Interim Measures Technical Memorandum

Remedial Investigation/Feasibility Study
Iron King Mine – Humboldt Smelter Superfund Site
Dewey-Humboldt, Yavapai County, Arizona
EPA Identification No. AZ0000309013

Remedial Action Contract 2 Full Service
Contract: EP-W-06-004

Prepared for

U.S. Environmental Protection Agency
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LIST OF ACRONYMS AND ABBREVIATIONS

As	Arsenic
AOI	Area of Interest
COPC	Contaminant of potential concern
EA	EA Engineering, Science, and Technology, Inc.
EPA	U.S. Environmental Protection Agency
FS	Feasibility Study
IM	Interim measures
NPL	National Priorities List
ppb	Part(s) per billion
POE	Point-of-entry
POU	Point-of-use
PRP	Potentially Responsible Party
RI	Remedial Investigation
Site	Iron King Mine – Humboldt Smelter Superfund Site

1. INTRODUCTION

EA Engineering, Science, and Technology, Inc. (EA) has been authorized by the U.S. Environmental Protection Agency (EPA), under Remedial Action Contract No. EP-W-06-004, Task Order 0034-RICO-09MX, to conduct a Remedial Investigation/Feasibility Study (RI/FS) at the Iron King Mine – Humboldt Smelter Superfund Site (Site). EA has prepared this Interim Measures (IM) Technical Memorandum in accordance with: (1) specifications provided in the EPA Statement of Work (SOW), dated 3 March 2008 (EPA 2008); and (2) the EPA-approved EA Work Plan (Revision 01), dated 22 May 2008 (EA 2008).

This IM Technical Memorandum evaluates opportunities for implementation of interim remedial measures at the Site. In general, an IM is defined as a set of short-term actions or activities taken to quickly prevent, mitigate or remedy unacceptable risk(s) posed to human health and the environment by an actual or potential release of a hazardous substance, pollutant or contaminant.

The ultimate goal of an IM is to control or abate threats to human health and/or the environment from releases of or exposures to hazardous substances, pollutants or contaminants, and to prevent or minimize the further spread of contamination while long-term remedies are evaluated. An IM is intended to provide a partial, albeit more immediate, solution while being consistent with the final Site remedy. This IM Technical Memorandum is not an exhaustive compilation of existing data nor is it a detailed engineering evaluation and cost analysis of interim response actions. Rather, it is a preliminary assessment of known or suspected site conditions in relation to their potential environmental impacts to the neighboring community and ecology with emphasis of practical and cost-effective short- and medium-term site management strategies that can be implemented while RI activities are ongoing.

1.1 SITE BACKGROUND

The Site is located in Dewey-Humboldt, Yavapai County, Arizona (Figure 1). The Site is a combination of sources and releases from two separate facilities: the Iron King Mine property and the Humboldt Smelter property. A portion of the Town of Humboldt is situated between the mine and the smelter (Figure 2).

During the site visit that was conducted on 19 March 2008, the following Areas of Interest (AOI) were identified:

- Iron King Mine – The Iron King Mine Proper Area, Iron King Operations Area, Former Fertilizer Plant Area, and ancillary associated properties;
- Humboldt Smelter and ancillary associated properties;
- Off-site Soil in the vicinity of the Site;
- Waterways - Including the Chaparral Gulch, Galena Gulch, Aqua Fria River, and adjoining drainage channels and outfalls; and
- Ground Water - Shallow alluvial and deep bedrock ground water.

These five AOIs were combined into a single Operational Unit for the purpose of conducting the RI/FS because: (1) ore from the Iron King Mine may have been processed at Humboldt Smelter; (2) off-site migration of particulates from the Iron King Mine and Humboldt Smelter may have overlapping air-depositional areas; (3) mine tailings from the Iron King Mine may have migrated onto the Humboldt Smelter property via the Chaparral Gulch; (4) the Aqua Fria River and its contributing waterways (e.g., Chaparral Gulch and Galena Gulch) may have impacts from both the Iron King Mine and Humboldt Smelter; and (5) ground water may be impacted from both the Iron King Mine and Humboldt Smelter.

The Iron King Mine property, located west of Highway 69, occupies approximately 153 acres. The Iron King Mine property is bordered by Chaparral Gulch, to the north, Galena Gulch to the south, Highway 69 to the east, and undeveloped land to the west. The Iron King Mine was a periodically active gold, silver, copper, lead, and zinc mine from 1906 (when the mine produced fluxing ore for the Humboldt Smelter) until 1969. Ore from the Iron King Mine may have been processed at the Humboldt Smelter, which operated from the late 1800s until 1969.

The Humboldt Smelter property, located at the east end of Main Street, occupies approximately 189 acres. The smelter is situated less than 1 mile east of the Iron King Mine property. The Humboldt Smelter property is bordered by the Town of Humboldt to the west and north, the Agua Fria River to the east, and the Chaparral Gulch to the south.

The Iron King Mine property includes the following three subordinate properties (Figure 3):

- The Iron King Mine Proper Area, which consists of a large tailings pile and a plant area. In addition, there are 5 retention ponds or impoundments: Main Retention Pond, Pond 40-01A, Pond 40-02A, Pond 100-003F, and Pond 200-5S.

- The Iron King Operations Area, which historically contained at least 11 buildings, including the assay laboratory office, main office, change rooms, and the mechanical room. This property also contains multiple mine shafts, and the former Glory Hole; the latter of which has more recently been used as a landfill.

- The Former Fertilizer Plant Area includes several abandoned buildings, concrete pads, sumps, tanks, and an ore bin.

The Humboldt Smelter property consists of several abandoned buildings, a smelter stack, a tailings pile (763,000 square feet), a smelter ash pile (1,041,200 square feet), and a slag pile (456,000 square feet) (Figure 4). On-site ponds, pits, and lagoons were reportedly used for the leaching of minerals from mined ore.

Chaparral Gulch, a natural drainage channel, flows from northwest to southeast along the border of the Iron King Mine property. The gulch crosses under Highway 69, passes through a residential area, and then enters the northeast boundary of the Humboldt Smelter property, flowing through the southwest corner. A tailings dam located on the smelter property within the Chaparral Gulch has retained tailings from both the Iron King Mine and Humboldt Smelter properties. The Chaparral Gulch flows into the Agua Fria River approximately ¼ mile downstream of the Chaparral Gulch dam. The Aqua Fria River also flows from the north to the south along the eastern boundary of the Humboldt Smelter property.

Presently, the full extent of off-site soil contamination and possible ground water contamination has not been assessed. Arsenic and other metals have impacted on-site soil, sediments, surface water, and ground water at concentrations significantly above background levels. The 2006 Expanded Site Inspection revealed arsenic concentrations in ground water ranging from 1.2 parts per billion (ppb) to 306 ppb. The Federal Maximum Contaminant Level for arsenic in public drinking water is 10 ppb. At this point, the data are inconclusive regarding the Site's contribution to the arsenic concentrations detected in ground water samples, due to elevated levels of naturally-occurring arsenic in this area. Additional investigation of the ground water is required to identify possible sources of arsenic contamination.

A Potentially Responsible Party (PRP) lead removal action was completed in 2006 to remove contaminated soil from four off-site residential properties. Staff from EPA's Office of Emergency Response supervised the sampling and removal of the contaminated soil conducted by the PRP's contractor.

Portions of this Site were regulated under the Arizona Department of Environmental Quality's Voluntary Remediation Program. In September 2007, EPA received a response from Arizona Governor Napolitano consenting to the placement of the Site on the National Priorities List (NPL). On 19 March 2008, EPA formally proposed the Site to the NPL.

