

Feasibility Study Report Klondyke Tailings WQARF Site Klondyke, Graham County, Arizona

Prepared for:

Arizona Department of Environmental Quality Waste Programs Division Remedial Projects Unit 1110 West Washington Street Phoenix, Arizona 85007

Prepared by:

Amec Foster Wheeler Environment & Infrastructure, Inc. Phoenix, Arizona



May 5, 2017

Project No. 14-2016-2018

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Arizona Department of Environmental Quality 1110 West Washington Street Phoenix, Arizona 85007

Attn: Kyle Johnson

#### Subject: Feasibility Study Report Klondyke Tailings WQARF Site Klondyke, Arizona

Dear Mr. Johnson,

Amec Foster Wheeler Environment & Infrastructure, Inc. (Amec Foster Wheeler) is pleased to submit this *Feasibility Study Report* (FS Report) for the Klondyke Tailings Water Quality Assurance Revolving Fund (WQARF) Site located in Klondyke, Arizona (Site). This FS Report has been prepared in accordance with the FS Work Plan dated December 2014 (ADEQ, 2014) and Arizona Administrative Code R18-16-407(C). This FS Report recommends the proposed remedy for the Site that will be incorporated into the Proposed Remedial Action Plan.

If you have any questions or comments regarding this report, please contact Mr. Jim Clarke at 602-733-6055.

Sincerely,

#### Amec Foster Wheeler Environment & Infrastructure, Inc.



James N. Clarke, PG Associate Geologist Arizona Registered Geologist #29374 Reviewed by:



Chris J. Courtney, PG Senior Associate Geologist

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## ACRONYMS AND ABBREVIATIONS

A.A.C.	Arizona Administrative Code									
ADEQ	Arizona Department of Environmental Quality									
ADWR	Arizona Department of Water Resources									
Amec Foster Wheeler	Amec Foster Wheeler Environment & Infrastructure, Inc.									
A.R.S	Arizona Revised Statutes									
ASRAC	Arizona Superfund Response Action Contract									
ASWQS(s)	Arizona Surface Water Quality Standard(s)									
AWQS(s) Arizona Water Quality Standard(s)										
bas	below ground surface									
CAB	Community Advisory Board									
Comprehensive Environmental Response Compensat										
OEROE/	Liability Act									
COCs	Contaminant(s) of Concern									
DEUR	Declaration of Environmental Use Restriction									
FPA	United States Environmental Protection Agency									
ERA(s)	Early Response Action(s)									
FP	Eloodplain area within Flood Zone A									
FS	Fassibility Study									
ft	foot feet									
IT FV	fiscal year									
apm	allons per minute									
ISDT	Jalions per minute In-situ Phosphata Traatmont									
	Lower Tailings Pile									
	nilligrams par kilogram									
mg/l	milligrams per liter									
	Northeast									
	Northwest									
	NUTITIVESI									
	Proposed Remedial Action Plan									
	Proposed Remedial Action Plan									
	Periodic Sile Review									
	Remedial Action Completion Report									
	Remedial Investigation									
RU(s)	Remedial Objective(s)									
	Record of Decision									
RSRL(S)	Residential Soll Remediation Level(s)									
SC	source control									
Site	Klondyke Tailings WQARF Site									
SE	Southeast									
SVOCs	semi-volatile organic compounds									
SW	Southwest									
URS	URS Corporation									
USEPA	United States Environmental Protection Agency, see also EPA									
UTP	Upper Tailings Pile									
VOCs	volatile organic compounds									
VRP	Voluntary Remediation Program									
WQARF	Water Quality Assurance Revolving Fund									
XRF	X-ray fluorescence									

#### EXECUTIVE SUMMARY

This Feasibility Study (FS) was conducted pursuant to Arizona Administrative Code (A.A.C.) R18-16-407. The proposed remedy addresses soils only; therefore, pursuant to A.A.C. R18-16-407C, an analysis of alternative remedies is not required. For the purposes of this FS, the impacted properties are identified as General Use Parcels and the Mill Site. The Remedial Objectives (ROs) include restoring soil conditions to meet current use standards for properties Zoned General Use and the Mill Site; and, remediating soils at the Mill Site to a level that no longer threatens surface water quality. Based on the findings of the Remedial Investigation (RI), ROs for groundwater were not required.

Surface soil at the Site is impacted by lead and arsenic above the residential soil remediation levels (RSRLs) of 400 milligrams per kilogram (mg/kg) and 10 mg/kg, respectively. For the purposes of this FS, surface soil is considered the upper six inches of the soil. However, arsenic is typically not reported above 10 mg/kg when lead is below 400 mg/kg in surface soil. Therefore, remediating lead below 400 mg/kg in surface soil is expected to result in arsenic being remediated below 10 mg/kg. By remediating lead in surface soil below 400 mg/kg, the land use and surface water use ROs are expected to be achieved.

During 2010-2011, 2015, and 2016, Early Response Actions (ERAs) were performed to remove lead impacted soils around existing residential structures on the General Use Parcels. Additionally, during 2008, the upper tailings pile (UTP) on the Mill Site was consolidated, capped, and armored to remove the UTP as a source of lead impacted tailings to Aravaipa Creek. The ERAs are considered completed portions of the proposed remedy and have achieved the ROs. The risk assessment performed by Arcadis evaluated residential use for the ERA remediated areas surrounding existing residences and recreational/trespasser use for undeveloped areas of the Site. Therefore, based on current land use and the risk assessment performed by Arcadis, to-be-implemented portions of the proposed remedy include the following:

- Consolidation, capping, and armoring of the lower tailings pile (LTP) on the Mill Site; and
- Remediation of the hillside tailings deposit on General Use Parcel 110-47-006.

The LTP will be consolidated, capped, and armored similar to the design used for the UTP. Therefore, no additional remedial alternatives for the LTP were evaluated and consolidation, capping, and armoring is selected as a portion of the overall remedy for the Site. Five remedial alternatives were evaluated to remediate the lead contaminated surface soils on the portions of the Mill Site and impacted General Use Parcels not previously remediated by the ERAs. All four remedial alternatives are capable of achieving the ROs. However, with the exception of portions of Parcel 110-47-006, in-situ consolidation and capping was evaluated to be the most cost effective and technically feasible of the four alternatives. Therefore, with the exception of portions of Parcel 110-47-006, in-situ consolidation and capping is recommended as the final remedy for the lead contaminated surface soils. Capping-in-place is recommended as the final remedy on the hillside tailings deposit located approximately 200 feet northeast of the residence on Parcel 110-47-006. As an engineering control, this remedy will require a Declaration of Environmental Use Restriction (DEUR).

The properties within the Site boundaries are zoned by Graham County A General Use Minimum 1-acre, which includes residential use. This indicates that portions of the General Use Parcels within the Site boundaries may be developed residentially in the future to a minimum of a 1-acre lot. Property owners can also build additional residences on their properties without subdividing their properties. The risk assessment performed by Arcadis identified currently undeveloped areas within the Site boundaries that are impacted with lead in surface soil that are not protective of residential use. Remediation of these areas is non-time critical and may be considered in the future as a contingency. If a property owner plans to construct a residence on currently undeveloped portions of their property in the future, the property owner must notify ADEQ and the plans must be coordinated with ADEQ and Graham County. ADEQ will determine if the planned construction is within an area protective of residential use or if remediation to levels protective of residential use is required prior to construction. Remediation may be performed in the future based on prioritization, the schedule provided by the property owner, and available funding. Prioritization will be determined by the property owner providing an approved construction permit from Graham County.

The Mill Site, which is also zoned General Use, will be limited to non-residential uses by a DEUR. The risk assessment performed by Arcadis indicates that after the LTP is capped, the lead concentrations in surface soils above the non-residential SRL (NRSRL) of 800 mg/kg are protective of the current undeveloped use considering a recreational/trespasser exposure scenario. However, should portions of the property be considered for commercial development in the future, then remediation of lead in surface soil below 800 mg/kg will be required. As with the General Use Parcels, remediation of the Mill Site to conditions protective of potential future commercial use is also considered non-time critical and may also be considered in the future as a contingency. The same conditions presented previously for future residential development of the General Use Parcels will be applied to future commercial development of the Mill Site.

The proposed remedy has or will achieve the ROs and meets the remedial action requirements in Arizona Revised Statutes (A.R.S.) §49-282.06. The final remedy is consistent with current and future land and surface water use; is protective of public health, welfare, and the environment; and is reasonable, necessary, cost effective, and technically feasible.

## 1.0 INTRODUCTION

This Feasibility Study (FS) Report provides the recommended remedy for the Klondyke Tailings Water Quality Assurance Revolving Fund (WQARF) Registry Site (Site) that will be developed or incorporated into the Proposed Remedial Action Plan (PRAP). This FS Report has been prepared in accordance with Arizona Revised Statutes (A.R.S) §49-287.03 and Arizona Administrative Code (A.A.C.) R18-16-407.

## 1.1 **Project Authorization**

Amec Foster Wheeler Environment & Infrastructure, Inc. (Amec Foster Wheeler) has been retained by the Arizona Department of Environmental Quality (ADEQ) to perform the following for the Site: completion of early response actions (ERAs) on the Mill Site and developed properties zoned General Use; identification of data gaps required for the FS; collecting additional data and information to fill the data gaps; preparing the FS Report; and, preparing the PRAP. Therefore, this FS Report has been prepared in accordance with the scope of work and terms and conditions of the Arizona Superfund Response Action Contract (ASRAC) No. ADEQ14-077536 between Amec Foster Wheeler and ADEQ; and, ADEQ Task Order No. ADEQ14-077536:14.

## **1.2** Purpose and Scope of the FS Report

The remedy for the Site will address only soils. Therefore, per A.A.C. R18-16-407C, an analysis of alternative remedies is not required. Based on this, this FS Report will demonstrate the following:

- 1. That the proposed remedy addresses the contaminated soil in a manner that achieves compliance with A.R.S. §49-152 and A.A.C. R18-7-2 and will achieve the remedial objectives (ROs) for the use of the affected properties.
- 2. That the proposed remedy was selected based upon best engineering, geological, or hydrogeological judgment following engineering, geological, or hydrogeological standards of practice, considering the following information:
  - a. The remedial investigation (RI);
  - b. Best available scientific information concerning available remedial methods and technologies; and
  - c. A written analysis explaining how the remedy is consistent with A.R.S. § 49-282.06, including a brief explanation of the comparison criteria as applied to the remedy.

#### 1.3 Report Organization

ADEQ has provided the Table of Contents for an FS Report. Based on the ADEQ guidance, the organization of this FS Report is provided in the Table of Contents. As indicated above, for remedies that address only soils, an analysis of alternative remedies is not required. Therefore, this FS Report does not include "Development of the Reference Remedy and Alternative Remedies,"

both of which are associated with selection of the recommended remedy for groundwater impacted sites.

#### 2.0 SITE BACKGROUND AND CONCEPTUAL SITE MODEL

The Site is located approximately 1.5 miles northeast of the unincorporated community of Klondyke, Graham County, Arizona (Figure 1). Klondyke is located approximately 45 miles west of the City of Safford, Arizona, and approximately 150 miles southeast of Phoenix, Arizona. Access to Klondyke is principally via Klondyke Road, a maintained dirt road located 12 miles northwest of Safford, Arizona, extending along U.S. Route 70.

According to ADEQ, lead, zinc, copper, silver, and gold mining were conducted in the Klondyke area of the Aravaipa Mining District in Arizona from the 1870s through the 1950s (ADEQ, 2009). In 1948, the Athletic Mining Company constructed a flotation-processing mill next to Aravaipa Creek that operated until about 1958. During the time of operation, lead, zinc, and copper concentrates were produced, along with two mine waste piles, the Lower Tailings Pile (LTP) and the Upper Tailings Pile (UTP). The LTP contained approximately 36,000 cubic yards of tailings and the UTP contained approximately 34,000 cubic yards of tailings (ATSDR 1999; ADEQ-URS 2013).

In March 1993, a complaint concerning erosion and runoff from the tailings pile was filed with ADEQ, and an investigation began. The results of that investigation revealed high levels of lead and arsenic in the tailings piles and surrounding soils and acidic runoff emanating from the Site. In October 1993, ADEQ received an Arizona Water Protection Fund Grant to conduct a preliminary investigation, compile existing data, and evaluate possible remedial alternatives at the Site. The U.S. Fish and Wildlife Service conducted fish tissue sampling and analysis of fish in Aravaipa Creek at two sites within the Nature Conservancy property. The results of that investigation revealed elevated levels of arsenic, cadmium, and lead in fish tissue, though not at levels that threatened native fish species. The Site was listed on Arizona's WQARF Registry in September 1998 after a Bureau of Land Management regional surface water quality monitoring program detected concentrations of lead in Aravaipa Creek that exceeded surface water quality standards. From 2005 to 2006, ADEQ conducted an ERA that included minor earth moving repairs to contain storm water runoff on the tailings piles. In 2008, ADEQ and their contractors completed the consolidation, capping, and installation of erosion protection on the UTP (ADEQ, 2012).

#### 2.1 Site Description

The Site includes a former mill containing two mine-waste tailings piles with a combined volume of approximately 70,000 cubic yards (referred to as the Mill Site and Parcel 110-47-003g). The tailings piles are designated as the UTP and the LTP based on the relative up and downstream positions along the northwesterly flowing Aravaipa Creek. There is also a former mill and small mine-waste tailings pile present on Parcel 110-47-006.

Land use in the area is characterized by mixed-use residential and agricultural (e.g., cattle ranching and hay farming) home-sites (Figure 2). According to Graham County, property zoning is designated A-General Use minimum 1-acre, referred to as General Use Parcels for the purposes of this FS Report. Therefore, the affected properties can be subdivided and

residentially developed up to a density of 1-acre. However, this process for seven of the properties is limited due to portions of them lying within the flood zones for Aravaipa and Laurel Canyon Creeks (see Appendix A). If a structure is planned for a portion of a property within a designated flood zone, then the structure must be elevated above the expected depth of the flood event (see Graham County Flood Protection Ordinance and Federal Emergency Management Agency guidance in Appendix A). In most cases this requires placement of fill material to raise the foundation of the structure. However, portions of the Flood Zone A areas shown in Appendix A are also within the Waters of the United States jurisdictional area of the creeks. Therefore, any filling activities performed in these areas will require a Section 404 Permit from the United States Army Corps of Engineers. The construction restrictions and requirements for Flood Zone A have been taken into consideration in development of the remedy and associated costs for the Site.

Vegetation in the area is generally characterized by chaparral vegetation including mesquite and tamarisk trees, desert shrubs, and cacti populating small hills surrounding the Site. The area receives approximately 17 inches of rain per year (URS, 2014). According to residents, Laurel Creek and Aravaipa Creek occasionally flood due to short duration, high-intensity rain events common during the summer months. Other land uses in the area are primarily recreational and include fishing and swimming in Aravaipa Creek downstream of the Site, allterrain vehicle use, camping, hunting, and hiking.

# 2.1.1 Previous Remedial Actions and Early Response Actions/Interim Response Actions

The previous remedial actions are the RI and ERAs that included consolidation and capping of the UTP, removal of lead impacted tailings from residential properties, and removal of lead impacted tailings from Klondyke Road. The ERAs are included as components of the overall remedy for the Site.

## 2.1.2 Remedial Investigation

In 1999, ADEQ contracted with URS Corporation (URS) to conduct the RI for the Site. The RI included the following:

- Sampling of surface and subsurface soils;
- Sampling of groundwater;
- A geomorphic and floodplain analysis of the Site; and
- Magnetic and electromagnetic geophysical surveys to identify the possible presence of buried drums, tanks, and piping that may contain contaminants.

URS conducted an extensive surface and subsurface soil sampling investigation between 2006 and 2007. The investigation identified elevated levels of lead and arsenic in residential soils at concentrations above the Residential Soil Remediation Levels (RSRLs) of 400 milligrams per kilogram (mg/kg) and 10 mg/kg, respectively at nine parcels adjacent to or near the two tailings piles. Lead was detected in samples through X-ray fluorescence (XRF) analysis at concentrations up to 18,000 mg/kg on residential properties. At the former Mill Site, lead was

detected at concentrations up to 50,000 mg/kg in samples collected from the tailings piles. Antimony, arsenic, beryllium, cadmium, copper, lead, manganese, and zinc were also detected at concentrations above their respective Arizona RSRLs in samples collected from the piles (ADEQ, 2008). As an additional part of this investigation, a floodplain analysis of Aravaipa Creek was performed that indicated the UTP was within, and subject to, erosion from 25-, 50-, and 100-year flood events on Aravaipa Creek, as well as erosion by the potential lateral movement of Aravaipa Creek (ADEQ, 2008). URS determined that the downstream pile (the LTP) was not at risk from 10-, 25-, and 50-year return period flood events on Aravaipa Creek. However, a portion of LTP was within and subject to erosion from 100-year flood events on Aravaipa Creek as well as the potential lateral migration of Aravaipa Creek. The study also indicated the LTP was potentially subject to erosion from 10-, 25-, 50-, and 100-year flood events on Laurel Canyon Wash, a tributary to Aravaipa Creek (ADEQ, 2008). The locations of the UTP and LTP in relation to Aravaipa Creek and Laurel Canyon Wash are shown on Figures 2 and 5 and the location of Flood Zone A in relation to the UTP and LTP is shown in Appendix A.

