EA Engineering, Science,
and Technology, Inc.

South Central Region
405 S. Highway 121, Suite C-100
Lewisville, TX 75067
Telephone: 972-315-3922
Fax: 972-315-5181
www.eaest.com

13 October 2010

Mrs. Monika O'Sullivan
Task Order Monitor
U.S. Environmental Protection Agency (EPA)
75 Hawthorne Street SFD-6-2
San Francisco, CA 94105

Subject: **Remedial Alternatives Evaluation Technical Memorandum (Revision 01)**
Iron King Mine - Humboldt Smelter Superfund Site
Remedial Investigation/Feasibility Study
EPA Region 6 Remedial Action Contract 2
Contract: EP-W-06-004
Task Order: 0034-RICO-09MX

Dear Mrs. O'Sullivan:

EA Engineering, Science, and Technology, Inc. (EA) has addressed the ADEQ's comments on the Remedial Alternatives Evaluation Technical Memorandum for the above-referenced Task Order as follows:

General Comments:

1. EPA does not require that reports created during the Remedial Investigation/Feasibility Study (RI/FS) be stamped by a Professional Engineer or Professional Geologist. However, Remedial Designs are stamped by a Professional Engineer. The EA Arizona Professional Engineer for the project is Geoff Tizard.

2. Discussion of Declaration of Environmental Use Restrictions (DEUR) has been added to Section 4.1.2. Additional details regarding Institutional Controls and DEURs will be provided in the Feasibility Study Report.

3. Discussion of mine shafts and tunnels have been added to Section 1.7.2. In addition, the use of engineering controls (e.g. fencing) to limit access to mine shafts and tunnels has been added to Section 4.1.2.

4. Remediation of house dust was not evaluated because it was assumed that the indoor dust concentrations would be similar to the outdoor ambient air and surface soil in the vicinity of the residence. These datasets are considered sufficient to make a remedial decision.

5. Fencing costs will be included in the detailed cost estimates in the FS.

Specific Comments:

1. The sentence was not deleted because it addresses acid mine drainage, which is integral to understanding the mobility of the primary COPCs (e.g., arsenic, sulfate, etc.).

2. The mention of diarrhea and diuretic health effects has been added to Section 1.5.6.4.

3. See General Comment 3.

4. See General Comment 2.

5. The buildings that require remediation due to asbestos have been included in Section 3.1.6. The community will have an opportunity to formally comment during the Proposed Plan stage of the project.

6. See General Comment 2.

If you have any questions regarding this submittal, please call me at (972) 459-5046.

Sincerely,

Doug McReynolds

Doug McReynolds
Project Manager

Enclosure

cc: Arizona Department of Environmental Quality (hard copy)
File

ARIZONA DEPARTMENT OF ENVIRONMENTAL QUALITY

1110 West Washington Street • Phoenix, Arizona 85007
(602) 771-2300 • www.azdeq.gov

Janice K. Brewer
Governor

Benjamin H. Grumbles
Director

September 22, 2010
FPU 11-069

Attention: Monika O'Sullivan, Project Manager
EPA Region IX
75 Hawthorne Street
San Francisco, CA 94105

RE: ADEQ review of the Remedial Alternative Evaluation Technical Memorandum (RAETM) for the Iron King Mine-Humboldt Smelter Superfund Site

Dear Ms. O'Sullivan,

ADEQ appreciates the opportunity to review and comment on the Remedial Alternative Evaluation prepared for EPA by EA Engineering Revision 00 dated August 2010.

General Comments:

1. In accordance with ADEQ policy and Arizona statute, please ensure that the Final Remedial Alternatives Evaluation (Version 01) be stamped by an Arizona registrant, either an Arizona Registered Geologist (R.G.) or Professional Engineer (P.E.). Arizona Revised Statutes, Title 32 Chapter 32-125, specifies that: (A) each seal shall bear the name of the registrant and shall state the profession in which the registrant is permitted to practice; (B) plans, specifications, plats or reports prepared by a registrant or a registrant's bona fide employee shall be issued under the registrant's seal; (C) the registrant is responsible for all documents that the registrant signs, stamps or seals, including those documents prepared by the registrant's bona fide employee.

2. It is recommended to add information about the Declaration of Environmental Use Restrictions (DEURs) used in Arizona. Throughout the document, institutional controls (ICs) are mentioned as a component to be considered for remediation. The report doesn't mention Arizona's DEUR program. It also neglects to mention that land use controls are at the discretion of the property owner. In Arizona, any environmental land use restriction, protective barrier, etc. where contamination is left above regulatory levels requires a DEUR. While the document mentions ICs it does not describe the minimum detail of what is entailed in maintaining this designation in Arizona. The landowner(s) are the party who file, maintain and pay fees for the DEUR to be maintained. At a minimum, the Report should mention the steps involved in placing ICs at properties in Arizona.

3. Shafts and tunnels pose an immediate safety risk to the public and would be an easy remedy to fix. It would be prudent to add this as a topic of discussion in the RAETM and Feasibility Study.

4. Was remediation and prevention of house dust for primarily lead considered as a remedial alternative? This may be a consideration for homes nearby the site particularly at the Humboldt Smelter that have been exposed to years of dust. Other mine sites commonly find that dust in houses is a problem.

5. Fencing of critical areas such as the settling ponds, smelter stack and soil sealant covered ash piles could be costed out in the Feasibility Study to provide further site safety.

Specific Comments:

1. Section 1.4.1.2: Please delete the fourth sentence from this paragraph as it doesn't relate to the subject heading of COPCs.

2. Section 1.6.4 *Ground Water AOI,* page 15 of 42: It is mentioned that sulfates may cause harmful effects (e.g. dehydration). To be clear it is suggested to add diuretic effect or diarrhea as well as dehydration to help explain the health effects more clearly other than just dehydration.

3. Section 1.7 *Data Gaps, Recommendations and Additional Considerations*, page 17 of 42: It is mentioned in the RI Report on page 39 of 344 when discussing the Humboldt Smelter AOI that several underground structures (e.g. tunnels and shafts) "...may pose an impediment to future use and will be considered in the evaluation of remedial alternatives." There is very little further discussion of the underground tunnels in the RAETM. These tunnels pose an immediate safety concern due to instability and risk of collapsing and should be included as part of the remedy to render the site safe. A discussion could be added to the recommendations and applicable section of the RAETM such as in section 3.1.6 *Structures/Debris*.

4. Section 3.1.1 *General Response Action*, page 26 of 42: Institutional Controls in Arizona are commonly implemented in the form of a Declaration of Environmental Use Restrictions (DEURs) either for institutional or engineering controls and are filed with the County. DEURs run with the burden of the land and include several requirements such as financial assurance and many years of future reporting and inspections.

5. Sections 3.1.6 and 3.2.2.5 indicates that any buildings on-site that have asbestos containing materials (ACM) will be remediated by removing the ACM, demolishing the building and properly disposing of building and debris material. While this document is only an initial discussion, it may be prudent to outline which buildings contain ACM and whether or not owner(s) of those buildings will approve ACM removal and/or demolition. In addition, in the discussion of ACM removal and building demolition, at a minimum stake holders and the Town should be contacted and aware that EPA plans to demolish structures. Many public meeting attendees have expressed an interest in

maintaining historical buildings in the Town, where feasible. As the Report currently reads, it sounds as though EPA will demolish buildings on the site where ACM is present.

6. Section 4.1.2 General Response Action -*Limited Action*: In this section again examples of ICs mention restrictive covenants and deed notices. To be more specific an explanation of the Arizona DEURs would be helpful for readers of the report, property owners and should be cost out in the Feasibility Study.

If you have any questions e-mail me at ***Stonebrink.Brian@azdeq.gov*** or call (602) 771-4197.

Sincerely,

Brian Stonebrink

Brian Stonebrink,
Project Manager
Federal Projects Unit,
Waste Programs Division, ADEQ

cc: Joellen Meitl, ADEQ Project Hydrologist
Project and Reading File

EA Engineering, Science,
and Technology, Inc.

South Central Region
405 S. Highway 121, Suite C-100
Lewisville, TX 75067
Telephone: 972-315-3922
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Task Order Monitor
U.S. Environmental Protection Agency (EPA)
75 Hawthorne Street SFD-6-2
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Subject: **Remedial Alternatives Evaluation Technical Memorandum (Revision 01)**
Iron King Mine - Humboldt Smelter Superfund Site
Remedial Investigation/Feasibility Study
EPA Region 6 Remedial Action Contract 2
Contract: EP-W-06-004
Task Order: 0034-RICO-09MX

Dear Mrs. O'Sullivan:

EA Engineering, Science, and Technology, Inc. (EA) is enclosing two original hard copies and two electronic copies on compact disc (CD) of the Remedial Alternatives Evaluation Technical Memorandum for the above-referenced Task Order. An electronic copy of this document was transmitted via e-mail on 13 October 2010.

If you have any questions regarding this submittal, please call me at (972) 459-5046.

Sincerely,

Doug McReynolds

Doug McReynolds
Project Manager

Enclosure

cc: Michael Pheeny, EPA Contracting Officer (letter only)
Rena McClurg, EPA Project Officer (letter only)
Fritz Meyer, EA Program Manager (letter only via e-mail)
Jeff Hills, EA Financial Manager (letter only via e-mail)
Arizona Department of Environmental Quality (2 hard copies and 2 electronic copies on CD)
Site Information Repository at the Public Library in Humboldt, Arizona (1 hard copy and 1 electronic copy on CD)
File

TRANSMITTAL OF DOCUMENTS FOR ACCEPTANCE BY EPA			DATE: **13 October 2010**	TRANSMITTAL NO.: **0000023**
TO: **Mrs. Monika O'Sullivan** **U.S. Environmental Protection Agency Region 9**		FROM: **Mr. Doug McReynolds** **EA Engineering, Science, and Technology, Inc.**		
SUBTASK NO.	DELIVERABLE		NO. OF COPIES	
10	Remedial Alternatives Evaluation Technical Memorandum (Revision 01) Iron King Mine - Humboldt Smelter Superfund Site Remedial Investigation/Feasibility Study		2 Hard Copies and 2 Electronic Copies on Compact Disc (CD) 2 Hard Copies and 2 Electronic Copies on CD to the Arizona Department of Environmental Quality 1 Hard Copy and 1 Electronic Copy on CD to the Site Information Repository at the Public Library in Humboldt, Arizona	
ACCEPTANCE ACTION				
DOCUMENTS FOUND ACCEPTABLE (LIST BY SUBTASK NO.)		NAME/TITLE/SIGNATURE OF REVIEWER DATE		

Remedial Alternatives Evaluation
Technical Memorandum

Iron King Mine - Humboldt Smelter Superfund Site
Dewey-Humboldt, Yavapai County, Arizona

Remedial Investigation/Feasibility Study
Contract: EP-W-06-004
Task Order: 0034-RICO-09MX

Prepared for

U.S. Environmental Protection Agency
Region 6
1445 Ross Avenue
Dallas, Texas 75202-2733

Prepared by

EA Engineering, Science, and Technology, Inc.
405 S. Highway 121
Building C, Suite 100
Lewisville, Texas 75067
(972) 315-3922

October 2010
Revision: 01
EA Project No. 14342.34

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ACRONYMS AND ABBREVIATIONS

µg/L	Microgram per liter
ADEQ	Arizona Department of Environmental Quality
AMD	Acid mine drainage
ARAR	Applicable or Relevant and Appropriate Requirement
AOI	Area of Investigation
BRAPF	Baseline Risk Assessment Problem Formulation
BTV	Background threshold value
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	Contaminants of concern
COPC	Chemical of potential concern
CSM	Conceptual Site Model
DEUR	Declaration of Environmental Use Restriction
EA	EA Engineering, Science, and Technology, Inc.
ELCR	Excess Lifetime Cancer Risk
EPA	U.S. Environmental Protection Agency
ERA	Ecological Risk Assessment
ESA	Environmental Site Assessment
ET	Evapo-transpiration
FS	Feasibility Study
GRA	General response action
HHRA	Human Health Risk Assessment
HI	Hazard Index
IC	Institutional control
MCL	Maximum Contaminant Levels
mg/kg	Milligram per kilogram
NCP	National Oil and Hazardous Substance Pollution Contingency Plan
NFA	No Further Action
NSDWS	National Secondary Drinking Water Standards
OSWER	Office of Solid Waste and Emergency Response
PA/SI	Preliminary Assessment/Site Inspection

PRP	Potentially responsible parties
RAE	Remedial Alternatives Evaluation
RAO	Remedial action objective
RI	Remedial Investigation
RME	Reasonable maximum exposure
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SAPS	Successive alkalinity producing system
Site	Iron King Mine – Humboldt Smelter Superfund Site
SLERA	Screening Level Ecological Risk Assessment
TBC	To Be Considered
TDS	Total dissolved solids
TCLP	Toxic Characteristic Leaching Procedure
UCL	Upper confidence limit
UPL	Upper prediction limit

1. INTRODUCTION

This document presents the Remedial Alternatives Evaluation (RAE) conducted by EA Engineering, Science, and Technology, Inc. (EA) for the Iron King Mine – Humboldt Smelter Superfund Site (Site) in Dewey-Humboldt, Arizona. EA performed the RAE for the U.S. Environmental Protection Agency (EPA) Region 6 under Remedial Action Contract Number EP-W-06-004 and Task Order 0034-RICO-09MX. The framework and requirements are documented in the EPA Statement of Work Revision 02 (EPA 2010) and the EA Work Plan and Cost Estimate (Revision 04) (EA 2010a).

The Remedial Investigation (RI) Report (EA 2010b), which contained the Human Health Risk Assessment (HHRA) and Ecological Risk Assessment (ERA), provide the basis for this RAE. The following regulation and guidance documents that were utilized in this evaluation included, but were not limited to, the following:

- National Oil and Hazardous Substance Pollution Contingency Plan (NCP), 40 Code of Federal Regulations (CFR) Part 300
- *Guidance for Conducting Remedial Investigation and Feasibility Studies* under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (Office of Solid Waste and Emergency Response [OSWER] Directive 9355.3-01) (EPA 1988)
- *Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (OSWER Directive 9355.0-75) (EPA 2000).

1.1 PURPOSE OF REPORT

This RAE will be used as a foundation for the Feasibility Study (FS) and will support remedy selection in the Record of Decision (ROD). In this document, potential remedial alternatives are qualitatively developed and assessed against nine evaluation criteria to determine which remedial alternatives will be considered in the FS; remedial alternatives will be more fully evaluated against the evaluation criteria in the FS. EPA will make the determination regarding final selection of the remedial alternatives to be further developed in the FS.

The nine criteria to be employed in evaluation of remedial alternatives are:

- Overall protection of human health and the environment
- Compliance with Applicable or Relevant and Appropriate Requirements (ARAR)
- Long-term effectiveness and permanence
- Reduction in toxicity, mobility or volume through treatment
- Short-term effectiveness
- Implementability (technical and administrative)
- Cost

- State acceptance
- Community acceptance.

Fully developed cost estimates were not prepared for this RAE, but will be prepared for remedial alternatives that are evaluated in the FS.

1.2 SITE LOCATION AND DESCRIPTION

The Site is located in Dewey-Humboldt, Yavapai County, Arizona (Figure 1). The Site is a combination of sources and releases from two facilities: the Iron King Mine and the Humboldt Smelter. A portion of the Town of Dewey-Humboldt is situated between the mine and the smelter. Three waterways (Chaparral Gulch, Galena Gulch, and Agua Fria River) also transect the Site.

During the course of the investigation, EPA identified five Areas of Interest (AOI) (see Figure 2):

- **Iron King Mine** – Includes the Iron King Mine Proper Area, Iron King Mine Operations Area, Iron King Mine Small Tailings Pile, Former Fertilizer Plant Area, Salvage Yard, and ancillary associated properties.

- **Humboldt Smelter** – Includes several abandoned buildings, a smelter stack, a tailings pile, a smelter ash pile, and a slag pile.

- **Waterways** – Includes the Chaparral Gulch, Galena Gulch, Agua Fria River, and adjoining drainage channels and outfalls.

- **Off-site Soil (a.k.a., In-town Soil)** – Includes residential, commercial/industrial, , and ancillary properties (e.g., background soil areas, public spaces, etc.)

- **Ground Water** – Includes shallow alluvium and deep bedrock ground water.

These five AOIs were combined for the purpose of conducting the RI/FS because of the following: (1) migration of particulates from the Iron King Mine and Humboldt Smelter may have overlapping air-depositional areas; (2) mine tailings from the Iron King Mine have migrated onto the Humboldt Smelter property via the Chaparral Gulch; (3) the Agua Fria River and its contributing waterways (e.g., Chaparral Gulch and Galena Gulch) have impacts from both the Iron King Mine and Humboldt Smelter; and (4) ground water has been impacted from both the Iron King Mine and Humboldt Smelter.

Although the RI Report utilizes “off-site” in descriptions of areas, the Site is being evaluated holistically. The phrase “off-site” indicates areas that are located outside of the Iron King Mine or Humboldt Smelter AOIs, but are still considered to be part of the Site. The Site includes all areas where contamination has migrated. For purposes of the RAETM and the upcoming Feasibility Study, these areas will be referred to as “In-town Soil” areas.

1.2.1 Iron King Mine

The Iron King Mine AOI, located west of Highway 69, occupies approximately 153 acres. The Iron King Mine is bordered by Chaparral Gulch to the north, Galena Gulch to the south, Highway 69 to the east, and undeveloped land to the west (see Figure 2). The Iron King Mine was a periodically active gold, silver, copper, lead, and zinc mine from 1906 until 1969.

1.2.2 Humboldt Smelter

The Humboldt Smelter AOI, 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. The Humboldt Smelter is bordered by the Town of Dewey-Humboldt to the west and north, the Agua Fria River to the east, and the Chaparral Gulch to the south (see Figure 2).

1.2.3 Waterways

The Waterways AOIs includes the Chaparral Gulch, Galena Gulch, Agua Fria River, and adjoining drainage channels and outfalls. The Chaparral and Galena Gulches are ephemeral streams that only flow during infrequent episodic high rain events. 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 Galena Gulch flows from west to east along the southern boundary of Iron King Mine before it crosses under Highway 69; eventually, the Chaparral Gulch meets with the Agua Fria River south of the Site (see Figure 2).

1.2.4 In-town Soil

The In-town Soil AOI includes residential, commercial/industrial, and ancillary properties (e.g., background soil areas, public spaces, etc.) in the vicinity of the Iron King Mine and Humboldt Smelter (see Figures 3 and 4). Residential and commercial/industrial properties along with public spaces within the Town of Dewey-Humboldt are located immediately adjacent to and between the mine and smelter. Ancillary properties were mainly located to the south and west of the Iron King Mine and Humboldt Smelter.

1.2.5 Ground Water

Ground water is found in the shallow alluvial and deeper bedrock aquifers in the vicinity of the Site. Both shallow alluvial and deeper bedrock private and municipal wells are used for drinking water and other domestic uses in the vicinity of the Iron King Mine and Humboldt Smelter.

1.3 PREVIOUS INVESTIGATIONS

Site characterization activities at the Site date back to the late 1990s. Previous investigations by the Arizona Department of Environmental Quality (ADEQ) and EPA are as follows:

- Phase 1 Environmental Site Assessment (ESA) for the Ironite Products Facility

- Phase 1 ESA for the Iron King Smelter/Mill Site
- Preliminary Assessment/Site Inspection (PA/SI) of the Iron King Mine
- Phase 2 Sampling Report for the Iron King Smelter/Mill Site
- PA/SI of the Humboldt Smelter
- Soil Removal Assessment
- Residential Soil Cleanup of Four Properties
- Expanded Site Inspection of the Iron King Mine/Humboldt Smelter.

1.4 REMEDIAL INVESTIGATION RESULTS

1.4.1 Basis of Understanding

This section provides a summary of the following three elements of an RI Report: (1) identify potential source areas; (2) define the nature and extent of contamination; and (3) evaluate contaminant migration pathways.

The source identification, nature and extent discussion, and migration pathway analyses will be supported by the comparison of data to screening levels. Screening levels and chemicals of potential concern (COPC) are discussed in the following sections to provide a basis of understanding for these topics.

1.4.1.1 Screening Levels

The nature and extent evaluation includes a comparison of data from the Site to established screening levels. Although much of the current or likely future uses of the Site are commercial/industrial, some portions of the Site (e.g., In-town Soil AOI) include residential use. Therefore, to provide a consistent basis of comparison across AOIs, residential or domestic use screening levels are used in the nature and extent discussion.

Screening levels are based on conservative estimates of exposure and are not the same as cleanup levels. Screening level exceedances do not automatically designate an area as contaminated or trigger a response action. However, screening level exceedances suggest that further evaluation of the potential risks posed by site contamination is appropriate. The magnitude of exceedance is helpful in evaluating source areas, the nature and extent of contamination, and migration pathways within and amongst the AOIs.

1.4.1.2 Chemicals of Potential Concern

All chemicals that were detected in soil, sediment, surface water, ground water, and ambient air were considered COPCs for this Site. Arsenic, lead, and sulfate have been selected as the primary COPCs because these inorganics are the most prevalent (in terms of screening level exceedance and magnitude) and generally are co-located with other inorganic chemicals. A thorough understanding of the impacts from these primary chemicals across the AOIs provides a reliable yet concise picture of total inorganic chemical distribution. In addition, sulfate and other

critical indicators of geochemical conditions conducive to chemical mobility (e.g., acid mine drainage [AMD]) are discussed, as appropriate throughout these sections.

1.4.1.3 Source

Source material is a media that includes or contains hazardous substances, pollutants, or contaminants that acts as a reservoir for migration to other media or for direct exposure to humans or the environment. The EPA identifies source material as either a principal threat waste or a low-level threat waste depending on the toxicity and mobility of the material.

- **Principal Threat Wastes** – Source materials that are considered highly toxic or highly mobile and that generally cannot be reliably contained or would present a significant risk to human health or the environment if exposure were to occur. Highly toxic or highly mobile are relative terms. For the purpose of the nature and extent evaluation, materials that were three or four orders of magnitude greater than their respective screening levels meet this highly toxic threshold. Highly mobile materials are those that have demonstrated the ability for significant migration due to their proximity to migration pathways or are particularly susceptible to migration due to their physical characteristics (e.g., fine particle size).

- **Low-level Threat Wastes** – Source materials that exhibit low toxicity and low mobility and can be reliably contained or would present only a low risk to human health or the environment if exposure were to occur. Generally, materials that do not meet the criteria for principal threat wastes, but do demonstrate significant toxicity (i.e., due to their exceedance of screening levels by one or two orders of magnitude and background levels) and mobility are considered low-level threat wastes.

1.4.1.4 Nature and Extent of Contamination

EPA performed an analysis of the data to describe the nature and extent of contamination to soil, sediment, surface water, ground water, and ambient air. Chemical concentrations are incorporated with physical characteristics, historical information regarding Site activities, and other evidence to evaluate the nature and magnitude of contamination. Similar evidence is used to delineate the extent of contamination both horizontally and vertically. Spatial and temporal trends were evaluated as they are important in the analysis of migration pathways.

1.4.1.5 Migration Pathways

The nature and extent of contamination is combined with source identification and physical characteristic information to evaluate migration pathways. The following migration pathways are discussed in the RI:

- **Surface Water Transport** – Contaminant transport of particulates and dissolved phase contaminants via surface water transport occurs primarily during periodic high rain events.

- **Surface Water Partitioning** – Surface water in contact with sediments or suspended solids may partition into the dissolved phase.

- **Air Particulate Migration** – Moderate to high wind events that occur throughout the year carry fine-grained surface materials and particulates from source areas to adjoining AOIs.

- **Leaching to Ground Water** – As water percolates from the surface, through vadose zone soil, to the underlying ground water, it can carry dissolved phase constituents. The vadose zone is the area between land surface and the water table. Additionally, source material in contact with ground water can leach directly to ground water.

- **Ground Water to Surface Water** – Ground water may emanate as surface water at various points around the Site.

1.4.2 Conceptual Site Model

The Conceptual Site Model (CSM) presents a holistic view of the Site, provides a foundation for the evaluation of remedial alternatives, and supports remedy selection. The Conceptual Site Model incorporates the Site's surface features, potential source areas, nature and extent of contamination, contaminant migration pathways, and ancillary information, as appropriate.

1.4.2.1 Iron King Mine AOI

The Iron King Mine AOI includes the Iron King Mine Proper Area, Iron King Mine Operations Area, Small Tailings Pile, Former Fertilizer Plant Area, and Salvage Yard. The Iron King Mine AOI contains significant sources of tailings material, which contains high concentrations of arsenic and lead. This source material is either a principal threat waste or low-level threat waste depending on its concentrations (i.e., toxicity), potential for migration (i.e., mobility), and source volume. These source materials are migrating mainly via air particulate migration, surface water transport, and leaching to ground water. Affected nearby exposure areas/AOIs include the Galena Gulch, Chaparral Gulch, In-town Soil (including residential properties), and ground water (see Figure 5).

1.4.2.2 Humboldt Smelter AOI

The Humboldt Smelter AOI includes the Humboldt Smelter Ash Pile, Humboldt Smelter Slag, Humboldt Smelter Tailings Pile, Humboldt Smelter Operations Area, and Humboldt Smelter Off-site Migration. The Humboldt Smelter AOI contains significant sources of tailings, ash, slag, and building structures/debris. These materials are considered principal threat wastes or low-level threat wastes depending on the concentrations of arsenic, lead, or asbestos (i.e., toxicity); potential for migration (i.e., mobility); and source volume. These source materials are migrating mainly via air particulate migration, surface water transport, and leaching to ground water. Affected nearby exposure areas/AOIs include the Agua Fria River, Chaparral Gulch, In-town Soil (including residential properties), and ground water.

1.4.2.3 Waterways AOI

The Waterways AOI includes the Galena Gulch, Chaparral Gulch, Agua Fria River, and adjoining drainage channels and outfalls. The Waterways AOI contains significant sources of tailings and ash material, which contains high concentrations of arsenic and lead. This source material is either a principal threat waste or low-level threat waste depending on its concentrations (i.e., toxicity), potential for migration (i.e., mobility), and source volume. These source materials are migrating mainly via air particulate migration, surface water transport, and leaching to ground water. Affected nearby exposure areas/AOIs include the downgradient waterways (i.e., Galena Gulch, Chaparral Gulch, and Agua Fria River), In-town Soil (including residential properties), and Ground Water.

1.4.2.4 In-town Soil AOI

The In-town Soil AOI includes residential, commercial/industrial, and ancillary properties (e.g. background soil areas, public spaces, etc.).

<u>Residential, Commercial, and Public Properties</u>

Residential, commercial, and public properties located in the In-town Soil AOI were sampled to evaluate deposition of metals (e.g. from air or surface water) from suspected source areas. These areas included:

- Off-site Soil Area 02 through Off-site Soil Area 20
- Off-site Soil Area 101 through Off-site Soil Area 148
- Miscellaneous Off-site Area (e.g. collected during the 2005 Removal Assessment)

Arsenic and lead concentrations in surface soil are elevated on properties adjacent to the Chaparral Gulch or downwind of the Iron King Mine and Humboldt Smelter AOIs. These areas are not considered source areas because they do not pose a significant source of contamination to other media or properties. Nevertheless, residential soils are impacted by source materials, including ash and/or tailings. The In-town Soil AOI is impacted via the air particulate migration and surface water transport migration pathways from the Iron King Mine and Humboldt Smelter AOI.

Based on existing data, yards further away from the Iron King Mine and Humboldt Smelter AOIs are much less likely to be impacted from particulate migration or surface water transport from sources. Conversely, yards closer to the Iron King Mine or Humboldt Smelter AOIs have a higher probability of being impacted. These assertions were supported by the distribution of arsenic and lead in shallow surface soil samples. In addition, the deeper surface soil samples have lower concentrations of arsenic and lead that are near or below background values. This also supports the assertion that lead and arsenic impacts very near the surface are likely due to particulate migration or surface water transport, rather than being attributable to background conditions.

The full extent of residential impacts has not been determined as some yards have not yet been sampled. Additional parcels near the Chaparral Gulch or downwind of the Iron King Mine or Humboldt Smelter AOIs may be impacted by air particulate migration or surface water transport. Additional soil sampling of parcels in the vicinity of these areas will assist EPA in fully evaluating the impacts to residential and public areas (see Figure 3).

Background Areas

The background areas evaluation included three background areas and native bedrock material that were sampled as part of the EPA RI field investigation, and additional background areas that were sampled during previous field investigations. These datasets demonstrate that concentrations of arsenic and lead vary by soil type and proximity to the Site. Background Soil Type 1 was generally higher in arsenic and lead concentrations than either Background Soil Type 2 or 3. Background Soil Type 1 samples were collected northwest of the Iron King Mine AOI (see Figure 4). Background Soil Type 2 samples were collected southwest of the Iron King Mine AOI. Background Soil Type 3 samples were collected south of the Humboldt Smelter AOI. In addition, bedrock samples were collected at various locations throughout the Site. These samples generally contained elevated concentrations of arsenic, demonstrating that the native material in this area contains minerals (e.g., arsenopyrite) that have elevated concentrations of arsenic. The background concentration of arsenic is above its respective soil screening level.

Historic background dataset Background H-1 was collected in an area that is in an old surface water transport pathway for the Iron King Mine and the Background H-2 dataset was collected downwind from the Iron King Mine. Therefore, these two areas may have some anthropogenic or non-native contributions of metals from Iron King Mine migration pathways.

1.4.2.5 Ground Water AOI

The Ground Water AOI includes the shallow alluvium and deep bedrock ground water. The general direction of ground water flow is from west to east. As such, ground water flows from under the Iron King Mine AOI into areas under the residential neighborhoods to the east. In addition ground water under the Humboldt Smelter flows either towards the Aqua Fria or towards the Lower Chaparral Gulch.

At the Iron King Mine, sulfate, total dissolved solids (TDS), arsenic, and lead are present at concentrations in excess of twice their respective standards (i.e., maximum contaminant levels [MCL] or National Secondary Drinking Water Standards [NSDWS]). The presence of soluble metal ions (e.g., sulfate) to solution may be from an anthropogenic (i.e. man-made) mineral substrate (e.g., tailings) or from a natural geologic feature (e.g., ore or bedrock) that is high in sulfate. Although both mechanisms are likely occurring at various degrees throughout the Site, there is little doubt that the sulfate in ground water is at least exacerbated if not wholly attributable to historic mining processes (i.e., ground water contact with the mine shaft/adit material or tailings material). Similarly, arsenic concentrations in ground water are greater than the MCL in wells within or immediately adjacent to the mine shafts/audits. However, arsenic concentrations in ground water immediately downgradient (i.e., within the Iron King Mine Main Tailings Pile) are not greater than the MCL.

Ground water in the vicinity of Humboldt Smelter (i.e., MW-01-S and the wells to the north) have chloride as the dominant anion as opposed to sulfate. The source of chloride is likely from a natural geologic feature (i.e., alkali basalt) that is high in chloride, sodium, and potassium; monitoring well MW-01-S was completed in basalts of the Tertiary Hinkley Formation. Although the chloride in ground water is likely due to a natural geologic feature, it is possible that it could be related to historic smelting operations. During smelting operations, chlorination is commonly used to decompose spent cyanide in precious metals leaching operations; it is also used for oxidizing metal sulfides.

Ground water collected from municipal and private wells throughout Dewey-Humboldt reveal the presence of arsenic above the MCL in some residential wells. Elevated arsenic (i.e. arsenic above the MCL) was detected in private and municipal wells upgradient, cross-gradient, and many miles away from the Site. Other chemicals found in private and municipal wells include: sulfate, chloride, and TDS.

Elevated concentrations of arsenic in ground water are localized (i.e., in proximity of ore deposits or residual mine material). This is expected given the low mobility of arsenic under neutral pH conditions. Arsenic concentrations in ground water within the Iron King Mine Main Tailings Pile and immediately downgradient are less than the MCL. This indicates that elevated arsenic concentrations in ground water found in the Town of Dewey-Humboldt and surrounding area are due to natural geologic formations (e.g. arsenic bearing minerals in local volcanics) and not due to historic mining or smelting activities. The variability and magnitude of arsenic concentrations in the vicinity of the Site are similar to those throughout Arizona.

1.4.3 CSM Summary

The CSM presents a holistic view of the Site to provide a foundation for the remedial alternative evaluation and to support remedy selection. It incorporates the Site's surface features, potential source areas, nature and extent of contamination, contaminant migration pathways, and ancillary information as appropriate (see Table 1-1 and Figure 5).

The CSM for the Iron King Mine – Humboldt Smelter Superfund Site is centered on source media (e.g., tailings, ash, etc.) that migrates to other areas mainly via air particulate migration, surface water transport, and leaching to ground water (see Figure 5). Arsenic and lead have been detected in soils/sediments at concentrations in excess of their respective screening levels. At the Iron King Mine and Humboldt Smelter, this is primarily the result of original deposition of source materials (i.e., principal or low-level threat wastes) in the form of tailings, ash, etc. In the Waterway AOI, impacts are largely the result of surface water transport. In the In-town Soil AOI, impacts are mainly attributed to windborne deposition of fine-grained materials. However, residential parcels in close proximity to the Chaparral Gulch have been impacted by surface water transport. Although arsenic and lead concentrations in some areas are elevated, source attribution in these areas is complicated by elevated background concentrations of these metals. For areas with arsenic and lead concentrations slightly above background concentrations and/or screening levels, it is difficult to determine if the exceedance is due to natural background conditions or to historic mining and smelting activities.

Surface water and ground water have been impacted as a result of standard geochemical processes that occur when natural waters come in contact with materials with a high leaching potential. This geochemical reaction, known as Acid Mine Drainage generation, results in a localized decrease in the pH of water as well as the release of metals (e.g., arsenic, lead, etc.), and anions (e.g., sulfate, chloride, etc.), as well as an increase in the TDS. As the pH of the water becomes more neutral, the metals become less mobile, while the sulfate and TDS concentrations remain high.

