fund trailhead is not open to public use.

Tam O’Shanter Peak

The climbing area includes an assortment of crags located along a ridge of the Dripping Spring Mountains, including Tam O’Shanter Peak. Sparsely used, this area has been explored more recently for potential development as a climbing resource.

Oak Flat and Euro Dog Valley

The Oak Flat bouldering area is 0.5 to 1 mile southwest of Oak Flat Campground, east of Magma Mine Road (NFS Road 315) (see figure 3.9.3-7) and is managed by the Forest Service. Euro Dog Valley, Oak Flat East, and Oak Flat West all offer freestanding boulders and small cliff-lined canyons, with over 1,000 documented boulder routes and problems. The Phoenix Bouldering Contest and Phoenix Boulder Blast were held in Oak Flat from 1989 through 2004, and various other climbing and/or bouldering competitions have been held in this area as recently as 2016, including the Queen Creek Boulder Competition. These events drew competitive climbers from all over the world.

Mine Area

The Mine Area is immediately south of the East Plant Site and east (above) Apache Leap (see figure 3.9.3-7) and is on lands owned by Resolution Copper. Public access to the Mine Area has been limited since operations resumed at the former Magma Mine in the mid-2000s. Public users are not permitted beyond the security gate along Magma Mine Road. The Mine Area contains over 100 documented short sport routes (25–50 feet). Some portions of the Mine Area (nearest U.S. 60) are available to registered users.

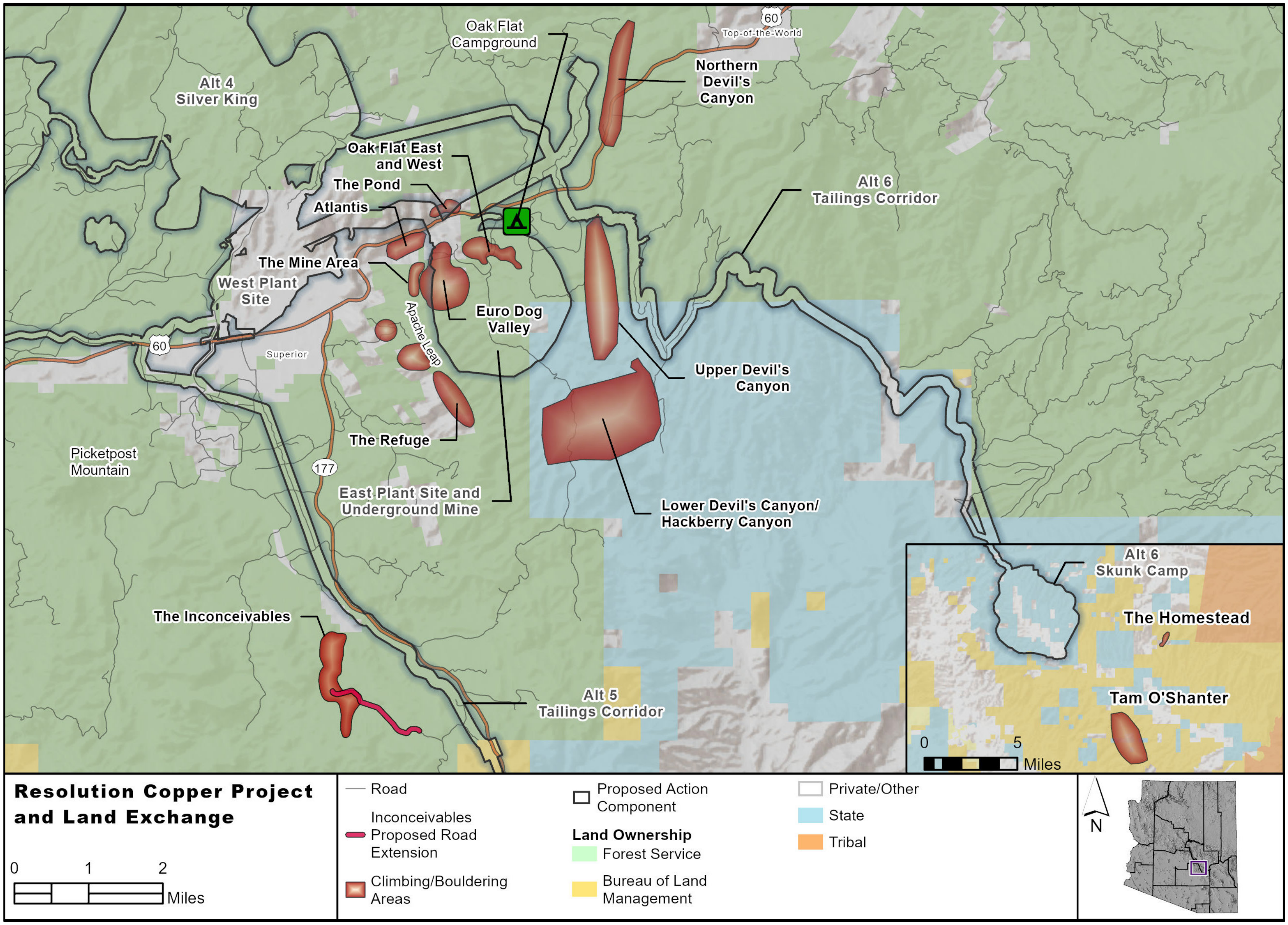


Figure 3.9.3-7. Climbing opportunities overview

Devil’s Canyon

Northern Devil’s canyon is located north of U.S. 60 (see figure 3.9.3-7). Upper Devil’s Canyon is accessed from Oak Flat Campground by way of NFS Road 2438. Lower Devil’s Canyon is accessed from Oak Flat Campground by way of NFS Road 315. There are over 400 documented climbing routes in Devil’s Canyon, with a mixture of sport and traditional routes on walls (including the 200-foot tall Nacho Wall), as well as numerous freestanding pinnacles and towers.

Apache Leap

Apache Leap contains many of the tallest climbing routes in the Queen Creek area. Climbing opportunities consist of mostly traditional routes, but also 80 bolted routes and 16 boulder problems. Popular established routes include the Lectra Area, Lost Horizon, Rim Gym, Staging Area, Punk Rock, Headstone, Citadel, The Draw, Musicland Wall, Geronimo Area, Skyscraper Area, and The Fin (Queen Creek Coalition 2015). Climbing routes in the Apache Leap area are accessed by way of Magma Mine Road (NFS Road 315). The majority of these routes are located on the escarpment (see figure 3.9.3-7) and are accessed from parking areas on NFS Road 315. Climbers hike to the east side of the Apache Leap SMA via overland undesignated routes and rappel into the climbing areas. Other areas in the central portion of the Apache Leap SMA, including a popular route called The Fin, are accessed via NFS Road 2440 and overland undesignated routes (U.S. Forest Service 2017d).

Resolution Copper Private Land (Queen Creek Canyon)

Generally, popular sport, crack, and crag climbing routes are available along or accessed from U.S. 60 northbound from the bridge and underground tunnel, north to the top of the canyon (a stretch of approximately 2 miles). The Pond and Atlantis can be accessed from within Queen Creek Canyon, along U.S. 60 (see figure 3.9.3-7). These areas, along with the Mine Area and other climbing areas containing established climbing routes, are on Resolution Copper property and now require that users register and sign a waiver via a free, online registry to gain legal access (Resolution Copper 2018a). Parking is located along U.S. 60 at various pull-offs along the highway, particularly on the north side of the tunnel.

3.9.4 Environmental Consequences of Implementation of the Proposed Mine Plan and Alternatives

Impacts that occur under more than one alternative are discussed under the first applicable alternative and are then referenced under other pertinent alternatives.

3.9.4.1 Alternative 1 – No Action

Under the no action alternative, the project would not be developed, and existing recreational uses would continue under current conditions. The settings, landscape, recreation sites, roads, and trails within the analysis area would continue to be affected by current conditions and ongoing actions. Oak Flat would remain open to public use. Routine maintenance of NFS roads, the Arizona Trail, and other recreation resources would continue.

Access to public land in the area would continue; rock climbing and bouldering opportunities in the Mine Area, Euro Dog Valley, and Oak Flat would remain available. Recreation opportunities in the analysis area would continue to be managed consistent with the ROS setting indicators and objectives of the forest plan. Hunting opportunities would not change in the analysis area. Motorized routes would not be closed as a result of any Resolution Copper mining activities, subject to existing rights and permits.

3.9.4.2 Impacts Common to All Action Alternatives

Impacts that would occur under each of the action alternatives are presented in this section. Regardless of action alternative, the principal adverse impact on recreational users of public lands as a result of the proposed action or alternatives would be through closure of lands to public access, meaning both direct loss of recreational use of the lands themselves and potential loss of access to adjacent lands because movement across these areas would become prohibited (see “Loss of Federal Land Base” below). Other impacts on recreational users may occur through increased traffic, increased noise, changes to the scenery or visual qualities of certain areas, and other mine-induced effects. Such effects are noted in the following text and addressed in greater detail in the portions of chapter 3 relevant to each of those resources.

A number of existing Resolution Copper–owned properties in the recreation analysis area are, by and large, already closed to public access: these include the privately held portions of the East Plant Site, the West Plant Site, and the filter plant and loadout facility. Thus, in the impact analyses presented in the sections that follow, loss of access to or across these private lands is not considered as a change from current, existing conditions. However, potential expansion of any of these facilities onto Tonto National Forest or other public lands as a result of project approval is considered a change from current conditions and thus an impact. So, too, is potential development of new facilities or physical alteration of lands that would result in closure of lands to recreational use or through-access, such as construction at any of the tailings storage facility locations or development of the anticipated subsidence area at Oak Flat.

The following project components that are common to all action alternatives are considered in the impact analyses: tailings storage facility including fence line boundary; subsidence area; East Plant Site expansion onto Tonto National Forest lands; MARRCO corridor; and conveyance of the Oak Flat Federal Parcel to Resolution Copper through the PL 113-291–mandated land exchange. It should be noted that tailings pipeline corridors and power transmission line corridors, though part of mine facilities under any alternative, may represent a change to recreation settings but are not considered in this analysis as precluding public crossing or other access.

Components or differing configurations of components that are unique to one or more alternatives are described and addressed in the portions of the analysis specific to each alternative.

Effects of the Land Exchange

The land exchange would have significant effects on recreation. The Oak Flat Federal Parcel would leave Forest Service jurisdiction, and with its myriad recreational opportunities currently available and used by the public. The Oak Flat bouldering area offers freestanding bounders and small cliff-lined canyons with over 1,000 documented boulder routes and problems. The area has held various bouldering and climbing competitions as recently as 2016 and the Phoenix Bouldering Contests and Phoenix Boulder Blasts through 2004; all climbing and bouldering areas would be lost when the Oak Flat Federal Parcel transfers out of Federal ownership. Additional recreational activities that would be lost include camping at the Oak Flat Campground, picnicking, and nature viewing. The campground currently provides approximately 20 campsites and a large stand of native oak trees. It also is boasted as an important birding destination with approximately 183 different species reported by birders.

The offered lands parcels would enter either Forest Service or BLM jurisdiction. The eight parcels would have beneficial effects; they would become accessible by the public and would be managed by the Federal Government for multiple uses, which could include recreational activities. Some parcels, specifically Cave Creek, Tangle Creek, and Turkey Creek, all have trails leading directly into them. Under Federal management, these parcels could provide an extension of current recreational activities in those areas. Specific uses would be identified by the respective agency upon conduction of the land exchange; however, the Forest Service and BLM have the capacity to also plan for dispersed, developed, and wilderness recreation opportunities on the offered lands parcels.

Most of the public recreation area being lost is relatively easily accessible to Maricopa, Gila, and Pinal County residents. Much of the land specified in the exchange is far less convenient for these residents as well as for most others who recreate in the area. Residents of these three counties would be farther from the offered lands than they are to the lands that would be lost to recreation when the lands are exchanged. This means residents of these three counties would need to plan for longer trips to reach their destinations as well as plan different activities, as the offered lands do not equate a 1:1 similarity in recreation settings or recreation opportunities. For example, none of the offered lands feature known climbing resources commensurate or even similar to the Oak Flat Federal Parcel.

Forest Plan Amendment

The Tonto National Forest Land and Resource Management Plan (1985b) provides guidance for management of lands and activities within the Tonto National Forest. It accomplishes this by establishing a mission, goals, objectives, and standards and guidelines. Missions, goals, and objectives are applicable on a forest-wide basis. Standards and guidelines are either applicable on a forest-wide basis or by specific management area.

A review of all components of the 1985 forest plan was conducted to identify the need for amendment due to the effects of the project, including both the land exchange and the proposed mine plan (Shin 2020). A number of standards and guidelines (18) were identified applicable to management of recreation resources. None of these standards and guidelines were found to require amendment to the proposed project, either on a forest-wide or management area-specific basis. For additional details on specific rationale, see Shin (2020).

While standards and guidelines were not found to require amendment, the project would have effects on the recreation resources within the Tonto National Forest by modifying the acres under ROSs. Table 3.9.4-1 lists the acres of the project footprint that would fall within each ROS category within each of the affected management areas. Also shown is the percentage this acreage represents of the total ROS category in each management area. Overall, for the semiprimitive category most likely to be affected by mining impacts (note there is no primitive acreage within these management areas), changes range up to 2 percent for MA 2F (nonmotorized category), and up to 2.6 percent for MA 3I (motorized category). Implementation of the project would require amending the forest plan by changing any significant percentages of areas with semiprimitive ROS categories within management areas 2F and 3I. The specific amendment that would be required for each alternative is detailed in chapter 1.

Table 3.9.4-1. Effect of the project on the recreation opportunity spectrum within Management Areas 2F and 3I (acres)

MA/ROS*	Alternatives 2 and 3	Alternative 4	Alternative 5	Alternative 6
2F				
R	–	–	–	
RN	539 (<1%)	480 (<1%)	916 (1.1%)	125 (<1%)
SPM	1,137 (<1%)	5,088 (3.0%)	95 (<1%)	246 (<1%)
SPNM	–	18 (<1%)	–	146 (<1%)
U	1,125 (8.6%)	1,828 (14.0%)	1,208 (9.3%)	1,123 (8.6%)
3I				

MA/ROS*	Alternatives 2 and 3	Alternative 4	Alternative 5	Alternative 6
R	–	–	–	–
RN	727 (1.1%)	128 (<1%)	128 (<1%)	128 (<1%)
SPM	3,270 (3.0%)	–	–	–
SPNM	–	–	–	–
U	–	–	–	–

Note: Table presents acres of project footprint within each ROS, and percentage of that ROS that could be changed by the project (in parentheses) for Forest Service lands only.
* ROS classifications: R = roaded, RN = roaded natural, SPM = semiprimitive motorized, SPNM = semiprimitive nonmotorized, U = urban

Loss of Federal Land Base

The effects of the land exchange as well as the preclusion of public access on action alternatives would result in a loss of Federal land base available to users. The unique recreation setting and world-class bouldering/climbing opportunities offered on the Oak Flat Federal Parcel are not replicable elsewhere; their loss therefore constitutes an unavoidable and irreparable adverse impact to area recreation resources. While there are little user data to quantify displacement forecasts, qualitatively, the impacts can range from negligible to significant. Seasonal fluctuations in user frequency and amount vary from relatively low use in the hot summer months to over-use and resource-damaging in the winter months. These fluctuations in use levels also complicate potential conflicts with motorized and nonmotorized users. Table 3.9.4-2 below provides an overview of Federal land base lost for dispersed recreation (acres covered up by developments or fenced off).

Table 3.9.4-2. Loss of Federal land base acreages

Alternative	Acres of Access to Federal Land Lost (Tailings)	Acres of Access to Federal Land Lost (Land Exchange)	Total
Alternative 1 – No Action			
Alternative 2 – Near West Proposed Action	5,687	2.422	8,109
Alternative 3 – Near West Ultrathickened	5,687	2.422	8,109
Alternative 4 – Silver King	6,278	2.422	8,700
Alternative 5 – Peg Leg	13,027	2.422	15,449
Alternative 6 – Skunk Camp	6,513	2.422	8,935

Note: Total may not sum exactly due to rounding.

Because recreationists would no longer have access to the lands within the areas of mining operations, it is likely that increased use would occur on other nearby lands that provide similar experiences, depending upon the recreational user type. A moderate increase in user activity would be expected to occur in recreational use areas similar to those displaced by the project elsewhere in the Globe Ranger District, as well as on other Federal, State, and County lands.

Effects of Compensatory Mitigation Lands

The compensatory mitigation lands are intended for conservation purposes and would have restrictive covenants imposed. These covenants may or may not provide for recreational access. If access is allowed, it likely would include low-impact recreation (hiking, birding), but not hunting, OHV use, or camping. Recreational use of the MAR-5/Olberg site is unlikely, given its location on the Gila River Indian

Community. Recreational use of Queen Creek is highly likely, given the proximity to trail systems and the new Castleberry Campground.

Effects of Recreation Mitigation Lands

The recreation mitigation lands are anticipated to affect recreation through the development of a planned recreation trail system on NFS lands. The existing roads and trails, as well as new planned routes, will provide opportunities for hikers, equestrians, mountain bicyclists, rock climbers, and OHV users. The planned trail system will better employ the currently underdeveloped recreation opportunities of NFS lands located in close proximity to Superior and the Phoenix metropolitan area.

The recreation mitigation lands also are anticipated to reduce conflicts between recreational use and other uses of the Tonto National Forest or nearby private property. Trails were designed to reduce user motorized and nonmotorized group conflicts, to avoid trails near illegal and unauthorized shooting areas, and to eliminate private land crossing, including access to an existing mine operation not associated with the Resolution Copper Project.

Summary of Applicant-Committed Environmental Protection Measures

A number of environmental protection measures are incorporated into the design of the project that would act to reduce potential impacts on recreation. These are non-discretionary measures, and their effects are accounted for in the analysis of environmental consequences.

Applicant-committed environmental protection measures by Resolution Copper include the following:

- Developing traditional and sport climbing open to the public on Resolution Copper property outside of the mining footprint through agreement with Queen Creek Coalition. Further detail can be found on the Queen Creek Coalition website and the agreement with REI.
- Developing a concentrate pipeline corridor management plan to reestablish crossing on the Arizona Trail after construction. Further detail can be found in the Concentrate Pipeline Corridor Management Plan (M3 Engineering and Technology Corporation 2019).

To prevent exposure of the public to geological hazards, Resolution Copper would use fencing, berms, locking gates, signage, natural barriers/steep terrain (25 to 30 percent or greater), and site security measures to limit access roads and other locations near areas of heavy recreational use.

General Setting

It is possible that users could be displaced or opportunities for public recreation activities could be diminished in portions of the action alternatives area where public access is restricted. The subsidence area (approximately 1,672 acres of NFS lands, prior to the land exchange) would be lost for public access in perpetuity. Based on current knowledge, the steep and unstable slopes of the subsidence area are projected to be unsafe for future public access. Adjacent and surrounding areas likely would experience increased recreational use displaced when Oak Flat becomes unavailable. This pressure could lead to overcrowding and overuse commensurate with future increases in recreation visitation.

The removal of covering vegetation during pre-mining and mining operations would have an indirect impact on adjacent recreational users in the analysis area from diminishing the quality of the recreational setting. The recreation setting would be changed as a result of the visual contrast these activities introduce to the existing landscape. Although the sight of mining activities may not affect some recreational users (e.g., hunting or OHV driving), those seeking the features of a natural setting may see the change to the existing landscape as an obstacle to their chosen recreation activity; for instance, noise from the power line or sight of mining disturbances.

Mining-related activities associated with each alternative (East Plant Site, subsidence area, power lines, and West Plant Site (where permitted by private landowners)) would lead to increased traffic (including large trucks) on U.S. 60 (the Gila-Pinal Scenic Road) during construction and delivery of heavy equipment. This additional activity would change the experience for some visitors driving on the scenic road, and it would affect visitor safety when visitors encounter these activities. As many as 44 round-trip truck traffic shipments would occur per day. Major deliveries requiring road shutdown would be coordinated to reduce the amount of time closures consistent with current Resolution Copper practices. However, the increase in heavy-truck traffic is expected to contribute to increased traffic noise and intermittent traffic slowdowns on this scenic portion of U.S. 60. The recreation experience for those visitors and locals who currently use U.S. 60 and the Gila-Pinal Scenic Road would change due to the increase in large truck traffic.

Pipeline corridor construction would require motorized access in some areas where there is no access, introducing a new use and changing the recreation setting.

The action alternatives area would eliminate motorized vehicle access via multiple modes and dispersed camping opportunity in GMU 24B. The majority of the routes that would be eliminated are unmaintained routes that do not require technical 4×4 vehicles or skill and are thus also popular for dispersed camping. The motorized routes that would remain open around mine facilities are more rugged and require more technical 4×4 vehicles and skill. As a result, the motorized routes remaining open would not accommodate all classes of vehicles and would restrict access to those with 4-wheel drive only. The loss of access also equates to elimination of motorized dispersed camping opportunity from the most accessible low-elevation portions of GMU 24B. Loss of motorized routes and dispersed camping areas likely would result in more concentrated recreation levels and congested conditions (e.g., camping, OHV, recreational shooting, horseback riding, etc.) along remaining low-elevation access points close to U.S. 60.

Special Use Activities

Existing permitted outfitter and guide services for recreation or hunting would continue to operate throughout the analysis area but would no longer be permitted to use areas within the East Plant Site (including Oak Flat), and, depending upon the alternative, the proposed tailings storage facility and tailings corridors that are closed to public access. Future special uses would be considered on a case-by-case basis as applications are received. Special use activities are not analyzed in the following text for each alternative; supporting analysis is in the project record.

Recreation Opportunity Spectrum

A direct loss of acreage available for recreation activities would occur under all action alternatives. Each of the action alternatives would result in the direct removal of differing amounts of acres from public entry, which represents the area that would be enclosed by perimeter fencing for public safety purposes. It is assumed that all areas on NFS land (and certain ASLD, BLM, and private lands), other than that excluded for safety, would eventually be opened to public access post-mining. The subsidence area (approximately 1,672 acres of NFS lands, prior to the land exchange) would be lost for public access in perpetuity. Based on current knowledge, the steep and unstable slopes of the subsidence area are projected to be unsafe for future public access. However, the exact area and timing of opening areas to public access would need to be evaluated at the end of mining activities. While not anticipated, some areas (other than the subsidence area, e.g., pipelines, rail lines, or power lines) may be not be safe for public access, while others may require public access restrictions until reclamation activities have been successfully completed.

In addition to the direct loss of acreage available for recreation activities and opportunities, a change from the existing undeveloped nature of the analysis area (semiprimitive settings) and surrounding area to a more developed, industrialized setting would occur under all action alternatives. During construction, active mining and operations, and closure and final reclamation, the affected areas would not be compatible with the established setting indicators for any of the ROS settings present.

The industrialized setting of the East Plant Site would include increased industrial noise, mine-related traffic, and equipment operation (including backup alarms). Traffic, construction, and equipment operation within the project area would result in increased noise, ranging from 80 to 30 dBA at the fence line surrounding mining operations. A noise level of 80 dBA is comparable to the sound of a forklift or front-end loader from 50 feet away. A noise level of 30 to 40 dBA is comparable to the sound of a quiet suburban area at night (Tetra Tech Inc. 2019).

Although these increased noise levels associated with operations would not be readily apparent to motorized recreational users over the sound of their personal vehicles, sounds during mine operations may be audible to campers, hikers, mountain bikers, and equestrians from the fence line surrounding mining operations or along access roads. In particular, campers using dispersed sites in close proximity to mining operations and daytime visitors to Apache Leap could be impacted by increased noise levels resulting from facility operations. However, the degree of impact from noise on dispersed recreation is largely dependent on timing, terrain shielding, open landscapes, and mining noise attenuation and dispersion.

Mining operations lighting would result in changes to the nighttime recreational setting on lands surrounding the East Plant Site by increasing sky glow and direct visible glare both from facilities and vehicles; design features would minimize the impact but would not eliminate it (Dark Sky Partners LLC 2018). These changes may contribute to displacement of dispersed, nonmotorized recreation activities and opportunities from lands within and surrounding the analysis area.

The location of the new power line corridors between Oak Flat Substation, East Plant Site, West Plant Site, and the MARRCO corridor would be the same under all action alternatives. During and following construction, the presence of a new power line would contribute to diminishing the recreation setting (classified as roaded natural) along the power line corridor but would be consistent with the management objectives for the area. The impacts on ROS that are specific to each alternative are discussed in the following text.

Hunting

Hunting opportunities (for both big and small game) could be displaced by mining activities. This would be a minor impact on hunting overall and would not completely eliminate hunting opportunities in the affected GMUs, since the areas within GMUs that are outside of the alternatives' footprints would remain available for hunting, subject to applicable laws and regulations. Resolution Copper would post signs in accordance with the laws and regulations for hunting to indicate the areas that would be closed to hunting to accommodate mining activities. Nonetheless, impacts on individual hunters may be moderate or even major if public use of an individual hunter's preferred hunting grounds is eliminated, decreasing the chances of a successful hunt. As shown in a recent AGFD report (Arizona Game and Fish Department 2018c), hunter valuation surveys found that a moderate to high number of hunters found the areas west of Superior, Arizona, to be of high value for hunting mule deer, white-tailed deer, javelina, quail, dove, and predator species.

In addition, human presence and mining activities likely would cause some wildlife species to temporarily avoid these areas. Many of the wildlife species being hunted likely would not be present during mining activities due to increased noise, light, and human activity. Following mining activities, disturbed areas would return to preexisting conditions to the extent practicable. It is expected that wildlife would no longer avoid areas but return to the extent that the native habitats return. Active impacts on hunting would cease and hunting opportunities likely would improve over time as wildlife habitats return to disturbed areas. Mining activities would not avoid hunting seasons in some instances and there would be site-specific, localized, moderate impact on individual hunters (or hunting groups and outfitters) during mining activities if their preferred access is temporarily or permanently closed or restricted. This impact would not extend to hunting overall, but could represent a long-term obstacle to an individual hunter's preferred access to a particular area. Coordination with the AGFD would attempt to avoid and minimize these impacts. The number of Arizona hunting permits that are issued in individual GMUs would not change as a result of any of the action alternatives being implemented. The availability to hunt in the analysis area's GMUs and the number of hunting permits per GMU would not be affected under any action alternative. Further, hunter days would not change under any alternative, since hunting could persist elsewhere in the GMU. Hunting is not analyzed for each alternative.

SERI species are pursued by hunters and, because the proposed project would remove habitat for these species as well as change habitat use patterns, it is possible that hunting opportunities for these species could be reduced in localized areas near project facilities.

Recreation Sites

There would be no direct impacts on designated wilderness as a result of any of the action alternatives. Visitors to the Superstition Wilderness would have foreground and background views of the East Plant Site from trails and overlooks, which would be similar to the existing views of the East Plant Site but with a larger visual effect. The most affected views would be from the several trails that provide both motorized and nonmotorized access to mountain and ridgetop summits and would afford direct, superior (from above and oriented downward), and unadulterated views of mining operations (e.g., north of Superior or north of Oak Flat). Similarly, views from Apache Leap and Picketpost Mountain would have unadulterated views of the East Plant Site. Although the location and size of the different elements of the project vary by alternative, because of the distance and angle of views, the impacts on the public visiting the wilderness, Apache Leap, and Picketpost Mountain would be similar for all action alternatives. Views of the East Plant Site would contribute to a slightly more diminished sense of solitude and primitive setting for some wilderness visitors (see Section 3.11, Scenic Resources).

Activities from mine operations that produce sound (as described in Section 3.4, Noise and Vibration) would be noticeable to users of adjacent dispersed recreation areas. The degree of impact from noise on the recreation setting is largely dependent on the chosen recreation activity, terrain shielding, open landscapes, and mining noise dispersion.

ARIZONA NATIONAL SCENIC TRAIL

Regardless of the alternative chosen, new pipelines constructed within the MARRCO corridor would cross Passage 18 of the Arizona Trail. Any new development intersecting the Arizona Trail corridor would interfere with the nature and purposes of the Arizona Trail. We disclose the relative amount of interference to the Arizona Trail experience that would be expected to occur for each alternative, including the disturbance from the MARRCO corridor.

There would be short-term impacts on trail users during construction activities when disturbance precludes use for safety reasons (e.g., active grading, transport of heavy equipment, active construction).

These impacts would occur during the activity, and when conditions are safe for hikers, cyclists, and equestrian users, the impact would cease. Contractors would provide necessary detours or signage for Arizona Trail user awareness during these activities. Existing disturbances in this area include a railroad corridor, trailhead parking, and Hewitt Station Road.

Motorized Recreation

Under all alternatives, certain NFS roads would be closed to public use, either because the route would be covered or removed as a result of the construction of the East Plant Site or the West Plant Site, or because the route would no longer be safe for the public to use (e.g., the subsidence area), or both. Additionally, mine-related traffic/haul trucks using NFS roads could conflict with motorized recreation users. The most likely instance for conflict between motorized users and mine-related traffic (on NFS roads) would occur on the NFS Road 229/Silver King Mine Road area; however, in most cases, there would be no conflict at all since the mine-related traffic likely would be standard trucks transporting personnel. In many cases, NFS routes would be crossed by a linear feature such as the MARRCO corridor or the power line corridor and would be closed during construction, and after that time only closed for brief periods of maintenance when not safe for public use. Site-specific impacts on motorized recreation would occur but would cease if the route is safe for public use. The ability to piece together a looped travel route is an important aspect of motorized recreation; the fewer routes available, the more difficult it is to piece together complete loops. The analysis area, popular for day or half-day OHV trips, would have some specific loops or destinations that would no longer be feasible, would require further travel, or would have limited opportunity for easier, less-technical OHV use. Table 3.9.4-3 presents the NFS roads that would be impacted under all action alternatives.

Table 3.9.4-3. National Forest System roads that would be impacted under all action alternatives

NFS Road No.	Distance (miles)	Location
2432	0.78	East Plant Site/Subsidence area
2433	0.23	East Plant Site/Subsidence area
2434	0.29	East Plant Site/Subsidence area
2435	0.28	East Plant Site/Subsidence area
2438	0.32	East Plant Site/Subsidence area
315	2.28	East Plant Site/Subsidence area
3153	1.19	East Plant Site/Subsidence area
3791	0.01	East Plant Site/Subsidence area
1933	0.07	MARRCO corridor
229	0.01	MARRCO corridor
2396	0.01	MARRCO corridor
252	0.01	MARRCO corridor
293	0.01	MARRCO corridor
3454A	0.01	MARRCO corridor
3454C	0.01	MARRCO corridor
357	0.40	MARRCO corridor
8	0.01	MARRCO corridor
1010	0.37	West Plant Site
229	1.10	West Plant Site

NFS Road No.	Distance (miles)	Location
229	1.07	Silver King Mine Road realignment
2401	0.01	Silver King Mine Road realignment

Site-specific and localized moderate impact on individual motorized users (or groups or permitted guides/outfitters) during mining activities would occur if their preferred access is temporarily or permanently closed or restricted. Indirect impacts of the loss of routes shown in table 3.9.4-3 include changes in how users must reach destinations (i.e., a change to a user's recreation experience). If closed, a given route's destination may still be reachable but from a different ingress point and potentially a sequence of connected but much longer routes. This impact would not extend to motorized recreation in the analysis area overall but could represent an obstacle or change to an individual motorized user's preferred access to a particular area.

Rock Climbing

Rock climbing areas on the private lands of Queen Creek Canyon (e.g., The Pond, Atlantis) are outside mining activities but do lie atop the Never Sweat Tunnel. Rock climbing opportunities at Euro Dog Valley, Oak Flat, and portions of the Mine Area would be lost under all action alternatives. Table 3.9.4-4 provides a breakdown of the climbing opportunities that would be lost under all alternatives due to the development of the East Plant Site.

Table 3.9.4-4. Climbing resources that would be lost under all action alternatives

Climbing Area	Roped Climbing Routes	Boulder Problems
Oak Flat (East and West)	Sport routes: 2 Trad routes: 0 Top-rope routes: 3 Aid routes: 0 **Total: 5**	Boulder problems: 527 Top-rope boulder problems: 268 **Total: 795**
Euro Dog Valley	Sport routes: 37 Trad routes: 8 Top-rope routes: 2 Aid routes: 1 **Total: 48**	Boulder problems: 179 Top-rope boulder problems: 99 **Total: 278**
The Mine Area	Sport routes: 100 Trad routes: 27 Top-rope routes: 23 Aid routes: 0 **Total: 150**	Boulder problems: 41 Top-rope boulder problems: 0 **Total: 41**

Source: Oliver (2017)

The loss of Euro Dog Valley and Oak Flat would be a major, long-term impact on the climbing opportunities of central Arizona, particularly bouldering. There are no other developed climbing areas that are as specific to bouldering and that offer as many opportunities as Euro Dog Valley and Oak Flat in the analysis area. The nearest bouldering opportunities that even come close to the bouldering opportunities that are available at Euro Dog Valley and Oak Flat are located in northwest Phoenix (Icecapades and South Mountain); Prescott, Arizona; and Mount Lemmon near Tucson, Arizona.

3.9.4.3 Alternative 2 – Near West Proposed Action

The analysis for potential impacts on recreation resources of Alternative 2 where implemented only applies to the tailings storage facility location; all other project components and activities and their potential to impact recreation resources remain identical to those described earlier in this section under "Impacts Common to All Action Alternatives."

General Setting

The tailings storage facility would be located in an area of the Tonto National Forest that experiences high use (particularly during the fall and winter seasons) for both dispersed and motorized recreation. All public access on federal lands would be eliminated on approximately 8,109 acres, the area to be fenced surrounding the tailings storage facility and tailings corridor, the borrow area, the East Plant Site, land exchange boundary, and subsidence area (see table 3.9.4-2). Though the analysis area has a long history of mining, the current recreation setting would change in the tailings storage facility and immediately adjacent lands. Activities involving hiking or driving to ridgetops increase the likelihood that the tailings storage facility would be visible and change the recreation setting. The Arizona Trail is approximately 1 mile east of the tailings storage facility, paralleling the eastern boundary of the tailings storage facility for 3 miles. Dispersed recreation activities would be affected throughout the duration of construction all the way through reclamation (year 0 to 55) as noises, visual disturbances, and/or the presence of other humans could detract from their chosen recreation opportunities and activities. Recreation users who seek opportunities for solitude commonly seek areas where they would be less likely to see other humans. The use patterns for recreationists seeking opportunities for solitude would be affected, including displaced use or shifting proximity.

The changes to public motorized access could permanently change the OHV use patterns in the area, subject to Federal, State, and local OHV and traffic laws and regulations. New private access roads would be signed and would be closed to the public, but illegal OHV use may not be entirely preventable on the new access roads. Existing and new OHV users may be drawn to the tailings storage facility and tailings corridor through curiosity and interest in mining. Design features such as locked gates and signage indicating road status would decrease the magnitude of these impacts. Illegal and/or unauthorized use of access roads would be enforceable by Forest Service law enforcement, or other local jurisdiction law enforcement (e.g., County or State).

Recreation Opportunity Spectrum

The Alternative 2 tailings storage facility, borrow area, tailings pipeline corridor, and other facilities would result in the direct removal of public access on up to approximately 6,798 acres of Tonto National Forest lands, resulting in changes to the ROS setting (see table 3.9.4-1). Access to lands within the perimeter fence would be closed to the public for safety concerns.

None of the tailings storage facility would occur within the semiprimitive nonmotorized setting. Approximately 4,407 acres of the tailings storage facility would be within the semiprimitive motorized setting, and approximately 1,266 acres within the roaded natural setting; these areas would be unavailable for public use. Figure 3.9.3-3 shows the ROS settings that would be impacted by all action alternatives. The ground disturbance and installation of facilities associated with the tailings storage facility and tailings corridor would result in a change from the existing undeveloped, semiprimitive nonmotorized and motorized recreation setting on lands surrounding the tailings storage facility to a developed setting, visible from superior views for miles in all directions. People currently use these areas for a wide variety of recreation activities. This change would result in a reduction of and less than 1 percent of the available roaded natural setting within the Globe Ranger District, and about 1 percent of the available roaded natural setting within the Mesa Ranger District. While most of these lands would still be available for these uses after closure of the mine after reclaimed areas are potentially opened, the recreation opportunity available to the public would change during operations.

The activities proposed under Alternative 2 would represent a change to the existing recreational setting; however, it is anticipated that changes would be consistent with the designated ROS classification of semiprimitive motorized.

Recreation Sites

Visitors to the Superstition Wilderness, Picketpost Mountain, and Apache Leap would have foreground and background views of the Alternative 2 facilities from trails and overlooks, and the recreation setting from certain site-specific views would change if the tailings storage facility were visible. The tailings storage facility would be located 3.75 miles from the Superstition Wilderness, 3 miles from Picketpost Mountain, and 5.25 miles from Apache Leap.

ARIZONA NATIONAL SCENIC TRAIL

In the Passage 18 segment, 0.07 mile of the proposed tailings pipeline corridor would intersect the Arizona Trail, interfering with the nature and purpose of Passage 18 of the Arizona Trail. The Arizona Trail management corridor extends 0.5 mile on either side of the Arizona Trail; the proposed tailings pipeline corridor would affect approximately 45 acres of the Arizona Trail corridor. The intersection of the Arizona Trail occurs in two separate locations, approximately 4 miles north of the beginning (i.e., trailhead) of Passage 18, and approximately 14 miles south of the ending of Passage 18, where the Arizona Trail transitions to another passage at the southern boundary of the Superstition Wilderness.

The area of these intersections is in highly variable topography. At the point of intersections with Alternative 2, the Arizona Trail is located on the bottom of drainages associated with Potts and Whitford Canyons, flanked by steep canyon walls on all sides in an area that is relatively undisturbed, but does show signs of motorized uses and mining activities, such as traffic on NFS Road 982. NFS Road 982 shares the same point of intersection with the proposed Alternative 2 tailings corridor as the Arizona Trail. This area is currently managed under the ROS classification of semiprimitive motorized.

Because Alternative 2 would result in substantial interference with the nature and purpose of the Arizona Trail, Resolution Copper is proposing substantial design features. Resolution Copper would construct an “overpass” for the tailings corridor that would span the Arizona Trail, as shown on Figure 3.0-1h of the GPO. Recreation access along Passage 18 would be maintained during construction, and the span would not impede Arizona Trail access during operation or maintenance. There would be short-term impacts on trail users during construction activities when disturbance precludes use for safety reasons (e.g., active grading, transport of heavy equipment, active construction), but these would only occur during the activity, and when conditions are safe for hikers, cyclists, and equestrian users, the impact would cease. Contractors would provide necessary detours or signage for Arizona Trail user awareness during these activities. There would be long-term impacts to trail users (their experiences and the setting) during operation and maintenance, as the presence of the tailings corridor activities and the physical presence of the pipeline overpass would conflict with Segment 18’s nature and purpose, and change the recreation setting.

Motorized Recreation

The tailings storage facility would intersect 27 NFS roads. Section 3.5 provides a breakdown of the NFS roads that would be impacted by Alternative 2. Not all NFS roads impacted by project activities would be rerouted. However, where motorized access along connecting roads would be interrupted by the tailings storage facility, roads would be rerouted to maintain connectivity across the landscape. More detail can be found in Section 3.5, Transportation and Access.

Rock Climbing

There are no known or documented climbing resources within the proposed Alternative 2 tailings storage facility or along the tailings corridor; opportunities to develop new climbing resources would not be available. This tailings facility location would not have additional impacts on climbing resources outside of the impacts common to all.

3.9.4.4 Alternative 3 – Near West - Ultrathickened

The impacts would be the same as described under Alternative 2.

3.9.4.5 Alternative 4 – Silver King

General Setting

The recreation setting is similar to that described under Alternative 2. The area currently experiences slightly less use than Alternative 2 and 3 because access (both nonmotorized and motorized) requires traveling farther distances or more difficult routes than Alternatives 2 and 3. All public access on federal lands would be eliminated on approximately 8,700 acres, the area to be fenced surrounding the tailings storage facility and tailings corridor, the borrow area, the East Plant Site, land exchange boundary, and subsidence area (see table 3.9.4-2).

Recreation Opportunity Spectrum

The Alternative 4 tailings storage facility, borrow area, and tailings pipeline corridor, and other facilities would result in the direct removal of public access on up to approximately 7,542 acres of Tonto National Forest lands, resulting in changes to the ROS setting (see table 3.9.4-1). A total of approximately 18 acres would be within semiprimitive nonmotorized settings, approximately 5,088 acres within the semiprimitive motorized setting, and approximately 608 acres within the roaded natural setting; these areas would be unavailable for public use. In addition, approximately 1,828 acres of urban areas (or unclassified areas) would be unavailable for public use. Figure 3.9.3-3 shows the ROS settings that would be impacted by all action alternatives. The ground disturbance and installation of facilities associated with the tailings storage facility and tailings corridor would result in a change from the existing undeveloped, semiprimitive nonmotorized and motorized recreation setting on lands surrounding the tailings storage facility to a developed setting, visible from superior views for miles in all directions. People currently use these areas for a wide variety of recreation activities. This change would result in a reduction of less than one percent of the available semiprimitive nonmotorized setting and less than 1 percent of the available roaded natural setting within the Globe Ranger District, and less than 1 percent of the roaded natural setting within the Mesa Ranger District. While most of these lands would still be available for these uses after closure of the mine after reclaimed areas are potentially opened, the recreation opportunity available to the public would change during operations. After mine closure and reclamation, it is anticipated that the ROS value of semiprimitive nonmotorized would be restored to the Silver King area to the extent practical.

The activities proposed under Alternative 4 would represent a change to the existing recreational setting; however, it is anticipated that changes would be consistent with the designated ROS classification of semiprimitive motorized.

Recreation Sites

Visitors to the Superstition Wilderness, Picketpost Mountain, and Apache Leap would have foreground and background views of the tailings storage facility from trails and overlooks, and the recreation setting from certain site-specific views would change if the tailings storage facility were visible. The tailings storage facility would be located approximately 0.6 mile from the southern boundary of the Superstition Wilderness, 4 miles from Picketpost Mountain, and 1.95 miles from the north end of Apache Leap.

ARIZONA NATIONAL SCENIC TRAIL

The Arizona Trail is located within the Alternative 4 proposed tailings storage facility. This would result in substantial interference to the nature and purpose of the Arizona Trail. Implementation of Alternative 4 would require 3.05 miles of the Arizona Trail to be closed and relocated to an area that would be safe for public use, which would meet the intent of the National Trails System Act and fulfill the nature and purpose of the Arizona Trail. Relocation of the Arizona Trail would require identification, environmental studies, and construction to replace the approximately 4 to 5 miles of existing trail that would be impacted under Alternative 4. The new construction would require a different trailway approach and exit in addition to the 3.05-mile direct loss of Arizona Trail. A temporary route may be required for Arizona Trail through-hikers for approximately 1 to 2 years until a permanent reroute location is identified, studied, and designated. In addition to the Arizona Trail, the Silver King alternative also intersects NFS Roads 342 and 650.

Motorized Recreation

The tailings storage facility would intersect 24 NFS roads. Not all NFS roads impacted by this alternative would be rerouted. However, where motorized access along connecting roads would be interrupted by the tailings storage facility, roads would be rerouted to maintain connectivity across the landscape. More details can be found in Section 3.5, Transportation and Access.

Rock Climbing

There are no known or documented climbing resources within the Alternative 4 tailings storage facility or along the tailings corridor; opportunities to develop new climbing resources would not be available. This tailings facility location would not have additional impacts on climbing resources outside of the impacts common to all.

3.9.4.6 Alternative 5 – Peg Leg

General Setting

The majority of the tailings storage facility and tailings corridor for this alternative would be located on BLM-administered lands that experience heavy motorized and nonmotorized recreation. Recreation is generally concentrated on the existing routes and on lands adjacent to the Gila River, north of where the tailings storage facility would be located. BLM-administered lands within and adjacent to the tailings storage facility are managed as an ERMA. Nonetheless the area is used regularly by the public and possesses high recreation value and qualities due to the remote nature, varied topography, and presence of the Gila River. The tailings storage facility would block an existing unpaved route known as Peg Leg road, an important recreational access to public lands in the area, and a number of unnamed roads.
The storage facility would disrupt vehicle access to public lands north of the site, creating a nonmotorized area, unless vehicle access is provided through route realignment. All public access on federal lands would be eliminated on approximately 15,449 acres, the area to be fenced surrounding the tailings storage facility and tailings corridor, the borrow area, the East Plant Site, land exchange boundary, and subsidence area (see table 3.9.4-2). Areas associated with Arizona State Trust lands, generally open to

public access, would also be lost. The pipeline corridor crosses Battle Axe Road, a popular, unpaved BLM route heavily used for recreational access.

Approximately 8 miles of the pipeline corridor would be located on Tonto National Forest land south of the town of Superior, passing east and west of Picketpost Mountain and Boyce Thompson Arboretum. This area of the Tonto National Forest experiences high-use dispersed and motorized recreation and nonmotorized use on LOST trails. Impacts on recreation on Tonto National Forest lands and OHV use patterns on public lands would be similar to those described for Alternative 2.

Recreation Opportunity Spectrum

Only some portions of this alternative are located on Tonto National Forest land; therefore, only the acres of ROS that could be impacted by the tailings storage facility pipeline corridor rights-of-way described above are quantitively discussed in this section. Impacts on recreation on BLM-administered and State Trust lands are described under "General Setting."

None of the tailings storage facility would be within the identified ROS settings, and only portions of the tailings corridor would be within the identified ROS settings. The Alternative 5 facilities would result in the direct removal of public access on up to approximately 2,347 acres of Tonto National Forest lands, resulting in changes to the ROS setting (see table 3.9.4-1). A total of approximately 95 acres would be within the semiprimitive motorized setting, and approximately 1,044 acres within the roaded natural setting; these areas would be unavailable for public use. In addition, approximately 1,208 acres of urban areas (or unclassified areas) would be unavailable for public use. Figure 3.9.3-3 shows the ROS settings that would be impacted by all action alternatives. The ground disturbance and installation of facilities associated with the tailings storage facility pipeline corridor would result in a change from the existing undeveloped recreation setting on lands surrounding the tailings storage facility pipeline corridor right-of-way to a more developed setting. People currently use these areas for a wide variety of recreation activities. This change would result in a reduction of less than one percent of the of the available semiprimitive motorized setting, and about one percent of the available roaded natural setting within the Globe Ranger District, and less than one percent of the roaded natural setting within the Mesa Ranger District. While most of these lands would still be available for these uses after closure of the mine after reclaimed areas are potentially opened, the recreation opportunity available to the public would change during operations.

The activities proposed under Alternative 5 pipeline route would represent a change to the existing recreational setting; however, it is anticipated that changes would be consistent with the designated ROS classification of semiprimitive motorized.

Recreation Sites

Visitors to the White Canyon Wilderness would have background views of the tailings storage facility pipeline corridor from some trails and overlooks, and the recreation setting from certain site-specific views would change if the tailings storage facility pipeline corridor were visible. The White Canyon Wilderness is located approximately 0.6 mile from the tailings storage facility pipeline corridor at its nearest point.

ARIZONA NATIONAL SCENIC TRAIL

The Arizona Trail is within the Alternative 5 proposed tailings storage facility (for approximately 0.13 mile) pipeline corridor right-of-way. Impacts on the Arizona Trail Passage 16 (Gila River Canyons) as a result of the intersection with the pipeline corridor are discussed in more detail in the following text.

The Arizona Trail would be intersected by 0.18 mile of the proposed tailings storage facility pipeline corridor, in the Passage 16 segment. The Arizona Trail management corridor extends 0.5 mile on either side of the Arizona Trail; the proposed tailings storage facility corridor would affect approximately 116 acres of the Arizona Trail corridor. The intersection with the Arizona Trail is approximately 20 miles south of the beginning (i.e., trailhead at the Tonto National Forest boundary) of Passage 16, and approximately 6 miles north of the ending of Passage 16, where the Arizona Trail transitions to another passage when it crosses the Kelvin–Riverside Bridge.

The area of this intersection is in the uplands adjacent to the Gila River on BLM-administered land, with sweeping views of the Gila River Canyon and mountains to the south. At the point of intersection with the Alternative 5 tailings storage facility pipeline corridor, the Arizona Trail is located on the southern flank of uplands north of the Gila River floodplain and just southeast of The Spine, a prominent geological feature. The area is largely undisturbed; with the exception of the Southern Pacific rail line located on the south side of the Gila River, there is very little to no motorized access to the area. New road construction along the pipeline route would change the recreation setting during construction and operation, conflicting with the nature and purposes for this segment. The pipeline corridor would open vehicle access in small areas currently inaccessible to motor vehicles along the Gila River, changing the recreational setting along Passage 16, Gila River Canyons. Recreational users that seek opportunities for solitude commonly seek areas where they would be less likely to see other humans, and this would be harder to achieve in this area. Hikers, equestrian users, mountain bikers, and other dispersed activities would be affected as noises, visual disturbances, and/or the presence of other humans could detract from their chosen recreation opportunities and activities during the approximately 50-year mine life.

Because Alternative 5 would result in substantial interference with the nature and purpose of the Arizona Trail, Resolution Copper is proposing substantial design features. Resolution Copper would construct an “overpass” for the tailings corridors that would span the Arizona Trail, as shown in Figure 3.0-1h of the GPO. Recreation access along Passage 16 would be maintained during construction, and the span would not impede Arizona Trail access during operation or maintenance. There would be impacts on trail users during construction activities when disturbance precludes use for safety reasons (e.g., active grading, transport of heavy equipment, active construction), but these would only occur during the activity, and when conditions are safe for hikers, cyclists, and equestrian users, the impact would cease. Contractors would provide necessary detours or signage for Arizona Trail user awareness during these activities.

The BLM manages the area as Visual Resource Management Class III (see Section 3.11, Scenic Resources, for a detailed discussion of BLM Visual Resource Management classes) which allows for a moderate amount of visual change to the landscape, to which the activities proposed under Alternative 5 would conform. The presence of the tailings storage facility pipeline corridor in the area would result in long-term impacts on the undisturbed and natural character of the landscape, resulting in a change to the recreation setting of that portion of Passage 16.

OTHER TRAILS

The pipeline corridor would be visible from existing Tonto National Forest trails and overlooks on Picketpost Mountain. Resolution Copper anticipates burying the pipelines in visually sensitive areas; no buried pipeline locations have yet been identified.

Motorized Recreation

The Peg Leg alternative would intersect approximately 4 miles of existing Pinal County trail corridors and OHV trails (Logan Simpson Design Inc. 2007). These trails would be lost to public recreation use.

The tailings storage facility pipeline corridor right-of-way would intersect 18 NFS roads. The tailings storage facility would intersect three named roads (Tea Cup Road, Tea Cup Ranch Road, Peg Leg Road) and an unknown number of unnamed roads and trails. There would be approximately 23 miles of BLM routes that would be intersected by the tailing storage facility. The pipeline corridor would cross popular heavily used routes used for recreational access to BLM lands, including Mineral Mountain Road, Cottonwood Canyon Road, Sandman Road, Price Road, Whitlow Ranch Road, and Cochran Road. It would also cross Battle Axe Road, a popular route heavily used for recreational access. Both temporary and new access roads for construction and maintenance along the pipeline corridors would open vehicle access in small areas currently inaccessible to motor vehicle, changing the recreational setting. This would result in site-specific closures or delays, which could disrupt recreation user experiences. These delays are not anticipated to persist for more than several days at a time as construction progresses, and public safety can be maintained.

Not all NFS and BLM roads impacted by this alternative would be rerouted, closed, or restricted. However, where motorized access along connecting roads would be interrupted by the tailings storage facility, roads would be rerouted to maintain connectivity across the landscape. This would result in site-specific changes to the recreation setting, which could change recreation user experiences. These changes in user experiences range in severity depending upon conditions (e.g., a major change could be generations of users no longer being able to use an area; a minor change could be that it takes more time to arrive at a destination).

More detail can be found in Section 3.5, Transportation and Access.

Rock Climbing

There are no known or documented climbing resources within the tailings storage facility or tailings corridors.

3.9.4.7 Alternative 6 – Skunk Camp

General Setting

The majority of the tailings storage facility for this alternative would be located on Arizona State Trust and private lands that experience low levels of public dispersed recreation. The tailings corridor crosses Forest Service, Arizona State Trust and private lands with low levels of public dispersed recreation. The area shows evidence of OHV recreation, and numerous unnamed jeep trails are present throughout valley bottoms and along ridges; however, the majority of the area is undisturbed. BLM-administered lands adjacent to the tailings storage facility are managed as an ERMA, where typically recreation is non-specialized, dispersed, and does not require intensive management. All public access on federal lands would be eliminated on approximately 8,935 acres, the area to be fenced surrounding the tailings storage facility and tailings corridor, the borrow area, the East Plant Site, land exchange boundary, and subsidence area (see table 3.9.4-2). Areas associated with Arizona State Trust lands, generally open to public access, would also be lost.

Recreation users who seek opportunities for solitude commonly seek areas where they would be less likely to see other humans. Dispersed recreation activities in the vicinity of project operations would be subject to varying levels of noise, visual disturbances, and/or the presence of other humans throughout the project lifespan, which could detract from their chosen recreation opportunities and activities.

The pipeline corridor would be located on Tonto National Forest land adjacent to the town of Superior and would pass east of Oak Flat. The pipeline corridor crosses Devil’s Canyon. These areas of the Tonto National Forest experience high-use dispersed and motorized recreation.

Recreation Opportunity Spectrum

Similar to Alternative 5, only some portions of this alternative are located on Tonto National Forest land (none of the tailings storage facility would be located on areas of ROS classifications). Impacts on recreation on BLM-administered and State Trust lands are described under "General Setting."

The Alternative 6 facilities would result in the direct removal of public access on up to approximately 1,768 acres of Tonto National Forest lands, resulting in changes to the ROS setting (see table 3.9.4-1). A total of approximately 146 acres would be within the semiprimitive nonmotorized setting, approximately 246 acres within the semiprimitive motorized setting, and approximately 253 acres within the roaded natural setting; these areas would be unavailable for public use. In addition, approximately 1,123 acres of urban areas (or unclassified areas) would be unavailable for public use.

Figure 3.9.3-3 shows the ROS settings that would be impacted by all action alternatives. The ground disturbance and installation of facilities associated with the tailings storage facility, tailings corridor, and new powerline would result in a change from the existing undeveloped, recreation setting on lands surrounding the tailings storage facility to a developed setting. People currently use these areas for a wide variety of recreation activities. This change would result in a reduction of less than one percent of the available semiprimitive nonmotorized setting, less than one percent of the semiprimitive motorized setting, and less than 1 percent of the available roaded natural setting within the Globe Ranger District, and less than 1 percent of the roaded natural setting within the Mesa Ranger District. While most of these lands would still be available for these uses after closure of the mine after reclaimed areas are potentially opened, the recreation opportunity available to the public would change during operations.

The activities proposed under Alternative 6 pipeline route would represent a change to the existing recreational setting; however, it is anticipated that changes would be consistent with the designated ROS classification of semiprimitive motorized.

Recreation Sites

No designated recreation sites or scenic trails are located within the tailings storage facility or tailings corridors, nor would the tailings storage facility be visible from any designated wilderness areas. However, the portions of this alternative in Pinal County are designated Open Space suitable for recreation purposes (Logan Simpson Design Inc. 2007). The tailings pipeline corridor would be visible from the Superstition Wilderness.

Motorized Recreation

The tailings storage facility pipeline corridor right-of-way would intersect 23 NFS roads, and the transmission line corridor right-of-way would intersect four NFS roads.

The tailings storage facility would intersect three named roads (Dripping Springs Road, Troy Ranch Road, and Looney Springs Trail) and an unknown number of unnamed roads and trails within the Dripping Springs basin. There would be approximately 15 miles of BLM routes that would be intersected by the tailing storage facility. Not all NFS and BLM roads impacted by this alternative would be rerouted. However, where motorized access along connecting roads would be interrupted by the tailings storage facility, roads would be rerouted to maintain connectivity across the landscape. More details can be found in Section 3.5, Transportation and Access.

Rock Climbing

There are no known or documented climbing resources within the fence line of the Alternative 6 tailings storage facility; however, the pipeline corridor and power line corridor for Alternative 6 cross three areas of high-quality climbing resources. The pipeline corridor crosses Upper Devil's Canyon. There would be impacts on climbers during construction activities when disturbance precludes use for safety reasons (e.g., active grading, transport of heavy equipment, active construction), but this would only occur during the project-related activity. When conditions are safe for climbing, the impact would diminish but would not be eliminated since the pipeline corridor would change the recreation setting permanently.
The presence of the tailings storage facility pipeline corridor and transmission line infrastructure across the canyons may block or eliminate climbing routes, as well as change the recreation setting of the areas. Under this alternative, there would be long-term impacts on climbing resource access in the area.

3.9.4.8 Cumulative Effects

Full details of the cumulative effects analysis can be found in chapter 4. The following represents a summary of the cumulative impacts resulting from the project-related impacts described in Section 3.9.4, Environmental Consequences, that are associated with recreation, when combined with other reasonably foreseeable future actions.

The following actions were determined through the cumulative effects analysis process to be reasonably foreseeable, and have impacts that likely overlap in space and time with impacts from the Resolution Copper Project:

- Pinto Valley Mine Expansion
- Ray Land Exchange and Proposed Plan Amendment
- Ripsey Wash Tailings Project
- Silver Bar Mining Regional Landfill and Cottonwood Canyon Road
- Wild and Scenic River Eligibility Study

The cumulative effects analysis area for recreation includes the project footprint and MA 2F of the Globe Ranger District of the Tonto National Forest; Passages 15, 16, and 17 of the Arizona Trail; and GMUs 24A, 24B, and 37B. The metrics used to quantify cumulative impacts to recreation resources are (1) the physical footprint of RFFAs that occurs on lands open to recreation, either ASLD land or Federal lands [acres], (2) loss of recreational backroads or trails [number], and (3) impact to experience on the Arizona Trail [segments affected]. Recreation is impacted when users have less public land—either state or Federal—within which to recreate, whether camping, hiking, nature viewing, climbing, or biking. Motorized users and hikers would be impacted by increasing loss of miles of trail or roads available for recreation. Arizona Trail users would have a change in experience with more miles exposed to industrial development instead of natural areas.