2. OBJECTIVE

The objective of the IM Technical Memorandum is to identify and list known sources or points of exposure (hereafter referred to as "source areas") at each AOI, based on physical features, contaminants of potential concern (COPC), and COPC exposure and transport mechanisms and to assess where one or more of the following seven general interim remedial measures categories (i.e., Items):

1. Mitigate the migration of surface water into the Chaparral Gulch and Galena Gulch;
2. Address the source areas on the Humboldt Smelter property, which may be impacting the Agua Fria River;
3. Install (point-of-use) filtration systems on private wells to prevent exposure to arsenic in drinking water;
4. Address the tailings near the dam located in the Chaparral Gulch;
5. Restrict access to the Humboldt Smelter property;
6. Apply a soil sealant or biocover to prevent windblown dust from the Iron King Mine; and

7. Address other migration or exposure pathways impacting off-site properties/receptors.

3. TECHNICAL APPROACH

Table 1 lists the AOI-specific source areas along with relevant COPC, exposure/transport mechanisms, and site features information in relation to the seven general IM categories. Factors that were considered in assessing the need for IM implementation at a particular source area included the following:

- Actual or imminent threat of exposure to hazardous substances, pollutants or contaminants by nearby human populations, ecological receptors or ecosystem food web;
- Actual or imminent threat of contamination of drinking water supplies or sensitive ecosystems;
- Hazardous substances or wastes in piles or other bulk storage that may pose an imminent threat of release;
- High levels of hazardous substances, pollutants or contaminants in predominantly surface soils that may readily migrate;
- Weather conditions that may cause hazardous substances, pollutants or contaminants to migrate or be released; and
- Other situations or factors that may pose imminent threats to public health or welfare or the environment.

As illustrated by Table 1 more than one IM category may be warranted at a particular source area. Figures 3 and 4 show the location of the known source areas within the Iron King Mine and Humboldt Smelter AOIs. These source areas may directly affect the remaining three AOI; waterways (Chaparral and Galena Gulches), Off-site Soil and Ground Water AOI (e.g., private properties) and will either be addressed indirectly by implementation of IMs at the other AOI (e.g., Off-site Soil AOI will be addressed by mitigation of potential on-site sources such as the large tailings pile) or addressed directly by one of the IM categories (e.g., off-site ground water addressed by Item 3). The IM Technical Memorandum should be reviewed in tandem with the Conceptual Understanding of the Site, prepared under separate cover, that evaluates site conditions (e.g., geology, surface water, etc.) and potential routes of exposure in more detail than is presented in this document.

For each IM category, general response actions were developed for which remedial technologies were identified as shown on Table 2. A descriptive narrative is presented in Section 4 for each technology listed in Table 2. In practice, these technologies can be subsequently scaled, tailored, or combined, as deemed appropriate in the field to achieve the required level of protection or risk reduction for each of the source areas listed on Table 1. The selected IM remedial technologies were considered if they met the following criteria:

- An IM remedial technology that is generally a less complex type of remedial response, requiring minimal design effort, and somewhat presumptive in nature, thereby negating the need for rigorous treatability study or pilot testing;
- An IM remedial technology was based on a non-emergency situation to manage the source(s) of contamination, control the exposure pathway(s) and/or control the hazard(s) to human and environmental receptors; and
- An IM remedial technology that is consistent with the concept of best management practices wherein overall improvement in site conditions is achieved.

In all cases the IM remedial technologies that were identified are not intended to circumvent the more linear remedial investigation, remedial alternatives evaluation, remedial design and remedial action processes. However, if area-specific or Site characteristics suggest that an IM designed to control or abate imminent threats or prevent or minimize the further spread of contamination was potentially viable it was identified on Table 2. If gross measurable or visible contamination to the environment is evident this also served as a threshold criterion for IM consideration. A remedial technology screen was not conducted for this IM Technical Memorandum, since the subset of either presumptive or proven technologies was purposely selected for consideration as a component of the overall Site management strategy.

As evidenced by Tables 1 and 2, there is obvious overlap of the identified remedial technologies between IM categories. This may be an important consideration for deciding the type and sequence IMs that are implemented at the Site. Section 5 evaluates the efficacy of remedial technology implementation from both a hierarchical and overall risk reduction benefit with respect to IMs for the AOI source areas. This information may be useful for subsequent site management planning purposes.

4. REMEDIAL TECHNOLOGY DESCRIPTIONS

This section provides a brief technical overview on remedial technologies for each response action listed in Table 2. As part of the descriptive narrative, each technology is assessed in terms of its effectiveness as a discrete or potential component of an IM and its implementability. Although there is overlap of remedial technologies between response actions, each technology is described only once. Descriptive narratives are general for the more conventional technologies, whereas additional technical details are provided for remedial technologies that are not as common, but are nonetheless proven to be effective in similar situations as cited herein. The list of technologies has purposely been narrowed to a subset that "make sense" from both a technical and implementation perspective and has considered that the Site is in the early stages of investigations and further refinement to the list is possible. In addition, costs, safety, and potential environmental impacts should be considered in the decision point.

TABLE 1 Summary of Site Conditions That May Be Considered for Interim Measures

Area of Interest (AOI)	Location(s), Source(s), Point of Release(s)	Contaminants of Concern	Area or Volume of Impacted Media or Area to be Mitigated/ surface conditions	Primary Exposure Route or Contaminated Media Transport Mode	Interim Remedial Measure Categories[1]						
					ITEM 1 - Mitigate the migration of surface water into *the Chaparral Gulch and Galena Gulch*	ITEM 2 - Address the source areas on the Humboldt Smelter property, which may be impacting the Agua Fria River	ITEM 3 - Install (point-of-use) filtration systems on private wells to prevent exposure to arsenic in drinking water	ITEM 4 - Address the tailings near the dam located in the Chaparral Gulch	ITEM 5 - Restrict access to the Humboldt Smelter property	ITEM 6 - Apply a soil sealant or biocover to prevent windblown dust from the Iron King Mine	ITEM 7 - Address other migration or exposure pathways impacting off-site properties/ receptors
IK	Large Tailings pile	Arsenic, lead, and other metals	62 acres Vegetation/ground cover is sparse Some of the surface is armored, other areas are fine powder material	Surface water runoff and erosion captured by Main Retention Pond and Pond 200-5S The eastern half generates dust with prevailing northeast winds Prior breech of tailings released sediment downstream into Chaparral Gulch that rest behind concrete Dam on Humboldt Smelter Property	Tailings pile surface water runoff collected by ponds. Pipe from Pond 200-5S flows under Highway 69 and may be directed to Chaparral Gulch Based on available data not considered for Interim Measures	Tailings present in Chaparral Gulch behind Dam due to former breech of tailings pile on Iron King property. This may be a continuing source of sediment loading to Aqua Fria River. (See Item 4)	NA	Sediment from Iron King tailings pile breech behind dam on Humboldt causes storm water runoff in Gulch to bypass Dam and is redirected downstream towards Aqua Fria River (see Upstream of concrete Dam AOI source area below)	NA	Portions of this area are susceptible to windblown erosion and dust generation **Based on available data this is considered for Interim Measures**	Possible tailings erosion along steep side slopes of tailings or another slope failure resulting in a release to Galena Gulch Based on available data not considered for Interim Measures
	Small tailings pile	Arsenic, lead, and other metals	8 acres Surface is not fine powder Vegetation/ground cover is sparse	Immediately adjacent to Chaparral Gulch, washes directly into Gulch. Not likely susceptible to wind erosion	Tailings and surface runoff wash into Gulch contribute to migration of metals-contaminated sediment **Based on available data this is considered for Interim Measures**	NA	NA	NA	NA	Portions of this area are susceptible to windblown erosion and dust generation **Based on available data this is considered for Interim Measures**	NA
	Waste rock / fertilizer plant and Glory Hole	Arsenic, lead, and other metals	30 acre Surface is fine powder processed residue material in processing area No vegetation/ground cover is present	Area (surface) is contaminated. storm water drains unchecked into Galena Gulch along southwest corner of property	Surface water erosion channeled into Galena Gulch	NA	NA	NA	NA	Portions of this area are susceptible to windblown erosion and dust generation **Based on available data this is considered for Interim Measures**	No other pathways have not been quantified
	Ironite Plant Site	Arsenic, lead, and other metals	12 acres Surface is combination of buildings, paved or armored areas and fine powder	Most of SW runoff appears to be captured by ponds 40-01A, 40-02A and 100-003F before entering into Chaparral Gulch	Not a significant issue for this site Based on available data not considered for Interim Measures	NA	NA	Na	NA	Portions of this area are susceptible to windblown erosion and dust generation **Based on available data this is**	No other pathways have not been quantified