Ambient air in the vicinity of the Iron King Mine and Humboldt Smelter AOIs have higher concentrations of arsenic and/or lead than the background station or Humboldt In-Town station near the Humboldt Elementary School; these elevated concentrations demonstrate that the Iron King Mine and Humboldt Smelter AOIs are sources of contamination for downwind (e.g., residential) properties. Although the limit of particulate migration is subject to uncertainty, arsenic and lead in residential yard surface soil near the Iron King Mine and Humboldt Smelter AOIs are higher than further downwind (e.g., near the Humboldt Elementary School). This is consistent with the information obtained from the Humboldt In-town air sampling station near the Humboldt Elementary School, which had concentrations of arsenic and lead similar to background. These lines of evidence demonstrate that although arsenic and/or lead particulate migration from the Iron King Mine and Humboldt Smelter AOIs is occurring, the extent of air particulate migration is a few to several blocks from the source areas. Although National Ambient Air Quality Standards for lead and PM-10 were exceeded at the Humboldt Smelter, it should be noted that none of the maximum concentrations in the air samples exceeded the Health-Based Guidelines for Acute (i.e., Shorterm) Exposure.

Ground water has been impacted by arsenic, lead, sulfate, chloride, and TDS. Because of their low mobility, impacts from both arsenic and lead are localized. However, ground water downgradient of the Iron King Mine is impacted from sulfate-dominated TDS as a result of contact with tailings or from a natural geologic feature that is high in sulfate. Although both mechanisms are likely occurring at various degrees throughout the Iron King Mine AOI, there is little doubt that the sulfate in ground water is at least exacerbated if not wholly attributable to historic mining processes (i.e., contact with mine adit material or tailings material). Also, ground water in the vicinity of the Humboldt Smelter is impacted from chloride-dominated TDS from a natural geologic feature or as a result of smelting operations at the Humboldt Smelter. There are a few wells within the Iron King Mine and Humboldt Smelter AOIs that are impacted by arsenic from their proximity to ore deposits or residual mine material. However, elevated arsenic concentrations found in wells within the Town of Dewey-Humboldt and surrounding area are due to contact with natural geologic formations. The variability and magnitude of arsenic concentrations in the vicinity of the Site are similar to those throughout Arizona.

1.5 HUMAN HEALTH RISK ASSESSMENT

The following sections present the methodology and summary of results for the HHRA.

1.5.1 Introduction

The role of the HHRA is to quantify the risks associated with potential exposure to hazardous substances at a site in the absence of any remedial action or control, including institutional controls. Institutional controls are legal or administrative tools used to maintain protection of human health and the environment at sites (e.g. property use restrictions). Therefore, a HHRA was performed to estimate the probability and magnitude of potential adverse human health effects from exposure to contaminants associated with the Site assuming no remedial action was taken. It provides the basis for taking action and identifies the exposure areas, exposure pathways, and contaminants that may be considered for remedial action.

The HHRA contains the following information: the objectives, the methodology for data grouping and identification of COPC, the exposure assessment, the toxicity assessment, the site-specific risk assessment results, and the uncertainty analysis.

1.5.2 Objectives

The HHRA was conducted to estimate potential human health risks associated with possible exposure to site-related chemicals under current and potential future land use. It was conducted in the absence of remedial, engineering, or institutional controls and without regard to future remedial action. The specific objectives of the HHRA are to:

- Estimate potential human health risks associated with current and potential future land use conditions
- Identify the environmental media, COPCs, and pathways that pose the most risk.

To accomplish these objectives, the following framework was used to estimate potential risk to human health:

- **Selection of Chemicals of Potential Concern –** Groups analytical data by exposure area and medium for the selection of COPC.
- **Exposure Assessment** – Estimates the magnitude of actual and/or potential human exposures, the frequency and duration of these exposures, and the pathways (e.g., ingestion of contaminated soil) by which humans are potentially exposed.
- **Toxicity Assessment** – Determines the types of adverse health effects associated with chemical exposures, and the relationship between the magnitude of exposure (dose) and severity of adverse effects (response).
- **Risk Characterization and Uncertainty Analysis** – Summarizes and combines outputs of the exposure and toxicity assessments to provide a quantitative assessment of human health risks.

The HHRA was performed on human health exposure scenarios that estimated the reasonable maximum exposure (RME) to COPCs. The reasonable maximum exposure is defined as the highest contaminant exposure that is reasonably expected to occur at a Site. The reasonable maximum exposure is estimated for individual exposure pathways and then summed across multiple pathways as appropriate. The intent of the reasonable maximum exposure is to develop a conservative (i.e., safe) estimate of exposure that is still within the range of possible exposures.

1.5.3 COPC Identification

COPCs are chemicals that are carried through the quantitative exposure and risk estimate portions of the HHRA. All chemicals that were detected in soil, sediment, surface water, ground water, and ambient air data are COPCs. The only restriction used in the selection of COPCs was the removal of four inorganics (i.e., calcium, magnesium, sodium, and potassium) that are considered essential nutrients by EPA.

1.5.4 Exposure Assessment

An exposure assessment identifies potential human receptors that could be exposed to site-related chemicals as well as the routes, magnitude, frequency, and duration of the potential exposures. The exposure receptors that are evaluated in the HHRA include:

- Commercial/Industrial Workers
- Construction Worker
- Adult/Child Recreation/Trespasser
- Adult/Child Resident.

Although some of the exposure scenarios are not current (e.g., residential exposure to the Humboldt Smelter Ash Pile), no distinction was made between current and future exposure scenarios because the exposure parameters are identical. Therefore, exposure scenarios in the HHRA are considered protective of current/future exposure.

According to EPA guidance, a complete exposure pathway consists of four elements:

- A source and mechanism of chemical release
- A retention or transport medium/media
- A point of potential human contact with the medium (i.e., exposure point)
- An exposure route at the exposure point (e.g., ingestion, inhalation, dermal contact, etc.).

If any of these elements is missing, except when the source itself is the exposure point, then the exposure pathway is considered incomplete. For example, if receptor does not have contact with the source of contamination or transport medium (e.g. surface water), then the exposure pathway is considered incomplete and is not quantitatively evaluated for risk.

1.5.5 Toxicity Assessment

The purpose of a toxicity assessment is to evaluate whether COPCs are likely to cause adverse health effects in exposed individuals and provide an estimate of the increased likelihood or severity of the adverse effect. The toxicity assessment was accomplished via a hazard identification and dose-response assessment.

1.5.6 Risk Characterization

The final step in the HHRA is the characterization of the potential risks associated with exposure to chemicals detected at a site. The HHRA evaluated the Site for potential cancer risks and noncancer hazards from soil, sediment, surface water, ground water, and ambient air.

1.5.6.1 Iron King Mine, Humboldt Smelter, and Waterway AOIs

Most of exposure areas within the Iron King Mine, Humboldt Smelter, and Waterway AOIs have cancer risks greater than 1E-04 (1 in 10,000) or noncancer hazards greater than 1 for all four categories of receptors (i.e., commercial/industrial worker, construction worker, adult/child recreational/trespasser, and adult/child resident). Information from the EPA's reuse assessment was incorporated into the HHRA to present the cancer risk and noncancer hazards for the most likely exposure scenario for each area (see Table 1-1). The areas where soil/sediment have a cancer risk greater than 1E-04 (1 in 10,000), a noncancer hazard greater than 1, or a lead PRG 99th percentile exceedance are the areas that warrant an evaluation of remedial alternatives (see Figure 6). Risks were estimated for the adult/child recreational/trespasser exposure to Lower Chaparral Gulch Dam – Confluence, Agua Fria River, and Background Agua Fria River surface water; the risk estimates were either within or below the risk management range (see Table 1-1).

A residential-based quantitative screening evaluation was conducted for ephemeral surface water. The comparison of surface water concentrations to EPA Tap Water RSLs and MCLs is equivalent to a domestic use evaluation of water. Although, this may not be indicative of actual exposure for surface water, it does provide a good point of comparison to evaluate potential risk. All of the surface water exposure areas had cumulative risks greater than 1E-04, which is greater than the risk management range, due to elevated concentrations of arsenic (see Table 1-2). In addition, all of the exposure areas had exceedances of EPA MCLs. Because surface water concentrations are highly dependent on the underlying substrate, the remedial alternatives for impacted surface water will consider both soil/sediment and associated surface water.

1.5.6.2 Background Soil

It should be noted that Background Soil Type 1 has a cancer risk of 1E-04 (1 in 10,000) and a noncancer hazard of 5, which demonstrates the importance of background to the overall discussion of risk estimates (see Table 1-1). Background Soil Type 1 (i.e., BgD) is interpreted as being the dominant soil type at the Iron King Mine, Humboldt Smelter, and In-town Soil AOIs; therefore, this soil type will be used to evaluate background contributions for all exposure areas.

1.5.6.3 In-town Soil AOI

The HHRA evaluated data from 65 parcels in the In-town Soil AOI for adult/child residential exposure to soil (see Table 1-3). The 65 parcels included 17 residential parcels that were sampled in 2005 as part of the EPA Removal Assessment, 45 residential parcels that were sampled in 2008 and 2009, and the Humboldt Elementary School playground (3 parcels). Of the 65 parcels:

- 23 have a cancer risk greater than 1E-04 (1 in 10,000) or noncancer hazards greater than 10
- 36 have an exceedance of the lead PRG 99th percentile.

After analysis and review of the results, EPA determined that many residential yards have levels of arsenic and lead that could increase the potential for health effects over the long-term. These areas warrant an evaluation of remedial alternatives (see Figure 7). It should be noted that the Humboldt Elementary School playground in the Town of Dewey-Humboldt does not warrant further evaluation based on a toxicological review of the data. Furthermore, the levels of COPCs in the Humboldt Elementary School playground are similar to background concentrations of these chemicals. It should also be noted that many of the residential parcels have cancer risks or noncancer hazards similar to Background Soil Type 1, which has a cancer risk of 1E-04 (1 in 10,000) and a noncancer hazard of 5. Therefore, the evaluation of remedial alternatives for In-town Soil parcel areas should consider the contribution of background risks to the discussion of overall risk estimates.

1.5.6.4 Ground Water AOI

A residential-based quantitative screening evaluation was conducted for ground water. Ground water from 64 private and municipal wells was compared to EPA Tap Water RSLs and MCLs to evaluate domestic use of water (see Table 1-4). Please note that two ground water samples were collected from the Humboldt Water Company supply wells (i.e., GW-999951 and GW-999952). These wells supply water to approximately 10% of the residents in the vicinity of the Site. However, many of the residents obtain water from private wells.

Most of the ground water locations have cumulative risks greater than 1E-04 (1 in 10,000) due to elevated concentrations of naturally-occurring arsenic in ground water. The remaining locations have risks between 1E-04 (1 in 10,000) to 1E-06 (1 in 1,000,000). In addition, many of the locations have arsenic exceedances of the EPA Maximum Contaminant Level. EPA's Maximum Contaminant Levels are enforceable drinking water standards that apply to public water systems (i.e. systems that serve 15 locations or 25 people more than 6 months out of the year).

Wells within the Iron King Mine and Humboldt Smelter AOIs are impacted by arsenic from their proximity to ore deposits or residual mine material (see Figure 8). These locations warrant an evaluation of remedial alternatives. However, elevated arsenic concentrations found in private and municipal wells within the Town of Dewey-Humboldt and surrounding area are a result of contact with natural geologic formations and are not indicative of impacts from historic mining

and smelting operations. The variability and magnitude of arsenic concentrations in the vicinity of the Site are similar to those throughout Arizona.

Ground water downgradient of the Iron King Mine is impacted from sulfate-dominated TDS as a result of contact with tailings or from a natural geologic feature that is high in sulfate (see Figures 9 and 10); these elevated concentrations of sulfate may cause harmful effects (e.g. dehydration, diarrhea, or diuretic effects). Wells impacted by sulfate-dominated TDS warrant an evaluation of remedial alternatives. The ground water in the vicinity of the Humboldt Smelter is impacted from chloride-dominated TDS from a natural geologic feature or as a result of smelting operations at the Humboldt Smelter (see Figures 10 and 11); these elevated concentrations of chloride are unlikely to cause harmful effects but will be further evaluated to identify the source of chloride.

1.6 SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT AND BASELINE RISK ASSESSMENT PROBLEM FORMULATION

The ERA presents the results of the Screening Level Ecological Risk Assessment (SLERA) and Baseline Risk Assessment Problem Formulation (BRAPF). The ERA includes definition of assessment and measurement endpoints; exposure and toxicity assessment; data evaluation; and screening level risk characterization.

1.6.1 Conceptual Site Model and Problem Formulation

The ERA began with a screening level evaluation which identified that the majority of chemicals detected would require further evaluation in the ERA. A conceptual model was developed for the site based on review of site conditions and existing data. The model identified that the Site provides terrestrial and aquatic habitats. The conceptual model identifies arsenic, lead, and other metals associated with mining as the primary COPCs, although organic chemicals associated with specific areas may also be COPCs.

Based on the conceptual model, assessment endpoints were selected to represent a broad range of ecological receptors within the Site's ecological community. The assessment endpoints included the survival, growth, and reproduction of terrestrial plants, soil invertebrates, aquatic and benthic organisms, herbivorous mammals and birds, insectivorous mammals and birds, predatory mammals and birds, piscivorous birds, and reptiles. Based on expected patterns of site use by wildlife and differences between potential sources of chemicals, the site was divided into five exposure groupings: West Exposure Grouping; East Exposure Grouping; Agua Fria River Exposure Grouping; In-Town West Exposure Grouping; and In-Town East Exposure Grouping (see Figure 12).

1.6.2 Measurement Endpoints and Data Evaluation

Measurement endpoints were selected to provide a quantifiable means of characterizing risks. The measurement endpoints for plants, soil invertebrates, and aquatic and benthic organisms included comparison of maximum and mean exposure point concentrations to benchmarks. The benchmarks selected are highly precautionary and thus provide a conservative assessment of site

risks. Additional endpoints were evaluated for plants utilizing the data available from past habitat surveys to determine whether the plant species list for the site is similar to that off-site, and to identify any signs of vegetative stress.

For higher trophic level wildlife, measurement endpoints were based on the results of food web models that predict the dose of chemicals ingested by wildlife. These doses were compared to benchmarks and off-site background doses. The first measurement endpoint evaluated was a screening level comparison of maximum case scenario doses to no-effects benchmarks. Additional measurement endpoints included comparison of mean case scenario doses to no-effects benchmarks, low effects benchmarks, and background doses. Because of a lack of data available for assessment of reptile and amphibian exposures, measurement endpoints use qualitative means (surrogate receptors) to assess risks to reptiles and amphibians.

To test these measurement endpoints, both site-specific and literature-based information was used to develop exposure and toxicity methods and assumptions for use in estimating risks. These tools were used in the data evaluation to test each measurement endpoint as a line of evidence. Lines of evidence were combined in a qualitative weight of evidence discussion to determine the potential for risks.

The ERA concluded that the COPCs identified for the exposure groupings require additional consideration either through risk management or further assessment (see Table 1-5).

The East Grouping encompasses the Humboldt Smelter AOI, the Chaparral Gulch to the east of Highway 69, and the Agua Fria River (see Figure 12). The West Grouping encompasses the Iron King Mine AOI. The assessment found that highly elevated concentrations of metals pose risks to all receptor groups (i.e., terrestrial plants, terrestrial invertebrates, aquatic and benthic organisms, mammals, birds, and reptiles and amphibians). Therefore, cleanup levels will be developed for the evaluation of remedial alternatives for the East and West Groupings.

Benchmark exceedances indicate the potential for risks within the Agua Fria Exposure Grouping; however, benchmarks are based on precautionary data from the scientific literature, and habitat in the Agua Fria River appears relatively healthy. Nevertheless, cleanup levels will be developed for the evaluation of remedial alternatives for risks to aquatic and benthic organisms, birds, and reptiles and amphibians. Although the potential for risk could increase should chemicals continue to migrate from upstream uncontrolled sources, the potential for risk should decrease if upstream sources are controlled and elevated metal concentrations in sediment dissipate to near background concentrations over time. Risk management decisions within the Agua Fria itself should weigh the potential for ecological risk with the intrusiveness of remedial alternatives that may lead to a reduction of the habitat quality.

The In-Town East Exposure Grouping comprises commercial or residential parcels north, east, and west of the Humboldt Smelter (see Figure 12). The In-Town West Exposure Grouping comprises four commercial or residential parcels north of the Iron King Mine area and north of Chaparral Gulch. The assessment found that concentrations of metals were somewhat elevated and may pose risks to several receptor groups (i.e., terrestrial plants, terrestrial invertebrates, mammals, and reptiles). However, the assessment also identified that the areas evaluated

provide poor habitat due to development and that concentrations of several metals are similar to background values. Further efforts should focus on developing cleanup levels and evaluating habitat quality for use in the evaluation of remedial alternatives for the In-Town East and In-Town West Groupings.

1.7 DATA GAPS, RECOMMENDATIONS, AND ADDITIONAL CONSIDERATIONS

1.7.1 Data Gaps and Recommendations

Data gaps and recommendations for further characterization were identified based on the results of the RI. Therefore, beginning in May 2010, EPA began filling these data gaps as follows:

- The western dam within the Iron King Mine Main Tailings Pile has already exhibited failure. Therefore, an engineering evaluation of the Iron King Mine Main Tailings Pile is being conducted to evaluate the long-term stability of the dam. This engineering evaluation will be incorporated into the FS. In addition, the Iron King Mine Main Tailings Pile stability is being considered in the evaluation of remedial alternatives.

- EPA has sampled approximately 65 parcels in the Town of Dewey-Humboldt during the RI. Parcels with elevated arsenic and lead concentrations were located in close proximity to the Iron King Mine and Humboldt Smelter AOIs, or the Middle Chaparral Gulch. Based on existing data, yards further away from the Iron King Mine and Humboldt Smelter AOIs are much less likely to be impacted from particulate migration or surface water transport. Conversely, yards closer to the Iron King Mine or Humboldt Smelter AOIs have a higher probability of being impacted. The full extent of residential impacts has not been determined as many parcels have not yet been sampled. Additional parcels near the Chaparral Gulch or downwind of the Iron King Mine or Humboldt Smelter AOIs may be impacted by air particulate migration or surface water transport. Therefore, in May and June 2010, EPA sampled an additional 120 parcels in the vicinity of the Site (see the area outlined in Figure 7). These data are still undergoing quality assurance / quality control review and will be incorporated into the FS.

- The range of arsenic and lead concentrations in soil demonstrates that there is a great variability in concentrations in the native material of the area of the Site. Also, background contributions are important to the overall discussion of risk estimates and risk management for the Site. The Background Soil Type 1 (i.e., BgD) is interpreted as being the dominant soil type for the Iron King Mine, Humboldt Smelter, In-town Soil, and Waterways AOIs. Therefore, 30 additional background soil samples were collected from Background Soil Type 1 to supplement the 10 samples that were collected in 2008 (see Figures 13 and 14). Background data are evaluated fully in Appendix A.

- Ground water downgradient of the Iron King Mine is impacted from sulfate-dominated TDS as a result of contact with tailings or from a natural geologic feature that is high in sulfate (see Figure 5). The ground water in the vicinity of the Humboldt Smelter is impacted from chloride-dominated TDS from a natural geologic feature or as a result of

smelting operations at the Humboldt Smelter. The areas of impacted ground water are not well-defined. Therefore, a well inventory was conducted to identify wells within the area of potential impact. Ground water samples were collected from these wells and analyzed for metals and general chemistry parameters to assist in determining the extent of the sulfate and chloride impacts. Once a quality assurance / quality control review of these data are completed, it will be incorporated into the FS.

- The maximum lead concentration in soil of 18,100 milligrams per kilogram (mg/kg) in Off-site Soil Area 120 is considered an outlier. In May 2010, EPA conducted a visual investigation of this property. EPA considers this lead concentration to be associated with lead batteries that were observed amongst miscellaneous automotive parts/debris or is an artifact from lead based paint residue.

- The lead concentration in ground water at location GW-999953 was 49.8 micrograms per liter (µg/L), which is likely due to lead pipes. EPA was unable to investigate this ground water well further during the May 2010 field investigation.

1.7.2 Additional Considerations

Additional considerations were identified for local residents, community members, landowners, or potentially responsible parties (PRPs).

- Many private wells in the vicinity of the Site have arsenic concentrations above the EPA Maximum Contaminant Level of 10 µg/L. Although these wells are not considered impacted by the Site, drinking water with arsenic concentrations above the drinking water standard may present a health risk to consumers. Therefore, residents drinking from private wells should have their wells tested and take precautionary measures (e.g., filtering water), as appropriate. Additional information on drinking water from household wells can be found at the following website:

  http://www.epa.gov/privatewells/pdfs/household_wells.pdf

- Air monitoring was conducted to characterize the nature and extent of contamination and to evaluate human health and ecological risk. Air monitoring demonstrated that particulates containing COPCs from the Iron King Mine and Humboldt Smelter AOIs migrate to the residential areas during high wind events. During the May 2010 field investigation, EPA observed the following dust suppression activities: (1) wetting of tailings material at the Iron King Mine Main Tailings Pile, and (2) wetting of ash and application of Gorilla Snot, which is a soil sealant, on the Humboldt Smelter Ash Pile. These temporary dust mitigation measures are expected to decrease the particulate migration from source areas during high wind events.

- The Aerial Photographic Analysis (EPA 2008a) present a detailed presentation of historical mine shafts and tunnels. This information is also discussed the RI Report (EA 2010b). Mine shafts and tunnels may pose a physical hazard and considered an

impediment to future use. Although mine shafts and tunnels may not pose a chemical hazard, they may be considered by EPA in the evaluation of remedial alternatives.

- A Cultural Resource and Historic Building Survey was conducted in November 2008 in compliance with Section 106 of the National Historic Preservation Act. This evaluation concluded that the Iron King Mine and the Humboldt Smelter are eligible for inclusion in the National Register of Historic Places under Criterion D. Criterion D is for resources that have yielded information important in prehistory or history. Both properties yielded important information regarding the history of the Big Bug Mining District.

- In addition to other cultural resources, the survey identified an unmarked historic gravesite on the northeastern edge of the mine tailings within the boundaries of the Iron King Mine. If the remains cannot be avoided during ground disturbing activities, they must be disinterred and relocated according to state laws pertaining to unmarked and unregistered cemeteries and graves (ARS 41-844 and 41-865). As part of the protocols for reburial, steps must be taken to attempt identification of the buried individual and their next of kin, including archival research, oral interviews of local inhabitants, and notice in the local newspaper. If next of kin are identified, consultation must proceed with them to determine their preferences for the final treatment and disposition of the disinterred individual. Specific permits and a Court Order may also be required (ACS 2008).

- Sampling results indicate the presence of elevated levels of arsenic and lead at the Iron King Mine, Humboldt Smelter, and Chaparral Gulch that could present health risks if a person is exposed to these metals over a long period of time. Arsenic can enter the body through breathing and/or ingesting contaminated soil. Therefore, EPA recommends that residents limit or avoid contact with soils and any water in these areas and obey EPA caution signs. Chaparral Gulch is easily accessible to the public as no fences or gates prohibit access. However, EPA advises residents, especially young children, to stay out of the Chaparral Gulch.

2. REMEDIAL ACTION OBJECTIVES

This section contains the presentation of remedial action objectives (RAOs), identification of preliminary contaminants of concern (COC), evaluation of ARARs, and development of Preliminary Cleanup Levels (see Figure 15).

2.1 PRESENTATION OF REMEDIAL ACTION OBJECTIVES

According to the NCP, 40 CFR §300.430(a)(1)(i), the "national goal of the remedy selection process is to select remedies that are protective of human health and the environment, that maintain protection over time, and that minimize untreated waste." Based on information relating to types of contaminants, environmental media of concern, and potential exposure pathways, RAOs were developed to aid in the development and screening of remedial alternatives. Final RAOs will be documented in the ROD.

2.1.1 Generally Applicable Remedial Action Objectives

Generally applicable RAOs include the following:

- Utilize sustainable practices during site cleanup.
- Protect existing native ecological habitats and resources.
- Utilize solutions that support reasonably anticipated future land uses.

2.1.2 Media-specific Remedial Action Objectives

The RAO for ***soil/sediment*** (Iron King Mine AOI, Humboldt Smelter AOI, In-town Soil AOI, Galena Gulch, Upper Chaparral Gulch, Middle Chaparral Gulch, and Lower Chaparral Gulch) is:

- Prevent exposure to COCs in soil or sediment above acceptable human health and ecological cleanup levels.

- Prevent migration of COCs in soils or sediments above acceptable human health and ecological cleanup levels during surface water flow events up to the 100-year flood event.

- Prevent migration of COCs in soils/sediments above acceptable human health and ecological cleanup levels to ambient air.

The RAOs for ***aquatic sediment*** (Lower Chaparral Gulch Dam – Confluence and Agua Fria River) are:

- Prevent exposure to COCs in aquatic sediments above acceptable human health and ecological cleanup levels.

- Prevent migration of COCs in aquatic sediments above acceptable human health and ecological cleanup levels during surface water flow events up to the 100-year flood event.

The RAOs for ***surface water*** are:

- Prevent exposure to COCs in surface water above human health and ecological cleanup levels.
- Prevent migration or discharge of acid mine water.

The RAOs for ***ground water*** are:

- Prevent exposure to COCs in ground water above human health cleanup levels.
- Prevent further degradation of ground water from COCs above human health cleanup levels.
- Remediate COCs in ground water to allow for beneficial uses of the aquifer.

Due to the breach/failure of the ***tailings dams*** (i.e., Iron King Mine Main Tailings Pile), the RAOs are:

- Stabilize the tailings dams to prevent release of tailings during a seismic event producing 60 percent of peak ground acceleration or 0.3 g (i.e. three-tenths the force of gravity).
- Stabilize the tailings dams to prevent release of tailings during a 100-year flood event.

The RAO for ***structures/debris*** is:

- Prevent exposure to asbestos above the acceptable human health cleanup levels.

2.2 PRELIMINARY CONTAMINANTS OF CONCERN

Human health or ecological exposure areas with potential unacceptable risk are identified in Section 1 (see Tables 1-1 through 1-5) for soil, sediment, surface water, and ground water. EPA defines human health or ecological COCs as those chemicals that pose an Excess Lifetime Cancer Risk (ELCR) to human health greater than 1 cancer case in 1,000,000 individuals (1E-06), have a non-carcinogenic hazard index (HI) greater than (>) 1, an ecological HI greater than 1, or are found in media above chemical-specific ARARs (e.g., drinking water MCLs). Although formal COCs are determined by EPA in the ROD, this document presents Preliminary COCs that will be considered by EPA in a decision document. Preliminary COCs are those chemicals that pose an unacceptable risk (i.e., risk drivers) or exceed screening criteria (e.g. MCLs or lead screening levels) in Tables 1-1 through 1-5 for soil, sediment, surface water, and ground water (see Figure 15).

2.3 BACKGROUND THRESHOLD VALUE

Background Soil Type 1 through 3 areas were sampled from the Balon gravelly sandy clay loam (BgD), the Moano gravelly loam (MgD), and the Moano very rocky loam (MkF), which encompass approximately 70 percent of the surface area in the immediate vicinity of the Site. More importantly, the BgD map unit is interpreted as being the dominant soil type at the Iron King Mine, Humboldt Smelter, In-town Soil, and Waterway AOIs. Therefore, Background Soil Type 1 will be used to evaluate background contributions in the remedial decision process. Additional information regarding regional soils is provided in the background report (see Appendix A).

In the background report (see Appendix A), background threshold values (BTV) were calculated for the Background Soil Type 1 (see Figure 15). The BTVs were calculated as the 95% Upper Prediction Limit (UPL) for the mean and the 95% UPL for a single independent observation for the next 10 samples. This background evaluation includes a two-phase approach to determine if an exposure area is significantly greater than background (see Figure 15 and Table 2-1).

In the first comparison, the mean Site exposure area concentration is compared against the 95% UPL for the mean of the next 10 observations. This comparison is used to evaluate whether exposure areas are significantly greater than background on a central tendency basis.

In the second comparison, which evaluates whether small areas (i.e., hot spots) are significantly greater than background, the individual sample concentration is compared against the 95% UPL for the next 10 observations. This comparison is used to evaluate whether exposure areas are significantly greater than background based on the upper tail of the statistical distribution.

For a given metal, the BTV represents a threshold value that indicates the sample dataset is not consistent with background. In other words, exceedance of the BTV indicates that the soil was considered significantly greater than background soil.

2.4 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Applicable or Relevant and Appropriate Requirements are substantive federal and state environmental laws and regulations that specify clean-up levels or performance standards for CERCLA sites.

Section 121(d) of CERCLA, as amended by Superfund Amendments and Reauthorization Act (SARA), states that on-site remedial actions must attain ARARs. ARARs may include regulations, standards, criteria, or limitations promulgated under federal or state laws. An ARAR may be either “applicable” or “relevant and appropriate,” but not both. The NCP in 40 CFR §300 defines ARARs (EPA 1994).

Three categories of ARARs exist: chemical-, location-, and action-specific requirements. Chemical-specific ARARs are health- or risk-based numerical values or methodologies that, when applied to site-specific conditions, result in the establishment of numerical clean-up values.

These values establish the acceptable amount or concentration of a chemical that may be detected in or discharged to the ambient environment. Location-specific ARARs are restrictions on the concentrations of hazardous substances or on activities conducted at the Site that result from site characteristics or its immediate environment. For example, location of the Site or proposed remedial action in a flood plain, wetland, historic place, or sensitive ecosystem may trigger location-specific ARARs. Action-specific ARARs are technology- or activity-based requirements or limitations on actions taken. These requirements are triggered by the specific remedial activities selected. Action-specific ARARs do not in themselves determine the remedial alternative; rather, they indicate how an alternative must be conducted (EPA 1994). In addition to the legally binding requirements established as ARARs, many federal and state programs have developed criteria, advisories, guidelines, or proposed "To Be Considered" (TBC) standards. TBC material may provide useful information or recommend procedures if no ARAR addresses a particular situation or if existing ARARs do not provide protection. In such situations, TBC criteria or guidelines will be used to set remedial action levels. Chemical-, location-, and action-specific ARARs for each of the remedial alternatives are presented in Table 2-2.

2.5 PRELIMINARY CLEAN-UP LEVEL DERIVATION

Preliminary Cleanup Levels are acceptable exposure levels (i.e., contaminant concentration levels) that are protective of human health and the environment, and are developed considering ARARs, as specified in the NCP (see Figure 15). The term "Cleanup Level" is used in order to make clear that the remedy establishes binding requirements to ensure that RAOs are satisfied. These Preliminary Cleanup Levels will be used to define the areas and volumes of environmental media subject to remedial action in the FS. Preliminary Cleanup Levels were selected from the following sources:

- Chemical-specific ARARs
- Human health – Chemical-specific cancer risk = 1E-05 and/or target organ noncancer hazard index = 1
- Ecological – Hazard index = 1
- Background – 95% UCL from Background Soil Type 1

2.5.1 Chemical-Specific ARARs

Chemical-specific ARARs are health- or risk-based numerical values or methodologies that, when applied to site-specific conditions, result in the establishment of numerical clean-up values (see Section 2.5). These values establish the acceptable amount or concentration of a chemical that may be detected in or discharged to the ambient environment. Chemical-specific ARARs that were considered as Preliminary Cleanup Levels are presented in Table 2-2.

2.5.2 Human Health Preliminary Cleanup Levels

Human Health Preliminary Cleanup Levels were developed for the soil/sediment Preliminary COCs presented in Tables 1-1 and 1-3. Human Health Preliminary Clean-Up Levels were based

on a cancer risk of 1E-05 or a noncancer hazard of 1. When both cancer and noncancer values are available, the lowest value was selected. The Preliminary Cleanup Levels were calculated using the methodologies presented in the human health risk assessment (EA 2010b); exposure parameters, toxicity values, and chemical-specific parameters remain the same except for the following:

- Recreational/Trespasser Scenario – The Human Health Risk Assessment included a Recreational/Trespasser exposure scenario with an exposure duration of 250 days/year. A Recreational/Trespasser exposure scenario was added with an exposure duration of 50 days/year to evaluate areas of the Site with limited human access (i.e., Galena Gulch, Upper Chaparral Gulch, Agua Fria River, and Lower Chaparral Gulch Dam – Confluence).
- Chromium and hexavalent chromium – Cancer toxicity values were updated. A new oral cancer slope factor was adopted by EPA and the inhalation unit risk cancer toxicity value changed.
- Thallium – The oral noncancer reference dose was rescinded by EPA so Preliminary Clean-Up Levels were not determined. Thallium was a Preliminary COC in an exposure area with several other chemicals so the absence of a Preliminary Clean-Up Level will not affect the protectiveness of the evaluation.
- Arsenic bioavailability factor – The bioavailability factor for arsenic was 0.8 in the human health risk assessment. This value was updated to 0.6 based on an in-vivo swine study using arsenic impacted soil from the Site.

Human Health Preliminary Cleanup Levels for soil/sediment are presented in Table 2-3.

Preliminary COCs for surface water and ground water were presented in Tables 1-2 and 1-4. The Human Health Preliminary Cleanup Levels for surface water and ground water were the EPA MCL or NSDWS. These Preliminary Cleanup Levels are presented in conjunction with ecological values and ARARs in Section 2.6.5.

2.5.3 Ecological Preliminary Cleanup Levels

Ecological Preliminary Cleanup Levels were developed in Appendix B and presented in Tables 2-4 and 2-5. These Preliminary Cleanup Levels correspond to exposure point concentrations below which risk is unlikely to occur. For wildlife, values should only be applied using appropriate spatial analyses and consideration of population biology. For benthos and lower trophic level organisms, values should be applied across areas suspected to support distinct communities.

2.5.4 Background Levels

Background Soil Type 1 through 3 areas were sampled from the Balon gravelly sandy clay loam (BgD), the Moano gravelly loam (MgD), and the Moano very rocky loam (MkF), which encompass approximately 70 percent of the surface area in the immediate vicinity of the Site. More importantly, the BgD map unit is interpreted as being the dominant soil type at the Iron King Mine, Humboldt Smelter, In-town Soil, and Waterway AOIs. Therefore, Background Soil

Type 1 will be used to evaluate background contributions in the remedial decision process. Additional information regarding regional soils is provided in the background report (see Appendix A).

The 95 percent upper confidence limit on the arithmetic mean (95% UCL) for Background Soil Type 1 was recalculated in this report because 30 additional background soil samples were collected in May 2010 (see Table 2-6). Although Preliminary Cleanup Levels can be higher than these background levels, they cannot be lower; otherwise, exposure areas may be remediated to a concentration that is lower than those found in naturally occurring background samples/areas.