It should be noted that the Wild and Scenic River Eligibility Study overall represents a beneficial effect on recreation. For the purposes of the cumulative effects analysis, it has been analyzed in the same way as those RFFAs that would have adverse effects. This approach was chosen to avoid trying to qualitatively estimate whether beneficial and adverse effects from different RFFAs would offset each other. The resulting cumulative effects analysis should overestimate overall cumulative impacts to recreation resources.

- Loss of ASLD or Federal lands for recreation. The five reasonably foreseeable future actions above, combined with the Resolution Copper Project, represent about 26,800 acres of Federal or

State lands out of the 1.6 million acres of Federal and State lands within the cumulative effects analysis area, or about 1.7 percent. This represents the overall cumulative loss of lands potentially open to recreation.

- Back roads. Both the Ray Land Exchange and the Ripsey Wash projects would impact a number of back roads, as would the Resolution Copper Project. The Ray Land Exchange parcels include nine roads that could be impacted (Cochran Road, Price Box Canyon Road, Diversion Dam Road, Whitlow Ranch Road, Knisely Ranch Road, Tomlin Road, McCracken Mine Road, Sacramento Valley Road, and Battle Axe Road). Ripsey Wash includes a number of unnamed and undefined roads within the footprint. In both cases, these back roads form a network of recreational routes throughout the region. Losses of these back roads would be cumulative with losses of Forest Service roads associated with the Resolution Copper Project, limiting recreational opportunities within the area.
- Arizona Trail. The Arizona Trail is also impacted by these same projects. For the Ray Land Exchange parcels, the potential impact would be to Passage #16; though the type of impact is unknown, in general the land exchange would contribute to industrialization of areas that are not now disturbed. The Ripsey Wash Tailings Project would impact Passage #15 and would require a reroute of this portion of the trail. The Resolution Copper Project would potentially impact Passage #18 of the Arizona Trail by slurry pipeline crossings. While these impacts are not all on the same segment of the Arizona Trail, there could be cumulative impacts as multiple projects change the overall experience of users covering long distances of the trail.

3.9.4.9 Mitigation Effectiveness

Mitigation Identifier and Title	Authority to Require
FS-SV-03: Revised Reclamation and Closure Plans	Required – Forest Service
FS-TA-01: New Mitigation Aspects of Revised Road Use Plan	Required – Forest Service
FS-WR-01: GDEs and water well mitigation	Required – Forest Service
FS-WR-02: 404 Compensatory Mitigation Plan	Required – U.S. Army Corps of Engineers
FS-WR-04: Replacement of water in Queen Creek	Required – Forest Service
FS-RC-01: Relocation of Arizona National Scenic Trail	Required – Forest Service
FS-RC-02: Access to Oak Flat Campground	Required – Forest Service and Programmatic Agreement
FS-RC-03: Mitigation for adverse impacts to recreational trails (Forest multi-use trail plan)	Required – Forest Service
FS-RC-04: Establish an alternative campground site (Castleberry) to mitigate the loss of Oak Flat Campground	Required – Forest Service and Programmatic Agreement
RC-RC-05: Mitigation for impacts on climbing resources	Voluntary – Resolution Copper
RC-RC-06: Mitigation for public access to JI Ranch through Arizona Game and Fish Department cooperative agreement	Voluntary – Resolution Copper

We developed a robust monitoring and mitigation strategy to avoid, minimize, rectify, reduce, or compensate for resource impacts that have been identified during the process of preparing this EIS. Appendix J contains descriptions of mitigation measures that are being required by the Forest Service and mitigation measures voluntarily brought forward and committed to by Resolution Copper. Appendix J also contains descriptions of monitoring that would be needed to identify potential impacts and mitigation effectiveness.

This section contains an assessment of the effectiveness of design features associated with mitigation and monitoring measures found in appendix J that are applicable to recreation. See appendix J for full descriptions of each measure noted below.

Mitigation Effectiveness and Impacts of Required Mitigation Measures Applicable to Recreation

Appendix J contains mitigation and monitoring measures being required by the Forest Service under its regulatory authority or because these measures are required by other regulatory processes (such as the PA or Biological Opinion). These measures are assumed to occur, and their effectiveness and impacts are disclosed here. The unavoidable adverse impacts disclosed below take the effectiveness of these mitigations into account.

Revised Reclamation and Closure Plans (FS-SV-03). Implementing reclamation and closure plans ensure that post-closure landscape is successfully revegetated to the extent practicable, and that the landforms are stable and safe. This measure is effective at partially replacing habitat and vegetation over the long term within the footprint of all mine components, reducing long-term effects on surface water quality from erosion, and improving long-term resilience and safety of the tailings storage facility. Eventually these areas could be reopened to recreational activities.

New Mitigation Aspects of Revised Road Use Plan (FS-TA-01). Implementing the revised road use plan would help reduce the conflicts with existing traffic and recreational road users that would occur during construction and operations. However, an overall loss of access for recreational users would occur where current NFS roads are closed or become private. New mitigation measures incorporated in response to disclosed impacts include additional mitigation that would be effective at reducing impacts of road and pipeline crossings, especially with the Arizona Trail, maintaining access east of Oak Flat, and maintaining access for recreation activities.

GDE and water well mitigation (FS-WR-01). This measure would replace water sources for any riparian areas associated with springs or perennial streams (groundwater-dependent ecosystems) impacted by drawdown from the mine dewatering and block caving. Though this measure could change the overall natural character of riparian areas, it would be effective at preserving riparian vegetation and aquatic habitats, which are of importance to recreational users of the Tonto National Forest.

Clean Water Act Section 404 Compensatory Mitigation Plan (FS-WR-02). The compensatory mitigation parcels would offer conservation of riparian habitat, as well as overall improvement in the health and stability of riparian habitats, by minimizing invasive non-native species and returning conditions to a more natural state. This measure would be effective at replacing xeroriparian habitat lost within the project footprint. Whether recreation would be specifically allowed on these lands would be determined later, if compatible with conservation easements put in place to protect waters and habitat. The Queen Creek parcel would likely be effective at improving recreational opportunities in the immediate vicinity of Superior, when considered in combination with the Castleberry campground (FS-RC-04), implementing the Tonto National Forest multi-use trail plan (FS-RC-03), and replacement of water in Queen Creek (FS-WR-04).

Replacement of water in Queen Creek (FS-WR-04). This measure would replace the storm runoff in Queen Creek that otherwise would be lost to the subsidence area. It would be highly effective at minimizing the effects felt in Queen Creek caused by reduction in the watershed area, specifically impacts to surface water quantity and riparian habitat, which would prevent impacts to wildlife using this habitat. This would be effective at minimizing impacts to recreational users and birdwatchers drawn to riparian habitat in this area. Other stormwater losses would still occur under Alternatives 2, 3, and 4.

Relocation of Arizona National Scenic Trail (FS-RC-01). The relocation of the Arizona Trail away from some alternatives (Alternatives 2, 3, and 4) would be effective at reducing the impact of the mine on trail users by distancing them from industrialized landscapes, although the overall change in the character of the region could still be discernable in some areas.

Access to Oak Flat Campground (FS-RC-02). Maintaining access to Oak Flat Campground, to the extent practicable with respect to safety, would be effective at reducing impacts caused by the loss of the Oak Flat area to subsidence. However, the user experience at the campground likely would not be the same, given the open space, trails, roads, and climbing opportunities that would no longer abut the campground.

Mitigation for adverse impacts to recreational trails (Forest multi-use trail plan) (FS-RC-03). Implementation of this plan would replace over 20 miles of motorized routes and nonmotorized trail on Tonto National Forest around Superior. The Oak Flat area is heavily used for recreation, and the loss of Federal land base due to the land exchange (and the tailings storage facilities for some alternatives) would put pressure on remaining recreation areas. This plan would be effective at expanding the motorized and nonmotorized travel routes and recreational opportunities in a sustainable manner consistent with Tonto National Forest management direction.

Establish an alternative campground site (Castleberry) to mitigate the loss of Oak Flat Campground (FS-RC-04). Establishing the replacement campground would be effective at offsetting impacts caused by loss of dispersed camping opportunities on the Tonto National Forest, and the changes in the experience at Oak Flat Campground.

Mitigation Effectiveness and Impacts of Voluntary Mitigation Measures Applicable to Recreation

Appendix J contains mitigation and monitoring measures brought forward voluntarily by Resolution Copper and committed to in correspondence with the Forest Service. These measures are assumed to occur but are not guaranteed to occur. Their effectiveness and impacts if they were to occur are disclosed here; however, the unavoidable adverse impacts disclosed below do not take the effectiveness of these mitigations into account.

Mitigation for impacts on climbing resources (RC-RC-05). The impacts to climbing resources are substantial, with the loss of the world-class climbing opportunities at Oak Flat, and these lost climbing areas cannot be replaced. The suite of mitigation measures voluntarily undertaken by Resolution Copper, after consultation with climbing groups, including the Queen Creek Coalition, would be effective at offsetting these impacts by improving access to other climbing areas in the vicinity, and preventing impacts by maintaining access to existing climbing areas on Resolution Copper property.

Mitigation for public access to JI Ranch through AGFD Cooperative Agreement (RC-RC-06). This measure would be effective at offsetting the loss of open land base for recreation, including providing specific opportunities for hunting and motorized recreation.

Other Potential Future Mitigation Measures Applicable to Recreation

Appendix J contains several other potential future mitigation measures that the Forest Service is disclosing as potentially useful in mitigating adverse effects, but for which there is no authority to require.

There is no expectation that these measures would occur, and therefore the effectiveness is not considered in the EIS.

Voluntary achievement of "no net loss" of habitat (PF-WI-01). The acquisition of additional open space within the region would offer direct benefits to habitat, wildlife, and recreation.

Purchase lands in the "Preserve" (PF-RC-01). The acquisition of additional open space within the region would offer direct benefits to habitat, wildlife, and recreation.

Develop MARRCO corridor for tourism and reactivate rail (PF-RC-02). This mitigation would only be undertaken after study and resolution of potential safety and operational conflicts. If feasible, it would provide a new recreation opportunity in the town of Superior, which would be beneficial for socioeconomic development and tourism.

Fund extension of the LOST Queen Creek segment (PF-RC-03). This mitigation would add to recreational trail opportunities in the vicinity of the town of Superior, building on the suite of mitigation measures already being required (FS-RC-03). However, this use may not be compatible with the management of the Apache Leap SMA.

Unavoidable Adverse Impacts

Recreational use of the area would be permanently adversely impacted. Unavoidable adverse impacts on recreation include long-term displacement from the project area and the loss of public access roads throughout the project area. These impacts cannot be avoided or fully mitigated.

3.9.4.10 Other Required Disclosures

Short-Term Uses and Long-Term Productivity

Recreation would be impacted in both the short and long term. Public access would be restricted within the perimeter fence until mine closure, which is considered to be a short-term impact. However, most of the tailings and subsidence area would not be available for uses such as OHV or other recreational use in the future, depending on the final stability and revegetation of these areas.

Irreversible and Irretrievable Commitment of Resources

In general, there would be irretrievable and irreversible impacts as a result of displaced recreational users and adverse effects on recreation experiences and activities as reported above under "Loss of Federal Land Base." There would be irretrievable impacts on recreation with all action alternatives. Alternatives 2, 3, and 5 would cross the Arizona Trail. Alternative 4 would require rerouting of the trail.

Each action alternative would result in the permanent removal of off-highway routes, resulting in a permanent loss of recreation opportunities and activities. Public access would only be permitted outside the mine perimeter fence. Although routes through the project area might be reestablished after closure of the East Plant Site, West Plant Site, filter plant and loadout facility, and the MARRCO corridor, routes through the subsidence area and tailings storage facility would not be reestablished. Therefore, impacts on OHV routes are considered irretrievable for those that would be reestablished following mine closure, and irreversible for those that would be permanently affected.

Even after full reclamation is complete, the post-mine topography of the project area may limit the recreation value and potential for future recreation opportunities.

3.10 Public Health and Safety

3.10.1 Tailings and Pipeline Safety

3.10.1.1 Introduction

Overview

Among the primary concerns expressed by the public during the scoping period for the Resolution Copper Project EIS were the potential risks posed by mine operations to public health and well-being. These included the potential for toxic air emissions, contamination of groundwater and surface water, tailings storage facility failure, increased risk of wildfire, and increased potential for accidental spills or releases of hazardous chemicals or other pollutants. This section addresses, in three parts, tailings facility and pipeline safety, fire risks, and the potential for releases or public exposure to hazardous materials. Air emissions issues are analyzed in Section 3.6, Air Quality, and the potential for mine-related contamination of water sources is assessed in Section 3.7.2, Groundwater and Surface Water Quality.

During scoping, the public expressed concern for the potential failure of a tailings embankment as well as the potential for failure of the copper concentrate and tailings pipelines. Some commenters cited recent high-profile tailings facility failures in Brazil and British Columbia as examples of the possible consequences.

Tailings storage facilities represent a long-term source of risk to public health and safety that extends well beyond the operational life of the mine. Catastrophic failures are one type of risk. In these cases, the tailings embankment can fail either because of a design or foundation flaw, a failure in construction, errors in operation, natural phenomena like earthquakes or floods, and often combinations of these factors. While the tailings themselves are solid particles, the material stored behind the embankment is a mixture of tailings solids and water. With a catastrophic failure of a tailings embankment, the tailings material stored in the facility behaves like a liquid. Massive amounts of tailings materials can spill from the facility and flow downstream for long distances, even hundreds of miles.[79]

A tailings embankment failure is similar to other high-consequence, low-probability events, such as catastrophic wildfires, hazardous material spills, or 1,000-year floods. The likelihood of these events happening is low and given their nature it is not possible to predict when or how they might occur. However, they do occur, and when they occur the impacts can be severe.

Bowker (2019) cataloged 254 failures of tailings facilities worldwide occurring between 1915 and 2019, with 121 categorized as serious or very serious,[80] and at least 46 events resulting in loss of life. In the recent past, since 2000, Bowker documents the occurrence of 32 serious or very serious failure events, of which 18 resulted in loss of life.[81] More than 100 of the failures between 1915 and 2019 were in the United States, with about a quarter of them serious or very serious; the last serious failure in the United States was in Kentucky in 2017, which also resulted in loss of life. Bowker also documents a number of known tailings failures in the vicinity of the project, including Pinto Valley (1997, classified as a serious failure), Ray Mine (four failures between 1972 and 2011, including one classified as serious in 1993), and Magma Mine itself (1991, classified as a minor failure).

[79] Note that this refers primarily to slurry tailings facilities (like Alternatives 2, 3, 5, and 6). Alternative 4 is a filtered tailings facility and would likely react differently during a failure; this difference is described in this section.

[80] The researchers based this designation on loss of life, high release volume (more than 100,000 cubic meters), or long travel distance.

[81] Concerning recent high-profile events, the dataset includes the Mount Polley (British Columbia, 2014) and Fundão (Brazil, 2015) failures, as well the much-publicized failure of the tailings facility in Brumadinho, Brazil, in January 2019.

Based on a reported 18,000 mines around the world, the failure rate of tailings storage facilities in the past 100 years is estimated at 1.2 percent. The failure rate of the traditional water storage dam is 0.01 percent (Lyu et al. 2019). On average, three of the world's 3,500 tailings dams fail every year. The likelihood of tailings dam failure is several times higher than other conventional water-retaining dams (Berghe et al. 2011).

A tailings embankment failure has immediate consequences to those in the vicinity and living downstream, including loss of life, destruction of property and infrastructure, and destruction of entire ecosystems (aquatic or terrestrial). Once the tailings stop moving downstream, long-term consequences from a catastrophic failure continue through the contamination of large geographic areas, compromised water supplies, economic disruption, and displacement of large numbers of people.

Aside from catastrophic failures, tailings storage facilities can represent other long-term risks to public health and safety, including the potential for groundwater contamination from tailings seepage, erosion of material into downstream waters, and windblown dust. While tailings facilities gradually drain over time, becoming less susceptible to failure, the potential risks can last for many decades after closure. One study identified that roughly 80 percent of tailings facility failures occur in active facilities and 20 percent occur at closed facilities (Strachan and Van 2018).

The concentrate and tailings pipelines are also potentially susceptible to failure. Failures can occur from pipe damage due to geotechnical hazards such as rockslides or ground subsidence, from hydrologic hazards such as scour or erosion, seismic hazards, human interference, or even lightning. Failures of these types of pipelines are not generally tracked, because the consequences of tailings pipeline failures are substantially less severe than a tailings embankment failure. The petroleum industry is the only source of published information on the frequency of pipeline failures. Natural gas or petroleum pipelines run at much higher pressures than those planned for the tailings and concentrate pipelines and the contents are more immediately hazardous (flammable), but they still represent a useful estimate of the type and frequency of pipeline failures.

For the petroleum industry, the frequency of failures in the United States has been estimated as 16 gas or petroleum pipeline failures per year, out of roughly 500,000 miles of pipeline (Porter et al. 2016). This can be looked at in other ways as well. The research translates to roughly 0.03 failures per year per 1,000 miles of pipeline (Porter et al. 2016); for a 30-mile tailings pipeline, the risk of failure in any given year would be about 0.1 percent. Other research has found that the failure rate is substantially lower for large-diameter pipelines and decreases with the amount of soil cover (European Gas Pipeline Incident Data Group 2015). This research also indicates that the most common failure types are pinhole leaks and holes, and the least common failure type is a complete rupture of the pipeline (European Gas Pipeline Incident Data Group 2015).

Besides the potential magnitude of a release, pipeline failures are substantially different from embankment failures. Pipelines are monitored with pressure sensors and can shut down immediately upon a rupture being detected, leading to relatively localized releases that can likely be readily cleaned up. Pipeline risk also decreases to zero after closure, unlike the tailings embankment, which can still represent a risk decades after closure.

The tailings and pipeline safety analysis in the FEIS addresses three public safety and natural resource protection commitments of the Forest Service:

1. To disclose risks and the potential magnitude and type of downstream impacts from a hypothetical tailings embankment failure;

2. To disclose risks and potential impacts associated with a failure of the tailings or copper concentrate pipelines; and
3. To ensure that the design of any tailings storage facility built on Federal land meets all expectations for safety, including a minimum requirement to adhere to National Dam Safety Program guidelines.

Changes from the DEIS

One of the cornerstones for the design of modern tailings storage facilities is to conduct risk-based assessments of potential failures, known commonly as a failure modes and effects analysis (FMEA). We included an assessment of preliminary failure modes in the DEIS. However, the Forest Service included a requirement (mitigation measure FS-227) that a more robust and refined FMEA take place between DEIS and FEIS for the preferred alternative, in a collaborative fashion that included Resolution Copper, the Forest Service, and interested cooperating agencies. We updated this section to describe the FMEA process and outcomes. This process includes new information collected at the Skunk Camp location, and an estimate of the downstream extent of tailings in Dripping Spring Wash under a scenario reflective of many of the potential failure modes examined during the FMEA.

We also included additional information on the tailings slurry pipeline design, management, and failure risk in this section.

The DEIS described in detail the various government and industry regulatory frameworks under which tailings storage facilities are designed and managed. Additional industry guidance was developed since the DEIS and is described here. Based on this new guidance, clarification also is provided on the timing and factors involved in emergency response planning.

3.10.1.2 Analysis Methodology, Assumptions, and Uncertain and Unknown Information

Analysis Area

The analysis area for tailings and pipeline safety consists of all downstream areas that could be affected in the event of a partial or complete failure of the tailings embankment, as shown in figure 3.10.1-1, including human and natural environments, as well as the water bodies that could be impacted by a pipeline rupture or spill.

Analysis Techniques

A number of approaches are available to assess the risk of failure of a tailings storage facility, as well as the downstream effects of a failure. These techniques can be used to inform the decision process and to help analyze the potential differences between alternatives.

There are two basic steps frequently used to understand the potential size and extent of a failure.

- First, a risk-based design approach can be used to assess the inherent risks in a given design. One common tool is an FMEA. The purpose of conducting a risk-based design process is to identify potential ways an embankment could fail (modes), the type of failure (whether the tailings act as a fluid or a solid), and also to develop design and operational strategies to mitigate the risk.
- Second, in the event a failure were to occur, a breach analysis (also known as a runout analysis or inundation analysis) can be used to assess the potential downstream impacts of where the tailings would travel, how far, and how fast.

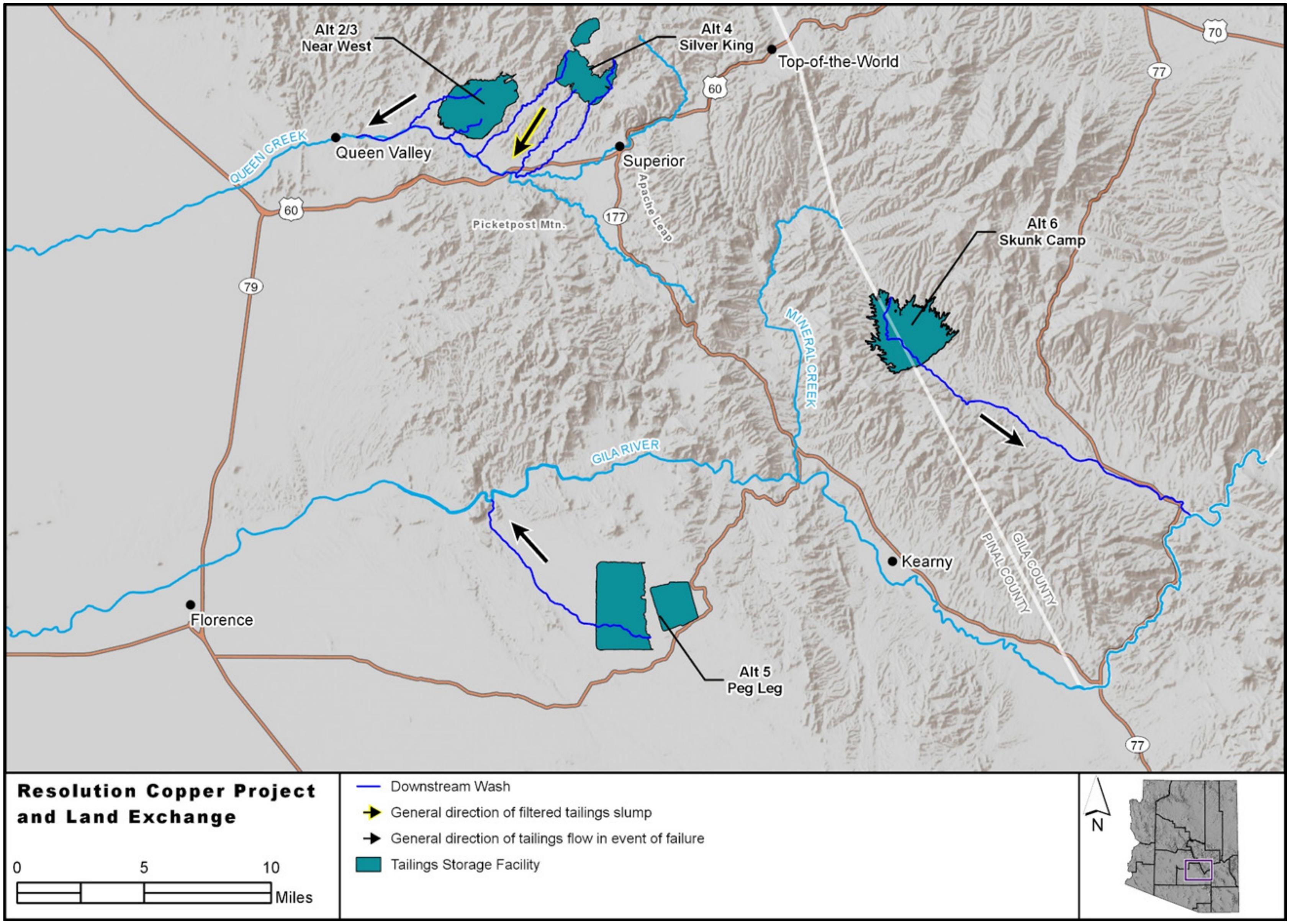


Figure 3.10.1-1. Overview of tailings safety analysis areas

The Forest Service is using both of these steps in the NEPA process. For the FEIS, a full FMEA was conducted, making use of the current designs for each alternative. Based in part on FMEA results, the Forest Service has considered a range of possible breach scenarios. Outcomes described in this section use one end of that range, using a worst-case assumption that a full breach would occur and that the tailings would act like a fluid as they ran out, with resulting catastrophic impacts. This type of analysis does not consider controls or design features that would be employed to prevent this type of failure or limit potential damage; these features are identified and discussed in "Summary of Applicant-Committed Environmental Protection Measures" in section 3.10.1.4. For more discussion of techniques evaluated by the Forest Service, see Newell and Garrett (2018c).

FAILURE MODES AND EFFECTS ANALYSIS

When tailings facilities fail, they fail for specific reasons, or often a combination of reasons related to design (design flaws, design oversights like unknown foundation conditions, or deviation from planned design), inadequate construction methods and/or poor construction quality control, operations (improper pond management or tailings deposition practices), and environmental triggers (seismic events, extreme precipitation). In general, these are known as "failure modes." There is no such thing as a "typical" facility failure, as each situation is the result of a specific failure mode or combination of failure modes.

An industry-standard step in the design of a tailings facility is to conduct an FMEA:

> Failure modes and effects analysis (FMEA) is a technique that considers the various fault (or failure) modes of a given element and determines their effects on other components and on the global system. It is an iterative, descriptive and qualitative analytical methodology that promotes, based on the available knowledge and information, the systematic and logical reasoning as a means to improve significantly the comprehension of the risk sources and the justification for the decisions regarding the safety of complex systems, namely dams. Without requiring mathematical or statistical frameworks, it intends to assure that any plausible potential failure is considered and studied, in terms of: *what can go wrong? How and to what extent can it go wrong? What can be done to prevent or to mitigate it?* (dos Santos et al. 2012) (emphasis in original)

Resolution Copper conducted a failure modes assessment for each tailings facility design (Klohn Crippen Berger Ltd. 2019a; Pilz 2019), identifying all potential failure modes, and identifying the design feature(s) to address each risk, in line with best industry practice, international design standards, and Federal and State regulations. The Forest Service reviewed the failure modes assessment, found it appropriate for the level of alternative design, and included a discussion of the work in the DEIS. This analysis remains pertinent and is discussed in "Summary of Applicant-Committed Environmental Protection Measures" in section 3.10.1.4 of the FEIS.

When preparing the DEIS, the Forest Service recognized that the failure modes analysis conducted by Resolution Copper was based on the DEIS alternative design documents and level of information available at the time. The Forest Service recognized that with more site-specific information, a more robust and refined FMEA could be conducted. The Forest Service required that this refined FMEA be conducted for the preferred alternative (Alternative 6) between the DEIS and FEIS (mitigation measure FS-227).

During an FMEA, the tailings storage facility is considered as a complete system with a number of components, including geology, foundation, engineered structures, seepage controls, drains, containment, diversions, and spillways. Sufficient information on the design and specifications of each component is needed to understand how components would function as a system, and how they might respond to anticipated stresses on the system. Information needed to support the collaborative, refined FMEA included the results of new site investigations, borrow material analyses and specifications, and engineered drawings and specifications.

The refined FMEA took place in February 2020, as a collaborative group process that included Forest Service personnel, cooperating agency representatives, Resolution Copper and its tailings experts and contractors, and the NEPA team and its tailings experts. The process was led by an outside facilitator with experience in leading FMEA workshops. The process considered possible failure modes, the probability of their occurring, and the consequences if they did occur. The combination of probability and consequence defines the overall risk associated with that failure mode. The results are captured in a final FMEA report and are discussed in detail in this section (Gannett Fleming 2020).

BREACH ANALYSIS

A breach analysis is used to model a tailings storage facility failure, including the volume of tailings released and how far it would run downstream. Some methods require no site-specific information except for basic facility design (such as embankment height or total facility volume). These methods include the empirical, rheological, and energy balance methods. Other methods use numerical modeling with the incorporation of detailed site-specific information. See Newell and Garrett (2018c) for further information on these techniques.

For the DEIS, as well as the FEIS, the Forest Service chose the following empirical method to disclose the effects of a failure. As noted in the following text, this approach likely represents a worst case. It does not consider embankment type, design features used to specifically address failure modes, foundation conditions, operational approaches, or real-world topography.

Rico Empirical Method

Empirical methods use the known, available characteristics of historical tailings facility failures in order to estimate the characteristics of a failure at a hypothetical future tailings facility. Empirical methods are often based on limited data, perhaps only the basic geometry of the facility (embankment height, total volume), rather than specific embankment design details and foundation conditions. This approach was introduced by Rico et al. (2007), who relied on a database of 29 known tailings facility failures worldwide that occurred between 1965 and 2000. This empirical method was updated in 2018 by Larrauri and Lall (2018) to include additional known failures, for a total of 35 worldwide tailings facility failures between 1965 and 2015. The Larrauri and Lall dataset includes the two largest and most recent failures (at the time): Mount Polley Mine in British Columbia in 2014, and Fundão in Brazil in 2015.

These researchers developed two statistical relationships. The first relationship predicts the volume of material released during a failure based on the total facility volume. Fundamentally this approach comes down to a basic equation that shows historic releases have on average released about 33 percent of the total facility volume. The second relationship predicts the maximum travel distance downstream based on the release volume and the embankment height.

There are substantial limitations to the empirical approach:

- The largest facility in the dataset is 74 million cubic meters,[82] compared with 1,000 million cubic meters (upon buildout) for the planned Resolution Copper facility. For this project, the extrapolation goes well beyond the bounds of the original dataset; this represents an uncertainty since larger facilities may or may not react like smaller facilities.

[82] The most common unit of volume used in the literature on tailings releases is cubic meters, or millions of cubic meters. For ease and consistency, these same units are being used in this section.

- Specific embankment construction methods are not factored into the empirical equations. Of the 35 facilities included in the Larrauri and Lall estimates, 24 used an upstream construction method, one used modified centerline (matching Alternatives 2 and 3), and none used centerline (matching Alternatives 5 and 6) (Bowker 2019). The empirical dataset is therefore not representative of the specific design proposed by Resolution Copper. The Resolution Copper facility would have a fundamentally different type of embankment than most of the previous failures (instead of an upstream embankment, Alternatives 2 and 3 use a modified-centerline, and Alternatives 5 and 6 use a centerline embankment).
- The dataset extends as far back as 1965 and may have been designed to lower factors of safety or higher acceptable levels of risk; the Resolution Copper facility would be designed to modern standards (described in more detail in "Relevant Laws, Regulations, Policies, and Plans" in section 3.10.1.3).
- The empirical estimates are based solely on embankment height or facility volume and take no account of operational methodologies, topography, or actual failure mode.

While recognizing these limitations, the Forest Service has selected the empirical method as the most reasonable method to inform the NEPA process and assess differences between alternatives. The level of current design and site-specific information is sufficient to use the empirical method, and the downstream effects reflect the real-world conditions experienced during other failures.

Additional FMEA-informed Breach Analysis

During the FMEA workshop, participants considered the downstream consequences in the event of a tailings storage facility failure. The method used to describe downstream consequences in the DEIS, the Rico Empirical Method, represents the movement of largely saturated tailings that are subject to liquefaction, meaning they flow as a liquid during the initial outflow, thus moving a large distance downstream.

During the FMEA workshop, participants agreed that many of the potential failure modes explored would not fail in this manner. The main tailings embankment is designed as a well-drained structure composed of compacted cycloned NPAG tailings. The NPAG tailings beach would largely be drained in the upper portions unless ponded water was present. During normal operations, the recycled water pond is maintained over the PAG cells near the rear of the facility, not on the NPAG tailings beach against the tailings embankment.

During the FMEA workshop, in order to assess the severity of downstream consequences, a rough approximation was used for a "dry" failure without liquefaction. This approximation assumed that the failure would extend 4 to 8 miles downstream along Dripping Spring Wash, but would not reach the Gila River. After the FMEA workshop, this failure scenario was formalized by Resolution Copper's tailings experts (KCB Consultants Ltd. 2020b). Together, the Rico Empirical Method and the "dry" failure scenario represent a range of possible outflow scenarios. Both scenarios are disclosed in this section.

3.10.1.3 Affected Environment

Relevant Laws, Regulations, Policies, and Plans

The regulations and policies that guide the design, construction, operation, and closure of tailings storage facilities come from a variety of sources. Some guidance is required to be met, such as the requirements of the National Dam Safety Program (on Federal land), Arizona State Mine Inspector's office, or Arizona APP program, while other guidance is followed voluntarily as part of industry best practices. What is considered acceptable in the design of a tailings storage facility is evolving as the industry and government respond to a number of recent and widely publicized catastrophic tailings failures. In this section, the Federal, State, and industry design standards are summarized, as well as recent proposals for better risk-based tailings design methods; ultimately, the design proposed by Resolution Copper is shown to meet the most stringent of these standards.

RECENT FAILURES

Post-failure investigations by independent industry experts were conducted in the Mount Polley (2014) and Fundão (2015) tailings failures. Both of these events are discussed here because they provide useful examples of the chain of events that can lead to a catastrophic failure, and because they underscore the need for stringent design requirements, regulatory oversight, and governance. In January 2019, during preparation of the Resolution Copper EIS, another tailings embankment failure in Brazil at the Córrego do Feijão facility resulted in the estimated deaths of over 300 people. Little was known about this failure at the time of publication of the DEIS, but details of the after-action investigation have been included below for the FEIS.

Mount Polley Failure (2014)

The Mount Polley investigative panel considered a wide range of potential failure modes that could have contributed to the failure (Mining and Mineral Resources Division 2015). Ultimately, the panel determined that the primary reason for the failure was the lack of understanding of the foundation conditions and how the increasing embankment height would change the foundation behavior. Specifically, the site characterization undertaken below a secondary embankment used to help impound the tailings prior to construction failed to identify the nature of glacial lakebeds in the subsurface, and therefore the design did not take into account the complexity of the foundation materials. As the embankment height increased, the geological unit in question changed properties and became susceptible to “undrained loading,” which means that under the great load of the tailings, this geological unit compressed and developed excess pore pressure, reducing the shear strength. These were factors that are well known and studied in soil mechanics but were not understood or applied correctly in the design process.

An additional aspect of the design that contributed to the failure was the use of a steep slope on the downwards face of the embankment (1.3:1). The original design criteria for the embankment called for a 2:1 slope, but that slope had not yet been achieved due to a lack of available rock fill material until later in the life of the tailings facility. The panel concluded that the embankment likely would not have failed if the 2:1 design slope had been achieved.

Although not a cause of the failure, the primary factor in the severity of the failure was the excess amount of water stored in the facility. When the failure occurred, permitting was still underway to allow treatment and discharge of the excess stored water downstream.

In summary, the Mount Polley failure resulted from the following:

- shortcomings in site characterization,
- inadequate design resulting from the flawed site characterization,
- inadequate construction resulting from temporary deviations from the original design due to logistical issues (availability of waste rock),
- logistical delays with the discharge of excess water from the facility, which increased the severity of the consequences of failure, and
- failure of regulatory oversight for adherence to design and operational parameters.

The Mount Polley failure released 21 to 25 million cubic meters of pond water and tailings. The failure of the embankment took place suddenly without any warning signs and became uncontrollable in less than 2 hours. Polley Lake (just upstream of the breach), Hazeltine Creek, and Quesnel Lake were impacted by the debris flow, and the discharge of water from Polley Lake was blocked by the tailings plug left behind (Golder Associates Ltd. 2015; Mining and Mineral Resources Division 2015). The tailings release impacted about 5 to 6 miles of Hazeltine Creek before entering Quesnel Lake. There was no loss of human life.

At the immediate discharge location, tailings were estimated to be 11 to 12 feet thick. Along Hazeltine Creek, the debris flow scoured some areas to bedrock (estimated 1.2 million cubic meters of material lost), and tailings deposits covered other areas (estimated 1.6 million cubic meters of material deposited). Authorities estimated that Quesnel Lake received almost 19 million cubic meters of tailings, eroded material, and discharged water. The discharge completely destroyed the aquatic habitat in Hazeltine Creek. It also affected the water quality in Quesnel Lake and Polley Lake through increased turbidity and copper content. Initial assessments within the first year after the release found relatively little permanent or ongoing impact on aquatic life or terrestrial life, but studies continue (Golder Associates Ltd. 2015).

Fundão Failure (2015)

The Fundão investigative panel determined that a chain of decisions made during operations ultimately led to the failure of the embankment (Fundão Tailings Dam Review Panel 2016). First, damage to the original starter dam resulted in a change of design that allowed for an increase of saturation in the facility beyond the original plans. Second, a series of unplanned deviations in the facility construction resulted in deposition of fine-grained tailings at unintended locations, and the subsequent raising of the embankment above these tailings. This unintended deposition was a result of a design flaw—an inadequate concrete structure below the embankment that prevented the original design from being implemented—but also a deviation in tailings and water management over several years, in which water was allowed to encroach much closer to the crest of the embankment than originally planned.

The stresses placed on the fine-grained materials underlying the embankment caused them to shift, ultimately weakening the embankment to “a precarious state of stability” (Fundão Tailings Dam Review Panel 2016). Ninety minutes before the failure a series of small earthquakes occurred, and these seismic shocks triggered the failure. The panel was careful to note that while the seismic event was the trigger mechanism, it was not the ultimate cause of the failure.

In summary, the Fundão failure resulted from the following:

- deviations from the original design that allowed greater saturation in the facility;
- deviations in the location of planned tailings deposition caused by an unexpected problem with a foundation structure;
- deviations in the location of planned tailings deposition caused by deviations from tailings and water management criteria;
- a seismic shock that triggered the failure of the already compromised embankment; and
- failure of regulatory oversight for adherence to design and operational parameters.

The Fundão embankment failure released 32 million cubic meters of tailings. The failure of the embankment took place suddenly, within 2 hours of the triggering earthquakes. The United Nations estimated that the tailings release ultimately traveled 620 km downstream, following the Gualoxo and Doce Rivers, to reach the Atlantic Ocean. The town of Bento Rodrigues was immediately downstream of the facility; over a dozen people lost their lives, an estimated 600 families were displaced, and the drinking water supply to over 400,000 people was disrupted (GRID-Arendal 2017). The tailings destroyed an estimated 3,000 to 4,000 acres of riparian forest and destroyed substantial aquatic habitat.

Córrego do Feijão Failure (2019)

The Feijão expert investigative panel released an assessment of the technical reasons for failure of the dam in December 2019 (Robertson et al. 2019). The failure investigation was unique in that there are a number of high-quality video scenes of the disaster unfolding. The panel found that the failure was the result of static liquefaction of materials of the embankment. The panel also found that far from being unmonitored, the embankment was extensively monitored with survey monuments, inclinometers, piezometers, and ground-based radar, as well as high-quality video from drone flights only 7 days prior to the failure. None of those methods detected significant deformation or failure. Only after analysis of satellite imagery after the failure were slow and continuous deformations observed; however, the panel noted that such deformations are consistent with long-term settlement of embankments and would not alone indicate any tendency toward failure.

The failed embankment was built as an upstream-type embankment. The causes of the failure were identified as a combination of operational and design measures that resulted in weak tailings close to the crest, interbedded layers of fine and coarse tailings within the embankment, a degree of bonding of the tailings that resulted in brittle behavior, and a lack of drainage within the embankment, including operations with water close to the embankment crest. Aside from the tailings characteristics themselves (loose, saturated, and potentially stiff and brittle due to bonding), parts of the embankment were under high loading due to the steepness of the embankment and high internal water levels. No specific trigger was identified, but the panel’s findings suggest that high and intense regional wet-season rainfall contributed to triggering the failure.

These three failures (and others) involved a combination of design, construction, and operational factors, specifically the role of water, that contributed to the final outcome. Industry best practice is evolving to understand that each of these issues must be managed in an overall management plan or system that reviews the design and construction process throughout the life of the facility to prevent such future incidents.

EVOLVING INDUSTRY DIRECTION TOWARD AN INTERNATIONAL STANDARD ON TAILINGS STORAGE FACILITIES

In 2018, Dr. Norbert Morgenstern delivered a lecture to the Brazilian Geotechnical Congress on the topic of Geotechnical Risk, Regulation and Public Policy (Morganstern 2018). Dr. Morgenstern noted that the recent high-profile failures have occurred “at locations with strong technical experience, conscientious operators and established regulatory procedures.” As part of that lecture, Dr. Morgenstern proposed a system for Performance-Based Risk-Informed Safe Design (PBRISD), construction, operation, and closure of tailings storage facilities. He further urged the International Council on Mining and Metals (ICMM) to support this proposed system and to facilitate its adoption in practice. In addition, Dr. Morgenstern praised The Mining Association of Canada’s (MAC’s) “Guide for the Management of Tailings Facilities” (Mining Association of Canada 2019) and noted the guide’s influence on “governance protocols needed to ensure safe tailings management from the conceptual stages through to closure.”

The ICMM is an international organization representing 27 signatory mining and metals companies, including Rio Tinto and BHP, partners in Resolution Copper. The ICMM also represents 36 associations, including the MAC and the National Mining Association.[83] Through these members, the ICMM delivers best practice guidelines and industry standards.

Following the 2014 tailings failure at the Mount Polley Mine in British Columbia, MAC launched a comprehensive internal and external review of their Tailings Guide. The resulting recommendations included “a risk-based ranking classification system for non-conformances and have corresponding consequences.” The recommendations also asked that guidance on risk assessment methodology be included. MAC noted that the resulting third edition of the Tailings Guide “is another step in the continual improvement process for tailings management, moving toward the goal of minimizing harm: zero catastrophic failures of tailings facilities, and no significant adverse effects on the environment and human health” (Mining Association of Canada 2019). Of note, the current edition includes a risk-based approach, “managing tailings facilities in a manner commensurate with the physical and chemical risks they may pose.” The revised guidance specifies: (1) regular, rigorous risk assessment; (2) application of most appropriate technology to manage risks on a site-specific basis (best available technology); (3) application of industry best practices to manage risk and achieve performance objective (best available performance); and (4) use of rigorous, transparent decision-making tools to select the most appropriate site-specific combination of best available technology and location for a tailings facility.

In February 2019, and in response to the recent Brumadinho tailings embankment failure in Brazil, the ICMM announced that it would establish an independent panel of experts to develop an international standard for tailings facilities (International Council on Mining and Metals 2019b). According to ICMM, this standard is expected “to create a step change for the industry in the safety and security of these facilities.” The details of the standard are expected to include (1) a global and transparent consequence-based tailings facility classification system with appropriate requirements for each level of classification; (2) a system for credible, independent reviews of tailings facilities; and (3) requirements for emergency planning and preparedness.

In support of developing an international standard, ICMM’s response to the Brumadinho failure also announced that the supporting guidance would include PBRISD, as recommended by Dr. Morgenstern, a conformance guide for ICMM’s tailings governance framework, and a critical controls management framework (International Council on Mining and Metals 2019a). The fundamental principle of a PBRISD tailings management system is accountability, achieved only by multiple layers of review, recurrent risk assessment, and performance-based validation, from construction through closure (Morganstern 2018).

Further to ICMM’s initial announcement, in March 2019, they announced they would co-convene the independent review along with the United Nations Environment Programme (UNEP) and the Principles for Responsible Investment (PRI) (International Council on Mining and Metals 2019c). This partnership will encourage broader acceptance of the eventual international standard, while still requiring commitment to it by ICMM’s member companies.

This process had started, but was not completed, as of the publication of the DEIS. In August 2020, the Global Industry Standard on Tailings Management was launched (International Council on Mining and Metals et al. 2020). The preamble to the new Global Industry Standard states:

> The Global Industry Standard on Tailings Management (herein ‘the Standard’) strives to achieve the ultimate goal of zero harm to people and the environment with zero tolerance for human fatality. It requires Operators to take responsibility and prioritise the safety of tailings facilities, through all

[83] The National Mining Association is an industry group located in the United States.

phases of a facility's lifecycle, including closure and post-closure. It also requires the disclosure of relevant information to support public accountability.

ICMM member companies will implement the Global Industry Standard as a commitment of membership. Both Rio Tinto and BHP, partners in Resolution Copper, are members of ICMM. Key aspects of the new Global Industry Standard include the following:

- Maintaining a comprehensive knowledge base, and requirements for periodic updates to facility management and design at least every 5 years, focusing on material changes in social, environmental, or local economic conditions.
- Identification of accountable parties, notably the Engineer of Record and the Accountable Executive.
- Use of an Independent Tailings Review Board (ITRB) and internal auditing.
- A focus on the mine lifecycle: operations, closure, and post-closure, extending until the facility is in a state of "safe closure." This means a closed tailings facility that does not pose ongoing material risks to people or the environment, which has been confirmed by an ITRB or senior independent technical reviewer and signed off by the Accountable Executive.
- Hazard classification based on downstream consequences, which in turn guides the selection of the seismic design standard and flood design standard. For example, for a hazard classification of "extreme", the flood design would be an annual exceedance probability of 1 in 10,000, or the Probable Maximum Flood (International Council on Mining and Metals et al. (2020:Annex 2, Table 2)). The seismic design criteria would be an annual exceedance probability of 1 in 10,000, or the Maximum Credible Earthquake (International Council on Mining and Metals et al. (2020:Annex 2, Table 3)).
- Requirements for assessing credible failure modes, developing a breach analysis, and conducting emergency planning.
- Document "as-built" construction methods and conditions.
- Use of operational surveillance with specific and measurable performance objectives, indicators, criteria, and performance parameters, and development of clear trigger action response plans.
- Commitment to public disclosure of and access to information, and transparency to support public accountability.

FEDERAL REQUIREMENTS FOR TAILINGS FACILITY DESIGN

Regulatory jurisdiction over a tailings embankment and facility depends largely on the location. If the tailings facility is located fully or in part on Federal land administered by the BLM or Forest Service, then tailings design and safety are analyzed and approved as part of the review process for the mining plan of operations, and a bond is required for any reclamation requirements associated with the tailings embankment. Mineral regulations specifically give the Forest Service the ability to regulate tailings: "All tailings, dumpage, deleterious materials, or substances and other waste produced by operations shall be deployed, arranged, disposed of or treated as to minimize adverse impact upon the environment and forest surface resources" (36 CFR 228.8(c)).

The BLM's mining regulations require the "prevention of unnecessary or undue degradation" (43 CFR 3809), in addition to the applicable considerations for surface use and occupancy (43 CFR 3715). This gives the BLM the authority and ability to regulate tailings storage facilities on BLM-administered land. This would apply to Alternative 5 – Peg Leg.

While neither BLM nor Forest Service guidance contains prescriptive[84] requirements for how tailings embankments must be constructed, the Federal Emergency Management Agency (FEMA) has developed the National Dam Safety Program, which includes standards that are applicable to structures constructed on Federal land. This includes tailings embankments. The National Dam Safety Program provides a conceptual framework that includes requirements for site investigation and design, construction oversight, operations and maintenance, and emergency planning, as outlined in table 3.10.1-1 (Federal Emergency Management Agency 2004, 2005, 2013).

The Forest Service would require that the Resolution Copper tailings storage facility adhere to National Dam Safety Program guidelines, if built on Federal land.[85] This is included in the "Adherence to National Dam Safety Program Standards" part of the "Mitigation Effectiveness and Impacts" section as a required mitigation on Federal land.

STATE REQUIREMENTS FOR TAILINGS FACILITY DESIGN

The APP program administered by the ADEQ contains prescriptive requirements for tailings embankments. While focused on protecting aquifer water quality, the APP program requires that tailings storage facilities be designed to meet the standards of Best Available Demonstrated Control Technology (BADCT). The BADCT guidance provides specific recommended geotechnical criteria for static stability and seismic stability of tailings embankments, including minimum design earthquake magnitude, factors of safety for various loading conditions, and maximum deformation under seismic loading (see Section 3.5 – Tailings Impoundments, in Arizona Department of Environmental Quality (2004)).

The Forest Service cannot ultimately approve a plan of operations that violates an applicable law or regulation. Eventually the issuance of an APP by the ADEQ to Resolution Copper would demonstrate to the Forest Service that the project complies with applicable Arizona laws and regulations. For the purposes of the FEIS, it is therefore assumed that Resolution Copper would demonstrate compliance with APP prescriptive BADCT requirements. The overlap of the APP BADCT requirements with the National Dam Safety Program requirements is shown in table 3.10.1-1.

[84] For the purposes of this discussion, a "prescriptive" design requirement is one where a specific technique or value is dictated by the guidance, rather than a conceptual or qualitative objective. For example, FEMA standards for "factor of safety" are non-prescriptive: "Factors of safety should be appropriate to the probability of the loading conditions…", whereas APP standards for factor of safety are prescriptive: "Static stability analyses should indicate a factor of safety of at least 1.3."

[85] The ability to require adherence to the National Dam Safety Program or other standards may also be within the discretion of the USACE as a condition of issuing a 404 permit under 33 CFR Part 325.l(d)(6). This requirement would be at the discretion of the USACE.

Table 3.10.1-1. Overview of key requirements of National Dam Safety Program and comparison with other guidance

National Dam Safety Program Process/Components	Specific FEMA Guidance	Arizona BADCT Guidance	ICMM et al. (2020)	Rio Tinto (2015)	ICMM (2016)	CDA (2014)	MAC (2017)	ANCOL D (2012)	MEM (2017)	USACE (2002, 2004)
Site Investigation and Design										
Hazard classification	III.B.1.a (FEMA 93) FEMA 333		X			X		X	X	
Selection of inflow design flood	III.B.1.b-c (FEMA 93) FEMA P-94	E.3.2, E.3.3, E.3.4	X			X		X	X	X
Selection of the hydraulic capacity of embankment	III.B.1.d (FEMA 93)	3.5.4.2; E.3.5	X			X		X		X
Seismic investigations	III.B.2.a-d (FEMA 93)	3.5.3.3; E.2.4.6	X					X		
Selection of design earthquake	III.B.2.e-f (FEMA 93) FEMA 65	3.5.3.3; E.2.4.3	X			X		X	X	X
Geotechnical aspects										
Site-specific exploration	III.B.3.a-b (FEMA 93)	3.5.3.2; E.2.3	X					X		X
Geotechnical design	III.B.3.c (FEMA 93)	3.5.3.3	X			X		X		X
Foundation treatment to ensure stability, control seepage, and minimize deformation	III.B.3.d (FEMA 93)	3.5.4.1	X			X		X		X
Embankment design parameters										
Site-specific design	III.B.5.a (FEMA 93)	3.5.3	X					X		X
Material evaluation	III.B.5.b (FEMA 93)	E.2.3	X					X		X
Seismic design	III.B.5.d.1 (FEMA 93)	3.5.4.4; E.2.4.3; E.2.4.6	X			X		X	X	X
Stability/factors of safety	III.B.5.d.2 (FEMA 93)	3.5.4.4; E.2.4.3; E.2.4.5				X		X	X	X
Settlement and cracking	III.B.5.d.3 (FEMA 93)	E.2.4.3						X		X
Seepage control	III.B.5.d.4 (FEMA 93)	3.5.4.3	X			X		X		X
Zoning to ensure stability and seepage control	III.B.5.d.5 (FEMA 93)									X
Erosion protection	III.B.5.d.6 (FEMA 93)							X		X
Construction management										
Inspection	III.B.3.f (FEMA 93)		X	X	X		X	X		X
Reevaluation of design	III.B.5.f (FEMA 93) III.C.2 (FEMA 93)		X	X				X		X
Construction quality assurance and testing	III.C.4 (FEMA 93)		X	X			X	X	X	X
Operations and maintenance										

National Dam Safety Program Process/Components	Specific FEMA Guidance	Arizona BADCT Guidance	ICMM et al. (2020)	Rio Tinto (2015)	ICMM (2016)	CDA (2014)	MAC (2017)	ANCOLD (2012)	MEM (2017)	USACE (2002, 2004)
Develop written operating and maintenance procedures	III.D.1.b-c (FEMA 93)	3.5.4.5	X	X	X	X	X	X	X	X
Periodic inspection	III.D.2.a-b (FEMA 93)	3.5.4.6	X	X	X	X	X	X	X	X
Instrumentation	III.B.3.e (FEMA 93) III.B.5.e (FEMA 93) III.D.2.c (FEMA 93)		X					X		X
Correction of deficiencies	III.D.2.d (FEMA 93)		X	X	X		X	X	X	X
Emergency Planning	III.A.1.f (FEMA 93) III.B.1.e-f (FEMA 93) III.D.3 (FEMA 93)									
Determine failure modes	III.D.3.b.1 (FEMA 93)		X							X
Inundation maps or breach analysis	III.D.3.b.2-3 (FEMA 93)		X			X		X	X	
Response times	III.D.3.b.4 (FEMA 93)		X							
Emergency action plan	III.D.3.c-d (FEMA 93)		X	X	X	X	X	X	X	X
Other aspects										
Use of outside review	III.A.6 (FEMA 93)		X	X	X	X	X	X	X	
Risk-based design	III.A.1.g (FEMA 93) 2.3.6 (FEMA P-94)		X	X	X	X	X	X	X	
Closure/Post-closure design	*	3.5.5	X	X	X	X	X	X	X	
Accountability	*		X	X	X	X	X		X	
Change management and documentation	*		X	X	X		X		X	X

Sources: Rio Tinto (2015); International Council on Mining and Metals (2016); CDA = Canadian Dam Association (2014); Mining Association of Canada (2017); ANCOLD = Australian National Committee on Large Dams Inc. (2012); MEM = Ministry of Energy and Mines (2017); U.S. Army Corps of Engineers (2002) and U.S. Army Corps of Engineers (2004); International Council on Mining and Metals et al. (2020)

Notes:

FEMA 93 = Federal Guidelines for Dam Safety, April 2004

FEMA 333 = Federal Guidelines for Dam Safety, Hazard Potential Classification System for Dams, April 2004

FEMA P-94 = Selecting and Accommodating Inflow Design Floods for Dams, August 2013

FEMA 65 = Federal Guidelines for Dam Safety, Earthquake Analyses and Design of Dams, May 2005

* While components of the National Dam Safety Program standards touch on these topics, they are not handled in great specificity or detail.

INDUSTRY BEST PRACTICES

The mining industry has adopted a number of industry standards and best practices that are equally or more restrictive than the requirements of either the National Dam Safety Program or the APP program. These are shown in comparison to the National Dam Safety Program and APP program in table 3.10.1-1 (Australian National Committee on Large Dams Inc. 2012; International Council on Mining and Metals 2016; International Council on Mining and Metals et al. 2020; Mining Association of Canada 2017; Ministry of Energy and Mines 2017; Rio Tinto 2015; U.S. Army Corps of Engineers 2002, 2004).

There are number of concepts in these documents that represent industry best practices that are not strongly represented in the National Dam Safety Program or APP program standards. These include the following:

- *Risk-based design*. Most industry best practices described above, including the Global Industry Standard on Tailings Management, incorporate risk-based design (such as conducting an FMEA). FEMA standards allow for risk-based design as an option (see for example FEMA P-94, Section 2.3.6, Risk-Informed Hydrologic Hazard Analysis), but do not require it, as these techniques were still evolving and yet to be widely used when FEMA's primary guidance was developed. APP BADCT requirements do not incorporate risk-based design.
- *Design for closure*. Most industry best practices described above, including the Global Industry Standard on Tailings Management, explicitly require design to consider closure of the tailings storage facility and post-closure conditions. FEMA standards are largely silent on the issue of closure and post-closure of tailings facilities, instead focusing primarily on the design, construction, and operation of embankments. APP BADCT requirements (section 3.5.5) include specific closure parameters be incorporated into the design, with a focus primarily on restricting discharges and ensuring stability of the facility.
- *Accountability*. Most industry best practices described above, including the Global Industry Standard on Tailings Management, require specific individuals to be identified that are responsible for ensuring safety of the facility. FEMA standards and APP BADCT requirements require qualified personnel be used, but do not specify a single individual accountable for the design, construction, or management of the tailings storage facility.
- *Change management*. FEMA and APP BADCT requirements both include various requirements for documentation; however, industry best practices include a strong focus on managing and evaluating deviations from the original design, construction, or operation plan.
- *Independent review*. One common feature in many of the industry best practices listed here is the use of independent technical review by an outside expert or panel of experts. Independent review is not an explicit requirement of either FEMA standards or APP BADCT requirements. Resolution Copper has employed an Independent Technical Review Board to review the tailings design, drawing on professionals with recognized expertise in tailings design and management[86] (Resolution Copper 2017b). The ITRB has made a number of specific comments on design considerations for liquefaction, seismic loading, design factors for seismic and flood risk, and seepage controls.

[86] The four members of Resolution Copper's ITRB are David Blowes, Ph.D. (University of Waterloo), David A. Carr (Registered Geologist), Richard Davidson (Professional Engineer), and Norbert Morgenstern, Ph.D. (Professional Engineer; Professor Emeritus, University of Alberta; Chair of the Mount Polley Independent Expert Engineering Investigation and Review Panel; Chair of the Fundão Tailings Dam Investigation Panel).

APPROPRIATENESS OF RESOLUTION COPPER PROPOSED DESIGN

Many of the design standards that Resolution Copper must comply with, particularly those of the National Dam Safety Program, are narrative and non-prescriptive in nature. Key design parameters that are prescriptive and readily comparable between guidance documents are shown in table 3.10.1-2.
The designs developed by Resolution Copper meet the most stringent of these standards, whether required (National Dam Safety Program for Federal lands or APP program) or solely industry best practice. Specific design parameters also meet the prescriptive requirements of the recently launched Global Industry Standard on Tailings Management.