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			Vegetation/ground cover is sparse							**considered for Interim Measures**	
	Other surface soil impacted by migration of COC	Arsenic, lead, and other metals	Not quantified	Most of remaining site likely impacted by wind blown dust of surface material Surface water runoff sediment erosion may or may not be captured, but not likely major contaminant transport mechanism	This issue has not been quantified Based on available data not considered for Interim Measures	NA	NA	NA	NA	Portions of this area are susceptible to windblown erosion and dust generation **Based on available data this is considered for Interim Measures**	No other pathways have not been quantified
	Ponds 40-01A, 40-02A, 100-003F, and 200-5S	Arsenic, lead, and other metals		These ponds receive SW flow from most of site. Most ponds allow for evaporation or infiltration	This issue has not been quantified Based on available data not considered for Interim Measures	N	NA	NA	NA	NA	NA
HS	Mine tailings	Arsenic, lead, and other metals	17.5 acres Surface is mixture of fine powder and coarser material Vegetation/ground cover is sparse	Yellow/Orange mine tailings erode into Chaparral Gulch and have filled behind the dam and is major contributor to sediment load in Galena Gulch Likely susceptible to wind erosion	Address sediment that causes surface runoff to divert around concrete Dam **Based on available data will be considered for Interim Measures**	Continued migration of sediment (i.e., tailings) along Chaparral Gulch **See Item 1**	NA	**Based on available data will be considered for Interim Measures under Item 1 and Item 4 for the "Upstream of concrete Dam" AOI/Source Area**	NA	Portions of this area are susceptible to windblown erosion and dust generation **Based on available data this is considered for Interim Measures**	Potential for dust generation **Based on available data will be considered for Interim Measures**
	Ash/Debris Piles	Arsenic, lead, and other metals	24 acres Surface is mixture of fine powder and coarser	Miscl. scattered piles of varied size material. Most of these piles are not located close to washes or Gulches	This issue has not been quantified. Based on available data not considered for Interim	This issue has not been quantified. Likely not a significant issue for this site	NA	NA	NA	Portions of this area are susceptible to windblown erosion and dust generation	Potential for dust generation **Based on available data**

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			material Vegetation/ground cover varies from pile to pile	Some piles may be susceptible to wind erosion Piles not located directly adjacent to River, Surface water pathways have not been quantified	Measures	Based on available data not considered for Interim Measures				**Based on available data this is considered for Interim Measures**	**will be considered for Interim Measures**
	Other surface soil impacted by migration of COC	Arsenic, lead, and other metals	Not quantified	Most of remaining site likely impacted by wind blown dust of surface material, Surface water runoff may not likely major contaminant transport mechanism	This issue has not been quantified Based on available data not considered for Interim Measures	NA	NA	NA	NA	Portions of this area are susceptible to windblown erosion and dust generation **Based on available data this is considered for Interim Measures**	No other pathways have not been quantified
	Slag Pile	Elevated metals (*this pile contains marginally elevated metals, but at comparatively lower levels that tailings or ash piles)*	11 acres Surface is fine coarse or crusty Vegetation/ground cover is sparse	This pile located adjacent and very close to Aqua Fria River Likely not susceptible to wind erosion Erosion potential low Surface water may leach metals and transport to stream	Not a significant issue for this site Based on available data not considered for Interim Measures	Not a significant issue for this site Based on available data not considered for Interim Measures	NA	NA	NA	NA	
	Upstream of concrete dam	Arsenic, lead, and other metals	Volume of sediment (tailings) has not been quantified	Most of sediment likely derived from tailings at IK site	**See Item 4**	**See Item 4**	NA	Tailings behind Dam divert surface water flow and do not allow for adequate surface water retention during storm runoff Sediment behind Dam is also windblown dust and downstream sediment transport issue **Based on available data this is**	NA	NA	NA

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					ITEM 1 - Mitigate the migration of surface water into *the Chaparral Gulch and Galena Gulch*	**ITEM 2** - Address the source areas on the Humboldt Smelter property, which may be impacting the Agua Fria River	**ITEM 3** - Install (point-of-use) filtration systems on private wells to prevent exposure to arsenic in drinking water	**ITEM 4** - Address the tailings near the dam located in the Chaparral Gulch	**ITEM 5** - Restrict access to the Humboldt Smelter property	**ITEM 6** - Apply a soil sealant or biocover to prevent windblown dust from the Iron King Mine	**ITEM 7** - Address other migration or exposure pathways impacting off-site properties/ receptors
								<u>**considered for Interim Measures**</u>			
Ground water	Well/Site specific	Arsenic, lead, and other metals	There are 10 to 15 that exceed MCLs now – including municipal well –	Some of these might not be used for domestic use –	NA	NA	<u>**Based on available data this is considered for Interim Measures**</u>	NA	NA	NA	NA
HS	Entire property	Arsenic, lead, and other metals			Gates, lock, bolster	NA	NA	NA	<u>**Based on available data this is considered for Interim Measures**</u>	NA	No other pathways have not been quantified

[i] Bolded Red Text in table indicates actionable Items

Table 2 Interim Measures, Response Actions, and Remedial Technologies

Interim Remedial Measure	Applicable AOI/Source Areas	Response Action	Remedial Technologies
ITEM 1 - Mitigate the migration of surface water into *the Chaparral Gulch and Galena Gulch*	• Iron King Mine/Small tailings Pile • Humboldt Smelter/Tailings Pile • Humboldt Smelter/Ash Piles	Surface Water/Sediment and Erosion Control	• Silt Fence • Storm water Retention Ponds • French Drain or Interceptor Trench • Dike or Berm for Runon/Runoff Control • Slope Stabilization
	• Humboldt Smelter/Ash Piles	Excavation/Relocation	• Mechanical Excavation and Removal/Re-location on Site
ITEM 2 - Address the source areas on the Humboldt Smelter property, which may be impacting the Agua Fria River	• Humboldt Smelter/Tailings Pile	See Item 1	• See Item 1 for this site
ITEM 3 - Install (point-of-use) filtration systems on private wells to prevent exposure to arsenic in drinking water	• Off-site Private Wells	Alternate Water Supply	• Point-of-use Treatment
ITEM 4 - Address the tailings near the dam located in the Chaparral Gulch	• Humboldt Smelter [1]/ Tailings Upstream of Concrete Dam	Excavation/Relocation	• Mechanical Excavation and Removal/Re-location on-site
ITEM 5 - Restrict access to the Humboldt Smelter property	• Humboldt Smelter AOI	Institutional Controls	• Access Restrictions (e.g. fencing and signage) • Site Security • Public Education
ITEM 6 - Apply a soil sealant or biocover to prevent windblown dust from the Iron King Mine	• Iron King Mine/Small Tailings Pile • Iron King Mine/Waste rock /Fertilizer Plant and Glory Hole	Dust suppression	• Soil Sealant • Biosolids • Vegetative Cover/ Phytostabilization
ITEM 7 - Address other migration or exposure pathways impacting off-site properties/receptors	• Humboldt Smelter/Ash Piles • Humboldt Smelter/Tailings Pile	Dust suppression	• Soil sealant • Biosolids • Vegetative Cover/ Phytostabilization

Note:
[1] Does not include any Dam reconstruction activities

4.1 INSTITUTIONAL CONTROLS

Institutional controls affect site management and/or activities occurring at the site. Institutional controls do not physically alter conditions at the Site and do not reduce the toxicity, mobility, or volume of COPCs at the Site. Rather, institutional controls are used to limit the potential for exposure to COPCs, primarily through restrictions to land use or site access.