2.5.5 Preliminary Clean-Up Level Summary

The Preliminary Cleanup Levels that will be used to define the areas and volumes of environmental media subject to remedial action for soil, sediment, surface water, and ground water are presented in Tables 2-7 through 2-9. When more than one Preliminary Cleanup Level is applicable to an exposure area, the lowest value will be selected as long as it is not smaller than the Background Soil Type 1 value; in this instance, the Background Soil Type 1 value is considered the Preliminary Cleanup Level.

3. DEVELOPMENT AND SCREENING OF ALTERNATIVES

The remedial alternatives were developed in accordance with EPA Guidance (EPA 1988). The development process starts by identifying general response actions (GRAs) and associated technologies for each media of interest that will satisfy the RAOs. GRAs are generic, medium specific remedial actions and may include no action, institutional controls, containment, removal, treatment, disposal, monitoring, or a combination thereof (EPA 1988). At this Site, the media of interest are:

- **Soil/sediment** – Applies to the Iron King Mine AOI, Humboldt Smelter AOI, In-town Soil AOI, Galena Gulch, Upper Chaparral Gulch, Middle Chaparral Gulch, and Lower Chaparral Gulch
- **Aquatic sediment** – Applies to the Lower Chaparral Gulch Dam – Confluence and Aqua Fria River
- **Surface water** – Applies to the Lower Chaparral Gulch Dam – Confluence and Aqua Fria River (all other surface water is considered transient and will be addressed via the underlying substrate)
- **Ground water** – Applies to arsenic at the Iron King Mine and Humboldt Smelter AOIs, sulfate/TDS downgradient of the Iron King Mine AOI, and chloride/TDS near the Humboldt Smelter AOI
- **Structures/debris** – Applies to the Humboldt Smelter AOI structures/debris due to asbestos, specifically the Assay Office, Humboldt Smelter, and several piles of debris from demolished buildings.

The GRAs and remedial technologies for each of the media of interest are identified and presented in Section 3.1. The GRAs and remedial technologies were then screened for effectiveness, implementability, and cost in Section 3.2 before being developed into remedial alternatives in Section 4. Remedial alternatives are technology combinations that were developed to meet the RAOs.

3.1 GENERAL RESPONSE ACTION AND REMEDIAL TECHNOLOGIES

GRAs may include no action, institutional controls, containment, removal, treatment, disposal, monitoring, or a combination thereof (EPA 1988).

3.1.1 All Media Types

The following GRAs will be considered for all media types:

- No Further Action (NFA)
- Limited Action

As required by the NCP (NCP § 300.430 [e][6]), the selected remedial alternatives must include the NFA alternative to be used as the baseline alternative against which the effectiveness of all other remedial alternatives are judged.

The limited action GRA utilizes institutional controls (IC) to achieve RAOs. ICs are non-engineered instruments such as administrative and legal controls that help minimize the potential for human exposure to contamination and protect the integrity of a remedy by limiting land or resource use. ICs can be used in all stages of the remedial process to accomplish various remedial objectives, and will be implemented in a series to provide overlapping assurances of protection against contamination. Examples of IC include restrictive covenants, deed notices, and Equivalent Zoning or Ordinances.

3.1.2 Soil/Sediment

This soil/sediment evaluation applies to the Iron King Mine AOI, Humboldt Smelter AOI, In-town Soil AOI, Galena Gulch, Upper Chaparral Gulch, Middle Chaparral Gulch, and Lower Chaparral Gulch. The GRAs evaluated for contaminated soil/sediment include the following:

- Containment
- Removal
- Treatment

These GRAs and the individual technologies considered for each GRA are presented in detail in Table 3-1 and are discussed briefly below.

Containment is an engineered remedy designed to prevent migration of the contaminant and eliminate exposure pathways to potential receptors. For soil/sediment, containment options

include capping the contaminated material in place, installing barriers to horizontal movement such as vertical liners, and consolidating the contaminated material into one location.

Physical removal of contaminated soil/sediment is a GRA that would be conducted by excavation, using standard construction equipment to remove material for on-site disposal, off-site disposal, or reuse. Removal may also be supplemented with other response actions (e.g., treatment) to achieve RAOs.

Treatment subjects contaminants to processes that alter their state, transform them to innocuous forms, or immobilize them. This GRA is usually preferred unless site- or contaminant-specific characteristics make it impracticable. Treatment may be physical, chemical, or biological, and can be performed *in-situ* or *ex-situ*. *In-situ* treatment systems treat the contaminated medium in place; consequently, the need for aboveground waste management is minimal. *Ex-situ* treatment requires the removal of the contaminated medium. In addition, *ex-situ* treatment systems require management of the resulting treated material. Examples of treatment technologies for soil/sediment include acid extraction, solidification/stabilization, and phytoextraction.

3.1.3 Aquatic Sediment

This aquatic sediment evaluation applies to the Lower Chaparral Gulch Dam – Confluence and Aqua Fria River. The GRAs evaluated for contaminated aquatic sediment include the following:

- Containment
- Removal
- Treatment

These GRAs and the individual technologies considered for each GRA are presented in detail in Table 3-2 and are discussed briefly below.

For aquatic sediment, containment options include capping, horizontal barriers, and sediment control barriers.

As with soil, physical removal of contaminated aquatic sediment would be conducted by excavation to remove material and load it into transport mechanisms for on-site or off-site disposal. Removal may also be supplemented with other response actions (e.g., treatment) to achieve RAOs.

Treatment options for contaminated aquatic sediment include *ex-situ* physical treatments such as solids dewatering, *ex-situ* chemical treatments such as alkaline leaching/acid extraction, *in-situ* physical treatment such as a settling basin or pond, *in-situ* chemical treatment such as solidification/stabilization, *in-situ* biological treatment such as phytoextraction, and chemical treatment such as demobilization.

3.1.4 Surface Water

The surface water evaluation applies to the Lower Chaparral Gulch Dam – Confluence and Aqua Fria River; all other surface water is considered transient and will be addressed via the underlying substrate. The GRAs evaluated for contaminated surface water include the following:

- Containment
- Treatment

These GRAs and the individual technologies considered for each GRA are presented in detail in Table 3-3 and are discussed briefly below.

The only containment option to be considered for surface water is diversion, which would consist of redirecting surface water flow away from contaminated soil and tailings by means of either open channels or a pipe system.

Surface water treatment options include *ex-situ* physical or chemical treatments such as lime neutralization, ion exchange, reverse osmosis, iron oxide coated sand, activated carbon, activated alumina, hydrogen peroxide and zero-valent iron; *in-situ* chemical treatment such as open limestone channels, anoxic limestone drains, or lime slurry addition; and *in-situ* biological treatment such as an anaerobic wetland, successive alkalinity producing system (SAPS), or a passive reactive barrier.

3.1.5 Ground Water

The ground water evaluation applies to arsenic at the Iron King Mine and Humboldt Smelter AOIs, sulfate/TDS downgradient of the Iron King Mine AOI, and chloride/TDS near the Humboldt Smelter AOI. The GRAs evaluated for contaminated ground water include the following:

- Alternative Water Supply
- Containment
- Treatment

These GRAs and the individual technologies considered for each GRA are presented in detail in Table 3-4 and are discussed briefly below.

Providing an alternative water supply to residences with private wells within the path of contaminated ground water plumes would mitigate exposure to contaminated ground water. Two alternative water supply process options are considered: connection to the existing municipal water supply and drilling new residential wells.

Ground water containment will consist of intercepting the contaminated plume before it reaches residences with private wells. Options for this GRA include slurry walls, grout curtains, interceptor trenches, or hydraulic containment.

Treatment options for ground water consist of *in-situ* treatment using a permeable reactive barrier, and *ex-situ* treatment using ion exchange and RO, either of which could be provided on a residential basis with point of use or point of entry treatment systems or through central pump and treat.

3.1.6 Structures/Debris

The structures/debris evaluation applies to the Humboldt Smelter AOI (i.e., Assay Office, Humboldt Smelter, and building debris piles) due to asbestos. The GRAs evaluated for contaminated ground water include the following:

- Treatment
- Removal
- Disposal

These GRAs and the individual technologies considered for each GRA are presented in detail in Table 3-5 and are discussed briefly below.

For buildings, treatment would consist of asbestos abatement from standing structures.

The removal GRA would be used in conjunction with the disposal GRA and would involve the demolition of standing structures that contain asbestos materials. Building debris would then be disposed of on-site in an engineered cell or off-site in a facility that is certified to accept asbestos-containing waste.

3.2 REMEDIAL TECHNOLOGY SCREENING

This section presents and screens the remedial technologies presented in Tables 3-1 through 3-5 that are potentially applicable to the areas of concern at the Site.

3.2.1 Preliminary Screening Criteria

Three preliminary screening criteria (effectiveness, implementability, and cost) were used to screen these remedial technologies. Definitions for these criteria are presented below, and the technology screening is presented in Tables 3-6 through 3-10.

Effectiveness

This criterion is a measure of the ability of an option to: (1) reduce toxicity, mobility, or volume; (2) minimize residual risks; (3) afford long-term protection; (4) comply with ARARs; (5) minimize short-term impacts; and (6) achieve protectiveness in a limited duration. Technologies that offer significantly less effectiveness than other proposed technologies may be eliminated from the alternative development process. Options that do not provide adequate protection of human health and the environment likewise are eliminated from further consideration.

Implementability

Implementability is a measure of the technical feasibility and availability of the option and the administrative feasibility of implementing it (e.g., obtaining permits for off-site activities, rights-of-way, or construction). Options that are technically or administratively infeasible or that would require equipment, specialists, or facilities that are not available within a reasonable period may be eliminated from further consideration.

Cost

Qualitative relative costs for implementing the remedy are considered. Costs were obtained from published sources. Technologies that cost more to implement, but that offer no benefit in effectiveness or implementability over other technologies, may be excluded from the alternative development process.

3.2.2 Screening Summary

The results of the technology screening are summarized in the following section, and the screening is presented in greater detail, including the explanation for whether technologies were retained or not, in Tables 3-6 through 3-10. From the list of technologies potentially applicable for remediation of the chemicals and media of concern, the following technologies were retained for development of alternatives because they were considered effective, implementable, and cost effective relative to the other alternatives under consideration.

3.2.2.1 Soil/sediment

Technologies retained for treatment of soil/sediment are:

- Traditional soil cap
- Capping with both evapo-transpiration (ET) and wet covers
- Consolidation
- Excavation and offsite disposal
- Excavation and onsite disposal in cell

- Recycling/reprocessing
- Solidification/Stabilization
- *In situ* treatment with chemical and biological soil amendments

3.2.2.2 Aquatic Sediment

Technologies retained for treatment of aquatic sediment are:

- Traditional soil cap
- Capping with both ET and wet covers
- Excavation and offsite disposal
- Excavation and onsite disposal in a dry cell
- Solids dewatering
- Settling basin/pond/wetland
- Solidification/stabilization

3.2.2.3 Surface Water

Technologies retained for treatment of surface water are:

- Diversion
- Open limestone channels
- Anoxic limestone channels

3.2.2.4 Ground Water

Technologies retained for treatment of ground water are:

- Municipal water supply
- Pump and Treat (ion exchange or reverse osmosis technology)
- Point of Use Treatment (ion exchange or reverse osmosis technology)

3.2.2.5 Structures/Debris

Technologies retained for treatment of structures/debris are:

- Asbestos abatement
- Building/structure demolition
- Onsite Disposal
- Offsite disposal

4. DEVELOPMENT OF REMEDIAL ALTERNATIVES

This section combines the technologies that were retained after screening to develop alternatives for the different exposure areas. Alternatives were developed generally based on the media they are designed to treat: soil/sediment, aquatic sediment, surface water, ground water, and building/debris. The media associated with the Lower Chaparral Gulch will be addressed wholesale since implementation of the alternatives may overlap and depend on a comprehensive remedial system.

If any alternative requires an institutional control regarding reuse, fencing and signage may be installed where appropriate to restrict public access. The developed alternatives are described below. These alternatives will be further developed during the FS.

4.1 GENERAL REMEDIAL ALTERNATIVES

4.1.1 No Further Action

As required by the NCP (NCP § 300.430 [e][6]), the alternatives must include the NFA alternative. This is to be used as the baseline alternative against which the effectiveness of all other remedial alternatives are judged. Under NFA, no remedial actions will be conducted at the Site. Soil contaminants will remain in place and will be subject to environmental influences. Furthermore, no action will be taken to prevent unauthorized access or development at the Site. No deed notices to inform interested parties regarding the site conditions will be implemented.

4.1.2 Limited Action

Limited action utilizes ICs, engineering controls, and/or long-term monitoring to achieve RAOs. ICs are administrative and/or legal instruments that place restrictions on the use or development of land and/or ground water within a defined area. They are legal and administrative tools used to maintain protection of public health and/or the environment, and to protect the integrity of a remedy by limiting land or resource use. IC instruments include restrictive covenants, deed notices, ordinances, zoning restrictions, building and excavation permits, easements, well drilling prohibitions, or combination thereof. The selection of IC instruments must be mutually acceptable to the EPA, ADEQ, and landowner.

Examples of ICs include restrictive covenants, deed notices, and Equivalent Zoning or Ordinances. ICs in Arizona are commonly implemented in the form of a Declaration of Environmental Use Restriction (DEUR) that documents institutional and/or engineering controls and is filed with the County. DEURs include several requirements such as financial assistance and many years of future reporting and inspections. Because some alternatives may include leaving material above EPA Preliminary Clean-up Levels, ICs (e.g. DEURs or zoning ordinances) will need to be included, not just for the Limited Action alternative. In the FS, ICs will be evaluated in greater depth for effectiveness, implementability, and cost.

Engineering controls are instruments such as fencing or signage that are used to minimize access to contaminated areas or areas that may pose a physical hazard (e.g., mine shafts

and tunnels). ICs and engineering controls can be used in all stages of the remedial process to accomplish various remedial objectives, and will be implemented in a series to provide overlapping assurances of protection against contamination.

The limited action alternative is evaluated for each of the media below.

4.2 SOIL REMEDIAL ALTERNATIVES

The following remedial alternatives were identified as potential alternatives for the remediation of soil/sediment:

- Alternative S-1: No Further Action
- Alternative S-2: Limited Action
- Alternative S-3: Consolidation with Soil Cap
- Alternative S-4: Consolidation with ET Cap
- Alternative S-5: Consolidation with Engineered Cover
- Alternative S-6: *In-Situ* Stabilization
- Alternative S-7: Excavation and Off-site Disposal
- Alternative S-8: Material Reuse

These alternatives are considered potential remedies for the following AOIs and exposure areas (Figure 6):

- **Iron King Mine** – Operations Area, Operations Area - Miscellaneous, Mine Plant, Main Tailings Pile, Small Tailings Pile, Glory Hole, Former Fertilizer Plant, and associated Impoundment-Ponds
- **Humboldt Smelter** – Tailings Pile, Ash Pile, Slag, Operations Area, Impoundment/Pond, and Off-site Migration
- **Offsite Soil** – Composed of 65 in-town parcels evaluated in the RI Report (EA 2010b) and an additional 120 in-town parcels sampled in May 2010
- **Waterways** - Galena Gulch, Upper Chaparral Gulch, Middle Chaparral Gulch, and Lower Chaparral Gulch, which are dry for most of the year.

Because these exposure areas all have similar media but different degrees and extent of contamination, historical use, reuse potential, and regulations, no one alternative will apply to all areas. With the exception of Alternative S-1: No Action and S-2: Limited Action, each of the following alternatives addresses all three soil RAOs. Table 4-1 presents each of the alternatives and describes how they meet the RAOs.

Because the tailings dams RAOs apply to the Iron King Mine Main Tailings Pile, the alternatives that involve leaving untreated tailings material will require structural stabilization to provide containment of the tailings.

4.2.1 Alternative S-2: Limited Action

The limited action alternative for soil consists of air monitoring in town and a combination of institutional and engineering controls to prevent access or use of areas that present unacceptable risk to ecological or human health.

4.2.2 Alternative S-3: Consolidation with ET Cap

Alternative S-3 addresses the soil media contamination by consolidating and capping the soil/sediment materials. This alternative addresses the soil-specific RAOs for preventing migration and exposure to contaminated materials by isolating them under a barrier. Contaminated soil/sediment from across the Site will be excavated, consolidated, and then the contaminated material will be covered by an ET cap with a capillary layer to prevent infiltration of surface water and oxygen into the tailings.

The Iron King Mine Main Tailings Pile is currently kept saturated and anoxic by surface impoundments and is therefore only generating AMD in the top foot or so of the tailings, there is some risk that preventing infiltration will dewater the tailings and allow for greater AMD generation. Pilot studies to determine the rate of dewatering within the tailings pile would allow for greater understanding of the current system and confirm the ability of Alternative S-3 to prevent the formation of AMD.

4.2.3 Alternative S-4: Consolidation with Soil Cover

Alternative S-4 is similar to Alternative S-3, but utilizes a different capping method. Contaminated soil/sediment from across the Site will be excavated and consolidated, then the contaminated material will be covered by a layer of clean soil and grass to prevent wind erosion.

The Iron King Mine Main Tailings Pile is currently kept saturated and anoxic by surface impoundments and is therefore only generating AMD in the top foot or so of the tailings, Alternative S-4 will neither prevent infiltration of water into the tailings nor ensure that the tailings remain saturated and anoxic. Dewatering pilot studies would provide more information on the risk of further AMD generation for this alternative.

4.2.4 Alternative S-5: Consolidation with Engineered Cover

As in Alternatives S-3 and S-4, contaminated material will be consolidated, but instead of isolating the contaminated material with an ET cap that requires vegetative cover, an engineered cover using geocomposite lining (GCL) will be used. The GCL will prevent infiltration and contact with the tailings, but will not require an established vegetative cover. Although a vegetative cover may be placed on the cap to reduce erosion, degradation of the cover material, and for aesthetics.

The Iron King Mine Main Tailings Pile is currently kept saturated and anoxic by water infiltration from surface impoundments and is therefore only generating AMD in the top foot or so of the tailings, preventing infiltration may dewater the tailings over a long period of time and

allow for greater AMD generation. Pilot studies to determine the rate of dewatering within the tailings pile would allow for greater understanding of the current system and confirm the ability of Alternative S-5 to prevent the formation of AMD.

4.2.5 Alternative S-6: *In-Situ* Stabilization

Alternative S-6 is an *in-situ* treatment that stabilizes and provides cover by mixing a stabilizing agent such as lime and organic matter such as biosolids into the top six inches of the exposure area. The pH adjustment will reduce leaching to surface water, while the biological amendment will increase soil moisture retention, making the soil/sediment less susceptible to wind migration and support vegetative cover. Pilot studies will be required for this alternative to determine which chemical and biological amendments are effective and to determine the application ratios.

This alternative is considered for small tailings deposits or areas with contaminated surface soil only, such as the following exposure areas:

- Iron King Mine Mine Plant
- Iron King Mine Operations Area
- Iron King Mine Operations Area – Miscellaneous
- Iron King Mine Former Fertilizer Plant

4.2.6 Alternative S-7: Excavation and Off-Site Disposal

The purpose of Alternative S-7 is to remove the contaminated soil/sediment. Disposal requirements will depend on whether the excavated material is classified as a hazardous waste, in which case land disposal restrictions (LDRs) would apply to disposal outside of the area of concern (55 Federal Register 8759). Classification of the excavated material as a hazardous waste will depend on two factors: its toxicity characteristics, as determined by the toxicity characteristic leaching procedure (TCLP) analytical test, and whether it falls under specific exclusions provided for mining industry wastes in 40 CFR Part 261.4(b)(7). TCLP samples were collected from the Iron King Mine Operations Area, Iron King Mine Main Tailings Pile, Humboldt Smelter Ash Pile, Humboldt Smelter Slag Pile, Humboldt Smelter Tailings Pile, Lower Chaparral Gulch, Lower Chaparral Gulch Dam – Confluence, and Iron King Mine Small Tailings Pile. Of these, only the sample from the Iron King Mine Main Tailings Pile exceeded the TCLP regulatory level, with an arsenic concentration of 7.2 mg/L. Solid waste that exceeds the TCLP regulatory level is considered to be a hazardous waste unless it meets specific exclusion categories as outlined in 40 CFR Part 261.4(b)(7). Hazardous wastes are land disposal restricted and require treatment prior to disposal. In addition to addressing soil-specific RAOs, this alternative will address the ground water RAO for preventing further degradation of ground water quality by removing the primary source material.

4.2.7 Alternative S-8: Material Reuse

Both the Iron King Mine Main Tailings Pile and the Humboldt Smelter Slag provide opportunities for reuse. The tailings could be reprocessed for various metals and the slag could be crushed to provide a base for roads or other construction projects. However, neither potential

use has been confirmed and will require both pilot testing and economic analysis. This alternative addresses both the soil-specific RAOs and the ground water RAO for preventing further degradation of ground water quality because the source material would be removed.

4.3 AQUATIC SEDIMENT

The following remedial alternatives were identified as potential alternatives for the remediation of aquatic sediment:

- Alternative A-1: No Further Action
- Alternative A-2: Limited Action
- Alternative A-3: Rock Armoring
- Alternative A-4: Excavation and Onsite Disposal
- Alternative A-5: Excavation and Offsite Disposal

These alternatives are considered potential remedies for the Lower Chaparral Gulch and Agua Fria River. All of the proposed alternatives, with the exception of Limited Action and NFA, address the two aquatic sediment RAOs. Table 4-2 presents each of the alternatives and describes how they meet or fail to meet each of the RAOs.

4.3.1 Alternative A-2: Limited Action

The limited action alternative for aquatic sediment consists of surface water monitoring for suspended or dissolved solids and a combination of institutional and engineering controls to prevent access or use of the areas that present an unacceptable risk to ecological or human health.

4.3.2 Alternative A-3: Rock Armoring

The purpose of Alternative A-3 is to prevent the movement of contaminated sediment downstream. For this alternative, gravel and rock will be placed over the contaminated sediment to support channel structures and control stream flow.

4.3.3 Alternative A-4: Excavation and Onsite Disposal

For Alternative A-4, contaminated sediment will be excavated, dewatered, placed in an upland cell onsite, and capped. This alternative may involve combining the dewatered sediment in one cell along with other contaminated materials from the Site. Additionally, excavated and dewatered sediment may be treated with a chemical amendment before disposal in order to reduce leaching if necessary.

4.3.4 Alternative A-5: Excavation and Offsite Disposal

The purpose of Alternative A-5 is to remove contaminated material. Contaminated sediment will be excavated, dewatered, and transported offsite for disposal. The sediment will be disposed at an approved disposal facility, depending on the toxicity characteristics of the excavated material.

Excavated and dewatered sediment may be treated with a chemical amendment before disposal in order to reduce leaching of arsenic.

4.4 GROUND WATER ALTERNATIVES

The following remedial alternatives were identified as potential alternatives for the remediation of ground water:

- Alternative GW-1: No Further Action
- Alternative GW-2: Limited Action
- Alternative GW-3: Point of Use Treatment
- Alternative GW-4: Connection to Municipal Water Supply
- Alternative GW-5: Pump and Treat, Reuse through Potable Supply
- Alternative GW-6: Pump and Treat, Ground Water Injection

These alternatives are considered potential remedies for the Ground Water AOI. Only Alternatives GW-5 and GW-6 address all three of the ground water RAOs.

Implementation of an effective ground water remedy requires a thorough understanding of ground water hydrology at the Site. At present, the hydrogeology has some limited data gaps and further studies will be necessary to address all of the ground water RAOs. Table 4-3 presents each of the alternatives and describes how they meet or fail to meet each of the RAOs.

4.4.1 Alternative GW-2: Limited Action

The limited action alternative for ground water consists of ground water monitoring and a combination of institutional and engineering controls to prevent ground water use that presents an unacceptable risk to human health.

4.4.2 Alternative GW-3: Point of Use Treatment

In order to prevent exposure to COCs in drinking water, Alternative GW-3 utilizes point of use reverse osmosis treatment units to be installed at residences. The RO units will remove sulfate and/or chloride from water intended for drinking or cooking, not all of the water to be used in the residence. This alternative addresses the ground water RAO for preventing exposure to COCs in ground water above human health cleanup levels, but does not address the ground water RAOs for preventing further ground water degradation or restoring the aquifer to allow for beneficial use.

4.4.3 Alternative GW-4: Connection to Municipal Water Supply

Alternative GW-4 addresses the RAO of preventing exposure to COCs by connecting residences to the local municipal water supply. Water mains are currently in place across the town, so connection to the existing mains would not be difficult; however, it may be necessary to expand the current capacity of the municipal treatment system in order to meet increased demand. This alternative addresses the ground water RAO for preventing exposure to COCs in ground water

above human health cleanup levels, but does not address the ground water RAOs for preventing further ground water degradation or restoring the aquifer to allow for beneficial use.

4.4.4 Alternative GW-5: Pump and Treat, Reuse through Potable Supply

Alternative GW-5 utilizes a series of extraction wells to prevent contaminated ground water from migrating from its source. After extraction, the water is treated using RO or ion exchange and piped to the local municipal water supply for potable use or discharged/reused as appropriate. This alternative addresses all the ground water RAOs.

4.4.5 Alternative GW-6: Pump, Treat and Ground Water Injection

This alternative is similar to Alternative GW-5 in its extraction and treatment components, but returns the extracted and treated water to the aquifer instead of removing it for municipal use. This alternative addresses all the ground water RAOs.

4.5 STRUCTURES/DEBRIS

The following remedial alternatives were identified as potential alternatives for the remediation of structures/building debris:

- Alternative B-1: No Further Action
- Alternative B-2: Limited Action
- Alternative B-3: Asbestos Abatement
- Alternative B-4: Demolition and Onsite Disposal
- Alternative B-5: Demolition and Offsite Disposal

These alternatives are considered potential remedies for asbestos containing materials within the Humboldt Smelter Operations Area exposure area. All proposed alternatives address the structures/debris RAO for preventing exposure to asbestos. Table 4-4 presents each of the alternatives and describes how they meet or fail to meet each of the RAOs.

4.5.1 Alternative B-2: Limited Action

The limited action alternative for structures and debris consists of a combination of institutional and engineering controls to prevent access or use of the structures and debris that present an unacceptable risk to human health.

4.5.2 Alternative B-3 Asbestos Abatement

Asbestos abatement requires selectively removing asbestos-containing building materials from standing structures. Although it is not currently known which materials in the standing structures contain asbestos, examples of building materials that may contain asbestos include ceiling coatings, tiles, and concrete structures. Once removed, building materials would be disposed either onsite or offsite in a landfill certified to accept asbestos-containing waste.

4.5.3 Alternative B-4 Demolition and Onsite Disposal

Instead of selectively removing certain building materials from the standing structures, Alternative B-4 requires the demolition of all standing structures onsite that contain asbestos materials. The demolition will require safety measures to ensure that asbestos is not released into the surrounding air, where it could impact residences or towns downwind. This may be accomplished by placing a tent over the demolition area and conducting operations under negative pressure, so that no asbestos-bearing air can escape. Once demolition is completed, the building debris will be consolidated with other asbestos-containing debris piles and buried in a cell onsite.

4.5.4 Alternative B-5 Demolition and Offsite Disposal

As in Alternative B-4, Alternative B-5 requires the demolition of all asbestos-containing standing structures. However, instead of disposing of building debris and existing debris onsite, all asbestos-containing debris will be transported offsite and disposed of in an appropriate landfill.

4.6 LOWER CHAPARRAL GULCH

The following remedial alternatives were identified as potential alternatives for the remediation of the Lower Chaparral Gulch and Lower Chaparral Gulch Dam – Confluence exposure areas:

- Alternative LCG-1: No Further Action
- Alternative LCG-2: Limited Action
- Alternative LCG-3: Excavation and Offsite Disposal
- Alternative LCG-4: Excavation and Onsite Disposal
- Alternative LCG-5: Stabilization/Solidification and Downstream Leachate Treatment
- Alternative LCG-6: Cover and Downstream Leachate Treatment
- Alternative LCG-7: *In-situ* Sediment Treatment and Downstream Leachate Treatment

The Lower Chaparral Gulch is provided with a separate set of alternatives because it presents a system where several different media types must be addressed in combination with each other. Soil/sediment mixed with tailings and surface water are the main media that must be addressed for this area, but due to periodic rain events and temporary standing water, aquatic sediment is occasionally present and must also be addressed. With the exception of the limited action alternative, each proposed alternative described below addresses the RAOs for soil, aquatic sediment, and surface water. Table 4-5 presents each of the alternatives and describes how they meet or fail to meet each of the RAOs.

4.6.1 Alternative LCG-2: Limited Action

The limited action alternative for the Lower Chaparral Gulch consists of surface water monitoring and a combination of institutional and engineering controls to prevent access or use of the areas that present an unacceptable risk to ecological or human health.

4.6.2 Alternative LCG-3: Excavation and Offsite Disposal

The purpose of Alternative LCG-3 is to remove all contaminated material from the Lower Chaparral Gulch and return the area to pre-mining condition. The contaminated sediment and tailings will be excavated, dewatered, and transported offsite for disposal. The sediment and tailings will be disposed at an approved disposal facility, depending on the toxicity characteristics of the excavated material. The dam will be removed after the sediments behind it are excavated.

4.6.3 Alternative LCG-4: Excavation and Onsite Disposal

For Alternative LCG-4, all contaminated sediment and tailings in the Lower Chaparral Gulch will be excavated, dewatered, chemically stabilized with lime or other amendments, placed in an upland cell along with other consolidated materials from Humboldt Smelter, and capped. After the sediment is excavated, the dam will be removed. This alternative will return the gulch to pre-mining conditions and prevent migration or exposure of the tailings and sediment.

4.6.4 Alternative LCG-5: Stabilization/Solidification and Downstream Leachate Treatment

Unlike Alternatives LCG-3 and 4, Alternatives LCG-5 through LCG-7 leave most of the contaminated sediment and tailings in place behind a new dam. In this alternative, the exposed surface of the contaminated sediment will be stabilized and solidified to prevent downstream migration of contaminated sediment or tailings. It will be necessary to remove several feet of sediment and tailings before solidification/stabilization to preserve the storage capacity of the gulch and prevent water from backing into residential areas during high rain events, since the solidification/stabilization process will increase the volume of the tailings. The excavated sediment will be dewatered, combined with a stabilizing amendment, and deposited in an upland cell onsite.

Because almost all of the sediment will be left in place, a new dam will be built directly downstream of the current dam to provide secure containment. AMD will continue to be generated, so a limestone leach bed or channel will be installed to intercept and treat the AMD leachate.

In addition to the solidification/stabilization of existing contaminated sediment and tailings, two wetlands will be constructed: one upstream of the area of treated sediment and one downstream of the leachate treatment area. The upstream wetland will serve as mitigation for any negative effects to the current wetland habitat; a vegetative filter to reduce the amount of sediment flowing past the dam; and a source of organic matter, which may act as an adsorbent media to reduce the downstream migration of arsenic. The downstream wetland will serve as a polishing step for further pH adjustment and metals precipitation, as well as a settling basin and vegetative filter to prevent migration of sediment downstream.

4.6.5 Alternative LCG-6: Cover and Downstream Leachate Treatment

Alternative LCG-6 follows a similar strategy to Alternative LCG-5, but instead of using solidification/stabilization to prevent downstream movement of contaminated sediment, an impermeable cover will be installed to prevent exposure to sediments, and erosion controls will be built in-stream to help control sediment movement.

Because all sediments will be left in place, a new concrete gravity dam will be constructed to replace the existing structure, and AMD will continue to be generated. As in Alternative LCG-5, a limestone-lined channel or limestone leach bed will be installed to intercept and treat the AMD leachate, and wetlands will be constructed upstream of the covered area and downstream of the leachate treatment.

4.6.6 Alternative LCG-7: *In-situ* Sediment Treatment and Downstream Leachate Treatment

The top few feet of sediment and tailings above the dam will be treated *in-situ* with chemical and/or biological amendments such as lime to reduce their toxicity and mobility. If the *in-situ* treatment increases the sediment volume or decreases the available storage area for the gulch, then a corresponding volume of sediment will be excavated, dewatered, and disposed of in an onsite upland cell. In addition to the amendments, erosion controls will be constructed to help control sediment movement.

As in Alternatives LCG-5 and 6, a new dam will be built to replace the current structure, a limestone channel or leach bed will be installed to treat AMD leachate, and wetlands will be constructed upstream of the dam and downstream of the leachate treatment. For this alternative, the upstream wetland will be located within the treated area if the treatment is compatible with vegetative growth.