Table 3.10.1-2. Comparison of key design criteria against requirements of National Dam Safety Program, Aquifer Protection Permit program, and industry best practices

	Downstream Slope	Minimum Factor of Safety (Static)	Minimum Factor of Safety (Dynamic or Seismic)	Design Earthquake	Inflow Design Flood	Independent Review	Breach Analysis and Emergency Planning
FEMA National Dam Safety Program (Required)	No specific requirement	1.5	1.2	Maximum Credible Earthquake (for high-hazard dam)	Probable Maximum Flood (for high-hazard dam)	No specific requirement	Determine failure modes; prepare inundation maps; time available for response; develop emergency action plans
Aquifer Protection Permit program BADCT (Required)	No specific requirement	1.3 to 1.5	1.0 to 1.1	Maximum Credible Earthquake (for risk to human life)	Probable Maximum Flood (for risk to human life)	No specific requirement	No specific requirement
Industry best practices	No steeper than 2H:1V (Ministry of Energy and Mines 2017)	1.5 (Ministry of Energy and Mines 2017) 1.3 to 1.5 (Australian National Committee on Large Dams Inc. 2012)	1.0 to 1.2 (Australian National Committee on Large Dams Inc. 2012)	2,475-year return period (Ministry of Energy and Mines 2017) 10,000-year return period up to Maximum Credible Earthquake (Canadian Dam Association 2014) 10,000-year return period up to Maximum Credible Earthquake (Australian National Committee on Large Dams Inc. 2012) 10,000-year return period up to Maximum Credible Earthquake (International Council on Mining and Metals et al. 2020); for extreme hazard facility)	1,000-year return period up to Probable Maximum Flood (Canadian Dam Association 2014) 975-year return period, with 72-hour duration (Ministry of Energy and Mines 2017) 100,000-year return period up to Probable Maximum Flood (Australian National Committee on Large Dams Inc. 2012) 10,000-year return period up to Probable Maximum Flood (International Council on Mining and Metals et al. 2020) for extreme hazard facility)	Required by most industry standards	Emergency action plans required by most industry standards; inundation maps required by Australian National Committee on Large Dams Inc. (2012), Canadian Dam Association (2014), Ministry of Energy and Mines (2017), and International Council on Mining and Metals et al. (2020)

	Downstream Slope	Minimum Factor of Safety (Static)	Minimum Factor of Safety (Dynamic or Seismic)	Design Earthquake	Inflow Design Flood	Independent Review	Breach Analysis and Emergency Planning
Resolution Copper design	Alternative 2 has a 4H:1V slope, and Alternatives 3, 5, and 6 all have a 3H:1V slope	1.5	1.2	Maximum Credible Earthquake Analysis indicates Maximum Credible Earthquake is equivalent to 10,000-year return period. The 10,000-year design earthquake is based on a mean value; the 95th percentile of the 10,000-year event was also considered.	Probable Maximum Flood, 72-hour duration	Use of ITRB to oversee tailings design process	Not yet completed. This would be a required step for the preferred alternative based on site-specific information and design.
Comparison of Resolution Copper criteria to guidelines	Slope is less steep than the most stringent prescriptive standard	Static factor of safety meets the most stringent prescriptive standard	Dynamic factor of safety meets the most stringent prescriptive standard	Design earthquake meets the most stringent prescriptive standard	Design flood meets the most stringent prescriptive standard	Review by ITRB is consistent with the industry standard	Not yet met, but would be met for preferred alternative

Existing Conditions and Ongoing Trends

DOWNSTREAM COMMUNITIES

The tailings alternatives are located upstream of population centers in central Arizona that could be affected in the event of a failure. Communities in the approximate flow path of a potential tailings release are shown in table 3.10.1-3, for roughly 50 miles downstream.[87] For Alternatives 2 and 3, the hypothetical flow path of a tailings release is assumed to follow Queen Creek, through Whitlow Ranch Dam, through the community of Queen Valley, through urban development in the East Salt River valley, and eventually onto the Gila River Indian Community. For Alternative 5, the hypothetical flow path is assumed to follow Donnelly Wash to the Gila River, and then downstream through Florence and eventually onto the Gila River Indian Community. For Alternative 6, the hypothetical flow path is assumed to follow Dripping Spring Wash to the Gila River toward Winkelman, Hayden, and Kearny.

Table 3.10.1-3. Communities and populations within 50 miles downstream of proposed tailings facilities

	Alternatives 2 and 3 – Near West Location	Alternative 4 – Silver King Location	Alternative 5 – Peg Leg Location	Alternative 6 – Skunk Camp Location
Nearest downstream residence	0.3 mile	4.5 miles	Directly adjacent	4 miles
Other points of interest		Boyce Thompson Arboretum = 3.7 miles		
Major communities				
1–10 miles downstream	Queen Valley CDP (654)	Queen Valley CDP (654)		Dripping Springs CDP (165)
11–20 miles downstream	San Tan Valley CDP (90,665)			
21–30 miles downstream	Town of Queen Creek (33,298) Town of Gilbert (232,176)		Town of Florence (26,066) Blackwater CDP [Gila River Indian Community] (1,653)	Town of Winkelman (262) Town of Hayden (483)
31–40 miles downstream	City of Chandler (245,160)		Sacaton Flats Village CDP [Gila River Indian Community] (457)	Town of Kearny (2,249)
41–50 miles downstream	Lower Santan Village CDP [Gila River Indian Community] (395) Stotonic Village CDP [Gila River Indian Community] (379) Sweet Water Village CDP [Gila River Indian Community] (152)		Sacaton CDP [Gila River Indian Community] (2,338) Upper Santan Village CDP [Gila River Indian Community] (391) Lower Santan Village CDP [Gila River Indian Community] (395) Stotonic Village CDP [Gila River Indian Community] (379) Sweet Water Village CDP [Gila River Indian Community] (152)	

[87] While the empirical estimates discussed in section 3.10.1.4 indicate that tailings could go farther than 50 miles in the event of a catastrophic failure, this analysis focuses on communities in the East Salt River valley and along the Gila River that would be within a distance of 50 miles downstream of the tailings storage facility alternative, which have the highest likelihood of being impacted if a catastrophic failure were to occur.

	Alternatives 2 and 3 – Near West Location	Alternative 4 – Silver King Location	Alternative 5 – Peg Leg Location	Alternative 6 – Skunk Camp Location
Estimated population within 50 miles	*602,879*		*31,831*	*3,159*

Source: ACS 2013–2017 5-year Estimates: Total Population (U.S. Census Bureau 2018b)

Note: CDP = Census designated place

DOWNSTREAM WATER SUPPLIES

The tailings facilities are also upstream of substantial water supplies in central Arizona, including both community potable water systems and agricultural irrigation districts, as shown in table 3.10.1-4. In the event of a tailings failure, water supplies would be at risk from destruction of infrastructure and potential contamination of surface water and groundwater sources.

Table 3.10.1-4. Water supplies in central Arizona within 50 miles downstream of proposed tailings facilities

Water Supply	Population/ Acreage Served	Source of Water	Downstream of Alternatives
Community Water Systems			
Queen Creek Water Company	74,842	Groundwater (wells within 2,000 feet of Queen Creek)	Alternatives 2 and 3
Town of Gilbert	247,600	Surface water (SRP, CAP); Groundwater (wells directly adjacent to Queen Creek)	Alternatives 2 and 3
Apache Junction (Arizona Water Company)	57,647	Groundwater (wells 10–11 miles from Queen Creek)	Alternatives 2 and 3
Superior (Arizona Water Company)	3,894	Groundwater (wells 3–4 miles from Queen Creek)	Alternatives 2 and 3
Central Arizona Project	~850,000	Delivery of surface water to over a dozen downstream contract holders, including systems serving Tucson, Florence, Marana, Coolidge, and Casa Grande	Alternatives 2, 3, 5, and 6
Diversified Water Utilities	3,868	Groundwater (wells directly adjacent to Queen Creek)	Alternatives 2 and 3
Queen Valley Domestic Water Improvement District	1,000	Groundwater (wells directly adjacent to Queen Creek)	Alternatives 2 and 3
City of Chandler	247,328	Surface water (SRP, CAP); Groundwater (wells 1–2 miles from Queen Creek)	Alternatives 2 and 3
Johnson Utilities	62,158	Groundwater (wells 1–2 miles from Queen Creek)	Alternatives 2 and 3
Town of Florence	14,880	Groundwater (wells directly adjacent to Gila River)	Alternative 5
Johnson Utilities – Anthem at Merrill Ranch	7,028	Groundwater (wells 1–2 miles from Gila River)	Alternative 5
Gila River Indian Community – Casa Blanca/Bapchule	2,603	Groundwater (well locations unknown)	Alternative 5
Gila River Indian Community – Sacaton	5,307	Groundwater (well locations unknown)	Alternative 5
Winkelman (Arizona Water Company)	468	Groundwater (wells within 1,000 feet of Gila River)	Alternative 6
ASARCO Hayden Operations	779	Groundwater (wells directly adjacent to Gila River)	Alternative 6
Town of Hayden	870	Groundwater purchased from ASARCO	Alternative 6

Water Supply	Population/ Acreage Served	Source of Water	Downstream of Alternatives
Town of Kearny	2,070	Groundwater (wells directly adjacent to Gila River)	Alternative 6
Major Irrigation Districts			
New Magma Irrigation and Drainage District	~27,000 acres	Groundwater; CAP	Alternatives 2 and 3
Queen Creek Irrigation District	~16,000 acres	Groundwater; CAP	Alternatives 2 and 3
San Tan Irrigation District	~3,000 acres	Groundwater; CAP	Alternatives 2 and 3
San Carlos Irrigation and Drainage District	~50,000 acres	Surface water (Gila River); CAP; Groundwater	Alternatives 5 and 6

DOWNSTREAM WATERS AND HIGH-VALUE RIPARIAN AREAS

Riparian Areas Downstream of Tailings Storage Facility

High-value riparian ecosystems exist downstream of all of the tailings alternative locations. These include the following:

- Queen Creek at Whitlow Ranch Dam (downstream of Alternatives 2, 3, and 4). Perennial flow occurs in Queen Creek at Whitlow Ranch Dam, which is the outlet for subsurface flow in the Superior Basin. Approximately 45 acres of riparian vegetation have grown up behind Whitlow Ranch Dam, supported by flowing surface water and shallow groundwater. There is a dense understory. Saltcedar dominates the woody vegetation, although other riparian tree species are also present, including cottonwood and willow. This area is important to birding and outdoor recreation. Endangered southwestern willow flycatchers have been documented in this habitat in ongoing surveys conducted by Resolution Copper; endangered western yellow-billed cuckoos have not been detected during surveys, but the habitat is appropriate for the species.
- Gila River between Dripping Spring Wash and Ashurst-Hayden Dam (downstream of Alternatives 5 and 6). This reach of the Gila River is generally perennial, though flow is regulated by releases from the San Carlos Reservoir upstream. A riparian gallery exists along substantial portions of this reach, dominated by saltcedar, with some mesquite, cottonwood, willow, and wet shrublands (Stromberg et al. 2005). This reach of the Gila River includes critical habitat for the endangered southwestern willow flycatcher and proposed critical habitat for the threatened western yellow-billed cuckoo and northern Mexican gartersnake, and is habitat for a number of native species (desert sucker, Gila longfin dace, Sonoran sucker, roundtail chub), amphibians (lowland leopard frog), reptiles (desert tortoise, box turtle), and bats (pallid bat, pale Townsend’s big-eared bat, and California leaf-nosed bat). Recreational activities along this stretch of the Gila River include hiking, birding, and camping, particularly along the Arizona Trail, which crosses the Gila River downstream of Kearny. Additionally, the abandoned town of Cochran, Arizona and the associated coke ovens are accessible from this stretch of the Gila River.
- In 1994, BLM completed a legislative EIS evaluating 20 river systems in Arizona, to identify those suitable for designation in the National Wild and Scenic Rivers System. Approximately 7.5 miles of the Gila River from Dripping Spring Wash to the town of Winkelman was determined to be suitable, with a “recreational” classification. The outstandingly remarkable values identified in the area are scenic, fish, and wildlife habitat. This river segment includes two developed recreation sites, providing access to the river for wildlife, viewing, fishing, hunting, camping, and picnicking (Bureau of Land Management 1994a). The Gila River between Dripping Spring Wash and the Ashurst Hayden Dam also is used for small-craft river floating activities

(kayak, inflatable canoe, tubing), and fishing. Recreational river use is highest upstream from Winkelman, with less recreational use downstream from the town. Although this area was studied and recommended for designation under the Wild and Scenic Rivers Act, there has been no official designation for this section of the Gila River.

- A number of wetland[88] areas are associated with the Gila River (downstream of Alternative 5). A large wetland complex has developed along the Gila River Indian Community's MAR-5 managed aquifer recharge project, located near Sacaton, Arizona. The community is planning to enhance this area with the development of the Gila River Interpretive Trail and Education Center (Gila River Indian Community 2016).

Riparian Areas Crossed or Paralleled by Tailings and Concentrate Pipelines

Copper Concentrate Pipeline and Tailings Pipelines for Alternatives 2, 3, and 4

The copper concentrate pipeline route from the West Plant Site to the filter plant and loadout facility crosses a number of ephemeral washes that are tributary to Queen Creek: Silver King Wash, Rice Water Wash, Potts Canyon, Benson Spring Canyon, and Gonzales Pass Canyon. All contain some amount of xeroriparian habitat in linear strands along the drainage, typically mesquite, palo verde, ironwood, and desert shrubs in concentrations greater than found in the uplands. The width of xeroriparian habitat crossed by the pipeline varies, from roughly 50 feet to 500 feet wide. The copper concentrate pipeline route also parallels an ephemeral portion of Queen Creek upstream of Whitlow Ranch Dam, which has a well-developed xeroriparian community.

The tailings pipeline route to Alternatives 2 and 3 also crosses Silver King Wash, Rice Water Wash, and Potts Canyon, and the tailings pipeline route to Alternative 4 crosses Silver King Wash. Similar xeroriparian habitat exists at these crossings.

Alternative 5 Tailings Pipeline

The tailings pipeline route for Alternative 5 crosses several ephemeral washes, including Zellweger Wash and Walnut Canyon, both tributaries to the Gila River, with similar xeroriparian habitat as that described earlier. Walnut Canyon has a riparian reach designated as part of the White Canyon Wilderness. Important resources values in this area are outstanding scenic, wildlife, and cultural values.

The Queen Creek pipeline crossing would be constructed underground, installed using either trenching techniques or horizontal directional drilling. At this location, the stream is ephemeral and approximately 400 feet wide; however, the pipeline route nearby also crosses an unnamed tributary that receives effluent from the Superior Wastewater Treatment Plant. Thick hydroriparian vegetation is supported along this wash, and the streamflow feeds a perennial reach of Queen Creek located a few hundred feet downstream.

The pipeline route also parallels a portion of upper Arnett Creek for about 2 miles, near SR 177. Arnett Creek in this area is largely ephemeral with xeroriparian habitat, but portions of Arnett Creek downstream of this location have perennial flow.

[88] In this section, a number of references are made to wetland or riparian areas. The intent is to identify physical features on the landscape with high value for habitat, recreation, aesthetics, and other uses. These references to wetlands should not be construed to mean that these are jurisdictional waters of the U.S., as regulated under Section 404 of the Clean Water Act. That designation would be made by the USACE when appropriate.

Where the pipeline route crosses the Gila River it would be underground, installed using trenching techniques or horizontal directional drilling. At this location, the river is perennial, approximately 1,000 feet wide, and supports both aquatic habitat and hydroriparian vegetation.

Alternative 6 Tailings Pipeline

Since the DEIS, the Alternative 6 pipeline route was modified, in response to public comments and to avoid impacts to the endangered Arizona hedgehog cactus. The rerouted pipeline considered in the FEIS is now substantially shorter and avoids perennial water and critical habitat along Mineral Creek entirely, except for a trenchless underground crossing[89] upstream of Government Springs Ranch.

The tailings pipeline route for Alternative 6 crosses several ephemeral washes tributary to Queen Creek, including Conley Springs Wash and Yellowjack Wash. Some xeroriparian vegetation is associated with these washes, but sparse due to the steep and rocky terrain. Queen Creek lies about 2 miles downstream of the pipeline crossings, and is generally intermittent in this area, but with some hydroriparian vegetation adjacent to the channel (cottonwood, sycamore, ash, walnut). The pipeline route also crosses Queen Creek itself in this same area using a bridge crossing.

The pipeline route crosses Devil's Canyon upstream of where perennial flow first occurs, using an overhead span. Within a few miles downstream of the pipeline crossing, Devil's Canyon is characterized by perennial flow, flowing springs, deep pools, and a closed-canopy hydroriparian corridor (ash, sycamore, alder), with associated aquatic habitat. The pipeline route crosses Rawhide Canyon, an ephemeral wash tributary to Devil's Canyon near the corridor, with relatively sparse xeroriparian habitat.

The pipeline route now avoids perennial flow associated with both Lyons Fork and Mineral Creek, with only a single crossing that would avoid Mineral Creek habitat and flow entirely, using an underground trenchless crossing.

INFRASTRUCTURE

In addition to population centers, water supplies, and high-value riparian areas, a number of important transportation or water supply structures are downstream of the proposed tailings facilities. These include the following:

- Whitlow Ranch Dam. Whitlow Ranch Dam is a flood control structure located on Queen Creek, immediately downstream of Alternatives 2 and 3. The dam was built in 1960 to reduce the risk of flood damage to farmland and developed areas, including the communities of Chandler, Gilbert, Queen Creek, and Florence Junction, as well as the former Williams Air Force Base (now Phoenix-Mesa Gateway Airport). The USACE evaluated the structure in 2009 and rated it as inadequate (due to foundation seepage and piping), but with a low probability of failure (U.S. Army Corps of Engineers 2012b). The capacity of Whitlow Ranch is approximately 86 million cubic meters (Maricopa County Flood Control District 2018); the ability of the dam to retain or detain a tailings release from Alternatives 2 or 3 would depend on the specific size of a failure.
- East Salt River valley canals and flood control. Three major distribution canals are downstream of the flow path of a hypothetical tailings release from Alternatives 2 or 3. The Eastern and Consolidated Canals pass through the communities of Chandler and Gilbert and are part of the SRP distribution system. The Roosevelt Canal is part of the Roosevelt Conservation District and parallels a major flood control structure, the East Maricopa Floodway. This floodway is

[89] The trenchless crossing would likely be accomplished using horizontal directional drilling, which is a technique commonly used to place pipelines under roads and highways without causing traffic closures. A borehole would be drilled that passes completely underneath the riparian habitat and creek, and then the pipeline would be pulled through the borehole.

essentially an urbanized extension of Queen Creek; the ability of the floodway to retain or detain a tailings release would depend on the specific size of a failure.

- Central Arizona Project aqueduct. The CAP aqueduct transports water from the Colorado River, through Lake Pleasant north of Phoenix, and then transits the East Salt River valley. The aqueduct crosses Queen Creek near the communities of Queen Creek and San Tan Valley; flows from Queen Creek bypass the canal using a syphon system. The canal is raised and tends to block overland flow along much of its length; the ability of the canal levee to retain or detail a tailings release would depend on the specific size of a failure. The CAP canal also crosses the Gila River near Florence, but unlike the Queen Creek crossing, the flows from the canal are routed below the Gila River. The aqueduct continues through Pinal County and provides water as far south as Tucson and Green Valley.
- Arizona Water Company infrastructure. The potable water pipeline serving the town of Superior is located within the MARRCO corridor and would be downstream of a potential tailings release from Alternatives 2 or 3. This system serves approximately 4,000 people.
- Ashurst-Hayden Dam, Northside Canal, Florence Casa Grande Canal. These water diversion structures are located east of Florence and form the headworks to divert water from the Gila River for irrigation, including to the San Carlos Irrigation and Drainage District.
- U.S. Route 60. U.S. 60 crosses Queen Creek near Florence Junction. This highway forms one of only a few regional connections between the Phoenix metropolitan area and the communities of the central Arizona highlands (Globe–Miami) and the White Mountains of eastern Arizona (Show Low, Pinetop-Lakeside, Springerville).
- U.S. Route 77. U.S. 77 crosses the Gila River near Winkelman and Dripping Spring Wash near its confluence with the Gila River. This highway forms the main regional connector for the areas between Tucson and Globe, connecting to the Upper Gila valley at Safford and the White Mountains northeast of Globe.
- U.S. Route 79. U.S. 79 crosses the Gila River near Florence. This highway forms the main regional connector for the agricultural areas between Tucson and the East Salt River valley.
- Christmas, Shores, and Winkelman Campgrounds. These are improved recreational facilities located adjacent to the Gila River and important for water-based recreation activities.

3.10.1.4 Environmental Consequences of Implementation of the Proposed Mine Plan and Alternatives

Alternative 1 – No Action

Under the no action alternative, the tailings facility would not be constructed, pipelines would not be built, and there would be no risk to public health and safety associated with potential failure of a tailings embankment or pipelines.

Impacts Common to All Action Alternatives

EFFECTS OF THE LAND EXCHANGE

The Oak Flat Federal Parcel would leave Forest Service jurisdiction. The role of the Tonto National Forest under its primary authorities in the Organic Administration Act, Locatable Minerals Regulations (36 CFR 228, Subpart A), and Multiple Surface Use Act of 1955 (30 U.S.C. 601–615) is to ensure that mining activities minimize adverse environmental effects on NFS surface resources. The removal of the Oak Flat Federal Parcel from Forest Service jurisdiction negates the ability of the Tonto National Forest to regulate effects on these resources. However, nothing related to the tailings storage facilities is associated with the Oak Flat Federal Parcel, and the land exchange would not have an effect on public health and safety in this regard.

The offered lands parcels would enter either Forest Service or BLM jurisdiction. Section 3003, Subsection (f), of PL 113-291 specifies that any land acquired by the United States in the land exchange is withdrawn from all forms of entry, appropriation, or disposal under the public land laws, location, entry, and patent under the mining laws, and disposition under the mineral leasing, mineral materials, and geothermal leasing laws.

Specific management of mineral resources on the offered lands would be determined by the agencies, subject to the withdrawal in Subsection (f) of PL 113-291. Given these restrictions, little or no tailings-related activity would be expected to occur on the offered lands.

FOREST PLAN AMENDMENT

The Tonto National Forest Land and Resource Management Plan (1985b) provides guidance for management of lands and activities within the Tonto National Forest. It accomplishes this by establishing a mission, goals, objectives, and standards and guidelines. Missions, goals, and objectives are applicable on a forest-wide basis. Standards and guidelines are either applicable on a forest-wide basis or by specific management area.

A review of all components of the 1985 forest plan was conducted to identify the need for amendment due to the effects of the project, including both the land exchange and the proposed mining plan of operations (Shin 2020). No standards and guidelines were identified applicable to management of tailings from a safety perspective. See the process memorandum (Shin 2020) for additional details.

EFFECTS OF COMPENSATORY MITIGATION LANDS

No tailings would be associated with compensatory mitigation lands, and the compensatory mitigation lands would have no effect on concerns of tailings and pipeline safety.

EFFECTS OF RECREATION MITIGATION LANDS

No tailings would be associated with recreation mitigation lands, and the recreation mitigation lands would have no effect on concerns of tailings and pipeline safety.

SUMMARY OF APPLICANT-COMMITTED ENVIRONMENTAL PROTECTION MEASURES

A number of environmental protection measures are incorporated into the design of the project that would act to enhance tailings safety. These are non-discretionary measures, and their effects are accounted for in the analysis of environmental consequences.

Applicant-committed environmental protection measures for tailings and pipeline safety include those outlined in the tailings design documents (Golder Associates Inc. 2018a; Klohn Crippen Berger Ltd. 2018a, 2018b, 2018c, 2018d, 2019d), the Tailings Corridor Pipeline Management Plans (AMEC Foster Wheeler Americas Limited 2019), the Concentrate Pipeline Corridor Management Plan (M3 Engineering and Technology Corporation 2019), and the GPO (Resolution Copper 2016c).

Partially in response to public comments on the DEIS and further review by the Forest Service, a Pipeline Protection and Integrity Plan specific to the Skunk Camp location (Golder Associates Inc. 2020) was developed between the DEIS and FEIS. This new plan is discussed in the "Mitigation Effectiveness" section.

Tailings Storage Facility Design and Operational Measures

The following measures, which enhance the safety of the tailings storage facility, have been incorporated into the tailings design:

- use modified centerline (Alternatives 2 and 3) or centerline embankment (Alternatives 5 and 6) for NPAG;
- use full downstream embankment for PAG tailings (Alternatives 5 and 6);
- perform thickening of both PAG, NPAG, and NPAG overflow tailings (Alternatives 2, 3, 5, and 6), and additional ultrathickening of NPAG tailings (Alternative 3);
- segregate PAG tailings into smaller separate cells (Alternatives 5 and 6); and
- use filtered tailings (Alternative 4).

A failure modes analysis has already been completed to identify all potential failure modes and to align them with design measures appropriate to address those modes (Klohn Crippen Berger Ltd. 2019a; Pilz 2019). The design measures are aligned with international best practice and Federal and State regulations. Resolution Copper has identified both preventive measures to minimize the potential for failure, and reactive measures if problems are seen to develop. These are considered applicant-committed environmental protection measures and are summarized in table 3.10.1-5.

Table 3.10.1-5. Applicant-committed environmental protection measures addressing key failure modes, during both design and operations

Failure Mode	Preventative Controls	Responsive Actions (if problems develop)
Failure through foundation. Certain types of geological materials can exhibit problematic behavior due to the stress of supporting millions of tons of material, including consolidation, liquefaction, or bedding plane weaknesses.	Removal of materials (design); use of shear keys (design); thorough site investigation (design); slope flattening (design); monitoring of pore pressure and deformations (operations).	Construct berms (operations); move water pond farther from embankment (operations).
Slope failure through tailings. These failures occur when the tailings or tailings embankment loses strength, caused by increased pore pressures that reduce strength and lead to liquefaction. Failure can be triggered by either static (i.e., a gradual increase of stress as the facility grows) or seismic means.	Use of modified-centerline or centerline embankments (design); quality assurance/control during construction to confirm density requirements (operations); monitoring of pore pressure and deformations (operations); minimize perforations (pipes) through embankments (operations).	Flatten embankment slopes (operations); maintain water pond farther from embankment (operations).
Failure through internal erosion or piping. Flow developing within the embankment or foundation can wash out fine particles, gradually leading to voids and a vicious cycle of greater flow and greater washout. Controlling movement and loss of fine particles using filter materials is a key design element.	Facility beach length and structure (design); inclusion of filter materials (design); quality assurance/control during construction to confirm proper placement of materials (operations).	Placement of filters on downstream slope (operations); movement of pond away from embankment (operations); modify spigotting or tailings deposition to reduce hydraulic gradients (operations).
Failure by overtopping. When water accumulates in the pond behind the embankment and exceeds the crest height, water flowing over the top can erode the downstream face of the embankment.*	Design for adequate freeboard (Probable Maximum Flood); pond storage and management requirements (design); armoring of downstream slope (design); monitoring of water levels and maintain sufficient beach width (operations).	Maintain adequate embankment freeboard (operations); construction of emergency spillways (operations); pumping (operations); emergency embankment raising (operations).

Failure Mode	Preventative Controls	Responsive Actions (if problems develop)
Failure through surface erosion. Erosion of material from the downstream embankment, not only by directly causing a breach, but also by causing the downstream slope to become steeper than designed.*	Repair of erosion channels (operations); stormwater control (design); armoring or use of riprap (design); regular maintenance of erosion controls (operations).	Emergency repairs of eroded material (operations).

* Portions of all alternatives involve development within floodplains of major surface drainages, mapped or unmapped, as described in section 3.7.3. Management of stormwater specifically is addressed in the prescriptive tailings standards through selection of design flood events. The potential for erosion to jeopardize the tailings embankment specifically was considered during the FMEA process.

Pipeline Design and Operational Measures

A failure modes analysis was also completed for both the concentrate and tailings pipelines; an updated version specific to the Skunk Camp tailings pipeline was completed after the DEIS (Golder Associates Inc. 2020). The analysis informed the following design measures for both the tailings and concentrate pipelines that enhance the safety of the pipelines:

- Install pipe bridges for concentrate pipeline over Queen Creek outside the ordinary high-water mark of that drainage.
- For tailings pipelines that cross Devil’s Canyon and Mineral Creek (Alternative 6), pipeline corridors would pass overhead or beneath the streams, with no disturbance to riparian habitat or waters within the ordinary high-water mark.
- Fabricate and test all pipelines in corridors for concentrate, tailings, and water in accordance with the requirements of American Society of Mechanical Engineers (ASME) standards or equivalent for quality assurance and quality control purposes. A quality assurance/quality control system would be in place during construction (required by code and standards). A post-construction hydrostatic test would be conducted to prove the integrity of the newly installed pipeline.
- Locate pressure indicators on non-buried pipelines intermittently along water, tailings, and concentrate pipelines. Flow indicators would be placed near the tailings pumps and at the end of the line. A leak detection system would connect via fiber-optic cable to the control room at the West Plant Site and the control room at the tailings facility if a separate facility exists.
- Pipelines would be buried where feasible, given the geological setting, and where buried they would be appropriately wrapped. Field assessments would confirm the characterization of the pipeline route, including site-specific geophysical survey to approximate the extent of any suspected subsurface voids, and routing adjustments within the approved corridor would avoid unstable slopes or areas.
- Sacrificial anodes would be installed at determined intervals on the buried concentrate pipelines and select sections of tailings pipelines to mitigate corrosion of pipeline sections. Installation of sacrificial anodes would follow appropriate best practices for proper placement in order to minimize the potential for migration of metals resulting from dissolved or decayed metallic anodes.
- Shut-off valves would be located at booster pump stations.
- Double containment would be used on the concentrate pipeline at major stream crossings, and it would be routed through sleeves underneath major crossings. Tailings pipelines would be sleeved under major crossings. Expansion loops would be incorporated along the pipeline corridor.
- A minimum of 3.3 feet of horizontal and vertical separation would be used between pipelines and existing utilities or infrastructure.

- The tailings pipeline would be concrete and high-density polyethylene (HDPE) and non-pressurized for Alternatives 2 and 3, designed to flow approximately 50 percent full. The tailings pipelines to Alternatives 5 and 6 would likely be carbon steel and pressurized.
- The concentrate pipeline would be schedule 40 steel with an HDPE protective lining.
- Aboveground concentrate and tailings pipelines would be contained in a secondary containment ditch where possible and painted with an epoxy coating to prevent degradation.

In addition, a number of operational or management control measures for pipelines have been identified:

- Development of a tailings pipeline operations manual to summarize inspections and maintenance protocols (Operations, Maintenance, and Surveillance).
- Resolution Copper would have equipment available and/or contractors readily available on-site for pipeline repair. The pipeline access road would provide access to the full length of the line.
- There would be daily[90] patrols along the pipelines to look for leaks; containment spills, sediment build-up, and breaches; drainage sediment build-up, blockages, and wash-outs; access road erosion and damage; pipe bridges and over/underpass damage; landslides; third-party interference; and other potential hazards.
- The Operations, Maintenance, and Surveillance manual would be followed for immediately investigating, reporting, and implementing a response plan for suspected leaks from the tailings pipeline. Aberrations in flow rate, pump operation, and pressures would trigger investigations and emergency response if needed, as well as coordination with any agencies with surface management responsibility, such as the Forest Service.
- A tailings pipeline spill prevention and response plan (pipeline management plan) would be prepared as part of the comprehensive pipeline integrity program. The program would include maintenance of records, regular review of leak monitor data, regular corridor inspections, regular internal inspections using “smart-pigs,”[91] development of spill response plans, and having pre-positioned equipment and teams trained to respond to spills.
- The operating concentrate pipeline would contain pressure dissipation stations consisting of control valves, block valves, and ceramic orifice plate chokes. This control system would keep the normal pipeline operating pressure below 500 psig (pounds per square inch gauge) and would lower the pressure to an acceptable level at the filter plant and loadout facility.

OUTCOME OF FEBRUARY 2020 FMEA

FMEA participants collaborated in the analysis of 16 credible potential failure modes related to the preferred alternative (Alternative 6) tailings storage facility (Gannett Fleming 2020). FMEA participants considered an additional 23 potential failure modes but found them “to be so unlikely as to be considered non-plausible” (Gannett Fleming 2020). The 16 credible potential failure modes included the following:

- For the NPAG main tailings embankment:
  - Ten potential failure modes under normal loading conditions;
  - Three potential failure modes under seismic loading conditions; and

[90] The management plans for the concentrate pipeline and tailings pipeline call for daily inspections (AMEC Foster Wheeler Americas Limited 2019; M3 Engineering and Technology Corporation 2019). This frequency was modified for the pipeline management plan specific to Alternative 6, which indicates inspections at least 26 times per year (Golder Associates Inc. 2020).

[91] “Smart-pigs” are pieces of equipment that can be placed inside pipes that allow inspection of pipelines from the inside. These are useful to identify areas of unusual wear or weakness.

  - o Two potential failure modes under hydrologic loading conditions.
- For the PAG cells, one potential failure mode was analyzed under normal loading conditions.

The credible potential failure modes assessed during the FMEA workshop included the following:

- **Foundation failure modes**: seven of the potential failure modes involved foundation failure (N-1 through N-5, S1, and PAG-N1)
- **Liquefaction failure modes:** each of the three seismic potential failure modes (S-1, S-2, and S-3) involved liquefaction
- **Surface erosion:** two of the potential failure modes involved surface erosion (N-10 and H-2)
- **Piping and internal erosion**: one of the potential failure modes (N-9) involved internal piping and erosion
- **Embankment failure:** four potential failure modes involved embankment failure other than the mechanisms above (N-6, N-7, and N-8, and H-1)

Each potential failure mode is rated for consequence (from low to extreme) and probability of occurring (from remote to very high). The results are plotted in a "risk matrix," as shown in figure 3.10.1-2.

Of the 16 potential failure modes developed during the FMEA workshop, no unmanageable risks were identified, and most generally fall within acceptable societal risk levels.[92] The mitigations developed to address the potential failure modes include specific data information needs (five items), surveillance and monitoring (nine items), risk reduction measures, including future design considerations (15 items), future planned activities (10 items), and contingencies that could be implemented if a potential failure mode began to develop (nine items) (Gannett Fleming 2020).

[92] Acceptable societal risk is a generalization but is informed by international guidance for conducting risk assessments. See Federal Energy Regulatory Commission (2016) for a summary of six different approaches for identifying societal acceptable risk. The line shown on figure 3.10.1-2 is an interpretation primarily based on U.S. Army Corps of Engineers (2014) guidance.

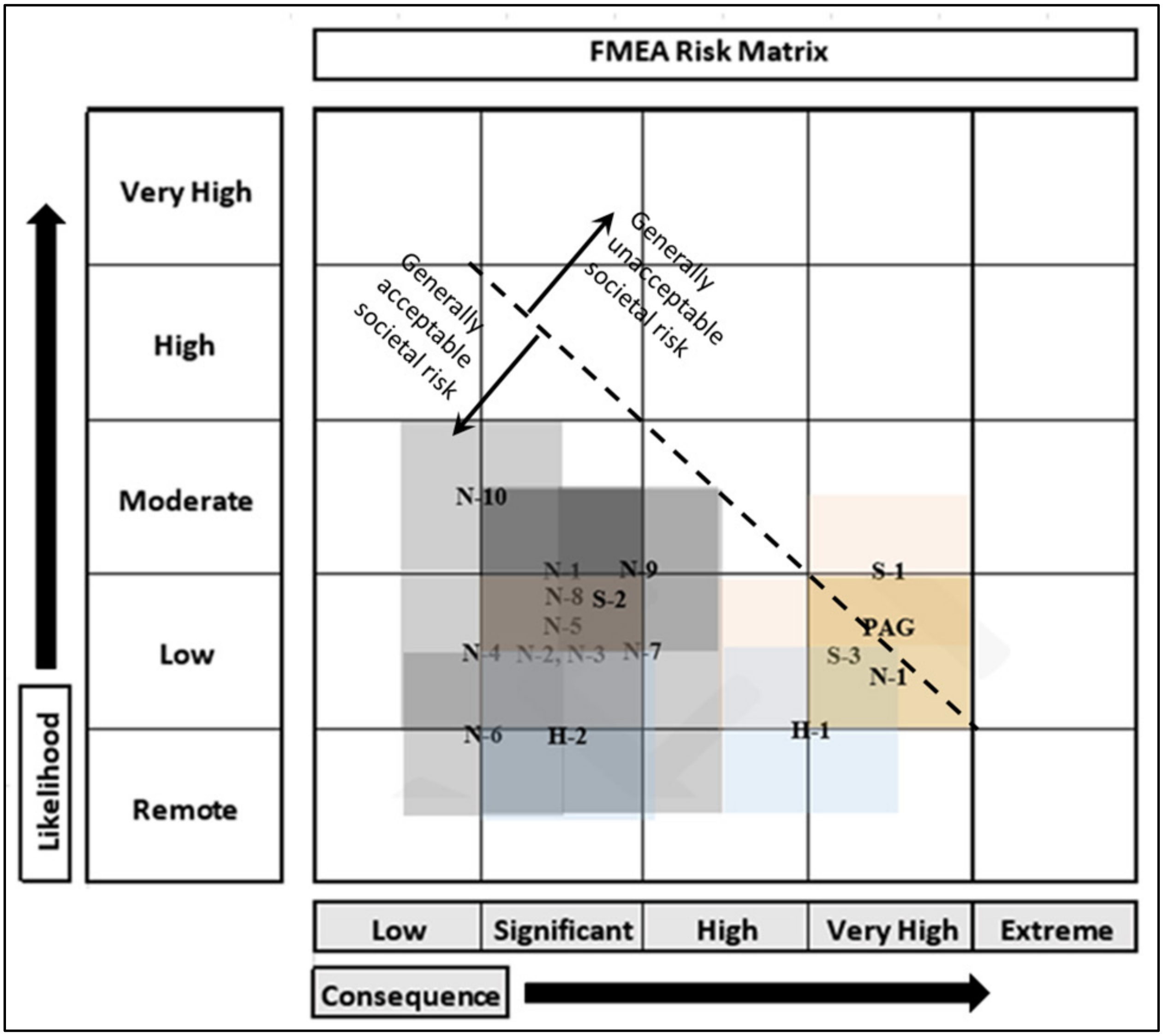


Figure 3.10.1-2. Risk matrix resulting from the February 2020 FMEA

ANALYSES SUPPORTING THE FMEA

Additional site investigation. A number of field investigations took place at the Skunk Camp location that were concluded and reported after publication of the DEIS (Fleming, Shelley, et al. 2018; KCB Consultants Ltd. 2019; Montgomery and Associates Inc. 2019a, 2020e, 2020g; WestLand Resources Inc. and Montgomery and Associates Inc. 2020; Wong et al. 2020b). Specific reports and types of investigations are detailed in section 3.2.

Overall, the on-site investigations largely confirmed the previous understanding of hydrology and geology at the site, as detailed in section 3.2. Updated results were available to FMEA participants and informed the discussions during the FMEA workshop. These included the refined understanding of groundwater depths and hydraulic conductivities, the presence, depth, and strength of underlying geological materials, and the types and quantities of materials available for construction and reclamation.

Slumping failure. As noted previously, during the FMEA workshop, in order to assess the severity of downstream consequences, a rough approximation was used for a “dry” failure without liquefaction, which assumed the movement of tailings 4 to 8 miles downstream. Following the FMEA workshop, this failure scenario was formalized by Resolution Copper’s tailings experts (KCB Consultants Ltd. 2020b).

The “dry” failure estimate assumed a breach of the main NPAG embankment, resulting in a release of tailings from the NPAG beach. This release is considered “dry” because under normal operations the recycled water pond is maintained over the PAG cells, which are located behind separate, free-standing downstream-type embankments approximately 1.4 miles upstream of the main embankment. The NPAG beach tailings are still saturated, but at variable amounts, with the tailings nearest the embankment and shallowest (depths of less than 100 feet) being the most drained and the least saturated. Unless mixed with water from the recycled water pond, these tailings would be largely non-flowable and would slump, much like a landslide. Note that the FMEA workshop considered credible potential failure modes where water would be present in the NPAG facility. The “dry” failure slumping estimate does not apply to these potential failure modes, but only to those failure modes where water is not present. Those potential failure modes that plot toward the right in figure 3.10.1-2 are considered higher risk and reflect more fluid tailings behavior with higher runout and consequences. Together, the Rico Empirical Method and the “dry” failure scenario represent a range of possible outflow scenarios.

Estimated parameters for the “slump” modeling were based on historic case studies and estimated tailings properties based on laboratory testing. The percentage of the total tailings projected to be released was calculated as 30 percent, which corresponds well with historic tailings releases. The runout distance was modeled as 5.7 miles from the toe of the main embankment.

Active faulting. An additional analysis undertaken after the FMEA concerns two faults (the Ransome and Dripping Springs Faults) that fall within the footprint of the tailings storage facility, requiring evaluation for whether they would be considered active faults. ADEQ guidance for mining facilities (Arizona Department of Environmental Quality 2004) defines an active fault as one that shows evidence of movement in the past 35,000 years (Quaternary era). Tertiary-era faults (with activity between 66 million years and 2.6 million years ago) do not fall into this category but often are candidates to evaluate for Quaternary activity. Tertiary faults can be ruled out as active faults if overlying Quaternary deposits show no evidence of fault-related deformation.

Two independent studies evaluated whether the faults at this location showed evidence of Quaternary activity, focusing on fault traces identified by previous geologists (KCB Consultants Ltd. 2019; Wong et al. 2020a). Taken together, these investigations used desktop mapping, field reconnaissance, and subsurface geophysics and drilling investigations to evaluate the mapped faults. The Forest Service also independently evaluated these two studies and concurred in general that there is sufficient evidence to argue against the presence of faults that cut surficial Quaternary or Tertiary deposits in mapped faults (Zellman and Cook 2020a).

Post-closure failure modes. During the FMEA workshop, Forest Service personnel raised a specific concern about post-closure failure modes being adequately addressed. For most of the 16 potential failure modes, the risk of failure decreases over time, as there will no longer be ponds on the tailings surface, the closure cover will reduce infiltration, and the entrained water will drain from the facility. However, two failure modes were identified for which the risk of failure could increase over time:

- Potential failure mode N-2 involves a slope instability through the foundation of the main embankment due to high porewater pressures. For this failure mode to occur, water behind the grout cutoff wall located just downstream of the main embankment could accumulate once shallow pumping wells are turned off. To mitigate this post-closure risk, the FMEA identified a potential need to remove the cutoff wall at the time of closure.

- Potential failure mode N-5 involves a slope instability through the foundation at the main embankment due to geochemical changes in the foundation over time. To mitigate this post-closure risk, the FMEA identified a potential need to continue to monitor water quality during the passive closure phase.

Resolution Copper prepared two reclamation and closure plans for the project (KCB Consultants Ltd. 2020c; Tetra Tech Inc. 2020); the Forest Service evaluated both of these plans (Enos and Meyer 2020; Epstein 2020; Garrett 2020h). This evaluation specifically included review of these two post-closure failure modes and found that specific mitigations were not incorporated into the plans.

Subsequent correspondence with Resolution Copper clarified aspects of these two failure modes (Resolution Copper 2020d).

- With respect to the grout curtain (potential failure mode N-2), Resolution Copper indicated that the elevation of the curtain would be low enough that accumulated water would not cause increased phreatic surface in the main embankment, but indicated that the grout curtain still would be removed after closure. Resolution Copper also clarified a concern raised by ADEQ with the Water Resources Workgroup that removal of the grout curtain would cause a “slug” of poor-quality water to migrate downgradient in the aquifer. Resolution Copper provided analysis that indicates concentrations in the aquifer would remain stable (Resolution Copper 2020d).
- With respect to long-term geochemical changes (potential failure mode N-5), Resolution Copper indicated that presently, the geochemical properties of the foundation and expected seepage water quality indicate that the foundation is very unlikely to degrade to low-strength material. However, if this were found to be a credible risk during construction, the embankment slope could be flattened. Resolution Copper also indicated that clogging of the underdrain was unlikely, but water quantity and quality monitoring to confirm the performance could be incorporated (Resolution Copper 2020d).

For both of these potential post-closure failure modes, Resolution Copper noted that the final design and closure configuration will be subject to an approved APP issued by ADEQ, and that the final tailings facility design, configuration, and closure/post-closure approach would be determined as part of that regulatory process.

DESCRIPTION OF HYPOTHETICAL TAILINGS BREACH

The Forest Service requires that the tailings storage facility design, construction, and operations adhere to National Dam Safety Program standards on Federal lands. This minimizes the risk for a catastrophic failure for Alternatives 2, 3, and 4, and likely for Alternative 5 as well (though this would be under the jurisdiction of the BLM). Adherence to the APP program BADCT standards also minimizes the risk for a catastrophic failure of the tailings storage facility for all alternatives. Adherence by Resolution Copper to the applicant-committed environmental protection measures, including industry best practices, further reduces the risk both by proactively providing robust design and containment measures, and by identifying operational steps that can be taken in reaction to a developing problem.

However, overall risk is the combination of both the probability of a failure and the consequences of that failure. While a tailings storage facility or pipeline failure is not reasonably foreseeable, the following discussion of a hypothetical tailings storage facility or pipeline failure provides a basis to compare the inherent risk in the tailings alternative locations and designs.

Estimated Magnitude and Downstream Effect

Table 3.10.1-6 summarizes the predicted volume released in a hypothetical tailings failure, and the downstream distance traveled, based on the empirical method (Larrauri and Lall 2018; Rico et al. 2007). The downstream distance traveled would roughly represent the downstream distance to the Colorado River, near Yuma, Arizona.

The filtered tailings (Alternative 4) would likely fail in a different manner than the slurry tailings alternatives (Alternatives 2, 3, 5, and 6). As described in table 3.10.1-6, rather than running out as a liquid, the tailings would slump in a relatively localized area.

There are a number of possible failure modes for filtered tailings. Identifying the most likely failure mode relies on whether the tailings are likely to experience liquefaction. The primary factors that would trigger liquefaction of tailings are material porosity and density, moisture content, fines content, static loading (the weight of the tailings themselves), and seismic loading (earthquakes). Generally, the dewatering requirements for practical filtered operations dictate fairly low moisture content; this is necessary for handling, transporting, and placing the tailings in the storage facility. The low moisture content necessary to handle tailings physically like this (estimated for Alternative 4 as 11 to 14 percent), represents a low potential for liquefaction. A filtered tailings facility that maintains drained conditions is expected to fail as a slump or landslide (rotational or wedge shape) with no flow of tailings downstream, regardless of whether the failure is triggered by static or seismic loading. Tailings release from a filtered tailings facility would be localized instead of flowing long distances (Witt et al. 2004).[93]

Table 3.10.1-6. Empirical estimates of a hypothetical failure

Distance to:	Alternatives 2 and 3 – Near West Location*	Alternative 4 – Silver King Location (filtered)†	Alternative 5 – Peg Leg Location	Alternative 6 – Skunk Camp Location	For Comparison: Actual Mount Polley Failure‡	For Comparison: Actual Fundão Failure‡
Calculated release volume (million cubic meters)	243 (136–436)	220	243 (136–436)	243 (136–436)	23.6	45
Calculated downstream distance traveled (miles)	277 (85–901)	~1–2.5	209 (65–669)	268 (83–868)	4.4	398

Source: Larrauri and Lall (2018). Calculations can also be run at https://columbiawater.shinyapps.io/ShinyappRicoRedo/.

Notes: Values shown reflect the median predicted result; values in parentheses indicate the range defined by the 25th and 75th percentiles.

Key parameters: Total facility volume at buildout = 1 billion cubic meters; Embankment height: Alt 2 (520 feet/158 m); Alt 3 (510 feet/155 m); Alt 5 (310 feet/94 m); Alt 6 (490 feet/148 m). Mount Polley and Fundão comparisons taken from Bowker (2019).

* Alternative 3 modeled as Alternative 2

† Alternative 4 uses filtered tailings and the empirical method is not applicable. A 220-million-cubic-meter release was modeled using the USGS LaharZ model instead.

‡ The Mount Polley release represented 32 percent of the total facility volume; the Fundão release represented 82 percent of the total facility volume.

Similar to assessing the failure modes for tailings embankments for slurry tailings facilities, an FMEA could be conducted on a filtered tailings facility to assess whether undrained failure modes could occur. An undrained condition would require that a phreatic surface (i.e., water table) develop within the tailings

[93] The USGS Lahar flow inundation zone simulation program (referred to as LaharZ) was used to estimate the runout zone from a potential failure of the filtered tailings (Schilling 2014). A failure angle of 10 degrees was assumed based on an estimate of the residual shear strength of the tailings in the event of saturation and/or lack of buttressing; this parameter changes with saturation levels and would change, depending on the failure modes defined in a refined FMEA.

mass itself. Under these conditions, the part of the tailings below the water table could experience liquefaction, while the part of the tailings above the water table would fail in a slump or landslide. Unlike the slurry tailings alternatives, as designed Alternative 4 would not have substantial amounts of water present and how an undrained scenario could develop is not clear. Defining a scenario under which the drainage would not occur and create a water table condition would likely require a combination of multiple factors, which could be identified during an FMEA-type of analysis.

Estimated Chemistry of Released Liquid

In the event of a failure, the materials potentially released downstream would include NPAG tailings (and associated water in the pore space), PAG tailings (and associated water in the pore space), and any standing water in the recycled water pond.

The potential effects of tailings on water quality are described in section 3.7.2 for stormwater and seepage. Water released during a potential failure would have similar characteristics, as shown in table 3.10.1-7. In the event of a release, concentrations above surface water quality standards would be anticipated for a number of metals, including cadmium, copper, nickel, selenium, silver, and zinc. Alternative 5 has the highest concentrations of cadmium, nickel, and notably copper.

Table 3.10.1-7. Potential for water contamination in the event of a tailings facility or pipeline failure

	Alternative 2 Released Water (mg/L)*	Alternative 3 Released Water (mg/L)*	Alternative 5 Released Water (mg/L)*	Alternative 6 Released Water (mg/L)*	Surface Water Standard for Most Restrictive Use (Gila River or Queen Creek)†	Surface Water Standard for Most Restrictive Use (Ephemeral Tributaries)†
Antimony	0.0114	0.0118	0.0056	0.0036	0.030	0.747
Arsenic	0.00092	0.00141	0.001853	0.00003	0.030	0.280
Barium	0.015	0.015	0.018	0.019	98	98
Beryllium	0.00124	0.00179	0.004552	0.00003	0.0053	1.867
Boron	0.85	0.44	0.331	0.27	1	186.667
Cadmium	0.016	0.015	0.0082	0.005	0.0043	0.2175
Chromium, Total	0.092	0.078	0.0364	0.030	1	–
Copper	0.199	0.199	4.604	0.194	0.0191	0.0669
Fluoride	2.4	2.4	3.3	2.9	140	140
Iron	0.001734	0.001727	0.008108	0.001717	1	–
Lead	0.0028	0.0021	0.00174	0.0009	0.0065	0.015
Manganese	2.23	2.23	2.182	0.63	10	130.667
Mercury	–	–	–	–	0.00001	0.005
Nickel	0.255	0.272	0.312	0.066	0.1098	10.7379
Nitrate	8.4	8.1	3.8	2.6	3,733.333	3,733.333
Nitrite	–	–	–	–	233.333	233.333
Selenium	0.346	0.349	0.149	0.113	0.002	0.033
Silver	0.079	0.073	0.030	0.026	0.0147	0.0221
Thallium	0.0058	0.0065	0.0022	0.0018	0.0072	0.075
Uranium	–	–	–	–	2.8	2.8

	Alternative 2 Released Water (mg/L)*	Alternative 3 Released Water (mg/L)*	Alternative 5 Released Water (mg/L)*	Alternative 6 Released Water (mg/L)*	Surface Water Standard for Most Restrictive Use (Gila River or Queen Creek)†	Surface Water Standard for Most Restrictive Use (Ephemeral Tributaries)†
Zinc	3.56	3.03	1.69	1.17	0.2477	2.8758

Notes: Dash indicates no results available for this constituent, or no standard applies to this constituent.

Shaded cells indicate the potential for concentrations to be above water standards.

* Results shown for all alternatives are based on predicted chemistry of "lost seepage," for year 41 representing full buildout of the facility (Eary 2018a, 2018b, 2018c, 2018d, 2018e).

† See appendix N, table N-5, for more details of applicable standards.

Estimated Chemistry of Released Solids

The solid tailings material deposited downstream once water drains away would also pose a contamination concern. As shown in table 3.10.1-8, concentrations of metals in remnant tailings materials would be above Arizona soil remediation levels for several constituents, including arsenic and copper, and require active cleanup to prevent further degradation of groundwater or surface water.

An accidental release because of a pipeline rupture would also pose similar concerns, whether a tailings pipeline or concentrate pipeline, as shown in table 3.10.1-8.

Table 3.10.1-8. Potential for contaminated material to be left in the event of a tailings facility or pipeline failure

	Copper Concentrate Material (mg/kg)*	Tailings Material (mg/kg)*	Arizona Soil Remediation Levels†
Antimony	2.2–13.3	0.18–0.71	31
Arsenic	11.4–1,180	2.0–20.9	10
Barium	20–70	120–360	15,000
Beryllium	0.05	1.62–3.53	150
Boron	–	–	16,000
Cadmium	6.56–28.1	0.09–0.24	39
Chromium, Total	28–77	36–68	120,000
Copper	>10,000	781–3,288	3,100
Fluoride	–	–	3,700
Iron	–	–	–
Lead	39.1–161.5	22–258	400
Manganese	5 - 35	20–902	3,300
Mercury	–	–	23
Nickel	32.1–71.2	17.4–45.5	1,600
Nitrate	–	–	–
Nitrite	–	–	–
Selenium	154–205	6–22	390
Silver	29–100	0.41–3.12	390
Thallium	0.17–4.57	0.29–0.82	5.2
Uranium	1–3.7	1.7–3.5	16

	Copper Concentrate Material (mg/kg)*	Tailings Material (mg/kg)*	Arizona Soil Remediation Levels†
Zinc	1,620–5,460	17–181	23,000

Notes: Dash indicates no results available for this constituent, or no standard applies to this constituent.

Shaded cells indicate the potential for concentrations to be above soil standards.

* Tailings and concentrate material values are based on whole rock analysis performed on simulated whole tailings and concentrate for four master composites (MC-1, MC-2, MC-3, MC-4) (MWH Americas Inc. 2014).

† Arizona Administrative Code R18-7-205. Values shown represent the most stringent soil standard for both residential and non-residential property uses. Chromium standard shown is for chromium III.

Alternative 2 – Near West Proposed Action

TAILINGS STORAGE FACILITY DESIGN

Tailings Embankment and Facility Design

The same design and safety standards apply to any tailings embankment (see table 3.10.1-2), regardless of whether the embankment has an upstream, modified-centerline, centerline, or downstream construction. However, even though the design standards are the same, there are still inherent differences between embankment types that can factor into the long-term probability of failure.

The majority of historic events that inform our understanding of when and how tailings facilities fail were constructed using the upstream method, in which the tailings themselves form part of the structure of the embankment. When designed and operated properly, these tailings facilities can be as safe as embankments constructed using modified-centerline or centerline methods.

However, based on expert investigation of historic failures, usually a failure is the result of a chain of events that might include improper characterization of the foundation and understanding of how foundation conditions potentially change with tailings (as with Mount Polley), as well as operational mistakes in which the embankment construction does not adhere to the design or is managed or operated improperly (as with Fundão). One of the main differences in embankment types is whether they are inherently resilient enough to withstand these series of unforeseen events or mistakes.

Even if embankments are designed to the same safety standards, an upstream embankment has less room for error when things do not go according to plan. A modified-centerline embankment is more resilient and has more ability to remain functional, despite any accumulated errors, and a centerline and downstream embankment have even higher resiliency.[94]

Alternative 2 would use a modified-centerline embankment, which is a design choice driven by the site geography, once the concept of an upstream embankment was abandoned (there is insufficient room at the Near West location for a full centerline embankment without expanding the footprint to another drainage). Modified-centerline embankments are inherently more resilient than upstream-type embankments, but less resilient to any accumulated missteps or unforeseen events than true centerline-type embankments.

The Alternative 2 main embankment is required to extend to three sides of the facility, is generally freestanding and not anchored to consolidated rock, and as such is the longest of the embankments

[94] A recent study indicates that roughly 70 percent of historic tailings failures involved upstream-type embankments, with the remainder roughly split between centerline and downstream-type embankments (Strachan and Van 2018). Note that there is inherent bias in these statistics, as the bulk of tailings structures have historically been upstream-type construction.

proposed (10 miles). These design features are not inherently unsafe, but are potentially less resilient than a shorter, well-anchored embankment (such as Alternative 6).

Foundation Materials

The difference between foundation materials between alternatives is whether they are built primarily on consolidated rock or unconsolidated alluvium. Either type of foundation—rock or alluvium—can be appropriate for a tailings facility, provided that there is adequate site characterization to identify all geological units present, understand their properties, and incorporate necessary treatment and preparation into the embankment design.

Alternative 2 is primarily built on consolidated rock, overlain by relatively thin surface soils and alluvial material along washes. Site preparation would likely involve removal of most loose material, including any weathered bedrock, and treating any problematic or weak spots in the exposed foundation. This allows better seepage control than an alluvial foundation. However, the proximity to Queen Creek downstream also limits the flexibility in adding seepage controls that can be employed in the event of unexpected seepage loss.

Storage of PAG Tailings

The method of storage of PAG tailings is another difference between alternatives that could affect outcomes associated with a failure of the facility. Alternative 2 employs a separate downstream-type starter embankment to initially contain the PAG tailings. Midway through the operational life, the PAG tailings are raised above the height of the starter embankment and therefore potentially would be released in the event of a failure of the primary embankment.

A downstream embankment is one that is fully self-supporting and has no deposited tailings incorporated into the structure, though it could be composed of cyclone tailings. A downstream embankment is considered the most resilient embankment type and has more ability to remain functional, despite accumulated errors.

POTENTIAL RISK TO LIFE AND PROPERTY

The Near West location (Alternative 2) is upstream of substantial populations due to the proximity to the Phoenix metropolitan area. An estimated 600,000 people live in the communities downstream that would be affected by a hypothetical tailings storage facility failure. This location also would offer relatively little reaction time for evacuation in the event of a sudden failure, due to the close downstream presence of Queen Valley.

POTENTIAL EXPOSURE TO CONTAMINANTS

All materials released during a hypothetical tailings failure pose risk of contamination. The water present in the tailings storage facility contains concentrations of metals (cadmium, copper, nickel, selenium, silver, zinc) above Arizona surface water quality standards (see table 3.10.1-7). If released, this water would potentially impact beneficial uses of surface waters, including wildlife use, aquatic habitat, livestock use, agricultural use, and potable use. Given the highly permeable soils associated with alluvial washes like Queen Creek, released water would likely infiltrate and affect groundwater resources as well, impacting other water uses.