4.1.1 Site Access Restrictions (Fencing, Signage, Etc.)

Site access restrictions include property access controls, restrictions, and limitations on future Site development using passive physical restraints such as fencing, barriers or posted signs. This interim remedial measure (Item 5 on Tables 1 and 2) specifically addresses the issue of Site access restrictions for the Humboldt Smelter property. However, it is equally important that Site access restrictions be implemented and maintained (if not already in place) at any AOI source area where other types of IMs involving physical modifications or alterations that would be subject to potential vandalism or tampering. These types of unauthorized actions, in addition to being a potential health threat, would potentially reduce or negate the beneficial effects of other IMs, including their effectiveness and longevity. An example of this situation would be restricted access to human activity, such as use off all-terrain vehicles in areas where surface soil was covered, sealed, or temporary berms and erosion controls were constructed.

Control of Site access can be accomplished through installation of fencing, upgrade of existing fencing (including gates), or in some cases, conscious and deliberate effort to ensure existing fencing and gates are physically intact, maintained, and locked, accordingly. Specific AOI or AOI source areas where access controls may be warranted is dependent upon whether or not other complimentary IMs are implemented or current access restrictions are already in place.

Site access restrictions would reduce the likelihood of unauthorized access or trespassing, but will not be 100% effective if breeched or not maintained. The primary purpose of access restrictions would be to reduce or eliminate human receptor direct exposure to surficial contamination and/or destruction or interference with other on-site IMs or RI activities. Site access restrictions would not reduce the toxicity, mobility, or volume of COCs. Site access restrictions are readily implementable and should be considered a prerequisite at areas where other IMs require protection from outside physical disturbances.

4.1.2 Site Security

In addition to passive physical Site access restraints, manned security could be provided either on a part or full-time basis. While this is not typical at most sites, it may be considered, if passive measures are not effective or Site security is required on an as-needed basis.

4.1.3 Public Outreach/Education

Another cost-effective measure is open public forums, meetings and other general public notification measures such as flyers or newspaper designed to educate the local community on ongoing Site activities and the importance of restricting public access to sensitive or contaminated areas during investigation and IMs. It can be stressed that IMs taken to protect the public or reduce risk will only be effective if sites can be secured from unauthorized public access.

4.2 EXCAVATION/RELOCATION

In the context of Site IMs, mechanical excavation is considered only for situations involving targeted removal of "hot spots" or isolated ash piles/tailings/debris (Items 1 and 2 on Tables 1 and 2) that may be impacting the Chaparral or Galena Gulches, support activities for other remedial measures (e.g., retention pond enlargement/construction or slope regrading) or removal of tailings from behind the concrete Dam (Item 4 on Tables 1 and 2). These situations involve removal and relocation of material using conventional excavation equipment.

Excavated material could be placed directly onto trucks transferred to a staging area or to designated on-site location(s). It is assumed that all areas will be dry, require minimal removal/treatment of ponded water, and can be addressed utilizing standard excavation practices and equipment. Table 3 presents a preliminary list of AOI source areas where excavation/relocation may be warranted, which is somewhat dependent on whether or not other complimentary IMs are implemented.

Table 3 AOI Source Areas Where Excavation/Relocation May Be Warranted

AOI or AOI/ Source Area	Type of Excavation	Rationale
Tailings Behind Concrete Dam	Partial or complete removal of tailings to allow for additional storm water retention capacity and/or minimize dust generation	Reservoir behind Dam is full. Storm water runoff is not retained
Humboldt Smelter/Ash Piles	Removal or consolidation of any piles that may impact surface water (i.e. Gulches) or contribute to airborne dust generation	Consolidate piles into manageable graded piles with appropriate storm water and erosion control measures or reduce dust generation
General Regrading Ancillary to Other Interim Actions	In general some IMs will cause generation of silt materials from the construction of diversion channels, drainage canals, limestone channels, berms, fences and others and slope stabilization activities.	Consolidate or relocate any residual material generated from construction activities involving land re-contouring

Excavation is a well-proven and highly effective method for removing impacted material from a site. Selective excavation is highly effective for the removal of well-defined, localized volumes of contaminant-impacted material. Confirmatory sampling would be conducted to verify the effectiveness of excavation. The required services and equipment for excavation are readily available.

4.3 SURFACE WATER AND SEDIMENT EROSION CONTROL

There are several source areas that could pose a threat to the Chaparral and Galena Gulches and ultimately to the Agua Fria River. These interim remedial measures (Items 1 and 2 on Tables 1 and 2) specifically address the issue of surface water and erosion control. Surface water migration, sediment erosion, and sediment transport are potential concerns, but these pathways have not been fully quantified. In lieu of more site-specific data relative to dissolved-phase COPC transport in surface water, the more immediate issue is the transport of contaminated soil, sediment, or tailings by erosion. From a broad perspective erosion of tailings and other stockpiled granular material typically occurs along steep-side slopes (e.g., large tailings pile), and to a lesser degree along natural accumulation points down-slope of tailings or ash piles. In most cases, existing storm water control systems capture the eroded material and storm water runoff on the Iron King property. However, in the past, large-scale slope failures, such as the breech of the large tailings pile, have contributed to the filling of the reservoir behind the concrete Dam. Elsewhere across the site, obvious areas of incidental erosion include the small tailings pile on the Iron King property that is immediately adjacent to Chaparral Gulch, portions of the waste rock area adjacent to Galena Gulch, yellow ore pile on the Humboldt Property immediately adjacent to Chaparral Gulch, and slag pile adjacent to the Agua Fria River. Erosion from ash piles on the Humboldt Property may also be a continuing issue. Since the erosion and accumulation points have not been fully quantified, it is difficult to identify locations where IMs can be implemented most effectively. Based on present site data, the immediacy of new or upgrades to storm water and sediment erosion controls may not be apparent under current or static conditions. However, it is worth noting that any other type of IM implemented across the Site that reduces the infiltration capacity (e.g., soil sealing or application of a cover), or any land re-contouring may require new or upgraded sediment and erosion controls during and pursuant to the IM construction activities. For example, a reduction of the infiltration capacity of the large tailings pile due to a particular type of soil sealant may increase surface water runoff and side-slope erosion that would commensurately require upgrades to the existing surface water and erosion control system. Whether storm water and sediment erosion controls are implemented as a standalone IM or as an ancillary component to another type of response action, the following conventional engineering controls should be considered:

- Sediment erosion control berms and silt curtains;
- Construction of diversion channels or rip-rapped channels;
- Construction of silt traps inside channels at regular intervals to minimize and avoid the silt materials from flowing into the Gulches or river;
- Slope stabilization of selected areas;
- Construction of new or expanding existing surface water retention ponds; and
- Construction of limestone channels, step pools, or basin to neutralize the acidic water.