5. REFERENCES

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Tables

Table 1-1. Key Site Characteristics

Area of Investigation	Sample Group	Surface Soil, Subsurface Soil, or Aquatic Sediment	Source Characterization: Principal Threat Waste	Source Characterization: Low-level Threat Waste	Source Characterization: Source Volume (cy)	Complete Migration Pathways: Surface Water Transport	Complete Migration Pathways: Surface Water Partitioning	Complete Migration Pathways: Air Particulate Migration	Complete Migration Pathways: Leaching to Ground Water	Complete Migration Pathways: Ground Water to Surface Water	Notes	Likely Future Land Use	Arsenic EPC (mg/kg unless noted below)	Cancer Risk for Reuse (1)	Cancer Risk Drivers / Preliminary Chemicals of Concern	Noncancer Hazard for Reuse (1)	Noncancer Hazard Drivers / Preliminary Chemicals of Concern	Lead EPC (mg/kg unless noted below)
Iron King Mine	Iron King Mine Main Tailings Pile	SS	X		6.4 million	X		X	X		AMD	R/T (2)	7,678	8E-03	Arsenic	2.1E+02	Antimony, Arsenic, Iron	**2,887**
Iron King Mine	Iron King Mine Main Tailings Pile	SB	X			X		X	X		AMD	R/T (2)	5,148	5E-03	Arsenic	1.5E+02	Antimony, Arsenic, Cadmium, Iron	**2,990**
Iron King Mine	Impoundment-Pond - Iron King Mine Main Tailings Pile	SS	X			X	X	X	X		AMD	R/T	5,251	5E-03	Arsenic	1.5E+02	Antimony, Arsenic, Iron, Thallium	**5,369**
Iron King Mine	Iron King Mine Mine Plant	SS		X	14,800	X		X				C/I	1,919	1E-03	Arsenic	7E+00	Arsenic	**5,184**
Iron King Mine	Iron King Mine Mine Plant	SB										C/I	42	2E-05	Arsenic	5E-01	--	27
Iron King Mine	Impoundment-Pond - Iron King Mine Mine Plant	SS		X	4,400	X		X				R/T	2,602	3E-03	Arsenic	8E+01	Arsenic, Iron	**4,729**
Iron King Mine	Iron King Mine Operations Area	SS		X	90,800	X		X				C/I	3,016	2E-03	Arsenic	1E+01	Arsenic	**11,220**
Iron King Mine	Iron King Mine Operations Area	SB		X	90,800	X		X				C/I	4,715	2E-03	Arsenic	2E+01	Arsenic	**6,122**
Iron King Mine	Iron King Mine Glory Hole	SS				X		X	X			C/I	131	1E-04	Arsenic	6E+00	--	272
Iron King Mine	Iron King Mine Glory Hole	SB				X		X	X			C/I	278	3E-04	Arsenic	1E+01	--	424
Iron King Mine	Iron King Mine Operations Area - Miscellaneous	SS		X	7,400	X		X				C/I	414	2E-04	Arsenic	2E+00	Arsenic	1,612
Iron King Mine	Iron King Mine Operations Area - Miscellaneous	SB			7,400	X		X				C/I	49	3E-05	Arsenic	5E-01	--	162
Iron King Mine	Iron King Mine Small Tailings Pile	SS	X		22,200	X		X			AMD	Res	1,045	2E-03	Arsenic, Chromium	4E+01	Arsenic, Iron	**1,388**
Iron King Mine	Iron King Mine Small Tailings Pile	SB	X		22,200	X		X			AMD	Res	762	2E-03	Arsenic, Chromium	3E+01	Arsenic	**415**
Iron King Mine	Iron King Mine Former Fertilizer Plant	SS		X	11,100	X		X				C/I	1,244	7E-04	Arsenic	5E+00	Arsenic	**5,066**
Iron King Mine	Iron King Mine Former Fertilizer Plant	SB			11,100	X		X				C/I	160	9E-05	Arsenic	1E+00	--	279
Iron King Mine	Iron King Mine Salvage Yard	SS				X		X				C/I	40	2E-05	Arsenic	5E-01	--	26
Humboldt Smelter	Humboldt Smelter Ash Pile	SS	X		250,000	X		X				Res	822	2E-03	Arsenic, Chromium, Chromium VI, Cobalt, Aroclor-1248	4E+01	Aluminum, Arsenic, Chromium, Copper	**1,129**
Humboldt Smelter	Humboldt Smelter Ash Pile	SB	X		250,000	X		X				Res	184	4E-04	Arsenic, Chromium, Cobalt	2E+01	Aluminum, Arsenic, Chromium, Cobalt, Copper, Manganese	**7,523**
Humboldt Smelter	Humboldt Smelter Slag	SS		X	1.7 million	X		X				R/T	297	3E-04	Arsenic	1E+01	Arsenic, Copper	**972**
Humboldt Smelter	Humboldt Smelter Slag	SB		X	1.7 million	X		X				R/T	38	4E-05	Arsenic	3E+00	Arsenic	58
Humboldt Smelter	Humboldt Smelter Operations Area	SS		X	42,200	X		X			Asbestos	Res	242	5E-04	Arsenic, Chromium, Cobalt, Benzo(a)pyrene, Dibenz(a,h)anthracene	2E+01	Arsenic, Cobalt	**285**
Humboldt Smelter	Humboldt Smelter Operations Area	SB		X	42,200	X		X			Asbestos	Res	19	4E-05	Arsenic, Chromium, Cobalt	5E+00	Manganese	28
Humboldt Smelter	Impoundment-Pond - Humboldt Smelter	SS	X		3,000	X		X				Res	65	1E-04	Arsenic, Chromium, Cobalt	1E+01	Aluminum, Arsenic, Chromium, Copper, Manganese	**940**
Humboldt Smelter	Humboldt Smelter Off-site Migration	SS				X		X				Res	32	7E-05	Arsenic, Chromium, Cobalt	5E+00	Arsenic, Manganese	85
Humboldt Smelter	Humboldt Smelter Tailings Pile	SS	X		185,000	X		X	X			Res	13,891	3E-02	Arsenic, Chromium, Cobalt	5E+02	Antimony, Arsenic, Cobalt, Iron, Manganese	**1,114**
Humboldt Smelter	Humboldt Smelter Tailings Pile	SB	X		185,000	X		X	X			Res	34	7E-05	Arsenic, Chromium, Cobalt	8E+00	Arsenic, Manganese	42
Waterways	Galena Gulch	SS		X	37,000	X		X				R/T	1,058	1E-03	Arsenic	3E+01	Arsenic	**4,297**
Waterways	Upper Chaparral Gulch	SS		X	??	X		X				Res	219	5E-04	Arsenic, Chromium, Cobalt	1E+01	Arsenic	**333**
Waterways	Middle Chaparral Gulch	SS		X	37,000	X		X				Res	294	6E-04	Arsenic, Chromium, Cobalt	2E+01	Arsenic	**344**
Waterways	Lower Chaparral Gulch	SS	X		417,000	X	X	X	X	X	AMD	R/T	614	6E-04	Arsenic	2E+01	Arsenic	**1,285**
Waterways	Lower Chaparral Gulch	SB	X		417,000	X	X	X	X	X	AMD	R/T	1,491	2E-03	Arsenic	5E+01	Antimony, Arsenic	**1,970**
Waterways	Lower Chaparral Gulch Dam-Confluence	SD		X	18,000	X				X		R/T	1,620	4E-04	Arsenic	1E+01	Arsenic	**266**
Waterways	Lower Chaparral Gulch Dam-Confluence	SW		X	18,000	X				X		R/T	118 µg/L	2E-05	Arsenic	2E+00	--	**41.6 µg/L**
Waterways	Agua Fria	SD		X	6,700	X				X		R/T	722	2E-04	Arsenic	5E+00	Arsenic	**3,419**
Waterways	Agua Fria	SW		X	6,700	X				X		R/T	7.2 µg/L	9E-07	--	2E-01	--	2.7 µg/L
Waterways	Background Agua Fria	SD			6,700	X				X		R/T	34	7E-06	Arsenic	4E-01	--	12
Waterways	Background Agua Fria	SW			6,700	X				X		R/T	13.5 µg/L	2E-06	Arsenic	7E-02	--	0.85 µg/L
Waterways	Background Chaparral Gulch	SD			6,700	X				X		R/T	37	4E-05	Arsenic, Chromium	2E+00	Arsenic	17
Waterways	Background Galena Gulch	SD			6,700	X				X		R/T	25	3E-05	Arsenic	3E+00	--	24
Off-Site Soil	Background Soil Type 1	SS				X		X				Res	61	1E-04	Arsenic, Chromium, Cobalt	5E+00	Arsenic	55
Off-Site Soil	Background Soil Type 2	SS				X		X				Res	17	4E-05	Arsenic, Chromium, Cobalt	7E+00	Cobalt, Iron, Manganese	13
Off-Site Soil	Background Soil Type 3	SS				X		X				Res	13	4E-05	Arsenic, Chromium, Cobalt	5E+00	Cobalt	14
Off-Site Soil	Off-site Soil Background H1	SS				X		X				Res	32	7E-05	Arsenic, Chromium	4E+00	Arsenic	21
Off-Site Soil	Off-site Soil Background H2	SS				X		X				Res	99	2E-04	Arsenic	4E+00	Arsenic	76
Off-Site Soil	Off-site Soil	SS				X		X				Res	50	1E-04	Arsenic, Chromium, Cobalt	6E+00	Arsenic	**129**
Off-Site Soil	Off-site Soil	SB				X		X				Res	30	6E-05	Arsenic	4E+00	Arsenic, Iron	2.2

Notes:

(1) The cancer risk and noncancer hazards are for the most conservative likely future land use (e.g., residential is more protective than commercial/industrial). For the Recreational/Tresspasser scenario, the values for a child are presented. The adult/child residential values are presented for the residential scenario.

(2) Mining workers are covered by medical monitoring and are not subject to land-use restrictions. Otherwise, recreational/tresspasser reuse applies to this exposure area.

BOLD = Bold values have exposure point concentrations greater than the lead Preliminary Remediation Goal 99th Percentile. For these areas, lead is considered a Preliminary Chemical of Concern.

C/I = Commercial/Industrial Worker

CW = Construction Worker

Res = Adult/Child Resident - The Adult/Child Resident exposure scenario represents the unrestricted reuse scenario.

R/T = Recreational or Trespasser

cy = Cubic yards

AMD = Acid mine drainage

EPC = Exposure point concentration

-- = Not applicable

🔴 = Carcinogenic risks > 1 x 10-4 or Noncarcinogenic Hazard Index > 10

🟠 = Carcinogenic risks > 1 x 10-6 but < 1 x 10-4 or Noncarcinogenic Hazard Index > 1 but < 10

🟢 = Carcinogenic risks < 1 x 10-6 or Noncarcinogenic Hazard Index < 1

µg/L = Micrograms per liter

mg/kg = Milligrams per kilogram

SD = Aquatic sediment from 0 to 0.5-feet bgs

SS = Surface soil/sediment from 0 to 2-feet bgs

SB = Subsurface soil from 2 to 10-feet bgs

SW = Surface water

DP = Deep soil > 10-feet bgs

Table 1-2. Surface Water Residential Based Quantitative Screening Evaluation

Exposure Area	Cumulative Cancer Risk (4)	Cumulative Hazard Index (4)	Analytes Greater Than MCL / Preliminary Chemicals of Concern
Agua Fria River	3E-04	4.E+00	ALUMINUM ARSENIC IRON MANGANESE
Background Agua Fria River	4E-04	2.E+00	ALUMINUM ARSENIC IRON MANGANESE
Galena Gulch	1E-02	1.E+02	ALUMINUM ANTIMONY ARSENIC BERYLLIUM CADMIUM IRON LEAD MANGANESE MERCURY ZINC
Impoundment-Pond - Iron King Mine Main Tailings Pile	4E+00	2.E+04	ALUMINUM ANTIMONY ARSENIC BERYLLIUM CADMIUM CHROMIUM COPPER FLUORIDE IRON LEAD MANGANESE MERCURY SELENIUM SULFATE TOTAL DISSOLVED SOLIDS ZINC
Impoundment-Pond - Iron King Mine Mine Plant	1E-03	1.E+01	ALUMINUM ARSENIC CADMIUM IRON LEAD MANGANESE NITRITE AS N SULFATE
Iron King Mine Small Tailings Pile	2E-04	1.E+00	ALUMINUM
Lower Chaparral Gulch	7E-03	2.E+02	ALUMINUM ARSENIC BERYLLIUM CADMIUM COPPER IRON LEAD MANGANESE SULFATE TOTAL DISSOLVED SOLIDS ZINC

Table 1-2. Surface Water Residential Based Quantitative Screening Evaluation

Exposure Area	Cumulative Cancer Risk (4)	Cumulative Hazard Index (4)	Analytes Greater Than MCL / Preliminary Chemicals of Concern
Lower Chaparral Gulch Dam-Confluence	2E-03	4.E+01	ALUMINUM ARSENIC CADMIUM IRON LEAD MANGANESE SULFATE ZINC
Middle Chaparral Gulch	2E-02	2.E+02	ALUMINUM ANTIMONY ARSENIC BARIUM BERYLLIUM CADMIUM IRON LEAD MANGANESE MERCURY ZINC
Upper Chaparral Gulch	5E-02	4.E+02	ALUMINUM ARSENIC BARIUM BERYLLIUM CADMIUM CHROMIUM IRON LEAD MANGANESE MERCURY THALLIUM ZINC

Notes:
MCL = Maximum Contaminant Level
RSL = Regional Screening Level
(1) Detected ground water chemicals were evaluated.
(2) Some essential nutrients and general chemistry parameters did not have screening levels.
(3) Lead toxicity is evaluated in conjuction with soil and air data separately.
(4) Screening values used in the evaluation are EPA Tap Water Regional Screening Levels (EPA 2009)
= Carcinogenic risks > 1 x 10-4 or Noncarcinogenic Hazard Index > 10
= Carcinogenic risks > 1 x 10-6 but < 1 x 10-4 or Noncarcinogenic Hazard Index > 1 but < 10
= Carcinogenic risks < 1 x 10-6 or Noncarcinogenic Hazard Index < 1

Table 1-3. Key Site Characteristics for In-Town Parcels

Sample Group	Arsenic Concentration (mg/kg)	Cancer Risk Summary		Noncancer Hazard Summary		Lead EPC (mg/kg)
		Resident Adult/Child	Cancer Risk Drivers / Preliminary Chemical of Concern	Resident Child	Noncancer Hazard Drivers / Preliminary Chemicals of Concern	
Off-site Soil Area 02	131	3E-04	Arsenic	5.E+00	Arsenic	84
Off-site Soil Area 03	100	2E-04	Arsenic	4.E+00	Arsenic	47
Off-site Soil Area 04	136	3E-04	Arsenic	5.E+00	Arsenic	94
Off-site Soil Area 06	42.1	9E-05	Arsenic	2.E+00	Arsenic	56
Off-site Soil Area 07	298	6E-04	Arsenic	1.E+01	Arsenic	71
Off-site Soil Area 08	131	3E-04	Arsenic	5.E+00	Arsenic	280
Off-site Soil Area 09	47.7	1E-04	Arsenic	2.E+00	Arsenic	50
Off-site Soil Area 10	48.2	1E-04	Arsenic	2.E+00	Arsenic	66
Off-site Soil Area 11	45.9	1E-04	Arsenic	2.E+00	Arsenic	883
Off-site Soil Area 12	52.9	1E-04	Arsenic	2.E+00	Arsenic	140
Off-site Soil Area 13	39.7	8E-05	Arsenic	2.E+00	Arsenic	84
Off-site Soil Area 14	38.2	8E-05	Arsenic	1.E+00	Arsenic	69
Off-site Soil Area 15	49.5	1E-04	Arsenic	2.E+00	Arsenic	140
Off-site Soil Area 16	56.1	1E-04	Arsenic	2.E+00	Arsenic	212
Off-site Soil Area 17	57.2	1E-04	Arsenic	2.E+00	Arsenic	70
Off-site Soil Area 19	36.4	8E-05	Arsenic	1.E+00	Arsenic	60
Off-site Soil Area 20	63.4	1E-04	Arsenic	2.E+00	Arsenic	47
Off-site Soil Area 101	192	4E-04	Arsenic, Chromium, Cobalt	1.E+01	Arsenic, Cobalt	130
Off-site Soil Area 102	37.9	8E-05	Arsenic, Chromium, Cobalt	5.E+00	Arsenic	88
Off-site Soil Area 103	66.3	1E-04	Arsenic, Chromium	5.E+00	Arsenic	289
Off-site Soil Area 104	33.5	7E-05	Arsenic, Chromium, Cobalt	6.E+00	Arsenic, Manganese	54
Off-site Soil Area 105	39.9	9E-05	Arsenic, Chromium, Cobalt	1.E+01	Aluminum, Antimony, Arsenic, Chromium, Copper	389
Off-site Soil Area 106	49	1E-04	Arsenic, Chromium, Cobalt	6.E+00	Arsenic, Cobalt	48
Off-site Soil Area 107	84.2	2E-04	Arsenic, Chromium, Cobalt	8.E+00	Arsenic	282
Off-site Soil Area 108	120	3E-04	Arsenic, Chromium, Cobalt	9.E+00	Arsenic, Manganese	628
Off-site Soil Area 109	70	2E-04	Arsenic, Chromium, Cobalt	7.E+00	Arsenic	298
Off-site Soil Area 110	26.7	6E-05	Arsenic, Chromium	3.E+00	Arsenic	76
Off-site Soil Area 111	165	4E-04	Arsenic, Chromium, Cobalt	1.E+01	Arsenic	924
Off-site Soil Area 112	28.3	6E-05	Arsenic, Chromium, Cobalt	4.E+00	Arsenic	18
Off-site Soil Area 113	29.9	6E-05	Arsenic, Chromium	4.E+00	Arsenic	23
Off-site Soil Area 114	104	2E-04	Arsenic, Chromium	7.E+00	Arsenic	72
Off-site Soil Area 115	34.5	8E-05	Arsenic, Chromium, Cobalt	6.E+00	Arsenic, Cobalt	67
Off-site Soil Area 116	246	5E-04	Arsenic, Chromium, Cobalt	1.E+01	Antimony, Arsenic, Manganese	111
Off-site Soil Area 117	123	3E-04	Arsenic, Chromium, Cobalt	8.E+00	Arsenic	95
Off-site Soil Area 118	198	4E-04	Arsenic, Chromium, Cobalt	1.E+01	Arsenic	1,610
Off-site Soil Area 119	65.6	1E-04	Arsenic, Chromium	6.E+00	Arsenic	312
Off-site Soil Area 120	20.5	4E-05	Arsenic, Chromium, Cobalt	9.E+00	Arsenic	18,100
Off-site Soil Area 121	57.2	1E-04	Arsenic, Chromium, Cobalt	6.E+00	Arsenic	95
Off-site Soil Area 122	25.1	5E-05	Arsenic, Chromium	3.E+00	--	123
Off-site Soil Area 123	26.5	6E-05	Arsenic, Chromium	3.E+00	Arsenic	41

Table 1-3. Key Site Characteristics for In-Town Parcels

Sample Group	Arsenic Concentration (mg/kg)	Cancer Risk Summary		Noncancer Hazard Summary		Lead EPC (mg/kg)
		Resident Adult/Child	Cancer Risk Drivers / Preliminary Chemical of Concern	Resident Child	Noncancer Hazard Drivers / Preliminary Chemicals of Concern	
Off-site Soil Area 124	26.7	**6E-05**	**Arsenic, Chromium**	**3.E+00**	**Arsenic**	47
Off-site Soil Area 125	22.5	**5E-05**	**Arsenic, Chromium**	**3.E+00**	**--**	68
Off-site Soil Area 126	64.1	**1E-04**	**Arsenic, Chromium, Cobalt**	**8.E+00**	**Arsenic, Cobalt, Iron, Manganese**	47
Off-site Soil Area 127	313	**7E-04**	**Arsenic, Chromium**	**1.E+01**	**Arsenic**	**328**
Off-site Soil Area 128	633	**1E-03**	**Arsenic, Chromium**	**3.E+01**	**Arsenic**	**398**
Off-site Soil Area 129	26.7	**6E-05**	**Arsenic, Chromium**	**4.E+00**	**Arsenic, Manganese**	57
Off-site Soil Area 130	18.7	**4E-05**	**Arsenic, Chromium**	**5.E+00**	**Manganese**	48
Off-site Soil Area 131	24.5	**5E-05**	**Arsenic, Chromium**	**5.E+00**	**Manganese**	50
Off-site Soil Area 132	131	**3E-04**	**Arsenic, Chromium**	**9.E+00**	**Arsenic**	**1,792**
Off-site Soil Area 133	368	**8E-04**	**Arsenic, Chromium, Cobalt**	**2.E+01**	**Arsenic**	**1,655**
Off-site Soil Area 134	29.7	**6E-05**	**Arsenic, Chromium**	**3.E+00**	**Arsenic**	47
Off-site Soil Area 135	43.0	**9E-05**	**Arsenic, Chromium**	**5.E+00**	**Arsenic, Manganese**	**132**
Off-site Soil Area 136	31.3	**7E-05**	**Arsenic, Chromium, Cobalt**	**5.E+00**	**Arsenic, Manganese**	58
Off-site Soil Area 137	17.4	**4E-05**	**Arsenic, Chromium**	**3.E+00**	**--**	65
Off-site Soil Area 138	52.8	**1E-04**	**Arsenic, Chromium**	**4.E+00**	**Arsenic**	**232**
Off-site Soil Area 139	17.7	**4E-05**	**Arsenic, Chromium, Cobalt**	**4.E+00**	**Manganese**	31
Off-site Soil Area 140	27.0	**6E-05**	**Arsenic, Chromium**	**4.E+00**	**Arsenic, Manganese**	**119**
Off-site Soil Area 141	64.8	**1E-04**	**Arsenic, Chromium**	**5.E+00**	**Arsenic**	**435**
Off-site Soil Area 142	331	**7E-04**	**Arsenic, Chromium**	**2.E+01**	**Arsenic**	**507**
Off-site Soil Area 143	76.6	**2E-04**	**Arsenic, Chromium**	**5.E+00**	**Arsenic**	**372**
Off-site Soil Area 144	27.1	**6E-05**	**Arsenic, Chromium**	**4.E+00**	**Arsenic, Manganese**	82
Off-site Soil Area 145	50.4	**1E-04**	**Arsenic, Chromium**	**6.E+00**	**Arsenic, Manganese**	**88**
Off-site Soil Area 146	39.1	**8E-05**	**Arsenic, Chromium, Cobalt**	**5.E+00**	**Arsenic, Manganese**	68
Off-site Soil Area 147	155	**3E-04**	**Arsenic, Chromium**	**8.E+00**	**Arsenic**	**126**
Off-site Soil Area 148	133	**3E-04**	**Arsenic, Chromium, Cobalt**	**1.E+01**	**Arsenic, Manganese**	**693**

Notes:

-- Not Applicable

EPC = Exposure point concentration

mg/kg = Milligrams per kilogram

BOLD = Bold values have exposure point concentrations greater than the lead Preliminary Remediation Goal 99th Percentile. For these areas, lead is considered a Preliminary Chemical of Concern.

= Carcinogenic risks > 1 x 10^{-4} or Noncarcinogenic Hazard Index > 10

= Carcinogenic risks > 1 x 10-6 but < 1 x 10-4 or Noncarcinogenic Hazard Index > 1 but < 10

= Carcinogenic risks < 1 x 10-6 or Noncarcinogenic Hazard Index < 1

Table 1-4. Ground Water Residential Based Quantitative Screening Evaluation

Exposure Area	Cumulative Cancer Risk (4)	Cumulative Hazard Index (4)	Analytes Greater Than MCL / Preliminary Chemicals of Concern
Cistern	3E-04	1E+01	ARSENIC IRON MANGANESE SULFATE TOTAL DISSOLVED SOLIDS ZINC
GW-511246	1E-04	6E-01	--
GW-551459	5E-04	2E+00	ARSENIC IRON
GW-573389	2E-04	8E-01	--
GW-586144	2E-04	1E+00	ARSENIC
GW-592720	3E-04	2E+00	ARSENIC IRON LEAD TOTAL DISSOLVED SOLIDS
GW-999901	3E-04	1E+00	ARSENIC
GW-999902	1E-04	1E-04	--
GW-999903	6E-05	7E-01	--
GW-999904	6E-05	4E-01	--
GW-999905	3E-04	1E+00	ARSENIC
GW-999906	7E-05	3E-01	--
GW-999907	6E-04	2E+00	ARSENIC
GW-999908	4E-04	2E+00	ARSENIC
GW-999909	9E-05	4E-01	--
GW-999910	4E-04	2E+00	ARSENIC
GW-999911	6E-05	4E-01	--
GW-999912	2E-04	1E+00	--
GW-999913	7E-05	5E-01	--
GW-999914	8E-05	7E-01	NITRATE AS N
GW-999915	4E-04	2E+00	ARSENIC
GW-999916	5E-04	2E+00	ARSENIC
GW-999917	2E-04	1E+00	--
GW-999918	1E-04	5E-01	--
GW-999919	1E-04	5E-01	--
GW-999920	3E-05	3E-01	IRON
GW-999921	5E-05	3E-01	--
GW-999922	5E-04	2E+00	ARSENIC
GW-999923	2E-04	1E+00	--
GW-999924	5E-05	2E-01	--
GW-999925	1E-04	6E-01	--
GW-999926	5E-05	3E-01	--

Table 1-4. Ground Water Residential Based Quantitative Screening Evaluation

Exposure Area	Cumulative Cancer Risk (4)	Cumulative Hazard Index (4)	Analytes Greater Than MCL / Preliminary Chemicals of Concern
GW-999927	9E-04	4E+00	ARSENIC IRON
GW-999928	2E-04	9E-01	ALUMINUM
GW-999929	5E-05	2E-01	--
GW-999930	5E-04	2E+00	ARSENIC
GW-999931	6E-05	3E-01	--
GW-999932	2E-04	9E-01	--
GW-999933	9E-05	9E-01	--
GW-999934	4E-04	2E+00	ARSENIC
GW-999935	4E-04	2E+00	ARSENIC
GW-999936	5E-04	3E+00	ARSENIC
GW-999937	4E-04	2E+00	ALUMINUM ARSENIC IRON
GW-999938	1E-04	6E-01	--
GW-999939	5E-04	2E+00	ARSENIC
GW-999940	1E-04	3E+00	--
GW-999941	3E-04	1E+00	ARSENIC
GW-999943	5E-04	2E+00	ARSENIC
GW-999944	4E-04	2E+00	ARSENIC
GW-999945	1E-04	1E+00	IRON SULFATE TOTAL DISSOLVED SOLIDS
GW-999946	5E-05	4E-01	ALUMINUM
GW-999947	1E-04	3E+00	CHLORIDE IRON MANGANESE NITRATE AS N TOTAL DISSOLVED SOLIDS
GW-999948	6E-03	3E+01	ALUMINUM ARSENIC IRON MANGANESE
GW-999949	4E-04	2E+00	ARSENIC TOTAL DISSOLVED SOLIDS
GW-999950	1E-04	6E-01	--
GW-999951 (5)	8E-05	6E-01	--
GW-999952 (5)	4E-04	2E+00	ARSENIC
GW-999953	1E-04	2E+00	ALUMINUM CHLORIDE LEAD NITRATE AS N TOTAL DISSOLVED SOLIDS

Table 1-4. Ground Water Residential Based Quantitative Screening Evaluation

Exposure Area	Cumulative Cancer Risk (4)	Cumulative Hazard Index (4)	Analytes Greater Than MCL / Preliminary Chemicals of Concern
GW-999954	🔴 2E-02	🔴 1E+02	ALUMINUM ARSENIC IRON LEAD MANGANESE SULFATE TOTAL DISSOLVED SOLIDS ZINC
GW-9999949	🔴 4E-04	🟡 2E+00	ARSENIC
GW-SW-08	🔴 2E-04	🟡 5E+00	ALUMINUM SULFATE TOTAL DISSOLVED SOLIDS
MW-01-S	🔴 4E-04	🔴 1E+01	ARSENIC CHLORIDE MANGANESE NITRATE AS N SELENIUM SULFATE TOTAL DISSOLVED SOLIDS
MW-02-S	🟡 1E-04	🟢 1E+00	TOTAL DISSOLVED SOLIDS
MW-03-S	🟡 1E-04	🟢 1E+00	ALUMINUM SULFATE TOTAL DISSOLVED SOLIDS
MW-04-S	🔴 2E-04	🟡 2E+00	ALUMINUM MANGANESE SULFATE TOTAL DISSOLVED SOLIDS
MW-05-S	🔴 2E-04	🟢 1E+00	ALUMINUM MANGANESE SULFATE TOTAL DISSOLVED SOLIDS
MW-06-D	🔴 6E-04	🟡 3E+00	ALUMINUM ARSENIC IRON MANGANESE

Notes:
MCL = Maximum Contaminant Level
RSL = Regional Screening Level
(1) Detected ground water chemicals were evaluated.
(2) Some essential nutrients and general chemistry parameters did not have screening levels.
(3) Lead toxicity is evaluated in conjuction with soil and air data separately.
(4) Screening values used in the evaluation are EPA Tap Water Regional Screening Levels (EPA 2009)
(5) Humboldt Water Company supply wells.
-- Analytes less than MCL
🔴 = Carcinogenic risks > 1 x 10-4 or Noncarcinogenic Hazard Index > 10
🟡 = Carcinogenic risks > 1 x 10-6 but < 1 x 10-4 or Noncarcinogenic Hazard Index > 1 but < 10
🟢 = Carcinogenic risks < 1 x 10-6 or Noncarcinogenic Hazard Index < 1

Table 1-5. Ecological Risk Assessment Summary

	Exposure Grouping				
	West	**East**	**Agua Fria**	**In-Town West**	**In-Town East**
Terrestrial Plants	· Aluminum, antimony, arsenic, chromium, cobalt, copper, lead, manganese, mercury, selenium, thallium, vanadium and zinc	· Aluminum, antimony, arsenic, chromium, cobalt, copper, lead, manganese, mercury, nickel, selenium, thallium, vanadium and zinc	· Receptor not evaluated for this exposure grouping	· Aluminum, arsenic, chromium, cobalt, manganese, selenium, vanadium and zinc	· Aluminum, arsenic, chromium, cobalt, copper, lead, manganese, mercury, selenium, vanadium and zinc
Terrestrial Invertebrates	· Arsenic, chromium, copper, manganese, mercury and zinc	· Arsenic, chromium, copper, manganese, mercury, selenium and zinc	· Receptor not evaluated for this exposure grouping	· Chromium, manganese, mercury and zinc	· Chromium, copper, manganese, mercury and zinc
Aquatic and Benthic Organisms	· Metals and combinations of metals in sediment and surface water	· Metals and combinations of metals in sediment and surface water	· Metals and combinations of metals in sediment and surface water	· Receptor not evaluated for this exposure grouping	· Receptor not evaluated for this exposure grouping
	· Arsenic, copper, lead and zinc used as indicators of mining related impacts	· Arsenic, copper, lead and zinc used as indicators of mining related impacts	· Arsenic, copper, lead and zinc used as indicators of mining related impacts		
Herbivorous Mammals	· Aluminum, arsenic and selenium	· Aluminum, arsenic, copper and selenium	· Receptor not evaluated for this exposure grouping	· Aluminum	· Aluminum
Insectivorous Mammals	· Aluminum, antimony, arsenic, cadmium, lead, selenium, thallium and zinc	· Aluminum, antimony, arsenic, copper, selenium, thallium, Aroclor 1248 and total PCBs	· Receptor not evaluated for this exposure grouping	· Arsenic and aluminum	· Aluminum, arsenic, selenium and thallium
Predatory Mammals	· Aluminum and arsenic	· Aluminum	· Receptor not evaluated for this exposure grouping	· Aluminum	· Aluminum
Herbivorous Birds	· Arsenic, lead, selenium and zinc	· Copper and selenium	· Receptor not evaluated for this exposure grouping	· No chemicals	· No chemicals
Insectivorous Birds	· Arsenic, lead, zinc and butybenzylphthalate	· Lead	· Receptor not evaluated for this exposure grouping	· No chemicals	· No chemicals
Predatory Birds	· No chemicals	· No chemicals	· Receptor not evaluated for this exposure grouping	· No chemicals	· No chemicals
Piscivorous Birds	· Arsenic, copper, lead, selenium and zinc	· No chemicals	· No chemicals	· Receptor not evaluated for this exposure grouping	· Receptor not evaluated for this exposure grouping
Reptiles and amphibians	· Metals and butybenzylphthalate	· Metals	· Metals	· Arsenic and aluminum in terrestrial media	· Metals in terrestrial media
Overall Conclusion	· Metals pose risks throughout Site	· Metals pose risks throughout Site	· Metals pose risks in sediment and surface water; may be limited to hotspots at outfalls and downstream of the Agua Fria/Chaparral Gulch confluence	· Metals pose risks throughout Site; other factors might apply	· Metals pose risks throughout Site; other factors might apply
	· Potential impacts from metal hotspots in soil, holding ponds and outfalls	· Potential impacts from metal hotspots in soil		· Potential impacts from metal hotspots in soil	· Potential impacts from metal hotspots in soil
		· PCBs in soil and surface water pose a risk to insectivorous mammals			
Recommendations	· Further efforts should focus on development of cleanup levels and on an evaluation of habitat quality as an approach for risk management	· Further efforts should focus on development of cleanup levels and on an evaluation of habitat quality as an approach for risk management	· Further efforts should focus on development of cleanup levels and on an evaluation of habitat quality as an approach for risk management. Risk management decisions should weigh the potential for ecological risk with the intrusiveness of remedial alternatives that may lead to a reduction of the habitat quality	· Further efforts should focus on development of cleanup levels and on an evaluation of habitat quality as an approach for risk management	· Further efforts should focus on development of cleanup levels and on an evaluation of habitat quality as an approach for risk management .

Notes:
Analytes that are idenfied in this table are considered Preliminary Chemicals of Concern.

Table 2-1. Background Threshold Values

Analyte	Number of Samples	Number of Detects	Dataset Distribution	Maximum Detected Concentration (Qualifier)		Units	95% UPL for Single Observation	95% UPL for Mean of 10 Observations
Aluminum	39	39	Normal	24,900		mg/kg	26,765	18,920
Antimony	39	9	Nonparametric	1.0	J	mg/kg	1.1	0.91
Arsenic	39	39	Normal	66		mg/kg	68	44
Barium	39	39	Lognormal	373		mg/kg	461	239
Beryllium	39	32	Nonparametric	0.86		mg/kg	0.93	0.53
Cadmium	39	30	Nonparametric	2.6		mg/kg	2.8	1.8
Calcium	39	39	Assumed Lognormal	68,900		mg/kg	84,898	11,381
Chromium	39	39	Assumed Normal	58		mg/kg	63	35
Cobalt	39	39	Normal	20		mg/kg	23	16
Copper	39	39	Lognormal	109	J-	mg/kg	169	69
Cyanide (Total)	39	1	Nonparametric	0.27	J	mg/kg	Insufficient Detects	
Iron	39	39	Normal	37,300		mg/kg	41,044	32,032
Lead	39	39	Lognormal	58		mg/kg	80	27
Magnesium	39	39	Lognormal	13,500		mg/kg	17,467	8,665
Manganese	39	39	Lognormal	2,470		mg/kg	2,585	1,008
Mercury	39	19	Nonparametric	0.17		mg/kg	0.17	0.10
Nickel	39	39	Assumed Normal	53		mg/kg	69	37
Potassium	39	39	Normal	4,000		mg/kg	4,467	2,885
Selenium	39	23	Nonparametric	1.2	J	mg/kg	1.2	0.81
Silver	39	14	Nonparametric	1.3		mg/kg	0.57	0.57
Sodium	39	37	Nonparametric	98	J	mg/kg	102	59
Sulfate	30	19	Nonparametric	86		mg/kg	64	24
Thallium	39	25	Nonparametric	6.1	J	mg/kg	5.6	2.9
Vanadium	39	39	Normal	83		mg/kg	95	68
Zinc	39	39	Assumed Lognormal	232		mg/kg	208	110

Notes:

All values are presented in milligrams per kilogram (mg/kg)

UPL = Upper prediction limit

UCL = Upper confidence limit of the mean

Shaded 95% UPLs are greater than the maximum dectected concentraiton, so the maximum detected concentration will be used in the comparison.