Similarly, the tailings material itself contains concentrations of metals (arsenic, copper) above Arizona soil remediation standards. This material would be deposited in large amounts along Queen Creek. Unless removed, the deposited tailings material would represent a long-term continuing source of contamination to groundwater and stormwater flows. The deposited tailings material could also represent a long-term hazard to public health if it became airborne during high-wind events. Wind direction is highly variable throughout the year and can include particularly intense wind events during the summer monsoon; the close proximity to the Phoenix metropolitan area would potentially expose a large population to airborne tailings.

The tailings samples have been analyzed for their long-term potential for oxidation of pyrite materials, the generation of acid, and the release of metals. While the bulk of the pyrite minerals has been segregated into the PAG tailings, both the NPAG and PAG tailings still show the potential for acid generation (see section 3.7.2). The continued oxidation of pyrite minerals in deposited tailings would represent a long-term source of impact on water quality, underlying and downstream soils, aquatic ecosystems, and the potential uses of downstream water and agricultural land.

POTENTIAL DISRUPTION OF WATER SUPPLIES AND INFRASTRUCTURE

A hypothetical tailings failure for Alternative 2 represents a substantial risk to water supplies. Eight community water systems, serving a total population of almost 700,000, were identified in the downstream flow path. Some of these water systems have robust water portfolios and draw on different water sources, including surface water that would be unimpacted by a tailings release. All of these systems, however, use groundwater in some capacity and have pumping wells located near the downstream flow path. The primary risk to these water systems is the potential for groundwater resources to be contaminated, or loss of water-related infrastructure.

In addition, substantial agricultural water use occurs downstream, including almost 20,000 acres in the Queen Creek Irrigation District and San Tan Irrigation District. Water supplies to agricultural users could also be disrupted through loss of wells, delivery infrastructure, or groundwater contamination.

In addition to the disruption of community water systems and agricultural supplies, a hypothetical tailings release could also destroy key water supply infrastructure. Damage to the SRP system (Consolidated Canal, Eastern Canal) or to the CAP aqueduct could disrupt water supplies throughout central and southern Arizona, well beyond the immediate flow path of a hypothetical tailings failure. For instance, in addition to agricultural users in Pinal County, more than a dozen CAP contract holders are located downstream, with systems serving over 850,000 people. As an example, the City of Tucson relies on CAP water (mixed with groundwater) as the primary supply for over 700,000 residents. In total, through disruption of community water systems and the CAP aqueduct, a hypothetical tailings release could affect the water supply for over 1.5 million people.

POTENTIAL DESTRUCTION OF HABITAT AND VEGETATION

The deposition of large amounts of tailings in downstream waters would have widespread effects on the ecosystem, including riparian vegetation, wildlife habitat, and aquatic habitat. The immediate effect nearest the release would be direct physical removal or burying of vegetation from the debris. This effect would reduce with distance downstream. While woody riparian vegetation (mesquite, cottonwood, willow, saltcedar) could survive the immediate arrival of the tailings, most near-stream herbaceous and wetland vegetation would be destroyed even by a few inches of tailings.

Aquatic habitat would either physically disappear—filled with tailings—or would be rendered uninhabitable for some distance downstream by high levels of suspended sediment. After the initial impact, the geomorphology of the system would also be fundamentally altered by erosion of native material and deposition of tailings material. Expected concentrations of metals in the released water are above at least some acute wildlife standards (copper, zinc), so immediate effects on fish populations not directly lost to tailings would also be expected. Until cleanup, the tailings materials could also act as a continuing source of elevated metal concentrations.

The high-quality riparian habitat at Whitlow Ranch Dam would almost certainly be lost. Downstream of Whitlow Ranch Dam, primarily xeroriparian habitat would be lost along Queen Creek.

LARGE-SCALE SOCIETAL IMPACTS

A number of direct effects would result from a hypothetical tailings release: potential loss of life, disruptions from evacuation and relocation, destruction of property, loss of habitat, destruction or damage of infrastructure, loss or disruption of public and agricultural water supplies, disruption of regional transportation, and the long-term potential for soil, surface water, and groundwater contamination.

The large-scale societal impact of a hypothetical tailings failure is the combination of all these impacts and the fundamental disruption of a substantial portion of Arizona's economy, the lives of a substantial portion of the population, and long-term changes to the environment.

The cost of remediation of such a release would be substantial. One research study developed a dataset of seven historical tailings failures between 1994 and 2008 for which estimates of natural resource losses could be quantified (albeit with difficulty) and found that the average natural resource loss per failure was over $500 million (in 2014 dollars) (Bowker and Chambers 2015). The size of the releases in the dataset ranged from 0.1 to 5.4 million cubic meters, much smaller than the release estimated using the empirical method.

Direct cleanup costs also can be substantial. As an example, the Mount Polley failure (23.6 million cubic meters) is estimated to have cleanup costs of roughly $67 million (Hoekstra 2014); it appears most of this cost is likely to be borne by Canadian taxpayers, not the mining company (Lavoie 2017). As another example, the mining companies involved in the Fundão failure agreed to pay over $5 billion in damages to the Brazilian government, which includes funds for remediation and restoration (Boadle and Eisenhammer 2016).

LONG-TERM IMPLICATIONS OF PRESENCE OF TAILINGS STORAGE FACILITY

The presence of a tailings storage facility on the landscape has implications for long-term potential for downstream impacts as well, even if an embankment failure never occurs. Water entrained with the NPAG tailings gradually drains from the facility over many decades. This draining is beneficial for tailings safety as it enhances stability and would continue to reduce the risk of failure. However, this seepage also causes the long-term potential for water quality impacts downstream. The long-term ramifications of seepage from tailings storage facilities is addressed in detail in Section 3.7.2, Groundwater and Surface Water Quality.

There are additional long-term impacts associated with the landform itself, including the potential for air quality impacts or windborne dust, or erosion from the tailings and subsequent sedimentation of downstream waters. The potential for windblown dust from the tailings storage facilities is addressed in detail in Section 3.6, Air Quality, but the analysis is focused largely on operations. One assumption is that over the long term, the application and revegetation of a closure cover on the tailings facility would prevent large amounts of erosion by wind or water. The potential success of revegetation and long-term stability of the ecosystem is addressed in Section 3.3, Soils, Vegetation, and Reclamation.

As noted, the risk of catastrophic failure decreases as water gradually drains from the facility due to reduced liquefaction potential of the tailings mass. The duration of active seepage management after closure for Alternative 2 has been estimated as lasting up to 100 years after closure (Klohn Crippen Berger Ltd. 2018a). This represents the time period during which sufficient seepage is still being generated to require treatment or disposal, rather than relying on passive evaporation. The risk does not decrease to zero after this time period. Other failure modes still exist. This time period is being presented here solely as a proxy for how long substantial water remains in the facility for each alternative.

POTENTIAL IMPACTS FROM PIPELINES

In the event of a potential rupture, spill, or failure of either the concentrate pipeline or the tailings pipeline, the type of effects would be similar to those of a tailings storage facility failure with respect to direct damage to vegetation and potential for contamination. However, because of the ability to monitor and shut down the pipeline immediately upon identifying a problem, the impact would be much more localized, involve much smaller volumes, and would be of a shorter duration.

All spills associated with the concentrate pipeline and the Alternative 2 tailings pipeline would occur in ephemeral drainages and would be unlikely to move far downstream if emergency cleanup were undertaken immediately. There would likely be localized impacts on xeroriparian vegetation. Potential for impact on groundwater quality would be relatively low, given limited release volumes and limited groundwater present in these ephemeral drainages.

The total length of pipeline corridors under Alternative 2 is about 27 miles (about 22 miles for the concentrate pipeline and about 5 miles for the tailings pipelines). At closure, the risk of pipeline failure falls to zero.

FINANCIAL ASSURANCE FOR LONG-TERM MONITORING AND MAINTENANCE

Alternative 2 potentially involves long time periods of post-closure maintenance and monitoring related to ensuring the continued stability of the tailings storage facility. This raises the concern for the possibility of Resolution Copper going bankrupt or otherwise abandoning the property after operations have ceased. If this were to happen, the responsibility for these long-term activities would fall to the Forest Service. The Forest Service would need to have financial assurance in place to ensure adequate funds to undertake these activities for long periods of time—for decades or even longer.

The authority and mechanisms for ensuring long-term funding are discussed in section 1.5.5. The types of activities that would likely need to be funded could include the following:

- Monitoring of the embankment movement or stability
- Long-term control of water in the facility, such as control of stormwater entering the facility, long-term drawdown of the recycled water pond, or long-term operation of pumpback facilities
- Long-term maintenance of drains to ensure embankment stability
- Monitoring of the post-closure landform for excessive erosion or instability, and performance of any armoring
- Maintenance and monitoring of post-closure stormwater control features
- Continued implementation and periodic updating of emergency notification plans and response requirements

Additional financial assurance requirements for long-term maintenance and monitoring are part of the Arizona APP program and include the following:

> [T]he applicant or permittee shall demonstrate financial responsibility to cover the estimated costs to close the facility and, if necessary, to conduct postclosure monitoring and maintenance by providing to the director for approval a financial assurance mechanism or combination of mechanisms as prescribed in rules adopted by the director or in 40 Code of Federal Regulations section 264.143

(f)(1) and (10) as of January 1, 2014. (ARS 49-243; also see Arizona Administrative Code R18-9-A203 for specific regulations and methods allowed for financial assurance)

The Arizona State Mine Inspector also has authority to require a mine reclamation plan and financial assurance for mine closure (Arizona Administrative Code Title 11, Chapter 2). The regulations for these focus primarily on surface disturbance and revegetation.

Alternative 3 – Near West – Ultrathickened

TAILINGS STORAGE FACILITY DESIGN

While the modified-centerline embankment construction is similar between Alternatives 2 and 3, the use of ultrathickened deposition in Alternative 3 results in less water entrained in the tailings storage facility, making the facility inherently more resilient.

After the initial raises, Alternative 3 uses a splitter berm of cyclone sand to separate PAG from NPAG tailings. While this has benefits to water quality, the splitter berm would not prevent release of PAG tailings in the event of an embankment breach. There would be little difference in release of PAG tailings between Alternatives 2 and 3.

POTENTIAL RISK TO LIFE AND PROPERTY

The potential risks are identical to those from Alternative 2.

POTENTIAL EXPOSURE TO CONTAMINANTS

The potential risks are identical to those from Alternative 2.

POTENTIAL DISRUPTION OF WATER SUPPLIES AND INFRASTRUCTURE

The potential risks are identical to those from Alternative 2.

POTENTIAL DESTRUCTION OF HABITAT AND VEGETATION

The potential risks are identical to those from Alternative 2.

LARGE-SCALE SOCIETAL IMPACTS

The potential risks are identical to those from Alternative 2.

LONG-TERM IMPLICATIONS OF PRESENCE OF TAILINGS STORAGE FACILITY

The risk of catastrophic failure decreases as water gradually drains from the facility. Because of the use of ultrathickened tailings, the duration of active seepage management after closure for Alternative 3 has been estimated as about 9 years after closure, compared with 100 years for Alternative 2 (Klohn Crippen Berger Ltd. 2018b). This represents the time period during which sufficient seepage is still being generated to require treatment or disposal, rather than relying on passive evaporation. Risk does not decrease to zero after this time period. Other failure modes still exist. This time period is being presented here solely as a proxy for how long substantial water remains in the facility for each alternative.

POTENTIAL IMPACTS FROM PIPELINES

The potential risks are identical to those from Alternative 2.

FINANCIAL ASSURANCE FOR LONG-TERM MONITORING AND MAINTENANCE

The financial assurances are identical to those from Alternative 2.

Alternative 4 – Silver King

TAILINGS STORAGE FACILITY DESIGN

The use of filtered tailings at the Silver King location represents the least risk to public health and safety related to a catastrophic failure. Filtered tailings are fundamentally more resilient than slurry facilities, and unlike the other alternatives, a failure of the filtered tailings would likely be more localized.

POTENTIAL RISK TO LIFE AND PROPERTY

The potential risk to life and property is less than the other alternatives, based on the smaller area impacted. No communities are immediately downstream of Alternative 4, within the area in which a slump or landslide failure would occur.

POTENTIAL EXPOSURE TO CONTAMINANTS

No water would be potentially released during a catastrophic failure of Alternative 4, and exposure to contaminants would be primarily related to the long-term exposure of solid material in washes, including erosion and movement downstream, and leaching of contaminants. The filtered materials are estimated to have more potential for water quality impacts, due to the chemical weathering from the ingress of oxygen into the pore space. The PAG tailings, in particular, if deposited in washes, would represent a long-term risk to water quality if not removed.

POTENTIAL DISRUPTION OF WATER SUPPLIES AND INFRASTRUCTURE

The potential disruption of water supplies and infrastructure is less than the other alternatives, based on the smaller area impacted and the specific location impacted.

POTENTIAL DESTRUCTION OF HABITAT AND VEGETATION

The potential destruction of habitat and vegetation is less than the other alternatives, based on the smaller area impacted. In addition, primarily xeroriparian habitat along ephemeral washes would be impacted, rather than perennial waters and hydroriparian and aquatic habitat.

LARGE-SCALE SOCIETAL IMPACTS

The large-scale societal impact of a failure at Alternative 4 is less than the other alternatives, based on the smaller area impacted and the specific location impacted.

LONG-TERM IMPLICATIONS OF PRESENCE OF TAILINGS STORAGE FACILITY

The risk of catastrophic failure decreases as water gradually drains from the facility. As there is relatively little seepage associated with Alternative 4, the amount of time for active seepage management after closure is only 5 years, compared with 100 years for Alternative 2 (Klohn Crippen Berger Ltd. 2018c). This represents the time period during which sufficient seepage is still being generated to require treatment or disposal, rather than relying on passive evaporation. Risk does not decrease to zero after this time period. Other failure modes still exist. This time period is being presented here solely as a proxy for how long substantial water remains in the facility for each alternative.

POTENTIAL IMPACTS FROM PIPELINES

Alternative 4 still requires concentrate and tailings pipelines; however, the overall distance is substantially less, and would represent less risk overall. The total length of pipeline corridors under Alternative 4 is less than 2 miles (there is no concentrate pipeline, and about 1.5 miles for the tailings pipelines).
At closure, the risk of pipeline failure falls to zero.

FINANCIAL ASSURANCE FOR LONG-TERM MONITORING AND MAINTENANCE

The regulatory framework to require financial assurance to ensure closure and post-closure activities are conducted is the same as for Alternative 2.

Alternative 5 – Peg Leg

TAILINGS STORAGE FACILITY DESIGN

Tailings Embankment and Facility Design

Alternative 5 uses a centerline-type NPAG embankment, representing a more resilient design than Alternatives 2 and 3. Like Alternatives 2 and 3, the main embankment is a side hill embankment that extends on three sides of the facility and is generally freestanding and founded on alluvium versus bedrock, which is inherently less resilient than Alternative 6. The length of the embankment (7 miles) is slightly shorter than Alternatives 2 and 3. The PAG embankments use downstream construction to maintain a water cover over the PAG tailings. The PAG embankments are divided into cells to minimize seepage, reduce evaporation, and allow concurrent reclamation during operations.

Foundation Materials

The main NPAG embankment for Alternative 5 would be primarily underlain by thick unconsolidated alluvium, with some bedrock occurring below the PAG cells. Detailed site characterization through drilling and excavation would be used to understand the specific properties of the alluvial material beneath the main embankment and develop a design to address any stability concerns. Seepage may be more difficult to control with Alternative 5, as losses to an alluvial foundation are substantial and the downstream alluvial aquifer is relatively wide.

Storage of PAG Tailings

Unlike Alternatives 2 and 3, Alternative 5 uses an entirely separate PAG tailings facility with a downstream embankment to contain the PAG tailings throughout the life of the facility. In addition, the PAG tailings facility is divided into cells to reduce evaporation and seepage and allow concurrent reclamation. In the event of a failure of the NPAG main embankment, the double embankment of Alternative 5 means that PAG tailings would not be released unless both the NPAG and PAG embankments failed simultaneously. Alternatively, if one of the PAG cells failed, the runout could be contained within the NPAG facility.

POTENTIAL RISK TO LIFE AND PROPERTY

The Peg Leg location is upstream of populations in Pinal County and the Gila River Indian Community. An estimated 32,000 people live in the communities downstream that could be affected by a hypothetical tailings storage facility failure. This location would offer some improvement in reaction time over Alternatives 2 and 3 for evacuation in the event of a sudden failure, with no major population centers downstream for roughly 20 miles. The Peg Leg location offers the greatest risk to the town of Florence and the Gila River Indian Community.

POTENTIAL EXPOSURE TO CONTAMINANTS

As with Alternatives 2 and 3, all materials released during a hypothetical tailings failure pose risk of contamination, with metal concentrations in water and tailings material above Arizona standards. The risks to beneficial uses of surface waters, groundwater, and public health are similar, though receptors would differ.

POTENTIAL DISRUPTION OF WATER SUPPLIES AND INFRASTRUCTURE

A hypothetical tailings failure for Alternative 5 represents a substantial risk to water supplies. Four community water systems, serving a total population of almost 30,000, were identified in the downstream flow path. Unlike the community water systems downstream of Alternatives 2 and 3, which have robust water portfolios, most of these systems are highly reliant on groundwater and most have wells directly adjacent to the Gila River. The primary risk to these water systems is the potential for groundwater resources to be contaminated, or loss of water-related infrastructure. The town of Florence has one of the closest water systems, serving roughly 15,000 people and relying on groundwater wells immediately adjacent to the Gila River.

The disruption of agricultural water supplies would have a substantial effect on Pinal County and the Gila River Indian Community. The Pinal County economy relies heavily on agriculture and is one of the most important agricultural areas in the United States. Pinal County is in the top 2 percent of counties in the United States for total agricultural sales (Bickel et al. 2018) and has more than 230,000 acres under irrigation (National Agricultural Statistics Service 2014). The NMIDD and the San Carlos Irrigation and Drainage District both lie largely within Pinal County and account for about a third of agricultural acreage. A potential tailings release could affect water supplies for the roughly 77,000 acres within these districts, through destruction of infrastructure, contamination of surface supplies from the Gila River, or contamination of groundwater sources below the Gila River.

The total contribution of on-farm agriculture to Pinal County sales was an estimated $1.1 billion in 2016, supporting over 7,500 full- and part-time employees (Bickel et al. 2018). Bickel et al. (2018) also estimated the effect of a hypothetical loss of 300,000 acre-feet of irrigation water and found there would be an economic impact of up to $35 million, with up to 480 job losses. This hypothetical reduction represents about a one-third reduction in total water use of 800,000 acre-feet (Water Resources Research Center 2018).

The Gila River Indian Community is also reliant on agriculture, with about 27,000 acres irrigated (National Agricultural Statistics Service 2014), and a total market value of agricultural products sold of $38.4 million (Duval et al. 2018). Increased agriculture is the centerpiece of Gila River Indian Community economic growth, through the continued construction of the Pima-Maricopa Irrigation Project, which is meant to use water provided under the Arizona Water Settlements Act of 2004. The Community intends to increase agricultural production to over 140,000 acres of irrigable land. Water sources potentially disrupted by a hypothetical tailings release include supplies from the Gila River, groundwater, and water stored in underground recharge projects.

POTENTIAL DESTRUCTION OF HABITAT AND VEGETATION

The potential destruction of habitat and vegetation for Alternative 5 is similar to Alternative 2, except the impacts would be borne by the Gila River, which has existing aquatic habitat as well as critical habitat and proposed critical habitat. The wetlands downstream on the Gila River Indian Community could also be impacted.

The modeled water quality results in table 3.10.1-7 suggest that Alternative 5 might have substantially higher dissolved metals, particularly copper, and would represent a greater risk of acute toxicity to aquatic wildlife in downstream waters not directly inundated by tailings.

LARGE-SCALE SOCIETAL IMPACTS

The societal impacts for Alternative 5 are similar to those discussed for Alternative 2. In addition, a hypothetical release from Alternative 5 could impact the town of Florence as well as the Gila River Indian Community. The Gila River Indian Community has a greater than 40 percent poverty rate, with a median household income about one-third of the national median (U.S. Census Bureau 2018b). The population of the areas downstream of Alternative 5 (3,655) represent roughly 30 percent of the total Community population (U.S. Census Bureau 2018b). The impact of a hypothetical tailings release would be much more pronounced on the Gila River Indian Community, and the ability to recover would be much less than other communities.

LONG-TERM IMPLICATIONS OF PRESENCE OF TAILINGS STORAGE FACILITY

Alternative 5 has similar long-term implications for air quality, revegetation success, and groundwater quality, as those described for Alternative 2, with differences noted in the specific EIS sections referenced.

As noted, the risk of catastrophic failure decreases as water gradually drains from the facility.
The duration of active seepage management after closure for Alternative 5 has been estimated to be up to 100 to 150 years after closure, similar to Alternative 2 (Golder Associates Inc. 2018b). This represents the time period during which sufficient seepage is still being generated to require treatment or disposal, rather than relying on passive evaporation. Risk does not decrease to zero after this time period. Other failure modes still exist. This time period is being presented here solely as a proxy for how long substantial water remains in the facility for each alternative.

POTENTIAL IMPACTS FROM PIPELINES

For the ephemeral drainages crossed by the Alternative 5 pipeline, impacts from a pipeline failure would be identical to Alternative 2. However, the Alternative 5 pipeline also crosses the Gila River, which represents a high-value riparian area that could be impacted in the event of a failure. In this case, the impacts would be similar to those described for a tailings storage facility runout reaching the Gila River, but more localized. The Alternative 5 pipeline also carries more risk for downstream habitat in Arnett Creek and Queen Creek by paralleling those water bodies for several miles and has a risk for destruction of downstream habitat associated with the White Canyon Wilderness.

The total length of pipeline corridors under Alternative 5 is about 47 miles (about 22 miles for the concentrate pipeline, and about 25 miles for the tailings pipelines). At closure, the risk of pipeline failure falls to zero.

FINANCIAL ASSURANCE FOR LONG-TERM MONITORING AND MAINTENANCE

The regulatory framework under the State of Arizona to require financial assurance for long-term closure activities is the same as described for Alternative 2. However, for the tailings facility, financial assurance requirements would be required by the BLM, not the Forest Service.

Like the Forest Service, the BLM also has regulatory authority to require financial assurance for closure activities, contained in their surface management regulations (43 CFR Subpart 3809). BLM considers that the financial assurance must cover the estimated cost as if BLM were hiring a third-party contractor to perform reclamation of an operation after the mine has been abandoned. The financial assurance must include construction and maintenance costs for any treatment facilities necessary to meet Federal and State environmental standards.

Alternative 6 – Skunk Camp

TAILINGS STORAGE FACILITY DESIGN

Tailings Embankment and Facility Design

Like Alternative 5, Alternative 6 uses a true centerline-type embankment, representing a more resilient design than Alternatives 2 and 3. The embankment design for Alternative 6 is substantially different from the other alternatives. This embankment uses a cross-valley construction, which would have a single face instead of three faces and would be tied into consolidated rock on either end. This construction results in a shorter face, only requiring 3 linear miles of embankment. As with the embankment type, all embankments would be designed to the same safety standards, but the simpler construction of the Alternative 6 embankment could be considered more resilient to accumulated missteps or unforeseen events.

Foundation Materials

Alternative 6 is similar to Alternatives 2 and 3 and would be primarily underlain by unconsolidated alluvium within drainages and a thick sequence of Gila Conglomerate bedrock. Below the PAG facility, which is farthest away from the NPAG embankment, alluvium is less, and the primary subsurface material is Gila Conglomerate. Compared with Alternative 5, seepage is easier to control, with much of the facility underlain by bedrock rather than alluvium. In addition, the downstream alluvial aquifer is narrow and any downstream seepage controls would likely be more effective than at Alternative 5.

Storage of PAG Tailings

Like Alternative 5, Alternative 6 uses an entirely separate PAG tailings cell with a downstream-type embankment that would contain the PAG tailings throughout the life of the facility. In addition, the PAG tailings are divided and stored in entirely separate cells. Because of this double embankment within one impoundment, with Alternative 6, PAG tailings would be less likely to be released, and individual cells would limit the amount of PAG tailings released.

POTENTIAL RISK TO LIFE AND PROPERTY

Like Alternative 5, the Skunk Camp location is upstream of populations in Pinal County. Approximately 3,000 people live in the communities downstream that would be affected by a hypothetical tailings storage facility failure. This location also would offer some improvement in reaction time over Alternatives 2 and 3 for evacuation in the event of a sudden failure, with the major towns (Hayden, Kearny, Winkelman) located over 20 miles downstream, but the nearest population center (Dripping Springs) is still within 10 miles of the facility.

Alternative 6 offers less risk to the town of Florence and Gila River Indian Community than Alternative 5, as these communities are over 50 miles distant from the tailings location.

POTENTIAL EXPOSURE TO CONTAMINANTS

As with Alternatives 2, 3, 4, and 5, all materials released during a hypothetical tailings failure pose risk of contamination, with metal concentrations in water and tailings material above Arizona standards. The risks to beneficial uses of surface waters, groundwater, and public health are similar, though receptors would differ.

POTENTIAL DISRUPTION OF WATER SUPPLIES AND INFRASTRUCTURE

A hypothetical tailings failure for Alternative 6 represents a risk to water supplies. Four community water systems are located along the Gila River above Donnelly Wash, serving approximately 3,000 people. These systems are entirely reliant on groundwater and most have wells directly adjacent to the Gila River. The primary risk to these water systems is the potential for groundwater resources to be contaminated, or loss of infrastructure.

The potential disruption of agricultural water supplies would be less than those described for Alternative 5.

POTENTIAL DESTRUCTION OF HABITAT AND VEGETATION

The potential destruction of habitat and vegetation for Alternative 6 is similar to Alternative 5, but somewhat less due to the greater distance between Alternative 6 and the Gila River, compared with Alternative 5 and the Gila River. Alternative 6 carries a risk of potential destruction of habitat and vegetation associated with the river segment identified by BLM as suitable for inclusion in the National Wild and Scenic Rivers System, between Dripping Springs Wash and Winkelman. This would include the loss of recreation opportunities along this corridor.

LARGE-SCALE SOCIETAL IMPACTS

The societal impacts for Alternative 6 are similar to those discussed for Alternative 5, but the impacts would be felt mainly in the communities of Kearny, Hayden, and Winkelman, located along the Gila River. These are small communities directly adjacent to the river, heavily dependent on the local water supply. The economic impact from property loss, business disruption, and destruction of local infrastructure would affect every aspect of these communities.

LONG-TERM IMPLICATIONS OF PRESENCE OF TAILINGS STORAGE FACILITY

Alternative 6 has similar long-term implications for air quality, revegetation success, and groundwater quality, as those described for Alternative 2, with differences noted in the specific EIS sections referenced.

As noted, the risk of catastrophic failure decreases as water gradually drains from the facility. The duration of active seepage management after closure for Alternative 6 has been estimated to be up to 20 years after closure (Klohn Crippen Berger Ltd. 2018d). This represents the time period during which sufficient seepage is still being generated to require treatment or disposal, rather than relying on passive evaporation. Risk does not decrease to zero after this time period. Other failure modes still exist. This time period is being presented here solely as a proxy for how long substantial water remains in the facility for each alternative.

POTENTIAL IMPACTS FROM PIPELINES

For the ephemeral drainages crossed by the Alternative 6 pipeline, the type of impacts from a pipeline failure would be identical to Alternative 2. However, the Alternative 6 pipeline must cross Devil’s Canyon. While the pipeline would cross Devil’s Canyon upstream and away from perennial flow, a failure would have the potential to affect the water, aquatic, and riparian habitat downstream. The underground crossing of Mineral Creek has less potential risk than an overhead crossing.

The total length of pipeline corridors under Alternative 6 is about 47 miles (about 22 miles for the concentrate pipeline, and about 25 miles for the tailings pipelines). At closure, the risk of pipeline failure falls to zero.

FINANCIAL ASSURANCE FOR LONG-TERM MONITORING AND MAINTENANCE

The regulatory framework under the State of Arizona to require financial assurance for long-term closure activities is the same as described for Alternative 2. However, Alternative 6 differs from the other alternatives because the tailings facility would not be located on lands managed by the Forest Service (Alternatives 2, 3, and 4) or BLM (Alternative 5). For Alternative 6, the Federal financial assurance mechanisms would not be applicable to the tailings storage facility.

Overall Conclusions of Potential Risk to Public Health and Safety

The Forest Service requirement for the tailings storage facility design, construction, and operation to adhere to National Dam Safety Program standards on Federal land (not applicable to Alternative 6), as well as APP BADCT standards, minimizes the risk for a catastrophic failure of the tailings storage facility. Adherence by Resolution Copper to the applicant-committed environmental protection measures, including industry best practices, further reduces the risk both by proactively providing a robust design and containment measures, and by identifying operational steps that can be taken in reaction to a developing problem.

There are some qualitative differences in alternatives that are inherent in the design and location of each alternative that affect the resilience of the facility, as shown in table 3.10.1-9. There are also differences in the downstream environment.

Table 3.10.1-9. Differences between alternatives pertinent to tailings and pipeline safety

	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Embankment type	Modified centerline	Modified centerline	Filtered tailings; structural zone, but no embankment. Most resilient alternative.	True centerline. Improved resilience, compared with Alternatives 2 and 3.	True centerline Improved resilience, compared with Alternatives 2 and 3.
Embankment size and design	Freestanding; 10-mile length	Freestanding; 10-mile length	No embankment†	Freestanding; 7-mile length	Cross-valley construction; 3-mile length. Improved resilience, compared with Alternatives 2, 3, and 5.
Potential for PAG release	PAG deposition inside NPAG facility, no separate embankment (at buildout)	PAG deposition inside NPAG facility, no separate embankment (at buildout)	Separate PAG facility. Downstream risk for PAG release less, due to localized failure.	Separate PAG facility; multiple cells; separate downstream embankment. Less risk for release of PAG tailings during catastrophic failure than Alternatives 2 and 3.	Separate PAG facility; multiple cells; separate downstream embankment. Less risk for release of PAG tailings during catastrophic failure than Alternatives 2 and 3.
Downstream population (within 50 miles)	600,000	600,000	700	32,000	3,200
Nearest population	Within 10 miles	Within 10 miles	Within 10 miles	Over 20 miles	Within 10 miles
Pipeline risk	Ephemeral drainages; relatively low risk	Ephemeral drainages; relatively low risk	Ephemeral drainages; relatively low risk	Higher risk from crossings of Queen Creek, Gila River, and parallel of Arnett Creek	Higher risk at crossing of Devil’s Canyon

	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Miles of pipeline	Concentrate = 22 Tailings = 5	Concentrate = 22 Tailings = 5	Concentrate = 0 Tailings = 1.5	Concentrate = 22 Tailings = 25	Concentrate = 22 Tailings = 25
Anticipated risk period for pipelines	41 years. LOM only. Risk ends upon closure	41 years. LOM only. Risk ends upon closure	41 years. LOM only. Risk ends upon closure	41 years. LOM only. Risk ends upon closure	41 years. LOM only. Risk ends upon closure
Anticipated risk period for tailings storage facilities*	150 years (LOM, plus estimated seepage for ~100 years post-closure)	50 years (LOM, plus estimated seepage for ~9 years post-closure)	45–50 years (LOM, plus estimated seepage for ~5 years post-closure)	150–200 years (LOM, plus estimated seepage or 100–150 years post-closure)	70 years (LOM, plus estimated seepage for 20 years post-closure)

Note: LOM = Life of mine

* The estimate shown here is the life of mine, plus the length of time active seepage management is anticipated to take after closure (see section 3.7.2). This is being presented as a proxy for risk, only to highlight differences in the period of drain-down between alternatives. A number of failure modes continue to be possible after active seepage management has been discontinued.

† The dry-stack tailings facility would not have an embankment but would have an outer structural zone. This structural zone would potentially need to meet the same design standards as a dam, depending on the applicable regulations (for example, requirements under an APP) and site-specific design.

Cumulative Effects

Full details of the cumulative effects analysis can be found in chapter 4. The following represents a summary of the cumulative impacts resulting from the project-related impacts described in Section 3.10.1.4, Environmental Consequences, that are associated with tailings safety, when combined with other reasonably foreseeable future actions.

The following actions were determined through the cumulative effects analysis process to be reasonably foreseeable, and have impacts that likely overlap in space and time with impacts from the Resolution Copper Project:

- ASARCO Mine, including the Hayden Concentrator and Smelter, and Superfund Site
- Ray Land Exchange and Proposed Plan Amendment
- Ripsey Wash Tailings Project

The cumulative effects analysis area for tailings and pipeline safety would match that of surface water quantity—the watersheds within which the project is located—as the risks of other large tailings facilities would generally follow similar flow patterns in the event of a failure. The metric used to quantify cumulative impacts to tailings and pipeline safety is the number of tailings facilities located within the same watershed. Multiple tailings storage facilities within the same watershed do not affect the safety of any individual tailings storage facility, or probability of failure of any given facility. However, the more tailings storage facilities in one watershed located upstream of a given person, residence, or community, the greater the risk that an incident or failure could impact that location in the future.

It is unknown whether a tailings storage facility would be part of the Ray Land Exchange parcels, but the possibility exists. If a tailings storage facility were built on the Ray Land Exchange parcels, it would be part of the Gila River watershed. The other two reasonably foreseeable future actions represent existing or future tailings storage facilities along the main stem of the Gila River. Within the cumulative effects analysis area, the three reasonably foreseeable future actions listed could include tailings storage facilities located potentially within the same watershed (Gila River) as the Resolution Copper Project tailings.
If either Alternative 5 – Peg Leg or Alternative 6 – Skunk Camp is selected as the location for the Resolution Copper Project tailings location, the downstream communities on the Gila River would

experience an overall greater risk of being impacted in the event of a partial or complete failure of a tailings storage facility.

Mitigation Effectiveness

Mitigation Identifier and Title	Authority to Require
FS-SV-03: Revised Reclamation and Closure Plans	Required – Forest Service
FS-PH-01: Satellite monitoring of tailings storage facility	Required – Forest Service
FS-PH-02: Adherence to National Dam Safety Program Standards	Required – Forest Service
FS-PH-03: Skunk Camp Pipeline Protection and Integrity Plan	Required – Forest Service
RC-PH-04: Maintain the existing hotline for community complaints	Voluntary – Resolution Copper
RC-PH-05: Adhere to Global Tailings Standard	Voluntary – Resolution Copper

We developed a robust monitoring and mitigation strategy to avoid, minimize, rectify, reduce, or compensate for resource impacts that have been identified during the process of preparing this EIS. Appendix J contains descriptions of mitigation measures that are being required by the Forest Service and mitigation measures voluntarily brought forward and committed to by Resolution Copper. Appendix J also contains descriptions of monitoring that would be needed to identify potential impacts and mitigation effectiveness.

This section contains an assessment of the effectiveness of design features associated with mitigation and monitoring measures found in appendix J that are applicable to tailings and pipeline safety. See appendix J for full descriptions of each measure noted below.

MITIGATION EFFECTIVENESS AND IMPACTS OF REQUIRED MITIGATION MEASURES APPLICABLE TO TAILINGS AND PIPELINE SAFETY

Appendix J contains mitigation and monitoring measures being required by the Forest Service under its regulatory authority or because these measures are required by other regulatory processes (such as the PA or Biological Opinion). These measures are assumed to occur, and their effectiveness and impacts are disclosed here. The unavoidable adverse impacts disclosed below take the effectiveness of these mitigations into account.

Revised Reclamation and Closure Plans (FS-SV-03). Implementing reclamation and closure plans ensure that post-closure landscape is successfully revegetated to the extent practicable, and that the landforms are stable and safe. This measure is effective at partially replacing habitat and vegetation over the long term within the footprint of all mine components, reducing long-term effects on surface water quality from erosion, and improving long-term resilience and safety of the tailings storage facility. Eventually, these areas could be reopened to recreational activities.

Satellite Monitoring of Tailings Storage Facility (FS-PH-01). High-resolution satellite imagery would be collected and processed at regular intervals. Processed output provided to the Forest Service or BLM would include beach width, tailings surface slope contours, and constructed site topography. This output could be provided for land manager verification of adherence to design criteria, as well as long-term monitoring of facility performance over time. This measure would be applicable to Alternatives 2, 3, 4, and 5 through 36 CFR 228.8 (Forest Service authority to regulate mining to minimize adverse environmental impacts on NFS surface resources) and 43 CFR 3809.2 (BLM authority to regulate mining to prevent unnecessary or undue degradation). This measure primarily focuses on tailings safety, which in turn is protective of human life, property, and numerous downstream resources.

Adherence to National Dam Safety Program Standards (FS-PH-02). For a tailings storage facility built on Federal land, the Forest Service is requiring that Resolution Copper adhere, at a minimum, to the requirements of the National Dam Safety Program discussed in “Relevant Laws, Regulations, Policies, and Plans” in section 3.10.1.3. This measure focuses on tailings safety, which in turn is protective of human life, property, and numerous downstream resources.

Skunk Camp Pipeline Protection and Integrity Plan (FS-PH-03). Implementing design and construction measures meant to mitigate specific potential failure modes ensures that the pipelines will be resilient and secure. Operational and maintenance measures ensure that problems are identified as they arise and that appropriate remedies are taken. These actions would be effective at reducing the risk of pipeline rupture and inadvertent spills, which also reduces potential risk to groundwater and surface water quality.

MITIGATION EFFECTIVENESS AND IMPACTS OF VOLUNTARY MITIGATION MEASURES APPLICABLE TO TAILINGS AND PIPELINE SAFETY

Appendix J contains mitigation and monitoring measures brought forward voluntarily by Resolution Copper and committed to in correspondence with the Forest Service. These measures are assumed to occur but are not guaranteed to occur. Their effectiveness and impacts if they were to occur are disclosed here; however, the unavoidable adverse impacts disclosed below do not take the effectiveness of these mitigations into account.

Maintain the existing hotline for community complaints (RC-PH-04). Maintaining the community hotline allows for incipient problems to be identified and remedied; these may or may not be applicable to the tailings storage facility or pipeline. Relevant notifications would help resolve issues before they resulted in off-site impacts.

Adhere to Global Tailings Standard (RC-PH-05). The preamble to the new Global Industry Standard on Tailings Management states: “The Global Industry Standard on Tailings Management (herein ‘the Standard’) strives to achieve the ultimate goal of zero harm to people and the environment with zero tolerance for human fatality. It requires Operators to take responsibility and prioritise the safety of tailings facilities, through all phases of a facility’s lifecycle, including closure and post-closure. It also requires the disclosure of relevant information to support public accountability.” This standard represents the best international industry practices, regardless of regulatory jurisdiction or land status. Adherence to this standard cannot eliminate the risk of a tailings storage facility failure, but can ensure that it is minimized to the extent practicable.

OTHER POTENTIAL FUTURE MITIGATION MEASURES APPLICABLE TO TAILINGS AND PIPELINE SAFETY

Appendix J contains several other potential future mitigation measures that the Forest Service is disclosing as potentially useful in mitigating adverse effects, but for which there is no authority to require. There is no expectation that these measures would occur, and therefore the effectiveness is not considered in the EIS. No potential future mitigation measures were identified applicable to tailings and pipeline safety.

UNAVOIDABLE ADVERSE IMPACTS

The mine and associated activities are expected to increase risks to public health and safety from the presence of a large tailings storage facility on the landscape, and the transport of concentrate and tailings by pipeline. These risks are unavoidable. However, risk of failure is minimized by required adherence to National Dam Safety Program and APP program standards, applicant-committed environmental protection measures, and the mitigation measures described here.

Other Required Disclosures

SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

Impacts from risk associated with tailings embankment safety would exist for a long time on the landscape and may result in some land uses downstream of the facility being curtailed. Over time, the reduction of risk would diminish, and productivity of downstream areas would recover.

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

Irreversible changes with respect to tailings safety are not expected. The risk from pipeline failures ends upon closure of the mine and would be considered irretrievable but not irreversible. The risk from a tailings facility would persist for decades but would diminish as the structure drains. Impacts on public safety from tailings or tailings and concentrate pipelines would constitute an irretrievable commitment of resources.

3.10.2 Fuels and Fire Management

3.10.2.1 Introduction

This section assesses fuels and fire management both in the project area and within the larger analysis area (figure 3.10.2-1). Fuel means any vegetation, including grass, shrubs, and trees, that could sustain a wildfire. “Fuels and fire management” refers to the ability of land managers and emergency responders to maintain fuel levels and conduct other activities to prevent wildfires or control their extent or severity. Mine operations would include activities that would change fuel loads in the area or increase the possibility of accidental ignition of a wildfire, which would result in increased risk of fire and would change the severity and extent of fires that could occur. This section discusses the vegetation communities present, fire history and fire management, wildfire-urban interfaces (WUIs), and changes in wildfire risk resulting from the proposed project.

Changes from the DEIS

Overall, few public comments were received specific to the analysis of fuels and fire management, resulting in few changes. As with all resources, Alternatives 5 and 6 no longer have alternative pipeline routes to reach the tailings storage facility; each alternative now has a single route each as described in chapter 2. In addition, we revised the Alternative 6 pipeline route primarily to address potential impacts to habitat and resources along Mineral Creek. These changes had no major impact on the fuels and fire analysis.

Aside from changes to the project footprint, we added a discussion of climate change effects on fuels and fire management. We updated the discussion with the recent Woodbury, Whitlow, and Sawtooth fires, and added a discussion specific to the risks new power lines pose with respect to fire management.

The cumulative effects analysis was revised for the FEIS to better quantify impacts. It is described in detail in chapter 4 and summarized in this section. Any mitigations developed between the DEIS and FEIS are summarized in appendix J and, if applicable to fuels and fire management, are analyzed for effectiveness in this section.

3.10.2.2 Analysis Methodology, Assumptions, and Uncertain and Unknown Information

Analysis Area

The analysis area for considering direct and indirect effects on fuels and fire management includes all proposed mine components, the four alternative tailings storage facility locations, and mine-related linear facilities such as pipelines, power lines, and roads. This area includes all lands where mine-related activities would increase fuel accumulations as a result of subsidence or increase the risk of inadvertent, human-caused fire ignitions that could spread to and impact adjacent NFS, BLM, State Trust, and private lands, as well as lands within the Pinal County "Community Wildfire Protection Plan" (CWPP)-designated WUI. This analysis area is depicted in figure 3.10.2-2. The temporal extent of analysis for fuels and fire management includes the construction, operations, and closure and reclamation phases of the proposed project.

Methodology

Analysts assess impacts associated with both fuel loading and fire risk qualitatively based on the types and locations of mining activities. Specific mine activities that analysts considered include blasting, increased vehicle traffic, storage and transportation of flammable materials, fuel loading from clearing of vegetation, impacts on vegetation from water use, introduction of noxious weeds, construction activities, and reduction in recreational use. Fuels and fire data (e.g., fire behavior-based fuel classifications, vegetation community-based fire regime information, local fire history, and jurisdictional wildfire response strategies) were compiled to identify where and when changes in wildfire risk are most likely to occur as a result of implementing the proposed project.

The available resources to analyze fuels and fire management impacts were adequate; no uncertain or unknown information has been identified.

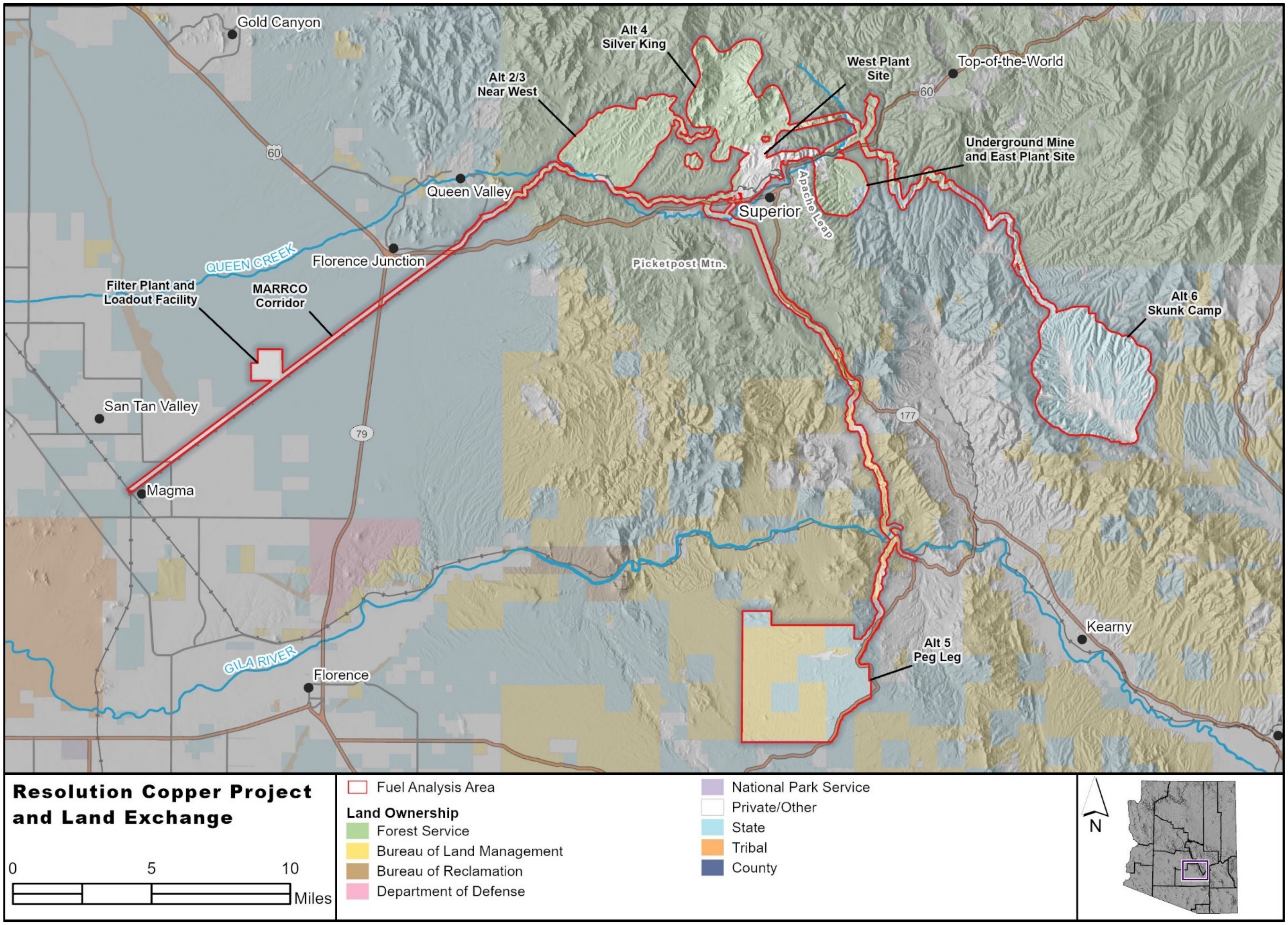


Figure 3.10.2-1. Fuels and fire management analysis area

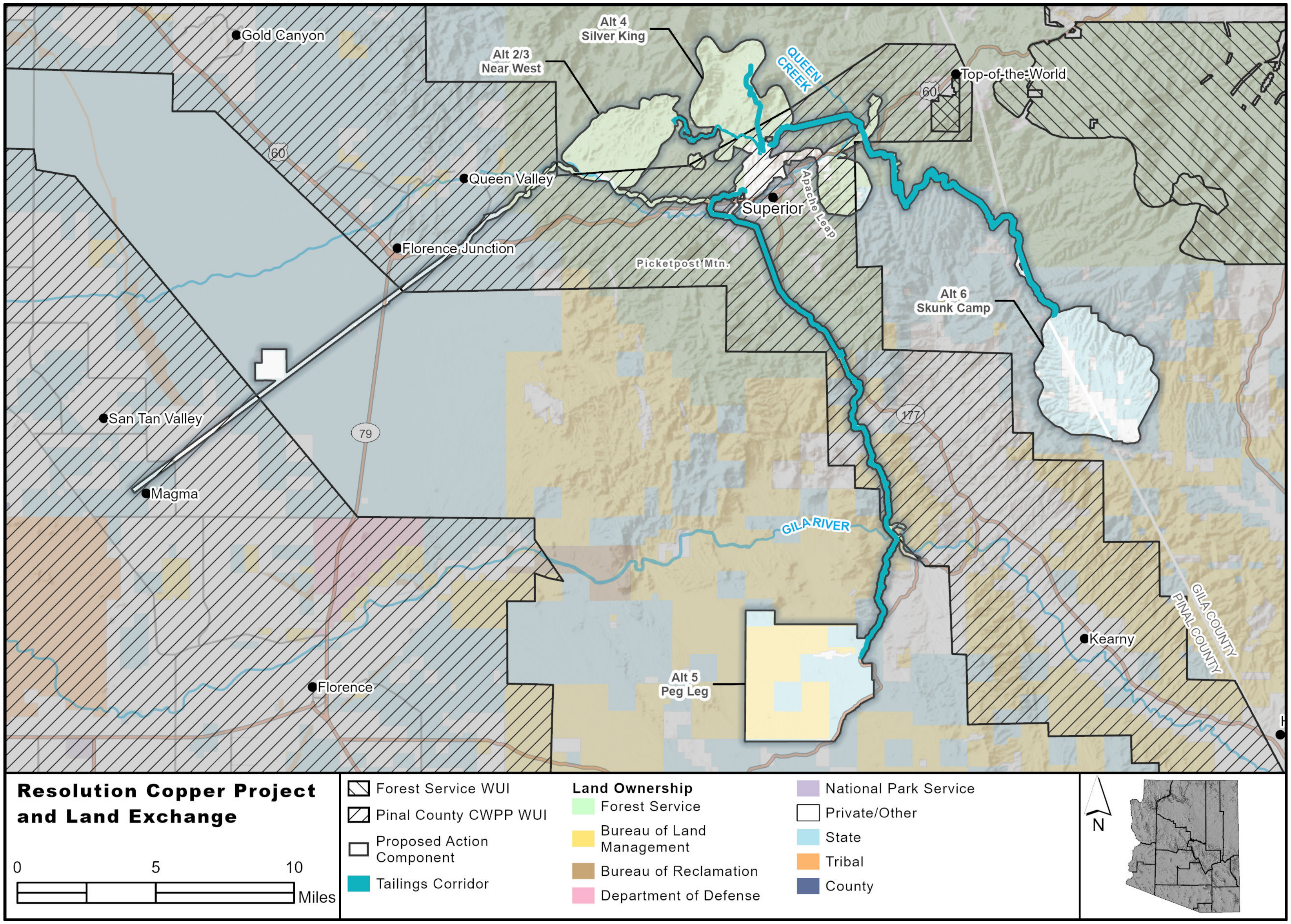


Figure 3.10.2-2. Wildland-urban interface delineation for the project area, comprising Forest Service–delineated and Pinal County CWPP–delineated WUI

3.10.2.3 Affected Environment

Relevant Laws, Regulations, Policies, and Plans

The legal authorities guiding this analysis of the effects of change on fuels and fire management as a result of the project, along with the alternatives identified in the EIS, are shown in the accompanying text box. A complete listing and brief description of the laws, regulations, reference documents, and agency guidance used in this fuels and fire management effects analysis may be reviewed in Newell and Garrett (2018b).

Primary Legal Authorities and Technical Guidance Relevant to the Fuels and Fire Management Effects Analysis

- Federal Wildland Fire Policy of 1995
- National Fire Plan (2001), including the Healthy Forest Restoration Act and the Healthy Forest Initiative
- Tonto National Forest Land and Resource Management Plan

Existing Conditions and Ongoing Trends

FUEL CLASSIFICATION

Fuel is the term given to vegetation that is available for combustion. Fuels generally belong to three categories: grass, shrubs, and timber.

Modeling fire behavior requires an additional breakdown of fuel characteristics: fuel-bed depth, surface area-to-volume ratio, and the amount of fuel loading in a given area. Surface fuels include litter, duff, and coarse woody debris greater than 3 inches in diameter. Surface fuel loading (quantities) influences fire behavior. High surface fuel loading can result in high-severity fire effects because the fire can smolder in place for long periods and transfer more heat into soils and tree stems. Lessening surface fuels reduces fire intensity and severity. Scott and Burgan's (2005) report on 40 fire behavior fuel models classifies the most dominant fuels in the project area as grass and shrub fuels, which are surface fuels consisting of grasses, forbs, shrubs, and Interior Chaparral.

VEGETATION COMMUNITIES

Three primary vegetation communities make up the majority of the overall project area: the Upland Subdivision and the Lower Colorado River Valley region of the Sonoran Desertscrub, and Interior Chaparral (see figure 3.3.2-2). In addition, Interior Riparian Deciduous Forest and Madrean Evergreen Woodland occur in limited extent, such as within the projected subsidence area at Oak Flat. Mining activities have disturbed some portions of the project area, and areas of bare ground and various nonnative invasive plant species are common (Resolution Copper 2016c).

The Sonoran Desertscrub (Arizona Upland Subdivision) is composed primarily of cactus, including saguaro (*Carnegiea gigantea*), chollas (*Cylindropuntia* spp.), and prickly pears (*Opuntia* spp.), as well as some common small trees and shrubs, including paloverde (*Parkinsonia* spp.), ironwood (*Olneya* sp.), velvet mesquite (*Prosopis velutina*), acacias (*Senegalia* spp.), and creosotebush (*Larrea tridentata*). This desertscrub community is undergoing an infrequent, high-severity fire regime (FR V) that would undergo stand-replacing fire with an average fire return interval of 103 to 1,428 years (Missoula Fire Sciences

Laboratory 2012). Infrequent fires are due to the slower and often inadequate accumulation of fuel in desert systems (Worthington and Corral 1987). When it does occur, wildfire typically kills Sonoran Desert cactus species (McLaughlin and Bowers 1982).

The Sonoran Desertscrub (Lower Colorado River Valley subdivision) is composed of creosotebush, white bursage (*Ambrosia dumosa*), and saltbush (*Atriplex* sp.). Creosotebush-white bursage communities have been described as "essentially nonflammable" because the shrubs are too sparse to carry fire (Humphrey 1974). Creosotebush is poorly adapted to fire because of its limited sprouting ability (Brown and Minnich 1986), particularly under severe burning conditions (Marshall 1995). White bursage similarly is killed by fire and has been found to have limited sprouting and seedling establishment even after 5 years post-fire (Brown and Minnich 1986).

Interior chaparral comprising shrub live oak (*Quercus turbinella*; also known as Sonoran scrub oak) experiences fire-return intervals of approximately 74 to 100 years (Tirmenstein 1999). Fires typically burn with high severity and cause stand replacement (FR IV). Shrub live oak is well adapted to survive fire, and even after complete stand replacement, the oak typically sprouts vigorously from the root crown and rhizomes (Davis 1977). Burned areas may be completely revegetated with shrub live oak within 4 to 8 years of a high-severity fire (Tiedemann and Schmutz 1966). Post-fire establishment by seed also occurs (Tirmenstein 1999). Following fire, the production of annual grasses may increase until the overstory is reestablished (Tiedemann and Schmutz 1966).

FIRE OCCURRENCE HISTORY

Since 1980, authorities have recorded over 3,900 wildfire ignitions within Pinal County (Logan Simpson 2018). Only 20 of those fires were within the footprint of the proposed project alternatives. Of those fires, only 20 percent ignited naturally; the remainder were a result of various human causes. Figure 3.10.2-3 shows the fire occurrence (ignition points and perimeters of previous fires) within the project boundary from 1980 to 2017. Most of these fires have been less than 1 acre in size. However, between 1979 and 2017, three large wildfires have occurred close to the project area: the Silverona Fire, which broke out in 1979 and consumed 1,730 acres; the Peachville Fire, which occurred in July 2005 and was 9,750 acres; and the Queen Fire, which occurred in 2012 and was 679 acres (Interagency Fuels Treatment Decision Support System 2018). These fire perimeters overlapped, as seen in figure 3.10.2-3.

The Peachville Fire was ignited by lightning on July 18, 2005, and threatened existing mining resources within the project area. The fire burned for 9 days through chaparral fuels and required 199 personnel, seven engines, one dozer, and three water tenders for suppression. Crews were supported by one helicopter for aerial suppression (Tonto National Forest 2005).

More recently and concurrent with publication of the DEIS, in June 2019 the Woodbury Fire, fueled by tall grasses, brush, and chaparral vegetation, burned 123,875 acres northwest of Superior in the Superstition Wilderness area of the Tonto National Forest (InciWeb 2019). In April 2020, the Whitlow Fire burned 842 acres of vegetation west of Superior in the Tonto National Forest (12 News 2020) followed in June 2020 by the Sawtooth Fire, which burned 24,729 acres north of Superior in the Tonto National Forest (InciWeb 2020). Although these fires did not burn within the project footprint, the fires influenced the vegetation communities and fuel loads on the Tonto National Forest within some of the same watershed and landscape potentially impacted by the project. These fire perimeters are shown in figure 3.10.2-3.