4.4 ALTERNATE WATER SUPPLY (POINT-OF-USE SYSTEMS)

Arsenic has been identified as a COPC in off-site ground water. The nature and extent as well as the physical and geochemical mechanisms have not been fully defined. However, Arsenic is commonly found in water as arsenate (As [V]) or the reduced arsenite ion (As [III]). The presence of oxidizing or reducing conditions in water bodies determines the oxidation state of arsenic. At pH values common in ground water , arsenite is in its neutral form, making species in the +3 oxidation state more mobile and generally more toxic. Arsenate is negatively charged at most drinking water pH levels, and, as a result, it is often more easily removed by treatment systems.

In-home treatment devices come in two sizes. Point-of-use (POU) devices are small treatment units that are commonly located under one or more sinks within a home. These devices treat only the water used at the tap and typically produce only a few gallons of potable water per day. Water used for non-potable uses, such as washing and bathing, are not treated by POU systems. Point-of-entry (POE) devices are larger systems designed to treat all of the water used within the home.

Because the negative health effects of arsenic are caused by ingestion, a POU device will reduce the majority of the health risk associated with arsenic-contaminated water. These devices are also generally less expensive and easier to maintain than a POE devices.

There are two main types of POU systems commonly available today. Both adsorptive media and reverse osmosis systems are capable of removing arsenic from drinking water. However, the effectiveness of the treatment process depends primarily on raw water quality and water use. Education of the end users will also be an important part of the utilization of these systems to assure proper maintenance, so that they are effective for their intended use.

Adsorptive media are aluminum- or iron-based media. In activated alumina adsorptive media processes, arsenic is adsorbed onto the surface of an aluminum-based media as the water passes through the device. When all of the adsorption sites are filled, the media is spent and must be replaced. Factors that affect the efficiency of activated alumina processes include pH (optimal range is 5.5-6.0) and arsenic speciation (As [III]) is often not efficiently removed). Particulates and colloids can also cause media fouling.

Ferric hydroxide-based media are also used in adsorptive media systems. As with activated alumina, arsenic ions are adsorbs to the media and once all the adsorption sites are filled, the media must be replaced. Water quality parameters can affect the efficiency of a ferric hydroxide-adsorptive media system. Particulates or colloids in the water can also lead to fouling of the media.

Advanced adsorptive media processes are able to operate over a wide range of water qualities and they can remove both As (III) and As (V). In addition to removing arsenic, adsorptive media processes also reduce heavy metal concentrations.

In reverse-osmosis (RO) treatment, untreated water flows under pressure past a semi-permeable membrane. The membrane allows treated water to flow through, while arsenic and other contaminants are retained and disposed of as a concentrated solution. RO systems are capable of effectively removing As (V), but do not typically have the same efficiency with respect to As (III). Turbidity, iron, and manganese can adversely impact RO systems. Most POU RO units are equipped with pre- and post-filtration units. Pre-filtration serves to reduce solids loading and extend the life of the membrane while post-filtration is used as a final polishing step. The most common membranes used in RO processes are cellulose acetate, thin-film polyamide composites, and sulfonated polysulfone.

4.5 DUST SUPPRESSION

High wind events combined with a semi-arid environment contribute to occasional erosion of the mine tailings piles, creating potentially contaminated fugitive dust blowing off of the Site. Exposed surface layers containing fine grain particles of wastes discarded from mineral processors are subject to regular erosion by wind and water. Interim remedial measure Items 6 and 7 on Tables 1 and 2 specifically address the issue of dust suppression.

There are many techniques controlling fugitive dust emissions. This group of response action technologies by-in-large is a subset of containment technologies specifically tailored, among other objectives, to prevent surface materials from being eroded and subsequently suspended and carried by wind (or carried by storm water). The technologies identified for this response action range from ones that may be consistent with a permanent remedy, such as application of biosolids to establish plant growth for stabilization of tailings material, to more short-term temporary measures, such as application of a soil sealant. Table 4 summarizes AOI source areas where dust suppression may be warranted.

Table 4 AOI Source Areas Where Dust Suppression May Be Warranted

AOI/Source Area	Dust Suppression Activities	Rationale
Large Tailings Pile	Partial or complete sealing on top and sloped areas for tailings to minimize dust generation and to allow infiltration. Load-bearing sealed surface not necessary.	Major dust generating surface
Spot sealing of surfaces such as waste rock area, small isolated piles of stockpiled fines or other areas where dust with entrained high level metals	Surface tack coat only	Secondary dust generation surfaces

4.5.1 Biosolids Application to Support Stable Vegetative Covers

Biosolids are the dark, organic, and nutrient-rich materials produced as a byproduct of current wastewater treatment practices. Biosolids are also used to improve fertility and structure of disturbed lands and mine tailings. Biosolids can provide much needed nutrients and organic matter to these barren materials by increasing microbial activity and nutrient cycling for sustained plant growth. In Arizona, the major goal of mine tailings reclamation is to facilitate plant establishment to control off-site dust and sediment runoff. For example, during periods of high winds and dryness, dust with high concentrations of As, lead (Pb), and other metals can be transported into residential areas, exposing its population to these toxic chemicals.

Similarly, during high rainfall periods, exposed mine tailing sediments can wash off-site and contaminate surface waters and wildlife. The application of biosolids to disturbed land is best determined by local soil, plant, and climatic conditions. For example, the addition of biosolids to disturbed lands in arid and semi-arid climates produces rich soil nutrient conditions favorable to microbial growth and nutrient cycling.

Biosolids have proven effective in the reclamation and treatment of former mining sites. They are able to cost-effectively establish a vegetative cover on contaminated lands and limit the movement of metals through erosion, leaching, and wind. A cap is formed upon the application of biosolids because their permeability and water adsorption characteristics prevent water contact with contaminants in the underlying soil. Depending on the amendments added, biosolids can serve many purposes, including pH control, metal control, and fertilization. Their adaptability allows them to conform to the specific characteristics of any reclamation site.

With few exceptions, the application rates of biosolids range between 5-20 tons of dry biosolids per acre, although higher application rates have been evaluated to produce an "instant soil." When reclaiming mine sites, biosolids are almost always applied with lime, either pre-mixed or in stages. Lime serves to increase the pH of the soil rapidly, which may be a temporary condition.

A biosolids application would typically be advantageous for longer-term remedial actions where there would be a low likelihood of short-term modifications to surface contours following biosolids application. Presumably a desire to establish a sustainable vegetation growth would be another important factor to selection of biosolids application, and would only be used on larger source areas. Biosolids may be a very good candidate for long-term or permanent remedy, but it may not be the most practical or cost-effective for a short-term IM. Ideally, a final remedy may employ a biosolids application to promote growth of a sustainable vegetative cover that was placed on a stable, properly graded material, and where every opportunity for consolidation of smaller waste streams was considered as part of the remedy.

4.5.2 Soil Sealants

Soil sealants are highly effective against the problems associated with dust pollution and soil erosion. A soil sealant is an excellent alternative to the costly options of excavating and replacing unsuitable soils or installing other types of expensive liner systems. Most sealants are easy to use and require no special equipment or handling procedures.

The types of sealants range from soluble water-based formulations, salts, petroleum-based, and copolymers, and can include sulfuric acid, calcium chloride, enzymes, lignosite, and polyacrylamides. The type of sealant is dependent on the desired longevity, which can range from days to years based on type and application rates. Consideration of the type of sealant is based on cost, toxicity, compatibility with long-term remedial objectives, and site conditions (weather, climate, soil conditions, and presence of other in-place engineering controls). Application is typically a sprayed dilute liquid (water and the sealant); however, some sealants can be spread dry and subsequently watered down to complete the effort.