URS completed the RI in September 2014 and the conclusions are summarized below (URS, 2014):

- <u>Contaminants of Concern (COCs)</u>: arsenic, cadmium, copper, mercury, lead, manganese, vanadium, and zinc. The primary marker metal is lead.
- <u>Impacted Media</u>: Soil and surface water.
- <u>Source Areas:</u> Klondyke mill tailings piles.
- <u>Potential Responsible Parties</u>: Orphan.
- <u>Release Mechanisms</u>: Wind and water erosion of mill tailings and possibly surface water transport from mine site.
- <u>Groundwater</u>: Aquifer Water Quality Standards (AWQSs) were not exceeded.
- <u>UTP and LTP</u>: Subject to flooding from Aravaipa and Laurel Creeks.

## 2.1.3 2005-2006 Early Response Action

ADEQ completed an ERA that involved the excavation of 11 geophysical targets previously identified during the geophysical survey. No buried tanks, drums or pipelines requiring removal were found. During the ERA, a small amount of laboratory reagents still present at the Mill Site were also removed. ADEQ also conducted minor earth moving repairs such as repairing berms around the tailings piles and correcting drainage problems to contain storm water runoff on the tailings piles.

## 2.1.4 Consolidation and Capping of the UTP

In June 2008, ADEQ and their contractors completed the consolidation of a portion of nearby surface soils onto the UTP as an ERA. Approximately 10,000 cubic yards of tailings from the portion of the LTP closest to Aravaipa Creek were also consolidated onto the UTP during this

action. The UTP was compacted in lifts then capped with a 2 foot (ft) soil cover. Gabion rock mattresses were installed around the edges for erosion and scour protection (URS, 2008a).

## 2.1.5 2012-2013 Lead Tailings Removals

In April 2010, the United States Environmental Protection Agency (USEPA) conducted a removal assessment of five residential home-sites near the tailings piles, identified as HS-01 through HS-05 (see Appendix B). The results of this assessment were reported in the Removal Assessment Report (Ecology & Environment [E&E], 2010). At each home site, USEPA collected soil samples from an approximately 200 ft by 200 ft area around the primary residential living area (i.e., the house, garage, and other structures in the immediate area around the primary residence). Due to the large size of the properties surrounding the residences, each property was subdivided into up to eight approximately equal subdivisions, with a five-point composite sample collected from each subdivision. In addition, discrete sample locations (e.g., gardens, play areas, rain gutter discharge points) were identified and collected during the sampling event. A total of 53 composite samples, each consisting of five-point aliquots, and 13 discrete samples were collected. Laboratory and field XRF results indicated lead and arsenic concentrations in surface soils exceeded the site screening levels of 400 mg/kg and 10 mg/kg, respectively. Lead in soil was detected as high as 17,000 mg/kg. Arsenic in soil was detected as high as 290 mg/kg (E&E, 2010).

During 2012 and 2013, USEPA conducted removal actions on three residential home-sites, Parcels 110-47-006 (HS-03 [Figure 11 in Appendix B]), 110-47-001m (HS-04 [Figure 12 in Appendix B]), and 110-47-003d (HS-05 [Figure 10 in Appendix B]). USEPA also conducted removal actions at Parcel 110-47-003g (Mill site) on the northern portion of Area A (designated as Area A-3 in this report), and Area D. Figure 2 shows the locations of these parcels. Per the USEPA Superfund Lead Contaminated Residential Sites Handbook (USEPA, 2003), excavations of 1 ft depth are protective of human health in most cases and this approach was applied by the USEPA to the residential removal actions. The exceptions were identified sustenance gardening areas where the soils were removed to a depth of 2 ft. Figures showing the removal action areas on the properties obtained from the Removal Action Report (E&E, 2014) are included in Appendix B. Excavated impacted soils were placed on the LTP (see Figure 3). Backfill material was obtained from Aravaipa Creek and stockpiled on the remediated Area D and used to backfill excavations on the residential home-sites. There were also repairs to the UTP cap using clav obtained from Area D. A cover was also placed on the portions of the LTP that received excavated soils for erosion control. Area A-3 was not backfilled. The USEPA removal action is documented in the Removal Action Report (E&E, 2014).

It should be noted that USEPA removed lead impacted tailings above the RSRL of 400 mg/kg only on Parcel 110-47-110m. On Parcels 110-47-006 and 110-47-003d, the USEPA removed lead impacted tailings above 800 mg/kg. The removal on Parcel 110-47-006 included a portion of the hillside tailings deposit; however, the entire tailings deposit was not removed and was left in place. Therefore, additional lead tailings removals were performed during November 2016 for these properties as ERAs (see Section 2.2.7).

## 2.1.6 March 2015 Lead Tailings Removal

During March 2015, Amec Foster Wheeler performed lead impacted tailings removals at Areas A-1, A-2, B, and C-1 on Parcel 110-47-003g (see Figure 3). Additionally, Area A-3 previously excavated by USEPA was backfilled. The purpose of the lead tailings removal from these areas was to complete preparation of this area for shaping and capping of the LTP and to make this area suitable for future development. The lead impacted tailings removal is documented in the *Tailings Removal Action Report, Parcel 110-47-003G, Klondyke Tailings WQARF Site, Klondyke, Graham County, Arizona*, dated May 20, 2015 (Amec Foster Wheeler, 2015).

## 2.1.7 Klondyke Road Sampling

The evaluation of COC concentrations on the portion of Klondyke Road that crosses the Site was identified as a data gap that needed to be addressed in order to complete the FS. Soil samples were not collected from Klondyke Road during the RI, and dust generated by vehicles represented a potential exposure pathway to area residents and visitors. On December 10, 2015, Amec Foster Wheeler collected soil samples from the portion of Klondyke Road that crosses the Site. The purpose of the soil sampling was to evaluate heavy metals concentrations, primarily lead and arsenic, on the roadway. The collected data was included in the risk assessment performed by Arcadis. The analytical results indicated that the portion of Klondyke Road between the southeastern corner of the Site and just east of Laurel Canyon Wash(see Figure 4) was impacted with lead concentrations. The results are documented in the *Technical Memorandum, Klondyke Tailings WQARF Site, Roadway Sampling Results* dated, February 12, 2016 (Amec Foster Wheeler, 2016a). Removal of the lead impacted tailings from the roadway is discussed in Section 2.2.9.

## 2.1.8 March-April 2016 Lead Tailings Removals

From March 21 to April 21, 2016, Amec Foster Wheeler performed lead tailings removals on three General Use Parcels (Parcels 110-47-003f, 110-47-001g, and 110-47-003b on Figure 2) and on Area C-2 on Parcel 110-47-003g (Figure 3). The locations of excavated areas are shown on Figure 5. The excavations were backfilled with 1.5-inch minus material obtained from the Aravaipa Borrow Area shown on Figure 5. This area had been previously used by URS and USEPA to obtain cap material for the UTP and backfill for lead tailings removal and was tested to contain lead and metal concentrations below RSRLs (E&E, 2010). The Fiscal Year (FY) 2015 tailings removal action performed at Parcel 110-47-003g depleted the available supply of 1.5-inch minus material to approximately 600 cubic yards. During January 2016, approximately 10,000 cubic yards of material was excavated from the Aravaipa Borrow Area (Figure 5). The material was processed into 1.5-inch minus, 2-4 inch gravel, and 4-8 inch rock and was stockpiled on Parcel 110-47-003g for future use as lead tailings removal backfill and cap materials for the LTP. The clean excavation and processing of materials is documented in the *Clean Fill Material Excavation and Processing Report, Klondyke Tailings WQARF Site, Klondyke, Arizona* dated February 26, 2016 (Amec Foster Wheeler, 2016b).

The removal actions are documented in the Fiscal Year 2016 Tailings Removal Action Report, Klondyke Tailings WQARF Site, Klondyke, Graham County, Arizona, dated June 8, 2016 (Amec

Foster Wheeler, 2016c). The excavations were 1 ft deep in accordance with USEPA Guidance (USEPA, 2003) and the previously completed removal actions (E&E, 2014), with the exception of the sustenance gardening area identified as G-1 on Parcel 110-47-003b (Figure 6). The removed lead tailings were consolidated on top of the LTP. The excavations were then backfilled to near pre-excavation conditions using 1.5-inch minus material obtained from the Aravaipa Borrow Area. Prior to backfill, soil samples were collected from the bottoms of the excavated areas. Figures 6 through 9 show the final excavated areas and lead concentrations remaining at the bottom of each excavated area.

## 2.1.9 Confirmation of URS Data

During the FY 2017 planning meeting on May 24, 2016, the proposed remedy for the Site was discussed between ADEQ, Arcadis, and Amec Foster Wheeler. ADEQ was concerned that the surface soil samples reported by URS with lead below 400 mg/kg might not be representative of current Site conditions. Rather than re-sample the Site, ADEQ requested that Amec Foster Wheeler perform statistically defensible surface soil sampling to confirm the URS results, specifically that the URS results remain valid for risk assessment and remedial decision-making. Amec Foster Wheeler, Arcadis, and ADEQ determined that 20 composite samples, plus 13 composite samples collected from Parcel 110-47-001g on January 20, 2016, would provide a statistically representative data set to confirm the URS data.

Amec Foster Wheeler collected the 20 confirmation composite surface soil samples on August 8-9, 2016. The samples were analyzed for lead and arsenic. The sample collection methods and results are documented in the *Klondyke Tailings WQARF Site, Confirmatory Soil Sampling Results Technical Memorandum* dated August 25, 2016 (Amec Foster Wheeler, 2016d). Based on the results, it was concluded that the URS data remained valid for risk assessment and remedial decision-making and that no additional pre-remediation characterization sampling was required.

#### 2.1.10 Klondyke Road Remediation

As discussed in Section 2.1.7, the portion of Klondyke Road that crosses the Site located east of Laurel Canyon Wash (see Figure 4) was impacted with concentrations of lead that represented a significant human health risk to area residents and visitors and current Site uses. Therefore, the area of remediation consisted of the approximate 2,100 linear ft section of Klondyke Road shown on Figure 10. The top average 8-inches of lead impacted soils were removed and then replaced with an average of 12-inches of the 1.5-inch minus material obtained from the Aravaipa Borrow Area. Graham County provided the roadway design. Though the road travel surface ranged from 22-27 ft wide, the excavation area was extended to an average width of 40 ft to remove the lead impacted soils. This portion of Klondyke Road is included as part of Parcels 110-47-003f, 110-47-003h, 110-47-001k, 110-47-003g, and 110-47-006.

The Klondyke Road remediation was performed October 31, 2016 to November 3, 2016 and from November 7, 2016 to November 9, 2016. Approximately 300 ft of road was completed per work day. An estimated 2,100 cubic yards of lead impacted soil were removed and placed on the LTP consolidation area. Prior to backfill of the excavated area, soil samples were collected

from the bottom of the excavation at approximately the same locations as the investigation samples. The post remediation lead concentrations are also shown on Figure 10. The excavation was backfilled with an estimated 2,780 cubic yards of 1.5-inch minus material obtained from the Aravaipa Borrow Area. The Klondyke Road remediation is discussed further in the *Fiscal Year 2017 Removal Action Report, Klondyke Tailings WQARF Site, Klondyke, Graham County, Arizona* dated December 16, 2016 (Amec Foster Wheeler 2016e).

## 2.1.11 November 2016 Lead Tailings Removals

A portion of Parcel 110-47-003d was remediated by the USEPA in 2010 (see Appendix B, Site HS-05). The USEPA remediated this area to a lead concentration of 800 mg/kg. Therefore, an approximate 4,706.91 sq. ft. area north of the residence was indicated to be impacted with lead between 400 mg/kg and 800 mg/kg (see Figure 11). From November 14-16, 2016, this area was excavated to a depth of 1 ft, resulting in the removal of approximately 174 cubic yards of lead impacted soil. The excavated soils were placed on the LTP consolidation area. Two confirmatory soil samples were collected from the bottom of the excavated area and analyzed for lead and arsenic by EPA Method 6010. The results are shown on Figure 11. The excavated area was backfilled with 1.5-inch minus material obtained from the Aravaipa Borrow Area.

A portion of Parcel 110-47-006 was remediated by USEPA in 2010 (see Appendix B, Site HS-03). USEPA remediated this area to a lead concentration of 800 mg/kg. Therefore, an approximate 0.13-acre area adjacent to the residence on the south was indicated to be impacted with lead between 400 mg/kg and 800 mg/kg (see Appendix B, Site HS-03). The property owner was concerned that excavation of this area would disturb existing vegetation. Upon further review of the USEPA characterization data, the average surface soil concentration in this area is less than 400 mg/kg. Therefore, the excavation area was changed to the driveway from Klondyke Road to the residence. This approximate 3,718.44 sq. ft. area, which is shown on Figure 12, was excavated to a depth of 1 ft during November 3-4, 2016, resulting in the removal of approximately 138 cubic yards of impacted soil. The excavated soils were placed on the LTP consolidation area. Four confirmatory soil samples were collected from the base of the excavated area and analyzed for lead and arsenic by EPA Method 6010. The results are shown on Figure 12. The excavated area was backfilled with 1.5-inch minus material obtained from the Aravaipa Borrow Area.

The removal actions on Parcels 110-47-003d and 110-47-006 are discussed further in the *Fiscal Year 2017 Removal Action Report, Klondyke Tailings WQARF Site, Klondyke, Graham County, Arizona* dated December 16, 2016 (Amec Foster Wheeler 2016e).

## 2.2 Land Use Designation

An important component in development of the conceptual site model is identification of current and future land uses. This was used to perform the risk evaluation and identify and prioritize areas of the Site requiring remediation. As previously discussed, property zoning is designated A-General Use minimum 1-acre. This allows the properties to be a minimum of 1-acre in size and developed residential or non-residential. The Mill Site, Parcel 110-47-003g, will be restricted to non-residential uses by application of a DEUR. Of the remaining impacted properties that are or could potentially be developed residentially, with the exception of Parcel 110-47-001k, the impacted properties are greater than 1-acre in area. These properties are referred to as General Use Parcels in this FS Report. Based on this, the property owners may potentially subdivide their properties into 1-acre parcels that are developed residentially. Impacted portions of the Mill Site and General Use Parcels 110-47-001i, 110-47-001m, 110-47-003b, 110-47-003d, 110-47-003f, and 110-47-003h also lie within Flood Zone A. Therefore, the following provides the land use designations used in this FS Report:

Land Use Designation	Description
Mill Site Upland	Impacted portions of Parcel 110-47-003g outside Flood Zone A (see Figure 12 in Appendix E).
Mill Site Floodplain (FP)	Impacted portions of the Mill Site within Flood Zone A and outside the Corps of Engineers Section 404 jurisdictional areas for Laurel Canyon Wash and Aravaipa Creek (see Figure 12 in Appendix E).
General Use Upland	Impacted portions of existing or potential residential areas outside Flood Zone A (see Figures 1-11 in Appendix E).
FP	Impacted portions of General Use Parcels 110-47-001i, 110-47-001m, 110-47-003b, 110-47-003d, 110-47-003f, and 110-47-003h within Flood Zone A and outside the Corps of Engineers Section 404 jurisdictional areas for Laurel Canyon Wash and Aravaipa Creek (see Figures 1-11 in Appendix E)

Due to construction restrictions within designated FP areas, the remedy will not include these areas.

## 2.3 Risk Evaluation Summary

The conceptual site model provided in the RI Report is included as Appendix C. Arcadis has performed a Human Health Risk Assessment (HHRA) to support the ERAs and the remedy selection process in this FS Report (Arcadis 2016a and 2017). The COCs identified by the HHRA are lead, arsenic, and vanadium. Therefore, the HHRA provides an evaluation of risks and hazards to human health from principally lead, arsenic, and vanadium in surface soil of residential properties following soil removal actions based on current land use. However, since the arsenic and vanadium are co-distributed with the lead, if lead soil remediation levels (SRLs) are achieved in surface soils, then the other COCs are expected to be below their respective SRLs. There is also potential for exposure to subsurface soils by residents and construction workers should excavation occur. However, lead concentrations generally attenuate below 400 mg/kg below 12 inches bgs. Additionally, according to the USEPA, excavations of 12 inches depth are protective of human health in most cases (USEPA, 2003). Therefore, remediating the upper 12 inches of the soil is considered capable of achieving the ROs for the Site.

## 2.3.1 Mill Site

The Mill Site (Parcel 110-47-003g) had acceptable levels of arsenic, cadmium, copper, lead, manganese, vanadium, and zinc in surface soil within the excavated areas identified on Figure 9. Concentrations of arsenic and lead in surface soil of upland areas on the Mill Site result in potential exposures that exceed protective levels. The Mill Site is proposed for a DEUR to mitigate these potential exposures. The Arcadis HHRA indicates that the remaining concentrations of lead in surface soils after completion of the ERAs and future capping of the LTP are protective of the current undeveloped use of the Mill site taking into consideration a trespasser/recreational exposure scenario (Arcadis, 2017).