TABLE 2-2. Tentative Determinations of Applicable or Relevant and Appropriate Requirements

ARAR	Citation (If Available)	Description
Chemical Specific ARARs		
Water		
Federal Safe Drinking Water Act, Primary and Secondary Drinking Water Standards (MCL, MCLg, Secondary MCL)	40 CFR 141,143	Establishes health-based standards for public water systems. It is applicable where contaminated groundwater is or may be directly used for drinking water. In this case, it would apply to the groundwater at the point of use for drinking.
Clean Water Act	40 CFR 131	Water Quality Criteria. These criteria set in-stream contaminant concentration levels for the protection of human health and wildlife.
Arizona Administrative Code Water Quality Standards	ARS § 49-222	Provides standards for navigable waters. These standards assure water quality for protection of public health and takes into consideration its use and value for public water supplies, the propagation of fish and wildlife, recreational, agricultural, industrial and other purposes including navigation.
Arizona Administrative Code Water Quality Standards	A.R.S. §§ 49-223-224	Aquifer water quality standards.
Arizona Administrative Code Water Quality Standards	A.A.C. §§ R18-11-104 (and Appendices A and B) and R18-11-108	Discharges to surface water.
Soil		
Arizona Administrative Code Soil Remediation Standards	ARS §§ 49-151 (Appropriate Definitions) and 49-152 (Subsections A and B) AAC R18-7-201 (Appropriate Definitions) AAC R18-7-202 through 206 (Including Appendix A)	Establishes the remediation standards for soil in Arizona
Waste		
Identification and Listing of Hazardous Waste	40 CFR 261.1 to 40 CFR 261.38	Defines a hazardous waste as exhibiting the characteristics of hazardous wastes, is a mixture of a solid waste and hazardous waste, or is a listed hazardous waste.
Land Disposal Restrictions	40 CFR 268	Restricts the land disposal of most hazardous wastes, and specified specific treatment standards that must be met before these wastes can be land disposed. May apply, based on results of waste characterization testing.
Air		
National Primary and Secondary Ambient Air Quality Standards (NAAQS)	40 CFR 50.4, 50.6, 50.8, 50.9, 50.11, 50.12	NAAQS define levels of air quality to protect the public health or the public welfare from any known or anticipated adverse effects of a federally regulated pollutant. NAAQS are promulgated for sulfur dioxide, particulate matter (PM 10 and PM 2.5), nitrogen dioxide, carbon monoxide, ozone, and lead. Sulfur dioxide, nitrogen dioxide, and carbon monoxide apply only to incineration and not to other process options.
Air Quality	A.A.C. R18-2- 604-608 and R18-2-614	Emissions from Existing and New Nonpoint Sources: Open Areas, Dry Washes, or Riverbeds; Roadways and Streets; Material Handling; Storage Piles; Mineral Tailings, and opacity standard for nonpoint source emissions.
Location Specific		
Floodplain and Wetlands Protection		
Statement of Procedures on Floodplain Management and Wetlands Protection	Executive Order 11990; 40 CFR 6.302 and Appendix A	Activities should avoid, to the extent possible, the adverse impacts associated with the destruction or loss of wetlands and to avoid new construction in practicable alternative exists. Applicable if wetlands are identified at the Site.
Section 404(b)(1) Guidelines for the Specification of Disposal Sites for Dredged or Fill Material	40 CFR 230	Requires discharges to address impact of discharge of dredge or fill material on the aquatic ecosystem. May be an ARAR if the remedial alternatives selected involve discharge to surface water.
Floodplain Management	Executive Order 11988; 40 CFR 6.302 and Appendix A	Requires federal agencies to evaluate the potential affects of actions they may take in a floodplain to avoid adverse impacts in a floodplain. This is an ARAR because portions of the site are within the 100-year floodplain.

TABLE 2-2. Tentative Determinations of Applicable or Relevant and Appropriate Requirements

ARAR	Citation (If Available)	Description
Location Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities	40 CFR 264.18	A facility located in a 100-year floodplain must be designed, constructed, operated, and maintained to prevent washout of any hazardous waste by a 100-year flood. The Site is located within the 100 year floodplain of Days Creek. Would be applicable to an on site containment cell.
Protected Species		
Endangered and Threatened Wildlife and Plants	50 CFR 17	Identifies those species of wildlife and plants determined to be endangered or threatened with extinction and also carry over the species and subspecies of wildlife designated as endangered under the Endangered Species Conservation Act of 1969. Statute requires that proposed actions minimize effects on endangered species.
Waste		
RCRA hazardous waste; treatment, storage or disposal.	40 CFR 264.18(a)	These regulations prohibit new treatment, storage, or disposal of hazardous waste within 200 feet of a fault displaced in Holocene time, and require that a facility must be designed and maintained to avoid washout if located within a 100-year floodplain.
Historic Properties		
Historic Preservation Act	40 CFR Part 800	Requires Federal agencies to take into account the effects of their undertakings on historic properties. There are no items located on the site which are eligible for inclusion on the National Register of Historic Places.
Arizonan Antiquities Act	A.R.S. §§ 41-841, 843, 844, and 845 and substantive sections of A.R.S. § 41-865	Human remains and funerary objects
Action Specific		
Waste		
Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities	40 CFR 264	Describes general facility requirements, preparedness and contingency requirements for remediation waste management sites that can be used in lieu of 40 CFR261 Subparts B, C, and D and 40 CFR 265.101. Provides requirements for monitoring and responding to releases from Solid Waste Management Units, and groundwater monitoring requirements for releases from Solid Waste Management Units. Includes requirements for surface impoundment, land treatment and waste pile design and operation.
Land Disposal Restrictions	40 CFR 268	Restricts the land disposal of most hazardous wastes, and specified specific treatment standards that must be met before these wastes can be land disposed.
Landfill Facilities	A.R.S. § 49-764	Monitoring and pollution control devices may be required at a solid waste facility if the facility may adversely affect public health or the environment.
Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities: Subpart N: Landfills	40 CFR 264.300 through 40 CFR 264.310	States requirements for liner system and exemptions for liner requirements; States requirements for surveying location, and monitoring and inspection of hazardous waste landfills. Only applies to alternatives that trigger land disposal restrictions (LDRs) (or placement).
Criteria for Identifying the Characteristics of Hazardous Waste and for Listing Hazardous Waste	40 CFR 261	Provides the criteria for identifying a characteristic or listed waste. Solid waste is a hazardous waste if it exhibits any of the characteristics of ignitability, corrosivity, reactivity, and toxicity or if it is a listed waste. Applicable to off site waste disposal.
Arizona Hazardous Waste Statutes	A.A.C. §§ R18-8	Establishes rules for hazardous waste management in Arizona
Site Restoration		
Arizona Administrative Code Mined Land Reclamation	A.A.C. §§ R11-2	Establishes rules for mined land reclamation in Arizona
Groundwater Wells/Water Discharge		
Underground Injection Control Program	40 CFR 144	Provides minimum requirements for Class 5 injection wells. Applicable to alternative where reagents will be injected below the water table.
National Pollutant Discharge Elimination System	40 CFR 122	Provides conditions that must be incorporated into NPDES permits. Applicable to discharge of water from the Site.
Arizona Aquifer Protection Permits	A.R.S. § 49-243B (Substantive Sections)	Exemptions for CERCLA remedial actions from Aquifer Protection Permits.

TABLE 2-2. Tentative Determinations of Applicable or Relevant and Appropriate Requirements

ARAR	Citation (If Available)	Description

Notes:
AAC - Arizona Administrative Code
ARAR - Applicable or relevant and appropriate requirements
ARS - Arizona Revised Statute
CERCLA - Comprehensive Environmental Response, Compensation and Liabilities Act
CFR - Code of Federal Regulations
DOT - Department of Transportation
LDR - Land Disposal Restrictions
MCL - Maximum Contaminant Level
MCLg - Maximum Contaminant Level goal
NCP - National Contingency Plan
NPDES - National Pollutant Discharge Elimination System
OSHA - Occupational Safety and Health Administration
RCRA - Resource Conservation and Recovery Act
TBC - To be considered
TCLP- Toxicity characteristic leaching procedure
USC - United States Code

Table 2-3. Human Health Preliminary Clean-Up Levels

Chemical	Child Recreational/ Trespasser (250 Days)		Adult Recreational/ Trespasser (250 Days)		Adult Recreational/ Trespasser (50 Days)		Child Recreational/ Trespasser (50 Days)		Commercial/ Industrial Worker		Construction Worker		Resident Adult/Child	
	Cancer Clean-up Level	Noncancer Clean-up Level	Cancer Clean-up Level	Noncancer Clean-up Level	Cancer Clean-up Level	Noncancer Clean-up Level	Cancer Clean-up Level	Noncancer Clean-up Level	Cancer Clean-up Level	Noncancer Clean-up Level	Cancer Clean-up Level	Noncancer Clean-up Level	Cancer Clean-up Level	Noncancer Clean-up Level
Aluminum	--	109,396	--	1,017,503	--	5,087,517	--	546,982	--	987,136	--	306,418	--	77,335
Antimony	--	44	--	409	--	2,044	--	219	--	409	--	124	--	31
Arsenic (3)	12	48	28	426	138	2,129	62	238	24	383	209	134	6.1	34
Cadmium	1,498,933	49	749,467	440	3,747,333	2,201	7,494,667	244	90,026	401	2,250,651	138	17,844	35
Chromium (1)	4.7	328	32	3,064	158	15,320	24	1,642	56	3,050	430	928	2.9	234
Chromium VI (1)	4.7	328	32	3,064	158	15,320	24	1,642	56	3,050	430	928	2.9	234
Cobalt	299,787	33	149,893	306	749,467	1,531	1,498,933	164	18,005	304	450,130	93	3,569	23
Copper	--	4,380	--	40,880	--	204,400	--	21,900	--	40,880	--	12,388	--	3,129
Iron	--	76,650	--	715,400	--	3,577,000	--	383,250	--	715,400	--	216,788	--	54,750
Manganese	--	2,622	--	24,271	--	121,353	--	13,110	--	22,611	--	7,247	--	1,827
Thallium (2)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aroclor-1248	3.6	--	24	--	119	--	18	--	7.4	--	76	--	2.2	--
Benzo(a)pyrene	0.24	--	1.6	--	8.0	--	1.2	--	2.1	--	21	--	0.15	--
Dibenz(a,h)anthracene	0.24	--	1.6	--	8.0	--	1.2	--	2.1	--	21	--	0.15	--

Notes:

All values are presented in milligrams per kilogram (mg/kg)

Human Health Preliminary Clean-Up Levels were developed for preliminary chemicals of concern.

Human Health Preliminary Clean-Up Levels were based on a cancer risk of 1E-05 or a noncancer hazard of 1. When both cancer and noncancer values are available, the lowest value is selected.

Human Health Preliminary Clean-Up Levels were calculated using the methodologies presented in the human health risk assessment. Exposure parameters, toxicity values, and chemical-specific parameters remain the same except as noted below.

The Human Health Risk Assessment included a Recreational/ Trespasser exposure scenario with an exposure duration of 250 days/year. A Recreational/ Trespasser exposure scenario was added with an exposure duration of 50 days/year to evaluate areas of the Site with limited human access (i.e., Galena Gulch, Upper Chaparral Gulch, Agua Fria River, and Lower Chaparral Gulch Dam - Confluence).

Lead toxicity is evaluated via a blood-lead level evaluation.

(1) Cancer toxicity values were updated. A new oral cancer slope factor of 0.5 (mg/kg-day)-1 was adopted by EPA. The inhalation unit risk cancer toxicity value changed from 0.12 (ug/m3)-1 to 0.084 (ug/m3)-1.

(2) The oral noncancer reference dose of 0.000065 mg/kg-day was rescinded by EPA so Preliminary Clean-Up Levels were not determined. Thallium was a preliminary chemical of concern in an exposure area with several other chemicals so the absence of a Preliminary Clean-Up Level will not affect the protectiveness of the evaluation.

(3) The bioavailability factor for arsenic was 0.8 in the human health risk assessment. This value was updated to 0.6 based on an *in-vivo* swine study using arsenic impacted soil from the Site.

Table 2-4. Ecological Preliminary Cleanup Levels for Soil for the On-Site East and West Exposure Groupings

Chemical	Soil Preliminary Cleanup Level - Based on Lowest Threshold for Wildlife (mg/kg)
ALUMINUM	1.76E+02
ANTIMONY	2.60E+00
ARSENIC	5.00E+00
CADMIUM	4.39E+00
COPPER	1.52E+02
LEAD	1.82E+02
SELENIUM	5.80E-01
THALLIUM	1.49E-01
ZINC	7.75E+02
TOTAL PCBs	8.33E-02
BUTYLBENZYLPHTHALATE	5.63E+00

Notes:

All values are presented in milligrams per kilogram (mg/kg)

Table 2-5. Preliminary Cleanup Levels for Aquatic Sediment and Surface Water for the On-Site East and West Exposure Groupings

Chemical	Surface Water Preliminary Cleanup Level - Aquatic Organism Effects Threshold (µg/L)	Sediment Preliminary Cleanup Level - Benthic Organism Effects Threshold (mg/kg)
ARSENIC	1.50E+02	9.79E+00
COPPER	2.90E+01	3.16E+01
LEAD	4.70E+01	3.58E+01
ZINC	3.80E+02	1.21E+02

Notes:

Sediment values are presented in milligrams per kilogram (mg/kg). Surface water concentrations are presented in micrograms per liter (µg/L).

Table 2-6. Exposure Point Concentration Summary for Background Soil Type 1 - Surface Soil

Chemical	Units	Number of Samples	Number of Detects	Arithmetic Detected Mean	Maximum Detected Concentration	95% UCLM	Reasonable Maximum Exposure		
							Medium EPC Value	Medium EPC Statistic	Medium EPC Rationale
ALUMINUM	mg/kg	39	39	1.67E+04	2.49E+04	1.77E+04	1.77E+04	95%UCLM-N	Regional Guidance
ANTIMONY	mg/kg	39	9	8.61E-01	1.00E+00	9.12E-01	9.12E-01	95%UCLM-KMt	Regional Guidance
ARSENIC	mg/kg	39	39	3.78E+01	6.63E+01	4.08E+01	4.08E+01	95%UCLM-N	Regional Guidance
BARIUM	mg/kg	39	39	2.08E+02	3.73E+02	2.27E+02	2.27E+02	95%UCLM-G	Regional Guidance
BERYLLIUM	mg/kg	39	32	4.44E-01	8.60E-01	4.73E-01	4.73E-01	95%UCLM-BCA	Regional Guidance
CADMIUM	mg/kg	39	30	1.64E+00	2.60E+00	1.61E+00	1.61E+00	95%UCLM-KMp	Regional Guidance
CALCIUM	mg/kg	39	39	1.19E+04	6.89E+04	2.44E+04	2.44E+04	95%UCLM-C	Regional Guidance
CHROMIUM	mg/kg	39	39	2.77E+01	5.77E+01	3.12E+01	3.12E+01	95% Modified-t UCL	Regional Guidance
COBALT	mg/kg	39	39	1.41E+01	1.98E+01	1.50E+01	1.50E+01	95%UCLM-N	Regional Guidance
COPPER	mg/kg	39	39	5.84E+01	1.09E+02	6.54E+01	6.54E+01	95%UCLM-G	Regional Guidance
CYANIDE	mg/kg	39	1	2.67E+00	2.70E-01	2.78E+00	2.70E-01	Maximum	N < 4
IRON	mg/kg	39	39	2.95E+04	3.73E+04	3.07E+04	3.07E+04	95%UCLM-N	Regional Guidance
LEAD	mg/kg	39	39	2.32E+01	5.82E+01	2.70E+01	2.70E+01	95%UCLM-L	Regional Guidance
MAGNESIUM	mg/kg	39	39	7.52E+03	1.35E+04	8.23E+03	8.23E+03	95%UCLM-G	Regional Guidance
MANGANESE	mg/kg	39	39	8.58E+02	2.47E+03	9.72E+02	9.72E+02	95%UCLM-G	Regional Guidance
MERCURY	mg/kg	39	19	9.91E-02	1.70E-01	9.52E-02	9.52E-02	95%UCLM-KMt	Regional Guidance
NICKEL	mg/kg	39	39	2.78E+01	5.29E+01	3.82E+01	3.82E+01	95%UCLM-C	Regional Guidance
POTASSIUM	mg/kg	39	39	2.45E+03	4.00E+03	2.64E+03	2.64E+03	95%UCLM-N	Regional Guidance
SELENIUM	mg/kg	39	23	7.01E-01	1.20E+00	7.64E-01	7.64E-01	95%UCLM-KMt	Regional Guidance
SILVER	mg/kg	39	14	4.31E-01	1.30E+00	5.11E-01	5.11E-01	95%UCLM-BCA	Regional Guidance
SODIUM	mg/kg	39	37	4.84E+01	9.84E+01	5.31E+01	5.31E+01	95%UCLM-KMt	Regional Guidance
SULFATE	mg/kg	30	19	1.78E+01	8.60E+01	3.41E+01	3.41E+01	97.5%UCLM-C	Regional Guidance
THALLIUM	mg/kg	39	25	2.41E+00	6.10E+00	2.51E+00	2.51E+00	95%UCLM-KMt	Regional Guidance
VANADIUM	mg/kg	39	39	6.01E+01	8.34E+01	6.35E+01	6.35E+01	95%UCLM-N	Regional Guidance
ZINC	mg/kg	39	39	9.54E+01	2.32E+02	1.07E+02	1.07E+02	95% Modified-t UCL	Regional Guidance

Definitions:

95%UCLM = 95 percent upper confidence limit of the mean

EPC = Exposure Point Concentration

mg/kg = milligrams per kilogram

USEPA = United States Environmental Protection Agency

Notes:

95%UCLM-G indicates that the 95 percent upper confidence limit on the mean is based on the approximate or adjusted gamma distribution.

95%UCLM-KMt indicates that the 95 percent upper confidence limit on the mean is based on the non-parametric Kaplan-Meier (KM) student's t-test.

95%UCLM-N indicates that the 95 percent upper confidence limit on the mean is based on the student's t-test for normal distributions.

95%UCLM-KMp indicates that the 95 percent upper confidence limit on the mean is based on the non-parametric Kaplan-Meier (KM) percentile boostrap test.

95%UCLM-L indicates that the 95 percent upper confidence limit on the mean is based on the Land (H) statistic for lognormal distributions.

95%UCLM-BCA indicates that the 95 percent upper confidence limit on the mean is based on the Kaplan-Meier (KM) Bias-Corrected Accelerated (BCA) percentile bootstrap test.

95%UCLM-C indicates that the 99 percent upper confidence limit on the mean is based on the non-parametric Chebyshev test.

97.5%UCLM-C indicates that the 99 percent upper confidence limit on the mean is based on the non-parametric Chebyshev test.

N < 4 indicates that the number of detected samples is less than 4, so the maximum detected value was used.

Table 2-7. Soil/Sediment Preliminary Clean-Up Levels

Chemical	Child Recreational/ Trespasser (250 Days)	Child Recreational/ Trespasser (50 Days)	Commercial/ Industrial Worker	Construction Worker	Resident Adult/Child	Arizona Soil Remediation Levels - Residential Exposure	Arizona Soil Remediation Levels - Non-Residential Exposure	Ecological Receptors - Based on Lowest Threshold for Wildlife	Background Soil Type 1 95%UCLM
Aluminum	109,396	546,982	987,136	306,418	77,335	76,000	920,000	176	17,724
Antimony	44	219	409	124	31	31	410	2.6	0.91
Arsenic	12	62	24	134	6.1	10	10	5.0	41
Cadmium	49	244	401	138	35	39	510	4.4	1.6
Chromium	4.7	24	56	430	2.9	30	65	--	31
Chromium VI	4.7	24	56	430	2.9	30	65	--	--
Cobalt	33	164	304	93	23	1,400	13,000	--	15
Copper	4,380	21,900	40,880	12,388	3,129	3,100	41,000	152	65
Iron	76,650	383,250	715,400	216,788	54,750			--	30,658
Lead (1)	150	150	150	150	150	400	800	182	27
Manganese	2,622	13,110	22,611	7,247	1,827	3,300	32,000	--	972
Selenium	--	--	--	--	--			0.58	0.76
Thallium	--	--	--	--	--			0.15	2.5
Zinc	--	--	--	--	--			775	107
Aroclor-1248	3.6	18	7.4	76	2.2	1.1	7.4	--	--
Benzo(a)pyrene	0.24	1.2	2.1	21	0.15	0.69	2.1	--	--
Butylbenzylphthalate	--	--	--	--	--			5.6	--
Dibenz(a,h)anthracene	0.24	1.2	2.1	21	0.15	0.69	2.1	--	--
Total PCBs	--	--	--	--	--			0.083	--

Notes:

All values are presented in milligrams per kilogram (mg/kg)

Human Health Preliminary Clean-Up Levels were based on a cancer risk of 1E-05 or a noncancer hazard of 1. When both cancer and noncancer values are available, the lowest value was selected.

Preliminary Clean-Up Levels were calculated using the methodologies presented in the risk assessments. Exposure parameters, toxicity values, and chemical-specific parameters remain the same except as noted on reference tables.

"--" = Value not calculated because chemical was not a preliminary chemical of potential concern.

The Preliminary Cleanup Level will vary by exposure area and human health reuse. Some exposure areas will not include an evaluation of ecological receptors, so only the human health and background values will be applicable.

(1) The Lead Preliminary Cleanup Level includes the Arizona Department of Environmental Quality (ADEQ) Soil Remediation Level (SRL) of 400 mg/kg for residential exposure, the ADEQ SRL of 800 mg/kg for commercial/industrial exposure, or the EPA Lead Level of 150 mg/kg (based on a 5 ug/dL blood lead level for potential deleterious effects).

Table 2-8. Aquatic Sediment and Surface Water Preliminary Clean-Up Levels

Chemical	Agua Fria River and Lower Chaparral Gulch Dam - Confluence Sediment			Agua Fria River and Lower Chaparral Gulch Dam - Confluence Surface Water			
	Human Health Child Recreational/ Trespasser (50 Days)	Benthic Organism Effects Threshold	Background Soil Type 1 95%UCLM	Human Health Surface Water	Arizona Lowest Human Health Surface Water (2)	Aquatic Organism Effects Threshold (1)	Arizona Aquatic and Wildlife - Warm Water (3)
Arsenic	62	9.8	41	10	10	150	150
Copper	--	32	65	--	--	29	29
Lead	--	36	27	--	--	47	11
Zinc	--	121	107	--	--	380	380

Notes:

Sediment values are presented in milligrams per kilogram (mg/kg). Surface water concentrations are presented in micrograms per liter (µg/L).

The Human Health Preliminary Sediment Clean-Up Level was based on a cancer risk of 1E-05. The Human Health Preliminary Surface Water Cleanup Level was based on the EPA Maximum Contaminant Level (MCL).

Preliminary Clean-Up Levels were calculated using the methodologies presented in the risk assessments. Exposure parameters, toxicity values, and chemical-specific parameters remain the same except as noted on reference tables.

"--" = Value not calculated because chemical was not a preliminary chemical of potential concern.

The lowest Preliminary Cleanup Level will be selected. The Preliminary Cleanup Level will vary by exposure area and human health reuse. Some exposure areas will not include an evaluation of ecological receptors, so only the human health and background values will be applicable.

(1) National Ambient Water Quality Criteria - Freshwater Chronic Criteria. Copper, lead, and zinc values have been adjusted for hardness (400 mg/L).

(2) The Agua Fria River is subject to Arizona Full Body Contact, Domestic Water Source, and Fish Consumption Criteria; the lowest value is presented.

(3) Values are for dissolved conentrations in warm freshwater for chronic exposure. Copper, lead, and zinc values have been adjusted for hardness (400 mg/L).

Table 2-9. Ground Water Preliminary Clean-Up Levels

Chemical	Human Health Ground Water
Aluminum	50
Arsenic	10
Chloride	250,000
Iron	300
Lead	15
Manganese	50
Nitrate As N	10,000
Selenium	50
Total Dissolved Solids	500,000
Zinc	5,000

Notes:
Ground water concentrations are presented in micrograms per liter (µg/L).
The Human Health Preliminary Ground Water Cleanup Level was based on the EPA Maximum Contaminant Level (MCL) or National Secondary Drinking Water Standards.

Table 3-1. Description of Technologies Potentially Applicable for Soil

General Response Action	Technology	Process Option	Description
Containment	Capping	Traditional caps, e.g. engineered cap or clay and soil cap	Provides an impermeable cap of clay and/or geosynthetic membranes over contaminated soil to prevent contaminants from becoming airborne, mitigate migration of contaminants into ground water, and prevent ingestion of soil by human and ecological receptors.
		Evapotraspiration (ET)/capillary cover	A capillary cover is used to prevent infiltration of water and oxygen into waste and results when a fine-textured soil overlies a coarse-textured soil. A capillary barrier exists because appreciable flow from the fine-textured soil into the coarse-textured soil will not occur unless the fine-textured soil becomes saturated. Vegetative cover is established to prevent soil saturation and erosion.
		Wet/phytoremediation cover	Provides a permeable cap over contaminated soil to prevent contaminants from becoming airborne and prevent ingestion of soil by human and ecological receptors. A wet cap uses standing water and a wetland system to preserve saturated, anoxic conditions in the tailing, which prevents the production of acid mine drainage.
	Horizontal barrier	Liners	Prevents horizontal migration of contaminants transferred to ground water or surface water.
	Consolidation	Consolidation	Combining one or more areas of contamination into central treatment areas.
Removal	Excavation-Off Site Disposal	Landfill	Contaminated material is collected and transported to an approved off site disposal facility. May be subject to Land Disposal Restrictions (LDR).
	Excavation-Onsite disposal	Disposal cell	Contaminated material is collected and transported to a disposal facility located within the Superfund site. The facility must be constructed such that it meets the substantive requirements of waste disposal regulations. May be subject to LDR
		Disposal in mine workings	Contaminated tailings are placed back into the abandoned mine shafts. May be subject to LDR
	Reuse	Recycling/Reprocessing	Tailings may have recoverable minerals with economic value. In this alternative, the minerals would be recovered prior to on or off site disposal.
Treatment	Ex-situ chemical treatment	Alkaline leaching and Acid extraction	Contaminated sediment is washed with an acidic or alkaline solution in order to mobilize the contaminants and separate them from soil.
		Soil flushing/soil washing	
	Ex-situ thermal treatment	Vitrification	Ex situ vitrification uses an electric current to melt soil or other earthen materials after they have been excavated and transported to a vitrification plant. Inorganic pollutants are incorporated and immobilized within the vitrified glass and crystalline mass.
	In-situ physical treatment	Electrokinetic separation	Electrokinetic separation relies upon application of a low-intensity current through the soil between electrodes to mobilize charged species. Metal ions and positively charged organic compounds move toward the cathode, while anions such as chloride, cyanide, fluoride, nitrate, and negatively charged organic compounds move toward the anode.

Table 3-1. Description of Technologies Potentially Applicable for Soil

General Response Action	Technology	Process Option	Description
Treatment	In-situ chemical treatment	Solidification/stabilization	The contaminated soils are mixed in place with grout or other cementitious material to bind and immobilize contaminants of concern.
	In-situ biological treatment	Biosolids and lime application	Adding biosolids or lime to contaminated soil can change soil pH, positively impacting mobility of contaminants. Addition of biosolids and lime can also be used to support vegetation growth for phytoremediation or vegetative covers.
		Phytoextraction	Uses plants to uptake contaminants through their root system. The contaminants are concentrated in the plants, which can be harvested and disposed at an approved disposal facility.
	In-situ thermal treatment	Vitrification	In situ vitrification (ISV) uses an electric current to melt soil or other earthen materials in place at extremely high temperatures which immobilize inorganics and destroys organic pollutants by pyrolysis. Inorganic pollutants are incorporated within the vitrified glass and crystalline mass.

Table 3-2. Description of Technologies Potentially Applicable for Aquatic Sediment

General Response Action	Technology	Process Option	Description
Containment	Cap	Traditional caps, e.g. engineered cap or clay and soil cap	Provides an impermeable cap of clay and/or geosynthetic membranes over contaminated soil to prevent contaminants from becoming airborne, mitigate migration of contaminants into groundwater, and prevent ingestion of soil by human and ecological receptors.
	Cap	Evapotraspiration (ET)/capillary cover	A capillary cover is used to prevent infiltration of water and oxygen into waste and results when a fine-textured soil overlies a coarse-textured soil. A capillary barrier exists because appreciable flow from the fine-textured soil into the coarse-textured soil will not occur unless the fine-textured soil becomes saturated. Vegetative cover is established to prevent soil saturation and erosion.
	Cap	Wet/phytoremediation cover	Provides a permeable cap over contaminated soil to prevent contaminants from becoming airborne and prevent ingestion of soil by human and ecological receptors. A wet cap uses standing water and a wetland system to preserve saturated, anoxic conditions in the tailing, which prevents the production of acid mine drainage.
	Horizontal barrier	Liners	Provides an impermeable barrier to prevent the horizontal movement of sediment and groundwater or sub-surface flow.
	Sediment Control Barriers	Channel improvement/rock armoring/earthen berms/rock embankments	Prevents movement of sediment by supporting channel structure and controlling streamflow.
	Sediment Control Barriers	Vegetative strip	Removes sediment, dissipates energy, and reduces the speed of runoff before it enters a water body, helping to reduce downstream movement of sediment.

Table 3-2. Description of Technologies Potentially Applicable for Aquatic Sediment

General Response Action	Technology	Process Option	Description
Removal	Excavation-Off Site Disposal	Landfill	Contaminated sediment is excavated, dewatered and carried offsite for disposal in a landfill. May be subject to Land Disposal Restrictions (LDR).
	Excavation-Onsite disposal	Dry cell	Contaminated sediment is excavated, dewatered and placed in an upland location onsite, using one of the capping methods discussed above.
	Excavation-Onsite disposal	Confined aquatic disposal	Sediment is excavated and consolidated in one place, then capped with one of the capping technologies discussed above
Treatment	Ex-situ physical treatment	Solids dewatering	Before aquatic sediments can be disposed of in a dry cell, they must be dewatered. This may be accomplished through use of a belt press, filter press, centrifuge, or evaporation.
	Ex-situ chemical treatment	Alkaline leaching/acid extraction	Contaminated sediment is washed with an acidic or alkaline solution in order to mobilize the contaminants and separate them from sediment.
	In-situ physical treatment	Settling basin/pond/wetland	Water velocity is reduced, allowing sediment to settle out before flow continues downstream and offsite.
	In-situ chemical treatment	Solidification/stabilization	Contaminated sediment is mixed in place with grout or other cementitious material to bind and immobilize contaminants of concern.
	In-situ biological treatment	Phytoextraction	Plants absorb and incorporate contaminants through their root system. The contaminants are concentrated in the plants, which can be harvested and disposed at an approved disposal facility.
	Chemical treatment	Demobilization	Sediment is mixed with a chemical stabilizer such as lime and organic matter. These amendments reduce contaminant and sediment mobility.

Table 3-3. Description of Technologies Potentially Applicable for Surface Water

General Response Action	Technology	Process Option	Description
Containment	Diversion	Open channel/Piping	Diverting clean surface water so that it does not come into contact with tailings material will prevent the formation of AMD.
Treatment	Ex-situ chemical/physical treatment	Lime neutralization/Precipitation/ Filtration	Lime or other neutralizing agents are added to AMD, which increases the pH and causes dissolved metals to precipitate out of solution. The metals can then be removed through flocculation or filtration.
		Ion exchange	Ionic species such as arsenate or arsenite are exchanged with less harmful ions by passing water through an exchange media, often a resin. The exchange media must be periodically replaced and/or regenerated.
		Reverse Osmosis	Water is forced through a semi-permeable membrane that does not allow arsenic to pass through.
		Granular ferric hydroxide, Iron oxide coated sand	Water passes through a bed of iron-based absorptive media, and arsenic is removed by bonding to the iron compounds. The media must be occasionally regenerated by washing with an acid bath to remove accumulated arsenic.
		Activated carbon	Water passes through a bed of activated absorptive media, and arsenic is removed.
		Activated alumina	Water passes through a bed of activated absorptive media, and arsenic is removed.
		Hydrogen peroxide/Potassium permanganate	Chemical additives that oxygenate water, facilitating metals precipitation and flocculation
		Zero-valent iron (PRB)	Arsenic is removed by absorption or by converting more mobile forms of arsenic to less mobile forms that precipitate out of solution.
	In-situ chemical treatment	Open limestone channels	Contact with limestone raises the pH of AMD, causing metals to precipitate out.
		Anoxic limestone drain	Raises the pH of AMD as in open limestone channels, but the exclusion of oxygen reduces clogging or armoring of limestone surface due to the formation of solid iron hydroxide
		Lime slurry addition	Addition of lime sand or slurry to an AMD-impacted stream raises the pH and is not impacted by the formation of solid precipitates, but must be added at short intervals or continuously.

Table 3-3. Description of Technologies Potentially Applicable for Surface Water

General Response Action	Technology	Process Option	Description
Treatment	In-situ biological treatment	Bioreactor, anaerobic wetland	In a constructed wetland, sulfate-reducing bacteria convert sulfate to sulfide, which forms precipitates with arsenic and other metals, then settles out. The process of sulfate reduction also raises the pH of the water.
		Successive alkalinity producing system (SAPS)	SAPS utilize sulfate-reducing bacteria, but form a vertical treatment system instead of constructed wetland, and combine the bacterial processes with limestone pH adjustment and/or absorptive media.
		Passive reactive barrier (PRB)	PRBs form a wall or trench where water flows through an absorptive, biologically active or oxidizing media. Although PRBs are usually used for treating ground water, in this case the wall would be located directly behind the dam, and low flows would pass through it before exiting at the base of the dam.