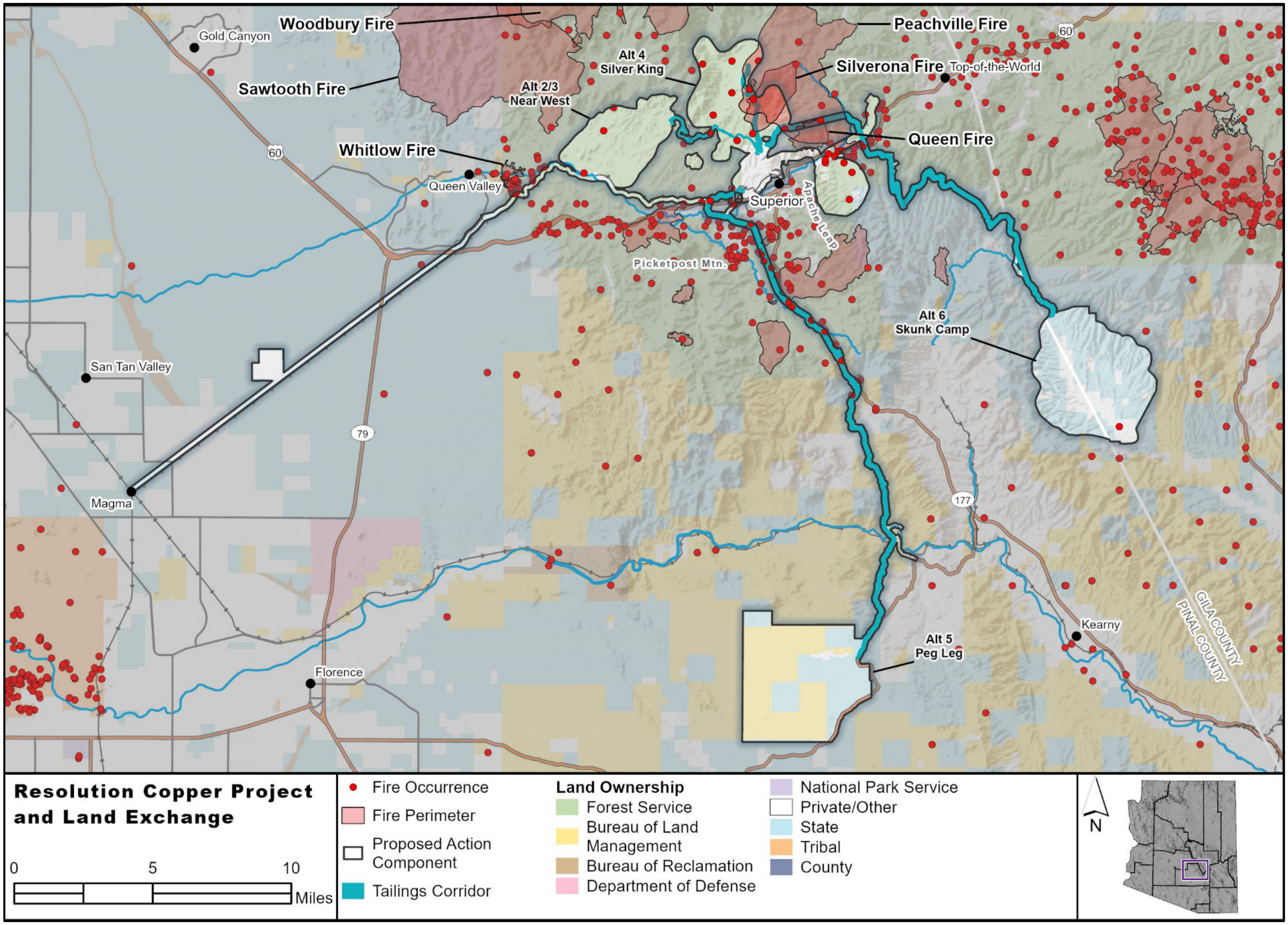


Figure 3.10.2-3. Fire occurrence history for the project area and surrounding lands

Due to the presence of non-native annual grasses, large wildfires that are uncharacteristic of the desert vegetation zone are becoming increasingly common. In addition, growing recreational use and transportation along highways has increased human-caused ignitions in the region. According to the Pinal County CWPP, the areas with the greatest potential for fire ignition, either from natural or human (though unplanned) causes, are found within the Tonto National Forest along the northeastern portion of the CWPP WUI (see figure 3.10.2-3), including Superior and Top-of-the-World. In figure 3.10.2-3, it is evident that most previous fires have occurred along transportation corridors and on NFS lands; fire occurrence on BLM lands is less frequent.

WILDFIRE RESPONSE

Wildland and structural fire response in and adjacent to the project area is provided by local fire departments and districts. The BLM and Tonto National Forest also provide support for initial wildland fire attack for areas within and adjacent to WUI areas. Initial attack response from additional local fire departments and districts can occur under the authority of mutual-aid agreements between individual departments or under the intergovernmental agreements that individual fire departments and districts have with the Arizona State Forester and adjacent fire departments and districts (Logan Simpson 2018).

Tonto National Forest

The project area falls in MA 2F on the Globe Ranger District and MA 3I on the Mesa Ranger District. Under the forest plan, fire management direction in both management areas is as follows:

> Wildland Fires will be managed consistent with resource objectives. Wildland Fires will be managed with an appropriate suppression response. Fire management objectives for this area include: providing a mosaic of age classes within the total type which will provide for a mix of successional stages, and to allow fire to resume its natural ecological role within ecosystems.
>
> Wildland Fires or portions of fires will be suppressed when they adversely affect forest resources, endanger public safety or have a potential to damage significant capital investments.

During the height of the fire season when there are multiple fires in northern and central Arizona response zones, there is a draw-down on resources leading to shortages. Responses to fires on the Tonto National Forest are timely but may not involve more than a single resource able to provide equipment and personnel.

BLM Lower Sonoran Field Office

According to the BLM Phoenix District and Safford District Resource Management Plans (Bureau of Land Management 1991, 2012), management response is to fully suppress all unplanned ignitions within the district. The resource management plans direct management actions to implement fuels treatments, suppression activities, and prevention activities that target reducing the size and number of human-caused wildland fires.

State Lands

State Trust lands occur on the periphery of the communities and are included in several of the alternatives. State Trust lands are administered by the ASLD and are managed for a variety of uses. The ASLD has a forestry division with fire and fuels crew who work on fire prevention activities, including hazardous fuels treatments around at-risk communities in the WUI. The Arizona Department of Forestry and Fire Management is responsible for prevention and suppression of wildland fire on State Trust land and private property located outside incorporated communities. The agency has ready access to over 3,000 local firefighting vehicles and more than 2,700 trained state and local wildland firefighters plus substantial national resources from Federal agencies.

Private Lands

Pinal County fire departments and districts maintain wildland fire response teams supported by various engines and other wildland equipment. Wildland fire response teams are composed of personnel with various levels of wildland firefighting training, including red-carded firefighters. Specially trained wildland fire response teams not only provide suppression response to brush fires but also community awareness programs and structural-fire risk assessments (Logan Simpson 2018).

The town of Superior is served by the Superior Fire Department. The fire department has improved wildland fire suppression response and continues public education and outreach programs concerning wildland fire threat and home-ignition-zone recommendations.

The community of Top-of-the-World is outside a fire district, is not under Forest Service jurisdiction for fire protection, and is outside of fire department jurisdiction. The Arizona Department of Forestry and Fire Management provides fire suppression. The community is prioritized in the Pinal County CWPP for fuel treatments because of its moderate risk and potential slow response times.

Resolution Copper

Resolution Copper Mining, LLC (called RCML in the quoted material here), holds an Emergency Services Agreement with the Town of Superior (called the Town, in the quoted material) for the provision of emergency services to the RCML property. In the Emergency Services Agreement, the Town agrees to

> [provide] certain emergency services . . . to the RCML Property. In the event RCML acquires additional property in the vicinity of the Town through a land exchange with U.S. Government or from BHP Copper Inc., such additional real property shall be considered part of the RCML Property for purposes of this Agreement and the Town shall provide or cause to be provided Emergency Services to all of the RCML Property, including such additional real property. (Town of Superior 2008)

Emergency services include police services, fire suppression services, and ambulance services. Specific to fire services, the agreement states:

> Fire suppression services, which shall include emergency fire suppression services for fire outbreaks on the surface and in above-ground improvements on the RCML Property. Nothing herein shall require the Town to provide fire suppression services for any underground fire on the RCML Property. (Town of Superior 2008)

The "Apache Leap Special Management Area Management Plan" (U.S. Forest Service 2017d) outlines the vision for the Apache Leap SMA. The "Vision Statement" (provided in appendix C of the "Apache Leap Special Management Area Management Plan") describes a vision for ongoing access by the Forest Service into the Apache Leap SMA for fire suppression actions (U.S. Forest Service 2017d).

AT-RISK COMMUNITIES AND WILDLAND-URBAN INTERFACE

The Arizona Department of Forestry and Fire Management compiles a list of communities at risk from wildfire each year. Six communities fall within Pinal County and three communities fall within the project area (Arizona Department of Forestry and Fire Management 2018). Typically, these at-risk communities are located within a defined WUI. The Tonto National Forest adopted the following definition for WUI in its Amendment #25:

> Wildland Urban Interface (WUI)—The line, area, or zone where structures and other human development meet or intermingle with undeveloped wildland or vegetation fuels.

The project area falls within the Tonto National Forest–defined WUI (see figure 3.10.2-2) but portions also fall within the broader WUI delineated for the Pinal County CWPP (Logan Simpson 2018). Figure 3.10.2-2 presents a map of both the Forest Service–derived and CWPP-derived WUI boundaries, relative to the project boundary.

The Pinal County CWPP analyzes risk and makes recommendations to reduce the potential for unwanted wildland fire within at-risk communities. Three of the communities within the Pinal County CWPP WUI—Superior, Queen Valley, and Top-of-the-World—fall within the project area. The CWPP makes recommendations for risk ratings for all communities within the county. Those 2018 recommendations rate all three communities as having moderate risk of wildfire. These ratings were used as the basis for the analysis in the following text. The Queen Valley community is adjacent to the project area and is discussed in the context of potential wildfire spread. The following is taken from the Pinal County CWPP (Logan Simpson 2018) and describes the conditions of these moderate-risk WUI communities.

Superior Sub-WUI

The Superior fire department provides structural and wildland fire response to over 1,459 housing units. The Superior sub-WUI is composed primarily of high wildland fire-risk vegetation associations in conjunction with a steadily rising elevation and slope from south to north throughout the sub-WUI. Substantial threats to structure and infrastructure are found within and adjacent to the community. Several large wildfires have occurred within or adjacent to the community. Vegetative associations within this sub-WUI range from desert scrub types on the desert floor to mixed desert shrub associations in the mountain foothills. These areas of the sub-WUI can create extreme risk during years of extraordinary rainfall, due to elevated growth of fine fuels. Analysis of fire-start data for the past 36 years (1980–2016) indicates that the highest incidences of ignition occur within or adjacent to Tonto National Forest lands along the northern portion of the sub-WUI. The majority (76 percent) of the Superior sub-WUI has a moderate wildfire risk, with an elevated risk from a density of developed areas in proximity to high-risk wildland fuels and elevated areas of risk in the Queen Creek riparian corridor; the overall wildland fire risk rating of the sub-WUI is moderate.

Top-of-the-World Sub-WUI

The Top-of-the-World sub-WUI includes the unincorporated community of Top-of-the-World and the Oak Flat area. Top-of-the-World is a rural community located along U.S. 60 near the Pinal County line. U.S. 60 is the only transportation route for this community. According to the 2000 census data, the population of the community of Top-of-the-World is 236 (Logan Simpson 2018). There are 196 housing units, of which 47 are classified as owner-occupied units and 61 are classified as detached single-family units, while 135 are classified as mobile homes. Top-of-the-World is not within a fire district and therefore has an Insurance Services Office (ISO) rating of 10 (the worst rating class for fire protection: 10 indicates virtually no protection). Fire suppression is provided by the Arizona Department of Forestry and Fire Management. The highest risk for wildland fires within the Top-of-the-World sub-WUI is a result of the combination of volatile vegetative associations occurring in conjunction with southerly exposures of increasing steep slopes. These areas of the sub-WUI can create extreme risk during normal precipitation years as well as during years of extraordinary rainfall. Analysis of fire-start data for the past 36 years (1980–2016) indicates that the highest incidences of ignition occur within or adjacent to the Tonto National Forest lands along the northern and eastern portions of the sub-WUI. The majority (97 percent) of the Top-of-the-World sub-WUI has a moderate to high wildfire risk, with an elevated risk from ignition history in areas of high-risk wildland fuels; the overall wildland fire risk rating of the sub-WUI is moderate.

Queen Valley Sub-WUI

The Queen Valley sub-WUI has areas at high risk from brush fires around homes with a high density of brush growth on adjacent hillsides. The population of Queen Valley has been declining over the last decade, with 712 residents in 2016. The Queen Valley Fire District has an ISO rating of 8. The Queen Valley sub-WUI is primarily composed of areas at moderate to high risk from wildland fire during extreme rainfall years. The Queen Valley sub-WUI consist of a steadily rising elevation and areas of increasing slope from the lower elevations of Queen Valley to the foothills of the Superstition Mountains within the northern portion of the sub-WUI. Vegetation associations within this sub-WUI range from desert scrub types on the desert floor to mixed desert shrub and woodlands in the foothills of the Superstition Mountains. The majority (92 percent) of the Queen Valley sub-WUI is classified at moderate risk for wildland fire (Logan Simpson 2018); the sub-WUI has an elevated risk from the density of developed areas in proximity to high-risk wildland fuels, but the area has a low to moderate ignition history and overall low wildfire effects.

COMMUNITY VALUES AT RISK

In addition to communities at risk, there are several values at risk that were identified in the Pinal County CWPP and by the Forest Service that are within or adjacent to the project area and analysis area. These include campgrounds, recreational trails and recreational areas, power lines, communication facilities, cultural and historic resources, sensitive wildlife habitat, watersheds, water supplies, and air quality.

ONGOING CLIMATIC TRENDS AFFECTING FUELS AND FIRE MANAGEMENT

Globally, climate change is producing warmer and drier conditions. These effects are especially pronounced in the American Southwest (Intergovernmental Panel on Climate Change 2013). Around the project area, groundwater levels have measurably decreased (see section 3.7.1) and ground and surface water is expected to further diminish with mining operations requiring aquifer dewatering. Drier conditions and warmer temperatures may affect the vegetation biomass and species assemblage within the project area.

Average temperatures in Arizona have increased about 2°F in the last century (U.S. Environmental Protection Agency 2016). In the Lower Colorado River basin, the annual mean and minimum temperature has increased 1.8°F–3.6°F from 1900–2002. Data suggest that spring minimum temperatures for the same time period have increased 3.6°F–7.2°F (Dugan 2018). Annual average temperatures are projected to rise by 5.5°F to 9.5°F by 2070–2099, with continued growth in global emissions (Melillo et al. 2014).

While future projected temperature increases are anticipated to change mean annual precipitation to a small degree, the majority of changes to annual flow in the Lower Colorado River basin are related to changes in runoff timing. Increased temperatures are expected to diminish the accumulation of snow and the availability of snowmelt, with the most substantial decreases in accumulation occurring in lower-elevation portions of the basin where cool season temperatures are most sensitive to warming (Dugan 2018).

These changes have ramifications on fuels and fire management and the effects in the aftermath of fires. Changes in precipitation patterns, particularly the lack of moisture during the winter and spring, results in drier and more volatile fuel loads as fire season begins. Extended and more extreme droughts are anticipated to exacerbate this situation. Wildfires are anticipated to become larger and more intense with increases in temperature and changing fuel loads. After large and intense fires there is the potential for extreme erosion. Changes in precipitation patterns, such as more intense precipitation during monsoon storm events, could increase this potential damage.

3.10.2.4 Environmental Consequences of Implementation of the Proposed Mine Plan and Alternatives

Proposed mining activities have the potential to change fuels and fire management conditions. The factors considered to address the fuels and fire management issues stated previously are (1) the type and location of activities that would change fuel loads, and (2) the type and location of activities that would increase risk for fire. Impacts associated with both fuel loading and fire risk are qualitatively assessed, based on the type and location of mining and mining-related activities.

Alternative 1 – No Action

Under the no action alternative, the project area would remain in its present condition. There would be no change to fuels and fire management conditions. Fires resulting from lightning would continue to occur at the same frequency. Human-caused fires from recreation, ranching, and transportation could increase over time as population continues to increase in the area and a corresponding increase in use of public land occurs. Continued invasion by annual grasses combined with climate change would likely result in a continuation of trends of increasing wildfire size and intensity, and increased potential for high-intensity fires when ignitions do occur. Continued growth of the WUI would expose more life and property to wildfire. Fire prevention and fire response would remain the same, with no change to access for emergency response.

Impacts Common to All Action Alternatives

The action alternatives are similar with respect to the types of mining activities proposed. The location of certain mining activities, particularly the locations of tailings, do vary by alternative. Most differences between alternatives are considered insignificant when assessing impacts on fuels and fire management, and as such effects common to all alternatives are presented. Mining operations or implementation of projects occurring on NFS, BLM, State, Pinal County, or Gila County land would need to comply with any fire restrictions that are in effect. Where differences between alternatives would have different impacts on fuels and fire management, these impacts are discussed separately by alternative.

General changes in fuel loading or risk of accidental ignition caused by mine activities include the following:

- Blasting. Regular blasting would take place under controlled conditions underground, although some aboveground blasting might be used during the construction phase for other facilities or pipelines. This could increase risk of ignition, but typically blasting is done with emergency response crews standing by.
- Increased vehicle traffic. Increased vehicle traffic increases risk of accidental ignition, through careless disposal of smoking materials, vehicles pulling over on combustible dry vegetation, or impact sparks from loose mechanical parts.
- Storage and transportation of flammable materials would not necessarily increase risk of accidental ignition but could worsen any fire that happened to occur. Adhering to hazardous and flammable material storage requirements would reduce this risk.
- Fuel loading from clearing of vegetation. Any stockpiled vegetation left to dry out would increase fuel loads, increasing the overall fire risk.
- Impacts on vegetation from water use. A number of riparian systems are predicted to be impacted by groundwater drawdown, but mitigation is largely expected to maintain vegetation communities in a relatively healthy condition and not increase fuel loading (see section 3.7.1 for analysis of these riparian areas).

- Introduction of noxious weeds. All surface-disturbing project activities increase the potential for spread of noxious and invasive weeds, which can increase fuel loads and overall fire risk. These effects would be reduced, but not eliminated by implementation of noxious weed management plans (see section 3.3 for analysis of noxious weeds).
- Construction activities. Use of power equipment and welding equipment specifically increases the risk of accidental ignition from sparks.
- Reduction in recreational use. Reductions in recreational use over large portions of the Tonto National Forest associated with the tailings storage facility would decrease the risk of accidental ignition caused by recreation, such as vehicles, shooting, or camping. However, this might be offset by the shift of recreation to other areas.
- Removal of brush may be required during archaeological data recovery, particularly on Oak Flat. In general, brush would be manually removed and chipped where necessary to allow access to features for data recovery. Tonto National Forest personnel recommended this work occur in the fall or winter to minimize fire risk, and that it is preferred to not pile wood chips more than 1 foot deep.

FIRE RISK FROM POWER LINES

In the last few years, greater attention is being focused on the wildfire risk posed by aging and poorly maintained power infrastructure. The project would include several new high-voltage power line segments, depending on the alternative. Alternatives 5 and 6 have the most extensive new power line infrastructure along the tailings pipeline corridor.

SRP would construct, own, operate, and maintain the power lines associated with the project. To reduce the potential for power line damage as well as reduce the potential for sparking wildfires, vegetation management along power lines is a fundamental aspect of the operation and maintenance activities that SRP undertakes. Based on current practice, SRP likely would perform routine vegetation management every 1 to 5 years across the entire circuit. Hazard vegetation treatment would occur as needed, estimated at about a single instance a year. The methodologies include (1) vegetation aerial inspection, (2) vegetation ground inspection, (3) routine vegetation maintenance, and (4) hazard vegetation treatment. Each of these methodologies is described below.

Vegetation aerial inspection. Aerial inspections of transmission line rights-of-way would occur by helicopter above conductor height (50 to 150 feet above ground level), except where terrain or trees require a higher observation elevation. Low-level flights are intended as a reconnaissance of general vegetation conditions within the right-of-way, to identify hazard vegetation, and plan the next routine maintenance cycle. Information from inspections may be used to plan access routes, collect data, refine the number of crews needed, and develop the vegetation treatment method and plan of work.

Vegetation ground inspection. Ground inspections of transmission line rights-of-way would occur by truck, UTV, or on foot as dictated by site conditions. The ground inspection is intended as a reconnaissance of the right-of-way that can occur in conjunction with aerial inspection, or occur when/where aerial inspection is not practical. Ground inspection will record general vegetation conditions within the right-of-way, identify hazard vegetation, and plan the next routine maintenance cycle. Information from inspections may be used to plan access routes, collect data, refine the number of crews needed, and develop the vegetation treatment method and plan of work.

Routine vegetation maintenance. This process involves pruning or removing vegetation within the right-of-way to maintain right-of-way safety and access. Pruning typically is limited to the edges of the right-of-way corridor. Pruning also is limited to where protected resources or species concerns exist, and pruning is required rather than removal of a tree or vegetation. Routine vegetation maintenance is separated into (1) lines that have been cleared to the recommended clearance standards and require only routine follow-up maintenance, and (2) lines that have not been cleared to the clearance standards and require extensive clearing. The schedule of routine vegetation maintenance projects is planned through the results of aerial and ground inspections. Power lines are cleared on a cyclical basis every 1 to 5 years depending on factors such as vegetation type and the clearance standards for the line type. Routine vegetation maintenance involves mechanical (mowing) and manual (hand crew) treatments. Mowing involves the use of a powered cutting device mounted on a tractor with rubber tires or tracks that cuts and masticates vegetation. The mower typically is operated by one driver and one grounds-person. The grounds-person directs the mower and may operate a chainsaw to cut trees that the mower cannot access. A hand crew may also follow the mower to clean up, scatter debris, and prune or remove trees that the mower could not access. All vegetation masticated by the mower is left on-site in the corridor, typically piled no higher than 4 inches. Hand crew treatment is the method of vegetation control used in areas where mowing is not possible. Hand crew removal and pruning of trees generally involves the use of chainsaw felling and pruning techniques.

Hazard vegetation treatment. These operations include using hand crews and power cutting tools to remove and/or prune vegetation that poses an immediate threat to a utility line or associated structure. Because hazard vegetation requires immediate treatment to maintain the line in a safe operating condition, not all species conservation measures to minimize and/or avoid impacts may be reasonably implemented. Therefore, hazard vegetation can be removed or pruned at any time of year, and at any location with the right-of-way.

The presence of a power line increases the potential for ignition. However, these vegetation management techniques reduce the potential for damage to the power line—which in turn reduces the risk of sparking a wildfire—and reduce the vegetation load near the line when a line does go down. These activities would reduce, but not remove, the overall wildfire risk associated with new power lines.

EFFECTS OF RECLAMATION

The tailings storage facility represents a large area of disturbance that would be reclaimed after closure. The success of reclamation and the ability to reestablish vegetation on the tailings storage facility surface would have a large effect on post-closure fire risk. Potential reclamation success is analyzed in detail in section 3.3. Overall, in areas where ground disturbance is relatively low, and soil resources (e.g., nutrients, organic matter, microbial communities) and vegetation propagules (e.g., seedbank or root systems to resprout) remain relatively intact, it would be expected that vegetation communities could rebound to similar pre-disturbance conditions in a matter of decades to centuries. In contrast, for the tailings storage facility, which would be covered in non-soil capping material (such as Gila Conglomerate), biodiversity and ecosystem function may never reach the original, pre-disturbance conditions even after centuries of recovery. The vegetation on the reclaimed tailings storage facility might be more sparse than the natural landscape, but also might increase fuel loading if survivorship of plants is low.

EFFECTS OF THE LAND EXCHANGE

The Oak Flat Federal Parcel would leave Forest Service jurisdiction. This would not impact the Forest Service's ability to fight any potential fires, as the Tonto National Forest would still cover fires occurring on private lands; however, the Tonto National Forest would lose their authority to actively manage wildfire suppression and prescribed fires within the parcel in order to meet management objectives. However, this change in management would not necessarily result in increased fire risk on the Oak Flat Federal Parcel.

The eight offered lands parcels would move into Federal jurisdiction and grant the Forest Service and BLM the authority to manage fuel loads and fire risks within those parcels where there was previously no Federal management. This would enable more cohesive management techniques as the parcels include inholdings surrounded by federally managed land. The respective Federal authority would manage the parcels for multiple uses, of which fire is recognized as a resource management tool with the potential included in a management prescription where it can effectively accomplish resource management objectives. In all, the main effect on fuels and fire management from the transfer of the offered lands parcels to Federal jurisdiction would be the authority of Federal agencies to actively manage for fires and could potentially reduce fire risks in those areas.

EFFECTS OF FOREST PLAN AMENDMENT

The Tonto National Forest Land and Resource Management Plan (1985b) provides guidance for management of lands and activities within the Tonto National Forest. It accomplishes this by establishing a mission, goals, objectives, and standards and guidelines. Missions, goals, and objectives are applicable on a forest-wide basis. Standards and guidelines are either applicable on a forest-wide basis or by specific management area.

A review of all components of the 1985 forest plan was conducted to identify the need for amendment due to the effects of the project, including both the land exchange and the proposed mine plan (Shin 2020). As a result of this review, 30 standards and guidelines were identified as applicable to management of ecosystems and vegetation communities. None of these standards and guidelines was found to require amendment to the proposed project, on either a forest-wide or management area-specific basis. For additional details on specific rationale, see Shin (2020).

EFFECTS OF COMPENSATORY MITIGATION LANDS

While activities on the compensatory mitigation lands would modify vegetation to some extent, overall there would be no substantial change in fuel loading. The placement of land into conservation easements likely would reduce future human use of the land, reducing overall risk of ignition.

EFFECTS OF RECREATION MITIGATION LANDS

The recreation mitigation lands are anticipated to affect fuels and fire management, but not overall fire risk. The planned trail system would not result in any substantial changes to fuel loading. Existing roads and trails, as well as new planned routes, would be located on NFS lands and be under active management by the Tonto National Forest for wildfire suppression and prescribed fires in order to meet management objectives. By changing recreational use patterns, the development of the recreation mitigation lands could increase risk of wildfire in some newly opened areas. However, by reducing the haphazard development of unauthorized trails, fire risk would be reduced in other areas.

SUMMARY OF APPLICANT-COMMITTED ENVIRONMENTAL PROTECTION MEASURES

A number of environmental protection measures are incorporated into the design of the project that would act to reduce potential impacts on fuels and fire management. These are non-discretionary measures, and their effects are accounted for in the analysis of environmental consequences.

In appendix M of the GPO, Resolution Copper has committed to various measures to reduce impacts on fuels and fire management:

- Any vegetation cleared from the site would be temporarily stored on-site at a location with minimal fire risk, well within a cleared area away from ignition sources. Handheld and large equipment (e.g., saws, tractors) used for vegetation clearing would be equipped with working spark arresters. Resolution Copper would take additional precautions if work is to be conducted during critical dry season, which may include larger amounts of extinguishing agents, shovels, and possibly a fire watch.

- Parking will be prohibited on vegetated areas and proper disposal of smoking materials will be required. All surface mine vehicles would be equipped with, at a minimum, fire extinguishers and first aid kits.
- Resolution Copper will establish an emergency service or maintain contracts and agreements with outside emergency response contractors for emergency response support services to surface facilities on a 24/7 on-call basis. Fire emergency and response procedures specific to underground operations would be prepared and implemented.

Alternative 2 – Near West Proposed Action

Potential impacts on fuels and fire management would be the same as described earlier in this section in “Impacts Common to All Action Alternatives.” The tailings facility for Alternative 2 would be located on NFS lands, in an area that has historically received very few wildfire ignitions. Although the tailings facility footprint includes a portion of the Queen Valley WUI, the majority of the footprint is 2 miles or more from the community. Fuel types in the area of the tailings facility are characterized by grass/shrub fuels and Sonoran Desert vegetation that does not typically transmit wildfire. Following very wet years, however, these fuel types would be at elevated risk of large fire spread due to the presence of annual grass fuels. This risk may be mitigated, but not eliminated, using noxious weed management techniques. Fire response to the area would be rapid, due to the emergency services provided by both the Tonto National Forest and the Town of Superior. Fires have a better chance of being contained during initial attack, before they can gain in size.

Alternative 3 – Near West – Ultrathickened

Potential impacts on fuels and fire management would be the same in magnitude and nature as those described for Alternative 2 since they have the same footprint, and differences in the tailings site embankment structure would not increase or decrease potential impacts between the two alternatives.

Alternative 4 – Silver King

Potential impacts on fuels and fire management from proposed project activities would be similar to those described earlier in this section in “Impacts Common to All Action Alternatives,” but the location of the tailings facility, the location of the filter plant and loadout facility, and other emergency storage ponds would increase the West Plant Site footprint and require different access road alignment along Silver King Mine Road, compared with the GPO and Alternatives 2, 3, 5, and 6. Because the facilities would be contained within the West Plant Site, the potential exposure of surrounding areas to West Plant Site–related ignitions resulting from transportation of materials or construction activities would be slightly reduced.

Alternative 4 includes areas classified with shrub fuels (SH7) that burn with high intensity in the event of an ignition. Intense fire behavior was observed within the footprint of Alternative 4 during the Peachville Fire, which burned a portion of the proposed tailings area in 2005. Several after-wildfire ignitions have also occurred within the footprint over the past several decades. The southern portion of the Alternative 4 footprint is located within the WUI for the town of Superior, showing that the location would expose life and property to wildfire impacts, should an ignition occur. Because of the close proximity to Superior, fire response to the area would be rapid due to the emergency services provided by both the Tonto National Forest and the Town of Superior. Fires have a better chance of being contained during initial attack, before they can gain in size.

Alternative 5 – Peg Leg

Potential impacts on fuels and fire management from proposed project activities would be similar to those described earlier in this section in "Impacts Common to All Action Alternatives." The area of disturbance would be larger under Alternative 5 in order to accommodate two separate facilities, one for NPAG tailings and one for PAG tailings, as well as ancillary tailings facilities such as borrow and storage areas, roads, and realignment of two existing transmission line corridors (10,782 acres). This would increase construction impacts on fuels and fire management and increase the length of the perimeter that abuts wildland fuels, elevating the potential for wildfire spread. However, the tailings facility is located at a greater distance from residential areas, and outside of any delineated WUI areas, which reduces the potential for fire originating from tailings activities to spread to homes and structures. Alternative 5 tailings facilities are also located in an area that has experienced lower fire occurrence historically than locations for other alternatives.

Alternative 5 would use ASLD, BLM, and private lands for the tailings facilities. Fire management would therefore differ when compared with other alternatives, including potentially slower response times due to the location. BLM fire management policy is to fully suppress all unplanned ignitions that occur in the district. Fire suppression on ASLD and private lands is provided by the Arizona Department of Forestry and Fire Management. Fires have a better chance of being contained during initial attack, before they can gain in size.

Alternative 6 – Skunk Camp

Potential impacts on fuels and fire management from proposed project activities would be similar to those described earlier in this section in "Impacts Common to All Action Alternatives." Similar to Alternative 5, Alternative 6 would be located at a greater distance from residential areas than Alternatives 2, 3, and 4, but slightly closer to WUI areas along the SR 177 corridor than Alternative 5. The footprint for the tailings facility under Alternative 6 would be substantially larger than under Alternatives 2, 3, and 4, but smaller than the footprint for Alternative 5. The tailings facility would be located in an area of steep terrain and heavy shrub fuels (fuel model SH7) that would burn with intense fire behavior in the event that an ignition occurs; however, historically fire occurrence in the area has been infrequent and potential ignitions originating from the tailings facility would be limited, due to the nature of the activities there and fencing, which prevents unauthorized access.

This alternative is the only alternative that would require a new transmission line to be constructed outside of an existing corridor. This would increase the risk of fire, by exposing surrounding wildland fuels to construction-related ignition sources.

This alternative would use ASLD and private lands. Fire suppression on ASLD and private lands is provided by the Arizona Department of Forestry and Fire Management. Fires have a better chance of being contained during initial attack, before they can gain in size.

Cumulative Effects

Full details of the cumulative effects analysis can be found in chapter 4. The following represents a summary of the cumulative impacts resulting from the project-related impacts described in Section 3.10.2.4, Environmental Consequences, that are associated with fuels and fire management, when combined with other reasonably foreseeable future actions.

The following actions were determined through the cumulative effects analysis process to be reasonably foreseeable, and have impacts that likely overlap in space and time with impacts from the Resolution Copper Project:

- APS Herbicide Use within Authorized Power Line ROWs on NFS lands
- Ray Land Exchange and Proposed Plan Amendment

The cumulative effects analysis area for fuels and fire management includes all lands where mine-related activities would increase fuel accumulations due to subsidence or increase the risk of inadvertent, human-caused fire ignitions. The metric used to quantify cumulative impacts to fuels and fire management is the physical footprint within the analysis area. Risk of wildfire increases with industrial activity on the landscape, which can include a wide variety of actual activities including maintenance, traffic, visitors, industrial processes, or storage/use of explosives or flammable materials. Physical footprint serves as a proxy for the overall level of activity occurring on the landscape that contributes to fire risk.

It should be noted that the APS herbicide use overall represents a beneficial effect on fuels management, as it reduces fire risk below power lines. For the purposes of the cumulative effects analysis, it has been analyzed in the same way as those RFFAs that would have adverse effects. This approach was chosen to avoid trying to qualitatively estimate whether beneficial and adverse effects from different RFFAs would offset each other. The resulting cumulative effects analysis should overestimate overall cumulative impacts to fuels and fire management.

The two reasonably foreseeable future actions above, combined with the Resolution Copper Project, represent about 26,000 acres of the 700,000-acre cumulative effects analysis area, or about 3.7 percent. This increase in general disturbance or activity overall increases the potential for fire risk in the area.

Mitigation Effectiveness

Mitigation Identifier and Title	Authority to Require
None	None

We developed a robust monitoring and mitigation strategy to avoid, minimize, rectify, reduce, or compensate for resource impacts that have been identified during the process of preparing this EIS. Appendix J contains descriptions of mitigation measures that are being required by the Forest Service and mitigation measures voluntarily brought forward and committed to by Resolution Copper. Appendix J also contains descriptions of monitoring that would be needed to identify potential impacts and mitigation effectiveness. No mitigations were identified—required or voluntary—related to fuels and fire management.

UNAVOIDABLE ADVERSE IMPACTS

While increased risks of fire ignition from mine activities cannot be entirely prevented, risks are expected to be substantially mitigated through adherence to a fire plan that requires mine employees to be trained for initial fire suppression and to have fire tools and water readily available.

Other Required Disclosures

SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

Impacts from increased mine-related traffic, increased fire hazard, and hazardous materials use in mine operations would be short term and would end with mine reclamation.

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

With respect to fuels and fire management, no irretrievable or irreversible impacts on resources are expected. Vegetation and fuels in the project area would be constantly changing as reclamation procedures are implemented. Eventually, reclamation is expected to return site vegetation to a state that is reminiscent of existing vegetation communities in the area.

3.10.3 Hazardous Materials

3.10.3.1 Introduction

Hazardous materials in the context of this project include fuels, chemicals, and explosives that are used for mine equipment and operations. These materials must be transported to the mine properties, stored, and if not consumed by the process, disposed of properly.

Changes from the DEIS

Overall, few public comments were received specific to the analysis of hazardous materials, resulting in few changes. As with all resources, Alternatives 5 and 6 no longer have alternative pipeline routes to reach the tailings storage facility; each alternative now has a single route as described in chapter 2. In addition, we revised the Alternative 6 pipeline route, primarily to address potential impacts to habitat and resources along Mineral Creek. These changes had no major impact on the analysis of hazardous materials.

The cumulative effects analysis was revised for the FEIS to better quantify impacts. It is described in detail in chapter 4 and summarized in this section. Any mitigations developed between the DEIS and FEIS are summarized in appendix J and, if applicable to hazardous materials, are analyzed for effectiveness in this section.

3.10.3.2 Analysis Methodology, Assumptions, and Uncertain and Unknown Information

Analysis Area

The geographic extent of the analysis area for hazardous materials, as shown in figure 3.10.3-1, encompasses any environmental impacts that may result from the transport, storage, use, or disposal of hazardous materials at the proposed project. Thus, it includes all primary mine components (East Plant Site, West Plant Site, tailings storage proposed and alternative locations, MARRCO corridor and filter plant and loadout facility, and linear facilities such as pipelines), as well as primary transport routes to and from each location. Utility corridors were not considered in the analysis area, as the use and risk of release of hazardous materials in these areas is considered negligible. In terms of supply routes, while there is no guarantee that shipments to mine facilities, including those of hazardous materials, would come solely from the Phoenix metropolitan area eastward along U.S. 60, this is considered the most likely scenario.

The analysis area for hazardous materials encompasses the operational areas of the proposed project (i.e., mine process facilities, fuel storage tanks, storage ponds), where hazardous materials would be used and stored. The potential exists at these locations for accidental leaks, spills, or releases to the environment (e.g., soils, vegetation, wildlife, aquifers, surface water drainages).

The temporal bounds of analysis for hazardous materials for the project includes the construction, operations, and closure and reclamation phases.

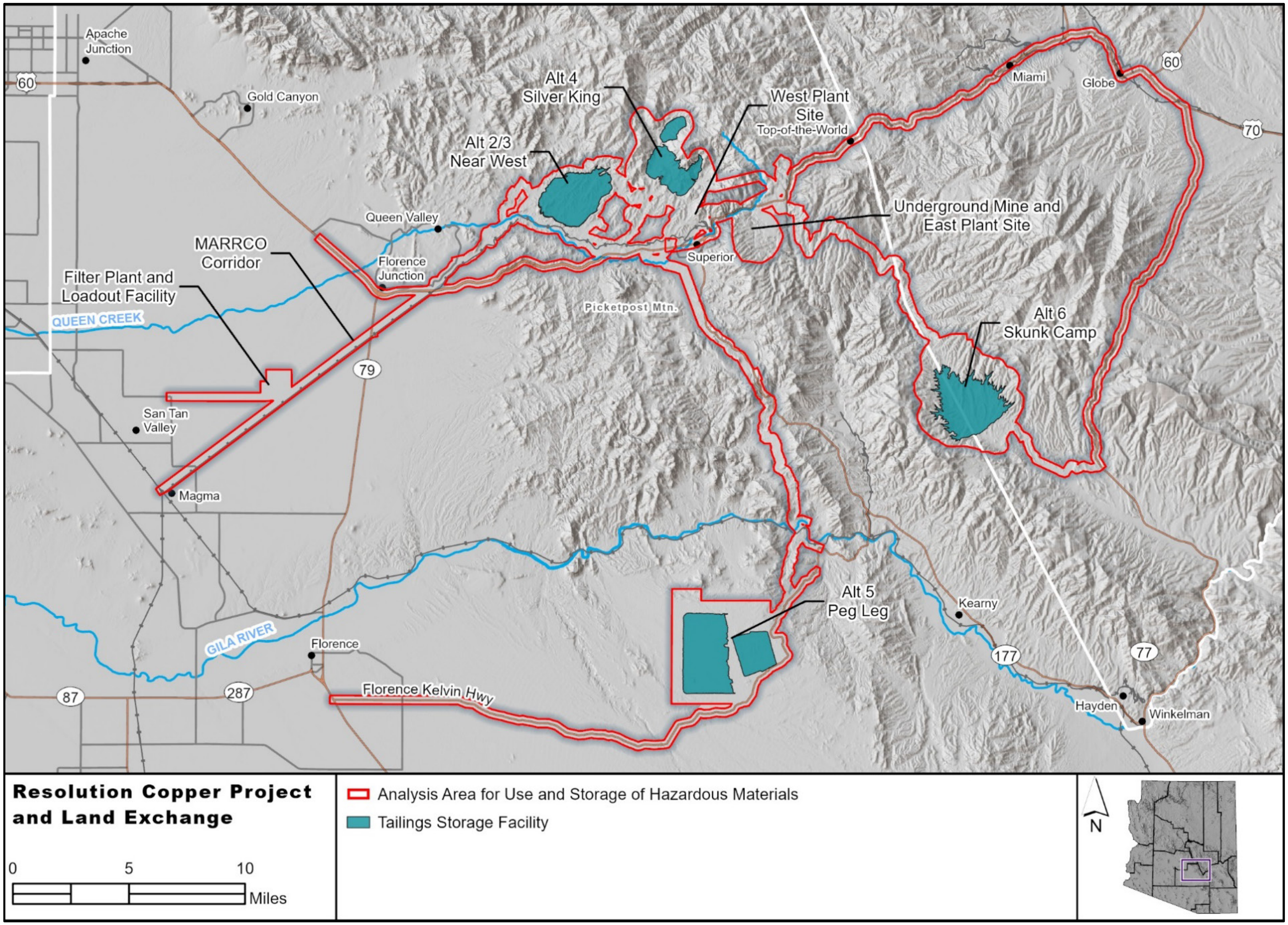


Figure 3.10.3-1. Hazardous materials analysis area

Note that the potential for and impacts of a release of concentrate, tailings, and process water during a pipeline failure or catastrophic failure of a tailings facility are analyzed in Section 3.10.1, Tailings and Pipeline Safety; the anticipated impacts from the expected migration of seepage from the tailings facility are analyzed in Section 3.7.2, Groundwater and Surface Water Quality; and the anticipated impacts from air emissions are analyzed in Section 3.6, Air Quality.

3.10.3.3 Affected Environment

Relevant Laws, Regulations, Policies, and Plans

The use, storage, transport, and disposal of hazardous materials are governed by a variety of Federal and State laws, as well as Forest Service guidance. For more detail on the applicable guidance, see Newell and Garrett (2018c).

Primary Legal Authorities and Technical Guidance Relevant to the Hazardous Materials Analysis

- Resource Conservation and Recovery Act, including mining waste exclusion provisions (Subtitle C)
- Arizona Revised Statutes Title 49, Chapter 5 (Hazardous Waste Disposal)
- Emergency Community Planning and Right to Know Act
- Arizona Pollutant Discharge Elimination System (AZPDES) and Stormwater Pollution Prevention Plans
- Forest Service Manual 2100, “Environmental Management,” Chapter 2160, “Hazardous Materials Management”
- BLM Manual 1703, “Hazard Management and Resource Restoration (HMRR) Program”

Existing Conditions and Ongoing Trends

HISTORICAL AND CURRENT HAZARDOUS MATERIALS USE

Hazardous materials have historically been used for mining operations at the East Plant Site and West Plant Site and are currently being used for exploratory operations. The tailings facilities and filter plant and loadout facility are, in general, undeveloped natural desert that do not have a historical or current use of hazardous materials. Therefore, the following discussion provides the existing conditions for hazardous materials at the East Plant Site and West Plant Site.

EAST PLANT SITE

The East Plant Site is at the former site of the Magma Mine, which employed the use of hazardous materials like those that Resolution Copper currently uses for mineral exploration activities. Because the East Plant Site is currently in use, all Federal and State laws regarding the storage, use, transportation, and disposal of hazardous materials must be followed. Hazardous materials used at the East Plant Site for the exploratory operations include diesel fuel, oil/lubricants, antifreeze, and solvents. These materials are used for the operation and maintenance of mining equipment aboveground and belowground and are delivered to the East Plant Site by delivery trucks using Magma Mine Road from U.S. 60. Gasoline is not stored at the East Plant Site, but vehicles traveling to and parked at the East Plant Site use gasoline. At the East Plant Site, hazardous materials are stored in appropriate sealed containers (tanks, drums, and totes).

Resolution Copper stores diesel fuel in an existing aboveground storage tank. The mine collects spent hazardous materials and either disposes of or recycles them with qualified vendors. To prevent potential surface spills from spreading and leaving the East Plant Site, a contact water basin contains surface water runoff.

WEST PLANT SITE

Parts of the West Plant Site were historically used as a concentrator and smelter site for the Magma Mine. The concentrator became operational in 1914, and the smelter site was operational between 1924 and 1972. These historic-era facilities are located adjacent to the town of Superior.

Particulate emissions from the smelter stack and fugitive emissions from other mineral processing operations (e.g., crushing and concentrating) led to soil contamination with elevated levels of arsenic, copper, and lead. In 2011, Resolution Copper conducted a site characterization study under the authority of the ADEQ Voluntary Remediation Program to understand the nature and extent of the historical soil contamination. The results of the site characterization study are presented in "Site Characterization Report for the West Site Plant, Superior, Arizona" (Golder Associates Inc. 2011).

After Resolution Copper conducted the site characterization study and the nature and extent of the soil contamination was better understood, they developed site-specific soil remediation levels for the contaminated soils that were approved by the ADEQ Voluntary Remediation Program. Resolution Copper then developed a Remedial Action Work Plan for returning the affected area to pre-contamination levels. The Remedial Action Work Plan involves excavating the contaminated soils, using the contaminated soils as fill for reclamation efforts at Tailings Pond 6, and capping the reclaimed tailings pond with cover material in accordance with APP requirements. The Remedial Action Work Plan was approved by the ADEQ in 2016, and remediation efforts for the historic smelter site are currently underway. Removal of the smelter building and stack was completed in December 2018.

The West Plant Site currently processes development rock from the East Plant Site's exploratory operations. Because the West Plant Site is a currently operating mine facility, all Federal and State laws regarding the storage, use, transportation, and disposal of hazardous materials must be followed. Hazardous materials currently used at the West Plant Site are the same as described for the East Plant Site, except for the lab chemicals and reagents used at the West Plant Site's laboratory to test the development rock. These chemicals are stored in appropriate individual containers in the Chemical Storage Facility in Building 203. The West Plant Site employs stormwater management controls and containment measures to prevent the spread of chemicals following an accidental release.

3.10.3.4 Environmental Consequences of Implementation of the Proposed Mine Plan and Alternatives

Alternative 1 – No Action

Under the no action alternative, the project area would remain in its present condition. The potential of additional impacts from hazardous materials would not occur, and there would be no risk of a potential accident or spill involving hazardous materials from the proposed project activities. Transportation of hazardous materials along U.S. 60 would continue to occur for non-mine-related businesses and industries that currently use the highway for hazardous materials deliveries.

Impacts Common to All Action Alternatives

Based on the preliminary GPO, potentially hazardous materials, including petroleum products, processing fluids, and reagents and explosives, would be transported to and stored within the boundaries of the mine in large quantities for use in various operational components of the mine (Resolution Copper 2016c). Hazardous and non-hazardous materials and supplies are included in section 3.9 of the GPO, "Materials, Supplies and Equipment." Transportation of hazardous materials as well as proposed mining activities have the potential to release these materials into the environment and affect the natural condition of soils, vegetation, wildlife, surface water and groundwater resources, and air quality within the analysis area. The issues considered in this section are (1) the use, storage, and disposal of hazardous materials within the project area; (2) the transportation of hazardous materials to the project area; and (3) the potential for those materials to enter the environment in an uncontrolled manner, such as by accidental spill.

An accidental release or significant threat of a release of hazardous chemicals into the environment could result in direct and indirect harmful effects on or threat to public health and welfare or the environment. The environmental effects of a hazardous chemical release would depend on the substance, quantity, timing, and location of the release. A release event could range from a minor diesel fuel spill within the boundaries of the mine, where cleanup would be readily available, to a major or catastrophic spill of contaminants into a stream or populated area during transportation. Some hazardous chemicals could have immediate destructive effects on soils and vegetation, and there also could be immediate degradation of aquatic resources and water quality if spills were to enter surface water. Spills of hazardous materials could potentially seep into the ground and contaminate the groundwater system over the long term.

EFFECTS OF THE LAND EXCHANGE

The land exchange would have an effect on the potential presence and use of hazardous materials on these lands.

The Oak Flat Federal Parcel would leave Forest Service jurisdiction. The role of the Tonto National Forest under its primary authorities in the Organic Administration Act, Locatable Regulations (36 CFR 228 Subpart A), and Multiple-Use Mining Act is to ensure that mining activities minimize adverse environmental effects on NFS surface resources; this includes use of hazardous materials. The removal of the Oak Flat Federal Parcel from Forest Service jurisdiction negates the ability of the Tonto National Forest to regulate effects on these resources. No hazardous materials are presently being used at the Oak Flat Federal Parcel; once the land exchange occurs, Resolution Copper could use hazardous materials on this land without approval. However, all other environmental laws regarding the use, storage, transport, and disposal of hazardous materials would still apply and need to be followed.

The offered land parcels would enter either Forest Service or BLM jurisdiction. This would provide a new level of control over the use of hazardous materials on these properties.

EFFECTS OF FOREST PLAN AMENDMENT

The Tonto National Forest Land and Resource Management Plan (1985b) provides guidance for management of lands and activities within the Tonto National Forest. It accomplishes this by establishing a mission, goals, objectives, and standards and guidelines. Missions, goals, and objectives are applicable on a forest-wide basis. Standards and guidelines are either applicable on a forest-wide basis or by specific management area.

A review of all components of the 1985 forest plan was conducted to identify the need for amendment due to the effects of the project, including both the land exchange and the proposed mine plan (Shin 2020). No standards and guidelines were identified as applicable to hazardous materials. For additional details on specific rationale, see Shin (2020).

EFFECTS OF COMPENSATORY MITIGATION LANDS

Activities on the compensatory mitigation lands would not generate or use hazardous materials, though some mechanized equipment could be used for short periods during construction. These activities would follow best management practices as described below and likely would not have any impact on the compensatory mitigation lands.

EFFECTS OF RECREATION MITIGATION LANDS

No hazardous materials would be associated with the recreation mitigation lands, and the recreation mitigation lands would have no effect on concerns of hazardous materials.

SUMMARY OF APPLICANT-COMMITTED ENVIRONMENTAL PROTECTION MEASURES

A number of environmental protection measures are incorporated into the design of the project that would act to reduce potential impacts from hazardous materials and to reduce impacts on public safety from hazardous materials. These are non-discretionary measures outlined in a variety of protection plans (listed here and included in the GPO) and their effects are accounted for in the analysis of environmental consequences.

Applicable emergency response protection plans include the following:

- Spill Prevention Control and Countermeasures Plan (Appendix O of the GPO)
- Emergency Response and Contingency Plan (Appendix L of the GPO)
- Stormwater Pollution Prevention Plan (Appendix W of the GPO)
- Fire Prevention and Response Plan (Appendix M of the GPO)
- Environmental Materials Management Plan (Appendix V of the GPO)
- Explosives Management Plan (Appendix P of the GPO)
- Hydrocarbon Management Plan (Appendix U of the GPO)
- Tailings Pipeline Management Plan (AMEC Foster Wheeler Americas Limited 2019)
- Concentrate Pipeline Management Plan (M3 Engineering and Technology Corporation 2019)

PROPOSED ACTION AND ACTION ALTERNATIVES

The impacts from the proposed action and the other action alternatives are identical with respect to the type and quantity of hazardous materials used, stored, disposed of, and transported. There may be slight variations in the location of use amongst the alternatives, such as the exact location of hazardous materials storage within the plant site, but these changes are considered insignificant for assessing impacts.

Transportation of Hazardous Materials

All hazardous materials and petroleum products would be transported to and from the project area by commercial trucks and rail access, in accordance with 49 CFR and 28 ARS. Transporters must be properly licensed and inspected, in accordance with ADOT guidelines. Hazardous materials must be properly labeled, and shipping papers must include information describing the substance, health hazards, fire and explosion risk, immediate precautions, firefighting information, procedures for handling leaks or spills, first aid measures, and emergency response contact information. Because of the quantity and number of daily deliveries, petroleum fuels are of the greatest concern.

Waste that may be classified as hazardous, such as grease, unused chemicals, paint and related materials, and various reagents, would be shipped to an off-site disposal facility licensed to manage and dispose of hazardous waste. Prior to disposal, Resolution Copper would be required to characterize the waste and properly mark and manifest each shipment.

Transportation of Hazardous Materials within the Mine

Transportation of hazardous materials within the boundaries of the mine would occur on the primary access roads, in-plant roads between facilities, and haul roads. Hazardous materials would enter and exit the plant along the primary access roads. Once inside, all hazardous materials would be delivered to their appropriate storage location.

Reagents would be received from vendors and stored in individual storage tanks, drums on pallets, dry-storage silos, or a nitrogen tank. Refer to section 3.9 of the GPO, “Materials, Supplies, and Equipment,” for more detail on material being delivered and stored on-site. Deliveries of reagents, diesel fuel and gasoline, and nitrogen would be direct to storage locations. The plant layout would be designed so that these delivery trucks would remain in the right-hand traffic lanes.

Frequency of Shipments of Hazardous Materials

Hazardous materials would be transported to the project area during the pre-mining and active mining phases of the mine. Section 3.4.2.1 of the GPO, “Construction Phase,” provides more detail regarding the estimated shipment of hazardous material in large quantities to and from the East Plant Site or West Plant Site, along with the expected quantities and number of trips. The most sensitive times of the day are considered to be around shift change and early weekday mornings and afternoons during school bus hours on U.S. 60.

Analytical Laboratory

The analytical laboratory would be a pre-engineered building located at the West Plant Site.
The laboratory would consist of a sample preparation area, a wet laboratory, a metallurgical laboratory, an environmental laboratory, offices, lunchroom, and restrooms. It would contain sample crushers, pulverizers, sample splitters, and a dust collection system to capture and contain any dust generated from this operation. The analytical laboratory would also contain a reagent storage area, balance rooms, and various types of analytical equipment. Disposal of chemical and laboratory waste would follow appropriate regulatory requirements, depending on the waste generated.

Storage of Hazardous Materials within the Mine

Storage of hazardous materials would begin during the pre-mining phase and continue through the active mining phase. All hazardous materials storage facilities would be removed during the final reclamation and closure phase of the mine. The storage facilities would be maintained throughout this period. Refer to appendix V of the GPO, “Environmental Materials Management Plan,” for more information.

Hazardous Waste Management and Disposal

A waste management plan was prepared for the preliminary GPO. The disposal of hazardous waste and petroleum products, along with the type of storage container, location, use, and quantity of these materials, is described in appendix V of the GPO, "Environmental Materials Management Plan."

Many of the petroleum products and potential hazardous materials would be consumed during use by the various components of the mining operation and mineral processing circuits. However, potential hazardous waste that may be generated at the mine includes waste paint materials and thinners, chemical wastes such as acetone from the on-site laboratory, and residue wastes from containers or cans. As a generator of hazardous waste, Resolution Copper would be required to file for a hazardous waste identification number from the EPA and register as a hazardous waste generator with the ADEQ. Based on the proposed activities, the Resolution Copper Mine would likely qualify as a conditionally exempt small-quantity generator of hazardous wastes. Conditionally exempt small-quantity generators generate 100 kilograms or less per month of hazardous waste, or 1 kilogram or less per month of acutely hazardous waste.

Fate and Transport of Potential Releases

The potential impacts of accidental releases of hazardous materials or wastes depend on the nature of the material, the amount released, where in the environment the material or waste is released (soil, groundwater, or surface water), and the potential for migration of the material or waste.

Potential Releases to Soils or Surface Waters within the Mine

Releases of hazardous materials within the boundaries of the mine could include accidental spills during use, rupture of storage tanks, release during emergency fire or explosion, or improper disposal. In almost all cases, hazardous materials would be released to soils. Release of hazardous materials into soils does not present a major environmental risk. Both wildlife and vegetation would be largely absent within the mine boundaries. Soils absorb and immobilize small amounts of hazardous materials, and within the controlled boundaries of the mine, it would be relatively easy to excavate and dispose of them.

The more significant risk is for hazardous materials, once within the soil matrix, to migrate to surface water or groundwater, either in dissolved phase or through erosion and movement of contaminated soil. With respect to stormwater, the mine stormwater management has been designed with two basic premises in mind: divert all possible stormwater away from the plant site (i.e., East Plant Site or West Plant Site) to avoid the potential for contamination, and treat all stormwater within the plant site as potentially contaminated, to be retained, recycled, and not discharged. For more information, refer to GPO Appendix W, "Stormwater Pollution Prevention Plan;" and GPO Section 4.5.4, "Stormwater Management." There are no likely exposure pathways where a spill to soils or surface waters within the mine boundary would leave the site and impact downstream wildlife, vegetation, waters, or people.

Potential Releases to Groundwater within the Mine

Any release of hazardous materials to soils presents the potential for release to groundwater, either directly if large enough quantities of hazardous materials are released, or indirectly through infiltration of precipitation or runoff through contaminated soils. In addition, the various storage ponds would provide a concentration point for potentially contaminated runoff, and infiltration could occur directly to groundwater from these locations.

The process water temporary storage ponds are double-lined with leak detection and collection in accordance with the ADEQ BADCT requirements. Infiltration is unlikely to occur under normal operating conditions, and leak detection is incorporated into the process water portion of the pond (see Section 3.3, “Milling and Processing,” of the GPO).

If an unplanned spill were to occur, once released to groundwater the primary concern is migration of contaminants. Based on groundwater flow modeling (see section 3.7.2), releases underground are unlikely to migrate, as the dewatering has created a large hydraulic sink that prevents outward movement for hundreds of years. Spills at the surface within the East Plant Site would potentially migrate to the Apache Leap Tuff aquifer, which during operations generally would be draining toward the subsidence area and would be unlikely to migrate beyond the property boundaries. The tailings facilities all incorporate a suite of engineered seepage controls to capture seepage, and migration of an unplanned spill would be controlled as a matter of operations.

The primary concern would be spills within the West Plant Site that entered groundwater. These spills would likely migrate toward Queen Creek and eventually downstream. The primary exposure point would likely be Whitlow Ranch Dam, where groundwater is forced to the surface and supports perennial flow. If a spill migrated this far, it could impact wildlife, vegetation, and surface waters; the exact nature of impact is not possible to know without knowing the release volume and type of material released.

Potential Releases during Transportation

Potential releases of hazardous materials during transportation could occur, but the fate and transport of those hazardous materials depend entirely on where the release occurs and the quantity of the release. In general, releases during transportation of hazardous materials on U.S. 60 could, if sufficient quantities were released, migrate to Queen Creek or Silver King Wash, either directly or as a result of contact between surface runoff and contaminated soil.

Significance of Potential Releases

The following uses present little risk of release, or risk of minor releases only:

- Laboratory reagents. Laboratory reagents are used in controlled conditions and in negligible or minor quantities.
- Cleaning fluids. Cleaning fluids generally are used in controlled conditions and in negligible or minor quantities.
- Sulfide mineral processing. These reagents are stored and used in minor quantities or are dry ingredients, presenting little risk for accidental release or migration.
- Hazardous waste. Hazardous waste does not present a high risk of accidental release when stored, transported, and disposed of properly.

Overall, the significant unmitigated risks of released hazardous materials based on amount, storage, and use are as follows:

- Catastrophic release of contaminant or petroleum product (i.e., gasoline, diesel, kerosene, new or used engine and gear oil, transmission fluid) during transportation.
- Catastrophic release of contaminants or major releases of petroleum product at storage tank locations within the mine or from the fuel piping system.

Effects from Catastrophic Release during Transportation

The effects of a catastrophic release of hazardous materials and/or petroleum products during transportation would depend on the specific location and amount of release. In general, there would be direct impacts on plants and wildlife in the immediate vicinity, direct impacts on soil in the immediate vicinity, and possible migration into surface water either directly or via stormwater runoff from contaminated areas. If migration occurs, there would be indirect effects downstream on vegetation, aquatic species, and wildlife. Along U.S. 60, most downstream impacts would occur along Queen Creek and its tributaries. Direct impacts on vegetation could include mortality or long-term loss of vigor; indirect effects could include long-term exposure of wildlife or humans.