Should portions of the property be considered for commercial development in the future, then remediation of lead in surface soil below 800 mg/kg will be required. The Arcadis GIS-risk model for future commercial development is based on an average residual lead concentration in soil of less than 800 mg/kg within theoretical 40,000-square foot (sq. ft.) Commercial Exposure Units. The commercial exposure areas were developed assuming the current Graham County zoning restriction of one acre minimum density would be continued into the future. Based on the 50-ft by 50-ft (50'x50') grid cells sampled by URS, the theoretical commercial exposure areas were developed for each parcel by creating multiple overlapping polygons consisting of 16 50'x50' grid cells totaling 40.000 sg. ft. A GIS-based risk model was developed by Arcadis to provide complete coverage of the currently undeveloped portions of the Mill site. Overlapping the 40,000-acre Commercial Exposure Units ensured that any future subdivision of the current Mill site would be represented. The GIS-risk model was then used to identify the number of acres on each of the upland areas of the Mill site that are impacted with lead at concentrations that prevent attainment of the 800 mg/kg average residual lead concentration, which is considered protective of residential use (Arcadis 2017). Subtracting previously remediated areas and the planned capping of the LTP, an estimated 6 acres of the Mill Site Upland are impacted with lead above 800 mg/kg (see Figure 12 in Appendix E).

## 2.3.2 General Use Parcels

The surface soils in the areas surrounding the residences on General Use Parcels 110-47-001g, 110-47-001m, 110-47-003b, 110-47-003d, 110-47-003f, and 110-47-006 have been remediated to concentrations protective of current use by the ERAs. Estimated risk to residential receptors at the properties were modeled by Arcadis under three scenarios: 1) residential exposure to metals in surface soil within 200 feet of existing houses; 2) residential exposure to metals in soil within 200 feet of houses plus recreational exposure to metals in surface soil on outlying portions of each residential parcel; and, 3) residential and recreational exposure to metals over the entire parcel and inhalation of fugitive dust from Klondyke Road from vehicular traffic. Scenario 3 was addressed by remediation of Klondyke Road. Therefore, with the exception of the residence on Parcel 110-47-006, the risk modeling concluded that these properties currently have acceptable levels of metals in soil for the scenarios described above. Due to the presence of an un-capped tailings deposit with lead concentrations as high as 18,000 mg/kg approximately 200 feet northeast of the residence (see Figure 12 and Appendix D – SE Panel, lead was not at an acceptable concentration for the current use (Arcadis, 2016a). Therefore, this area will be addressed by the remedy.

The Arcadis GIS-risk model for future residential development is based on an average residual lead concentration in soil of less than 400 mg/kg within theoretical 40,000-square foot (sq. ft.) Residential Exposure Units. The residential exposure areas were developed assuming the current Graham County zoning restriction of one house per acre maximum density would be continued into the future. Based on the 50-ft by 50-ft (50'x50') grid cells sampled by URS, the theoretical residential exposure areas were developed for each parcel by creating multiple overlapping polygons consisting of 16 50'x50' grid cells totaling 40,000 sq. ft. A GIS-based risk model was developed by Arcadis to provide complete coverage of the currently undeveloped portions of the existing parcels. Overlapping the 40,000-acre Residential Exposure Units ensured that any future subdivision of the current General Use Parcels would be represented. The GIS-risk model was then used to identify the number of acres on each of the undisturbed portions of the current General Use Parcels that are impacted with lead at concentrations that prevent attainment of the 400 mg/kg average residual lead concentration, which is considered protective of residential use (Arcadis 2017).

## 2.4 Extent of Contamination

The contamination is limited to soil and the COCs are arsenic, cadmium, copper, mercury, lead, manganese, vanadium, and zinc. The COCs are co-distributed with the lead, and therefore, it is assumed that remediation of lead below applicable risk-based concentrations will result in concentrations of the other COCs that will also be below applicable risk-based concentrations. Therefore, the primary marker metal is lead.

As part of the RI, URS conducted extensive soil sampling to establish the extent of lead contamination. The extent of lead contamination in the soil above 400 mg/kg is depicted by the boundary of the Site shown on Figure 2. This encompasses an area of approximately 132 acres. Appendix D provides panel maps (Northwest [NW], Northeast [NE], Southeast [SE], and Southwest [SW]) of lead concentrations at the surface, 6-inches, 12-inches, and 24-inches (URS, 2014). The extent of lead contamination is discussed separately for the Mill Site (Parcel 110-47-003g) and the surrounding residential properties. The extents of lead contamination for each impacted parcel are provided in Appendix E (shown as yellow shaded areas).

## 2.4.1 Mill Site (Parcel 110-47-003g)

The Mill Site is located on a portion of Parcel 110-47-003g that includes the capped UTP, the uncapped LTP, and the former mill (see Figures 2 and 3). The Mill Site is generally regarded as the source of the lead soil contamination on the surrounding residential properties. The aerial and vertical extents of lead soil contamination at the Mill Site are shown on the SE and SW Panel Maps provided in Appendix D(URS, 2014). The removal actions (approximately 5 acres), capping of the UTP (2.75 acres), and future capping of the LTP (2.6 acres) has and will remediate a total of 10.35 acres of the lead impacted area to levels that are protective of current use (see Figure 3and the SE and SW Panel Maps in Appendix D. Areas A, C, and D were remediated to a depth 12 inches below ground surface (bgs) and Area B was remediated to a depth of 24 inches bgs. The property owner has agreed to sign a Declaration of Environmental Use Restriction (DEUR) on the Mill Site .

After completion of the ERAs and capping of the LTP, the lead concentrations remaining in surface soils in the upland areas of the Mill Site are protective of the current undeveloped use taking into consideration a trespasser/recreational use exposure scenario. However, as indicated previously, an estimated 6 acres are impacted with lead concentrations that are not protective of future commercial development (Removal Action Areas on Figure 12 in Appendix E). As shown on Figure 12 in Appendix E, impacted portions of the Mill Site lie within Flood Zone A.

According to the SE and SW Panel maps in Appendix D, there is minimal data available to evaluate the vertical extent of impact below the surface soil. Lead contamination above 800 mg/kg likely extends to at least 2 ft bgs below the UTP, LTP, and Area A. However, Area A has been excavated and capped with 1 ft – 2.5 ft of clean fill and the UTP has been capped with 2 ft of clean fill. Therefore, these areas have been remediated to levels that are protective of human health (USEPA, 2003). Lead concentrations remaining at 12 inches and 24 inches in Area A are shown on the respective SE Panels in Appendix D.

Prior to excavation to 12 inches, Area C (consisting of C-1 and C-2 on Figure 3) was characterized by surface soil lead concentrations ranging from 6,200 mg/kg to 38,000 mg/kg (see SE Panel Map). Post-excavation lead concentrations at 12 inches in Area C ranged from 30 mg/kg to 20,000 mg/kg (see Lead in Subsurface Soils at 12-inches Depth, SE Panel in Appendix D). Lead concentrations generally attenuate with depth. Area C has been excavated to 1 ft depth and has been capped with 1 ft of clean fill. Therefore, Area C has been remediated to lead levels that are protective of human health (USEPA, 2003).

Prior to excavation to 24 inches, Area B was characterized by surface soil lead concentrations ranging from 590 mg/kg to 30,000 mg/kg (see SE and SW Parcel Maps in Appendix D). Post-excavation lead concentrations at 24 inches within Area B ranged from 38 mg/kg to 460 mg/kg (Amec Foster Wheeler, 2015). Based on this, it is expected that lead concentrations attenuate below 800 mg/kg by 24 inches bgs outside the footprints of the UTP and LTP and Areas A and C.

## 2.4.2 General Use Parcels

The General Use Parcels located within the Site boundaries are listed as follows (see Figure 2); 110-47-001b, 110-47-001g, 110-47-001h, 110-47-001i, 110-47-001k, 110-47-001m, 110-47-003b, 110-47-003d, 110-47-003f, 110-47-003h, and 110-47-006. The extent of lead impact on these properties is generally based on lead concentrations above the RSRL of 400 mg/kg.

Based on the Arcadis risk assessment, the lead concentrations in surface soils after the completed ERAs are protective of the current uses of these properties, with the exception of Parcel 110-47-006. The GIS-risk model developed by Arcadis was used to identify the number of acres on each of the undisturbed portions of the current General Use Parcels that are impacted with lead at concentrations that prevent attainment of the 400 mg/kg average residual lead concentration that is considered protective of future residential development. As shown in Appendix A and Figures 1-11 of Appendix E, however, impacted portions of Parcels 110-47-001i, 110-47-001m, 110-47-003b, 110-47-003d, 110-47-003f, and 110-47-003h lie within area FP. . Due to construction restrictions, these areas will remain undeveloped currently and for the

foreseeable future. Therefore, Arcadis evaluated the risk to current and future property uses associated with the surface soil lead concentrations based on a recreation/trespasser exposure scenario. The GIS risk-based model indicated that lead concentrations in surface soils within Area FP are protective of current and future use..

Based on available data, lead concentrations generally attenuate below 400 mg/kg within the top 24 inches of the soil. Using the GIS-based risk model, the estimated number of acres requiring remediation of lead concentrations protective of future residential development on each parcel is discussed in the following subsections. The selected removal areas are shown as yellow shaded areas on Arcadis Figures 1-11 in Appendix E. Based on the estimates presented below, approximately 31 total upland acres of these properties are currently impacted with lead in surface soil that are not protective of future residential development.

## 2.4.2.1 Parcel 110-47-001b

No previous remediation has been performed on this parcel. This property is approximately 1 acre in area and is currently undeveloped. Based on the Arcadis risk assessment, the lead concentrations in surface soil are protective of current property use. Therefore, no remediation is required for the current use. However, based on the GIS model, approximately 0.06 acres of this parcel are impacted with lead concentrations in surface soil that are not protective of future residential use. The yellow shaded remediation area is shown on Figure 2 in Appendix E.

## 2.4.2.2 Parcel 110-47-001g

This property is 5 acres in area and is currently developed with a small residence. During March 2016, approximately 0.11 acres of this parcel were remediated to a depth of 12 inches (see Figure 8). Based on the Arcadis risk assessment, the lead concentrations in surface soil are protective of current property use. Therefore, no additional remediation is required for the current use. However, based on the Arcadis GIS model, approximately 1.98 upland acres of this parcel are impacted with lead concentrations in surface soil that are not protective of future residential use. The yellow shaded remediation area is shown on Figure 3 in Appendix E.

## 2.4.2.3 Parcel 110-47-001h

No previous remediation has been performed on this parcel, which is 10 acres in area and is currently undeveloped. Based on the Arcadis risk assessment, the lead concentrations in surface soil are protective of current property use. Therefore, no additional remediation is required for the current use. However, based on the Arcadis GIS model, approximately 0.43 acres of this parcel are impacted with lead concentrations in surface soil that are not protective of future residential use. The remediation areas are shown as yellow shaded areas on Figure 4 in Appendix E.

## 2.4.2.4 Parcel 110-47-001i

No previous remediation has been performed on this parcel, which is 40 acres in area and is currently undeveloped. Based on the Arcadis risk assessment, the lead concentrations in surface soil are protective of current property use. Therefore, no additional remediation is required for the current use. However, based on the Arcadis GIS model, approximately 9.81

acres of upland area are impacted with lead concentrations in surface soil that are not protective of future residential use (see yellow shaded areas on Figure 1 in Appendix E).

## 2.4.2.5 Parcel 110-47-001k

This approximate 0.21-acre parcel is currently undeveloped. With the exception of the southwest corner that is located on a remediated portion of Klondyke Road, no previous remediation has been performed on this parcel. Based on the Arcadis risk assessment, the lead concentrations in surface soil are protective of current property use. Therefore, no additional remediation is required for the current use. However, based on the Arcadis GIS model, approximately 0.12 acres of this parcel are impacted with lead concentrations in surface soil that are not protective of future residential use. The remediation areas are shown as yellow shaded areas on Figure 5 in Appendix E.

## 2.4.2.6 Parcel 110-47-001m

This 39.79 acre property is currently developed with a residence and the area around the residence was remediated by the USEPA in 2012 (see Appendix B, Site HS-04). As shown on Figure 2, approximately 24 acres of this property are within the Site boundary. Based on the Arcadis risk assessment, the lead concentrations in surface soil are protective of current property use. Therefore, no additional remediation is required for the current use. However, based on the Arcadis GIS risk-based model, approximately 1.66 upland acres of this parcel are impacted with lead concentrations in surface soil that are not protective of future residential use (see yellow shaded areas on Figure 6 in Appendix E).

#### 2.4.2.7 Parcel 110-47-003b

This 39.8 acre property is currently developed with a residence and lead impacted soils were removed from the area around the residence in April 2016 (see Figure 6). Approximately 2.3 acres around the residence have been remediated to lead concentrations below 400 mg/kg in the upper 12 inches of the soil. Based on the Arcadis risk assessment, the lead concentrations in surface soil are protective of current property use. Therefore, no additional remediation is required for the current use. However, based on the Arcadis GIS risk-based model, approximately 9.07 upland acres of this parcel are impacted with lead concentrations in surface soil that are not protective of future residential use (see yellow shaded areas on Figure 7 in Appendix E).

#### 2.4.2.8 Parcel 110-47-003d

This 6.9 acre property is developed with a residence and approximately 0.22 acres around the residence were remediated by the USEPA in 2012 (see Appendix A, Site HS-05). An additional 0.10 acres were remediated during November 2016 (see Figure 11). Based on the Arcadis risk assessment, the lead concentrations in surface soil are protective of current property use. Therefore, no additional remediation is required for the current use. However, based on the Arcadis GIS risk-based model, approximately 1.03 acres of this parcel are impacted with lead concentrations in surface soil that are not protective of future residential use (see yellow shaded areas on Figure 8 in Appendix E).

## 2.4.2.9 Parcels 110-47-003f and 110-47-003h

These parcels have the same owner and cover an area of 8.92 acres. Parcel 110-47-003f is developed with a residence and Parcel 110-47-003h is undeveloped. During March 2016, approximately 0.98 acres surrounding the residence were remediated to lead concentrations below 400 mg/kg in the upper 12 inches of soil (see Figure 7). Additionally, during the week of October 31, 2016 approximately 0.13 acres of Klondyke Road that is a portion of these parcels were remediated. Based on the Arcadis risk assessment, the lead concentrations in surface soil are protective of current property use. Therefore, no additional remediation is required for the current use. However, based on the Arcadis GIS risk-based model, approximately 1.84 upland acres of these combined parcels are impacted with lead concentrations in surface soil that are not protective of future residential use (see yellow shaded areas on Figures 9 and 10 in Appendix E).

## 2.4.2.10 Parcel 110-47-006

This 39 acre parcel is developed with a residence. However, only the approximate western 13 acres of this parcel are within the boundary of the Site (see Figure 2). Approximately 0.26 acres around the residence were remediated by the USEPA in 2012 (see Appendix A, Site HS-03). An additional 0.64 acres consisting of Klondyke Road and the residential driveway were remediated during November 2016 (see Figure 12). Based on the Arcadis risk assessment, due to the presence of a 0.5 acre tailings deposit approximately 200 feet from the existing residence, the lead concentrations in surface soil are not protective of current property use. Therefore, additional remediation of the tailings deposit is required to meet lead concentrations protective of current use. Additionally, based on the Arcadis GIS risk-based model, approximately 4.82 acres of this parcel are impacted with lead concentrations in surface soil that are not protective of future residential use (see Figure 11 in Appendix E).

## 3.0 FEASIBILITY STUDY SCOPING

#### 3.1 Regulatory Requirements

Remediation at the Site involves soil only. According to A.R.S §49-282.06 (A), remedial actions shall:

- 1. Assure the protection of public health and welfare and the environment.
- 2. To the extent practicable, provide for the control, management or cleanup of the hazardous substances in order to allow the maximum beneficial use of the waters of the state.
- 3. Be reasonable, necessary, cost-effective and technically feasible.

A.R.S §49-282.06 (B.4.a) states that the selection of remedial actions includes the establishment of the level and extent of cleanup at a site or a portion of a site. The rules provide that the selected remedial action meet the requirements of subsection A of A.R.S §49-282.06 and for remediation of soil, the selected remedial action shall be consistent with the soil remediation standards adopted pursuant to section §49-152.

According to A.R.S §49-282.06 (C), the following factors must be considered in selecting remedial actions for soil:

- Population, environmental and welfare concerns at risk.
- Routes of exposure.
- Amount, concentration, hazardous properties, environmental fate, such as the ability to bio-accumulate, persistence and probability of reaching the waters of the state and the form of the substance present.
- Physical factors affecting human and environmental exposure, such as hydrogeology, climate and the extent of previous and expected migration.
- The technical practicality and cost-effectiveness of alternative remedial actions applicable to a site.
- The availability of other appropriate federal or state remedial action and enforcement mechanisms, including, to the extent consistent with this article, funding sources established under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), to respond to the release.

The Remedy Selection Rule A.A.C. R-18-16-407(C) states for remedies addressing only soils, an analysis of alternative remedies is not required. Therefore, an FS report shall be prepared that demonstrates:

- 1. That the proposed remedy addresses the contaminated soil in a manner that achieves compliance with A.R.S. §49-152 and A.A.C R18-7-2 and will achieve the ROs for the use of the property.
- 2. That the proposed remedy was selected based upon best engineering, geological, or hydrogeological judgment following engineering, geological, or hydrogeological standards of practice, considering the following information:
  - a. The RI;
  - b. Best available scientific information concerning available remedial methods and technologies; and
  - c. A written analysis explaining how the remedy is consistent with A.R.S. §49-282.06, including a brief explanation of the comparison criteria as applied to the remedy.

#### 3.2 Delineation and Description of Remediation Areas

As discussed in Section 2. 2, ERAs conducted at the Site have remediated the UTP and portions of Parcels 110-47-001g, 110-47-001m, 110-47-003b, 110-47-003d, 110-47-003f, 110-47-003g, 110-47-003h (Klondyke Road area only), and 110-47-006. The completed ERAs are considered a component of the overall remedy for the Site. Therefore, this section describes the delineation of remediation areas scheduled to-be-completed for the Mill site and the portions of the General Use Parcels that have not been previously remediated by ERAs.