Erosion is controlled by creating a three-dimensional cap or surface crust, depending on the application rates. Heavier application rates can generate qualities similar to cement, which are load-bearing, and useful for soil solidification and stabilization found in road building. By adjusting the application rates, soil sealants can remain effective from weeks to several years. Many of the commercially available formulations are biodegradable and environmentally safe to use. Depending on sealant type, permeability of the treated material can either be increased (by

coagulation of fine particles into larger ones *in situ)* or decreased by filling in porous space with sealant.
A typical application may involve mixed sealant reagent with water and applied over the surface of the area of coverage with one or more applications. In most cases, all that is needed is a water truck or other means of even distribution of the diluted sealant. Hydroseeding often contains a latex agent or other binder and seed can be presoaked to speed germination. Another advantage to some soil sealants is they can be simultaneously applied with seed. For example, native vegetation seed could be spread over a designated area and covered with a thin layer of composted material, soil, or biosolids. The sealant acts like a plastic wrap, coating the area trapping the moisture into the soil. It allows the seeds to germinate faster. Water could still be applied to the surface, which would penetrate into the soil. When some sealants are used in sufficient quantities, it can ultimately transform the surface of the stockpiled material into an impermeable moisture resistant liner.

4.5.3 Phytostabilization

Phytostabilization is a common practice used to revegetate spoiled mine lands to prevent soil erosion and deposition of contaminated soils in streams and nearby lands. Phytotechnologies use plants to contain, stabilize, reduce, detoxify, and degrade contaminants in soil, ground water, surface water, or sediments. The EPA defines it as:

1. Immobilization of a contaminant in soil through adsorption and accumulation by roots, adsorption onto roots, or precipitation within the root zone of plants; and

2. Use of plants and plant roots to prevent contaminant migration via wind and water erosion, leaching, and soil dispersion.

Ideal plants for this technique use metal-tolerant, drought-resistant, fast-growing crops that can also grow in nutrient-deficient soils. The advantages are that it is a relatively inexpensive technique, soils do not need to be removed, ecosystem restoration is enhanced, and disposal of hazardous materials or biomass is not required.

The application of biosolids fits well with this phytoremediation technique as it provides necessary fertilizing agents and aids in microorganism establishment. Although biosolids limit the phytoavailability and bioavailability of toxic metals, they do not remove metal contaminants from the soil. Their application serves to control the mobility of heavy metals and various other contaminants, such as sulfates, through the soil. When combined with phytotechnologies, however, biosolids could not only contain contaminants, but also provide higher degrees of extraction than that offered by typical vegetative covers.

For purposes of the IMs assessment, the primary objective is to stabilize the fine-grained material and reduce erosion. Any fortuitous removal of metals from the surface or reduction in infiltration or surface water runoff was not considered as a primary factor in determining whether or not to retain this remedial technology for the short-term consideration. The application of biosolids to remediate mining sites is considered an innovative technology; however, unlike many others, it can be used effectively and efficiently at the current state of the technology. Biosolids technology is already available.

5. PRELIMINARY EVALUATION OF RESPONSE ACTIONS

Remedial technologies for the resolution of the seven interim remedial measures are shown in Table 2. Many of the remedial technologies solve more than one of the interim remedial measures, and some are so important that the failure to implement the technology could easily prevent or undo any benefits from other technologies. Consequently this section is provided as an initial prioritization effort for consideration during the implementation of any of these remedial measures. The suggested priority for these technologies is as follows:

1. Institutional Controls—Without appropriate institutional controls such as restricted Site access, the benefits of many of the remedial efforts, such as dust suppression, could be rendered moot.

2. Dust Suppression—A targeted implementation of dust suppression technologies at both the Iron King Mine and Humboldt Smelter areas will assist in achieving several of the interim remedial measures, by limiting airborne dissemination of contaminated particles as well as ameliorating overland flow of contaminated soil into the adjacent ditches and gulches.

3. Erosion Control—Adequate erosion control, combined with dust suppression will assist in limiting further contamination of Chaparral and Galena Gulch, as well as the Agua Fria River.

A brief discussion of the prioritization of these remedial technologies follows.

5.1 INSTITUTIONAL CONTROLS

The initiation of institutional controls to restrict Site access are critical to the successful implementation of any remedial measure. An effective public education program will serve multiple purposes. It will educate the public of the physical and chemical dangers associated with traversing either the Iron King Mine or Humboldt Smelter areas. In addition, it will allow for the introduction of the public of proposed security measures, be they signage, security fencing or site security. As noted earlier, without effective site management, many of the physical remedial technologies (e.g. dust suppression and erosion control) can be seriously compromised.

5.2 DUST SUPPRESSION

Regardless of the dust suppression technique chosen (soil sealant, biosolids, or phytostabilization), once the site is secure, it is second most important priority. Without control of dust, any remedial effort can be negated by a single dust storm. Properties in Dewey-Humboldt that have been cleaned up could be re-contaminated, and overland flow can move contaminants from the tailings piles into adjacent ditches and gulches. More than one type of dust suppression technology may be used, as well as others not listed in the IM Technical Memorandum, such as wind barriers or tarps.

5.3 EROSION CONTROL

Upon the successful control of surface dust in tailings piles at Iron King Mine and Humboldt Smelter, appropriate erosion control for the infrequent yet significant storm events is important. The use of a combination of storm water collection, along with slope stabilization and silt fencing, should limit the overland flow of contaminants from the sites into the adjacent ditches, gulches, and rivers.

5.4 OTHER RESPONSE ACTIONS

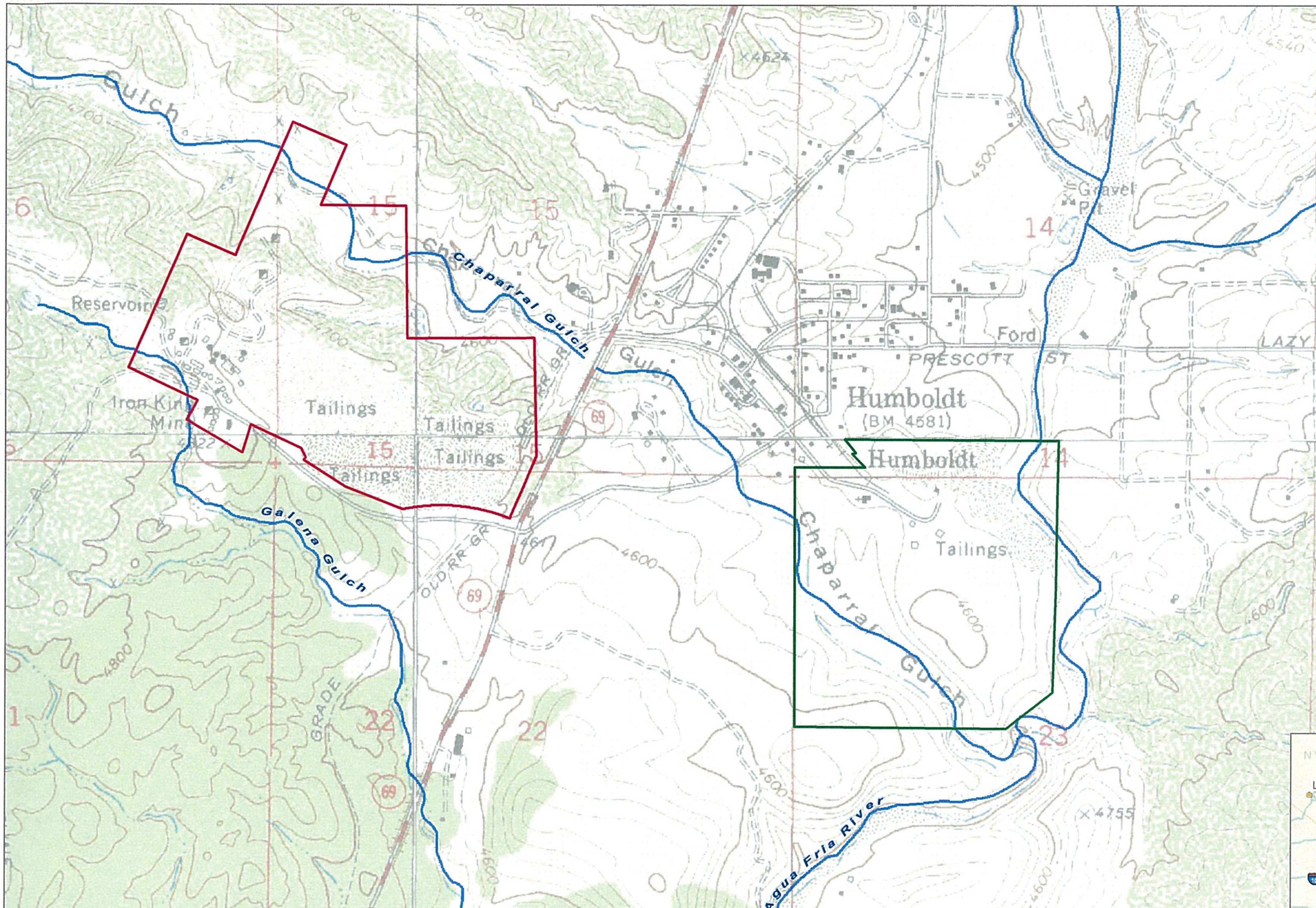
The prioritization of the above response actions is not intended to minimize the importance of other actions, such as excavation or relocation of contaminated material or providing an alternate water supply. This prioritization serves only to indicate a preliminary assessment of the order to tackle the complex response actions necessary to respond to the interim remedial measures necessary at Iron King Mine and Humboldt Smelter areas.