There is also the potential for migration into groundwater, depending on the exact location of the release. Typically, a one-time accidental release, even if catastrophic, does not pose as large a risk for groundwater contamination as it does for contamination of surface water or soils, as product is often held up in soil or recovered during the emergency response before migration can occur.

Effects from Catastrophic or Major Releases within the Mine

Minor amounts of petroleum products accidentally released within the boundaries of the mine can often be completely mitigated. Major releases unable to be completely mitigated can come in two forms: catastrophic release and long-term undetected release.

Catastrophic release would include damage to a storage tank or fuel piping system and the immediate loss of most or all of the stored product. This type of release would differ from a similar catastrophic release experienced during transportation; within the mine there are fewer receptors, less potential for migration, and more opportunities to fully control any spill. In general, there would be immediate direct impacts on soil and vegetation, but there would be little potential for migration beyond the boundaries of the mine either in surface water or groundwater. Most of the areas within the mine site are developed with little vegetation or natural soil, making either direct impacts (mortality, loss of vigor) or indirect impacts (long-term exposure of wildlife or humans to pollutants) unlikely.

In the event of a long-term undetected release, quantities are small enough that there would be no immediate effects on plants or animals and little potential for migration via stormwater. There is a greater potential for direct effects on soil and groundwater in the immediate vicinity, as the minor releases migrate downward undetected. As noted earlier in this section, the only facility with a likely migration downstream is at the West Plant Site, in close proximity to Queen Creek.

Cumulative Effects

Full details of the cumulative effects analysis can be found in chapter 4. The following represents a summary of the cumulative impacts resulting from the project-related impacts described in Section 3.10.3.4, Environmental Consequences, that are associated with hazardous materials transportation, storage, or use, when combined with other reasonably foreseeable future actions.

The following actions were determined through the cumulative effects analysis process to be reasonably foreseeable, and have impacts that likely overlap in space and time with impacts from the Resolution Copper Project:

- Pinto Valley Mine Expansion
- Ray Land Exchange and Proposed Plan Amendment

The cumulative effects analysis area for hazardous materials includes the project footprint and transportation routes to these areas, as the potential for impacts from hazardous materials from other projects would largely follow the same transportation routes. The metric used to quantify cumulative impacts to hazardous materials is the amount of hazardous materials traveling roads [trips or tonnage].

Overall, hazardous material transportation could increase along U.S. 60 and SR 177. The types and amounts of hazardous materials transported are not known at this time, but regarding both the Pinto Valley Mine expansion and the Ray Land Exchange parcels, these would probably be similar to what is occurring now, though they would continue over an extended time frame. Combined with Resolution Copper Project transportation of hazardous materials on these roads, the overall risk of accident or release would increase.

Mitigation Effectiveness

Mitigation Identifier and Title	Authority to Require
None	None

We developed a robust monitoring and mitigation strategy to avoid, minimize, rectify, reduce, or compensate for resource impacts that have been identified during the process of preparing this EIS. Appendix J contains descriptions of mitigation measures that are being required by the Forest Service and mitigation measures voluntarily brought forward and committed to by Resolution Copper. Appendix J also contains descriptions of monitoring that would be needed to identify potential impacts and mitigation effectiveness. No mitigations were identified—required or voluntary—related to hazardous materials.

UNAVOIDABLE ADVERSE IMPACTS

While the risk of hazardous materials spills would increase during construction and active mining phases, following applicable Federal and State laws and regulations for storage, transport, and handling of such materials is expected to mitigate for this risk. Resolution Copper has prepared a wide variety of emergency response and material handling plans; implementation of these plans minimizes the risk for unexpected releases of hazardous materials and provides for rapid emergency cleanup.

Other Required Disclosures

SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

Impacts from increased mine-related traffic, increased fire hazard, and hazardous materials use in mine operations would be short term and would end with mine reclamation.

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

Irreversible impacts with respect to public health and safety are not expected. All potential hazards discussed are limited solely to the construction and operations phases and are not expected to remain after closure of the mine. Therefore, they would constitute an irretrievable commitment of resources.

With respect to hazardous materials, no irretrievable or irreversible impacts on resources are expected. Although there is the potential for contamination of surface water, groundwater, or soils in the event of a spill or accidental release, this is not expected to occur, and environmental remediation is possible (and required by law) if it does occur.

3.11 Scenic Resources

3.11.1 Introduction

Overview

Potential scenery impacts of the proposed action and its alternatives are assessed using two different but complementary analysis systems: the Forest Service Visual Management System and the BLM Visual Resource Management system. Each involves an evaluation of likely changes to the visual landscape from key observation points, or KOPs, which are points in the landscape determined to be most representative of what viewers may see before and after development of the GPO-proposed project or its alternatives. KOP view analyses focus in particular on anticipated landscape-scale changes in form, line, color, and texture, and on how contrasting changes in the landscape may affect viewers.

This section addresses the existing conditions of scenic resources (including dark skies) in the area of the proposed action and alternatives. It also addresses the potential changes to those conditions from construction and operation of the proposed project. The information contained in this section reflects the analysis information in the process memorandum (Newell and Grams 2018).

Scenery resources are the visible physical features on a landscape; they include land, water, vegetation, animals, structures, and other features. The combination of these physical features creates scenery and provides an overall landscape character. The variety and intensity of the landscape features and the four basic elements—form, line, color, and texture—make up the landscape character. These factors give an area a unique quality that distinguishes it from its immediate surroundings. Usually, if the elements coexist harmoniously, the more variety of these elements a landscape has, the more interesting or scenic the landscape becomes. Scenic quality is the relative value of a landscape from a visual perception point of view.

The scenery resources analysis area (figure 3.11.1-1) lies within the Mexican Highland section of the Basin and Range physiographic province. The province is generally characterized by roughly parallel mountain ranges separated by semi-flat valleys. The analysis area, located at the northern end of the Basin and Range area, includes classic Basin and Range characteristics, with rugged mountains to the north, east, and south, combined with broad basin valleys. Elevations in the area range from 1,520 feet amsl (western terminus of MARRCO corridor) to 7,848 feet amsl (Pinal Peak).

3.11.1.1 Changes from the DEIS

We have made a number of changes to the scenic resources analysis in response to comments received on the DEIS. Alternatives 5 and 6 no longer have alternative pipeline routes to reach the tailings storage facility; each alternative now has a single route as described in chapter 2. In addition, we revised the Alternative 6 pipeline route, primarily to address potential impacts to habitat and resources along Mineral Creek. As a result of these changes, we updated all calculations of acreage impacts used in the analysis.

We clarified use of the Forest Service and BLM visual resource regulatory framework and the effects of the project on those categories. We also included an expanded dark skies analysis and have conducted a number of new visual simulations, which are contained in the background materials (Newell and Grams 2018). These include visual analysis of potential fog plumes over Oak Flat due to the shaft ventilation.

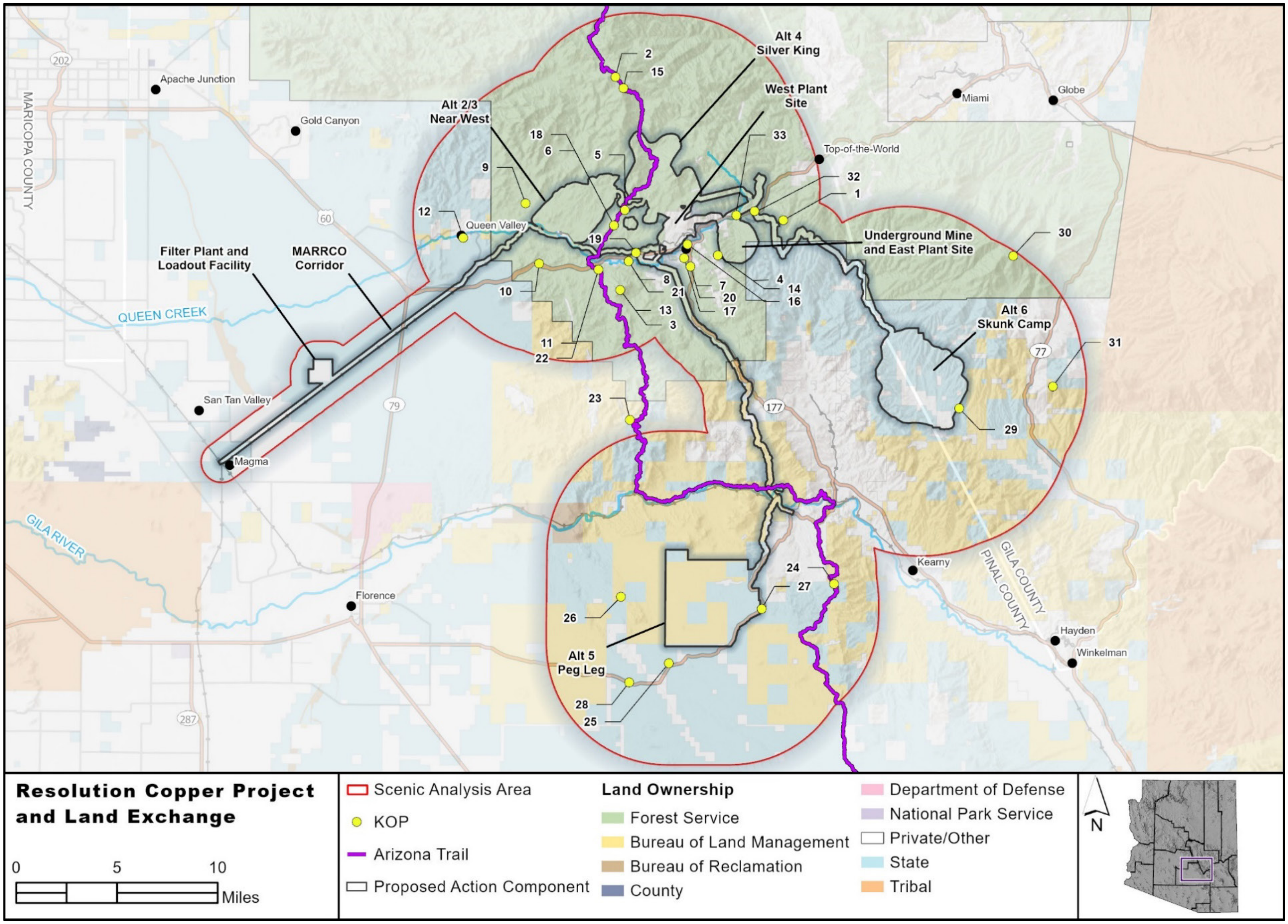


Figure 3.11.1-1. Scenic resources analysis area

The cumulative effects analysis was revised for the FEIS to better quantify impacts and is described in detail in chapter 4 and summarized in this section. Any mitigations developed between the DEIS and FEIS are summarized in appendix J and, if applicable to scenic resources, are analyzed for effectiveness in this section.

3.11.2 Analysis Methodology, Assumptions, and Uncertain and Unknown Information

3.11.2.1 Analysis Area

We considered the potential viewsheds of different proposed project components and alternatives to develop an overall analysis area for impacts on scenery resources (see figure 3.11.1-1). We based the analysis area on specific distance buffers for the proposed action and alternatives components. We assumed that impacts would be accounted for within these project component buffers.

Scenery Analysis Area Project Component Buffers

- 6 miles – Tailings facility alternatives
- 2 miles – Slurry pipeline corridor alternatives
- 2 miles – East Plant Site and subsidence area
- 2 miles – West Plant Site
- 2 miles – Transmission lines
- 1 mile – MARRCO corridor
- 1 mile – Filter plant and loadout facility

3.11.2.2 Expected Scenery Changes

Our analysis presents the scenery changes and impacts that we expect based on the mine plans and design, and we present these for each mine component. Further, the analysis includes a qualitative discussion on anticipated changes in contrast between the existing landscape and the proposed activities and facilities. We also discuss the analysis in terms of sensitive viewers in the analysis area. The distance zones and scenery contrast definitions are presented in the accompanying text box. The distance zones differ from those found in the Forest Service Visual Management System (U.S. Forest Service 1974) to reflect the potential views in the desert landscape relative to the scale of the proposed project.

The scenery impact analysis methodology primarily follows the BLM Visual Resource Management system rather than the Forest Service Visual Management System (both described in section 3.11.3.1) to systematically describe project scenery impacts. The Forest Service and BLM apply the analysis concepts slightly differently, using different terminology and different ranges and distances, for example. However, the contrast analysis process, based upon changes in landscape form, line, color, and texture described below, is common to both systems and is used to determine conformance with management plan objectives. Contrast analysis was used to characterize changes to scenic quality within the analysis area. It also was used to assess potential scenic quality impacts. The degree of landscape contrasts created by the proposed project was compared with the area's existing landscape character and scenic management objectives to determine whether the project-related landscape contrasts are consistent with designated scenery management objectives. These would be the designated Visual Quality Objectives for the Forest Service; for the BLM, these would be the Visual Resource Management System class objectives.

Distance Zones

Foreground = Up to 1 mile

Middle Ground = 1 to 3 miles

Background = Beyond 3 miles

Contrast Impact Definitions

None: The contrast is not visible or perceived.

Weak: The element contrast can be seen but does not attract attention.

Moderate: The element contrast begins to attract attention and begins to dominate the characteristic landscape.

Strong: The element contrast demands attention, would not be overlooked, and is dominant in the landscape.

3.11.2.3 Viewshed Analysis

The Forest Service and NEPA team developed the viewshed analysis of the tailings facilities for the proposed action and alternatives to illustrate where the facilities would theoretically be visible. We modeled the approximate heights of the tailings facilities and determined, based upon landform and elevation, where the facilities would potentially be visible in the surrounding landscape. The viewshed model does not account for vegetation, structures, and other landscape elements that could obstruct views, but it does provide an approximation of the facility visibility within the analysis area. The viewshed analysis also includes miles of sensitive linear corridors from which the facilities would potentially be visible. The viewshed analyses for each alternative tailings facility are in the process memorandum (Newell and Grams 2018).

3.11.2.4 Key Observation Points and Contrast Rating Analysis

Contrast analysis is a method that measures potential project-related changes to the landscape. The Forest Service and the BLM use this methodology to analyze the impacts on scenic quality and describe landscapes. The method allows for a level of objectivity and consistency in the process and reduces subjectivity associated with assessing landscape character and scenic quality impacts. We used the BLM's Visual Resource Contrast Rating system, as outlined in BLM Manual 8431 – Visual Resource Contrast Rating (Bureau of Land Management 1986a), for the contrast analysis. The system determines the degree to which a proposed project would affect the scenic quality of a landscape based on the visual contrast created between the proposed project and the existing landscape. The method measures contrast by comparing the proposed project features with the major features in the existing landscape using basic design elements of form, line, color, and texture.

We conducted the contrast rating analysis for 33 key observation points (KOPs) representing sensitive views from residential areas, travel routes, and recreation areas of the proposed action and alternative tailings facilities, transmission lines, and pipeline corridors (see figure 3.11.1-1). KOPs were selected by reviewing the potential visibility for all sensitive viewing platforms in the region of the mine plan components and choosing points that best represented the range of impacts to the range of viewing platforms. KOPs represent a range in elevation and distance from facilities and present the most visible locations from sensitive viewing areas. KOPs include trails, OHV corridors, community residential areas, culturally sensitive locations, roads and highways, and highpoints in the landscape surrounding facilities.

The contrast rating worksheets for each KOP are in the process memorandum Newell and Grams (2018). To support the contrast rating analysis and disclose potential visibility of the proposed action and alternative tailings facilities, we provide photographic simulations of the theoretical views of the proposed action and alternatives from the KOPs (Newell and Grams 2018). The simulations are intended to provide a theoretical view of the tailings facilities post-reclamation. We completed most of the simulations with on-site photography. Some simulations were completed using a "block model" process that illustrates the model of the tailings facility with Google Earth imagery.

The visual simulations presented in appendix C of Newell and Grams (2018) illustrate a spectrum of impacts from the tailings facility alternatives. The "block model" style simulations present tailings facility location and scale as viewed from regional high points in the landscape surrounding the facilities. The "photorealistic" simulations present the best estimation of what the tailings facilities would look like after successful reclamation at the end of mining. These simulations were developed by referencing the revegetation species, density, and success, completed by Resolution Copper at their West Plant Site legacy tailings areas. This West Plant Site revegetation information informed the vegetation density, color, and species used in the DEIS visual simulations for each of the proposed tailings facility alternatives. Appendix D of Newell and Grams (2018) also includes simulations for the preferred alternative, Alternative 6 – Skunk Camp, to illustrate the approximate view of the tailings facility at 15-, 20-, and 30-year intervals. This illustrates the scenery impact over time and accounts for concurrent reclamation activities beginning at approximately year 10.

3.11.3 Affected Environment

3.11.3.1 Relevant Laws, Regulations, Policies, and Plans

Federal

FOREST SERVICE VISUAL MANAGEMENT SYSTEM

The Tonto National Forest Land and Resource Management Plan (1985b) uses the Visual Management System (U.S. Forest Service 1974) for management of forest scenery resources. The Visual Management System establishes Visual Quality Objectives (VQOs) for the forest and designates an acceptable degree of alteration of the characteristic landscape (table 3.11.3-1). This method measures the degree of alteration in terms of visual contrast with the surrounding landscape generated by introduced changes in form, line, color, and texture.

Table 3.11.3-1. Forest Service Visual Quality Objective classification descriptions

VQO Category	Description
Preservation	Allows ecological change only and management activities that are not noticeable to observers. Applies to wilderness areas, primitive areas, and other special classified areas.
Retention	Allows management activities that are not evident to the casual forest visitor. Under Retention, activities may only repeat form, line, color, and texture which are frequently in the characteristic landscape. Changes in their qualities of size, amount, intensity, direction, pattern, etc., should not be evident.
Partial Retention	Allows management activities that may be evident to the observer but must remain subordinate to the characteristic landscape. Activities may repeat form, line, color, or texture common to the characteristic landscape but changes in their qualities of size, amount, intensity, direction, pattern, etc., remain visually subordinate to the characteristic landscape.

VQO Category	Description
Modification	Allows management activities that may dominate the characteristic landscape but that must, at the same time, use naturally established form, line, color, and texture. Activities which are predominately introduction of facilities such as buildings, signs, roads, etc., should borrow naturally established form, line, color, and texture so completely and at such scale that their visual characteristics are compatible with the natural surroundings.
Maximum Modification	Allows management activities of vegetative and landform alterations that dominate the characteristic landscape. When viewed as foreground or middle ground, they may not appear to borrow completely from naturally established form, line, color, or texture.

BUREAU OF LAND MANAGEMENT VISUAL RESOURCE MANAGEMENT

The BLM uses the Visual Resource Management (VRM) system to manage visual resources on public lands (Bureau of Land Management 1984, 1986a, 1986b). The VRM system provides a framework for managing visual resources on BLM-administered lands. The four VRM class objectives describe the different degrees of modification allowed to the basic elements of the landscape (i.e., line, form, color, and texture) (table 3.11.3-2). Relevant authority for managing visual resources on BLM lands is in the FLPMA. BLM VRM classes are established by resource management plan decision based on visual resource inventories that identify an area’s scenic quality, viewing distance, and visual sensitivity to change in the landscape. A Visual Resource Inventory was completed for the BLM Tucson Field Office that identified Visual Resource Inventory Classes based on the three components of the inventory process. The Visual Resource Inventory Classes may differ from the VRM Classes, which are developed to protect resources or accommodate land use activities. The current VRM Classes for public lands in the analysis area are interim classes, which will be reviewed in the future in a revision of the Tucson Field Office resource management plan. The BLM Visual Resource Inventory identifies a Class II area along the Gila River corridor and along the Arizona National Scenic Trail. This represents a “higher” visual value as determined though the inventory process (Visual Resource Inventory Class II) than reflected by the current Interim VRM Class management designation (VRM Class III).

Table 3.11.3-2. Visual Resource Management Class descriptions

VRM Class	Description
I	The objective of this class is to preserve the existing character of the landscape. This class provides for natural ecological changes; however, it does not preclude very limited management activity. The level of change to the characteristic landscape should be very low and should not attract attention.
II	The objective of this class is to retain the existing character of the landscape. The level of change to the characteristic landscape should be low. Management activities may be seen but should not attract the attention of the casual observer. Any changes must repeat the basic elements of form, line, color, and texture found in the predominant natural features of the characteristic landscape.
III	The objective of this class is to partially retain the existing character of the landscape. The level of change to the characteristic landscape should be moderate. Management activities may attract attention but should not dominate the view of the casual observer. Changes should repeat the basic elements found in the predominant natural features of the characteristic landscape.
IV	The objective of this class is to provide for management activities that require major modification of the existing character of the landscape. The level of change to the characteristic landscape can be high. These management activities may dominate the view and be the major focus of viewer attention. However, every attempt should be made to minimize the impact of these activities through careful location, minimal disturbance, and repeating the basic elements of the landscape.

State of Arizona Scenic Road Designation

Arizona Revised Statutes 41-512 through 41-518 provide for the establishment of parkways, historic roads, and scenic roads. ADOT implements and administers the law. The “Scenic Road” designation includes a roadway (or segment of a roadway) that offers a memorable visual impression, is free of visual encroachment, and forms a harmonious composite of visual patterns. The analysis area contains the Gila-Pinal Scenic Road and the Copper Corridor Scenic Road West, described in section 3.11.3.2.

Local Lighting Ordinances

The Pinal County Outdoor Lighting Code and the Gila County Outdoor Light Control Ordinance contain guidelines and lighting requirements for projects that are proposed in the counties.

3.11.3.2 Existing Conditions and Ongoing Trends

Forest Service and BLM Scenery Management Designations

The number of acres under Tonto National Forest VQO and BLM VRM designations for the scenery resources analysis area are presented in table 3.11.3-3 and illustrated in figure 3.11.3-1.

Table 3.11.3-3. Acreages by scenery management designation

Scenery Designation	Acres
Forest Service VQO	
Preservation	25,410
Retention	26,902
Partial Retention	53,379
Modification	32,638
Maximum Modification	15,014
BLM VRM Class	
Class I	2,606
Class II	0
Class III	110,129
Class IV	737

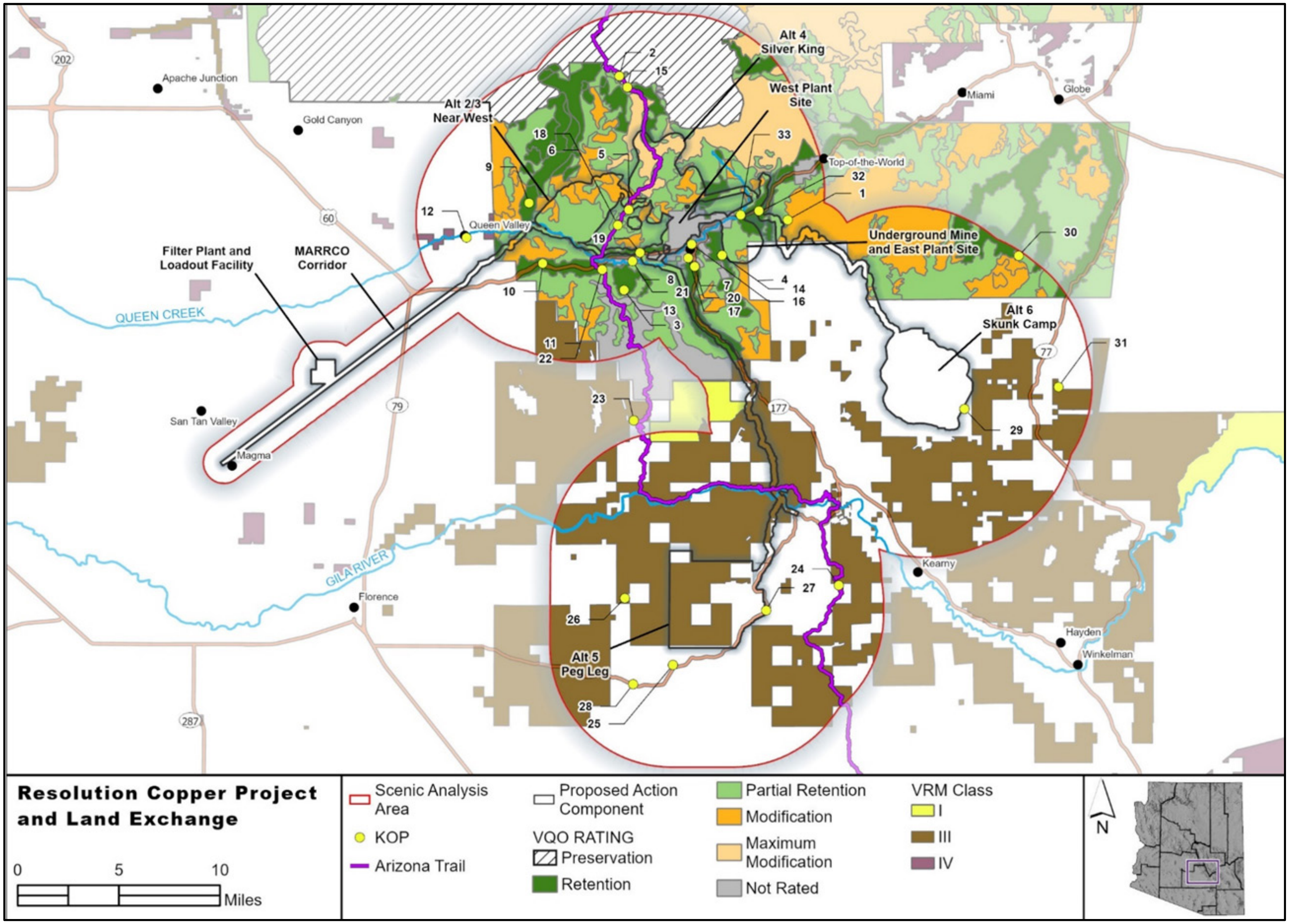


Figure 3.11.3-1. Forest Service and BLM scenery management designations (VQO and VRM)

Scenery Resources in the Analysis Area

The analysis area contains multiple types of scenic resources that could be impacted by construction of the proposed action or alternatives.

- **Arizona National Scenic Trail**. The Arizona Trail extends 800 miles across the state of Arizona from the U.S. border with Mexico to the state of Utah. The trail was designated a National Scenic Trail by Congress in 2009 (U.S. Forest Service 2018b). Approximately 55 miles of the trail—including Passage 15 Tortilla Mountains, Passage 16 Gila River Canyons, Passage 17 Alamo Canyon, and Passage 18 Reavis Canyon—are in the scenery analysis area. The high visual quality of scenery from these passages is diverse and includes steep rocky canyons, high-point vistas, riparian riverways, and developed trailheads and trail facilities. Passage scenery is described in more detail in the process memorandum (Newell and Grams 2018).
- **Apache Leap.** The Apache Leap escarpment is a geographically, culturally, and historically unique feature in the analysis area. The dramatic escarpment visually dominates the eastern skyline from the basin below and provides a scenic backdrop for the town of Superior. Climbers and hikers access the top of Apache Leap by climbing routes and undesignated trail routes. Views from the top of Apache Leap include broad long-distance views of the expansive valley below and more confined views to the east toward the Oak Flat area.

Apache Leap South End parcels, looking east from Donkey Canyon toward the Apache Leap escarpment

- **Picketpost Mountain.** Picketpost Mountain is a prominent mountain feature in the analysis area. At 4,377 feet amsl, it rises dramatically above the valley with rugged geological features and rock cliffs and outcrops. Hikers climb the rugged mountain using undesignated routes. Views from the top of the mountain include broad and expansive views into the valley to the north and views to the south toward the White Canyon Wilderness and the Gila River, including rugged and rolling desert mountains.

Picketpost Mountain, looking east from the Arizona Trail trailhead

- **Superstition Mountains**. The Superstition Mountains are a popular mountain range providing a scenic desert mountain backdrop in the northern portion of the analysis area. They include many heavily used roads and trails. Views from locations in the analysis area include broad and expansive views into the valley below and farther south to Picketpost Mountain and the Gila River valley in the background.
- **Pinal Mountains.** The Pinal Mountains, located south of Globe, Arizona, on the east side of the analysis area, provide popular high-elevation recreation to the surrounding region. Recreationists visit the mountain forest during the hot summer months to enjoy the cooler temperatures. The highest point, Pinal Peak (rising to 7,848 feet amsl), is accessible by dirt road and is frequently visited by recreationists. From Pinal Peak scenic views include background views of the Gila River valley to the east and the wide desert landscapes to the west. Middle ground views include the surrounding Pinal Mountains rugged terrain, including the Dripping Springs Valley.
- **Town of Superior, Arizona.** Located in the northern portion of the analysis area, the town of Superior is surrounded by the Tonto National Forest and the natural forest landscape, including Apache Leap and the Superstition Mountains, providing a scenic backdrop to the town. Scenic views from the town include middle ground views of surrounding desert rolling hills and canyons, with background views of rugged mountains, including Apache Leap, Picketpost Mountain, and the Superstition Mountains.

View overlooking the town of Superior and the West Plant Site

- **Queen Valley, Arizona.** Queen Valley, a residential community located in the eastern portion of the analysis area, lies south and east of the Tonto National Forest. Views of the national forest include background views of rolling desert hills and canyons as well as the rugged and scenic Superstition Mountains.
- **Gila-Pinal Scenic Road (U.S. 60)**. The Gila-Pinal Scenic Road is a 35-mile route following U.S. 60 between Forest Junction and Globe, Arizona (Arizona Department of Transportation 2018). The road travels from the western Sonoran Desert habitats through canyons and up to higher ponderosa pine forests in the Globe area. Scenic features along the route include views of the Superstition Mountains, Apache Leap escarpment, the Boyce Thompson Arboretum, Picketpost Mountain, and the town of Superior. The history of copper mining in the region is evident along the eastern portion of the route.
- **Copper Corridor Scenic Road West (U.S. 177).** The Copper Corridor Scenic Road West is a 20-mile route following U.S. 177 between Kearny and Superior, Arizona (Arizona Department of Transportation 2018). The road travels through rugged mountains and river valleys and passes by the vast Ray Mine operations. The Dripping Spring Mountains are on the east side of the road and the White Canyon Wilderness is located to the southwest of the route. Upon the northern approach to Superior, the scenery is dominated by the Superstition Mountains, Apache Leap, and Picketpost Mountain.
- **Florence-Kelvin Highway**. The Florence-Kelvin Highway is a partially paved, partially graded dirt road that extends approximately 32 miles from outside of Florence, Arizona, eastward to U.S. 177. Views along the road include classic Sonoran Desert vegetation of creosote, cholla, ocotillo, and saguaro cactus. Unique rock outcrops appear near the Cochran Road intersection. The road travels northeast and crosses the Gila River, where it joins U.S. 177.
- **Off-Highway Vehicle Recreation Roads**. Dozens of miles of OHV recreation roads are located within the analysis area (see Section 3.9, Recreation, for more detailed information on OHV roads). These roads are used to travel through the Tonto National Forest, BLM-managed lands, and Arizona State Trust lands to visit recreation sites and as scenic tours. Views from these roads

include a broad array of scenery, including natural desert rolling hills and canyon, mountain backdrops, and specific scenic features. A heavily used set of OHV roads is located in the northern portion of the analysis area on the Tonto National Forest. The Cochran and Battle Axe Roads in the southern portion of the analysis area are popular roads on State of Arizona–managed and BLM-managed lands that offer views of the White Canyon Wilderness mountains to the north, the Gila River, and an open desert landscape. The Dripping Springs Road, located in the eastern portion of the analysis area, is a moderately used OHV recreation road with views of the Pinal Mountains, rural ranches, and rugged desert rolling hills.

- **Climbing Areas.** Climbing areas are described in detail in Section 3.9, Recreation. The Apache Leap area (described above in this list) represents a climbing area that could be impacted by construction of the proposed action and alternatives, as are the climbing areas located on Oak Flat.
- **Boyce Thompson Arboretum**. The Boyce Thompson Arboretum is located in the northern portion of the analysis area south of U.S. 60. It was established in 1924 and is a popular regional destination with thousands of annual visitors. The arboretum includes a visitor center, demonstration gardens, picnic area, and trails that lead visitors through exhibits of unique vegetation and desert ecosystems. Views from the area range from confined foreground views of rugged rock outcrops, desert vegetation, and canyons to views of expanded vistas of the surrounding Tonto National Forest, Picketpost Mountain, the Superstition Mountains, and Apache Leap.

Regional Dark Skies

Current dark sky conditions in the analysis area are described in the report titled “Impact Assessment of the Proposed Resolution Copper Mine on Night Sky Brightness” (Dark Sky Partners LLC 2018). The report illustrates that current dark sky conditions in the analysis area are influenced by lighting in developed communities and current mining operations. In general, light sources that influence dark skies in the analysis area include the Phoenix metropolitan area (western portion of analysis area), the town of Superior, the Ray Mine, and Florence, Arizona. Specifically, the study measured current lighting using light-measurement cameras from four locations in the analysis area: Queen Valley, Boyce Thompson Arboretum, town of Superior, and Oak Flat Campground.

The regional night sky current condition was measured at each of the four locations mentioned above using equipment and scientific methods described in “Impact Assessment of the Proposed Resolution Copper Mine on Night Sky Brightness” (Dark Sky Partners LLC 2018). All observations were made when the moon was below the horizon, representative of the darkest conditions observable at these locations. Several sky brightness metrics were measured. The metrics used and discussed in this analysis are the “number of stars visible to the naked eye over the entire sky” and the Average Sky Luminance (ASL). The “number of stars” indicator represents impacts because increased sky brightness from proposed facilities may decreases contrast, causing fainter stars to become undetectable and the total number of visible stars to decrease. ASL is a measure of the diffuse brightness of the night sky. The current condition for these dark sky indicators, from each of the dark sky observation points, is presented below in table 3.11.3-4.

Table 3.11.3-4. Dark sky conditions at observation points

Dark Sky Observation Point	Average Sky Luminance (mag/ arcsec^2)*	Number of Stars Visible
Superior	20.44	2,997
Oak Flat Campground	20.51	2,783
Boyce Thompson Arboretum	20.40	2,996
Queen Valley	20.04	2,709

* mag/ arcsec^2 = magnitude per square second of arc. Additional information related to Average Sky Luminance can be found in “Impact Assessment of the Proposed Resolution Copper Mine on Night Sky Brightness” (Dark Sky Partners LLC 2018).

Selected Lands

Scenery in the Oak Flat Federal Parcel consists of rolling to steep hillslopes with rounded boulder outcrops, interspersed with high desert vegetation. Background views include the eastern slopes of Apache Leap and the steep and rugged Queen Creek canyon hillslopes. Visitors to Oak Flat Campground, rock climbers climbing the numerous boulder features, OHV recreationists, and hikers represent the sensitive viewers that frequent the Oak Flat Federal Parcel. VQO designations for the Oak Flat Federal Parcel are as follows: Retention—785 acres, Partial Retention—1,416 acres, and Modification—137 acres, with the remaining 84 acres not rated.

3.11.4 Environmental Consequences of Implementation of the Proposed Mine Plan and Alternatives

3.11.4.1 Alternative 1 – No Action

Under the no action alternative, the proposed action or alternatives would not be constructed and therefore no changes to scenery would occur. There would be no impacts on scenic resources.

3.11.4.2 Impacts Common to All Action Alternatives

Some components of the project would occur under all action alternatives. The “common to all” components and their associated scenery impacts are described in table 3.11.4-1.

Effects of the Land Exchange

The selected Oak Flat Federal Parcel would leave Forest Service jurisdiction. The role of the Tonto National Forest under its primary authorities in the Organic Administration Act, Locatable Regulations (36 CFR 228 Subpart A), and Multiple-Use Mining Act is to ensure that mining activities minimize adverse environmental effects on NFS surface resources; this includes effects on the scenery resources that occur on the Oak Flat Federal Parcel. The Oak Flat Federal Parcel would become private at the completion of the NEPA process, and the current VQOs (Retention, Partial Retention, Modification), which provide protection to scenery resources, would be removed. The Forest Service would not have the ability to require mitigation for effects on scenery resources on the lands; thus, effects on scenery could be greater than if the parcel retained the VQO designation.

The offered lands parcels would come under Federal jurisdiction. Specific management of the scenery resources of those parcels would be determined by the agencies to meet desired conditions or support appropriate land uses. In general, these parcels contain a variety of scenery resources similar to those found in the analysis area, that would come under Federal jurisdiction.

Table 3.11.4-1. Impacts on scenic resources common to all action alternatives

Mine Facility and Phase	Visual Impact Assessment
East Plant Site Facilities	
Construction	Visual disturbance from construction equipment movement and activity, fugitive dust, and overall change in contrast in form and color from the existing landscape would occur. Areas in the East Plant Site vicinity that remain open to future public visitation are limited. Because of this and the landscape topography, the East Plant Site would be visible from a limited number of locations on the national forest; primarily, visibility would be from high points to the east on NFS Road 2466, approximately 2.5 miles from the East Plant Site. The visual dominance of construction would be short term with intensity of views varying based upon distance and topography, resulting in overall moderate impact on scenery.
Operations	Long-term impacts on scenery would result from a change in contrast from existing landscape conditions from new development. Because of existing facility development at the East Plant Site and the limited visibility from the area, the anticipated change in contrast is moderate. The scenery impact would be long term in duration; however, visual dominance and intensity of scenery impacts would be reduced as a result of limited visibility from sensitive viewers. Ventilation air exiting the exhaust shafts at the East Plant Site will be at or near saturation, which will lead to the formation of a fog plume that may be visible under certain environmental conditions. An analysis of the site-specific meteorological data from 2015 and 2016 demonstrates fog plume formation is more likely to occur during December and January when conditions are cooler and more humid (Tipple 2020). A fog plume model was developed to evaluate the frequency and size of the estimated fog plumes using mine operation data and meteorological data from 2015 and 2016 (Tipple 2020). The model results indicate that the largest fog plume (1% occurrence scenario) would be visible from the selected KOPs fewer than 4 days per year and be approximately 361 feet high by 656 feet in length. A more frequent fog plume (10% occurrence scenario) would be visible fewer than 37 days per year and would be approximately 131 feet high and 328 feet in length. KOPs analyzed for fog plume visibility include KOP 1 NFS Road 2466 East of Subsidence Zone, KOP 2 Arizona Trail Montana Mountain, KOP 5 Arizona Trail Ridge, and KOP 10 U.S. 60 Milepost 219; fog plume simulations for these KOPs are included in appendix E of Newell and Grams (2018). The simulations illustrate the 1% scenario would be clearly visible from KOP 1 NFS Road 2466 East of Subsidence Zone and minimally visible from KOP 2 Arizona Trail Montana Mountain and KOP 5 Arizona Trail Ridge. The 10% scenario would only be visible from KOP 1 NFS Road 2466 East of Subsidence Zone. The fog plume would be visible to travelers on U.S. 60 in the vicinity of the East Plant Site. However, it would not create a safety hazard as the modeled length and extent would not reach the highway.
Closure and Reclamation	Mine facilities at the East Plant Site would be largely removed, and the area would be reclaimed to natural conditions to the maximum amount possible. Headframes and hoists and some roads would remain in place for use in post-closure groundwater monitoring. Long-term visual dominance and intensity from development of the East Plant Site to the scenery would move from moderate to minor with increased site revegetation and successful site reclamation.
Subsidence Area	
Operations	Subsidence breakthrough is anticipated to begin at approximately mine year 12. Subsidence would expand slowly to the maximum width and depth at approximately mine year 47. As described earlier in this section, because of limited public access and visibility, visual dominance from changes in form, line, color, and texture of the subsidence area would be limited to small portions of the adjacent Tonto National Forest. KOP 1 (NFS Road 2466, east of the subsidence area) illustrates long-term scenery impacts from subsidence. The visual simulation shows the anticipated change in contrast from the existing landscape expected from ground subsidence (Newell and Grams 2018). Because of distance and angle of view to the subsidence area, the anticipated visual dominance and intensity to scenery from this KOP is weak (visible, but does not attract attention). Figure 3.11.4-1 presents a visual simulation of anticipated subsidence at end of mining from an aerial perspective using Google Earth imagery.

Mine Facility and Phase	Visual Impact Assessment
Closure and Reclamation	At the end of mine operations, a fence or berm would be constructed around the continuous subsidence area and no reclamation activities, including revegetation, would occur because of safety hazards. Design details currently are not available for either the perimeter fence or berm. It is assumed that the fence would be constructed of three-strand barbed wire with t-posts at a height of approximately 4 feet to allow for animal passage, with warning signage at appropriate intervals. It is assumed that the berm height will be approximately 4 to 6 feet in height to allow for animal passage while providing a visible barrier and would revegetate over time. As with the fence, hazard signage will be placed along the berm at appropriate intervals. The dominance of the safety barriers would be more visible within the foreground where the forms and lines would be more discernible. As the viewing distance increases, the elements of these barriers will become less desirable and would be absorbed visually into the surrounding landscape where surrounding views of adjacent landforms become the focus of attention. Long-term impacts on scenery would remain weak from KOP 1, which is approximately 1.5 miles from the subsidence zone. Views of the subsidence area itself are most accessible from the elevated viewpoints where the viewer is in a superior position, for example a ridgeline or from the air. Visualizations of the subsidence area from these elevated viewpoints that illustrate the different fracture zones are presented in the visual simulation package and do not include safety fencing or safety berms (Newell and Grams 2018). Visual dominance and intensity impacts on views from the air would be strong; however, there would be very few people viewing from this angle and elevation.
West Plant Site Facilities	
Construction	Impacts on scenery in the area would result from the construction activity, including heavy equipment operation, traffic and heavy truck transportation, fugitive dust from ongoing land disturbance, and power line construction. Areas within 2 miles of the West Plant Site could be impacted by construction activities by a change in landscape form, line, color, and texture and the dominance of new landscape features in the view. This area includes the town of Superior and recreation roads on the Tonto National Forest. The overall impact on scenery from these construction activities would be strong because of the visual dominance related to changes in form, line, color, and texture, and intensity of views in the landscape foreground.
Operations	During operations, impacts on scenery would continue to be strong within 2 miles of the area.
Closure and Reclamation	Mine operation facilities would be largely removed and the area would be reclaimed to natural conditions to the maximum amount possible. Some facilities and roads would remain to support long-term monitoring at the site. Visual dominance and intensity of impacts, after facility removal and successful restoration and revegetation, would potentially go from strong to moderate, depending upon reclamation success. Because of the scale of the facility ground disturbance, the site contrast would likely remain visible for many years post-reclamation.

Mine Facility and Phase	Visual Impact Assessment
Transmission Lines	
3.5-mile 230-kV line from existing Silver King substation to new Oak Flat substation at East Plant Site.	Construction: Scenery impacts from construction activities would include active construction equipment and traffic, land clearing, and fugitive dust emissions. Construction activity visual disturbances would temporarily impact viewers adjacent to the transmission corridors. Travelers on Gila-Pinal Scenic Road (U.S. 60) would view transmission line construction activities, specifically in areas where the line is directly adjacent to and crossing over the highway in the steep, rocky section of the highway near the East Plant Site.
Follows existing line.	Operations: The upgraded towers and wires would be visible from the Gila-Pinal Scenic Road (U.S. 60). Although there is an existing line in this corridor, the new adjacent line would be larger and more visible than the existing line. Depending upon the angle of view and exact locations of the transmission towers, the contrast would range from moderate to strong. In areas where the transmission line has potential to "skyline" (i.e., to be visible on high landscape features with sky in the background), the transmission line would present strong contrast. In areas where there are landscape features in the background of the view, contrast would be moderate. Where the transmission line corridor crosses U.S. 60 near the East Plant Site, the structures would present a strong contrast, depending upon their siting relative to the steep canyon walls. Visual dominance and intensity, related to changes in form and line would be increased relative to the existing transmission lines in the corridor, particularly in the Oak Flat area along U.S. 60.
	KOP 33 (U.S. 60 transmission lines) illustrates scenery impacts from transmission line construction in the vicinity of Oak Flat on U.S. 60 and shows the anticipated change in contrast relative to the existing landscape expected from transmission line operation ((Newell and Grams 2018). The new transmission line would dominate the view for sensitive viewers traveling on U.S. 60, the designated Gila-Pinal Scenic Road. The transmission line also would present strong contrast and visual dominance relative to the existing landscape from changes in line and color from the wires and poles at the top of the canyon walls.
	Closure and Reclamation: The closure and reclamation plan for the transmission facilities is currently unknown. If a post-mining use for the power facilities and transmission lines is identified, the facilities would remain on the landscape. If not, the structures would be removed and the area reclaimed.
3.5-mile 230-kV line from new Oak Flat substation (East Plant Site) to new West Plant Site substation.	Construction: General construction impacts are the same as described above. This line segment also is adjacent to and crosses the Gila-Pinal Scenic Road (U.S. 60) and would have similar impacts on that area. This segment traverses the hills above the town of Superior and is approximately 0.5 to 1.0 mile from the community. Construction disturbance could temporarily impact scenery resources in the town, including operation of construction equipment and fugitive dust.
New line.	Operations: Operations impacts are similar to those described above. The new towers and wires would be visible from the town of Superior and in areas where the angle of view creates "skylining," and where new roads are constructed the contrast would be strong. In areas without new road construction and where the line contrast is absorbed by a landscape background, the contrast would range from moderate to weak.
	Closure and Reclamation: Same as described above.
Tailings Facility	
Construction	General construction impacts on scenery resources for each tailings facility alternative would be similar. During initial tailings facility development (mine years 0 to 6), activities would include construction of perimeter fencing, access roads, drainage control structures, containment ponds, monitoring wells, and an office and equipment storage facility. Construction of these facilities would impact scenery resources in the area surrounding the tailings in the foreground, middle ground, and background through facility development and ground disturbance. Large areas of ground disturbance, vegetation removal, and fence construction would create a strong change in contrast with the background landscape that would be visible by a range of viewers extending from the foreground to the background (beyond 3 miles). Viewers in the vicinity would be impacted by the change in contrast created by land disturbance and vegetation removal, fugitive dust emissions from traffic and land-disturbing activities, and construction equipment operation, and the impact on these users would be strong (demands attention). The scale of the tailings facility would dominate long-term views in the vicinity of the tailings facility from intense changes in form, line, color, texture, vegetative pattern, and scale related to the existing landscape.

Mine Facility and Phase	Visual Impact Assessment
Operation	General operation impacts on scenery resources for each tailings facility alternative would be similar. The facility would slowly grow to the full facility. Prior to reclamation activities, as the embankment grows, the facility would become increasingly visible from sensitive viewpoints in the region surrounding the tailings facility. In general, the tailings facility would become more and more visible over time, and the color of the tailings stockpile would be a medium gray color. Concurrent reclamation activities vary and are described for each alternative. Impacts from concurrent reclamation activities would include construction activity including heavy equipment operation and potentially dust generation during the reclamation process. The scale of the tailings facility would dominate long-term views in the vicinity of the tailings facility with increasing intensity as the facility grows and dominates the view with changing form, line, color, texture, and vegetative pattern.
Closure and Reclamation	The tailings facility would be revegetated during closure and reclamation. Contrast would be reduced as vegetation grows on the tailings embankment faces and other parts of the facility. Contrast would continue to be strong in the middle ground and foreground after revegetation because of the change in landform. The scale of the tailings facility would continue to dominate the views of the landscape with obvious difference in form, line, color, and texture from the surrounding landscape. Vegetation growth on the facility over time would begin to resemble the background landscape and produce reduced changes in vegetative pattern but would continue to contrast with the existing landscape vegetative pattern.

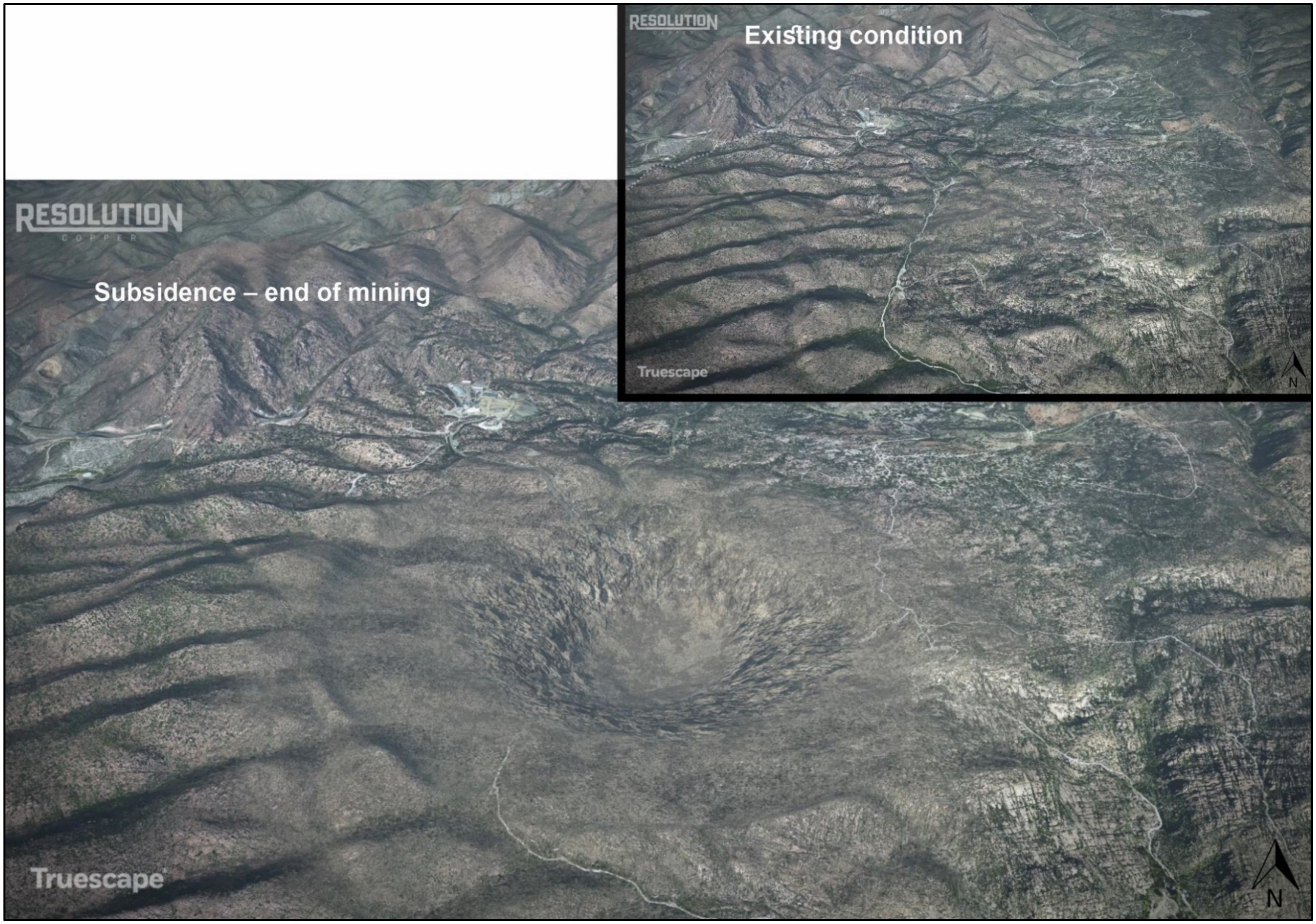


Figure 3.11.4-1. Subsidence area visual simulation from aerial perspective at end of mining using Google Earth imagery

Effects of Forest Plan Amendment

The Tonto National Forest Land and Resource Management Plan (1985b) provides guidance for management of lands and activities within the Tonto National Forest. It accomplishes this by establishing a mission, goals, objectives, and standards and guidelines. Missions, goals, and objectives are applicable on a forest-wide basis. Standards and guidelines are either applicable on a forest-wide basis or by specific management area.

A review of all components of the 1985 forest plan was conducted to identify the need for amendment due to the effects of the project, including both the land exchange and the proposed mine plan (Shin 2020). A number of standards and guidelines were identified as applicable to management of scenery resources. A plan amendment would lower the current VQOs and remove protections from amended areas and allow for greater impacts to scenery than are allowed under the current forest plan.

The project would have effects on the scenery resources within the Tonto National Forest by modifying the current forest plan VQO designations, for some alternatives. In general terms, Retention and Partial Retention do not allow for the proposed project activities as a whole. Retention requires that activities be “not visually evident.” Partial Retention requires that activities be “visually subordinate” to the characteristic landscape. The Modification designation allows for activities to visually dominate the original character of the landscape, but vegetation and landform should mimic the natural landscape. With adequate mitigation, including revegetation, the project as proposed could meet the Modification designation. Implementation of the project would require amending the forest plan by changing the areas designated Retention and Partial Retention to the Modification VQO category, for some alternatives.

Table 3.11.4-2 lists the VQO designation acres for each alternative within each of the affected management areas. It presents the total acres for Retention and Partial Retention that would be changed to Modification by alternative and the percentage change in acreage for each category in the applicable management areas (Shin 2020). The table also presents acreage associated with the Oak Flat Federal Parcel that would be exchanged and no longer under Forest Service jurisdiction and therefore would not require a plan amendment.

Table 3.11.4-2. Scenery management designations by management area and alternative (acres)

Management Area/VQO	Alternatives 2 and 3	Alternative 4	Alternative 5	Alternative 6	Oak Flat Federal Parcel†
Globe Ranger District (MA 2F)					
Retention*	180	180	500	227	785
Partial Retention*	1,217	3,294	626	369	1,415
Modification	389	1,023	67	274	137
Maximum Modification	0	1,847	0	0	0
Not Rated	1,299	1,350	1,305	1,049	70
Percent change in Management Area Retention, Partial Retention, and Modification VQO Designation	*Retention* – no change *Partial Retention* – 1% (32% to 31%) *Modification* – 1% (32% to 33%)	Same as Alternatives 2 and 3	No change	No change	N/A

Management Area/VQO	Alternatives 2 and 3	Alternative 4	Alternative 5	Alternative 6	Oak Flat Federal Parcel†
Mesa Ranger District (MA 3I)					
Retention*	50	28	28	28	0
Partial Retention*	2,768	80	80	80	0
Modification	1,180	19	19	19	0
Maximum Modification	0	0	0	0	0
Not Rated	0	0	0	0	0
Percent change in Management Area Retention, Partial Retention, and Modification VQO Designation	No change	No change	No change	No change	N/A

* Under the action alternatives, these Retention and Partial Retention acreages would change to a Modification management designation.

† Acreage associated with the Oak Flat Federal Parcel that will no longer be under Federal scenery management upon execution of the land exchange under all alternatives.

Effects of Compensatory Mitigation Lands

The compensatory mitigation lands would have beneficial effects on scenic resources. These lands generally would be preserved as natural areas, using conservation easements or similar restrictions.

Effects of Recreation Mitigation Lands

The recreation mitigation lands are anticipated to affect visual resources. Existing roads and trails, as well as new planned routes, would provide access for recreationists to viewsheds within the Tonto National Forest that are not currently accessible by authorized trails. The trail system is designed to maximize and preserve the outstanding natural scenery of the area. The area in which the recreation mitigation lands are located has visual quality objectives that range from retention to modification. The new uses would be compatible with these designations.

Applicant-Committed Environmental Protection Measures

A number of environmental protection measures are incorporated into the design of the project that would act to reduce potential impacts on scenic resources. These are non-discretionary measures and their effects are accounted for in the analysis of environmental consequences.

Applicant-committed environmental protection measures by Resolution Copper include those outlined in the dark skies analysis (Dark Sky Partners LLC 2018):

- Implement an outdoor lighting plan that would reduce potential impacts from artificial night lighting.
- Reduce illumination levels where appropriate while still meeting MSHA requirements for lighting sufficient to provide safe working conditions.
- Adhere to the Pinal County Outdoor Lighting Code.
- Use control systems that can turn off lights at particular times of night or are activated by detecting motion while still meeting MSHA requirements for lighting sufficient to provide safe working conditions.

Additional applicant-committed environmental protection measures by Resolution Copper include the following:

- Use non-reflective earth-tone paints on buildings and structures to the extent practicable.
- Bury concentrate pipelines to the extent practicable. Concentrate pipelines will have approximately 3.3 feet (1 m) of cover over buried sections. See detailed concentrate pipeline protection plan for further information.
- Build rust colored towers or use wooden poles on transmission lines.
- Use shafts constructed of rust colored metal headframes that blend with the scenery.
- Bury tailings and other pipelines to the extent practicable.
- Perform concurrent reclamation of tailings embankment. The approximate year in which concurrent reclamation can begin varies by alternative: Alternative 2 (year 12), Alternative 3 (year 30), Alternatives 4 and 5 (undetermined), and Alternative 6 (year 10).
- Use a reclamation seed mix of weed-free native species consistent with surrounding vegetation.
- Build concentrator building behind mountain terrain to screen views from the town of Superior.
- Use colors that blend in with the desert environment.

3.11.4.3 Alternative 2 – Near West Proposed Action

Impacts on scenery specific to Alternative 2, in addition to the impacts common to all action alternatives (see table 3.11.4-1), are described in table 3.11.4-3.