Table 3-4. Description of Technologies Potentially Applicable for Ground Water

General Response Action	Technology	Process Option	Description
Alternative Water Supply	Outside source	Municipal water supply	All residences at risk for contaminated ground water are connected to the local municipal water supply.
	Alternative groundwater	New residential wells	Residences using contaminated private wells are provided with new wells that draw from uncontaminated ground water.
Containment	Ground water Interception	Slurry Walls	An underground clay wall provides an impermeable barrier to ground water flow
	Ground water Interception	Grout Curtain	Grout or other cementitious material is injected into holes drilled to intercept ground water paths, filling and blocking the paths and preventing ground water flow.
	Ground water Interception	Interceptor trenches	Excavated trenches are filled with gravel in order to intercept ground water and provide a path of least resistance that avoids residential wells.
	Hydraulic containment	Pumping wells - no treatment	A series of extraction wells are placed to remove contaminated ground water before it reaches residences. Extracted groundwater is then re-injected further upgradient or disposed of without treatment.
Treatment	In-situ treatment	Permeable reactive barrier (PRB)	An excavated trench filled with permeable material and an absorptive, biologically active or oxidizing media. Contaminated ground water is treated as it flows perpendicularly through the trench.
	Ex-Situ Treatment	Pump and treat	A series of extraction wells are placed to remove contaminated ground water before it reaches residences. Extracted water is then treated and may be reinjected, released to surface water, or provided to a drinking water supplier.
	Ex-Situ Treatment	POU/POE Filters	Each residence affected by ground water contamination is provided with individual treatment units that utilize one of the technologies described below. A point of use (POU) filter treats water specifically for drinking and cooking, while a point of entry (POE) filter treats all water used at a residence.
	Chemical treatment	Ion exchange	Ionic species such as sulfate are exchanged with less harmful ions by passing water through an exchange media, often a resin. The exchange media must be periodically replaced and/or regenerated.
	Physical treatment	RO	Water is forced through a semi-permeable membrane, leaving contamination behind and producing clean water.

Table 3-5. Description of Technologies Potentially Applicable for Structures/Debris

General Response Action	Technology	Description
Treatment	Remove Asbestos	Asbestos abatement consists of selectively removing building materials that contain asbestos from within standing structures.
Removal	Demolish buildings	Standing structures are demolished under controlled conditions to prevent release of asbestos into the air.
Disposal	Onsite cell	Building debris is buried in a cell onsite.
	Offsite landfill	Building debris is trucked offsite and placed in a landfill certified to accept asbestos-containing waste.

Table 3-6. Technology Screening: Soil

General Response Action	Technology	Process Option	Effectiveness	Implementability	Cost	Status
No Action	--	--	Will not address RAOs	Implementable as no remedial action will be conducted.	Low	Retained as required under the NCP
Institutional Controls	--	--	Can be used to address some RAOs	Implementable	Low	Retained
Containment	Capping	Traditional cap, e.g. engineered cap, clay, or soil cap	Will address relevant RAOs	Implementable	Medium	Retained
		Evapotraspiration (ET)/vegetative cover	Will address relevant RAOs	Implementable	Medium	Retained
		Wet/phytoremediation cover	Will address relevant RAOs	Considered implementable - new technology	Medium	Retained
	Horizontal barrier	Liners	Will not address relevant RAOs for soil and tailings that are not submerged in water.	Implementable for some areas	Medium	Not retained since it will not meet RAOs
	Consolidation	Consolidation	In combination with proper capping process, will address relevant RAOs	Implementable	Low	Retained
Removal	Excavation-Off Site Disposal	Landfill	Will address relevant RAOs	Implementable, but difficult due to the large volume of contaminated material	High	Retained
	Excavation-Onsite disposal	Disposal cell	Will address relevant RAOs	Implementable, but difficult due to the large volume of contaminated material	High	Retained
		Disposal in mine workings	Will address relevant RAOs	Difficult to implement, creates risk of AMD production	Medium	Not Retained due to potential AMD issues.
	Reuse	Recycling/Reprocessing	Will address relevant RAOs	Implementable for slag, which has low leaching potential, but not for tailings, which do not meet leaching requirements	Low	Retained
Treatment	Ex-situ chemical treatment	Alkaline leaching and Acid extraction	Will address relevant RAOs	Implementable for some areas, will create a significant secondary waste stream to handle.	High	Not retained due to secondary waste issues
		Soil flushing/soil washing	Will address relevant RAOs	Not implementable - ground water paths are not well understood and recovery of mobilized arsenic would be difficult. Will create a significant secondary waste stream to handle.	Medium	Not retained due to arsenic recovery and secondary waste issues
	Ex-situ thermal treatment	Vitrification	Will address relevant RAOs	Implementable for some areas--not proven over this large an area. Would require significant energy to implement.	High	Not retained due to cost and implementability issues.
	In-situ physical treatment	Electrokinetic separation	Will not address relevant RAOs within a reasonable time frame	Not implementable - soil is too well-drained	High	Not retained because it would not be implementable
	In-situ chemical treatment	Solidification/stabilization	Will address relevant RAOs	Implementable for some areas	High	Retained
	In-situ biological treatment	Biosolids/amendments/lime application	Will address relevant RAOs	Implementable for some areas	High	Retained
	In-situ biological treatment	Phytoextraction	Will address relevant RAOs	Not considered implementable. In some areas due to the nature of water flows during storm events, it is likely soil and plant matter will be washed out.	Medium	Not retained due to issues with implementability.
	In-situ thermal treatment	Vitrification	Will address relevant RAOs	Implementable for some areas	High	Not retained due to high cost. Once vitrified, the tailings could not mined for additional minerals.

Note:
Cost estimates are relative within each General Response Action

Table 3-7. Technology Screening: Aquatic Sediment

General Response Action	Technology	Process Option	Effectiveness	Implementability	Cost	Status
No Action	--	--	Will not address RAOs	Implementable as no remedial action will be conducted.	None	Retained as required under the NCP
Institutional Controls	--	--	Can be used to address some RAOs	Implementable	Low	Retained
Containment	Cap	Traditional cap, e.g. Engineered cap, soil, or clay cap	Will address relevant RAOs	Implementable	Medium	Retained
		Evapotraspiration (ET)/vegetative cover	Will address relevant RAOs	Implementable	Moderate	Retained as a component of combined alternatives
		Wet/phytoremediation cover	Will address relevant RAOs	Considered implementable - new technology	Moderate	Retained as a component of combined alternatives
	Horizontal barrier	Liners	Will address relevant RAOs	Not implementable due to sediment movement during storm events	Moderate	Not retained due to implementability concerns
	Sediment Control Barriers	Channel improvement/rock armoring/earthen berms/rock embankments	Will address relevant RAOs	Implementable	Moderate	Retained
		Vegetative strip	May address RAOs. Depends on stability of vegetation through storm events	Implementable	Low	Not retained due to limited effectiveness
Removal	Excavation-Off Site Disposal	Landfill	Will address relevant RAOs	Implementable	High	Retained
	Excavation-Onsite disposal	Dry cell	Will address relevant RAOs	Implementable		Retained
		Confined aquatic disposal	Will address relevant RAOs	Not implementable - Flow rates through the area are too variable	High	Not retained due to implementability concerns
Treatment	Ex-Situ Treatment	Solids Dewatering	Will not address RAOs	Implementable	High	Retained as a component of combined alternatives
	Ex-Situ Treatment	Alkaline leaching/acid extraction	Will address relevant RAOs	Implementable for some areas	High	Not retained due to secondary waste issues
	In-situ treatment	Settling basin/pond/wetland	Will address relevant RAOs	Implementable	Moderate	Retained
		Solidification/stabilization	Will address RAOs for sediment, but will not meet RAOs for sustainability, ecological resources or future land use	Implementable	High	Retained
		Phytoextraction	Will not address relevant RAOs within a reasonable time frame.	Considered implementable - new technology	Moderate	Not retained due to limited effectiveness
		Demobilization of metals by addition of amendments, which may include: -Phosphate/Apatite -Caustic Soda -Hydrated Lime -Anhydrous Ammonia -Hydrogen Peroxide -Potassium Permanganate -Soda Ash - Sodium Carbonate	Will address relevant RAOs, but duration is uncertain	Considered implementable, but difficult due to location of contaminated sediments under steep banks	Moderate	Not retained due to problems with implementation

Note:
Cost estimates are relative within each General Response Action

Table 3-8. Technology Screening: Surface Water

General Response Action	Technology	Process Option	Effectiveness	Implementability	Cost	Status
No Action	--	--	Will not address RAOs	Implementable as no remedial action will be conducted.	None	Retained as required under the NCP
Institutional Controls	--	--	Can be used to address some RAOs	Implementable	Low	Retained
Containment	Diversion	Open channel/Piping	Can be used to address some RAOs	Implementable	Low	Retained as a component of combined alternatives
Treatment	Ex-situ chemical/physical treatment	Lime neutralization/Precipitation/ Filtration	Will address applicable RAOs	Implementable	High	Not Retained due to cost of long term system operation requirement
		Ion exchange, Reverse Osmosis	Will address applicable RAOs	Implementable, but may require pre-treatment for pH adjustment	High	
		Granular ferric hydroxide, Iron oxide coated sand	Can be used to address some RAOs	Implementable	High	
		Activated carbon	Only effective in removing certain arsenic species, may not address applicable RAOs	Implementable	High	
		Activated alumina	Can be used to address some RAOs	Implementable	High	
		Hydrogen peroxide/Potassium permanganate	Can be used to address some RAOs	Implementable	High	
		Zero-valent iron (PRB)	Can be used to address some RAOs	Implementable	High	
	In-situ chemical treatment	Open limestone channels	Will address applicable RAOs	Implementable	Low	Retained
		Anoxic limestone channels	Will address applicable RAOs	Implementable	Low	Retained
		Lime slurry addition	Will address applicable RAOs	Implementable	Moderate	Not retained due to long term O&M requirements.
	In-situ biological treatment	Bioreactor/Anaerobic wetland	Will address applicable RAOs	Implementable, but a bioreactor in an arid environment will likely have high maintenance requirements	Moderate	Rejected based on uncertainty associated with attempting to maintain a biologically active system in an arid environment
		Successive alkalinity producing system	Will address applicable RAOs	Implementable, but a bioreactor in an arid environment will likely have high maintenance requirements	Moderate	Not retained based on uncertainty associated with attempting to maintain a biologically active system in an arid environment
		Passive reactive barrier	Will address applicable RAOs	Implementable	High	Not retained due to high cost - technology is proprietary

Note:
Cost estimates are relative within each General Response Action

Table 3-9. Technology Screening: Ground Water

General Response Action	Technology	Process Option	Effectiveness	Implementability	Cost	Status
No Action	--	--	Will not address RAOs	Implementable as no remedial action will be conducted.	None	Retained as required under the NCP
Institutional Controls	--	--	Can be used to address some RAOs	Implementable	Low	Retained
Alternative Water Supply	Outside source	Municipal water supply	Will mitigate exposure to ground water - meets applicable RAOs	Implementable - water mains already in place, only individual hook-ups required	Moderate	Retained
	Alternative ground water	New residential wells	If an unimpacted source of ground water is available, will meet applicable RAOs	Not implementable - unknown ground water paths make it unlikely that new wells would produce higher quality water	High	Not Retained
Containment	Ground water Interception	Slurry Walls	May meet applicable RAOs, more information is needed	Not implementable - unknown ground water paths through fractured bedrock	High	Not Retained due to implementability concerns
	Ground water Interception	Grout Curtain	May meet applicable RAOs, more information is needed	Not implementable - unknown ground water paths through fractured bedrock	High	Not Retained due to implementability concerns
	Ground water Interception	Interception trenches	Will not meet applicable RAOs due to fractured ground water paths	Not implementable - unknown ground water paths through fractured bedrock	High	Not Retained due to implementability concerns
	Hydraulic containment	Pumping wells - no treatment	Will not meet RAOs over long term	Implementable	High	Not Retained
Treatment	In-situ treatment	Permeable reactive barrier	Will meet applicable RAOs for sulfate, but not for chloride.	Not implementable - unknown ground water paths through fractured bedrock	High	Not retained due to effectiveness concerns
	Ex-situ treatment	Pump and treat (see treatment technologies below)	Will mitigate exposure to ground water - meets applicable RAOs	Implementable, but will require long term O&M	High	Retained
	Ex-situ treatment	POU/POE Filters	Will mitigate exposure to ground water - meets applicable RAOs	Implementable	Low	Retained
	Chemical Treatment	Ion exchange	Will mitigate exposure to ground water - meets applicable RAOs	Implementable	Moderate	Retained
	Physical Treatment	RO	Will mitigate exposure to ground water - meets applicable RAOs	Implementable	Moderate	Retained

Note:
Cost estimates are relative within each General Response Action

Table 3-10. Technology Screening: Structures/Debris

General Response Action	Technology	Effectiveness	Implementability	Cost	Status
No Action	--	--	Implementable as no remedial action will be conducted.	None	Retained as required under the NCP
Institutional Controls	--	--	Implementable	Low	Retained
Treatment	Remove Asbestos	Will address RAOs by preventing exposure to asbestos	Not safely implementable - buildings are in bad condition and unstable	Moderate	Retained
Removal	Demolish buildings	In combination with proper disposal action, will address relevant RAOs	Implementable	Moderate	Retained
Disposal	Onsite cell	In combination with removal action, will address relevant RAOs	Implementable	Moderate	Retained
	Offsite landfill	In combination with removal action, will address relevant RAOs	Implementable	High	Retained

Note:
Cost estimates are relative within each General Response Action

Table 4-1. Remedial Alternatives for Soil/Sediment

	Remedial Action Objectives					
	Media-specific RAOs			General RAOs		
	Prevent exposure to COCs in soil/ sediment	**Prevent migration of COCs in soils/ sediments during surface water flow events up to the 100-year flood event**	**Prevent migration of COCs in soils/ sediments to ambient air**	**Utilize Sustainable Practices**	**Protect Ecological Habitats**	**Support Future Land Use**
Alternative S-1: No Further Action	Does not address	Does not address	Does not address	No use of energy or other resources required	Does not address	Does not address
Alternative S-2: Limited Action	Human exposure prevented through institutional and engineering controls, which may have limited effectiveness for ecological receptors	Does not address	Does not address	Limited use of energy and other resources to implement	Does not address	Does not address
Alternative S-3: Consolidation with Soil Cover	Cover prevents exposure to contaminated soil	Cover prevents migration of contaminated soil	Cover prevents migration of contaminated soil to air	Sustainable measures during construction can reduce energy use and GHG emissions, minimal use of resources required for long-term O&M	Establishes vegetative growth and prevents exposure to contaminated material	Does not address
Alternative S-4: Consolidation with ET Cap	Cap prevents exposure to contaminated soil	Cap prevents migration of contaminated soil	Cap prevents migration of contaminated soil to air	Sustainable measures during construction can reduce energy use and GHG emissions, minimal use of resources required for long-term O&M	Establishes vegetative growth and prevents exposure to contaminated material	Does not address
Alternative S-5: Consolidation with Engineered Cover	Cover prevents exposure to contaminated soil	Cover prevents migration of contaminated soil	Cover prevents migration of contaminated soil to air	Sustainable measures during construction can reduce energy use and GHG emissions, minor use of resources required for O&M, will provide valuable ecological habitat	Prevents exposure to contaminated material	Does not address
Alternative S-6: In-Situ Stabilization	Stabilization amendments reduce the toxicity and mobility of COCs	Organic amendments reduce erodibility of soil and encourage vegetative cover	Organic amendments reduce erodibility of soil and encourage vegetative cover	Sustainable measures during construction can reduce energy use and GHG emissions, addition of organic amendments will help establish ecological habitat	Establishes vegetative growth and prevents exposure to contaminated material	Does not address
Alternative S-7: Excavation and Off-site Disposal	Contaminated soil is removed	Contaminated soil is removed	Contaminated soil is removed	High energy requirements due to transportation	Removes contaminated material from the site	Removes contaminated material from the site to allow development
Alternative S-8: Material Reuse	Contaminated materials are removed	Contaminated materials are removed	Contaminated materials are removed	Provides recycled materials for beneficial use	Removes contaminated material from the site	Removes contaminated material from the site to allow development

Table 4-2. Remedial Alternatives for Aquatic Sediment

	Remedial Action Objectives				
	Media-specific RAOs		General RAOs		
	Prevent exposure to COCs in aquatic sediment	**Prevent migration of COCs in aquatic sediment during surface water flow events up to the 100-year flood event**	**Utilize Sustainable Practices**	**Protect Ecological Habitats**	**Support Future Land Use**
Alternative A-1: No Further Action	Does not address	Does not address	No use of energy or other resources required	Does not address	Does not address
Alternative A-2: Limited Action	Does not address	Does not address	Limited use of energy and other resources to implement	Does not address	Does not address
Alternative A-3: Rock Armoring	Rock cover prevents exposure to contaminated sediment	Rock placement provides channel stabilization and prevents movement of contaminated sediment	Sustainable measures during construction can reduce energy use and GHG emissions, minimal use of resources required for long-term O&M	Prevents exposure to contaminated material, but discourages vegetative growth along streambanks	Does not address
Alternative A-4: Excavation and Onsite Disposal	Prevents exposure to contaminated sediment	Prevents migration of contaminated sediment	Sustainable measures during construction can reduce energy use and GHG emissions, minor use of resources required for O&M, will provide valuable ecological habitat	Establishes vegetative growth and prevents exposure to contaminated material	Does not address
Alternative A-5: Excavation and Off-site Disposal	Contaminated sediment is removed	Contaminated sediment is removed	High energy requirements due to transportation	Removes contaminated material from the site	Removes contaminated material from the site to allow development

Table 4-3. Remedial Alternatives for Ground Water

	Remedial Action Objectives					
	Media-specific RAOs			General RAOs		
	Prevent further degradation of ground water from COCs	**Prevent exposure to COCs in ground water**	**Remediate COCs in groundwater to allow for beneficial uses of the aquifer**	**Utilize Sustainable Practices**	**Protect Ecological Habitats**	**Support Future Land Use**
Alternative GW-1: No Further Action	Does not address	Does not address	Does not address	No use of energy or other resources required	Does not address	Does not address
Alternative GW-2: Limited Action	Monitoring	Prohibits exposure to groundwater	Does not address	Limited use of energy and other resources to implement	N/A	Does not address
Ground Water Use						
Alternative GW-3: Point of Use Treatment	N/A	Removes COCs prior to ground water exposure	N/A	N/A	N/A	N/A
Alternative GW-4: Connection to Municipal Water Supply	N/A	Prevents exposure to ground water	N/A	N/A	N/A	N/A
Ground Water Treatment						
Alternative GW-5: Pump and Treat, Reuse through Potable Supply	Prevents continued migration of contaminated ground water	Removes COCs from ground water and contains footprint of the contamination plume	Potential to restore aquifer, if hydrogeolocial conditions can been understood well enough for proper system design	Water reuse protects water resources and can reduce overall use	Removal/treatment of ground water prevents contamination from migrating to surface water which presents potential exposure area to ecological habitats	Restoration of aquifer
Alternative GW-6: Pump and Treat, Ground Water Injection	Prevents continued migration of contaminated ground water	Removes COCs from ground water and contains footprint of the contamination plume	Potential to restore aquifer, if hydrogeolocial conditions can been understood well enough for proper system design	Sustainable measures during construction can reduce energy use and GHG emissions, but energy and resources will be required for long term O&M	Removal/treatment of ground water prevents contamination from migration to surface water which presents potential exposure area to ecological habitats	Restoration of aquifer

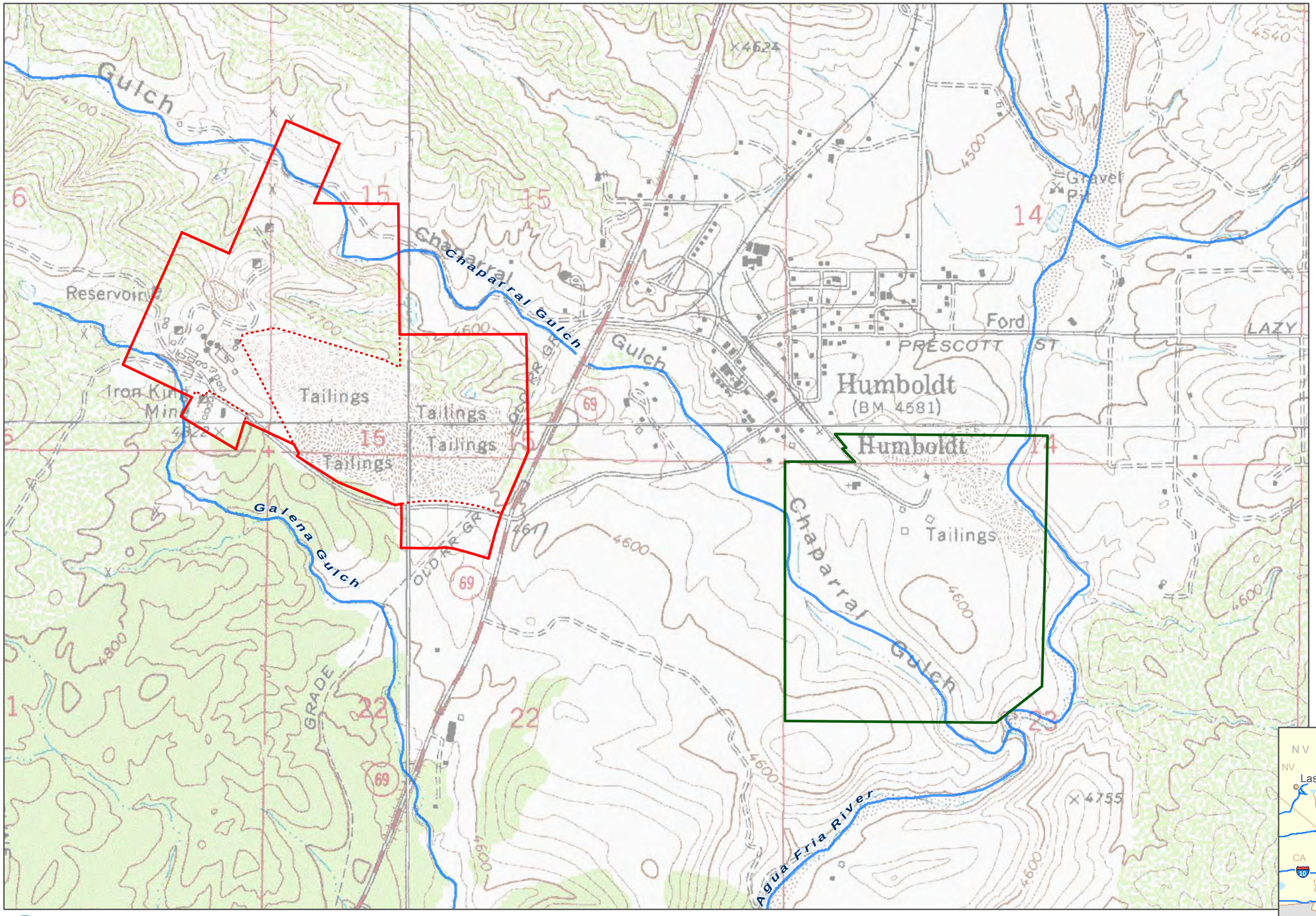
Table 4-4. Remedial Alternatives for Structures/Debris

	Remedial Action Objectives			
	Media-specific RAOs	General RAOs		
	Prevent exposure to asbestos in structures/debris	**Utilize Sustainable Practices**	**Protect Ecological Habitats**	**Support Future Land Use**
Alternative B-1: No Further Action	Does not address	No use of energy or other resources required	Does not address	Does not address
Alternative B-2: Limited Action	Exposure prevented through institutional and engineering controls	Limited use of energy and other resources to implement	Does not address	Does not address
Alternative B-3: Asbestos Abatement	Exposure prevented by selectively removing asbestos-containing materials	Sustainable measures during construction can reduce energy use and GHG emissions, minimal use of resources required for long-term O&M	Removes contaminated material from the site	Removes contaminated material from the site to allow development
Alternative B-4: Demolition and Onsite Disposal	Exposure prevented by removing all structures/debris	Sustainable measures during construction can reduce energy use and GHG emissions, minor use of resources required for O&M, will provide valuable ecological habitat	Establishes vegetative growth and prevents exposure to contaminated material	Removes contaminated material from the site to allow development
Alternative B-5: Demolition and Off-site Disposal	Exposure prevented by removing all structures/debris	High energy requirements due to transportation	Removes contaminated material from the site	Removes contaminated material from the site to allow development

Table 4-5. Remedial Alternatives for the Lower Chaparral Gulch and Agua Fria

	Remedial Action Objectives									
	Source Control				Exposure to COCs - Human and Ecological			General		
	Prevent migration of COCs in aquatic sediments	**Prevent migration or discharge of acid mine water - Above Dam**	**Prevent migration or discharge of acid mine water - Below Dam**	**Stabilize dam to prevent release of tailings**	**Prevent exposure to COCs in surface water - Above Dam**	**Prevent exposure to COCs in surface water - Below Dam**	**Prevent exposure to COCs in aquatic sediments**	**Utilize Sustainable Practices**	**Protect Ecological Habitats**	**Support Future Land Use**
Alternative LCG-1: No Further Action	Not addressed	Not addressed	Not addressed	Not addressed	Not addressed	Not addressed	Not addressed	No use of energy or other resources required	Not addressed	Not addressed
Alternative LCG-2: Limited Action	Not addressed	Not addressed	Not addressed	Not addressed	Exposure prevented through institutional and engineering controls	Exposure prevented through institutional and engineering controls	Exposure prevented through institutional and engineering controls	Limited use of energy and other resources to implement	Does not address	Does not address
Alternative LCG-3: Excavation and Offsite Disposal	Source removal	Source removal	Source removal	Dam and tailings are removed	Source removal	Source removal	Source removal	High energy requirements due to transportation	Returns waterway to pre-mining condition	Returns waterway to pre-mining condition
Alternative LCG-4: Excavation and Onsite Disposal	Source removal	Source removal	Source removal	Dam and tailings are removed	Source removal	Source removal	Source removal	Sustainable measures during construction can reduce energy use and GHG emissions, minimal use of resources required for long-term O&M	Returns waterway to pre-mining condition	Returns waterway to pre-mining condition
Alternative LCG-5: Stabilization/Solidification and Downstream Leachate Treatment	Stabilization decreases mobility	Stabilization of sediments decrease leachability	Downstream treatment precipitates metals, raises pH	Replace dam	Decrease mobility and exposure through treatment	Decrease mobility and exposure through treatment	Decrease mobility and exposure through treatment	S/S amendments provide opportunity for recycled material use, passive treatment has low energy requirement	Tailings and AMD treatment will allow re-establishment of ecological habitats over time	Protects Ecological Habitat
Alternative LCG-6: Cover and Downstream Leachate Treatment	In-stream structures and vegetation decrease erodibility	Cover prevents leaching	Downstream treatment precipitates metals, raises pH	Replace dam	Decrease toxicity by preventing water contact with tailings	Decrease toxicity through treatment	Downstream treatment removes contaminants of concern	Passive treatment has low energy requirement	Tailings cover and AMD treatment will allow re-establishment of ecological habitats over time	Protects Ecological Habitat
Alternative LCG-7: In-situ Sediment Treatment and Downstream Leachate Treatment	In-stream structures and vegetation decrease erodibility, surface treatment of tailings removes source	In-situ treatment decreases metal mobility	Downstream treatment precipitates metals, raises pH	Replace dam	Decrease mobility and exposure through treatment	Decrease toxicity through treatment	Downstream treatment removes contaminants of concern	Passive treatment has low energy requirement	Encourages establishment of wetland habitat	Protects Ecological Habitat

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

Remedial Alternatives Evaluation

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

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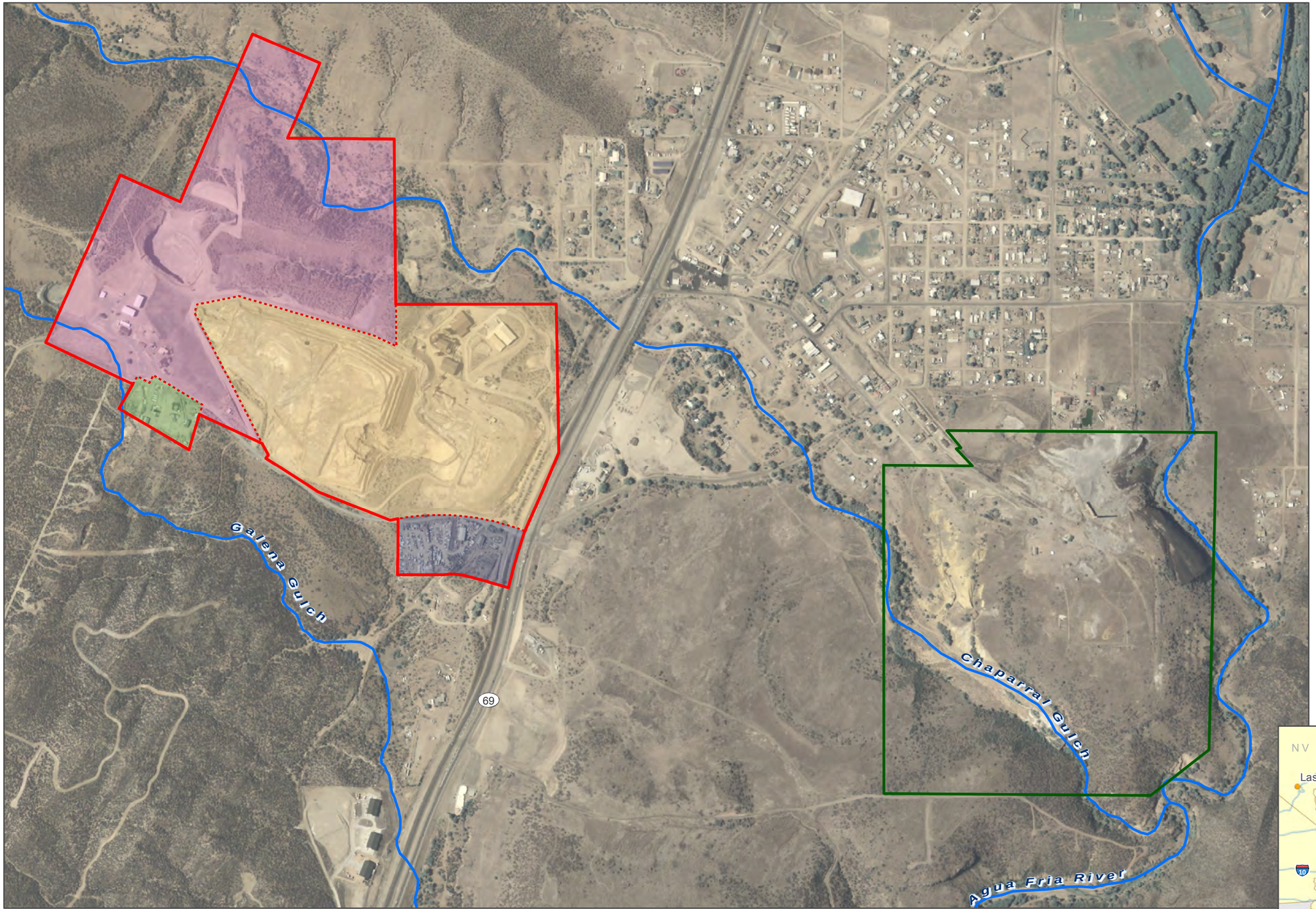

Legend

Five Areas of Interest

Iron King Mine

- Iron King Mine Proper Area
- Iron King Operations Area
- Former Fertilizer Plant Area
- Salvage Yard

Humboldt Smelter

Waterways
Chaparral Gulch, Galena Gulch, Agua Fria River

In-town Soil
Area not depicted but includes adjacent properties

Ground Water
Area not depicted but includes ground water from shallow alluvial and deep bedrock

Note:
Boundaries are approximate and may be subject to change

0 500 1,000
Feet

EPA Identification Number: AZ0000309013

Aerial Photo Source: Yavapai County GIS, 2007
Basemap Source: ESRI StreetMap, 2006

Figure 2 – Areas of Interest
Remedial Alternatives Evaluation

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

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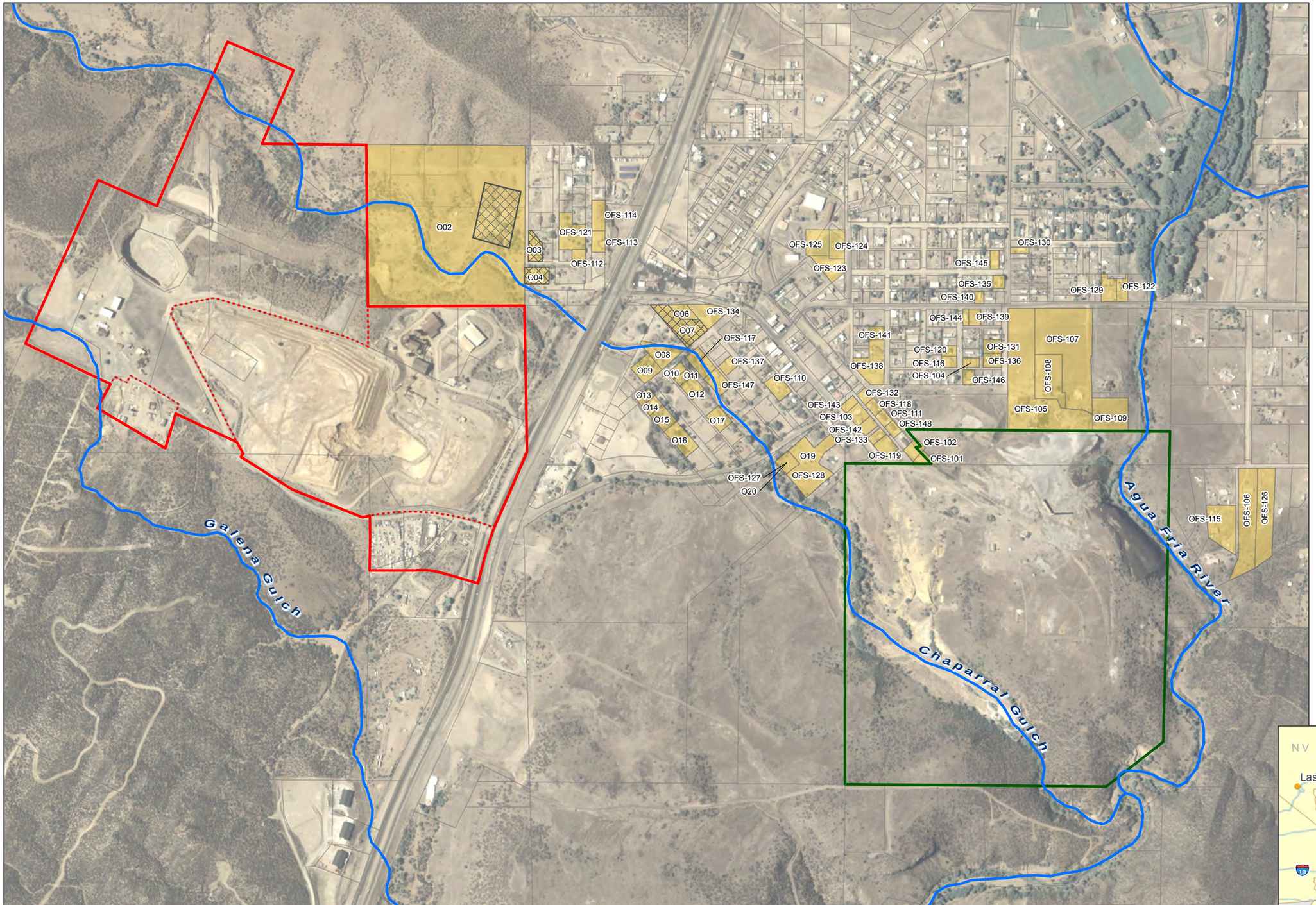