## 3.2.1 Mill Site (Parcel 110-47-003g)

There is one area to be remediated on the Mill site to achieve lead concentrations protective of current uses, capping of the LTP. However, un-remediated portions of the Mill site are impacted with concentrations of lead in surface soil that are not protective of future commercial use.

## 3.2.1.1 Lower Tailings Pile

The LTP is currently exposed and was being used for on-site consolidation of tailings excavated by the ERAs. The ERAs are completed; therefore, the LTP will be capped and armored using a similar design for the capping and armoring of the UTP. The capping and armoring are intended to minimize exposure to the tailings and to protect the LTP from future flood events on Laurel Canyon and Aravaipa Creeks. As shown on Figure 3, the planned footprint of the capped and armored LTP covers an area of approximately 110,995 square ft or 2.6 acres.

## 3.2.1.2 Portions of the Mill Site not Remediated by ERAs and Capping of the LTP

The risk assessment performed by Arcadis indicates that after the LTP is capped, the lead concentrations remaining in surface soils on the undeveloped upland portions of the Mill site are protective of the current undeveloped use considering a recreational/trespasser exposure scenario. However, should portions of the property be considered for commercial development in the future, then remediation of lead in surface soil below the NRSRL of 800 mg/kg will be required. Based on the Arcadis risk-based GIS model, 6 acres of impacted upland area will be required to be remediated to achieve lead concentrations that are protective of future commercial use. These areas are shown as removal areas on Figure 12 in Appendix E. Remediation of these areas is non-time critical and may be considered in the future as a contingency. If the property owner plans to perform commercial development of these currently undeveloped portions of their property in the future, the property owner must notify ADEQ and the plans must be coordinated with ADEQ and Graham County. ADEQ will determine if the planned construction is within an area protective of commercial use or if remediation to levels protective of commercial use is required prior to construction. Remediation may be performed in the future based on prioritization, the schedule provided by the property owner, and available funding. Prioritization will be determined by the property owner providing an approved construction permit from Graham County.

#### 3.2.2 General Use Parcels

As previously discussed, with the exception of Parcel 110-47-006, the completed ERAs have remediated the General Use Parcels to concentrations of lead in surface soil that are protective of the current use. However, the zoning for the properties allows future residential development of the undeveloped portions of the current residentially developed General Use Parcels (Parcels 110-47-001g, 110-47-001m, 110-47-003b, 110-47-003d, 110-47-003f, and 110-47-006) and the currently undeveloped Parcels (110-47-001b, 110-47-001h, 110-47-001i, 110-47-001k, and 110-47-003h). The Arcadis GIS-risk model for future residential development is based on an average residual lead concentration in soil of less than 400 mg/kg within theoretical 40,000 sq. ft. Residential Exposure Units. The exception is portions of these properties located within area FP, which will not be included in the remedy due to construction restrictions currently in-place

for these areas. These areas for each parcel are listed as follows (yellow shaded areas on Figures 1-11 in Appendix E):

Parcel Number	Estimated Remediation Area to Achieve Future Residential Remediation Goal (Acres)
110-47-001b	0.06
110-47-001g	1.98
110-47-001h	0.43
110-47-001i	9.81
110-47-001k	0.12
110-47-001m	1.66
110-47-003b	9.07
110-47-003d	1.03
110-47-003f	1.94
110-47-003h	1.04
110-470-006	4.82
Total	30.83

Remediation of the above areas to foreseeable use are considered non-time critical and may be performed as a contingency based on future development plans. If a property owner plans to construct a residence on currently undeveloped portions of their property in the future, the property owner must notify ADEQ and the plans must be coordinated with ADEQ and Graham County. ADEQ will determine if the planned construction is within an area protective of residential use or if remediation to levels protective of residential use is required prior to construction. Remediation may be performed in the future based on prioritization, the schedule provided by the property owner, and available funding. Prioritization will be determined by the property owner providing an approved construction permit from Graham County.

#### 3.3 Remedial Objectives

The *Final Remedial Objectives Report* dated August 2014 and prepared by ADEQ presents the ROs for the Site (ADEQ, 2014). The RO report relied upon the land and water use study questionnaires collected in 2008 and the solicitation of proposed ROs during the comment period on the Draft RI report in 2014. The land and water use questionnaires are included in Appendix F of the RI Report prepared by URS for ADEQ (URS, 2014).

ROs are established for the current and reasonably foreseeable uses of land and waters of the state that have been or are threatened to be affected by a release of a hazardous substance. Pursuant to A.A.C. R18-16-406(D), it is specified that reasonably foreseeable uses of land are those likely to occur at the Site and the reasonably foreseeable uses of water are those likely to occur within one hundred years unless site-specific information suggests a longer time period is more appropriate.

Reasonably foreseeable uses are those likely to occur, based on information provided by water providers, well owners, land owners, government agencies, and others. Not every use identified in the RI Report has a corresponding RO. Uses identified in the RI Report may or may not be

addressed based on information gathered during the public involvement process, limitations of WQARF, and whether the use is reasonably foreseeable.

The ROs must be stated in the following terms: (1) protecting against the loss or impairment of each use; (2) restoring, replacing, or otherwise providing for each use; (3) when action is needed to protect or provide for the use; and (4) how long action is needed to protect or provide for the use; and (4) how long action is needed to protect or provide for the use.

## 3.3.1 Remedial Objectives for Land Use

The Site is located in a rural residential area. Based on land and water use study questionnaires provided by property owners at the Site, land use in the area is characterized as mixed use residential and agricultural. Agricultural uses are predominately cattle ranching and hay farming. According to the questionnaires, there are no immediate plans to change the land use or zoning for properties within the Site boundaries. Some residents indicate the desire to build several residences on their properties. The exception is Parcel 110-47-003g where a DEUR will be filed by the property owner limiting the property to non-residential uses.

As discussed in Section 2.2, ERAs performed to date at the Site included consolidation and capping of the UTP and the removal, and replacement with clean fill, of 1 ft of contaminated soils in the immediate area of the primary residential living area on six properties. These ERAs reduced the exposure to COCs detected in the surface soils at the Site. The immediate area is defined as an area approximately 200 ft by 200 ft around the primary residential living area. The primary residential living area also includes garages and other structures in the area around the primary residence. In addition, soil was removed and replaced with clean fill material to a depth of 2 ft in areas on the properties used for sustenance gardening.

The removal actions described above are based on the assumption that removal of surficial contaminated soils and placement of a cover of clean soil is protective of human health and the environment. Furthermore, the ERAs are based on the assumption that a minimum of 12-inch soil cover is adequate (EPA, 2003).

Typically, ROs for land use are established for those properties known to be contaminated with hazardous substances above an SRL or a risk-based level. Outside of the source area property that contains the UTP and LTP (Parcel 110-47-003g), approximately 30.83 acres of 11 General Use Parcels that may be developed for potential residential use are impacted by lead concentrations in surficial soils that are not protective of residential use. The 11 General Use Parcels impacted include; 110-47-001b, 110-47-001g, 110-47-001h, 110-47-001i, 110-47-001k, 110-47-001m, 110-47-003b, 110-47-003d, 110-47-003f, 110-47-003h, and 110-47-006 (Figure 2). General Use Parcels with full-time residences received the priority for consideration of ERAs in the immediate area of the primary residential living area. As previously described, these are Parcels 110-47-001g, 110-47-003b, 110-47-003b, 110-47-003d, 110-47-003d, 110-47-003d, 110-47-003f, a portion of 110-47-003h (Klondyke Road portion only), and 110-47-006.

With the exception of Parcel 110-47-003g, the General Use Parcels within the Site are either currently developed with residences or may be developed with residences in the future. Therefore, RSRLs apply to these parcels. As previously stated, a DEUR will be filed on Parcel

110-47-003g; therefore, the NRSRLs apply to this parcel. The ROs for land use at the Site are (ADEQ-URS, 2013):

To restore soil conditions to the remediation standards for residential use specified in A.A.C. R18-7-203 (specifically background remediation standards prescribed in R18-7-204, predetermined remediation standards prescribed in R18-7-205, or site-specific remediation standards prescribed in R18-7-206) that are applicable to the hazardous substances identified. This action is needed for the present time and for as long as the level of contamination in the soil on the property threatens the use as a residential property.

## 3.3.2 Remedial Objectives for Groundwater Use

The groundwater use portion of the RI is an inclusive summary of information gathered from the reports describing groundwater use in the area, the Arizona Department of Water Resources (ADWR), and land owners. According to the responses to the ADEQ questionnaire, the current property owners at Klondyke use their wells for water supply, domestic purposes, irrigation, and livestock watering. Projected water use according to the questionnaires will be a water supply for new or additional residences. The reasonably foreseeable uses of groundwater at the Site are not expected to change.

Water wells located in the vicinity of the Site are typically completed in the shallow alluvium of the Aravaipa Valley groundwater basin. Well depths vary from 10 to 100 ft and may yield up to 1,200 gallons per minute (gpm). However, some wells in the vicinity of the Site produce less than 10 gpm. The subsurface alluvial sediments in Aravaipa Valley vary with depth and lateral distance from the valley slopes. Wells near the center of the valley and in the Aravaipa Creek floodplain generally are completed in coarse-grained sand and gravel and produce larger amounts of water. Wells installed at upslope locations are completed in finer grained or thinner alluvial units and include more clay layers, which results in lower well productivity (ADEQ-URS 2013).

In July 2001, ADEQ conducted a regional groundwater sampling event of domestic wells upgradient and downgradient of the Site. Wells in the vicinity of the Site that were sampled include domestic wells on Parcels 110-47-001i, 110-47-006, and 110-47-003d. Domestic wells upgradient of the Site include Garwood and Sollers. Wells downgradient of the Site include three wells on Cobra Ranch (CR-01 through CR-03), Sollers, Stampfer, Luepke, Franzone, and three Nature Conservancy wells. Samples were analyzed by USEPA Method 200 series for metals. No analytes were detected above AWQSs and generally indicated water of excellent quality (ADEQ-URS, 2013).

Since 2006, four domestic water wells located at the Site have been sampled to assess water quality and to assist in characterizing the groundwater quality in the area. Groundwater samples for metals were unfiltered. Groundwater samples were analyzed for 15 total metals by USEPA Method 200 series. Following a flood event on Laurel Canyon Wash during July 2006, lead was detected at a concentration of 0.145 milligrams per liter (mg/L) in the sample collected from the Parcel 110-47-001m (Curtis) well on August 29, 2007, which exceeded the AWQS for lead of 0.05 mg/L resulting in a re-sampling event on October 17, 2007. The analytical results for the

October 17, 2007 re-sampling event did not detect lead above the laboratory detection limit of 0.005 mg/L. Therefore, the detection of lead above the AWQS could not be confirmed. No other metals have been detected above an AWQS (ADEQ-URS, 2013; URS, 2014).

Four monitor wells on the Mill Site (Parcel 110-47-003g) have been sampled 11 times since their installation in December 2005. Groundwater samples were analyzed for 15 total metals by EPA Method 200 series. No metals were detected above their respective AWQSs (URS, 2014).

In 2006 and 2007, samples from these wells were analyzed for cyanide by EPA Method 4500-CN. Cyanide was not detected above the laboratory reporting limit. In 2007 samples from all four wells were analyzed for volatile organic compounds (VOCs) by EPA Method 8260B and semi-volatile organic compounds (SVOCs) by EPA Method 8270C. No VOCs or SVOCs were detected above laboratory reporting limits (URS, 2014).

Current groundwater use within the Site boundaries is for domestic use, irrigation, and livestock watering. Only one sample has exceeded a water quality standard since sampling began in 2001. Based on this information, an RO for the groundwater is not needed.

## 3.3.3 Remedial Objectives for Surface Water Use

Aravaipa Creek and Laurel Creek are ephemeral and typically dry at the Site. Surface water generally only flows during winter storms, in early spring, and in July and August as a result of summer thunderstorms. According to the responses to the ADEQ land and water use questionnaire, the current property owners at Klondyke do not use surface water. Surface water uses in the area of the Site are not expected to change in the future (ADEQ-URS, 2013).

Located approximately five miles downstream from the Site, Aravaipa Creek's 17-mile long perennial flow stretch is considered by the Arizona Game and Fish Department to have the best remaining assemblage of desert fishes in Arizona. The stretch is home to seven native species including three federally-listed endangered species; the Spikedace, Loach Minnow, and the Gila Topminnow. Aravaipa Creek, from its confluence with Stowe Gulch to the downstream boundary of the Aravaipa Canyon Wilderness Area, is designated an outstanding Arizona water under A.A.C R18-11-112. The Site lies approximately four miles upstream of the Nature Conservancy's Aravaipa Canyon Preserve and approximately six miles upstream of the upper boundary of the Bureau of Land Management's Aravaipa Canyon Wilderness Area (ADEQ-URS, 2013).

A.A.C R18-11-123, Appendix B, list the designated uses for this section of Aravaipa Creek as; full body contact, fish consumption, agricultural livestock watering, and aquatic and wildlife, warm water. In 1977, the Department of Botany and Microbiology at Arizona State University conducted a micro-chemical analysis of Aravaipa Creek and adjacent aquatic habitats relative to land and water use management. Fifteen water quality sampling stations were established along the Aravaipa Creek and its tributaries from downstream of the Site to the confluence of the San Pedro River. Sampling was conducted in August 1976, October 1976, November 1976 and January 1977. The samples were analyzed by USEPA 200 series for dissolved and total metals (ADEQ-URS, 2013).

Except for one mercury sample, the study concluded that metals were within water quality standards in effect at the time. However, the total metals concentrations of lead exceeded current water use standards which are applicable to Aravaipa Creek. The maximum concentration of lead was found to be 0.146 mg/L, which is higher than the current Arizona Surface Water Quality Standard (ASWQS) for full body contact of 0.015 mg/L and the agricultural livestock watering standard of 0.100 mg/L (ADEQ-URS, 2013).

Reported concentrations of copper, lead, selenium, and zinc in the perennial reach of Aravaipa Creek and lead in the vicinity of the Klondyke tailings were greater than the hardness-adjusted National Ambient Water Quality Criteria. In the long term, this may increase the risk to fish, invertebrates, or insectivorous and piscivorous birds or mammals. Furthermore, metals concentrations in surface water can rise dramatically during storm events when bottom sediments are re-suspended and surface runoff leaches water-soluble metals and salts into the creek. Since many fish and amphibian species hatch during the spring when rain events are common, they may be exposed to higher than normal concentrations of dissolved metals and low pH exposure, egg-sac fry, alevins, and tadpoles are much more sensitive than adults. Therefore, water quality conditions that are non-threatening to adults could cause adverse effects on juvenile life history stages (ADEQ-URS, 2013).

The Bureau of Land Management and ADEQ monitored water quality by collecting water samples from six locations in the perennial reach of Aravaipa Creek between 1986 and 1992. Samples were analyzed for general chemistry and metals. The results indicated that except for iron, the detected concentrations of metals did not exceed recommended water quality standards.

Whole body fish were taken from Aravaipa Creek on October 28, 1997, by Kirke King and Mike Martinez of the U.S. Fish and Wildlife Service. Samples were analyzed for arsenic, cadmium, lead, and mercury. Concentrations of an element were considered elevated when they exceeded the 85 percentile of the 1990 National Contaminant Biomonitoring Program. Analytical results for arsenic, cadmium, and lead indicated that fish from Aravaipa Creek were above this 85 percentile. Mercury was not detected. King and Martinez concluded the effect of this contamination is difficult to quantify. Seven species of native fish thrived in the creek, which suggested that these 1997 levels of contaminants were below adverse effect thresholds. King and Martinez recommended that proactive efforts should be made to prevent further contamination of the creek.

Three surface water samples were collected by ADEQ in August 2006 following a large storm event. One surface water sample collected approximately four miles upstream from the Site did not contain metals at concentrations exceeding the corresponding ASWQS for full body contact and fish consumption. Arsenic, copper, iron, lead, manganese, nickel, and zinc were detected above the corresponding laboratory reporting limits.

The surface water sample collected just downstream of the Site and upstream of the Aravaipa Creek/Laurel Canyon Wash confluence and the surface water sample collected approximately two miles downstream from the Site contained arsenic, beryllium, cadmium, chromium, copper, iron, lead, manganese, nickel, and zinc above the corresponding laboratory reporting limits.

Lead was detected above the ASWQS for full body contact of 0.015 mg/L in both samples at a concentration of 0.020 mg/L.

Current surface water use in the area of the site are; full body contact, fish consumption, agricultural livestock watering, and aquatic and wildlife, warm water. The RO for surface water use at the Site is to protect surface water for the designated uses from contamination at the Site. This action is needed for the present time and for as long as the level of contamination in the tailings and soils at the source property threatens the use of surface water for its intended uses.

# 4.0 IDENTIFICATION AND SCREENING OF REMEDIAL MEASURES AND REMEDIAL STRATEGIES

The remedy for the Site is focused on soil only and has the following components:

- 1) The completed ERAs;
- 2) Consolidation and capping of the LTP;
- Contingency non-time critical remediation of currently undeveloped upland areas of the Mill Site (Parcel 110-47-003g) to concentrations of lead in surface soil that are protective of commercial use;
- 4) Remediation of the tailings deposit on Parcel 110-47-006 to meet current use; and,
- 5) Contingency non-time critical remediation of currently undeveloped upland areas of General Use Parcels 110-47-001g, 110-47-001m, 110-47-003b, 110-47-003d, 110-47-003f, 110-47-003h, 110-47-006, 110-47-001b, 110-47-001h, 110-47-001i, and 110-47-001k to concentrations of lead in surface soil that are protective of residential use.