REFERENCES

EA Engineering, Science, and Technology, Inc. 2008. "Remedial Investigation/ Feasibility Study Work Plan for Iron King Mine – Humboldt Smelter Superfund Site (Revision 01), Dewey-Humboldt, Yavapai County, Arizona, EPA Identification No. AZ0000309013." 22 May.

U.S. Environmental Protection Agency. 2008. "RAC II Statement of Work for Remedial Investigation/Feasibility Study (RI/FS), Iron King Mine – Humboldt Smelter Superfund Site, Dewey-Humboldt, Yavapai County, Arizona." 3 March.

FIGURES



Legend

- Iron King Mine
- Humboldt Smelter

Note:
Boundaries are approximate and may be subject to change pending further investigation

0 — 1,000
Feet

EPA Identification Number: AZ0000309013

Topographic Map Source:
USDA-NRCS-NCGC, 2002
Basemap Source: ESRI StreetMap, 2006

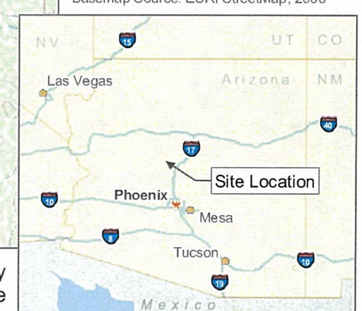


Figure 1 – Site Location
Interim Measures

Remedial Investigation/Feasibility Study
Iron King Mine - Humboldt Smelter Superfund Site
Dewey-Humboldt, Yavapai County, Arizona

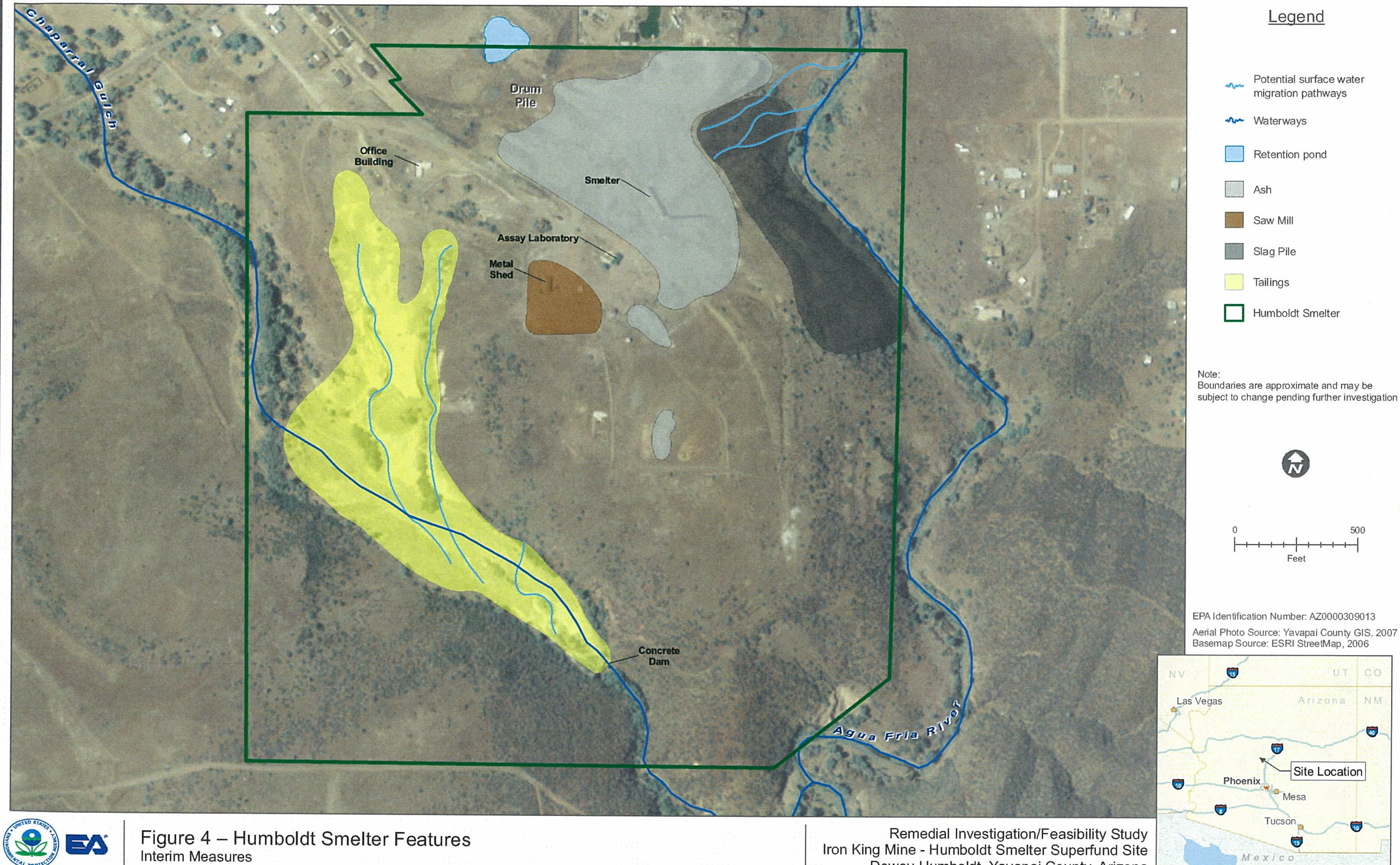


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Figure 4 – Humboldt Smelter Features

Interim Measures

Remedial Investigation/Feasibility Study
Iron King Mine - Humboldt Smelter Superfund Site
Dewey-Humboldt, Yavapai County, Arizona