Legend

- Road Centerlines
- Waterways
  Chaparral Gulch, Galena Gulch, Agua Fria River
- Residential Sampled Properties
- Properties Remediated during EPA Removal Action
- Parcels
- Iron King Mine
- Humboldt Smelter

0 500 1,000
Feet

EPA Identification Number: AZ0000309013

Aerial Photo Source: Yavapai County GIS, 2007
Basemap Source: ESRI StreetMap, 2008

Figure 3 – In-town Soil Areas

Remedial Alternatives Evaluation

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

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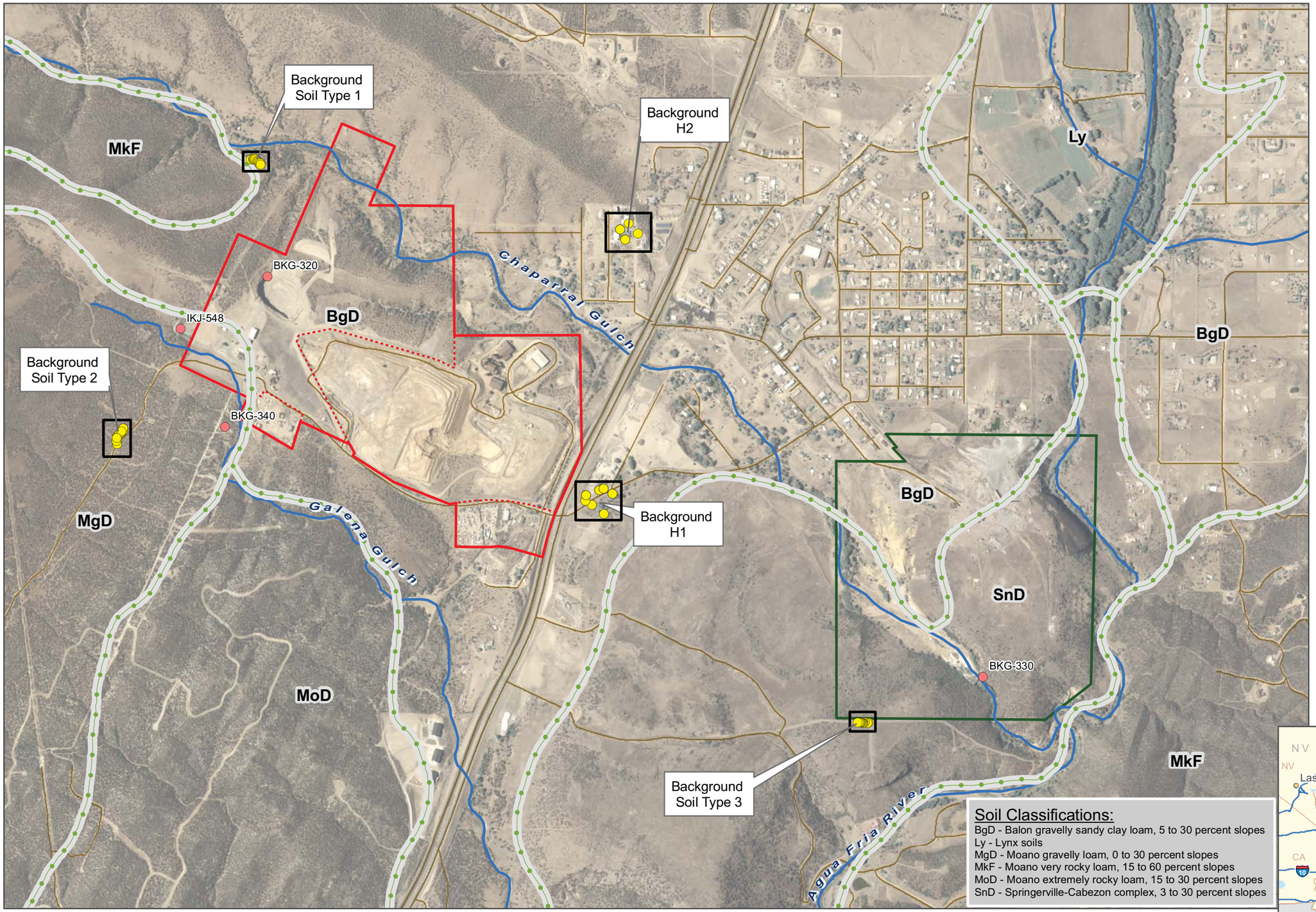

Legend

- Soil Sample Location
- Bedrock Sample Location
- Waterways: Chaparral Gulch, Galena Gulch, Agua Fria River
- Road Centerlines
- Iron King Mine
- Humboldt Smelter
- Soil Classification Area
- BgD Soil Classification Text

0 1,000 Feet

EPA Identification Number: AZ0000309013

Aerial Photo Source: Yavapai County GIS, 2007
Basemap Source: ESRI StreetMap, 2008

Soil Classifications:

BgD - Balon gravelly sandy clay loam, 5 to 30 percent slopes
Ly - Lynx soils
MgD - Moano gravelly loam, 0 to 30 percent slopes
MkF - Moano very rocky loam, 15 to 60 percent slopes
MoD - Moano extremely rocky loam, 15 to 30 percent slopes
SnD - Springerville-Cabezon complex, 3 to 30 percent slopes

Figure 4 – Background Areas

Remedial Alternatives Evaluation

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

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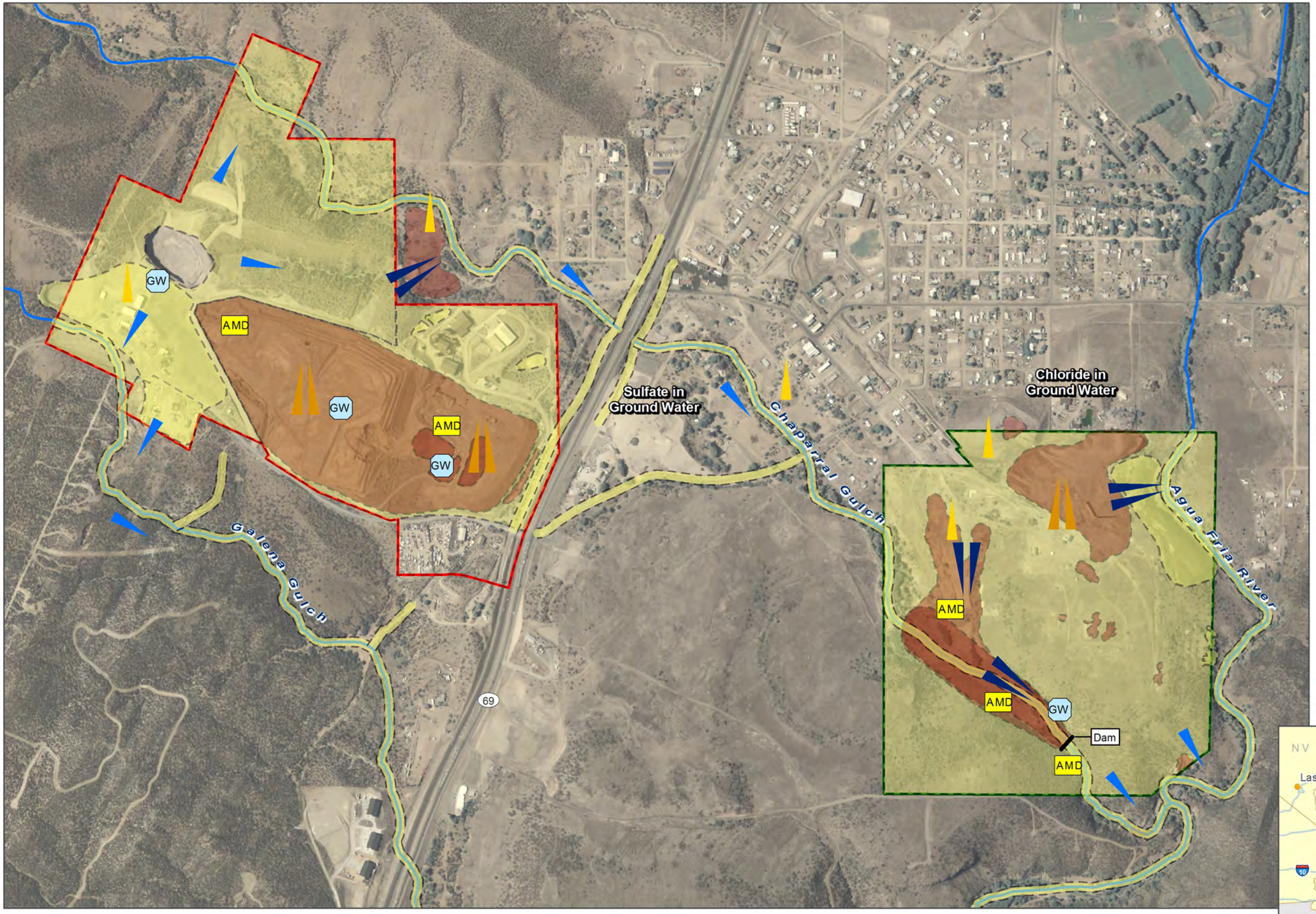

Legend

- Humboldt Smelter
- Iron King Mine
- Areas with Low-Level Threat Waste
- Areas with Principal Threat Waste
- Waterways
  - Chaparral Gulch, Galena Gulch, Agua Fria River

Primary Migration Pathways

- AMD — Acid Mine Drainage
- GW — Leaching to Ground Water
- Air Particulate, High Degree of Severity
- Air Particulate, Low Degree of Severity
- Surface Water, High Degree of Severity
- Surface Water, Low Degree of Severity

Notes:
1. Boundaries are approximate and may be subject to change.
2. No threat waste is associated with the following sample groups: Iron King Mine Glory Hole, Iron King Mine Salvage Yard, Humboldt Smelter Off-site Migration, Off-site Soil Area 02 through 020, Off-site Soil Area 101 through 148, and Ground Water.
3. In-town Soil AOI not depicted but includes adjacent properties.
4. Ground Water AOI not depicted but includes on-site and off-site ground water from shallow alluvial and deep bedrock.

0 1,000
Feet

EPA Identification Number: AZ0000309013

Aerial Photo Source: Yavapai County GIS, 2007
Basemap Source: ESRI StreetMap, 2006

Figure 5 – Conceptual Site Model
Remedial Alternatives Evaluation

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

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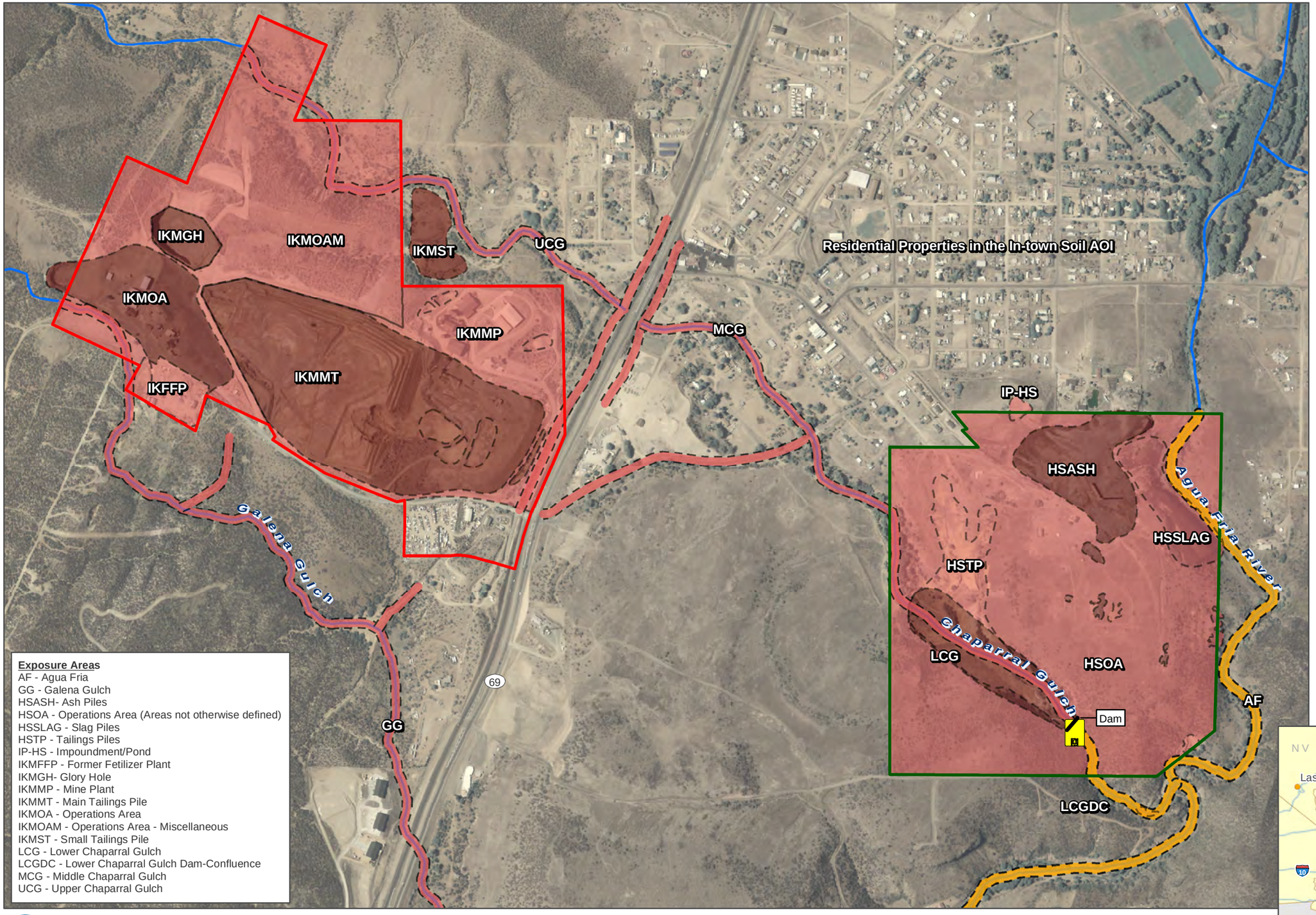

Exposure Areas
AF - Agua Fria
GG - Galena Gulch
HSASH- Ash Piles
HSOA - Operations Area (Areas not otherwise defined)
HSSLAG - Slag Piles
HSTP - Tailings Piles
IP-HS - Impoundment/Pond
IKMFFP - Former Fetilizer Plant
IKMGH- Glory Hole
IKMMP - Mine Plant
IKMMT - Main Tailings Pile
IKMOA - Operations Area
IKMOAM - Operations Area - Miscellaneous
IKMST - Small Tailings Pile
LCG - Lower Chaparral Gulch
LCGDC - Lower Chaparral Gulch Dam-Confluence
MCG - Middle Chaparral Gulch
UCG - Upper Chaparral Gulch

Legend

AMD Acid Mine Drainage

Humboldt Smelter

Iron King Mine

Soil, Tailings, Terrestrial Sediment, and Aquatic Sediment Areas that are shaded have a cancer risk > 1E-04 or a noncancer hazard > 10. Some areas also have a lead screening level exceedance.

Aquatic Sediment

Soil, Tailings and Terrestrial Sediment, 0-2 ft bgs

Soil, Tailings and Terrestrial Sediment, 0-10 ft bgs

Waterways
Chaparral Gulch, Galena Gulch, Agua Fria River

Note:
Buildings and structures within the Humboldt Smelter AOI are subject to Remedial Alternatives

0 1,000
Feet

EPA Identification Number: AZ0000309013

Aerial Photo Source: Yavapai County GIS, 2007
Basemap Source: ESRI StreetMap, 2006

Figure 6 - Key Site Characteristics
Remedial Alternatives Evaluation

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

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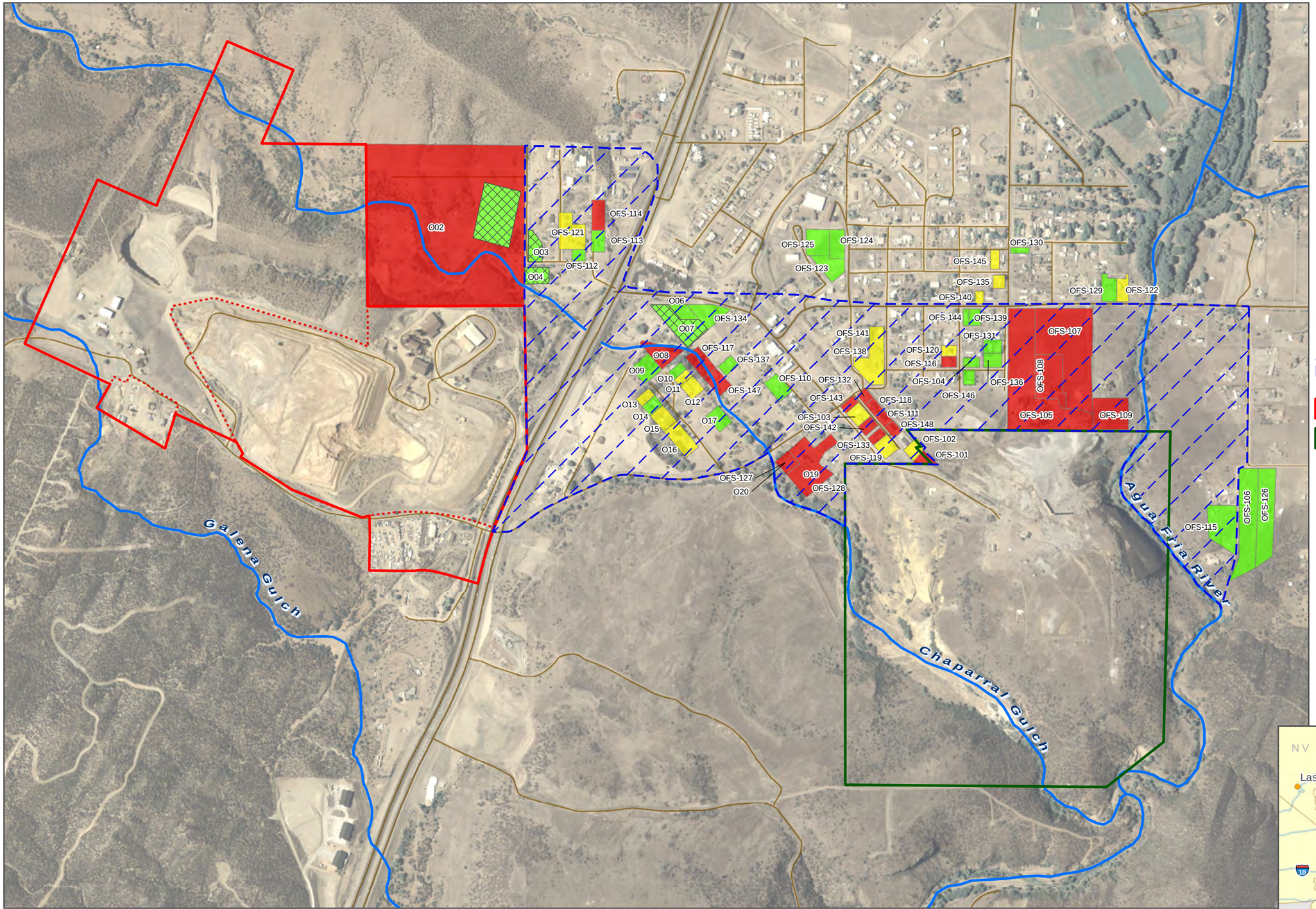

Legend

- Road Centerlines
- Waterways
  Chaparral Gulch, Galena Gulch, Agua Fria River
- Cancer risk > 1E-04, noncancer hazard > 10, or lead screening level exceedance
- Lead screening level exceedance, but cancer risk < 1E-04 and a noncancer hazard < 10
- Cancer risk < 1E-04, noncancer hazard < 10, and no lead screening level exceedance
- Properties Remediated during EPA Removal Action
- Additional characterization may be conducted (boundaries are approximate)
- Iron King Mine
- Humboldt Smelter

0 500 1,000
Feet

EPA Identification Number: AZ0000309013

Aerial Photo Source: Yavapai County GIS, 2007
Basemap Source: ESRI StreetMap, 2008

Figure 7 - Key Site Characteristics for In-Town Soil Parcels

Remedial Alternatives Evaluation

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

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Figure 8 – Arsenic in Ground Water

Remedial Alternatives Evaluation

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

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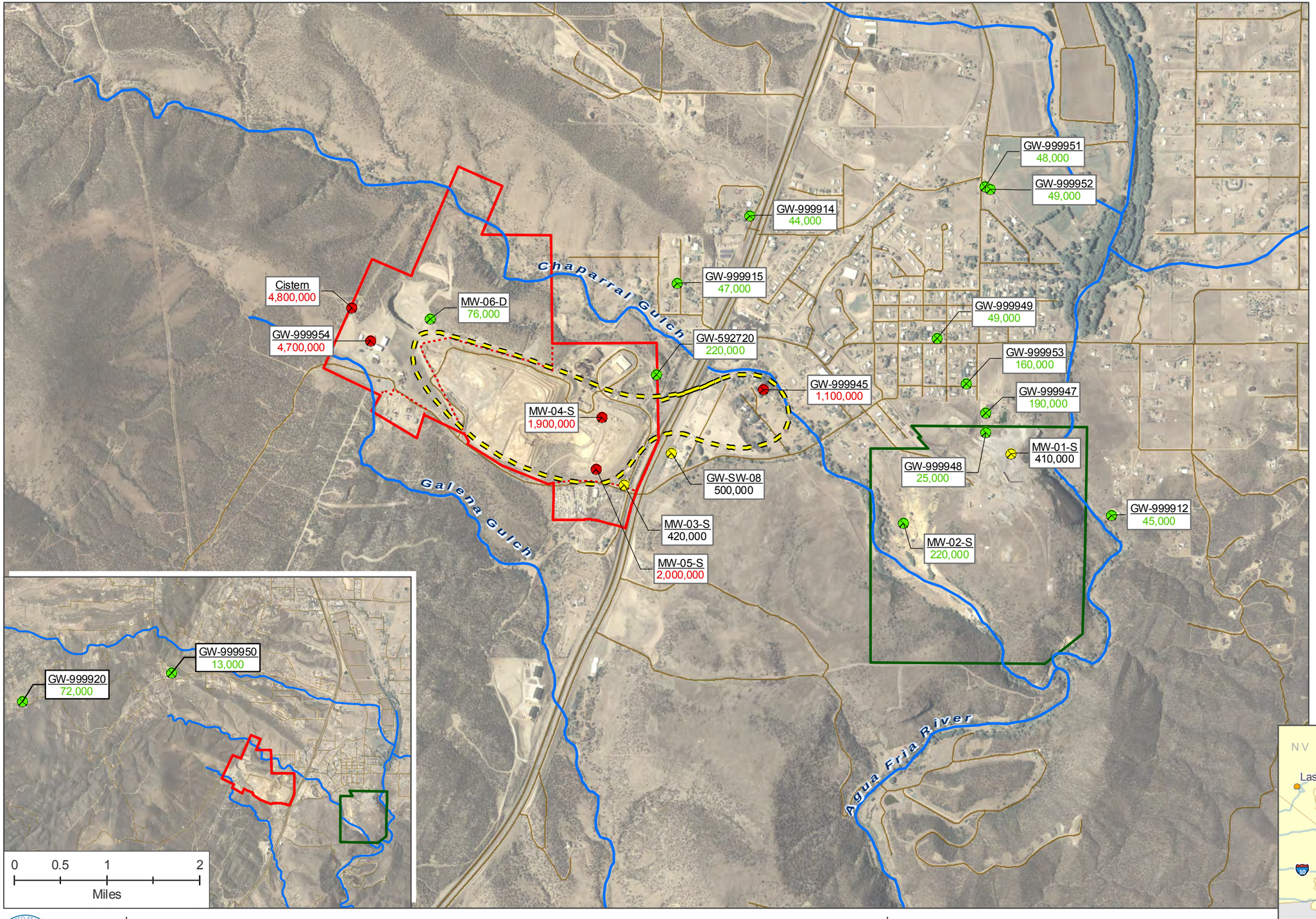

Legend

Ground Water Sample Location

"Sample Identification"
"Concentration"

"Concentration"
units = µg/L - Microgram per Liter
Green less than or equal to NSDWR
Black between MCL and 2 times NSDWR
Red greater than 2 times NSDWR

Approximate Plume Boundaries

Road Centerlines

Waterways
Chaparral Gulch, Galena Gulch, Agua Fria River

Iron King Mine

Humboldt Smelter

Notes
NSDWR= National Secondary Drinking Water Standards 250,000 µg/L

0 1,000 2,000
Feet

EPA Identification Number: AZ0000309013

Aerial Photo Source: Yavapai County GIS, 2007
Basemap Source: ESRI StreetMap, 2008

Figure 9 – Sulfate in Ground Water

Remedial Alternatives Evaluation

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

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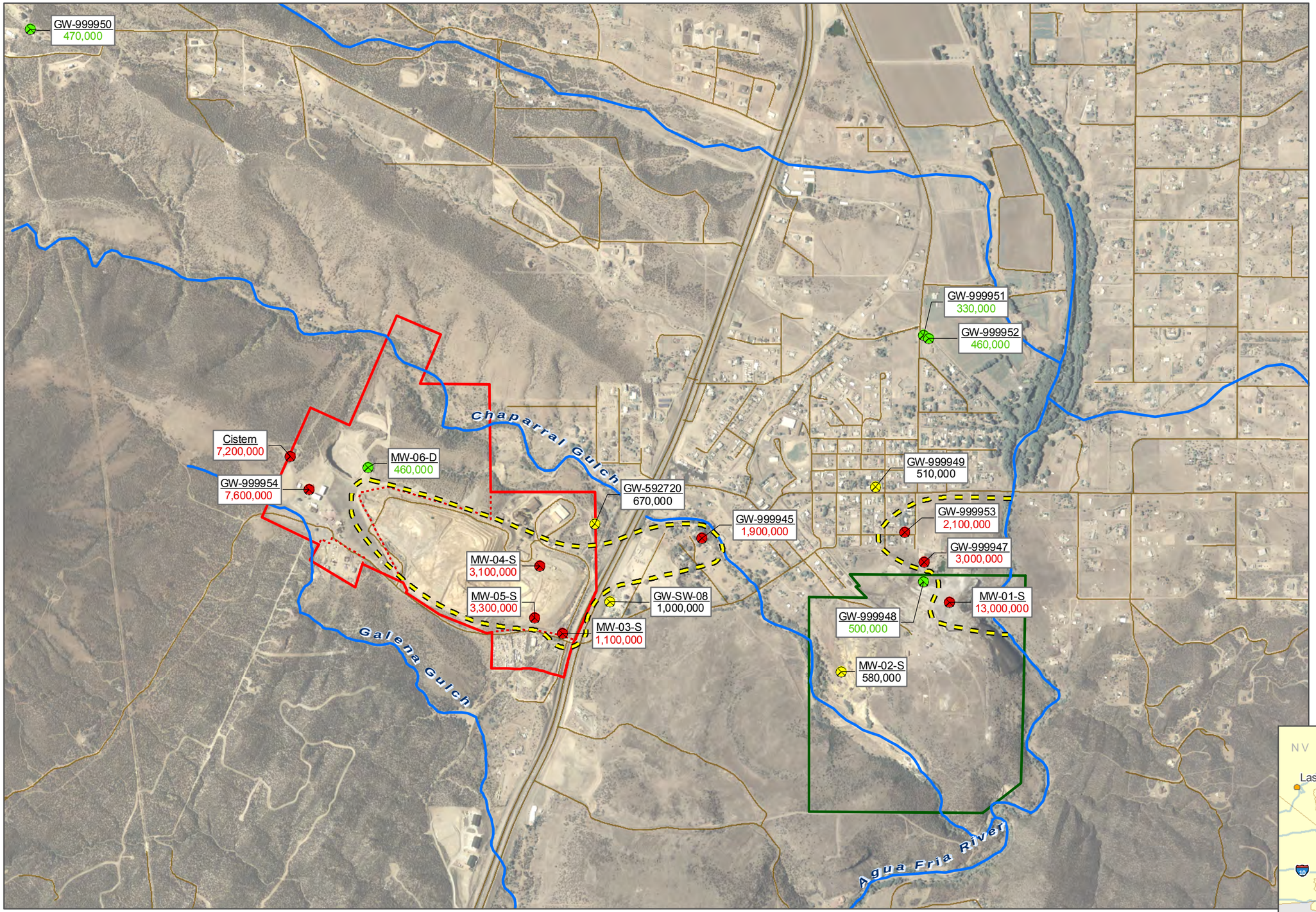

Legend

Ground Water Sample Location

"Sample Identification"
"Concentration"

"Concentration"
units = µg/L - Microgram per Liter
Green less than or equal to NSDWR
Black between MCL and 2 times NSDWR
Red greater than 2 times NSDWR

Approximate Plume Boundaries

Road Centerlines

Waterways
Chaparral Gulch, Galena Gulch, Agua Fria River

Iron King Mine

Humboldt Smelter

Notes
NSDWR = National Secondary Drinking Water Standards 500,000 µg/L

0 500 1,000 2,000
Feet

EPA Identification Number: AZ0000309013

Aerial Photo Source: Yavapai County GIS, 2007
Basemap Source: ESRI StreetMap, 2008

Figure 10 – Total Dissolved Solids in Ground Water

Remedial Alternatives Evaluation

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

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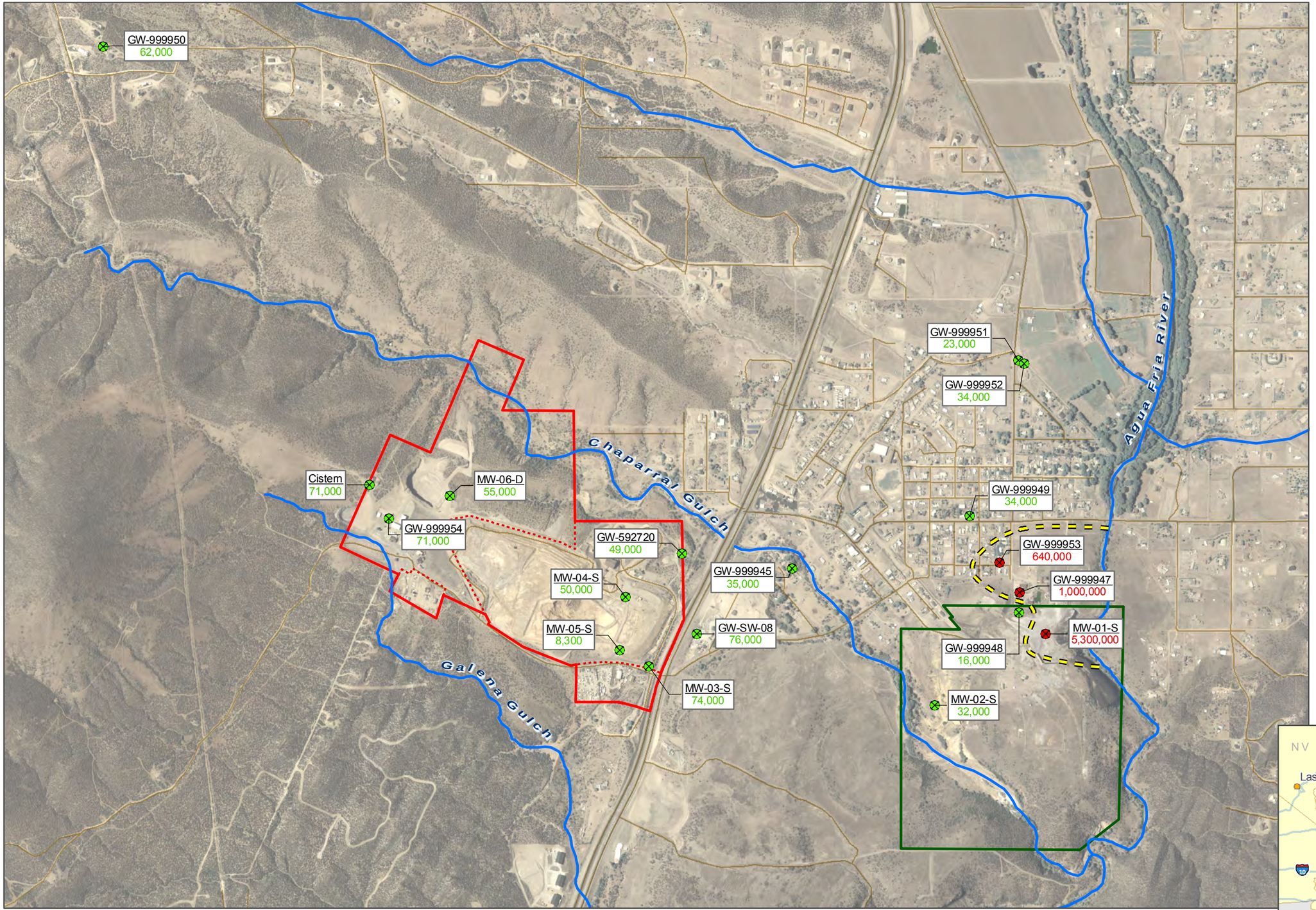

Legend

- Ground Water Sample Location
- "Sample Identification" "Concentration"

"Concentration"
units = µg/L - Microgram per Liter
Green less than or equal to NSDWR
Black between MCL and 2 times NSDWR
Red greater than 2 times NSDWR