Table 3.11.4-3. Impacts on scenic resources under Alternative 2

Mine Facility and Phase	Visual Impact Assessment
Tailings Pipeline Corridor	
Construction	Impacts on the area scenery from construction activities would affect sensitive users on the Arizona Trail (Passage 18 Reavis Canyon) and NFS OHV roads in the vicinity of the pipeline corridor (up to 2 miles). The corridor crosses NFS Road 650, a popular OHV road. NFS Road 982 parallels the corridor near the Arizona Trail and provides access to this area near the western end of the pipeline corridor. Scenery impacts from construction activities on these users would include fugitive dust from ground disturbance, and visual disturbance from construction equipment, including construction vehicles accessing the area on NFS Roads 650 and 982. For forest users in the vicinity of the construction activities, impacts on scenery would be strong.
Operations	Impacts on scenery would result from linear mine support facilities in the corridor causing a strong change in contrast with the existing landscape. A strong contrast from vegetation removal in the 150-foot-wide corridor would be visible from 2 miles or more, depending on the vantage viewpoint. The 34.5-kV transmission line following the corridor would include approximately 35-foot-tall transmission line structures. The structures would present strong contrasting horizontal and vertical lines from associated towers and wires. Long-term visual dominance from prominent changes in form and line would occur in areas where recreation facilities cross the corridor. Impacts on sensitive viewers using OHV roads in the vicinity of the tailings would occur in areas where the roads cross or are parallel to the corridor. KOP 5 (Arizona Trail Barnett Camp) was established to illustrate long-term scenery impacts on the Arizona Trail from the tailings pipeline corridor. The visual simulation presents views of the elevated pipeline bridge from the Arizona Trail in the Barnett Camp area approximately 800 feet from the facilities (Newell and Grams 2018). The bridge presents dominant contrasting horizontal and vertical lines in light and dark gray colors in the foreground of the view. The pipeline bridge would dominate the view from this KOP for the long term with strong visual contrast (demands attention and is dominant in the landscape).
Closure and Reclamation	The tailings corridor and associated infrastructure would be removed and the corridor area would be regraded to mimic the natural condition and planted with native vegetation. Long-term impacts on scenery would be expected to persist because revegetation of disturbed landscapes in this type of desert ecosystem is difficult. The tailings corridor would likely be visible and present a permanent linear corridor contrast across the background landscape. Initial scenery impacts would be strong and would potentially reduce to moderate as vegetation growth increases in the corridor over many years. Intensity and dominance of the corridor form and line in the scenic landscape would be reduced over time.
MARRCO Corridor	
Construction	Temporary impacts on scenery from construction equipment operation and traffic, facility construction, land disturbance, and fugitive dust emissions would occur. Sensitive viewers in the area around the MARRCO corridor include travelers on U.S. 60, Queen Valley Road, Hewitt Station Road, OHV roads in the vicinity, and hikers on the Arizona Trail (Passage 18 Reavis Canyon). These areas close to the corridor would experience strong contrast (demands attention) from the construction activities. This impact would be temporary as construction activities moved down the corridor. The construction activities would dominate landscape views for sensitive viewers in the foreground with changes in form, line, and color.
Operations	New facilities in the MARRCO corridor would result in a change in scenery contrast in areas adjacent to the facilities. Although the corridor is currently disturbed, the addition of several pipelines and road improvement would increase the visual contrast to a moderate to strong level because of the change. Sensitive areas in the vicinity include the Arizona Trail as it parallels and then crosses the corridor, Hewitt Station Road and a portion of Queen Valley Road, and the Gila-Pinal Scenic Road (U.S. 60). Moderate to strong changes in contrast would result. Facilities in the corridor would introduce changes in form, line, and color that would create long-term dominant changes in the landscape.
Closure and Reclamation	The closure and reclamation plan for the MARRCO corridor facilities and utilities is unknown at this time. It is known that the copper concentrate lines would be removed and the area around the lines recontoured and revegetated. Other facilities, including transmission lines, water lines, and the upgraded railroad facility, may be left in place. The impact on scenery in the area around the facilities would continue to be moderate to strong.

Mine Facility and Phase	Visual Impact Assessment
Filter Plant and Loadout Facility	
All mine phases	Impacts on scenery would be from construction equipment operation and traffic, facility construction, fugitive dust emissions, and rail line traffic on-site. However, sensitive viewers in the area around the facility are few as the parcel is isolated, and impacts on viewers and scenery in the area would therefore be minimal. Overall impacts on scenery would be weak.

Tailings Facility

Sensitive viewers in the foreground (within 1 mile) under Alternative 2 that would be impacted are users of the Arizona Trail (Passage 18 Reavis Canyon) and OHV users on the area NFS roads (Hewitt Station Road, NFS Roads 982, 1904, 1903). These users would be impacted by the change in contrast created by land disturbance and vegetation removal, fugitive dust emissions from traffic and land-disturbing activities, and construction equipment operation, and the impact on these users would be strong (demands attention). The scope and scale of the tailings facility would visually dominate the existing landscape features and scenery with highly visible, long-term changes in landscape form, line, color, and texture. During mine operations, the tailings facility would slowly grow to the full facility size of approximately 4,864 acres and 520 feet high. The tailings embankment would be constructed at a 4H:1V slope and reclamation/revegetation of the embankment would begin in approximately mine year 12 with the majority of the outside slope revegetated by approximately mine year 28.[95] Concurrent reclamation (beginning in mine year 12) would begin to reduce the contrast as vegetation grows on the tailings embankment faces. The borrow pit, approximately 0.5 mile to the east of the Arizona Trail, would be visible from several locations along the trail as it passes the borrow pit area. This area would be stripped of vegetation and soil removed, leaving a visual impact on the landscape. Contrast with the surrounding landscape would be strong.

Viewshed Analysis. The viewshed for Alternative 2 is presented in the process memorandum (Newell and Grams 2018). It illustrates the general visibility of the tailings facility across the landscape within the analysis area and shows the high points and location where the facility could be most visible. There are approximately 10,643 acres from which the tailings storage facility would be visible in the foreground, 15,113 acres from which it would be visible in the middle ground, and 13,971 acres from which it would be visible in the background. The viewshed analysis for the linear features in the analysis area is presented in table 3.11.4-4.

Table 3.11.4-4. Viewshed analysis for linear features (roads and trails) in Alternative 2

Linear Viewshed Component	Total Miles in Analysis Area	Total Miles within Viewshed	Duration of Visibility (minutes)*	Scenery Impact Discussion
U.S. 60	32.5	21.2	23	Views of the facility would vary and would depend on landscape feature such as structures and vegetation. Visible locations closest to the facility would be most impacted and would have strong to moderate changes in contrast relative to distance, angle of view, and potential visual obstructions. The tailings facility would visually dominate views, compared with the existing landscape, as a result in changes in form, line, and color. The intensity and dominance would be greater in areas in the foreground and middle ground with unobstructed views. Specific views from the road are described in the KOP analysis in table 3.11.4-5.
SR 177	2.9	2.5	3	Although the viewshed illustrates that the tailings facility would be visible from a majority of the road, landscape features such as structures and vegetation could obstruct some views. With distance to the facility ranging from 4.75 to 5 miles, the tailings feature would appear in the background landscape when visible. Visual dominance would be minimal because changes in form, line, and color would be less visible due to the distance to the tailings facility. Specific views from the road are described in the KOP analysis in table 3.11.4-5.

[95] There is a possibility that the embankment could be constructed at a 3H:1V slope rather than the steeper 4H:1V slope as designed and that reclamation could begin approximately in mine year 22; this analysis assumes the steeper slope and later commencement of reclamation.

Linear Viewshed Component	Total Miles in Analysis Area	Total Miles within Viewshed	Duration of Visibility (minutes)*	Scenery Impact Discussion
Arizona Trail	23.0	11.0	330 (5.5 hours)	For persons traveling on the Arizona Trail, scenic views would be impacted by the proposed tailings facility. As described above, landscape features may obstruct views. The tailings facility would visually dominate views, compared with the existing landscape, as a result in changes in form, line, and color. The intensity and dominance would be greater in areas in the foreground and middle ground with unobstructed views. Specific views along the trail are described in the KOP analysis in table 3.11.4-5.

* Duration calculated using average vehicle speed of 55 mph and hiking speed of 2 mph (based upon moderately rugged trail terrain).

KOP Scenery Analysis. The Forest Service and NEPA team identified sensitive viewpoints around the tailings facility to analyze impacts on the area's scenery resources (see figure 3.11.1-1). An Alternative 2 impact summary for these KOPs is presented in table 3.11.4-3. The contrast rating analysis process (described in section 3.11.2.4) was conducted for each KOP and is presented in table 3.11.4-5. More detail on the KOPs, along with the related contrast rating worksheets and the visual simulations, is provided in the process memorandum (Newell and Grams 2018).

Table 3.11.4-5. Alternative 2 key observation point descriptions and contrast rating analysis

KOP Number	KOP Name	View Description and Contrast Rating Analysis
1	NFS Road 2466 east of subsidence area	*Analysis presented earlier in this section under the subsidence operation analysis in table 3.11.4-1*
2	Arizona Trail northwest of Montana Mountain*	The tailings facility would be visible from this location and would present a change in contrast ranging from moderate to strong. As the facility grows, contrast would increase with the strongest contrast presented at the end of mining operations, but before closure and reclamation is complete.
3	Picketpost Mountain*	The tailings facility would be highly visible from this KOP and would present prominent changes in the middle ground and background views in form, line, color, and texture. The changes would result in strong contrast.
4	Apache Leap*	The tailings facility would be moderately visible from this KOP and would present changes in background views in line and color. The changes would result in moderate contrast because the distance and angle of view of the facility would potentially blend with the background landscape.
5	Arizona Trail – Barnett Camp†	*Analysis presented earlier in this section under the tailings corridor operation analysis in table 3.11.4-3.*
6	Arizona Trail – Ridge†	The facility would be located in the foreground and middle ground views of the KOP and would present a strong change in form, line, color, and texture in the landscape. As the facility develops, it would become increasingly visible due to the changes in landscape color and form, with the facility presenting a gray tone and new line features within the rolling terrain. The facility would be most visible prior to commencement and implementation of successful concurrent reclamation activities. It is anticipated that concurrent reclamation would begin to mitigate visual contrast in approximately mine years 12 to 28.
7	SR 177 from Kearny†	Because of distance and angle of view, the tailings facility would be minimally visible to persons traveling on SR 177. The change in contrast in form and color would be weak.
8	Picketpost House – (Boyce Thompson Arboretum)†	The tailings facility would be visible in the KOP's middle ground view. Prior to concurrent reclamation activities, contrast would be moderate to strong for changes in form, line, and color in the landscape. The facility's gray color would be visible from the KOP. Upon implementation of successful concurrent reclamation, the contrast would be reduced to moderate.
9	NFS Road 172†	The tailings facility would be visible in the foreground to middle ground of this KOP. Impacts on scenery are similar to the discussion presented for KOP 6.

KOP Number	KOP Name	View Description and Contrast Rating Analysis
10	U.S. 60 Milepost 219†	The tailings facility would be visible in the middle ground and background views of the KOP. As the tailings facility grows, it would become increasingly visible from this KOP because of the color, line, and form changes in the landscape. The facility would be most visible prior to successful concurrent reclamation. The contrast would be strong but could become moderate with successful concurrent reclamation. The visual simulation for KOP 10 is presented in figure 3.11.4-2.
11	Arizona Trail at Picketpost Trailhead†	The tailings facility would be visible in the middle ground view of the KOP. Existing terrain features and angle of view reduce the visibility and noticeability of the facility from trail users. Changes in contrast would be weak to moderate prior to concurrent reclamation and potentially weak after successful reclamation.
12	Queen Valley, North Charlotte Street†	The tailings facility is minimally visible within the background views of the KOP. The terrain features a low saddle between higher hills in the background. A small part of the highest portion of the tailings facility would be visible from this KOP. However, it would not be noticeable to the casual viewer, and the anticipated change in contrast from this location is weak.

* Block model Google Earth visual simulation

† Photograph visual simulation

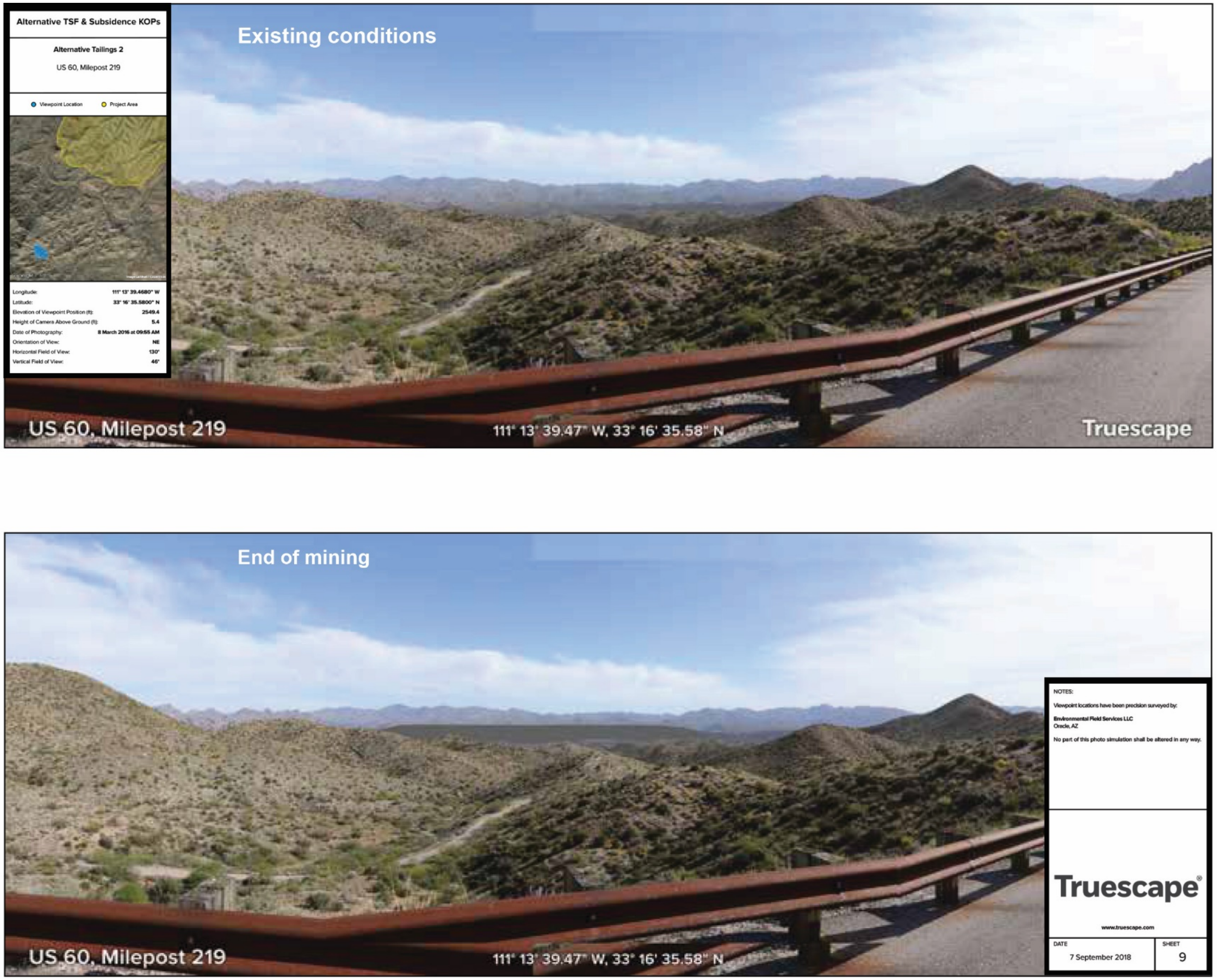


Figure 3.11.4-2. Visual simulation of Alternative 2 tailings facility from KOP 10 – U.S. 60 Milepost 219

Dark Skies

Lighting fixture numbers and their associated lumens proposed for all mining facilities, as presented and analyzed in Dark Sky Partners LLC (2018), under Alternative 2 are shown in table 3.11.4-6.
The proposed mining activities under Alternative 2 would increase lighting at the East Plant Site, West Plant Site, tailings facility, pump stations, and the filter plant and loadout facility. This increased lighting would impact current dark sky conditions in the analysis area as presented in table 3.11.4-7. The increase in ASL (sky brightness) would have a maximum increase from 40 percent to 160 percent at the dark sky observation points. These maximum changes would likely be visible to casual observers. The number of stars visible would decrease between 1 percent and 6 percent with the largest decrease anticipated in the Oak Flat area.

Table 3.11.4-6. Alternative 2 mine plan proposed lighting fixtures and associated lumens

Mine Plan Component	Lighting Fixtures	Lumens
West Plant Site	1,385	11,098,127
East Plant Site	732	4,145,795
Tailings facility	50	291,106
Pump stations	11	106,410
Filter plant and loadout facility	174	1,081,674
Total	**2,352**	**16,723,112**

Table 3.11.4-7. Change in Average Sky Luminance and number of visible stars under Alternative 2

Dark Sky Observation Point	Percentage Increase in Average Sky Luminance (average / maximum)	Percentage Decrease in Number of Stars Visible
Superior	6% average / 160% max	5%
Oak Flat Campground	9% average / 40% max	6%
Boyce Thompson Arboretum	4% average / 40% max	4%
Queen Valley	<1% average / 40% max	1%

Based on this analysis, the mine operation facilities would be visible and noticeable at night from the town of Superior, U.S. 60, Boyce Thompson Arboretum, the Arizona Trail, and the surrounding national forest landscape. The GPO states that exterior lighting would be kept to the minimum required for safety and security purposes and that lighting would be directed downward and hooded where practicable.

The mine facility lighting plan would comply with the Pinal County Outdoor Lighting Code as long as mine safety and operations are not compromised and there are not conflicts with MSHA regulations (M3 Engineering and Technology Corporation 2018). The mine facilities would be regulated by the code's Lighting Zone 3 (the most restrictive zones) that allows the maximum lumen density (amount of light) as 19 lumens per square foot from all light sources.

3.11.4.4 Alternative 3 – Near West – Ultrathickened

The differences in impacts on scenery between Alternatives 2 and 3 are described in the following text.

Tailings Facility

Unlike the proposed action that includes concurrent reclamation of the tailings facility beginning in mine year 12, concurrent reclamation activities for Alternative 3 would not occur until mine year 30. Reclamation of the tailings embankment face would begin during construction of the tailings embankment face during mine year 30 and continue through the end of mining operations (mine year 46). Under Alternative 3, the tailings facility would present strong contrast in the region's scenery for all sensitive viewers for approximately 18 additional years, compared with Alternative 2. The scope and scale of the tailings facility would visually dominate the existing landscape features and scenery with highly visible, long-term changes in landscape form, line, color, and texture. The tailings facility would create a strong contrast in the landscape that would increase over many years, with the strongest contrast occurring between commencement of concurrent reclamation (year 30) and when successful reclamation has occurred at the facility (approximately mine year 50 to 55).

The borrow pit, approximately 0.5 mile to the east of the Arizona Trail, would be visible from several locations along the trail near the borrow pit area. This area would be stripped of vegetation and soil removed, leaving a visual impact on the landscape. Contrast with the surrounding landscape would be strong.

Dark Skies

General impacts on the area's night skies would be the same as described under Alternative 2.

3.11.4.5 Alternative 4 – Silver King

The differences in impacts on scenery between Alternatives 2 and 4 are described in the following text.

West Plant Site

Under Alternative 4, the filter plant and loadout facility would be moved to the West Plant Site. However, the addition of this facility would result in generally the same scenery impacts as presented in "Impacts Common to All Action Alternatives" earlier in this section.

Tailings Pipeline Corridor

Tailing slurry would be delivered from the West Plant Site to the Silver King tailings facility via pipelines approximately 1.5 miles long. General impacts on scenery related to pipeline construction are described under Alternative 2. Under Alternative 4, an overall reduction in the length of tailings slurry pipeline, a consolidation of mine operations facilities, and reduced footprint would result in reduced impacts on scenery from tailings pipeline construction and operation.

Tailings Facility

Although there are differences between the proposed action tailings facility and the Silver King tailings facility in terms of design and processing, general scenery impacts from the two are the same as described under "Impacts Common to All Action Alternatives" and Alternative 2. Additions of two filter plants, mechanical conveyers, and emergency slurry overflow ponds, while adding to the facilities, would not change the general impacts described previously. However, the Silver King facility would be the tallest at over 1,000 feet in height and approximately double the height of the Alternative 2 and 3 facilities. The height of the facility increases the visual dominance of the overall form in the existing canyon landscape and increases visibility from sensitive viewing locations.

Reclamation and contouring of the filtered tailings would occur concurrently during mining operations. However, it is unknown at this time what year the concurrent reclamation would occur. Assuming it is similar to the reclamation timing under Alternative 2 (concurrent reclamation beginning in mine year 12) impacts would be same as described earlier in this section.

Viewshed Analysis. The viewshed for Alternative 4 is presented the process memorandum (Newell and Grams 2018). It illustrates the general visibility of the tailings facility across the landscape within the analysis area and shows the high points and location where the facility could be most visible. There are approximately 10,333 acres from which the tailings storage facility would be visible in the foreground, 14,176 acres from which it would be visible in the middle ground, and 20,736 acres from which it would be visible in the background. The viewshed analysis for the linear features in the analysis area is presented in table 3.11.4-8.

Table 3.11.4-8. Viewshed analysis for linear features (roads and trails) in Alternative 4

Linear Viewshed Component	Total Miles in Analysis Area	Total Miles within Viewshed	Duration of Visibility (minutes)*	Scenery Impact Discussion
U.S. 60	26.3	18.3	20	Viewing distance to the facility ranges from approximately 2 to 6 miles. This alternative contains approximately 2 fewer miles of highway within the viewshed than Alternative 2. Impacts are similar to those described under Alternative 2. Specific views from the road are described in the KOP analysis in table 3.11.4-9.
SR 177	4.2	3.6	4	Viewing distance to the facility ranges from approximately 2 to 6 miles. This alternative contains approximately 1 more mile of highway within the viewshed than Alternative 2. Impacts are similar to those described under Alternative 2. Specific views from the road are described in the KOP analysis in table 3.11.4-9.
Arizona Trail	21.0	16.3	489 (8.2 hours)	This alternative contains approximately 5.3 more miles of the Arizona Trail within the viewshed than Alternative 2. Impacts are similar to those described under Alternative 2. Specific views from the trail are described in the KOP analysis in table 3.11.4-9.

* Duration calculated using average vehicle speed of 55 mph and hiking speed of 2 mph (based upon moderately rugged trail terrain).

KOP Scenery Analysis. We identified sensitive viewpoints (KOPs) in the area around the Silver King tailings facility to analyze impacts on the area's scenery resources (see figure 3.11.1-1). The contrast rating analysis process (described in section 3.11.2.4) for each KOP is presented in table 3.11.4-9. The related contrast rating worksheets and the visual simulations are provided in the process memorandum (Newell and Grams 2018).

Table 3.11.4-9. Alternative 4 key observation point descriptions and contrast rating analysis

KOP Number	KOP Name	View Description and Contrast Rating Analysis
13	Picketpost Mountain*	The tailings facility would be highly visible from this KOP as presented in the visual simulation package (Newell and Grams 2018). The facility would present prominent changes in the middle ground and background views in form, line, color, and texture. The changes would result in strong contrast and would be highly visible from this KOP.
14	Apache Leap – Tailings*	The tailings facility would be moderately visible from this KOP as presented in the visual simulation package (Newell and Grams 2018). The facility would present changes in background views in line and color and result in moderate contrast because the distance and angle of view of the facility would potentially blend with the background landscape and hill slopes in the foreground of the facility.
15	Arizona Trail – Montana Mountain (Silver King view)*	The tailings facility would be visible from this location and would present a change in contrast ranging from moderate to strong. The foreground hills hide a large portion of the facility. As the facility grows, contrast would increase with the strongest contrast presented at the end of mining operations, but before closure and reclamation is complete.
16	Town of Superior, South Stone Avenue†	The tailings facility would be visible from this location in the middle ground and background. Prior to successful reclamation, the tailings facility would present a strong contrast in the landscape. After reclamation, the contrast would be moderate to weak, depending on the success of revegetation.
17	Town of Superior, Baseball Field†	The tailings facility would be visible from this location in the background view. The facility would obscure a portion of the background ridgeline and present a strong change in form, line, and color. The change in contrast would be most strong and prominent prior to successful concurrent reclamation activities. After reclamation is complete, the facility would be less visible and present a moderate change in contrast. The visual simulation for KOP 17 is presented in figure 3.11.4-3.
18	Arizona Trail – Ridge†	The tailings facility would be visible from this KOP in the middle ground to background landscape, although it would be obscured by some hill slopes in the foreground. Prior to reclamation, the contrast would be strong and would decrease with post-reclamation activities, as described above.
19	U.S. 60 – Near Silver King Wash†	The tailings facility would be visible in the middle ground and background and present strong contrast to viewers traveling the highway. The facility is not obscured by the foreground landscape. The strong contrast would be as described above.
20	SR 177 from Kearny†	The tailings facility would be visible with strong contrast presented in the middle ground to background landscape. The change in form, line, and color would obscure the existing ridgeline. Changes in contrast over time are described above.
21	Picket Post House – (Boyce Thompson Arboretum)†	The tailings facility would be visible with strong contrast presented in the in the background landscape. Changes in contrast related to reclamation and contrast over time are described above.
22	Arizona Trail at Picketpost Trailhead†	The tailings facility would not be visible from this KOP.

* Block model Google Earth visual simulation

† Photograph visual simulation

Figure 3.11.4-3. Visual simulation of Alternative 4 tailings facility from KOP 17 – Town of Superior baseball field

MARRCO Corridor

Under Alternative 4, active railcars would transport copper concentrate via the MARRCO corridor instead of pipelines. The two 50-railcar trains would follow the upgraded rail corridor twice a day. Construction impacts on scenery would be similar to those described under Alternative 2. During the operations phase, railcars passing two times per day would present a weak to moderate impact on scenery. Although the trains would be noticeable to viewers along the corridor, the visibility and impact are transitory in nature.

Dark Skies

General impacts on the area's night skies would be similar to those described under Alternative 2. However, some mining components would be in different locations. The Resolution Copper Outdoor Lighting and Pinal County Outdoor Lighting Code Technical Memorandum (M3 Engineering and Technology Corporation 2018) contains lighting data that were used to prepare the "Impact Assessment of the Proposed Resolution Copper Mine on Night Sky Brightness" (Dark Sky Partners LLC 2018). This technical memorandum also includes lighting information for the tailings facility alternative locations, including Alternative 4 – Silver King. The Silver King tailings facility would produce a similar amount of lighting (270,820 lumens) as the Alternative 2 tailings facility (291,106 lumens). The filter plant and loadout facility would be moved to the West Plant Site area and increase lighting in this location by 1,322,086 lumens at the West Plant Site, compared with Alternative 2. Changes in location for these mining components would place the tailings facility closer to the West Plant Site and increase lighting at the West Plant Site. These changes are closer in proximity to, and therefore would increase lighting impacts to the town of Superior, compared with Alternative 2.

3.11.4.6 Alternative 5 – Peg Leg

The differences in impacts on scenery between Alternatives 2 and 5 are described in the following text.

Tailings Pipeline Corridor

The general scenery impacts described for the tailings pipeline corridor construction, operation, and closure/reclamation would be the same as those described under Alternative 2. However, the pipeline would be in a different location. Scenery impacts associated with the tailings pipeline corridor are described in the following text.

Tailings Pipeline Corridor—The pipeline corridor would be visible from U.S. 60 (at the crossing), NFS and BLM OHV roads, Boyce Thompson Arboretum, SR 177, the Arizona Trail (Gila River Canyon Passage 16), the Florence-Kelvin Highway, and upland areas within the White Canyon Wilderness. The pipeline would cross the Arizona Trail just north of the Gila River approximately 6 miles west from where Kelvin Bridge crosses the Gila River (see figure 3.11.3-1). The pipeline would be underground in this area of the trail. A representative KOP analysis for pipeline impacts is presented under Alternative 6 at KOP 32 – Tailings Pipeline U.S. 60.

Tailings Facility

Although there are differences between the proposed action tailings facility and the Peg Leg tailings facility in terms of design, general impacts on scenery from the facility are similar to those described under Alternative 2. Reclamation would occur concurrently during mining operations. However, it is unknown at this time what year the concurrent reclamation would occur. Assuming it is similar to the reclamation timing under Alternative 2 (concurrent reclamation beginning in mine year 12), impacts would be the same as described earlier in this section.

Viewshed Analysis. The viewshed for Alternative 5 is presented in the process memorandum (Newell and Grams 2018). It illustrates the general visibility of the tailings facility across the landscape within the analysis area and shows the high points and location where the facility could be most visible. There are approximately 16,704 acres from which the tailings storage facility would be visible in the foreground, 16,329 acres from which it would be visible in the middle ground, and 21,490 acres from which it would be visible in the background. The viewshed analysis for the linear features in the analysis is presented in table 3.11.4-10.

Table 3.11.4-10. Viewshed analysis for linear features (roads and trails) in Alternative 5

Linear Viewshed Component	Total Miles in Analysis Area	Total Miles within Viewshed	Duration of Visibility (minutes)*	Scenery Impact Discussion
U.S. 60	27.7	1.5	2	Although the viewshed model shows that the Peg Leg tailings facility could potentially be viewed from U.S. 60, the facility is too far away to be visible.
SR 177 Tailings Pipeline	11.6	1.4	2	Although the viewshed model shows that the Peg Leg tailings facility could potentially be viewed from SR 177 pipeline route, the facility is too far away to be visible.
Arizona Trail	37.2	8.7	261 (4.4 hours)	This alternative contains approximately 2 fewer miles of the Arizona Trail within the viewshed than Alternative 2. Specific views from the trail are described in the KOP analysis in table 3.11.4-11.

* Duration calculated using average vehicle speed of 55 mph and hiking speed of 2 mph (based upon moderately rugged trail terrain).

KOP Scenery Analysis. Sensitive viewpoints (KOPs) in the area around the Peg Leg tailings facility were identified to analyze impacts on the area's scenery resources (see figure 3.11.1-1). The contrast rating analysis process (described in section 3.11.2.4) was conducted for each KOP and is presented in table 3.11.4-11. The related contrast rating worksheets and the visual simulations are presented in the process memorandum (Newell and Grams 2018).

Table 3.11.4-11. Alternative 5 key observation point description and contrast rating analysis

KOP Number	KOP Name	View Description and Contrast Rating Analysis
23	Arizona Trail – Peg Leg North*	The tailings facility would be visible in the background landscape. Because of distance and angle of view, the change in contrast would be moderate. The facility would be noticeable to the casual observer but would not dominate the view.
24	Arizona Trail – Tortilla Mountains*	The tailings facility would be visible in the background landscape view. Because of distance and angle of view, the change in contrast would be moderate. The facility would be noticeable to the casual observer but would not dominate the view.
25	Cochran OHV Parking[†]	The tailings facility would be visible from this KOP. Although the foreground landscape topography shields the view of the lower portion of the facility, the upper portion would be visible and present a moderate to strong contrast to the existing landscape. The facility would be most visible at the end of mine life and prior to reclamation and revegetation activities. After successful reclamation, the contrast could be reduced to moderate. The visual simulation for KOP 25 is presented in figure 3.11.4-4.
26	Cochran Road OHV Dispersed Site[†]	The tailings facility would be visible from this KOP. A strong contrast in form, line, and color would dominate the middle ground view. The facility would be most visible at the end of mine life and prior to reclamation and revegetation activities. After successful reclamation, the contrast could be reduced to moderate.
27	Florence-Kelvin Highway – East Side[†]	The tailings facility would be visible from this KOP in the foreground. A strong contrast would be present in form, line, and color, with strong straight lines dominating the view. The facility would be most visible at the end of mine life and prior to reclamation and revegetation activities. After successful reclamation, the contrast could be reduced to moderate.

KOP Number	KOP Name	View Description and Contrast Rating Analysis
28	Florence-Kelvin Highway – South†	The tailings facility would not be visible from this location.

* Block model Google Earth visual simulation

† Photograph visual simulation

Dark Skies

General impacts on night skies from the mining operations facilities would generally be the same as those described under Alternative 2. However, lighting at the tailings facility would be in a different location. Lighting from the tailings facility would be seen and noticed by nighttime recreationists in the area, Arizona Trail users, and persons traveling on the Florence-Kelvin Highway. This alternative would also comply with the Pinal Outdoor Lighting Code as described under Alternative 2.

Figure 3.11.4-4. Visual simulation of Alternative 5 tailings facility from KOP 25 – Cochran OHV parking

3.11.4.7 Alternative 6 – Skunk Camp

The differences in impacts on scenery between Alternatives 2 and 6 are described in the following text.

Tailings Pipeline Corridor

The general scenery impacts described for the tailings pipeline corridor construction, operation, and closure/reclamation would be the same as those described under Alternative 2. However, the pipeline would be in a different location. Scenery impacts associated with the tailings pipeline corridor are described in the following text.

Tailings Pipeline Corridor—The pipeline corridor contains the pipeline corridor and access roads as described in chapter 2, section 2.2.8. The corridor would be visible from U.S. 60 (at the crossing), NFS Road 2466, and Dripping Springs Road. KOP 32 (Tailings Pipeline U.S. 60) illustrates scenery impacts from construction and operation of the tailings pipeline in the vicinity of U.S. 60, the designated Gila-Pinal Scenic Road, and the Oak Flat area. The visual simulation shows the anticipated change in contrast from the existing landscape expected from tailings pipeline operation (Newell and Grams 2018).
The tailings pipeline corridor would be visible in the vicinity of the crossing with U.S. 60 at the crossing and on the north and south side of the highway. The visual dominance and contrast would be strong in line, color, and texture. Post-reclamation contrast would be moderate upon successful revegetation and reclamation.

The portion of the pipeline west of Queen Creek Canyon would be tunneled underground and not visible on the surface. Localized vegetation and ground disturbance is anticipated on the east and west sides of Kings Crown Peak where pipeline boring locations are located. Exposed soil and vegetation disturbance is expected to create moderate contrast resulting from the light-colored disturbed soils contrasting with the surrounding dark vegetation and dark-colored landform surfaces. The pipeline would have two aboveground spans. One, over Queen Creek Canyon, would span approximately 250 feet of the canyon and cross above North Queen Creek Canyon Road. This span would be highly visible from the road.
The second pipeline would cross Devil's Canyon with an approximate 450-foot span that would be highly visible to recreationists in Devil's Canyon. These pipeline spans represent strong visual contrast to all viewers in the vicinity. The pipeline corridor, beginning at the intersection with the proposed transmission lines (approximately 0.4 mile north of U.S. 60) would include a collocated transmission line.
The transmission line would cross U.S. 60 at the pipeline crossing area and present a strong contrast to viewers traveling on this highway in both directions. After crossing Devil's Canyon, this portion of the pipeline corridor, with the collocated transmission line, is in a remote area without sensitive viewing areas or KOPs. However, viewers in the area would easily see the facilities. When viewed, these facilities would present a strong contrast to the existing scenery.

Transmission Line Corridor—A new power line, approximately 11.5 miles in length, would be constructed between the Silver King substation, north of U.S. 60, and the Skunk Camp tailings facility. Impact on scenery from transmission line construction would generally be the same as described under Alternative 2. This line would be visible from U.S. 60, NFS Road 2466, and Dripping Springs Road.

Tailings Facility

Although there are differences between the proposed action tailings facility and the Skunk Camp tailings facility in terms of design, general impacts on scenery from the facility are similar as those described under Alternative 2. Concurrent reclamation would occur beginning in mine year 10. Strong contrast would be visible at the facility until concurrent reclamation is started and successful revegetation of the facility occurs. Although the visual simulations, as described in table 3.11.4-12, illustrate strong to moderate contrast from the tailings facility from locations in foreground area (KOP 29 – Dripping Springs

Road). In general, impacts on scenery and sensitive viewers in the Skunk Camp area are less than for the other alternatives. This is because there are limited areas where the facility would be visible and fewer sensitive viewers in the vicinity.

Viewshed Analysis. The viewshed for Alternative 6 is presented in the process memorandum (Newell and Grams 2018). It illustrates the general visibility of the tailings facility across the landscape within the analysis area and shows the high points and location where the facility could be most visible. There are approximately 12,333 acres from which the tailings storage facility would be visible in the foreground, 7,712 acres from which it would be visible in the middle ground, and 4,652 acres from which it would be visible in the background. Linear facilities (U.S. 60, SR 177, and the Arizona Trail) are not visible within the viewshed model for the Skunk Camp tailings facility.

KOP Scenery Analysis. Sensitive viewpoints (KOPs) in the area around the Skunk Camp tailings facility were identified to analyze impacts on the area's scenery resources (see figure 3.11.1-1). The contrast rating analysis process (described in section 3.11.2.4) was conducted for each KOP and is presented in table 3.11.4-12. The related contrast rating worksheets and the visual simulations are presented in the process memorandum (Newell and Grams 2018). Appendix D of Newell and Grams (2018) contains simulations for the Skunk Camp tailings facility from KOP 29 for three additional mine-life stages, at 15-, 20-, and 30-year construction intervals. These simulations illustrate the views of the tailings facility over time and the view of concurrent reclamation activities that begin in approximately year 10.

Table 3.11.4-12. Alternative 6 key observation point description and contrast rating analysis

KOP Number	KOP Name	View Description and Contrast Rating Analysis
29	Dripping Springs Road*	At project completion, the tailings facility would be highly visible from this KOP and the contrast in form, line, color, and texture would be strong. The facility would dominate the foreground view and obscure the mountains and ridgeline views of the background. Because of proximity and angle of view, the contrast would remain strong and dominate the view after closure and reclamation. This visual simulation for KOP 29 is presented in figure 3.11.4-5. Additional visual simulation for mine years 15, 20, and 30 illustrate how the views of the facility would change over time. At year 15 the facility dam would be primarily unvegetated and present strong contrast in form, line, color, and texture. As concurrent reclamation is conducted, starting in approximately year 10, this contrast would be reduced as illustrated in the simulations for years 20 and 30.
30	Pinal Peak†	The tailings facility would be visible from this KOP in the background valley below. The contrast would be strong in form, line, and color until reclamation is complete. Post-reclamation contrast would be moderate upon successful revegetation and reclamation of the facility.
31	San Carlos†	The tailings facility would be visible from this KOP in the background valley below. The contrast would be strong in form, line, and color until reclamation is complete. Post-reclamation contrast would be moderate upon successful revegetation and reclamation of the facility.
32	Tailings Pipeline U.S. 60*	The tailings pipeline corridor would be visible in the vicinity of the crossing with U.S. 60 at the crossing and on the north and south side of the highway. It would also be intermittently visible to persons traveling east on U.S. 60. The visual dominance and contrast would be strong in line, color, and texture. Post-reclamation contrast would be moderate upon successful revegetation and reclamation.

* Photograph visual simulation

† Block model Google Earth visual simulation

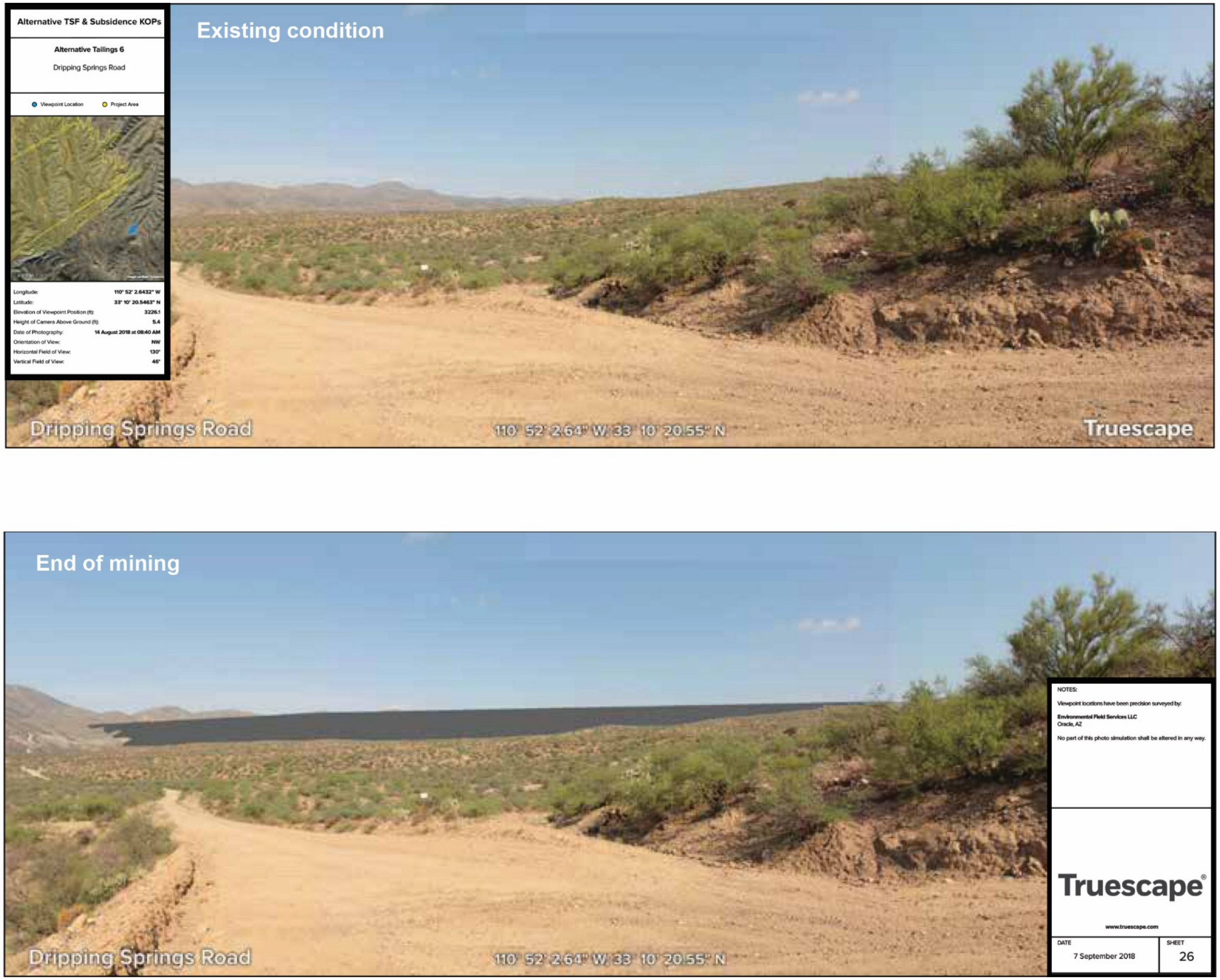


Figure 3.11.4-5. Visual simulation of Alternative 6 tailings facility from KOP 29 – Dripping Springs Road

Dark Skies

General impacts on night skies from the mining operations facilities would generally be the same as described under Alternative 2. However, lighting at the tailings facility would be in a different location. The facility would be lit and visible from the surrounding area. There would be few observers of the night sky in the area because of the remote location of the facility. This alternative would also comply with the Pinal Outdoor Lighting Code as described under Alternative 2. The Skunk Camp tailings facility would be located in Gila County and the lighting plan for this component would be designed in compliance with the Gila County Outdoor Light Control Ordinance.

Forest Service and BLM Scenery Management Designations

Table 3.11.4-13 presents the Tonto National Forest and the BLM scenery management designation acreages by project area alternative component. The acreages represent areas where the proposed project components cross Federal lands. Total acreages vary, depending upon the amount of private or State lands included in the project area alternatives. The table includes the acreage associated with the Oak Flat Federal Parcel that no longer will be under Federal scenery management upon execution of the land exchange under all alternatives. The Oak Flat Federal Parcel acreage is not included in the scenery management designation acreage by alternative.

The majority of project area alternatives on NFS lands are designated Retention, Partial Retention, and Modification. In general terms, Retention and Partial Retention do not allow for the proposed project activities as a whole. Retention requires that activities be “not visually evident.” Partial Retention requires that activities be “visually subordinate” to the characteristic landscape. The Modification designation allows for activities to visually dominate the original character of the landscape, but vegetation and landform should mimic the natural landscape. With adequate mitigation, including revegetation, the project as proposed could meet the Modification designation. Under Alternative 4, 1,847 acres of the project area are designated Maximum Modification. With mitigation, this designation would allow for the proposed project activities.

Portions of NFS lands that would not meet the VQO designations include the following:

- Retention Acres—Alternatives 2 and 3 (230), Alternative 4 (208), Alternative 5 (528), Alternative 6 (255)
- Partial Retention Acres—Alternatives 2 and 3 (3,985), Alternative 4 (3,374), Alternative 5 (706), Alternative 6 (449)

Alternatives 2 and 3 have the least acres designated Retention, with Alternative 5 having the most. Alternative 6 has the least acres designated Partial Retention with Alternative 4 having the most.

Alternative 5 is the only alternative on BLM lands, and it intersects with BLM VRM Class III designation (7,086 acres). The designation does not preclude mining activities but does require that activities not dominate the view of the casual observer. The level of change to the characteristic landscape from Alternative 5 would be too great to meet the requirements of the Class III designations because the tailings facility and pipeline would dominate the view from several sensitive viewpoints, including the Arizona Trail and the Gila River crossing area.

Table 3.11.4-13. Project area alternative scenery management designation acreage

	Alternatives 2 and 3	Alternative 4	Alternative 5	Alternative 6	Oak Flat Federal Parcel*
VQO					
Preservation	0	0	0	0	0
Retention	230	208	528	255	785
Partial Retention	3,985	3,374	706	449	1,415
Modification	1,569	1,042	86	293	137
Maximum Modification	0	1,847	0	0	0
Not Rated	1,299	1,350	1,305	1,049	70
VRM					
Class III	0	0	7,086	0	0
Class I, II, IV	0	0	0	0	0
Total Acreage	**7,083**	**7,821**	**9,711**	**2,046**	**2,047**

* Acreage associated with the Oak Flat Federal Parcel that no longer will be under Federal scenery management upon execution of the land exchange under all alternatives.
Oak Flat Federal Parcel acreage not included in the scenery management designation by alternative.

3.11.4.8 Cumulative Effects

Full details of the cumulative effects analysis can be found in chapter 4. The following represents a summary of the cumulative impacts resulting from the project-related impacts described in Section 3.11.4, Environmental Consequences, that are associated with scenic resources, when combined with other reasonably foreseeable future actions.

The following actions were determined through the cumulative effects analysis process to be reasonably foreseeable, and have impacts that likely overlap in space and time with impacts from the Resolution Copper Project:

- Ray Land Exchange and Proposed Plan Amendment
- Ripsey Wash Tailings Project

The cumulative effects analysis area for scenic resources consists of a 6-mile buffer around the project footprint; 6 miles was determined to represent potential background views of the proposed tailings facilities from sensitive viewing locations. The metric used to quantify cumulative impacts to scenic resources is the physical footprint of the RFFAs. The impact to scenic resources is specific to individual facility designs, locations, and nearby landscapes. In general, however, multiple facilities within sight would have cumulative impacts on a given resident, traveler, or recreational user. Physical footprint serves as a proxy for the overall level of disturbance of the landscape that contributes to degradation of scenic resources. Similarly, impacts to dark skies is specific to individual facility lighting plans and locations, but physical footprint serves as a proxy for the overall level of lighting and development in the area.

The two reasonably foreseeable future actions above, combined with the Resolution Copper Project, represent about 29,000 acres of the 375,000-acre cumulative effects analysis area, or about 7.7 percent. Physical footprint is only a proxy for visual resource impacts. In reality, these types of developments can be seen for much longer distances, though the effect is sensitive to the specific terrain and observation points. This combined level of disturbance contributes to the overall industrialization and change in scenic integrity of the area.

3.11.4.9 Mitigation Effectiveness

Mitigation Identifier and Title	Authority to Require
FS-SV-03: Revised Reclamation and Closure Plans	Required – Forest Service
FS-WR-01: GDEs and water well mitigation	Required – Forest Service
FS-WR-02: 404 Compensatory Mitigation Plan	Required – U.S. Army Corps of Engineers
FS-WR-04: Replacement of water in Queen Creek	Required – Forest Service
FS-RC-01: Relocation of Arizona National Scenic Trail	Required – Forest Service
FS-SR-01: Minimize visual impacts from transmission lines	Required – Forest Service

We developed a robust monitoring and mitigation strategy to avoid, minimize, rectify, reduce, or compensate for resource impacts that have been identified during the process of preparing this EIS. Appendix J contains descriptions of mitigation measures that are being required by the Forest Service and mitigation measures voluntarily brought forward and committed to by Resolution Copper. Appendix J also contains descriptions of monitoring that would be needed to identify potential impacts and mitigation effectiveness.

This section contains an assessment of the effectiveness of design features associated with mitigation and monitoring measures found in appendix J that are applicable to scenic resources. See appendix J for full descriptions of each measure noted below.

Mitigation Effectiveness and Impacts of Required Mitigation Measures Applicable to Scenic Resources

Appendix J contains mitigation and monitoring measures being required by the Forest Service under its regulatory authority or because these measures are required by other regulatory processes (such as the PA or Biological Opinion). These measures are assumed to occur, and their effectiveness and impacts are disclosed here. The unavoidable adverse impacts disclosed below take the effectiveness of these mitigations into account.

Revised Reclamation and Closure Plans (FS-SV-03). Implementing reclamation and closure plans ensure that post-closure landscape is successfully revegetated to the extent practicable, and that the landforms are stable and safe. This measure is effective at partially replacing habitat and vegetation over the long term within the footprint of all mine components, reducing long-term effects on surface water quality from erosion, and improving long-term resilience and safety of the tailings storage facility. These would have long-term beneficial effects on scenic resources, reducing the contrast with the natural landscape, though the form and line of the tailings storage facilities would remain noticeable.

GDE and water well mitigation (FS-WR-01). This measure would replace water sources for any riparian areas associated with springs or perennial streams (groundwater-dependent ecosystems) impacted by drawdown from the mine dewatering and block caving. Though this measure could change the overall natural character of riparian areas, it would be effective at preserving riparian vegetation and aquatic habitats, which are of scenic value.

Clean Water Act Section 404 Compensatory Mitigation Plan (FS-WR-02). The compensatory mitigation parcels would offer conservation of riparian habitat, as well as overall improvement in the health and stability of riparian habitats, by minimizing invasive non-native species and returning conditions to a more natural state. This measure would be effective at replacing xeroriparian habitat lost within the project footprint. Overall, these would be beneficial to scenic resources, though not necessarily within the same vicinity as the impact of the tailings storage facility.

Replacement of water in Queen Creek (FS-WR-04). This measure would replace the storm runoff in Queen Creek that otherwise would be lost to the subsidence area. It would be highly effective at minimizing the effects felt in Queen Creek caused by reduction in the watershed area, specifically impacts to surface water quantity and riparian habitat, which would prevent impacts to wildlife using this habitat. This would be effective at minimizing impacts to scenic resources along this riparian corridor. Note that other stormwater losses would still occur under Alternatives 2, 3, and 4.

Relocation of Arizona National Scenic Trail (FS-RC-01). The relocation of the Arizona Trail away from some alternatives (Alternatives 2, 3, and 4) would be effective at reducing the impact of the mine on trail users by distancing them from industrialized landscapes, although the overall change in the character of the region could still be discernable in some areas.

Minimize visual impacts from transmission lines (FS-SR-01). Resolution Copper would use best management practices or other guidelines (when on NFS lands) that would minimize visual impacts from transmission lines. Measures could include using non-specular transmission lines, transformers, and towers; avoiding use of monopole transmission structures; avoiding “skylining” of transmission and communication towers and other structures (i.e., considering topography when siting transmission structures to avoid “skylining” of structures on high ridges in the landscape); and using air transport capability to mobilize equipment and materials for clearing, grading, and erecting transmission towers in areas of the highest visual sensitivity with difficult access. These measures would be effective at reducing and minimize the scenery impacts and project contrast of mining operations in the surrounding landscape and impacts upon sensitive viewers. The power line corridors occur mainly on NFS lands, and the mitigation measures can be required within those areas, regardless of alternative.

Mitigation Effectiveness and Impacts of Voluntary Mitigation Measures Applicable to Scenic Resources

Appendix J contains mitigation and monitoring measures brought forward voluntarily by Resolution Copper and committed to in correspondence with the Forest Service. These measures are assumed to occur but are not guaranteed to occur. Their effectiveness and impacts if they were to occur are disclosed here; however, the unavoidable adverse impacts disclosed below do not take the effectiveness of these mitigations into account. No additional mitigation measures were voluntarily brought forward for scenic resources.

Other Potential Future Mitigation Measures Applicable to Scenic Resources

Appendix J contains several other potential future mitigation measures that the Forest Service is disclosing as potentially useful in mitigating adverse effects, but for which there is no authority to require. There is no expectation that these measures would occur, and therefore the effectiveness is not considered in the EIS. No potential future mitigation measures were identified applicable to scenic resources.

Unavoidable Adverse Impacts

The subsidence area and residual tailings storage facility would constitute a permanent adverse impact that cannot be avoided or completely mitigated. While night brightness from mine facility lighting would be mitigated to a large degree, residual impacts would remain that are not avoidable and cannot be completely mitigated.

3.11.4.10 Other Required Disclosures

Short-Term Uses and Long-Term Productivity

Impacts on visual resources would be both short and long term. While impacts associated with processing plant buildings and structures such as utility lines and fences would cease when they are removed at closure, the subsidence area and tailings storage facility would permanently alter the scenic landscape and affect the scenic quality of the area in perpetuity. Impacts on dark skies from night lighting would cease after mine closure and reclamation.

Irreversible and Irretrievable Commitment of Resources

For all action alternatives, there would be an irretrievable loss of scenic quality from increased activity and traffic during the construction and operation phases of the mine. The size and extent of the tailings facilities would create losses of scenic quality until rock weathering and slope revegetation have reduced color, form, line, and texture contrasts to a degree that they blend in with the surrounding landscape; revegetation would occur relatively soon after closure, but weathering would take such a long time scale as to be considered permanent. Due to the geological time frame necessary for these processes to occur, the loss of scenic quality associated with the tailings facilities would effectively be irreversible.

For each action alternative, the visual contrasts that would result from the introduction of facilities associated with the project would be an irretrievable loss of the undeveloped, semi-primitive setting until the project is closed and full reclamation is complete. Under all of the action alternatives, existing views would be irreversibly lost behind the tailings storage facility because of the height and extent of the piles.

There would be an irretrievable, regional, long-term loss of night-sky viewing during project construction and operations because night-sky brightening, light pollution, and sky glow caused by mine lighting would diminish nighttime viewing conditions in the direction of the mine. Impacts on dark skies due to night lighting would cease after mine closure and reclamation. Regional dark skies would continue to brighten due to other development factors in the region throughout the mine life. Therefore, it is unlikely that a return to current dark sky conditions would occur after mine closure.

3.12 Cultural Resources

3.12.1 Introduction

> **Overview**
>
> Applicable laws that oversee cultural resources management in the United States include the National Historic Preservation Act, Archaeological Resources Protection Act, and numerous other laws and regulations at various levels of government. Despite the host of laws in place to mandate and oversee the detailed cultural resources surveys undertaken on behalf of Resolution Copper, it is likely that some portion of currently buried or otherwise undetected prehistoric (Native American only) and historic (Native American and Euro-American) artifacts and resources could be lost to mine-related construction and operation. This is especially true in areas such as Oak Flat, the Queen Creek watershed, and the Superior area, which have long histories of human habitation. Even those sites and artifacts that researchers have recorded and archived would be irrevocably altered.

Cultural resources consist of the physical aspects of the activities of past or present cultures, including archaeological sites, historic buildings and structures, trails, roads, infrastructure, traditional cultural properties, and other places of traditional, cultural, or religious importance. Cultural resources can be human-made or natural features and are, for the most part, unique, finite, and nonrenewable. Cultural resources are often discussed in terms of historic properties under the National Historic Preservation Act (NHPA); however, the term "historic properties" has a very specific definition that may omit other resources that are critical to NEPA analysis but do not qualify as historic properties. This analysis is designed to capture potential impacts on cultural resources within the project area; however, it focuses on the potential impacts on historic properties (i.e., cultural resources that are listed in or have been determined eligible for listing in the National Register of Historic Places (NRHP)) and cultural resources that have not been evaluated for their NRHP status. The numbers and types of historic properties and those resources that may be historic properties represent the best possible information about cultural resources that can be verified and quantified.

3.12.1.1 Changes from the DEIS

Since the publication of the DEIS, surveys for cultural resources have been completed and reported on for the majority of the project area and alternatives; these data were compiled and used in the FEIS analysis. Design elements for project components, including alternatives, have been refined and are reflected in the analysis. Alternatives 5 and 6 now have only a single pipeline route to reach the tailings storage facility, as described in chapter 2. Additionally, we revised the Alternative 6 pipeline route, primarily to address potential impacts to habitat and resources along Mineral Creek. These changes are reflected in this section.

In response to comments on the DEIS, information and analysis on indirect or atmospheric impacts to the built environment of Superior, Globe, and Miami was added, as well as a discussion of the Section 106 area of potential effects (APE) and its relationship to the analysis area. Methods for the visual analysis have been brought more in line with those used in Section 3.11, Scenic Resources. Expanded background information on the Historic Euro-American period has been added. Mitigation discussions have been updated to reflect measures that were developed for the Section 106 PA in consultation with the tribes, local communities, the public, and cooperating agencies to resolve adverse effects; these measures are summarized in appendix J.

The cumulative effects analysis was revised for the FEIS to better quantify impacts. It is described in detail in chapter 4 and summarized in this section.

3.12.2 Analysis Methodology, Assumptions, and Uncertain and Unknown Information

3.12.2.1 Analysis Area

There are three distinct analysis areas for this discussion: the direct impacts analysis area, the indirect impacts analysis area, and the atmospheric impacts analysis area. The analysis areas for cultural resources for the GPO generally correspond to the Section 106 of the NHPA direct and indirect APEs, defined by 36 CFR 800.16(d) as "the geographic area or areas within which an undertaking may directly or indirectly cause alterations in the character or use of historic properties."

The APE was developed through consultation with the Arizona SHPO, Advisory Council on Historic Preservation (ACHP), BLM, ASLD, affected tribes, and other consulting parties. The APE has been broadened several times throughout the consultation process to now include most of what is known as the "Copper Triangle" (see figure 1.2-1). It generally consists of a 6-mile buffer around the GPO project area, all tailings facility alternatives, and the Oak Flat Federal Parcel. The buffer has been extended outward in two areas: 7 miles to the east to include the community of Top-of-the-World, and up to 9 miles southeast to incorporate additional historic mining areas. As the project analysis progressed, several areas outside the buffer were added to the APE. The historic districts of Globe and Miami were added at the request of the SHPO as discontiguous portions of the APE. Also added were the compensatory mitigation lands required by the USACE CWA Section 404 permit. This expansive APE was designed to capture direct, indirect, and cumulative effects within three zones: (1) physical effects within the project footprint up to the fence lines, the Oak Flat Federal Parcel, and the 404 mitigation parcels; (2) auditory effects within 2 miles of the project footprint and Oak Flat Federal Parcel; and (3) visual/atmospheric/socioeconomic effects within 6 to 9 miles of the project footprint, and the historic districts of Globe and Miami.