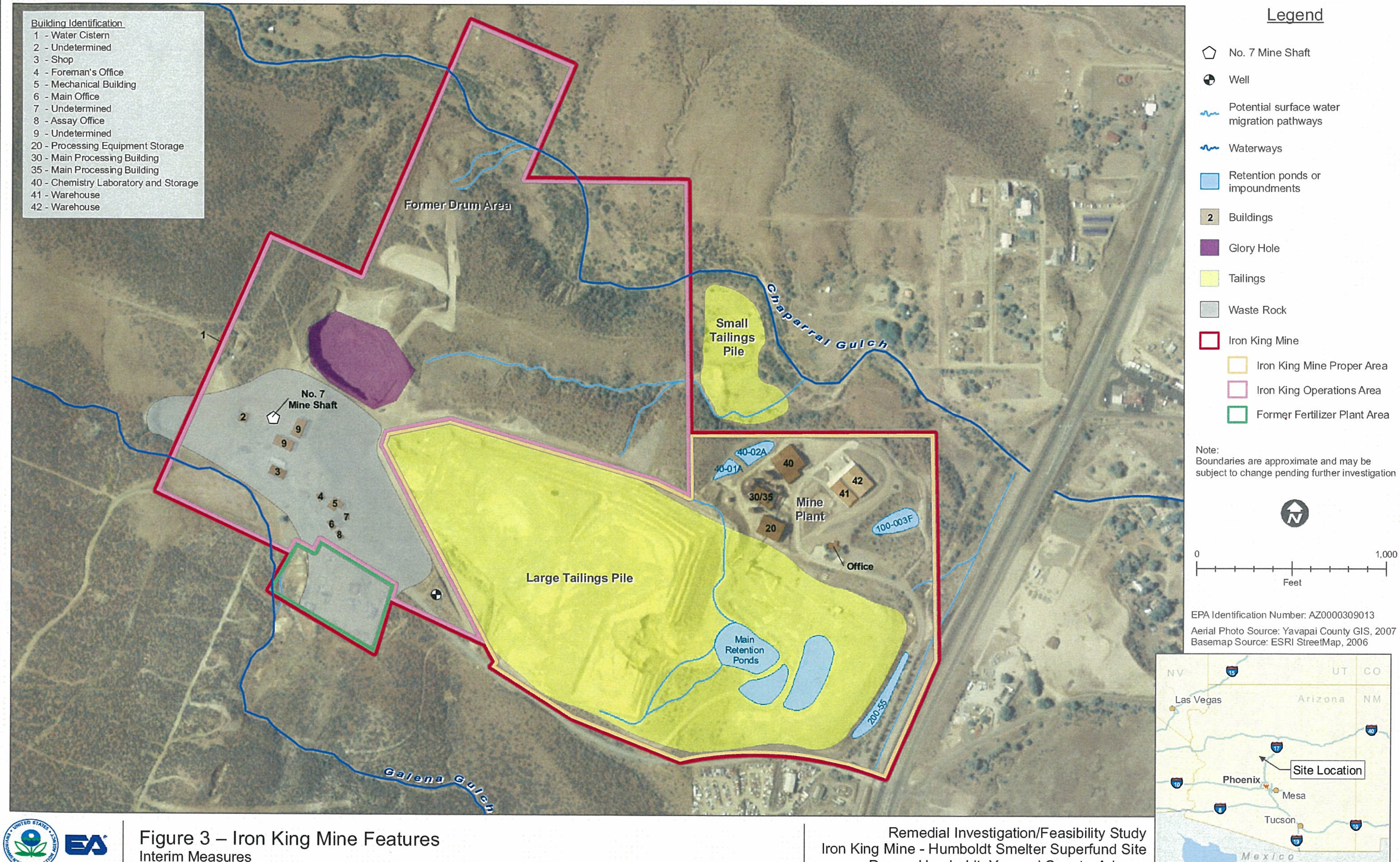

Figure 3 – Iron King Mine Features
Interim Measures

Remedial Investigation/Feasibility Study
Iron King Mine - Humboldt Smelter Superfund Site
Dewey-Humboldt, Yavapai County, Arizona

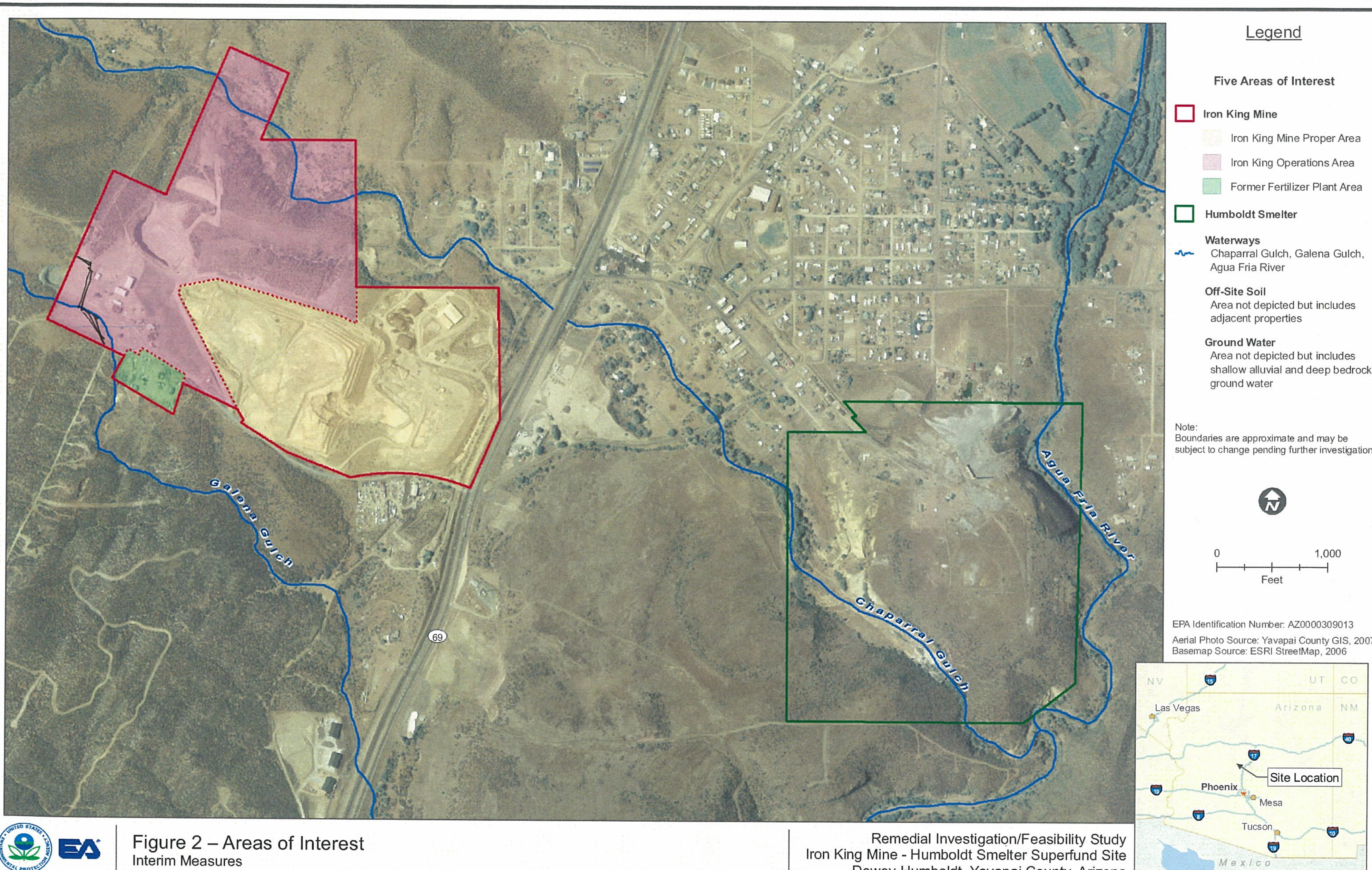

Figure 2 – Areas of Interest
Interim Measures

Remedial Investigation/Feasibility Study
Iron King Mine - Humboldt Smelter Superfund Site
Dewey-Humboldt, Yavapai County, Arizona