#### 4.1 Remedy Selection Criteria and Site Assumptions

The remedy selection is performed in accordance with the criteria set forth in A.R.S §49-282.06. Pursuant to the soil remediation rules, A.A.C. R18-7-2, The key Site assumptions used to develop the remedy for current uses are listed as follows:

- Remaining lead concentrations in surface soils on Parcels 110-47-001g, 110-47-001m, 110-47-003b, 110-47-003d, 110-47-003f, 110-47-003h, 110-47-001b, 110-47-001h, 110-47-001i, and 110-47-001k are protective of current use; With the exception of the tailings pile located 200 feet from the existing residence, remaining lead in surface soils on Parcel 110-47-006 are protective of the current use of this parcel; and,
- With the exception of the uncapped LTP, remaining lead in surface soils on Parcel 110-47-003g are protective of current use.

Remediation to future uses is identified as a contingency. As previously indicated, remediation of currently undeveloped upland areas of the Mill Site (Parcel 110-47-003g) and General Use Parcels 110-47-001b, 110-47-001g, 110-47-001h, 110-47-001i, and 110-47-001k. 110-47-001m, 110-47-003b, 110-47-003d, 110-47-003f, and 110-47-006 may be performed in the future as a contingency. If remediation is performed, the remedial goal is lead concentrations in surface soil that are protective of the planned development.

#### 4.2 Identification of Remedial Measures and Strategies

The remedial strategies considered in the development of the remedy per A.C.C. R18-16-407F are as follows:

- 1) Physical containment (PC): a strategy to contain contaminants within definite boundaries.
- 2) Source control (SC): a strategy to eliminate or mitigate a continuing source of contamination.

The other remedial strategies listed in A.C.C. R18-16-407F are plume remediation, controlled migration, and monitoring, which are generally related to groundwater impacted sites. There are no ROs for groundwater; therefore, they are not applicable to the Site. No action is also listed as a remedial strategy in A.C.C. R18-16-407F. The surface soil is impacted with lead above the RSRL; therefore, the "no action" strategy is also not applicable to the Site.

A.A.C. R-18-16-407(C) states for remedies addressing only soils, an analysis of alternative remedies is not required. However, alternatives for remediation of the lead impacted soils have been identified and were screened as follows:

IDENTIFIED REMEDIAL MEASURES										
Remedial Measure	РС	SC	Comments	Retained for Screening						
Completed ERAs										
ERAs on developed General Use Parcels	х		Achieved land use RO and are protective of residential use of developed portions of the properties.	Not applicable						
ERA consolidation and capping of the UTP	х	Х	Achieved surface water use RO and allows non-residential use of the property per to-be-filed DEUR.	Not applicable						
ERA soil removal at the Mill site		х	Achieved surface water use RO and allows non-residential use of the property per to-be-filed DEUR.	Not applicable						
ERA soil removal on Klondyke Road	Х	Х	Removes source of lead impact to residential properties	Not applicable						
	Mill	Site (t	to-be-implemented)							
Consolidation and capping of the LTP	х	х	Will achieved surface water use RO and allow non-residential use of the property per to-be-filed DEUR. No screening required, retained as a component of the remedy.	Not applicable						

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IDENTIFIED REMEDIAL MEASURES										
Remedial Measure	РС	SC	Comments	Retained for Screening						
Remediation of impacted s	Remediation of impacted soil outside footprints of capped UTP, LTP and previous ERAs									
In-situ consolidation/capping		х	Will achieve surface water use RO and allow non-residential use of the property per to-be-filed DEUR.	Yes						
In-situ phosphate treatment (ISPT)/capping		Х	Will achieve surface water use RO and allow non-residential use of the property per to-be-filed DEUR.	Yes						
Excavation – consolidation on LTP (pre-capping of LTP)		Х	Will achieve surface water use RO and allow non-residential use of the property per to-be-filed DEUR.	Yes						
Excavation – consolidation in new consolidation cell on Area A		х	Will achieve surface water use RO and allow non-residential use of the property per to-be-filed DEUR.	Yes						
Excavation – off-site disposal		х	Will achieve surface water use RO and allow non-residential use of the property per to-be-filed DEUR.	Yes						
Contingency non-time criti	ical s	oil ren reme	nediation of General Use Parcels r diated by ERAs	not previously						
In-situ consolidation/capping	Х		Is considered protective of future development.	Yes						
ISPT/capping	Х		Is considered protective of future development	Yes						
Excavation – consolidation in new consolidation cell on Area A	х		Is considered protective of future development.	Yes						
Excavation – off-site disposal	Х		Is considered protective of future development.	Yes						
Installation of clean soil pads (capping) above impacted soils	Х	х	Is considered protective of future development.	Yes						

## 4.3 Screening and Retention of Remedial Measures

The screened remedial measures are associated with remediation of lead impacted soils outside the footprints of the capped UTP and LTP and the completed ERAs. The identified remedial alternatives were generally screened per A.R.S. § 49-282.06 based on 1) protectiveness, 2) reasonableness, 3) necessity, 4) cost effectiveness, and 5) technical feasibility. These general screening constraints were developed into screening criteria which

were applied to the remedial alternatives (Table 1). The nine screening criteria provided in Table 1 are obtained from A.R.S. § 49-282.06, A.A.C R18-16-407(E&H). A description of the process and potential COC removal and technical feasibility for each alternative is presented in Table 1, and a qualitative score ranging from 1 to 3 is assigned to each remedial alternative for nine screening criteria. For consistency, 3 indicates a favorable rating and 1 indicates an unfavorable rating. For example, a score of 3 for the screening criteria "Cost" indicates that the cost for the remedial alternative in question is relatively low. Section 5 includes detailed costs for the proposed remedy.

Table 1 - Screening of Soil Remedial Alternatives, Klondyke Tailings WQARF Site											
Remedial Alternative	Description	COC Removal	Technical Feasibility	Land Use Compatibility <sup>a</sup>	Treatment Effectiveness	Time for COC Removal	Constructability	O&M Considerations	Health and Safety Considerations	Flexibility	Cost
1. In-situ consolidation/capping	Upper 2 feet of soil is ripped, turned over, and returned to the excavation. Soil samples are screened in field using XRF to evaluate if cleanup goal for lead has been achieved. Four confirmatory soil samples are then collected and analyzed for lead and arsenic by a fixed-based lab for compliance and risk assessment purposes. Four inches of clean fill from Aravaipa Creek is placed on top of the disturbed area.	Meets EPA guidance for lead removal (EPA, 2003) and ROs for surface water use (Mill site) and land use (General Use Parcels).	Easily implemented due to soil being managed in- situ. Access to the property is readily available. Fill soil is readily available from Aravaipa Creek.	3	3	3	3	Not required	3	3	3 (\$22,300/acre)
2. In-situ phosphate treatment (ISPT)	Designed to decrease toxicity of lead in soil. Requires removal and management of upper 4-inches of soil. Remaining soil to a depth of 12-inches is manually mixed with phosphate and then the treated soil is capped with 4-inches of clean fill from Aravaipa Creek. Removed soil must be placed in an on-site consolidation cell or managed off-site at additional cost.	Meets EPA guidance for lead removal (EPA, 2003) and ROs for surface water use (Mill site) and land use (General Use Parcels).	Moderately feasible due to required management of removed soil. Soil treatment is easily implemented. Access to the property is readily available.	3	3	3	3	Not required	3	3	2 (\$50,000/acre <sup>b</sup> )
3. Excavation and backfill	Requires removal and management of upper 12-inches of soil. Excavation is backfilled with clean soil from Aravaipa Creek. Removed soil must be placed in an on-site consolidation cell or managed off-site at additional cost.	Meets EPA guidance for lead removal (EPA, 2003) and ROs for surface water use (Mill site) and land use (General Use Parcels).	Lowest feasibility rating due to volume of soil required to fill the excavation (3 times more than Alternatives 1 and 2) and required management of removed soil (3 times more than Alternative 2). Easily implemented. Access to the property is readily available.	3	3	3	3	Not required	3	3	1 (\$57,000/acre <sup>b</sup> )

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Table 1 - Screening of Soil Remedial Alternatives, Klondyke Tailings WQARF Site											
Remedial Alternative	Description	COC Removal	Technical Feasibility	Land Use Compatibility <sup>a</sup>	Treatment Effectiveness	Time for COC Removal	Constructability	O&M Considerations	Health and Safety Considerations	Flexibility	Cost
4. Installation of clean soil pad (capping) above impacted soil or tailings.	A 2-foot cap is required for the hillside tailings area northeast of the residence on Parcel 110-47- 006 (approximately 0.5 acre area). A 1-foot pad/cap may be installed as a contingency on heavily vegetated and limited access areas. An additional 8-inch thick cap may be installed as a contingency on areas remediated by Alternative 1 above if surface soils remain impacted with lead above 400 mg/kg.	Meets EPA guidance for lead removal (EPA, 2003) and ROs for surface water use (Mill site) and land use (General Use Parcels).	Easily implemented. Access to the property is readily available. Fill soil is readily available from Aravaipa Creek.	3	3	3	3	Periodic inspection and maintenance of the hillside tailings cap may be required.	3	3	2 (\$39,000/acre)

Notes:

<sup>a</sup> Qualitative ratings: 3 = highest rating; 2 = middle rating; 1 = lowest rating for criteria <sup>b</sup> Cost does not include management of removed soil.

#### 4.3.1 Mill Site

As previously discussed, A DEUR will be filed on the Mill Site limiting the property to nonresidential uses. Therefore, other than capping the LTP, no additional remediation is required for the current undeveloped use of the property considering the trespasser/recreational exposure scenario. However, the Arcadis GIS risk-based model has identified that 6 acres of the undeveloped upland portions of the Mill Site are impacted with lead in surface soil that are not protective of future commercial use. Should commercial development be considered in the future, remediation of these areas may be performed as a contingency. The screening of the remedial alternatives for the Mill Site is presented in Table 1. Based on technical feasibility, cost, and ability to meet the ROs, in-situ consolidation/capping has been selected as the proposed contingency remedy for surface soils with lead concentrations that are not protective of future commercial use. ISPT and excavation/removal were not selected due to higher costs per acre for treatment and requirements and costs to manage excavated soils.

## 4.3.2 General Use Parcels

With the exception of the tailing deposit on Parcel 110-47-006, lead in surface soils on Parcels 110-47-001g, 110-47-001m, 110-47-003b, 110-47-003d, 110-47-003f, 110-47-003h, 110-47-001b, 110-47-001h, 110-47-001i, and 110-47-001k are protective of current property uses. Installation of a clean soil pad has been selected to remediate the tailings deposit on Parcel 110-47-006. After the tailings deposit is capped, lead concentrations in surface soils on Parcel 110-47-006 will also be protective of current uses.

The remedy does not include remediation to future uses. Based on zoning, the currently undeveloped upland portions of Parcels 110-47-001b, 110-47-001g, 110-47-001h, 110-47-001i, 110-47-001k, 110-47-001m, 110-47-003b, 110-47-003d, 110-47-003f, 110-47-003h, and 110-47-006 may be developed residentially in the future. The Arcadis GIS risk-based model has identified that portions of the undeveloped upland portions of these properties are impacted with lead in surface soil that are not protective of residential use. However, should residential development be considered in the future, remediation of these areas may be performed as a contingency. Therefore, the screening of the remedial alternatives for the future residential use of these properties is also presented in Table 1. Based on technical feasibility, cost, and ability to meet residential land use, in-situ consolidation/capping has been selected as the proposed contingency remedy for remediation of currently undeveloped portions of the properties to lead concentrations in surface soils that are protective of residential use. Installation of a clean soil pad may be implemented for future contingency residential development if limited access prevents in-situ consolidation/capping. ISPT and excavation/removal were not selected with higher costs per acre for treatment and requirements and costs to manage excavated soils.

#### 5.0 PROPOSED REMEDY

Based on the identification and screening of remedial measures presented in Section 4, the proposed remedy for the Site consists of the following components:

- 1) The completed ERAs;
- 2) Consolidation and capping of the LTP with a DEUR;
- Installation of a clean soil cap on the hillside tailings deposit on Parcel 110-47-006 with a DEUR;
- Contingency future in-situ consolidation/capping of currently undeveloped upland areas of the General Use Parcels to concentrations of lead in surface soil that are protective of residential use; and
- 5) Contingency future in-situ consolidation/capping of currently undeveloped upland areas of the Mill site to concentrations of lead in surface soil that are protective of commercial use.

Table 2 presents the components of the proposed remedy based on the following:

- 1) Process and reason for selection.
- 2) Achievement of ROs in accordance with A.A.C R18-16-407(C)(1).
- 3) Achievement of remedial action criteria pursuant to A.R.S §49-282.06;
  - a. Protectiveness,
  - b. Reasonableness,
  - c. Necessity,
  - d. Cost Effectiveness, and
  - e. Technical Feasibility.
- Consistency with Current and Future Land Use in accordance with A.A.C R18-16-407(H)(2).
- 5) Contingencies.

The components of the proposed remedy are discussed in the following subsections.

### 5.1 Completed ERAs

### 5.1.1 ERA Soil Removals on Developed General Use Parcels

The ERA soil removals were performed on the developed General Use Parcels in 2012-2013, March-April 2016, and November 2016, in order to remediate areas surrounding existing residences to conditions protective of human health (USEPA, 2003). The LTP was available as an on-site consolidation cell, which decreased costs associated with the management of the removed soils. The alternative was off-site transportation and disposal at an estimated maximum cost of \$600 per ton if managed as a hazardous waste. No further monitoring or maintenance is required for the ERA areas.

### 5.1.2 Mill Site (Portion of Parcel 110-47-003g)

Brief descriptions of the ERAs completed on the Mill site are provided in the following subsections.

			Table 2 - Components of th	e Proposed Remedy, Klondyk	e Tailings WQARF Site				
				Remedia	I Action Criteria		I	Consistent	
Remedial Component	Remedial ComponentProcess and Reason for Selection		Protectiveness	Reasonableness	Necessity	Cost Effectiveness	Technical Feasibility	with Current and Future Land Use	Contingencies
ERA soil removal on General Use Parcels (completed)	The ERA soil removals were performed to remediate the areas surrounding the existing residences to a condition that is protective of human health (EPA, 2003).	Yes, meets EPA guidance for lead removal (EPA, 2003) and land use RO.	Per EPA guidance, is protective of human health (EPA, 2003).	Yes - focused on addressing COCs and contaminated media and meets EPA guidance for lead removal.	Yes - surface soils around existing residences were impacted with lead above the RSRL of 400 mg/kg.	Yes - estimated cost was \$57,000 per acre based on on-site consolidation on the LTP. Alternative was off-site disposal @ maximum estimated cost of \$600/ton or \$1,452,000 per acre.	Yes	Yes - meets EPA guidance for lead removal (EPA, 2003) and RO land use.	None required.
Consolidation/Capping of UTP (completed)	Only on-site remedial alternative for remediation of the UTP	Yes, meets EPA guidance for lead removal (EPA, 2003) and surface water RO.	Removes continuing source of COCs to surface water and surrounding residential properties	Yes - focused on addressing COCs and contaminated media and meets EPA guidance for lead removal.	Yes - removed continuing source of COCs to surface water and surrounding residential properties.	Yes - Only on-site remedial alternative available.	Yes	Yes - property will be restricted to non-residential uses per a DEUR.	Requires long-term annual inspection and possible maintenance. Maintenance will be minimized if access to the UTP is minimized.
ERA soil removal at Mill site (completed)	The ERA soil removals were performed to remediate the area between the UTP and LTP and to prepare the area for the footprint of the consolidated and capped LTP	Yes, meets EPA guidance for lead removal (EPA, 2003) and surface water RO.	Removes continuing source of COCs to surface water and surrounding residential properties	Yes - focused on addressing COCs and contaminated media and meets EPA guidance for lead removal.	Yes - removed continuing source of COCs to surface water and surrounding residential properties.	Yes	Yes	Yes - property will be restricted to non-residential uses per a DEUR.	None required.
ERA Klondyke Road remediation (completed)	Performed to eliminate nearby residents exposure to lead impacted dust originating from the roadway.	Yes, meets EPA guidance for lead removal (EPA, 2003) and land use RO.	Removes continuing source of COCs to surrounding residential properties	Yes - focused on addressing COCs and contaminated media and meets EPA guidance for lead removal.	Yes - removed continuing source of COCs surrounding residential properties.	Yes	Yes	Yes	None required. Graham County will be responsible for on-going maintenance of the remediated road.
Consolidation/Capping of LTP	Only on-site remedial alternative for remediation of the LTP	Yes, meets EPA guidance for lead removal (EPA, 2003) and surface water RO.	Removes continuing source of COCs to surface water and surrounding residential properties	Yes - focused on addressing COCs and contaminated media and meets EPA guidance for lead removal.	Yes - will remove continuing source of COCs to surface water and surrounding residential properties.	Yes - Only on-site remedial alternative available.	Yes	Yes - property will be restricted to non-residential uses per a DEUR.	Requires long-term annual inspection and possible maintenance. Maintenance will be minimized if access to the LTP is minimized.