Direct Analysis Area

The direct impacts analysis area for each alternative consists of the complete footprint of all project elements, including the lands leaving Federal management under the land exchange, the recreation mitigation lands, and the 404 mitigation parcels. For the direct analysis area, the analysis assumes that all areas within those boundaries or fence lines would be disturbed. The direct analysis area for the proposed action (GPO and land exchange) is approximately 38,446 acres and consists of the following areas of assumed disturbance, which includes access roads and other linear infrastructure:

- East Plant Site and subsidence area, including the reroute of Magma Mine Road (1,861 acres that is partially within the Oak Flat Federal Parcel and includes private, NFS, and ASLD lands);
- 2,422-acre Oak Flat Federal Parcel of NFS land to be exchanged with Resolution Copper;
- 940-acre West Plant Site;
- 6.96-mile Silver King to Oak Flat transmission line;
- 685-acre MARRCO railroad corridor and adjacent project components;
- 553-acre filter plant and loadout facility; and
- Alternatives 2–6 tailings storage facilities and tailings corridors: tailings storage facility and tailings corridor for Alternatives 2 and 3; and Alternative 4 – Silver King, Alternative 5 – Peg Leg, and Alternative 6 – Skunk Camp, which have different locations and overall footprints from the GPO tailings storage facility and tailings corridor.

Various permitted archaeological contractors over the past 15 years collected data through Class I records searches (records check at local, State, and Federal levels) and Class III pedestrian surveys (field crews systematically walk the analysis area and record resources). As of August 2020, crews had surveyed the majority of the direct analysis areas for cultural resources. This analysis includes as many of these data as were available. Please note that some survey results are preliminary and may change after the FEIS is published.

Indirect Impacts Analysis Area

The indirect impacts analysis area consists of a 2-mile buffer around all project and alternative components. The 2-mile buffer is designed to account for impacts on resources not directly tied to ground disturbance and outside the direct analysis area. Potential indirect impacts include, but are not limited to, inadvertent damage, vandalism, unsanctioned collecting, and impacts caused by vibration from mine construction and operations.

Atmospheric/Socioeconomic Impacts Analysis Area

The atmospheric/socioeconomic impacts analysis area (including visual and auditory impacts) consists of a 6-mile buffer around all project and alternative components. The atmospheric impacts analysis area encompasses approximately 729,674 acres for all project components under all alternatives. The analysis area for cultural resources is shown in figure 3.12.2-1.

VISUAL IMPACT ANALYSIS

The visual impact analysis for cultural resources follows the scenic resources analysis for the EIS presented in Newell and Grams (2018). The visual impacts analyzed are within the scenic resources analysis area (see section 3.11) which is defined by buffers around project components:

- 6 miles around tailings facility alternatives
- 2 miles around slurry pipeline corridors, the East Plant Site and subsidence area, the West Plant Site, and transmission lines
- 1 mile on either side of the MARRCO corridor

For the 2-mile buffer around slurry pipeline corridor alternatives, the East Plant Site and subsidence area, the West Plant Site, and transmission lines, and the 1-mile buffer for the MARRCO corridor, it was assumed that those project components could be seen within these buffer areas with no obstructions.

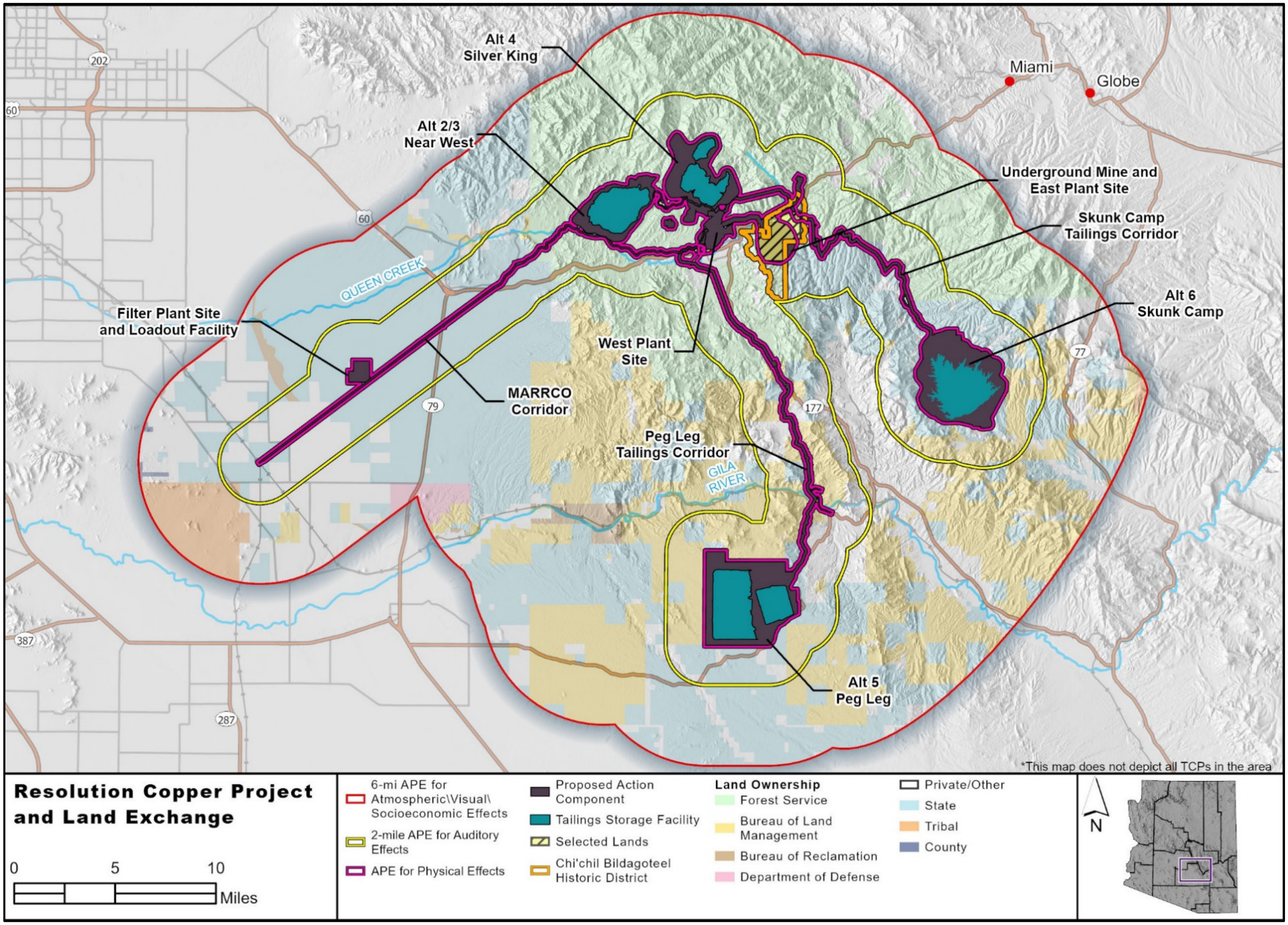


Figure 3.12.2-1. Analysis areas for cultural resources

3.12.2.2 Impact Indicators

Direct impact on a historic property would consist of damage, loss, or disturbance caused by ground disturbance that would alter the characteristic(s) that make the property eligible for listing in the NRHP. Indirect impacts would consist primarily of visual impacts from alterations to setting, feeling, or association of a resource where setting is a significant component of its NRHP eligibility; however, other indirect impacts such as auditory impacts or inadvertent disturbance are also assessed.

Impact indicators for this analysis include the following:

- Loss, damage, or disturbance to resources listed in State or Federal registers;
- Loss, damage, or disturbance to resources that are eligible or may be eligible for State or Federal registers;
- Loss, damage, or disturbance to traditional cultural properties (TCPs); and
- Alterations to setting, feeling, or association for a historic property listed in or eligible to be listed in the National or State register under Criteria A, B, and/or C.

Adverse impacts on historic properties would be avoided, minimized, or mitigated through the NHPA Section 106 process.

3.12.3 Affected Environment

3.12.3.1 Relevant Laws, Regulations, Policies, and Plans

The primary Federal, State, and agency regulations, policies, and guidelines used to analyze potential impacts on cultural resources in the project analysis area are shown in the accompanying text box.

Primary Legal Authorities and Technical Guidance Relevant to the Cultural Resources Effects Analysis

- National Historic Preservation Act (NHPA) of 1966 (54 U.S.C. 300101 et seq.)
- Archaeological Resources Protection Act (ARPA) of 1979 (16 U.S.C. 470aa–470mm)
- American Indian Religious Freedom Act (AIRFA) of 1978 (42 U.S.C. 1996)
- Native American Graves Protection and Repatriation Act (NAGPRA) of 1990 (25 U.S.C. 3001–3013)
- Executive Order 13007 (May 24, 1996), "Indian Sacred Sites"
- Executive Order 13175 (November 6, 2000), "Consultation and Coordination with Indian Tribal Governments"
- Arizona Antiquities Act of 1960 (ARS 41-841 through 41-844)
- State Historic Preservation Act of 1982 (ARS 41-861 through 41-865)
- Tonto National Forest Land and Resource Management Plan
- Programmatic Agreement among the USDA Forest Service Tonto National Forest, Arizona State Historic Preservation Officer, The Advisory Council on Historic Preservation, Regarding Compliance with the National Historic Preservation Act on the Resolution Copper Project and Southeast Arizona Land Exchange Near Superior, Arizona

A complete listing and brief description of the legal authorities and agency guidance used in this cultural resources impacts analysis may be reviewed in Newell (2018a).

Compliance with Section 106 of the NHPA

The most pertinent law or regulation for the proposed project is Section 106 of the NHPA and its implementing regulations found at 36 CFR 800. Section 106 requires federal agencies to consider the effects of an undertaking on historic properties which are defined by 36 CFR 800.16(l)(1) as any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion in, the NRHP. An undertaking is a project, activity, or program funded in whole or in part under the direct or indirect jurisdiction of a Federal agency, including those carried out by or on behalf of a Federal agency; those carried out with Federal financial assistance; and those requiring a Federal permit, license, or approval (36 CFR 800.16(y)).

36 CFR 800 sets forth the procedures to be followed during the Section 106 process: initiation of the Section 106 process, identification of historic properties, assessment of adverse effects, and resolution of adverse effects. The following summarizes each step in the process and how the Forest Service has fulfilled its responsibilities as lead Federal agency for the undertaking.

During the initiation of the Section 106 process (36 CFR 800.3), the Federal agency establishes that there is an undertaking and determines that it has the potential to affect historic properties. The agency then ascertains whether other State or Federal agencies are involved, identifies the appropriate SHPO and/or Tribal Historic Preservation Officers (THPOs), identifies appropriate tribes and others consulting parties, and makes a plan for involving the public in the process. The Forest Service initiated consultation with the SHPO on March 31, 2017; with ACHP on December 7, 2017; and with 11 tribes on the prefeasibility exploration plan for the Resolution Copper Project via a letter dated June 6, 2008, for the land exchange via a letter dated August 4, 2015, and with four additional tribes on December 3, 2018.

The Forest Service determined that due to the complexity of the project, a PA would be needed to modify the Section 106 processing moving forward. The Forest Service has developed a PA in consultation with SHPO, ACHP, tribes, and other consulting parties; the final version of the PA circulated for signature can be found in appendix O. The PA outlines the roles and responsibilities of parties, the procedure for identification and evaluation of historic properties, assessment for effects, and each party's responsibilities under the Section 106 process. Several versions of the PA were sent out for review and comment to the consulting parties including the tribes. Comments were received and incorporated into each new draft of the PA. In addition, the Forest Service held meetings with the tribes to discuss the PA on October 28 and 29, 2019. The following processes described below are in accordance with those described in the PA.

During the identification of historic properties (36 CFR 800.4), the Federal agency determines the APE in consultation with the SHPO/THPO, tribes, and other consulting parties, identifies resources that may be historic properties within the APE to the appropriate level of effort in consultation with the SHPO/THPO, tribes, and other consulting parties, and evaluates the historic significance of each resource through application of the NRHP criteria and determining whether a resource is eligible for the NRHP in consultation with the SHPO/THPO, tribes, and other consulting parties.

The Forest Service continuously consulted with the SHPO, tribes, and consulting parties regarding the APE. The APE has changed and been shaped by the input of these parties over time. We assert that this APE is expansive enough to account for direct, indirect, and cumulative effects of the project (see section 3.12.2.1 above for discussion of APE development).

For the APE for physical effects, the Forest Service directed the completion of pedestrian surveys across the majority of the physical APE where project-related ground-disturbing activities might occur (see below for an expanded discussion of these survey and their results). Areas surveyed include the Oak Flat Federal Parcel, GPO project components (East Plant Site, West Plant Site, MARRCO corridor, and filter plant and loadout facility), and the proposed tailings locations for Alternatives 2, 3, 4, 5, and 6. Results from these cultural resource inventories have been compiled into three reports and shared with the SHPO, relevant land-managing agencies, and consulting tribes.

For the APE for auditory effects and the APE for visual effects, a Class I records search for archaeological sites and built environment resources was conducted of the entire APE (see below). The Forest Service also sought information on places of traditional and cultural importance to tribes through three measures: tribal consultations, compilation of an ethnographic and ethnohistoric report, and pedestrian surveys by tribal monitors of the APE for physical effects. Along with agency determinations on eligibility, survey results have been or will be shared with SHPO, land-managing agencies, and consulting tribes. Please note that some reports contain sensitive information provided by the tribes and therefore this information is shared in a summarized form as part of consultation.

During the assessment of adverse effects (36 CFR 800.5), the Federal agency, in consultation with the SHPO/THPO, tribes, and other consulting parties, applies the criteria of adverse effects on the historic properties in the APE and determines if the undertaking will result in an adverse effect on historic properties. If no adverse effects are found, then the undertaking may be implemented and the agency's Section 106 responsibilities have been fulfilled. If adverse effects on historic properties are found, the agency must consult with SHPO, tribes, and other consulting parties to resolve the adverse effects.

In consultation with SHPO, ACHP, tribes, and other consulting parties, the Forest Service determined that the project will have an adverse effect on historic properties. However, because of the complexity of the project, all of the effects would not be known prior to implementation of the project. The processes for addressing these effects is outlined in the PA (see appendix O).

Resolution of adverse effects (36 CFR 800.6) involves the agency consulting with SHPO, tribes, and other consulting parties to develop strategies to avoid, minimize, or mitigate adverse effects on historic properties. This is done through the development and implementation of an agreement between the Federal agency, the ACHP, the SHPO, and tribes and other consulting parties. The development shall also include the public.

In accordance with 36 CFR 800.2(d)(3), the Forest Service intentionally relied on a NEPA public participation strategy to assist the Federal agencies in satisfying the public involvement requirements under Section 106. This strategy included involving interested parties in the NEPA process, providing project information to the public, giving them opportunities to comment on the project including Section 106 issues through five public scoping meetings held on April 4, 5, 6, March 31, and June 9, 2016; two alternatives workshops held on March 21 and 22, 2017; and DEIS public meetings on September 10, 12, 17, 19, and October 8 and 10, 2019. Specific workshops to hear public comments and concerns about Section 106 compliance and the PA were held on June 13, 14, and 15, 2018. A workshop for consulting parties to discuss the PA was held on December 11, 2019. Additionally, the Forest Service received public comments through the NEPA process on the PA as presented in the DEIS.

3.12.3.2 Existing Conditions and Ongoing Trends

Human occupation of east-central Arizona spans from the Paleoindian period to today, with the primary occupation in the project area vicinity from the Formative era to the Late Historic period. The following section is a brief overview to provide context for discussing potential impacts from the proposed project.

Cultural History

PALEOINDIAN PERIOD

The earliest human occupation of the Southwest and Arizona is known as the Paleoindian tradition and associated with hunters living in the end of the Pleistocene glaciations (9500–8500 B.C.). The Paleoindian tradition is defined by a series of large projectile (spear) points that are often found in association with late Pleistocene megafauna such as the mammoth and bison. Clovis, the earliest Paleoindian complex, is characterized by distinctive lanceolate points. Following Clovis is the Folsom complex (8900–8200 B.C.), identified by a smaller fluted point most commonly found in association with bison remains. Most Folsom finds in Arizona come from the Colorado Plateau. The Folsom tradition is followed by a series of other poorly dated and sometimes overlapping complexes, including the Plainview, Agate Basin, and Cody complexes. Most of the point types (Plainview, Agate Basin, Eden, and Scottsbluff) associated with these complexes have also been found on the Colorado Plateau.

ARCHAIC PERIOD

The Archaic period spans roughly from 8000 B.C. to A.D. 300 in the Southwest, beginning around the time of the Pleistocene-Holocene transition and the extinction of the Pleistocene big game. Archaeologists divide the Archaic period based on projectile point styles: Early Archaic (8000–5000 B.C.), Middle Archaic (5000–ca. 2000 B.C.), and Late Archaic–Early Agricultural (ca. 2000 B.C. up to A.D. 250). Archaic groups were hunter-gatherers specializing in exploiting small-game and plant resources. They traveled in a seasonal pattern exploiting specific resources in their territory as those resources became available or ripe. Archaic remains are represented by campsites or resource procurement and/or processing sites.

The Late Archaic is also referred to as the Early Agricultural period. The introduction of agriculture transformed cultures in the Southwest, but there is still debate about when and how this transformation occurred. Maize was introduced from Mexico before A.D. 1, and possibly as early as 2100 B.C. The Late Archaic–Early Agricultural period sees the beginning of village life, with agricultural communities appearing on floodplains. However, while maize and other crop cultivation became increasingly important over time, wild resources continued to play a large role in Late Archaic–Early Agricultural subsistence patterns. The end of the Late Archaic–Early Agricultural period is signaled by the adoption of ceramic vessels.

FORMATIVE PERIOD

Hohokam

The Formative era begins with the appearance of pottery in the archaeological record. In central Arizona, the best-documented and most common archaeological remains are attributed to the Hohokam culture. The Hohokam lifeway was characterized by a mixed subsistence pattern of wild resources and agricultural products, pottery (both plain and decorated red-on-buff wares), pit houses, and canal irrigation. Later Hohokam participated in large exchange networks and constructed ball courts and platform mounds. However, by the Late Formative, the Hohokam were in decline due to overpopulation, loss of agricultural production, and droughts.

Salado

During the Late Formative, Salado ceramics began to appear in central Arizona. The Salado culture was centered on the Tonto Basin in the Late Formative, and, while heavily influenced by Hohokam culture, developed with a unique set of traits and patterns. Salado culture is characterized by polychrome pottery and aboveground masonry structures within compounds. Evidence of trade networks can be seen in the spread of polychrome pottery in southern Arizona. At the end of the Formative, a reorganization of Salado sites can be seen, with many villages abandoned in favor of a smaller number of larger settlements, possibly due to conflicts. The Salado went into decline likely due to environmental factors and population pressure, and by the end of the Formative period most Salado sites were abandoned.

PROTOHISTORIC AND HISTORIC NATIVE AMERICAN

The project area is within the traditional territories of the Western Apache, the Yavapai, and the Akimel O'odham or Upper Pima. The histories of the Western Apache—a group that includes ancestors of the White Mountain, San Carlos, Cibecue, and Tonto Apache—tell of migrations into Arizona where they encountered the last inhabitants of villages along the Gila and San Pedro Rivers. The Western Apache practiced a mixed subsistence strategy of farming in the summer in the north, and hunting and gathering in the winter in the south. In the 1870s, the Apache were forced onto reservations, which curtailed much of their seasonal round. However, not all Apache stayed on the reservations, and some continued to use the vicinity of the project area into the twentieth century. Like the Western Apache, the Yavapai practiced a mixed subsistence strategy with an emphasis on hunting and gathering. Yavapais had little contact with Euro-Americans until the 1860s, and also like the Apache, after silver was discovered in Arizona, they were forced onto reservations in the 1870s. The Akimel O'odham were primarily farmers who also practiced hunting and gathering of wild resources. They and other O'odham groups are the likely descendants of the Hohokam, and like the Hohokam, lived along the Gila River to the west of the project area. The year-round source of water allowed them to settle large villages and cultivate more crops with irrigation agriculture than some of the other O'odham groups in harsher areas of the desert while still gathering resources from the surrounding areas.

HISTORIC EURO-AMERICAN

Spanish, Mexican, and Euro-American settlers began to arrive in appreciable numbers in the eighteenth century. The ensuing period of historical exploitation was marked by mining, ranching, and homesteading interests. After the end of the Mexican–American War and the signing of the Treaty of Guadalupe in 1848, the United States acquired what was to become Arizona from Mexico.

The discovery of gold in California, the 1862 Homestead Act, and development of gold and silver mines in western and central Arizona heralded the arrival of a large number of Euro-American settlers. However, in the vicinity of the project area, the Apache presence prevented much settling of the area until they were forcibly removed by the U.S. Army and several forts were established in the area. Mining became a significant industry by the late 1800s, with mines in Globe, Miami, Ray, and Superior. Some of these mines were exhausted quickly; others, like the Ray Mine, are still in operation today. Mining brought all sorts of people to the area looking for work, including Mexican Americans and Native Americans as well as Anglo miners and settlers. Ranchers also came to the area in the late 1800s, and several small ranches were established. These ranches remained small operations but often supplied food to local miners; ranchers also worked for the mines to supplement their income.

Concerns over environmental degradation in the area due to overgrazing and drought led to the establishment of the Tonto National Forest (then the Tonto National Reserve) in 1905 to protect the Salt River Watershed. Some of the Tonto National Forest was transferred to the Crook National Forest in 1908, but was eventually returned. During the Works Progress Administration era, a large erosion control project was conducted in the project area, as well as establishing the Oak Flat Campground. Nature-based tourism and recreation continues to play an important role in the area, enhancing the quality of life and economy of local communities.

Inventories of the Direct Impacts Analysis Area

To date, 56 cultural resource surveys, inventories, assessments, or monitoring projects have been completed within the direct analysis area.[96] Twenty surveys have been conducted in the selected lands and/or East Plant Site (Benz 2006; Buckles 2008; Buckles and Granger 2009; Chamorro 2014a, 2015; Deaver 2010, 2017; Dolan and Deaver 2007; Lindeman 2003; Lindeman and Whitney 2005; Prasciunas and Chamorro 2012; WestLand Resources Inc. 2009). Three surveys or inventories were conducted within the West Plant Site (Chamorro 2015; Deaver 2012; Steely 2011). Four surveys or monitoring projects were conducted within the Near West tailings storage facility (Alternatives 2 and 3) and corridor (Chamorro 2014b; Chamorro et al. 2016; Hooper 2014; Hooper and Tinseth 2015). Eight surveys were conducted within the MARRCO corridor and the filter plant and loadout facility (Buckles 2007; Buckles and Jerla 2008; Buckles et al. 2012; Cook 2007a, 2007b; King and Buckles 2015; Ryden et al. 2004). Surveys of the Silver King, Peg Leg, and Skunk Camp alternatives have been completed (Chamorro, Brown, et al. 2019; Chamorro, Tinseth, et al. 2019). Reports for Silver King and Peg Leg are now final; the Skunk Camp report is in draft form and has been submitted to the Tonto National Forest for review. Two surveys have been conducted of proposed transmission line routes (Charest 2020; Deaver 2012).

Surveys have also been completed of areas identified for projects to mitigate adverse impacts to resources other than cultural resources. For recreation, two surveys were conducted: Recreational Users Group trail (Taylor et al. 2019) and Inconceivables Road (Poseyesva 2020b). Surveys were also conducted of the proposed Castleberry Campground and an associated water line (Gruner 2020; Poseyesva 2020a); the campground is proposed as a mitigation for recreation and cultural resources. For Section 404 of the CWA compensatory mitigation, nine surveys were conducted of proposed parcels (Charest 2016a, 2016b, 2016c, 2016d; Charest and Francis 2016; Daughtrey 2015, 2016; Gruner 2017; Taylor and Poseyesva 2020) , and two assessments of parcels on Gila River Indian Community reservation land (Gila River Indian Community 2012, 2018).

Surveys have also been completed of the Superior Airport parcels and Fairview Cemetery parcel (Brown and Buckles 2019; King 2019). These parcels may be requested by the Town of Superior as part of a future land exchange as described in Section 3003(h) of PL 113-291. These parcels have yet to be requested for conveyance by the Town of Superior and are not included in the FEIS analysis.

Incomplete or Missing Information

Seventy-eight percent of all alternatives and mitigation parcels have been surveyed. Missing survey coverage within the alternatives is largely due to terrain and access issues, as well as post-survey design changes.

The reports on the results of the survey of the pipeline corridor for Alternative 5 – Peg Leg and the survey of Alternative 6 – Skunk Camp are still in draft form; changes to NRHP-eligibility status may occur as a result of consultation. For the built environment, data from previously conducted historic building surveys were used for Globe and Miami; a survey update will be conducted as part of the Section 106 process but was not necessary for the EIS analysis. No historic built environment data were available for Top-of-the-World and a survey will be conducted as part of the Section 106 process; however, it is not expected that any historic properties are present at Top-of-the-World.

[96] Two of the surveys listed cover more than one mine facility. Readers should note that while all references and citations for the EIS are made available via the EIS website, reports containing locational information of cultural resources are considered to be sensitive; therefore, only redacted versions may be made available, subject to the decision of the Forest Supervisor.

Inventory of the Indirect Impacts Analysis Area

For the indirect impacts analysis area, SWCA Environmental Consultants (SWCA) conducted a Class I records search of the area. The cultural resources team searched AZSITE—the online cultural resources database that contains records from the SHPO, BLM, and the ASLD—as well as records housed at the Tonto National Forest Phoenix Office, the BLM Tucson and Lower Sonoran Field Offices, and the Arizona State Museum, for all recorded archaeological sites within 2 miles of the direct analysis area. The NRHP database was also searched for historic properties listed within 2 miles of the direct analysis area.

Inventory of the Atmospheric Impacts Analysis Area

For the atmospheric impacts analysis area, SWCA conducted a Class I records search of the area. The cultural resources team searched AZSITE, the Tonto National Forest Phoenix Office records, Arizona State Museum, and the BLM Tucson and Lower Sonoran Field Offices records for resources (historic properties) eligible for the NRHP under Criteria A, B, and/or C. Previous built environment surveys for Superior, Globe, and Miami were consulted for properties eligible under Criteria A, B, and/or C. Personnel also searched the NRHP for resources listed under Criteria A, B, and/or C. Historic properties eligible for the NRHP under Criteria A, B, and/or C are more likely to be sensitive to impacts on setting than properties determined to be eligible under Criterion D.

Direct Analysis Area

ARCHAEOLOGICAL SITES

Within the direct impacts analysis area, 644 archaeological sites have been recorded. Of the 645 sites, 506 are recommended or determined eligible for the NRHP, 116 are recommended or determined not eligible for the NRHP, 21 are undetermined, and one is exempt from Section 106 compliance.

The archaeological sites range in age from the Archaic to Historic periods and several sites have two or more temporal components. Cultural site components are attributed to Archaic peoples (12), Hohokam (64), Hohokam-Salado (48), Salado (311), Apache-Yavapai (18), Native American (91), Euro-American (151), and unknown (3). Archaeological sites found in the analysis area represent short- and long-term habitations, agricultural sites, resource procurement and processing sites, campsites, a historic-age campground, communication sites, ranching sites, mining sites, soil conservation, utilities, transportation (roads and trails), recreation activities, water management, and waste management.

TRADITIONAL CULTURAL PROPERTY

One NRHP-listed TCP is located within the direct analysis area: the *Chí'chil Biłdagoteel* Historic District. The *Chí'chil Biłdagoteel* Historic District was listed on the NRHP in 2016 as an Apache TCP and its boundaries contain 38 archaeological sites that contribute to the overall eligibility of the district, in addition to sacred places, springs, and other significant locations. See Section 3.14, Tribal Values and Concerns, for a more detailed discussion of the resource. Of the 38 archaeological sites within the TCP, six are found within the direct impacts analysis area.

HISTORIC BUILDINGS AND STRUCTURES

Twenty-eight historic buildings or structures have been recorded within the direct analysis area. Seventeen of the historic buildings or structures are associated with the Magma Mine; however, all but three have been demolished as part of a reclamation plan. No formal recommendation or determination of eligibility has been made for the Magma Mine resources. The remaining eight resources are in-use historic-era linear resources (roads and utility lines) and a ranch. All eight are recommended not eligible for the NRHP.

Indirect Analysis Area

The Class I records search of the indirect analysis area resulted in 602 cultural resources. Of the 602, eight are listed in the NRHP, 291 are eligible for listing in the NRHP either individually or as contributing to a district, 245 are unevaluated, and 58 are not eligible. The majority of the eligible resources are prehistoric and historic archaeological sites eligible under Criterion D for their information potential. The eight listed resources are the Gabel House, The Eleven Arches, the Erskine P. Caldwell House, the Magma Hotel, the Boyce Thompson Arboretum, the Butte-Cochran Charcoal Ovens, the Queen Creek Bridge, and the Devil's Canyon Bridge. Thirty-four buildings in Superior are eligible for listing individually or as contributing to the Superior Commercial Historic District and the Magma Heights Historic District.

Atmospheric Analysis Area

The Class I records search of the atmospheric analysis area for historic properties listed in or eligible for listing in the NRHP under Criterion A, B, or C resulted in 25 historic buildings, structures, or districts listed in the NRHP, 33 eligible individually or as contributors to a district in Superior, two listed districts in Globe, three potential districts in Miami, the listed *Chí'chil Biłdagoteel* Historic District, and 46 archaeological sites eligible for listing in the NRHP. The historic buildings include several houses, commercial buildings, churches, a school, a post office, a courthouse, a mine rescue headquarters, a motel, and a hotel. Historic structures include five bridges, charcoal ovens, and the Boyce Thompson Arboretum. Archaeological sites include Civilian Conservation Corps features, mining sites, roads and highways, railroads, canals, and transmission lines, as well as prehistoric artifact scatters and petroglyph sites.

3.12.4 Environmental Consequences of Implementation of the Proposed Mine Plan and Alternatives

3.12.4.1 Alternative 1 – No Action

Direct Impacts

Under the no action alternative, the Forest Service would not approve the GPO, and current management plans would be in place. Resolution Copper would continue current activities on private property. As described in section 2.2.3, the no action alternative analyzes the impacts of (1) the Forest Service's not approving the GPO, and (2) the land exchange's not occurring.

If the GPO is not approved, the proposed Resolution Copper Project would not occur, and no adverse direct impacts on cultural resources would be anticipated. If the land exchange does not occur, the selected lands would remain under Federal management, and no direct adverse impacts on cultural resources would be anticipated. Current management of historic properties and other cultural resources would continue as it is today.

Indirect Impacts

If the GPO is not approved, the mine would not occur, and no adverse indirect impacts on cultural resources would be anticipated. If the land exchange does not occur, the selected lands would remain under Federal management, and no indirect adverse impacts on cultural resources would be anticipated.

Atmospheric Impacts

If the GPO is not approved, then none of the proposed mining facilities would be constructed, so no adverse indirect impacts on cultural resources would be anticipated from mining facilities. If the land exchange does not occur, no adverse indirect impacts on cultural resources would be anticipated.

3.12.4.2 Impacts Common to All Action Alternatives

Effects of the Land Exchange

The land exchange would have effects on cultural resources.

The Oak Flat Federal Parcel would leave Forest Service jurisdiction. The role of the Tonto National Forest under its primary authorities in the Organic Administration Act, Locatable Regulations (36 CFR 228 Subpart A), and Multiple-Use Mining Act is to ensure that mining activities minimize adverse environmental effects on NFS surface resources; this includes cultural resources. The removal of the Oak Flat Federal Parcel from Forest Service jurisdiction negates the ability of the Tonto National Forest to regulate effects on these resources. If the land exchange occurs, 31 NRHP-eligible archaeological sites and one TCP within the selected lands would be adversely affected. Under Section 106 of the NHPA and its implementing regulations (38 CFR 800(a)(2)(vii)), historic properties leaving Federal management is considered an adverse effect, regardless of the plans for the land, meaning that, under NEPA, the land exchange would have an adverse effect on cultural resources.

The offered lands parcels would enter either Forest Service or BLM jurisdiction. Entering Federal management would offer additional protection for any cultural resources on these lands. Cultural resources surveys of the offered lands have identified 93 archaeological sites: 65 eligible and 28 not eligible. Of the 65 eligible sites, three have an Archaic component, 12 have a Hohokam component, 24 have a Hohokam/Salado or Hohokam/Pueblo component, seven have a Southern Sinagua component, four have a Salado component, two have a Sobaipuri or Sobaipuri/Apache component, four have a Native American not further specified component, 10 have a Euro-American component, and two components are Unknown. Native American sites consist of habitations, including hamlets, villages, pueblos, compounds, and a rockshelter; agricultural sites, including terraces, gridded fields, rock piles, and field houses; resource procurement and processing sites; and rock art. Euro-American sites consist of roads, homesteads and ranches, and mining sites.

Effects of Forest Plan Amendment

The Tonto National Forest Land and Resource Management Plan (1985b) provides guidance for management of lands and activities within the Tonto National Forest. It accomplishes this by establishing a mission, goals, objectives, and standards and guidelines. Missions, goals, and objectives are applicable on a forest-wide basis. Standards and guidelines are either applicable on a forest-wide basis or by specific management area.

A review of all components of the 1985 forest plan was conducted to identify the need for amendment due to the effects of the project, including both the land exchange and the proposed mine plan (Shin 2020). A number of standards and guidelines (10) were identified as applicable to management of cultural resources. None of these standards and guidelines were found to require amendment to the proposed project, either on a forest-wide or management area-specific basis. For additional details on specific rationale, see Shin (2020).

Effects of Compensatory Mitigation Lands

Cultural resources surveys identified five archaeological sites on the compensatory mitigation lands: three eligible and two not eligible for the NRHP. The three eligible sites are a highway, a transmission line, and a resource processing and procurement site. The planned activities on the compensatory mitigation lands are focused on restoring riparian systems and, if sites are avoided during the restoration, would not have an effect on cultural resources.

Within the parcels slated for recreation mitigation, 14 NRHP-eligible or undetermined archaeological sites have been recorded. Three sites have a Hohokam component, one has a Salado component, five have Native American components, and six have Euro-American components. Prehistoric sites include habitation, field house, campsites, resource procurement and processing sites, and a rockshelter. Historic sites include roads or trails, transmission lines, a townsite, and waste piles.

Effects of Recreation Mitigation Lands

The recreation mitigation lands are anticipated to have an adverse effect on cultural resources. While preliminary trail alignments and trailhead areas were surveyed for cultural resources that are eligible for the NRHP and trail designs were refined to reduce conflict with cultural resources, any ground disturbance is deemed to be an adverse effect on cultural and tribal resources.

Summary of Applicant-Committed Environmental Protection Measures

A number of environmental protection measures are incorporated into the design of the project (the GPO, not the land exchange) that would act to reduce potential impacts on cultural resources. These are non-discretionary measures, and their effects are accounted for in the analysis of environmental consequences.

Applicant-committed environmental protection measures to reduce impacts on cultural resources are covered in the GPO. Specifically, Resolution Copper has committed to following the Section 106 process for the resolution of adverse effects on historic properties, including the development of a PA (see appendix O) and will design the footprint of the project to avoid resources to the maximum extent possible. Aspects of the PA are discussed in the “Mitigation Effectiveness” section below.

3.12.4.3 Alternative 2 – Near West Proposed Action

Direct Impacts

Under Alternative 2, 138 cultural resources would be impacted: 120 NRHP-eligible and 18 undetermined archaeological sites. Ninety-five percent (9,288 acres) of the total alternative has been surveyed at the time of this review. Table 3.12.4-1 presents the number of cultural resources that are listed in or eligible for the NRHP or that are of undetermined NRHP status within each project element. Some sites would be impacted by more than one project element; hence, the total numbers in the following tables are different from the total number of sites overall.

Of the site components present in Alternative 2, six can be attributed to the Archaic, 17 to the Hohokam, 21 to Hohokam-Salado, 49 to the Salado, 13 to the Apache-Yavapai, 12 to Native American, 13 to Euro-American, and one unknown. The Archaic components are represented by campsites. Formative period sites attributed to the Hohokam, Hohokam-Salado, or Salado are large and small habitation sites including one Hohokam village, campsites and resource processing sites, a Salado hilltop retreat, agricultural sites, and a lithic quarry. The Protohistoric-Historic Apache-Yavapai sites are campsites and one rockshelter. The Historic Euro-American sites consist of roads, trails, railroads and facilities, mineral exploration and exploitation, homesites, ranching sites, utility lines, and waste piles.

In addition, Alternative 2 would adversely impact one NRHP-listed TCP in the East Plant Site and undetermined historic buildings in the West Plant Site; this is true for Alternatives 2 through 6.

Table 3.12.4-1. Cultural resources directly impacted by Alternative 2

GPO Component	Number of NRHP-Listed or Eligible Sites	Number of NRHP-Undetermined Sites	Total
Oak Flat Federal Parcel	43	0	**43**
East Plant Site and subsidence area	24	0	**24**
West Plant Site	9	0	**9**
Tailings facility and corridor	20	16	**36**
Silver King Mine Road realignment	6	0	**6**
MARRCO corridor	38	2	**40**
Transmission line	15	0	**15**

Note: Some sites would be impacted by more than one project element; hence, total numbers in this table are different from the total number of sites overall.

Indirect Impacts

Within the indirect impact analysis area for Alternative 2, 62 cultural resources may be impacted: two listed, 41 eligible, and 19 unevaluated. Nine of those resources are within 2 miles of the tailings facility, one is within 2 miles of the East Plant Site and subsidence area (the *Chí'chil Biłdagoteel* Historic District), 38 are within 2 miles of the West Plant Site, one is within 2 miles of Silver King Mine Road, 12 are within 2 miles of the MARRCO corridor (including the Boyce Thompson Arboretum), and three are within 2 miles of the transmission line corridor. Of the 37 resources within 2 miles of the West Plant Site, 33 are buildings in Superior.

Indirect impacts to historic buildings in Superior, including those in the two potential historic districts, may occur from noise and vibration generated by increased traffic.

Atmospheric Impacts

Outside of the proposed project footprint for Alternative 2, there are 53 historic properties listed on or eligible for listing on the NRHP under Criterion A, B, or C within 2 miles of the East Plant Site, the West Plant Site, the subsidence area, and the transmission line. Four resources are listed on the NRHP: *Chí'chil Biłdagoteel* Historic District, the Boyce Thompson Arboretum, the Devil's Canyon Bridge, and the Hotel Magma. The *Chí'chil Biłdagoteel* Historic District is less than 1 mile from the East Plant Site/subsidence area, the West Plant Site, and the Silver King to Oak Flat transmission line corridor. Other historic properties within 2 miles of the East Plant Site, the West Plant Site, the subsidence area, and the transmission line include 14 archaeological sites, two proposed historic districts in Superior, and 33 historic buildings. Many of the historic buildings are within the two proposed historic districts. If project components are visible from these properties, adverse visual impacts may occur.

For the Alternative 2 tailings, 54 historic properties listed on or eligible for the NRHP under Criteria A, B, and/or C are within 6 miles of the Alternative 2 tailings facility and within the scenic resources viewshed analysis area (see section 3.11). When plotted against the viewshed analysis for the tailings piles, the tailings pile would not be visible to three historic resources and not very visible to an additional 40, including the majority of buildings in Superior. The Superior Commercial District, as a whole, would have slightly better visibility, along with two archaeological sites. The tailings pile would be very visible from eight resources, including the TCP and the Boyce Thompson Arboretum.

In addition, increased socioeconomic pressure on housing and commercial building stock in Superior, Globe, and Miami may indirectly impact historic buildings in those communities.

3.12.4.4 Alternative 3 – Near West – Ultrathickened

Direct Impacts

The direct impacts of Alternative 3 on cultural resources are the same as Alternative 2.

Indirect Impacts

The indirect impacts of Alternative 3 on cultural resources are the same as Alternative 2.

Atmospheric Impacts

The atmospheric impacts of Alternative 3 on cultural resources are the same as Alternative 2.

3.12.4.5 Alternative 4 – Silver King

Direct Impacts

Sixty-nine percent (7,227 acres) of Alternative 4 has been surveyed to the fence line at the time of this review. Portions of the Alternative 2 tailings facility were unable to be surveyed because of steep and dangerous terrain. In addition, design changes that increased the size of the fence line but not the planned amount of ground disturbance occurred after survey was complete and the decision was made to concentrate survey resources on ground-disturbance areas of the other alternatives.

Under Alternative 4, 147 cultural resources would be adversely impacted: 145 NRHP-eligible and two undetermined archaeological sites. Table 3.12.4-2 presents numbers of cultural resources that are listed in or eligible for the NRHP or that are of undetermined NRHP status within each project element. Alternative 4 would adversely impact nine more NRHP-eligible or undetermined sites than Alternative 2 or 3. Some sites would be impacted by more than one project element; hence, the total numbers in the tables are different from the total number of sites overall.

Of the site components present in Alternative 4, two can be attributed to the Archaic, 12 to the Hohokam, 27 to Hohokam-Salado, 52 to the Salado, 11 to the Apache-Yavapai, 22 to Native American, 63 to Euro-American, and one unknown. The general site types within Alternative 4 are similar to those of Alternatives 2 and 3.

Table 3.12.4-2. Cultural resources directly impacted by Alternative 4

Facility	Number of NRHP-Listed or Eligible Sites	Number of NRHP-Undetermined Sites	Total
Oak Flat Federal Parcel	43	0	**43**
East Plant Site and subsidence area	24	0	**24**
West Plant Site	9	0	**9**
Silver King tailings facility and corridor/pipeline corridor	48	0	**48**
MARRCO corridor	38	2	**40**
Loadout facility	1	0	**1**
Transmission line	15	0	**15**

Facility	Number of NRHP-Listed or Eligible Sites	Number of NRHP-Undetermined Sites	Total
Roads	2	0	**2**

Note: Some sites would be impacted by more than one project element; hence, total numbers in this table are different from the total number of sites overall.

Indirect Impacts

Within the indirect impact analysis area for Alternative 4, 58 cultural resources may be impacted: two listed, 44 eligible, and 12 unevaluated. Five of those resources are within 2 miles of the tailings facility, one is within 2 miles of the East Plant Site and subsidence area (the *Chí'chil Biłdagoteel* Historic District), 37 are within 2 miles of the West Plant Site, one is within 2 miles of the access roads, 12 are within 2 miles of the MARRCO corridor (including the Boyce Thompson Arboretum), one is within 2 miles of the pipeline corridor, and three are within 2 miles of the transmission line corridors.

The indirect impacts to buildings in Superior are the same as Alternatives 2 and 3.

Atmospheric Impacts

For Alternative 4, the atmospheric impacts on all project components except for the Alternative 4 tailings facility and pipeline corridor are the same as Alternatives 2 and 3. For the Alternative 4 tailings facility, 55 historic properties listed or eligible for listing under Criteria A, B, and/or C are found within the 6-mile buffer and viewshed analysis area. For four of those resources, the tailings pile would not be visible; for 40 it would be slightly visible, including for most of Superior. For six resources, the pile would start to be more visible, including for the TCP. The tailings pile for Alternative 4 would be less visible from the TCP than that of Alternatives 2 and 3. For three resources, the Alternative 4 pile would be very visible; these three include the Boyce Thompson Arboretum.

In addition, increased socioeconomic pressure on housing and commercial building stock in Superior, Globe, and Miami may indirectly impact historic buildings in those communities.

3.12.4.6 Alternative 5 – Peg Leg

Direct Impacts

Eighty percent (13,534 acres) of Alternative 5 has been surveyed, including the pipeline corridor. Within Alternative 5, 157 archaeological sites would be adversely affected: 154 NRHP-eligible sites and three undetermined or unknown. Table 3.12.4-3 presents numbers of cultural resources that are listed in or eligible for the NRHP or are of undetermined NRHP status for Alternative 5. Alternative 5 would impact 16 more sites than Alternative 2 or 3, and seven more than Alternative 4.

Eight sites in Alternative 5 have an Archaic component, 34 sites have a Hohokam component, 25 have a Hohokam-Salado component, 32 have a Salado component, 12 have an Apache-Yavapai component, 15 have a Native American component, and 62 have a Euro-American component. General site types are similar to Alternatives 2, 3, and 4.

Table 3.12.4-3. Cultural resources directly impacted by Alternative 5

Facility	Number of NRHP-Listed or Eligible Sites	Number of NRHP-Undetermined Sites	Total
Oak Flat Federal Parcel	43	0	**43**
East Plant Site and subsidence area	24	0	**24**

Facility	Number of NRHP-Listed or Eligible Sites	Number of NRHP-Undetermined Sites	Total
West Plant Site	9	0	**9**
Peg Leg tailings facility and pipeline corridor	70	3	**73**
MARRCO corridor	38	2	**40**
Transmission line	15	0	**15**
Roads	1	0	**1**

Note: Some sites would be impacted by more than one project element; hence, total numbers in this table are different from the total number of sites overall.

Indirect Impacts

Within the indirect impact analysis area for Alternative 5, 77 cultural resources may be impacted: two listed, 56 eligible, and 19 unevaluated. Thirty-seven resources are within 2 miles of the West Plant Site, one is within 2 miles of the East Plant Site and subsidence area (the *Chí'chil Biłdagoteel* Historic District), nine are within 2 miles of the access roads, 12 are within 2 miles of the MARRCO corridor (including the Boyce Thompson Arboretum), 18 are within 2 miles of the pipeline corridor, one is within 2 miles of Silver King Mine Road, and three are within 2 miles of the transmission line corridors.

The indirect impacts to buildings in Superior are the same as Alternatives 2, 3, and 4.

Atmospheric Impacts

For Alternative 5, the atmospheric impacts on all project components except for the Alternative 5 tailings facility and pipeline corridor are the same as Alternatives 2, 3, and 4.

For the Alternative 5 tailings facility and pipeline corridor, five historic properties listed or eligible under Criterion A, B, and/or C are found within the 6-mile analysis area and viewshed analysis area. The tailings pile would not be visible from two resources: Kelvin Bridge and an archaeological site. It would be slightly visible from two resources: a transmission line and charcoal ovens. The tailings pile will be more visible from the remaining site, a railroad spur, but only moderately.

In addition, increased socioeconomic pressure on housing and commercial building stock in Superior, Globe, and Miami may indirectly impact historic buildings in those communities.

3.12.4.7 Alternative 6 – Skunk Camp

Direct Impacts

For Alternative 6, 86 percent (13,450 acres) has been surveyed, including the pipeline corridor.[97] Within the alternative, 380 archaeological sites have been recorded: 377 are NRHP-eligible and three are unevaluated or undetermined. Table 3.12.4-4 presents NRHP-eligible and undetermined archaeological sites within Alternative 6. This alternative would impact a minimum of 226 more sites than Alternative 2, 3, 4, or 5.

[97] Section 3.12 of the DEIS noted that 96 percent of the area (16,049 acres) had been surveyed. The change in percentage is a result of modifications in the tailings storage facility footprint. Note that any remaining acreage slated for ground disturbance or land sale will be inventoried per the PA, and cultural sites identified and addressed in accordance with the PA.

The types of sites present in Alternative 6 are similar to those in Alternatives 2 through 5, although in much greater number. Alternative 6 also has a high number of Salado sites. Archaic components are found at two sites in Alternative 6. Ten sites have a Hohokam component, 25 have a Hohokam-Salado component, 272 have a Salado component (265 of those are Salado-only sites), 15 have an Apache-Yavapai component, 30 have a Native American component, 55 have a Euro-American component, and one is Unknown.

Table 3.12.4-4. Cultural resources directly impacted under Alternative 6

Facility	Number of NRHP-Listed or Eligible Sites	Number of NRHP-Undetermined Sites	Total
Oak Flat Federal Parcel	43	0	**43**
East Plant Site and subsidence area	24	0	**24**
West Plant Site	9	0	**9**
Skunk Camp tailings facility and pipeline corridor	292	0	**292**
Transmission lines	11	0	**11**
Silver King Mine Road realignment	6	0	**6**
MARRCO corridor	38	2	**40**
Roads	9	0	**9**

Note: Some sites would be impacted by more than one project element; hence, total numbers in this table are different from the total number of sites overall.

Indirect Impacts

Within the indirect impact analysis area for Alternative 6, 58 cultural resources may be impacted: two listed, 45 eligible, and 11 unevaluated. Thirty-seven resources are within 2 miles of the West Plant Site, one is within 2 miles of the East Plant Site and subsidence area (the *Chí'chil Biłdagoteel* Historic District), one (The Eleven Arches) is within 2 miles of the tailings facility, five are within 2 miles of the access roads, 12 are within 2 miles of the MARRCO corridor (including the Boyce Thompson Arboretum), six are within 2 miles of the pipeline corridor, one is within 2 miles of Silver King Mine Road, one is within 2 miles of the Skunk Camp transmission line corridor, and three are within 2 miles of the transmission line corridors.

The indirect impacts to buildings in Superior are the same as Alternatives 2, 3, 4, and 5.

Atmospheric Impacts

For Alternative 6, the atmospheric impacts on all project components except for the Alternative 6 tailings facility are the same as Alternative 2 through 5. Twelve historic properties listed or eligible are within the 6-mile buffer and viewshed analysis area. The tailings pile would not be visible to nine of those properties and only slightly visible from the remaining three properties.

In addition, increased socioeconomic pressure on housing and commercial building stock in Superior, Globe, and Miami may indirectly impact historic buildings in those communities.

3.12.4.8 Cumulative Effects

Full details of the cumulative effects analysis can be found in chapter 4. The following represents a summary of the cumulative impacts resulting from the project-related impacts described in Section 3.12.4, Environmental Consequences, that are associated with cultural resources, when combined with other reasonably foreseeable future actions.

The following actions were determined through the cumulative effects analysis process to be reasonably foreseeable, and have impacts that likely overlap in space and time with impacts from the Resolution Copper Project:

- LEN Range Improvements
- Pinto Valley Mine Expansion
- Ray Land Exchange and Proposed Plan Amendment
- Ripsey Wash Tailings Project
- Silver Bar Mining Regional Landfill and Cottonwood Canyon Road
- Superior to Silver King 115-kV Relocation Project

The cumulative effects analysis area for cultural resources is the APE, which has been determined through Section 106 consultation. The metric used to quantify cumulative impacts to cultural resources is the physical footprint of the RFFAs. Almost all projects result in disturbance of cultural sites, in many cases only after data recovery and mitigation activities. However, even if recorded and documented, loss of these cultural sites contributes to the overall impact to the cultural heritage of the areas. Often cultural sites are only known to be impacted if surveys have been conducted, which is not necessarily required on private land; physical footprint can serve as a proxy for the overall disturbance to cultural sites where no site-specific data exist.

The six reasonably foreseeable future actions above, combined with the Resolution Copper Project, represent about 28,500 acres of the 730,000-acre cumulative effects analysis area, or about 3.9 percent. This represents the potential area in which cultural resources could be lost, which contributes to an overall loss of cultural heritage within the area. While the footprint of these projects is used as a proxy for impacts to cultural resources, effects on cultural resources extend beyond destruction by physical disturbance. The presence of activities nearby also can change the character of prehistoric and historic cultural sites.

3.12.4.9 Mitigation Effectiveness

Mitigation Identifier and Title	Authority to Require
FS-RC-04: Establish an alternative campground site (Castleberry) to mitigate the loss of Oak Flat Campground	Required – Forest Service and Programmatic Agreement
FS-CR-01: Implementation of Oak Flat HPTP	Required – Forest Service and Programmatic Agreement
FS-CR-02: GPO Research Design	Required – Forest Service and Programmatic Agreement
FS-CR-03: Visual, Atmospheric, Auditory, Socioeconomic, and Cumulative Effects Mitigation Plan	Required – Forest Service and Programmatic Agreement
FS-CR-07: Archaeological Database Funds	Required – Forest Service and Programmatic Agreement
FS-SO-01: Community Development Fund	Required – Forest Service and Programmatic Agreement

We developed a robust monitoring and mitigation strategy to avoid, minimize, rectify, reduce, or compensate for resource impacts that have been identified during the process of preparing this EIS. Appendix J contains descriptions of mitigation measures that are being required by the Forest Service and mitigation measures voluntarily brought forward and committed to by Resolution Copper. Appendix J also contains descriptions of monitoring that would be needed to identify potential impacts and mitigation effectiveness.

This section contains an assessment of the effectiveness of design features associated with mitigation and monitoring measures found in appendix J that are applicable to cultural resources. See appendix J for full descriptions of each measure noted below.

Mitigation Effectiveness and Impacts of Required Mitigation Measures Applicable to Cultural Resources

Appendix J contains mitigation and monitoring measures being required by the Forest Service under its regulatory authority or because these measures are required by other regulatory processes (such as the PA or Biological Opinion). These measures are assumed to occur, and their effectiveness and impacts are disclosed here. The unavoidable adverse impacts disclosed below take the effectiveness of these mitigations into account.

Establish an alternative campground site (Castleberry) to mitigate the loss of Oak Flat Campground (FS-RC-04). Resolution Copper will develop a new campground on private land to offset the loss of the historic Oak Flat Campground. Several historic properties are found on the parcel intended for the campground. These historic properties will be preserved in place with interpretive signage for the visitors to the campground.

Implementation of Oak Flat HPTP (FS-CR-01). The Oak Flat Historic Properties Treatment Plan (HPTP) sets out a plan for treatments to resolve the adverse effects on 42 historic properties that have been identified within the Oak Flat Federal Parcel. In accordance with the plan, Resolution Copper would conduct archaeological data recovery on sites eligible for the NRHP under Criterion D that would be adversely affected. Project materials and archaeological collections would be curated in accordance with 36 CFR 79 (Curation of Federally-Owned and Administered Archaeological Collections) with Gila River Indian Community, Salt River Pima-Maricopa Indian Community, and the Arizona State Museum. This measure is applicable to all alternatives. Archaeological data recovery can reduce a portion of the adverse effect by sampling historic properties that are eligible for their scientific information potential under Criterion D of the NRHP. However, there are several limitations to data recovery's effectiveness. Data recovery by nature is destructive, and although archaeological investigative techniques are continually evolving, even today's state-of-the-art research strategies would not be able to recover all the data potential at the project area sites. Data recovery can record and preserve some of the materials from the sites, but it cannot preserve the current integrity of setting, association, workmanship, feeling, location, and design.

GPO Research Design (FS-CR-02). The GPO Research Design and data recovery plans will detail treatments to resolve adverse effects on historic properties within the GPO project area with the exception of those in the Oak Flat Federal Parcel. Data recovery would be conducted on archaeological sites eligible for the NRHP under Criterion D within the GPO project area. Project materials and archaeological collections would be curated in accordance with 36 CFR 79 (Curation of Federally-Owned and Administered Archaeological Collections) with Gila River Indian Community, Salt River Pima-Maricopa Indian Community, and the Arizona State Museum. This measure is applicable to all alternatives. As with all data recovery efforts, this measure would not prevent ultimate destruction of these cultural resources; however, the impact would be reduced by the proper treatment prior to anticipated land disturbance and destruction.

Visual, Atmospheric, Auditory, Socioeconomic, and Cumulative Effects Mitigation Plan (FS-CR-03). The Forest Service will ensure that additional mitigation plan(s) are prepared after the publication of the FEIS that describe mitigation measures to address visual, atmospheric, auditory, and cumulative effects on historic properties. This plan will be implemented upon concurrence of all signatories to the

PA. Tribal monitors may participate in mitigation of adverse effects. The effectiveness of these future plans to reduce effects on historic property are assumed, but cannot be defined at this time.

Archaeological Database Funds (FS-CR-07). Resolution Copper will provide funding to the State of Arizona to assist in the development of a new database or upgrading the existing database of archaeological resources in Arizona. The database is intended to allow the State of Arizona to better manage archaeological resources on State lands. These funds would not prevent impacts to historic properties, but would assist in the ensuring the effectiveness of the treatment activities described under measures FS-CR-01 and FS-CR-02.

Community Development Fund (FS-SO-01). Resolution Copper will establish a foundation for the communities of Superior, Miami, Globe, Kearny, Hayden, and Winkelman for the rehabilitation of historic buildings. This measure would be effective at helping prevent the loss of historic properties within the Copper Triangle, preserving them for future generations, and preserving the historic mining heritage of these towns.

Mitigation Effectiveness and Impacts of Voluntary Mitigation Measures Applicable to Cultural Resources

Appendix J contains mitigation and monitoring measures brought forward voluntarily by Resolution Copper and committed to in correspondence with the Forest Service. These measures are assumed to occur but are not guaranteed to occur. Their effectiveness and impacts if they were to occur are disclosed here; however, the unavoidable adverse impacts disclosed below do not take the effectiveness of these mitigations into account. No additional mitigation measures were voluntarily brought forward for cultural resources.

Other Potential Future Mitigation Measures Applicable to Cultural Resources

Appendix J contains several other potential future mitigation measures that the Forest Service is disclosing as potentially useful in mitigating adverse effects, but for which there is no authority to require. There is no expectation that these measures would occur, and therefore the effectiveness is not considered in the EIS. No potential future mitigation measures were identified applicable to cultural resources.

Unavoidable Adverse Impacts

Cultural resources and historic properties would be directly and permanently impacted. These impacts cannot be avoided within the areas of surface disturbance, nor can they be fully mitigated. The land exchange is also considered an unavoidable adverse effect on cultural resources.

3.12.4.10 Other Required Disclosures

Short-Term Uses and Long-Term Productivity

Physical and visual impacts on archaeological sites, tribal sacred sites, cultural landscapes, and plant and mineral resources caused by construction of the mine would be immediate, permanent, and large in scale. Mitigation measures cannot replace or replicate the historic properties that would be destroyed by project construction. The landscape, which is imbued with specific cultural attributions by each of the consulting tribes, would also be permanently affected.

Irreversible and Irretrievable Commitment of Resources

The direct impacts on cultural resources and historic properties from construction of the mine and associated facilities constitute an irreversible commitment of resources. Archaeological sites cannot be reconstructed once disturbed, nor can they be fully mitigated. Sacred springs would be eradicated by subsidence or tailings storage facility construction and affected by groundwater drawdown. Changes that permanently affect the ability of tribal members to use known TCPs for cultural and religious purposes are also an irreversible commitment of resources.