Table 2 - Components of the Proposed Remedy, Klondyke Tailings WQARF Site									
			Remedial Action Criteria						
Remedial Component	Process and Reason for Selection	Achievement of ROs	Protectiveness	Reasonableness	Necessity	Cost Effectiveness	Technical Feasibility	with Current and Future Land Use	Contingencies
Installation of clean soil pad (capping) above impacted soil	This alternative is selected for the hillside tailings on Parcel 110-47-006. This is also selected as a contingency for heavily vegetated and limited access areas and areas where in-situ consolidation/capping does not remediate lead below 400 mg/kg	Yes, meets EPA guidance for lead removal (EPA, 2003) and surface water RO.	Per EPA guidance, is protective of human health (EPA, 2003).	Yes - focused on addressing COCs and contaminated media and meets EPA guidance for lead removal.	Yes - surface soils are impacted with lead above the RSRL of 400 mg/kg.	Yes - only cost effective alternative available for hillside tailings in that tailings are managed on- site. Contingency capping is more cost effective than excavation and management of removed soil.	Yes	Yes - hillside area will be restricted to non-residential uses per a DEUR.	Hillside tailings pile cap will require long term monitoring and maintenance.
Contingency In-situ Consolidation/Capping of Surface Soils on Mill Site impacted with lead above NRSRL of 800 mg/kg	Five alternatives to remediate the impacted soils were screened in Section 4.0. All achieved the RO. In-situ consolidation/capping was selected as the most feasible and cost effective to meet the RO.	Yes, meets EPA guidance for lead removal (EPA, 2003) and surface water RO.	Removes continuing source of COCs to surface water and surrounding residential properties	Yes - focused on addressing COCs and contaminated media and meets EPA guidance for lead removal.	Yes - will remove continuing source of COCs to surface water and surrounding residential properties.	Yes - due to impacted soils being managed in- situ this is the lowest cost alternative that meets the RO.	Yes	Yes - property will be restricted to non-residential uses per a DEUR.	Based on confirmatory XRF testing, additional mixing may be required to meet cleanup goal. No long term monitoring or maintenance required.
Contingency In-situ Consolidation/Capping of Surface Soils on Currently Undeveloped Portions of Impacted General Use Parcels (outside the Mill Site)	Five alternatives to remediate the impacted soils were screened in Section 4.0. All achieved the RO. In-situ consolidation/capping was selected as the most feasible and cost effective alternative to meet the RO.	Yes, meets EPA guidance for lead removal (EPA, 2003) and surface water RO.	Per EPA guidance, is protective of human health (EPA, 2003).	Yes - focused on addressing COCs and contaminated media and meets EPA guidance for lead removal.	Yes - surface soils are impacted with lead above the RSRL of 400 mg/kg.	Yes - due to impacted soils being managed in- situ this is the lowest cost alternative that meets the RO.	Yes	Yes	Based on confirmatory XRF testing, additional mixing may be required to meet cleanup goal. No long term monitoring or maintenance required.

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# 5.1.2.1 Consolidation/Capping of the UTP

The consolidation/capping of the UTP was completed in 2008. As indicated in Table 2, consolidation/capping of the UTP meets the surface water RO. The cap will require long-term monitoring and maintenance. Inspections of the cap will be made annually in accordance with the *Inspection and Maintenance Plan, Klondyke Tailings WQARF Site, Early Response Action – FY08, Upper Tailings Pile Consolidation*, dated November 2008 (URS, 2008b). The estimated annual cost to inspect the UTP and the LTP and prepare the annual inspection report is \$6,500.

As long as access to the UTP is limited, the cap and erosion control should require minimal maintenance. According to Maccaferri (supplier of the gabion mattresses), the gabion mattresses are designed to be maintenance free. However, the gabion mattresses may require periodic repair or replacement. For cost estimation purposes, a 30-year maintenance period is assumed. This is also the same period of time the ADEQ Voluntary Remediation Program (VRP) uses to estimate DEUR fees. During this period, the maintenance cost estimate assumes three cubic yards of gabion mattress may be replaced every five years at a cost of \$250/cubic yard or \$750/event. Mobilization, oversight, and travel costs are estimated at \$2,000 per event. The estimated cost for six events over 30 years is \$16,500.

### 5.1.2.2 ERA Soil Removals

The ERA soil removals were performed on the Mill site in 2012-2013, March 2015, and March 2016, in order to meet the RO for surface water use and prepare the area for future consolidation/capping of the LTP. The LTP was available as an on-site consolidation cell, which decreased costs associated with the management of the removed soils. The alternative was off-site transportation and disposal at an estimated maximum cost of \$600 per ton if managed as a hazardous waste. No further monitoring or maintenance is required for the ERA areas.

### 5.2 To-Be-Completed Remedy Components

### 5.2.1 Mill Site (Portion of Parcel 110-47-003g)

A DEUR, which is an institutional control limiting the Mill site to non-residential uses, will be filed after the LTP is capped. Therefore, the remedial goal is remediation of lead in surface soil to concentrations protective of current use. Based on the Arcadis HHRA, capping of the LTP combined with the previously completed ERAs will result in the Mill site being remediated to the current undeveloped use considering the trespasser/recreational exposure scenario. However, future commercial development of the impacted upland areas will require remediation of these areas below the NRSRL of 800 mg/kg. Therefore, there are two components associated with remediation of the Mill site as follows:

- 1) Consolidation and capping of the LTP; and
- 2) Contingency remediation of the upland portions of the Mill Site to concentrations of lead in surface soil protective of commercial use.

# 5.2.1.1 Consolidation and Capping of the LTP

Unlike the UTP, the LTP was not considered to be imminently threatened by flooding of Aravaipa Creek and Laurel Canyon Wash, and was going to be utilized for consolidation of lead impacted soils removed by the ERAs. Therefore, the LTP was not capped as an ERA. After consolidation and capping, the LTP will no longer be available for on-site consolidation of soils excavated within the Site.

As presented in Table 2, the consolidation and capping of the LTP is necessary to meet the surface water use RO and to remove a continuing source of COCs to the surrounding residential properties. The consolidation of the LTP consists of two modes of engineering controls to ensure that possible human or wildlife exposure to contaminants on the Mill site is minimized. These include (1) a capping system, and (2) an erosion protection system. Both of the engineering controls are presented as follows:

- A detailed description of the engineering control describing how the control will prevent or minimize exposure to contaminants, the control's specifications, and operating life.
- Maintenance activities for the control are addressed.
- A contingency plan outlines the alternative methods of control if the engineering control fails and must be restored, or if it does not achieve the intended level of protection or mitigation.

For the engineering controls, the following restrictions are recommended, which should not be changed without an engineering analysis approved by ADEQ:

- The soil cap will not be disturbed by vehicles or equipment, except for brief periods during maintenance activities.
- The soil cap and slope will be maintained such that there are no surface impoundments or impediments to the flow of stormwater runoff, thus minimizing the opportunity for water infiltration.
- The drainage and runoff control system will not be modified or drainage impeded.
- No heavy structures will be placed on the cap without an appropriate geotechnical engineering evaluation.
- ADEQ must approve all activities that will or could affect the cap, including but not limited to placing something on top of the cap, adjusting features near the cap that could alter the cap or drainage around the cap, altering the cap, and conducting activities at the cap that could alter erosion or drainage. The LTP will be consolidated and capped similarly to the UTP (URS, 2008). A conceptual design for the purposes of this FS is provided as Appendix F A detailed conceptual cost estimate for consolidating and capping the LTP is also included in Appendix F The estimated cost based on the conceptual design is \$1,681,000 The unit costs used in the cost estimate were obtained from RSMeans® (RSMeans, 2014). The final design will be included as a separate attachment to the PRAP.

### 5.2.1.1.1 Capping System

With regular inspection and maintenance, a capping system provides long-term protection to human health and the environment by preventing physical contact with the tailings and minimizing surface water infiltration into tailings and potential transport of contaminants into the ground water.

The LTP cap system will consist of a compacted tailings sub-base layer overlain by a 2 ft thick compacted soil cap (see Appendix F. The soil for the cap was imported from the Aravaipa Borrow Area in October 2016 (see Figure 5).

### 5.2.1.1.2 Erosion Protection System

The erosion protection system for the LTP will consist of the following (see Appendix F):

- Geotextile fabric placed over the compacted soil cap material on the slopes followed by placement of rock-filled gabion mattresses.
- Gabion mattresses will be tied together over the entire sloped perimeter of the LTP. The gabion mattresses will also extend below grade to scour depth in order to protect against undercutting during major flooding events.
- The gabion mattresses will be constructed of plastic coated, heavy, zinc plated, 2.70 millimeter diameter wire mesh baskets filled with 4 to 8 inch rock in the existing on-site stockpile obtained from the Aravaipa borrow area. Sufficient 4 to 8 inch rock is not available; therefore, 2-4 inch gravel from the existing on-site stockpile will be used as make up. There are sufficient on-site materials to construct the erosion protection system. The gabion mattresses will be secured with a wire mesh lid that is attached to the top of the baskets with stainless steel clips.

### 5.2.1.1.3 Maintenance

The cap is going to require long term monitoring and maintenance. Inspections of the cap will be made annually in accordance with the *Inspection and Maintenance Plan, Klondyke Tailings WQARF Site, Early Response Action – FY08, Upper Tailings Pile Consolidation*, dated November 2008 (URS, 2008b). The estimated annual cost to inspect the LTP cap and prepare the annual inspection report is included in the cost to inspect the UTP.

As long as access to the LTP is limited, the cap and erosion control should require minimal maintenance. However, the gabion mattresses may require periodic repair or replacement. The estimated combined maintenance costs for the UTP and LTP are provided in Section 5.1.2.1.

### 5.2.1.2 Contingency Future Remediation of Undeveloped Upland Areas

Based on the Arcadis risk-based GIS model, approximately 6 upland acres of the Mill Site are impacted with lead in surface soil that is not protective of commercial use (see Figure 12 in Appendix E). Remediation of these areas is considered to be non-time critical and a contingency. If the property owner plans to commercially develop the upland portions of the Mill site property in the future, the property owner must notify ADEQ and the plans must be

coordinated with ADEQ and Graham County. ADEQ will determine if the planned construction is within an area protective of commercial use or if remediation to levels protective of commercial use is required prior to construction. Remediation may be performed in the future based on the following:

- Prioritization;
- The schedule provided by the property owner; and
- Available funding.

Prioritization and scheduling will be based on the property owner providing an approved construction permit from Graham County.

The proposed contingency remedy for future property use is in-situ consolidation/capping at an estimated cost of \$22,400 per acre. Based on available data, lead concentrations in the soil on the Mill Site attenuate below 800 mg/kg between 12 and 24 inches bgs. The remediation area will be staked out using GIS coordinates provided by Arcadis. The smallest standalone area that will be excavated is a 50'x50' area. Each remediation area will be initially excavated to a depth of 24 inches bgs. All work will be performed within the planned remediation area. Ripping may be utilized if the soils are tight or access is limited. Rototilling or mixing of the soil will be minimized as much as possible. The objective is to place the surface soils with the highest lead concentrations at the bottom of the excavation and to place soil with expected lead concentrations below 800 mg/kg within the top eight inches of the remediated area. Based on this, the in-situ consolidation/capping is described as follows:

- 1. Separate excavators will scoop soil in approximate 12 inch lifts, one designated for top soil and one designated for deeper soil.
- 2. The XRF may be used at selected excavations to confirm that the soil at the base of the excavated area is below the lead threshold concentration of 800 mg/kg. If the lead concentration exceeds 800 mg/kg, the excavated area may be deepened.
- 3. The soil in the excavator bucket containing the top 12 inches of soil will be returned to the excavated area first to ensure the top soil is at the bottom and to minimize mixing. This will be followed by the excavator bucket containing the bottom 12 inches of soil.
- 4. The above procedure will be repeated until the entire staked remediation area is completed.
- 5. The objective is to demonstrate that lead concentrations within 12 inches below ground surface are protective of human health per USEPA guidance (USEPA, 2003), in this case lead concentrations below 800 mg/kg. Therefore, to ensure this, the finished remediation area will be raised by 4 inches above ground surface using clean 1.5-inch minus soil obtained from the Aravaipa Creek borrow area (see Figure 5 for the location of the borrow area). Prior to placement of the 4 inches of clean fill, five soil samples will be collected at the surface and 8 inches deep from a 100'x100' area, one from each corner and one from the middle. The exception is a standalone single remediated 50'x50' area. The samples collected at the surface will be composited into a single sample and the samples collected at 8 inches deep will be composited into a single

sample, thus providing statistically average concentration samples for the area. The composite samples will be screened in the field for lead using the XRF. If the lead concentrations in the composite samples are below 800 mg/kg, then the four surface samples will be submitted to a fixed-base laboratory for lead and arsenic analysis using EPA Method 6010. The area will then be compacted to grade by rolling, and then covered with 4 inches of clean fill. If the concentrations are above 800 mg/kg, additional fill soil may be placed or soil mixing may be performed. XRF sampling and analysis will then be repeated until lead concentrations are below 800 mg/kg.

The fill material cost is based on having to obtain the 537 cubic yards of cap material from the Aravaipa Creek borrow area. However, the \$12/cubic yard cost includes mobilization/demobilization and use of the processing mill, which would not be applicable if less than six acres are remediated. In the event less than six acres are remediated during a Fiscal Year, larger rocks if present will be removed manually.

Based on available WQARF funding and the estimated cost per acre, it is anticipated that this component of the remedy can be performed during a single ADEQ Fiscal Year. After remediation is performed, a Remedial Action Completion Report (RACR) will be prepared and submitted. The estimated cost for a RACR will range from \$2,000 for a single acre, \$4,000 for two to four acres, \$8,000 for four to 16 acres, and \$10,000 for greater than 16 acres. Therefore, the minimum estimated cost for a RACR for one acre remediated is \$2,000. No further monitoring or maintenance is anticipated.

# 5.2.2 General Use Parcels

# 5.2.2.1 Current Property Use

Based on the risk assessment performed by Arcadis, with the exception of the tailings deposit on Parcel 110-47-006, remaining lead concentrations in surface soils on General Use Parcels 110-47-001b, 110-47-001g, 110-47-001h, 110-47-001i, and 110-47-001k, 110-47-001m, 110-47-003b, 110-47-003d, 110-47-003f, 110-47-003h, and 110-47-006 are protective of current use. Therefore, with the exception of capping of the tailings deposit on Parcel 110-47-006, no additional remediation is required to achieve lead concentrations in surface soil that are protective of current property uses.

The former mill site/tailings deposit on Parcel 110-47-006 is located on a hillside approximately 200 feet northeast of the residence that is characterized by steep and rocky terrain and elevated lead concentrations up to 18,000 mg/kg. Therefore, it is unlikely in-situ consolidation/capping as designed in Section 5.2.1.2 will be feasible. This area covers approximately 0.5 acres. Therefore, the proposed remedy for this area is cap in-place as follows:

- 1. Approximately two feet of clean 1.5-inch minus material will be placed as a cap over the impacted area;
- 2. Hydro-seeding will be utilized on top to promote vegetation growth as erosion control; and
- 3. A layer of 2-4 inch gravel will then be installed above the cap to provide additional erosion control.

The estimated cost to cap in-place this approximate 0.5 acre area is \$33,000, including a RACR. This area will not be suitable for residential use. Therefore, this area must be subdivided from the remainder of the residential portion of the property and limited to non-residential purposes using a DEUR. The DEUR must be signed by the property owner. The DEUR will require an annual inspection of the cap and performance of regular maintenance based on the findings of the inspection. The annual inspection and reporting costs are included with the annual inspection and reporting costs for the UTP and LTP on the Mill Site. The estimated cost to file the DEUR is \$30,000, which includes consultant/survey costs, and fees paid to ADEQ (assumes 30 year period). The cost estimate for remediation of Parcel 110-47-006 is provided in Table 3 and Appendix G.

# 5.2.2.2 Future Property Use

Remediation of the currently undeveloped portions of the General Use Parcels is considered to be non-time critical and a contingency. If a property owner plans to construct a residence on currently undeveloped portions of their property in the future, the property owner must notify ADEQ and the plans must be coordinated with ADEQ and Graham County. ADEQ will determine if the planned construction is within an area protective of residential use or if remediation to levels protective of residential use is required prior to construction. Remediation may be performed in the future based on the following:

- Prioritization;
- The schedule provided by the property owner; and
- Available funding.

Prioritization and scheduling will be based on the property owner providing an approved construction permit from Graham County.

The proposed contingency remedy for future property use is in-situ consolidation/capping at an estimated cost of \$22,400 per acre. The design for in-situ consolidation/capping is provided in Section 5.2.1.2, with the exception that the soil remedial goal for lead in the new surface soil is 400 mg/kg. However, areas where in-situ consolidation/capping is not feasible due to rocky soil, terrain, and/or heavy vegetation, a clean soil pad may be installed at a cost of \$39,000 per acre. An approximate 1-foot thick engineered soil pad consisting of clean fill soil obtained from Aravaipa Creek will be placed above the impacted soil. The installation of the 1-foot thick pad over this area is considered protective of residential use. Therefore, a DEUR and annual maintenance/inspection is not required.

After remediation is performed, a Remedial Action Completion Report (RACR) will be prepared and submitted. The estimated cost for a RACR will range from \$2,000 for a single acre, \$4,000 for two to four acres, \$8,000 for four to 16 acres, and \$10,000 for greater than 16 acres. Therefore, the minimum estimated cost for a RACR for one acre remediated is \$2,000.

# 5.2.3 Summary of Remedy Costs

The following Table 3 summarizes the estimated cost for the overall remedy based on the previous discussion.

Table 3 - Remedy Cost Summary, Klondyke Tailings WQARF Site								
Parcel Number	Remedy Description	Remediated Acres	Implementation Cost	Post Closure Cost <sup>1</sup>	Reporting Cost	DEUR Costs <sup>2</sup>	Maintenance Fees <sup>3</sup>	Total
Mill Site - 110-47-003g	LTP Cap and UTP + engineering control		\$1,680,792	\$15,000	\$44,000	\$30,000	\$211,500	\$1,981,292
110-47-006	Tailings capping in-place + engineering control	0.5	\$33,000	\$O	\$8,000	\$30,000	Included in cost for Mill Site	\$71,000
	Total Cost Estimate		\$1,713,792	\$15,000.00	\$52,000.00	\$60,000.00	\$211,500	\$2,052,292

1. Post-Closure sampling and abandonment of Mill Site monitoring wells.

2. Based on 30 year program and includes ADEQ fees, survey fees, and application preparation fees.

3. Based on 30 year program and includes annual inspection/reporting and replacement of 3 cubic yards of gabion mattress every 5 years.

### 6.0 COMMUNITY INVOLVEMENT

ADEQ is responsible for the selection of the remedy for the Site, based on the RI and FS Reports and summarized in the PRAP, and includes public involvement in this process. An FS Work Plan (ADEQ, 2014) was developed, pursuant to A.A.C. R18-16-407(B). A notice of availability of the FS Work Plan was posted on February 14, 2015. The PRAP will describe the proposed Site remedy, including estimated costs, and be issued for 90-day public comment after the FS Report is finalized. A Community Advisory Board (CAB) meeting will also be scheduled during the PRAP public comment period. CAB meeting agendas and minutes can be found at:

#### http://www.azdeq.gov/environ/waste/sps/reg.html.

Remedy selection will be documented in the Record of Decision (ROD), which is deemed a final administrative decision as defined by A.R.S. §41-1092 for the Site. The ROD will contain a description of the remedy, a responsiveness summary regarding all comments received on the PRAP, a time for completing the remedy, a total estimated cost, and a time frame for review. This FS Report forms the basis for the selection of the remedy for the Site and will provide the information necessary to support the development of the ROD.

### 7.0 PROPOSED REMEDY SCHEDULE

It is anticipated that the Final PRAP will be issued by June 30, 2017, and the ROD will be issued by ADEQ by December 31, 2017. Therefore, the earliest the planned components of the proposed remedy could be implemented is January 2018.

Remediation of the currently undeveloped portions of General Use Parcels 110-47-001b, 110-47-001g, 110-47-001h, 110-47-001i, and 110-47-001k, 110-47-001m, 110-47-003b, 110-47-003d, 110-47-003f, 110-47-003h, and 110-47-006 and the Mill Site may be performed as a contingency on an as-needed basis and based on current funding. Therefore, remediation to lead concentrations in soil that allow closure of the Site may require several years.

### 8.0 PERIODIC SITE REVIEWS

A.A.C. R18-16-410(B)(8) provides for the performance of periodic remedy reviews to evaluate the progress of the remedy, referred to as Periodic Site Reviews (PSRs). Intervals between PSRs will be determined at ADEQ's discretion. Selected stakeholders are also interviewed to receive input on the progress and applicability of the remedy. This will likely include property owners. The estimated cost to perform a PSR ranges from \$4,000 to \$7,000 depending on the amount of remedial work that was performed during the review period.

### 9.0 SITE CLOSURE AND POST CLOSURE REQUIREMENTS

### 9.1 Site Closure Requirements

A.A.C. R18-16-414 provides the requirements for a determination of No Further Action (NFA), also referred to as Site closure. If a PSR discussed in Section 8.0 determines that the completed remedy has achieved the ROs and the provisions of A.A.C. R18-16-414 (A) (1-3) have been met,

then ADEQ may proceed with Site closure. According to A.A.C. R18-16-414(B), a determination of NFA for a site or a portion of a site shall be published in the registry. This is done using a Closeout ROD. NFA can be applied to portions of the Site or the entire Site.

### 9.2 Post Closure Requirements

As previously discussed, the capped UTP and LTP on the Mill site, and the capped hillside tailings on Parcel 110-47-006 will require annual inspection and periodic maintenance in accordance with the *Inspection and Maintenance Plan, Klondyke Tailings WQARF Site, Early Response Action – FY08, Upper Tailings Pile Consolidation*, dated November 2008 (URS, 2008). The estimated annual cost to inspect the caps and prepare the annual inspection reports is \$6,500. This report will also be submitted to the ADEQ VRP to meet the annual reporting requirements.

As long as access to the UTP is limited, the cap and erosion control should require minimal maintenance. According to Maccaferri (supplier of the gabion mattresses), the gabion mattresses are designed to be maintenance free. However, the gabion mattresses may require periodic repair or replacement. For cost estimation purposes, a 30-year maintenance period is assumed. This is also the same period of time the ADEQ Voluntary Remediation Program (VRP) uses to estimate DEUR fees. During this period, the maintenance cost estimate assumes three cubic yards of gabion mattress may be replaced every five years at a cost of \$250/cubic vard or \$750/event. Mobilization, oversight, and travel costs are estimated at \$2,000 per event. The estimated cost for six events over 30 years is \$16,500. There are four groundwater monitoring wells located on the Mill Site identified as KW-1 through KW-4. These wells are reportedly 4-inches in diameter with total depths ranging from 82-84 ft bgs (URS, 2014). If these wells are no longer required for groundwater monitoring, they should be properly abandoned in accordance with ADWR requirements. However, prior to abandonment, the wells should be sampled to confirm that COCs remain below AWQSs. The wells will be abandoned in-place by filling with grout per Alternative 4 of the ADWR Well Abandonment Handbook, dated September 2008 (ADWR, 2008). The estimated cost to abandon the wells is \$15,000.

#### 10.0 REFERENCES

- Arizona Revised Statutes (A.R.S.) §49-152 Soil Remediation Standards; Restrictions on Property Use.
- A.R.S. §41-1092 Uniform Administrative Hearing Procedures.
- A.R.S. §49-282(06) Remedial Action Criteria; Rules.
- A.R.S §49-287(03) Remedial Investigation and Feasibility Study.
- Arizona Administrative Code (A.A.C.) R18-7-2 Department of Environmental Quality, Remedial Action, Soil Remediation Standards.
- A.A.C R18-11-112 Department of Environmental Quality, Water Quality Standards, Outstanding Waters.
- A.A.C R18-11-123, Appendix B Department of Environmental Quality, Water Quality Standards, Discharge Prohibitions, Surface Waters and Designated Uses.
- A.A.C. R18-16-404 Department of Environmental Quality, Water Quality Assurance Revolving Fund Program, Community Involvement Requirements.
- A.A.C. R18-16-406(D) Department of Environmental Quality, Water Quality Assurance Revolving Fund Program, Remedial Investigations.
- A.A.C. R18-16-407 Department of Environmental Quality, Water Quality Assurance Revolving Fund Program, Feasibility Study.
- A.A.C. R18-16-410 Department of Environmental Quality, Water Quality Assurance Revolving Fund Program, Record of Decision.
- A.A.C. R18-16-414 Department of Environmental Quality, Water Quality Assurance Revolving Fund Program, No Further Action.
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- Amec Foster Wheeler 2016e. Fiscal Year 2017 Removal Action Report, Klondyke Tailings WQARF Site, Klondyke, Graham County, Arizona. December 16
- Arcadis, 2016a. Human Health Risk Assessment, Klondyke Tailings Site, Klondyke, Arizona. June
- Arcadis 2017. Human Health Risk Assessment in Support of the Feasibility Study, Klondyke Tailings Site, Klondyke, Arizona. 2017
- Ecology & Environment, Inc. (E&E), 2010. *Klondyke Tailings Residences Removal Assessment Report*, Graham County, Arizona. December
- RSMeans, 2014. RSMeans® Site Work & Landscape Cost Data, 33rd Annual Edition, 2014
- URS Corporation (URS), 2008a. *Upper Tailings Pile Completion Report,* Klondyke Tailings WQARF Site, Early Response Action-FY08, Upper Tailings Pile Consolidation. November.
- URS, 2008b. Inspection and Maintenance Plan, Klondyke Tailings WQARF Site, Early Response Action – FY08, Upper Tailings Pile Consolidation. November.
- URS, 2014. *Final Remedial Investigation Report,* Klondyke Tailings WQARF Site, Klondyke, Graham County, Arizona. June.
- United States Environmental Protection Agency (USEPA), 2003. Superfund Lead-Contaminated Residential Sites Handbook. August.



FIGURES





Domestic Well Location

Parcel 110-47-006 Tailings Deposit

Parcel Boundary

Klondyke WQARF Site Boundary

110-47-003d	Well Identification		
110-47-003d	Parcel Identification		
UTP	Upper Tailings Pile		
LTP	Lower Tailings Pile		

0 30	0 600		1,200 Feet	N		
Feasibility Study Report Klondyke Tailing WQARF Site Klondyke, Arizona						
	Parcel Map					
FIGURE <b>2</b>	Job No.: 14-20   PM: JC   Date: 4/6/2   Scale: 1" = 4	016-2018 017 400'	amec			
The map shown here has I strictly for use with Amec P map has not been certified this map comes without wa no liability, direct or indirect	been created with all due and reas oster Wheeler Project Number 14 by a licensed land surveyor, and urranties of any kind. Amec Foste t, whatsoever for any such third p	conable care and is -2016-2018. This any third party use of r Wheeler assumes arty or unintended use.	foster wheele	er		









KR1	Sample Location Identification
RSRL	Residential Soil Remediation Level
mg/kg	Milligram per kilogram
UTP	Upper Tailings Pile
LTP	Lower Tailings Pile





Access Road (existing)

Clean Fill Stockpiling/Processing Area

Available Burrow Area

Parcel 110-47-006 Tailings Deposit

2016 Removal Action Areas

Klondyke WQARF Site Boundary

UTP	Upper Tailings Pile
LTP	Lower Tailings Pile





110-47-003d 🔶

is DS, USDA, USGS, AeroGRID, IGN,

# Legend



			Lead	1
	Sample ID	Sample	ADEQ RSRL <sup>1</sup>	
	Sample ib	Depth	400 Conc. (ma/ka)	-
	S1	2"	230	-
	S2	12"	440	
-	S3	2"	320	-
-	S4	12"	420	
	56	12"	290	-
-	S7	12"	260	-
	S8	12"	400	1
	S9	12"	780	
-	<u>S10</u>	12"	200	-
-	S11 S12	2"	200	-
-	S13	12"	450	
-	S14	12"	220	1
	S15	12"	130	
	S16	12"	340	-
-	<u>S1/</u>	12"	260	-
-	S19	12	230	-
-	S20	2"	230	-
F	S21	12"	280	1
	S22	12"	540	4
Ļ	S23	2"	250	4
ŀ	524	2"	200	1
ŀ	525 S26	12"	400	1
F	S27	12"	380	1
	S28	12"	53	]
	S29	12"	340	4
-	S30	2"	220	-
-	S31 S32	2"	280	-
-		2"	190	-
	S34	12"	190	1
	S35	12"	160	1
	S36	12"	840	
-	<u>S37</u>	12"	940	
-	538	12"	230	
-		12"	99	1
-	SRL2	2"	220	1
	G-1	24"	85	-
1	IOTES:	liation Law	(DODLa) abtained	
fr	om Arizona Administrative Cod	iation Leve ie (A A C) R	18-7-205	
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11	D - Identification			
n	ng/kg - milligrams per kilogram	1		
				N
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	Job No : 14.20	16 20	18	_
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no liability, direct or indire	varranties of any kind. Amec Foste ct, whatsoever for any such third p	er wheeler a arty or unin!	tended use. Whe	eler
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Decision Unit (50' x 50') Structure Footprint *2,266ft*<sup>2</sup> Excavation Area *42,683ft*<sup>2</sup>

	Sample	e ID	Sample Depth	ADEQ RSRL <sup>1</sup> 400 Conc. (ma/ka)	
	CE1	1	12"	690	
	CE2	2	12"	1100	
	CE3		12"	250	-
	CE4	1	12"	84	
	CE	5	12"	450	
	CE	5	12"	860	
	CET	7	12"	180	_
	CE8	3	12"	150	
	CES	)	12"	29	
	CE1	0	12"	1600	
	CE1	1	12"	830	
	CE1	2	12"	480	
	CE1	3	12"	520	
	CE1	4	12"	120	_
	CE1	5	12"	120	
	CE1	6	12"	530	
	CE1	7	12"	290	
	CE1	8	12"	/10	
	CE1	9	12"	1200	
	001	0	12	02	
Resu	its bolded a	nd shaded i	indicate result	exceeds RSRL	
<b>Resu</b> ID - Io mg/k	Its bolded a dentification g - milligram	nd shaded i Is per kilogr	ode (A.A.C) R <sup>4</sup> Indicate result am	exceeds RSRL	
Resu ID - Ic mg/k	Its bolded a dentification g - milligram	nd shaded i is per kilogr 80	indicate result	160	
Resu ID - Ia mg/k	Its bolded a dentification g - milligram	nd shaded i is per kilogr 80	indicate result	160	

Parcel 110-47-003f

FIGURE	PM:	JC		
7	Date:	4/6/2017		
-	Scale:	1" = 80 feet		amer
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Drip Line Decision Unit (5' x 5') Decision Unit (50' x 50') Excavation Area 5,000ft<sup>2</sup>

		Lead
Sample ID	Sample	ADEQ RSRL <sup>1</sup> 400
		Conc. (mg/kg)
R3	2"	73
R4	2"	73
R5	2"	46
R6	2"	74
R7	2"	61
R8	2"	91
R9	2"	82
R10	2"	64
R11	2"	64
R12	2"	96
R13	2"	130
R14	2"	270
RE15	12"	190
RE16	12"	130
RRL1	2"	55
Notes:		

ADEQ Residential Soil Remediation Levels (RSRLs) obtained from Arizona Administrative Code (A.A.C) R18-7-205 ID - Identification

mg/kg - milligrams per kilogram









KR1	Sample Location Identification
RSRL	Residential Soil Remediation Level
mg/kg	Milligram per kilogram
UTP	Upper Tailings Pile
LTP	Lower Tailings Pile













# APPENDIX A

GRAHAM COUNTY FLOOD ZONE MAP





# **APPENDIX B**

USEPA FIGURES SHOWING 2012-2013 REMOVAL ACTION AREAS (E&E, 2014)

TDD No. TO-02 09-11-09-0001 PAN 002693.2156.01RF





Y1

G1

Indicates yard section number

1 composite confirmation

Indicates garden section

confirmation sampling area

number 1 composite

sampling area

#### LEGEND

Decision Unit Excavation Boundary 1 foot below ground surface

Decision Unit Excavation Boundary 2 feet below ground surface

Undisturbed Area of Vegetation

5 point composite confirmation sample results:

Bottom of excavation prior to backfill is < 800 lead mg/kg investigation level

Bottom of excavation prior to backfill is > 800 lead mg/kg investigation level

NOTE: All excavation areas were backfilled to native grade with 1.5-inch minus material blended with mulch. At the request of the homeowner, some areas were backfilled with soil that did not contain mulch.

Figure 10 Homesite HS-05 **Removal Features** Klondyke Tailings Removal Graham County, Arizona 85643

cology and environment, inc.



#### LEGEND

- Improved Equipment Access Road
  - Excavation Boundary
- Undisturbed Area of Vegetation

5 point composite confirmation sample from bottom of excavation prior to backfill is < 800 lead mg/kg investigation level

- Decision Unit Excavation Boundary 1 foot below ground surface
- Discrete backfill sample < 800 mg/kg Lead investigation level</p>
- \* Discrete confirmation sample prior to backfill is < 800 mg/kg lead investigation level
- \* Discrete confirmation sample prior to backfill is > 800 mg/kg lead investigation level

NOTE: All excavation areas were backfilled to native grade with 1.5-inch minus material blended with mulch. At the request of the homeowner, some areas were backfilled with soil that did not contain mulch.

ABBREVIATIONS

Indicates yard section number 1

composite confirmation sampling

Y1

area

# Figure 11 Homesite HS-03 Removal Features Klondyke Tailings Removal Graham County, Arizona 85643





- Discrete backfill sample < 400 lead mg/kg investigation level</p>
- Undisturbed Vegetation
- / 5 point composite confirmation sample from bottom of excavation prior to backfill is < 400 lead mg/kg investigation level
  - Decision Unit Excavation Boundary 1 foot below ground surface

#### **ABBREVIATIONS**

Y1 Indicates yard section number 1 composite confirmation sampling area

G1 Indicates garden section number 1 composite confirmation sampling area

NOTE: All excavation areas were backfilled to native grade with 1.5-inch minus material. At the request of the homeowner, backfill soil was not amended with mulch.

# Figure 12 Homesite HS-04 Removal Features Klondyke Tailings Removal Graham County, Arizona 85643



TDD No. TO-02 09-11-09-0001 PAN 002693.2156.01RF

Basemap Source: ESRI World Imagery



Maximum Soil Lead Concentration Detected (mg/kg) using XRF analyzer operated in accordance with US EPA Method 6200

I		97 - 800		1
		801 - 1,600 } Discrete sample location from 75 ft confirmation sampling grid in SAP Labeled with Sample ID (e.g. AD-02-01) and Result		
	•	1,601 - 2,200		K
		Approximate Borrow Area for 'Area D Clay' cap material. After contaminated surface soils were removed to the LTP, this area was excavated at depths up to 15 ft bgs for high clay con		
	<b>*</b> 1	Vertical extent of contamination was not reached during excavation.	NOTES	
		2 ft bgs excavation area. Material removed to LTP.	Samples with IDs ending in:	
	$\mathbb{Z}\mathbb{Z}$	1 ft bgs excavation area. Material removed to LTP.	-01 or -12 = Taken 12 in bgs -24 = Taken 24 in bos	1
		Area Boundaries		1
		(Outline) Discrete sample location added in the field to extend grid across all unvegetated areas	XRF = X-ray fluorescence bgs = Below ground surface	
			All areas excavated below grade were backfilled with unscreened material from the Aravaipa borrow area to restore previous surface drainage patterns.	

Figure 13 Area D Removal Klondyke Tailings Removal Graham County, Arizona 85643




#### LEGEND

Existing drainage

- Constructed Surface Water Diversion Berm
- 4-6 ft bgs Excavation Area

1-4 ft bgs Excavation Area

Remaining Exposed Tailings

Temporary Cap Extent (Residential Removal Soils)

Berm to prevent surface runoff down steep side slopes of Lower Tailings Pile

Approximate extent of Sediment Basin

Area Boundaries

- Site Well
- Confirmation sample collected at the bottom of the excavation, suffix of the label indicates approximate depth below native grade in inches

Figure 14 Area A Removal and LTP Restoration Klondyke Tailings Removal Graham County, Arizona 85643





# **APPENDIX C**

URS CONCEPTUAL SITE MODEL (URS, 2014)

#### Figure 22 Conceptual Site Model Klondyke Tailings WQARF Site



exposed to subsurface soil brought to the surface during excavation activities

		Receptor		
Hu	man		Bi	ota
Area Residents	Site Visitors <sup>(1)</sup>	Construction Workers	Terrestrial	Aquatic
(3)	(3)	(4)	•	•
)(3)	(3)	(4)	٠	•
)(3)	(3)	(4)	•	•
•				
•				
•				
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٠	•	•		
•	•	•		
	1			

٠

Pathway is potentially complete and significant Pathway is negligible or incomplete



### APPENDIX D

URS CORPORATION FIGURES SHOWING EXTENT OF LEAD CONTAMINATION (URS, 2014)

# 700E 800E 900E 3200N 3100N 3000N 2900N 2800N 2700N 2600N 2500N 2400N 2300N 2200N Laurel Creek 2100N 2000N 1900N 1800N 1700N • • 1600N 1500N



Klondyke Tailings WQARF Site

#### Legend

#### Sampling Results

- Lead less than 10 mg/kg
- Lead less than 400 mg/kg
- Lead greater than or equal to 400 mg/kg

#### Reference Features

- Klondyke WQARF Site
- Sampling Grid
- Panel Match Line



Source: Topographical control provided by A TEAM Professional Assoc., Inc. Horizontal datum is NAD83 Arizona State Plane, Central Zone, Vertical datum is based on NAVD29. Aerial Photography provided by Kenney Aerial Mapping Inc., April 2006.



Map Produced: January 2008

P:\ADEQ\KLONDKYE\gis\plots\Figure\_x\_Surface\_11x17.pdf





# Lead in Surface **Soil Samples NW - Panel**

Klondyke Tailings WQARF Site

#### Legend

#### Sampling Results

- Lead less than 10 mg/kg
- Lead less than 400 mg/kg
- Lead greater than or equal to 400 mg/kg

#### **Reference Features**

- Klondyke WQARF Site
- Sampling Grid
- Panel Match Line



Source: Topographical control provided by A TEAM Professional Assoc., Inc. Horizontal datum is NAD83 Arizona State Plane, Central Zone, Vertical datum is based on NAVD29. Aerial Photography provided by Kenney Aeria Mapping Inc., April 2006.



#### Map Produced: January 2008

Figure y Surface 11y17 p



# Lead in Surface Soil Samples SE - Panel

Klondyke Tailings WQARF Site

#### Legend

#### Sampling Results

- Lead less than 10 mg/kg
- Lead less than 400 mg/kg
- Lead greater than or equal to 400 mg/kg

#### Reference Features

- Klondyke WQARF Site
  - Sampling Grid
- Panel Match Line



Source: Topographical control provided by A TEAM Professional Assoc., Inc. Horizontal datum is NAD83 Arizona State Plane, Central Zone, Vertical datum is based on NAVD29. Aerial Photography provided by Kenney Aerial Mapping Inc., April 2006.



#### Map Produced: January 2008

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# Lead in Surface Soil Samples SW - Panel

Klondyke Tailings WQARF Site

#### Legend

#### Sampling Results

- Lead less than 10 mg/kg
- Lead less than 400 mg/kg
- Lead greater than or equal to 400 mg/kg

#### Reference Features

- Klondyke WQARF Site
- Sampling Grid
- Panel Match Line



Source: Topographical control provided by A TEAM Professional Assoc., Inc. Horizontal datum is NAD83 Arizona State Plane, Central Zone, Vertical datum is based on NAVD29. Aerial Photography provided by Kenney Aerial Mapping Inc., April 2006.



#### Map Produced: January 2008

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# Lead in Subsurface Soil Samples at a 6-inch Depth **NW - Panel**

Klondyke Tailings WQARF Site

#### Legend

#### Sampling Results

- Lead less than 10 mg/kg
- Lead less than 400 mg/kg
- Lead greater than or equal to 400 mg/kg

#### **Reference Features**

Klondyke WQARF Site

Sampling Grid

Panel Match Line



Source: Topographical control provided by A TEAM Professional Assoc., Inc. Horizontal datum is NAD83 Arizona State Plane, Central Zone, Vertical datum is based on NAVD29. Aerial Photography provided by Kenney Aerial Mapping Inc., April 2006.



#### Map Produced: January 2008

s\Figure x 6in 11x17 nd



# Lead in Subsurface Soil Samples at a 6-inch Depth SE - Panel

Klondyke Tailings WQARF Site

#### Legend

#### Sampling Results

- Lead less than 10 mg/kg
- Lead less than 400 mg/kg
- Lead greater than or equal to 400 mg/kg

#### **Reference Features**

Klondyke WQARF Site

- Sampling Grid

Panel Match Line



Source: Topographical control provided by A TEAM Professional Assoc., Inc. Horizontal datum is NAD83 Arizona State Plane, Central Zone, Vertical datum is based on NAVD29. Aerial Photography provided by Kenney Aerial Mapping Inc., April 2006.



#### Map Produced: January 2008

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# Lead in Subsurface Soil Samples at a 6-inch Depth SW - Panel

Klondyke Tailings WQARF Site

### Legend

#### Sampling Results

- Lead less than 10 mg/kg
- Lead less than 400 mg/kg
- Lead greater than or equal to 400 mg/kg

#### Reference Features

Klondyke WQARF Site

— Sampling Grid

Panel Match Line



Source: Topographical control provided by A TEAM Professional Assoc., Inc. Horizontal datum is NAD83 Arizona State Plane, Central Zone, Vertical datum is based on NAVD29. Aerial Photography provided by Kenney Aerial Mapping Inc., April 2006.



#### Map Produced: January 2008

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Klondyke Tailings WQARF Site

#### Legend

#### Sampling Results

- Lead less than 10 mg/kg
- Lead less than 400 mg/kg
- Lead greater than or equal to 400 mg/kg

#### **Reference Features**

- Klondyke WQARF Site
- Sampling Grid
- Panel Match Line



Source: Topographical control provided by A TEAM Professional Assoc., Inc. Horizontal datum is NAD83 Arizona State Plane, Central Zone, Vertical datum is based on NAVD29. Aerial Photography provided by Kenney Aerial Mapping Inc., April 2006.



#### Map Produced: January 2008

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# Lead in Subsurface Soil Samples at a 12-inch Depth NW - Panel

Klondyke Tailings WQARF Site

#### Legend

#### Sampling Results

- Lead less than 10 mg/kg
- Lead less than 400 mg/kg
- Lead greater than or equal to 400 mg/kg

#### **Reference Features**

Klondyke WQARF Site

- Sampling Grid
- Panel Match Line



Source: Topographical control provided by A TEAM Professional Assoc., Inc. Horizontal datum is NAD83 Arizona State Plane, Central Zone, Vertical datum is based on NAVD29. Aerial Photography provided by Kenney Aerial Mapping Inc., April 2006.



#### Map Produced: January 2008

plots\Figure x 12in 11x17 p



# Lead in Subsurface Soil Samples at a 12-inch Depth SE - Panel

Klondyke Tailings WQARF Site

#### Legend

- Sampling Results

  Lead less than 10 mg/kg
  Lead less than 400 mg/kg
- Lead greater than or equal to 400 mg/kg

#### **Reference Features**

- Klondyke WQARF Site
  - Sampling Grid
- Panel Match Line



Source: Topographical control provided by A TEAM Professional Assoc., Inc. Horizontal datum is NAD83 Arizona State Plane, Central Zone, Vertical datum is based on NAVD29. Aerial Photography provided by Kenney Aerial Mapping Inc., April 2006.



#### Map Produced: January 2008

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# Lead in Subsurface Soil Samples at a 12-inch Depth SW - Panel

Klondyke Tailings WQARF Site

### Legend

- Sampling Results

  Lead less than 10 mg/kg
- Lead less than 400 mg/kg
- Lead greater than or equal to 400 mg/kg

#### **Reference Features**

- Klondyke WQARF Site
- Sampling Grid
- Panel Match Line



Source: Topographical control provided by A TEAM Professional Assoc., Inc. Horizontal datum is NAD83 Arizona State Plane, Central Zone, Vertical datum is based on NAVD29. Aerial Photography provided by Kenney Aerial Mapping Inc., April 2006.



#### Map Produced: January 2008

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# Lead in Subsurface Soil Samples at a 24-inch Depth **NW - Panel**

Klondyke Tailings WQARF Site

#### Legend

#### Sampling Results

- Lead less than 10 mg/kg
- Lead less than 400 mg/kg
- Lead greater than or equal to 400 mg/kg

#### **Reference Features**

Klondyke WQARF Site

Sampling Grid

Panel Match Line



Source: Topographical control provided by A TEAM Professional Assoc., Inc. Horizontal datum is NAD83 Arizona State Plane, Central Zone, Vertical datum is based on NAVD29. Aerial Photography provided by Kenney Aerial Mapping Inc., April 2006.



#### Map Produced: January 2008

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# Lead in Subsurface Soil Samples at a 24-inch Depth SE - Panel

Klondyke Tailings WQARF Site

#### Legend

#### Sampling Results

- Lead less than 10 mg/kg
- Lead less than 400 mg/kg
- Lead greater than or equal to 400 mg/kg

#### **Reference Features**

Klondyke WQARF Site

- Sampling Grid

Panel Match Line



Source: Topographical control provided by A TEAM Professional Assoc., Inc. Horizontal datum is NAD83 Arizona State Plane, Central Zone, Vertical datum is based on NAVD29. Aerial Photography provided by Kenney Aerial Mapping Inc., April 2006.



#### Map Produced: January 2008

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# Lead in Subsurface Soil Samples at a 24-inch Depth SW - Panel

Klondyke Tailings WQARF Site

#### Legend

#### Sampling Results

- Lead less than 10 mg/kg
- Lead less than 400 mg/kg
- Lead greater than or equal to 400 mg/kg

#### **Reference Features**

Klondyke WQARF Site

— Sampling Grid

Panel Match Line



Source: Topographical control provided by A TEAM Professional Assoc., Inc. Horizontal datum is NAD83 Arizona State Plane, Central Zone, Vertical datum is based on NAVD29. Aerial Photography provided by Kenney Aerial Mapping Inc., April 2006.



#### Map Produced: January 2008

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# APPENDIX E

ARCADIS RISK MODEL REMEDIATION MAPS













PM: ≧ (HCH) DED





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Study PA: ŝ N I N TECH) DEN DEN ž





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## APPENDIX F

CONCEPTUAL LTP CONSOLIDATION AND CAP DESIGN



LEGEND:
100 EXISTING GROUND SURFACE CONTOUR EL, FEET
100 PROPOSED GROUND SURFACE CONTOUR EL, FEET
PROPOSED SOIL CAP LIMITS

RROJECT KLONDYKE TAILINGS WQARF SITE

ARIZONA DEPARTMENT OF ENVIRONMENTAL QUALITY

CLIENT



#### LEGEND:

 PROPOSED GEOTEXTILE
NEW TAILINGS MATERIAL
PROPOSED SOIL CAP
PROPOSED GABION MATTRESS
PROPOSED STRUCTURAL FILL

CLIENT ARIZ	ONA	DEPAR	ΤM	IENT	OF E	INVIRONME	NTAL QUALITY		
PROJECT									
KLUNDIKE TAILINGS WUARF SITE									
CONCEPTUAL LTP CAP DESIGN SECTIONS & DETAILS								r	
DESIGNED BY	JAC	CHECKED BY		мн	DATE	ISSUED FOR	amec 📉		
DRAWN BY	JAC	APPROVED B	Y	JC	04/12/17	REVIEW	foster		
FILENAME		FIG	URE No	o. REV	PROJECT NO.				
2034-A120		A120		) A	14-2016-2018-03.02	wheeler			
## **Conceptual Cost Estimate** LTP Consolidation/Capping Klondyke Tailings WQARF Site

Item	Qty	Unit	Unit Cost	Total Cost	
Aerial Survey	1.00	EA	\$4,575.54	\$4,575.54	
2' Contours	0.00	AC	\$0.00	\$0.00	
Clearing and Grubbing	2.90	AC	\$1,437.50	\$4,168.75	126298.77sf
Rough Grading	1.00	EA	\$5,807.50	\$5,807.50	area up to 100,000sf 111,000sf
Compaction	1,400.00	CY	\$0.55	\$772.80	
2' Soil Can*	9 700 00	CY		\$0.00	130483.12*2=260966cf9665cv
Borrow, Loading and/or Spreading (Stone)	9.700.00	CY	\$25.74	\$249.648.90	
Hauling	9.700.00	CY	\$3.14	\$30,453,15	
Compaction	9,700.00	CY	\$0.55	\$5,354.40	
					[130/83 12-49639 47]-80843 7cf plus 3' overlap at
Gabion Mattresses (12" deep. stone filled)*	9.300.00	SY	\$97.75	\$909.075.00	crest893.52x3=2680.56sf9280.47sv
Borrow, Loading and/or Spreading (Stone)	3,100.00	CY	\$24.15	\$74,865.00	,
Hauling	3,100.00	CY	\$3.14	\$9,732.45	
					(Total surface area: 120/83 12 120/83 12-/0630 47 (top area) -
					80843.7sf., plus 4' overlap at top and bottom., 1363.54 (top area) –
					perimeter)+ $893.52$ (top perimeter) = $2257.06*4 = 9028.24+80843.7 =$
16 oz. Geotextile	11,000.00	SY	\$2.79	\$30,739.50	89871.9 plus 10% wastage 98859.1sf)
*On-site material from Aravaipa Creek (includes					
soil cap and gabion matress stone)	1.00	EA	\$128,800.00	\$128,800.00	
			Subtatal	\$1 4E2 002 00	
			\$1,433,332.99 624 000 00		
-		<b></b>	\$34,000.00		

Final Plan, Specifications, and Estimate (PS&E) \$20,000.00 **Construction Report** \$20,000.00 PM Costs (10%) \$152,799.30

Grand Total

\$1,680,792.29



## APPENDIX G

COST ESTIMATE FOR IN-SITU CONSOLIDATION/CAPPING

## Detailed Cost Estimate Per Acre In-situ Consolidation and Capping

ltem	Qty	Unit	Unit Cost	Total Cost
Field Oversight	40.00	Hrs	\$85.00	\$3,400.00
Subcontracted Fees				
Excavation Subcontractor	1.00	EA	\$7,420.00	\$7,420.00
Analytical fees	4.00	EA	\$43.13	\$172.52
Direct Costs				
Vehicle	5.00	DAY	\$75.00	\$375.00
XRF Rental	1.00	WK	\$700.00	\$700.00
GPS	1.00	DAY	\$150.00	\$150.00
Travel Costs				
Vehicle Mileage	344.00	MI	\$0.45	\$153.08
Subcontractor Lodging and Per Diem	1.00	WK	\$2,340.00	\$2,340.00
Amec Foster Wheeler Per Diem	4.00	DAY	\$36.00	\$144.00
*On-site material from Aravaipa Creek	537.00	CY	\$12.00	\$6,444.00

 Subtotal
 \$21,298.60

 PM Costs (5%)
 \$1,064.93

Grand Total

\$22,363.53

## Detailed Cost Estimate Installation of 12-inch Soil Pad

Item	Qty	Unit	Unit Cost	Total Cost	Comments
Oversight	1.00	EA	\$4,747.00	\$4,747.00	Assumes 1 week per acre and includes travel and per diem
Construction Report	1.00	EA	\$3,000.00	\$3,000.00	
					Includes mob/demob, obtaining and processing 1.5-inch minus material,
Construction SubContractor	1.00	EA	\$28,000.00	\$28,000.00	construction, and per diem
Subtotal				\$35,747.00	
			PM Costs (10%)	\$3,574.70	
		Capit	al Cost Grand Total	\$39,321.70	-