- Approximate Plume Boundaries
- Road Centerlines
- Waterways
  Chaparral Gulch, Galena Gulch, Agua Fria River
- Iron King Mine
- Humboldt Smelter

Notes
NSDWR = National Secondary Drinking Water Standards 250,000 µg/L

0 1,000 2,000
Feet

EPA Identification Number: AZ0000309013

Aerial Photo Source: Yavapai County GIS, 2007
Basemap Source: ESRI StreetMap, 2008

Figure 11 – Chloride in Ground Water

Remedial Alternatives Evaluation

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

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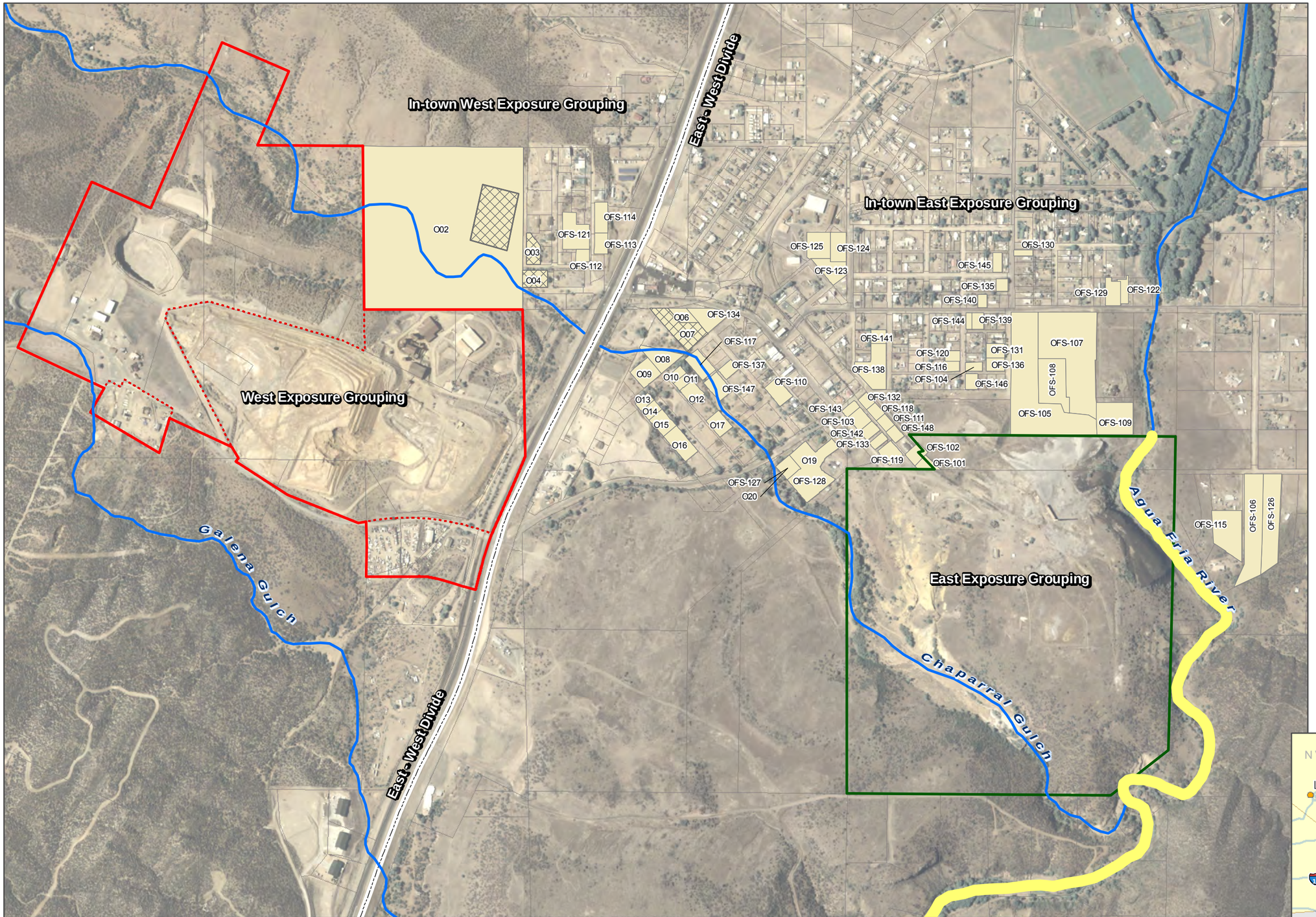

Legend

- Agua Fria River Exposure Grouping
- Waterways (Chaparral Gulch, Galena Gulch, Agua Fria River)
- Humboldt Smelter
- Iron King Mine
- Parcels
- Properties Remediated during EPA Removal Action
- Residential Sampled Properties

0 1,000
Feet

EPA Identification Number: AZ0000309013

Aerial Photo Source: Yavapai County GIS, 2007
Basemap Source: ESRI StreetMap, 2008

Figure 12 – Ecological Exposure Groupings for the Site
Remedial Alternatives Evaluation

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

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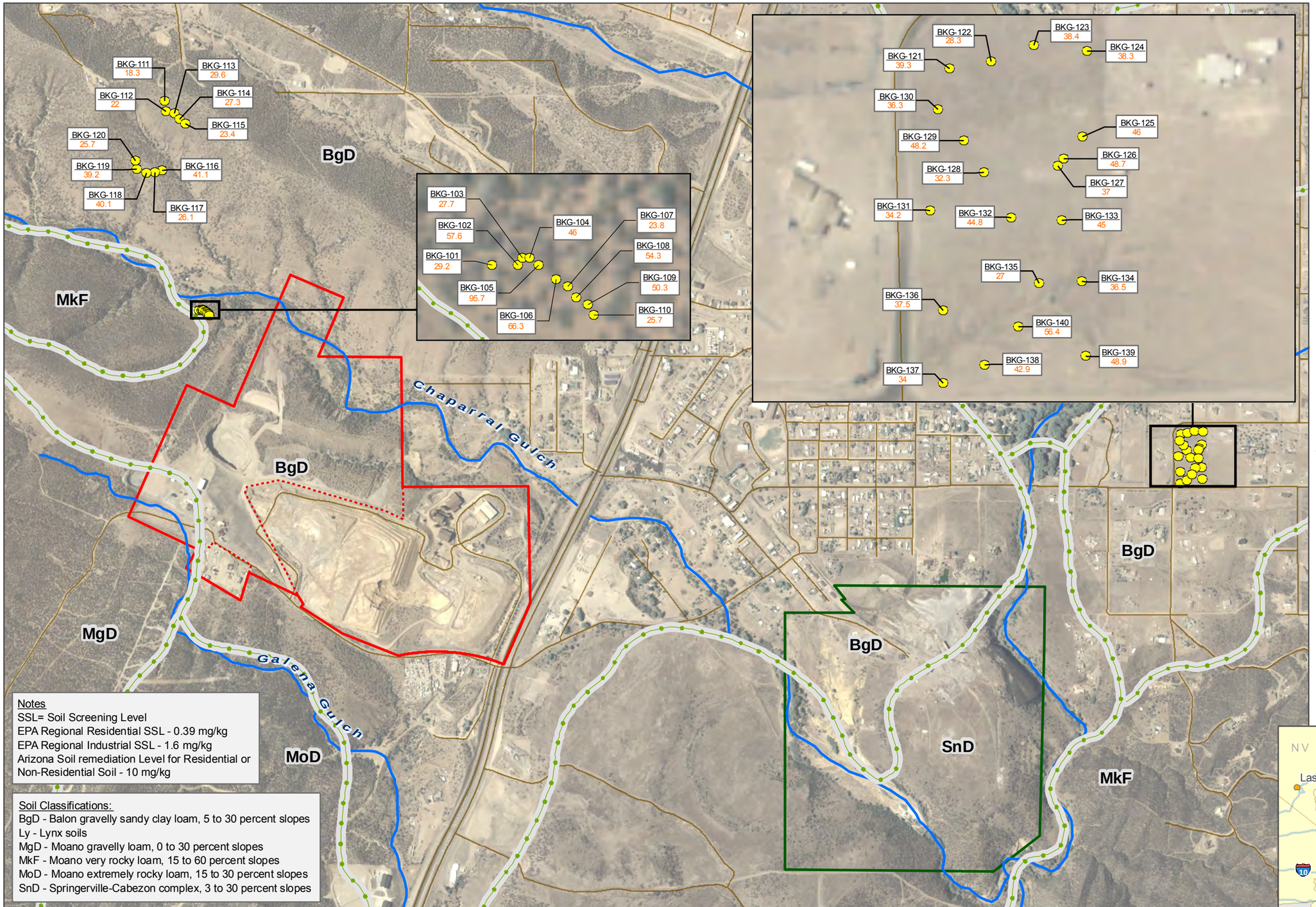

Notes
SSL= Soil Screening Level
EPA Regional Residential SSL - 0.39 mg/kg
EPA Regional Industrial SSL - 1.6 mg/kg
Arizona Soil remediation Level for Residential or Non-Residential Soil - 10 mg/kg

Soil Classifications:
BgD - Balon gravelly sandy clay loam, 5 to 30 percent slopes
Ly - Lynx soils
MgD - Moano gravelly loam, 0 to 30 percent slopes
MkF - Moano very rocky loam, 15 to 60 percent slopes
MoD - Moano extremely rocky loam, 15 to 30 percent slopes
SnD - Springerville-Cabezon complex, 3 to 30 percent slopes

Legend

Soil Sample Location

"Sample Identification"
"Concentration"

"Concentration"
units = mg/kg - milligrams per kilogram
Grey non-detect
Green < 10x Residential and Industrial SSL
Orange < 100x Industrial SSL
Red > 100x Industrial SSL

Waterways
Chaparral Gulch, Galena Gulch, Agua Fria River

Road Centerlines

Iron King Mine

Humboldt Smelter

Soil Classification Area

BgD Soil Classification Text

Notes:
The BTV (Background Threshold Value) is 91 mg/kg. 95%UCLM (Upper Confidence Limit of the Mean) is 61 mg/kg.

0 1,000
Feet

EPA Identification Number: AZ0000309013

Aerial Photo Source: Yavapai County GIS, 2007
Basemap Source: ESRI StreetMap, 2008

Figure 13 - Background Arsenic Concentrations, Soil Type 1

Remedial Alternatives Evaluation

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

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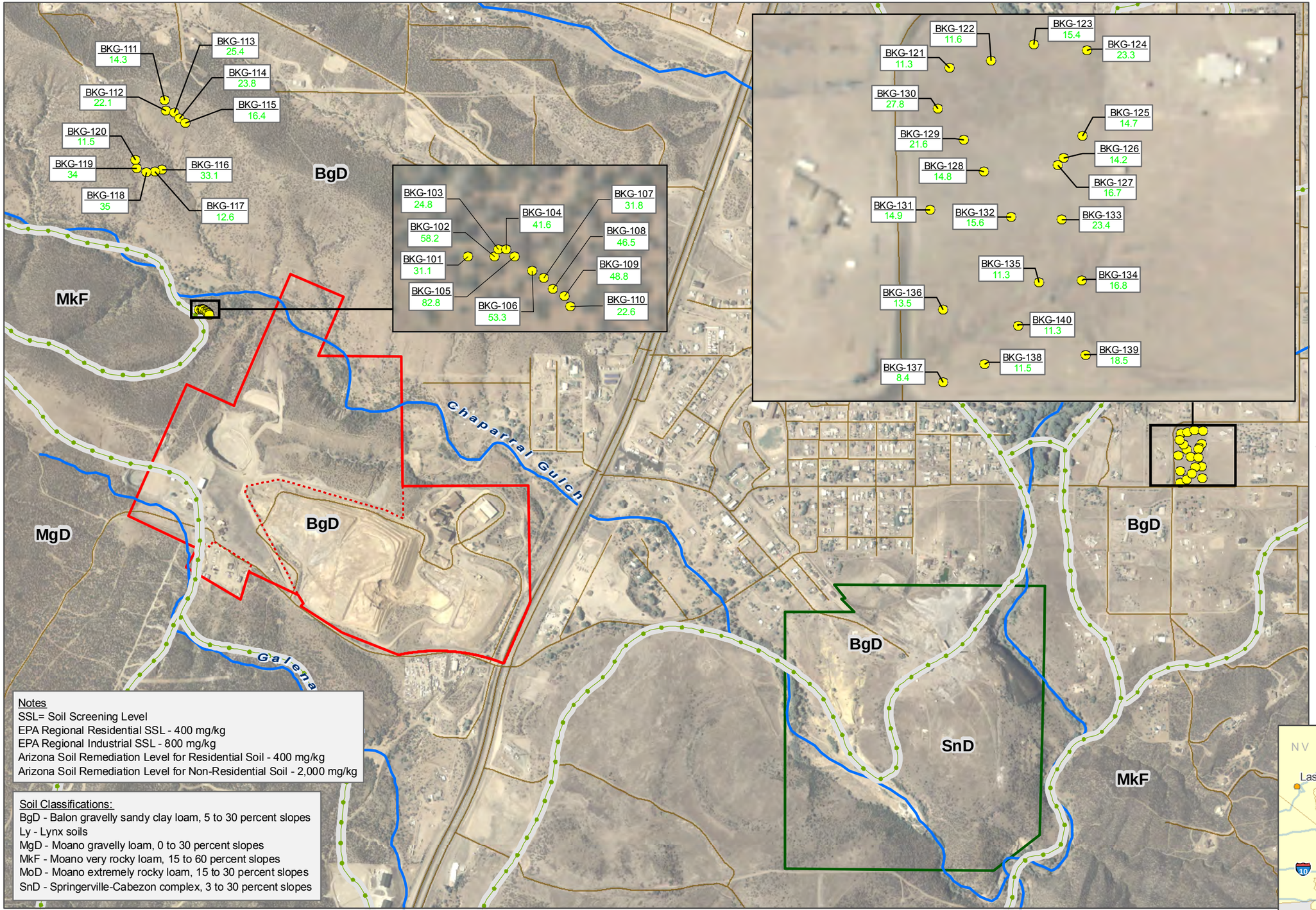

Notes
SSL= Soil Screening Level
EPA Regional Residential SSL - 400 mg/kg
EPA Regional Industrial SSL - 800 mg/kg
Arizona Soil Remediation Level for Residential Soil - 400 mg/kg
Arizona Soil Remediation Level for Non-Residential Soil - 2,000 mg/kg

Soil Classifications:
BgD - Balon gravelly sandy clay loam, 5 to 30 percent slopes
Ly - Lynx soils
MgD - Moano gravelly loam, 0 to 30 percent slopes
MkF - Moano very rocky loam, 15 to 60 percent slopes
MoD - Moano extremely rocky loam, 15 to 30 percent slopes
SnD - Springerville-Cabezon complex, 3 to 30 percent slopes

Legend

- Soil Sample Location
- "Sample Identification" "Concentration"

"Concentration"
units = mg/kg - milligrams per kilogram
Grey non-detect
Green less than Residential SSL
Orange less than Industrial SSL
Red greater than Industrial SSL

- Waterways: Chaparral Gulch, Galena Gulch, Agua Fria River
- Road Centerlines
- Iron King Mine
- Humboldt Smelter
- Soil Classification Area
- BgD Soil Classification Text

Notes:
The BTV (Background Threshold Value) is 79 mg/kg. 95%UCLM (Upper Confidence Limit of the Mean) is 55 mg/kg.

0 1,000
Feet

EPA Identification Number: AZ0000309013

Aerial Photo Source: Yavapai County GIS, 2007
Basemap Source: ESRI StreetMap, 2008

Figure 14 – Background Lead Concentrations, Soil Type 1

Remedial Alternatives Evaluation

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

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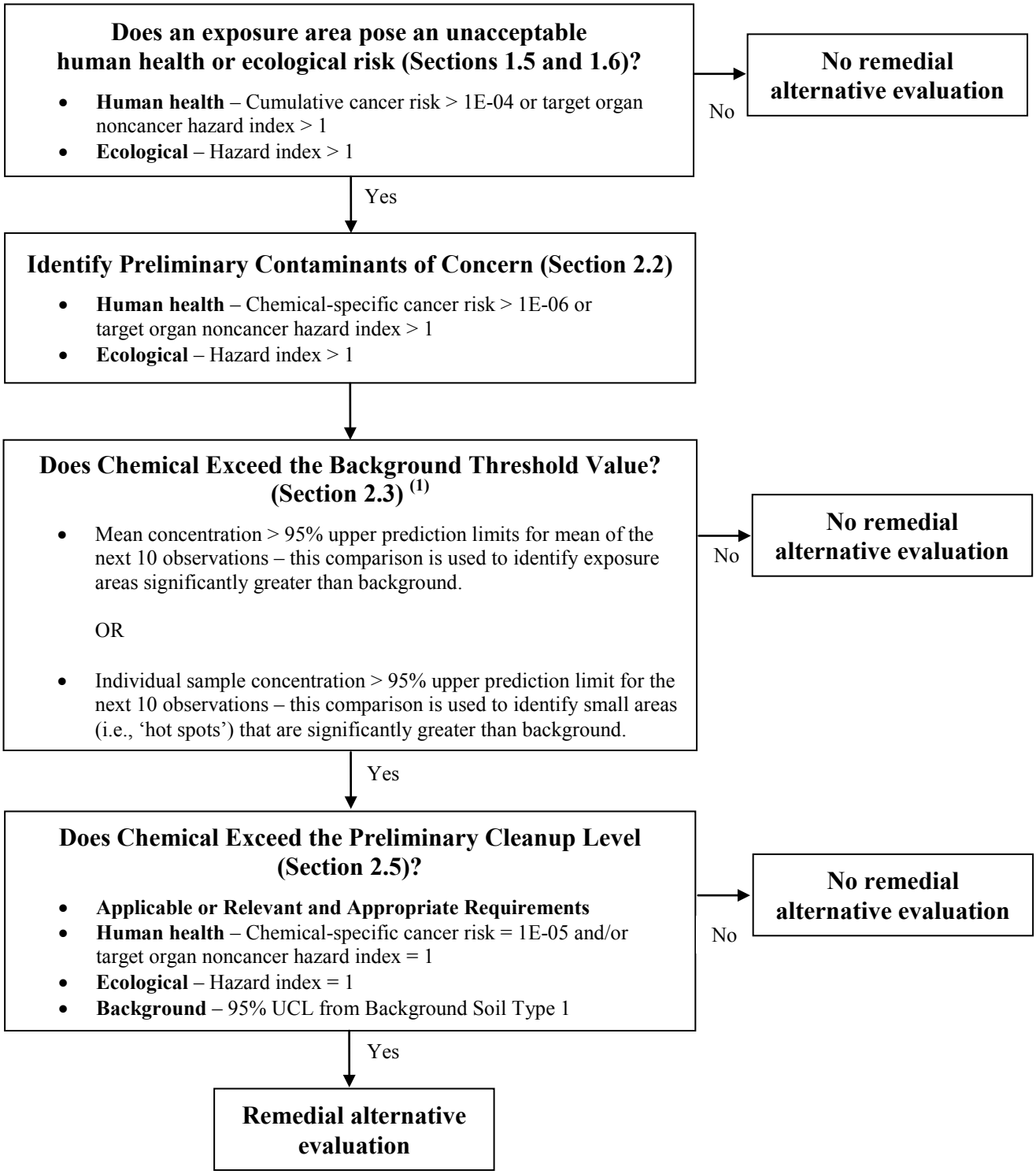

Arsenic and lead are the primary contaminants of concern because these inorganics are the most prevalent (in terms of human health and ecological risk) and are generally are co-located with other inorganic COPCs. Therefore, the exposure point concentration is compared to the Preliminary Cleanup Level to evaluate whether an exposure area is subject to a remedial alternative evaluation.

Notes:

(1) Areas may be evaluated using a two-population test if necessary.

(2) In-town parcels include a human health risk and background evaluation. The parcels do not include an ecological component because the habitat is poor for ecological receptors.

Figure 15 – Preliminary Cleanup Level Selection

Appendix A

Background Evaluation Report

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

Remedial Action Contract 2 Full Service
Contract: EP-W-06-004
Task Order: 0034-RICO-09MX

Prepared for

U.S. Environmental Protection Agency
Region 6
1445 Ross Avenue
Dallas, Texas 75202-2733

Prepared by

EA Engineering, Science, and Technology, Inc.
405 S. Highway 121
Building C, Suite 100
Lewisville, Texas 75067
(972) 315-3922

October 2010
Revision: 01
EA Project No. 14342.34

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   1.2 Data Quality Objectives 1

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1. INTRODUCTION

This document presents an analysis of the background soil and speciation data collected by EA Engineering, Science, and Technology, Inc. (EA) for the Iron King Mine – Humboldt Smelter Superfund Site (Site) located in Dewey-Humboldt, Yavapai County, Arizona. The background soil data sets consist of analytical data collected during the Remedial Investigation/Feasibility Study (RI/FS) field investigation. EA produced this report for the U.S. Environmental Protection Agency (EPA) Region 6 as part of Task Order No. 0034-RICO-00MX under Remedial Action Contract No. EP-W-06-004. This revised background evaluation report (Revision 02) is an update to the original background evaluation report contained in the Remedial Investigation Report (EA 2010).

The purpose and data quality objectives (DQOs) are provided in Sections 1.1 and 1.2. The site setting is provided in Section 2. A summary of the background soil field investigation is provided in Section 3. Section 4 contains analytical data quality information. The development of background threshold values (BTVs) is provided in Section 5. Section 6 presents the geochemical evaluation. An analysis of the lead and arsenic geochemical speciation results are contained in Section 7. References are provided in Section 8.

1.1 PURPOSE

The purpose of this report was to develop BTVs to help determine if soil data collected at the Site is impacted from activities related to historic operations at the Iron King Mine, Humboldt Smelter, or ancillary associated properties. To aid in this evaluation, BTVs and 95 percent upper confidence limit on the arithmetic mean (95% UCL) were calculated.

1.2 DATA QUALITY OBJECTIVES

The DQO process is a series of planning steps designed to ensure that the type, quantity, and quality of environmental data used in decision-making are appropriate for the intended application. The project-specific DQOs for the RI/FS process were developed and presented in the SAP (EA 2008b). The methods and techniques required to yield analytical data of acceptable quality and quantity to support DQOs are also outlined in the SAP.

The principal study questions for the Site derived from the DQO process are as follows:

> ***What are the nature and extent of air, soil, sediment, surface water, and ground water contamination at the Areas of Interest (AOI)?***

What are the migration pathways for these contaminants to be transported to other AOIs?

Are concentrations of AOI contaminants of potential concern (COPCs) significantly greater than background?

What is the potential risk to human health and ecological receptors from exposure to Site related COPCs at the AOIs?

In order to address these study questions and focus the investigation, a conceptual site model (CSM) was presented in Appendix B of the SAP (EA 2008b). The CSM was then used to outline the collection of soil samples.

2. SITE SETTING

This section presents a summary of the site setting for the background soil investigation conducted for the EPA RI investigation.

2.1 SITE LOCATION AND DESCRIPTION

The Site is located in Dewey-Humboldt, Yavapai County, Arizona. 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. Three waterways (Chaparral Gulch, Galena Gulch, and Agua Fria River) also transect the Site.

During the course of the investigation, EPA identified five Areas of Interest (AOI):

- **Iron King Mine** – Includes the Iron King Mine Proper Area, Iron King Mine Operations Area, Former Fertilizer Plant Area, Salvage Yard, and ancillary associated properties
- **Humboldt Smelter** – Includes ancillary associated properties
- **Waterways** – Includes the Chaparral Gulch, Galena Gulch, Agua Fria River, and adjoining drainage channels and outfalls
- **Off-site Soil** – Includes residential, background, and ancillary properties
- **Ground Water** – Includes shallow alluvium 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 have migrated onto the Humboldt Smelter property via the Chaparral Gulch; (4) the Agua Fria River and its contributing waterways (e.g., Chaparral Gulch and Galena Gulch) have impacts from both the Iron King Mine and Humboldt Smelter; and (5) ground water has been impacted from both the Iron King Mine and Humboldt Smelter.

2.2 GEOLOGY

A geologic map of the Bradshaw Mountain Quadrangle was published by the United State Geographic Survey (USGS) in 1905 (Jagger and Panache 1905.). Lindgren briefly described the geology of the Site with his focus being on the ore deposits of the region (1926). Creasy (1952) prepared a more detailed summary of the regional geology as part of his doctorate thesis. Additional geologic information is provided in electronic form in Appendix A-7 of EA 2010.

A geologic map of the area in the vicinity of the Site was prepared by the USGS (see Appendix A-7 of EA 2010). In general, the Site is underlain by the Tertiary Hickey Formation, which is a series of undifferentiated volcanic units, sedimentary interbeds, and rhyolitic tuffs. The Hickey Formation overlies a suite of Precambrian metamorphic rocks, primarily andesitic breccias and tuffs (Creasy 1952). The breccias are thought to be on the order of 4,000 feet (though almost vertical in the vicinity of the Site), while the tuffs may be closer to 6,000 feet thick. Most of the mineralization at the Iron King Mine is associated with hydrothermal veins in the form of a massive sulfide deposit that trends along the primary foliations in the rocks. Minerals mined at the Site have included copper, gold, lead, silver, and zinc. The rocks are highly foliated, with associated joints and fractures likely influencing ground water flow.

2.2.1 Bedrock

The site is underlain by the Paleoproterozoic (Precambrian) Yavapai metamorphic complex, which includes mafic to intermediate volcanic rocks, volcaniclastic, and sedimentary rocks that are intruded by calc-alkalic igneous rocks (Eisele and Isachsen, 2001). The volcanics and sedimentary rocks have been metamorphosed to green schist and amphibolite grade phyllites, schists, and gneisses. Within the vicinity of the site, Precambrian rocks have been intruded by Tertiary andesite porphyry, which resulted in the hydrothermal activity that resulted in ore genesis. Precambrian schists (similar to the geologic unit formerly known as the Pinal schist in Arizona) and Tertiary volcanic rocks are the primary hosts for the Iron King Mine ore deposits. Tectonic activity resulted in fractures that primarily followed the foliation planes of the Precambrian schists in the area and became preferred pathways for flow of hydrothermal ore-forming fluids.

2.2.2 Alluvial deposits

The native sediments are mostly composed of gray to rusty brown Tertiary gravels, gravelly sands and gravelly silts (identified as Trx in Appendix A-6 figures of EA 2010) using the nomenclature in the Roadside Geology of Arizona (Chronic, 1983). These materials were likely deposited as bolson fill during basin and range rifting. The coarse particles (gravel to boulder sized) are identified as metamorphic schist (Precambrian Pinal schist), andesite porphyry

(probably related to other porphyry systems throughout Arizona that are Tertiary in age), granodiorite (unknown age, but probably Precambrian), and vein quartz. The fine matrix is mostly composed of medium to fine quartz plus feldspar sand and silt formed from the erosion of micas. In some localized areas the sediments are cemented by caliche.

2.3 SOILS

A site-specific soils resources report was prepared for the Site by the Natural Resources Conservation Service (NRCS) of the United States Department of Agriculture (USDA) (USDA 2008). The Site and surrounding area was broken into a total of 11 map units, based on grain size and slope angle. Of these 11 units, three units the Balon gravelly sandy clay loam (BgD), the Moano gravelly loam (MgD), and the Moano very rocky loam (MkF), encompass approximately 70 percent of the surface area in the immediate vicinity of the Site (see Figure 1).

The BgD map unit is interpreted as being the dominant soil type at the Iron King Mine, Humboldt Smelter, Off-site Soil, and Waterway AOIs. It consists of precambrian granite, gneiss, and schist (Chronic 1983). Soils primarily consist of well-drained, shallow soils and rock outcrop on semiarid, mid-elevation hills and mountains. These soils formed in residuum weathered from granite, gneiss, rhyolite, andesite, tuffs, limestone, sandstone, and basalt (Hendricks 1985). These soils are very deep, well-drained soils that formed in mixed fan alluvium dominantly from schist, granite, basalt and related rocks. Slopes are generally 2 to 25 percent. Additional information regarding regional soils is provided in the NRCS soil resource report that is in electronic form in Appendix A-7 of EA 2010.

Because the BgD map unit is interpreted as being the dominant soil type at the Iron King Mine, Humboldt Smelter, Off-site Soil, and Waterway AOIs, the Background Soil Type 1 dataset was used to evaluate background contributions in the remedial decision process.

3. BACKGROUND SOIL FIELD INVESTIGATION

This section presents a summary of the background soil field investigation activities for the EPA RI investigation.

3.1 BACKGROUND SURFACE SOIL SAMPLING

Background refers to substances or locations that are not influenced by the releases from a Site and are usually described as naturally occurring or anthropogenic (EPA 2002b).

- Naturally Occurring – Substances present in the environment in forms that have not been influenced by human activity

- Anthropogenic – Natural and human-made substances present in the environment as a result of human activities (not specifically related to the CERCLA Site in question).

Some chemicals may be present in background as a result of both natural and man-made conditions (such as naturally occurring arsenic and arsenic from pesticide applications or smelting operations).

Background samples are collected to evaluate the naturally occurring and anthropogenic contributions to Site media. Generally, the type of background substance (natural or anthropogenic) does not influence the statistical or technical method used to characterize background concentrations. For comparison purposes soil samples should have the same basic characteristics as the site sample (i.e., similar soil depths and soil types).

3.2 SAMPLE LOCATION SELECTION

Three off-site surface soil types (i.e., Background Soil Type 1 through 3) were sampled to evaluate whether soil concentrations in the vicinity of the Site are consistent with background concentrations. Background Soil Type 1 is Balon gravelly sandy loam, Soil Type 2 is Moano gravelly loam, and Soil Type 3 is Springerville-Cabezon complex (see Figure 1). In addition, bedrock samples were collected to evaluate the native material at the Site.

The Background Soil Type 1 through 3 locations were selected by a background workgroup that consisted of representatives from the EPA, ADEQ, Bureau of Land Management, University of Arizona, and EA. Locations were selected based on the dominant geologic formations and soil types of the area. Other considerations included proximity to the Site, distance from other anthropogenic disturbances, as well as accessibility (minor influence).

It should be noted that two groups of background soil samples were collected during previous investigations (i.e., Background H1 and H2). However, the Background H1 samples were collected in a former Iron King Mine storm water migration pathway (see Aerial Photographic Analysis of Iron King Mine/Humboldt Smelter Superfund Site [EPA 2008a] in Appendix A-1). Similarly, the Background H2 samples were collected downwind of the Iron King Mine. It is likely that the elevated concentrations of metals in these two areas have some anthropogenic contributions of metals from Iron King Mine migration pathways and therefore were not included in the development of BTVs. In addition, information from Background Soil Types 2 and 3 were not further evaluated below because the Background Soil Type 1 was interpreted as being the dominant soil type at the Iron King Mine, Humboldt Smelter, Off-site Soil, and Waterway AOIs.

3.3 BACKGROUND SAMPLE COLLECTION

Background soil samples were collected from the surface (0 – 2 feet bgs). This depth interval was considered appropriate by the background workgroup because it was consistent with the surface soil depth intervals used in the RI and the deeper soils (e.g., greater than 2 feet bgs) were consistent with those found near the surface. The background soil samples were analyzed for TAL metals analysis.

The Sampling and Analysis Plan (EA 2008b) recommends that statistical approaches be consistent with EPA guidance, including ProUCL 4.0 User Guide (Singh, Singh, and Maichle

2007). This guidance recommends that a minimum of 8 to 10 samples are necessary for confident statistical evaluations.

In 2008, 10 background soil samples were collected from each of the three background soil types (see Figure 1). The range of arsenic and lead concentrations in soil demonstrates that there is a great variability in concentrations in the native material of the area of the Site. Also, background contributions are important to the overall discussion of risk estimates and risk management for the Site.

Because the Background Soil Type 1 (i.e., BgD) is interpreted as being the dominant soil type for the Iron King Mine, Humboldt Smelter, Off-site Soil, and Waterways AOIs, 30 additional background soil samples were collected in 2010 from Background Soil Type 1 to supplement the 10 samples that were collected in 2008 (see Figures 2 and 3).

3.4 BACKGROUND SOIL DATA SUMMARY

A summary of the soil background datasets collected during the EPA RI field investigation are provided in Tables 1 through 3. Because the Background Soil Type 1 (i.e., BgD) is interpreted as being the dominant soil type for the Iron King Mine, Humboldt Smelter, Off-site Soil, and Waterways AOIs, the Background Soil Type 1 dataset was used to evaluate background contributions in the remedial decision process.

Because Background Soil Type 1 is so integral to the risk management process, the dataset was evaluated for potential outliers via the Dixon and Rosner tests using ProUCL Version 4.0 (Singh, A., Singh, A.K., and R.W. Maichle 2007). The sample collected at BKG-105, which had an arsenic concentration of 95.7 mg/kg was identified as a potential outlier so was eliminated from further consideration. Therefore, the Background Soil Type 1 dataset used to develop BTVs and 95%UCLs only had 39, instead of 40 datapoints. No other outliers were identified for the Background Soil Type 1 dataset.

4. BACKGROUND THRESHOLD VALUES

This section presents the calculation of BTVs for each of the background soil metals. BTV were calculated for the Background Soil Type 1. The BTVs were calculated as the 95% Upper Prediction Limit (UPL) for the mean and the 95% UPL for a single independent observation for the next 10 samples (see Table 4). This background evaluation includes a two-phase approach to determine if an exposure area is significantly greater than background.

- In the first comparison, the mean Site exposure area concentration is compared against the 95% UPL for the mean of the next 10 observations. This comparison is used to evaluate whether exposure areas are significantly greater than background on a central tendency basis.

- In the second comparison, which evaluates whether small areas (i.e., hot spots) are significantly greater than background, the individual sample concentration is compared against the 95% UPL for the next 10 observations. This comparison is used to evaluate whether exposure areas are significantly greater than background based on the upper tail of the statistical distribution.

For a given metal, the BTV represents a threshold value that indicates the sample dataset is not consistent with background. In other words, exceedance of the BTV indicates that the soil was considered significantly greater than background soil.

5. BACKGROUND 95%UCLS

A 95 percent upper confidence limit on the arithmetic mean (95% UCL) was calculated using ProUCL Version 4.0 (Singh, A., Singh, A.K., and R.W. Maichle 2007). The lower of the 95% UCL and the maximum concentration was used as the Preliminary Cleanup Level for Background Soil Type 1. Statistical estimations for data sets with a few number of detected samples (i.e., less than 4) lack statistical power and cannot be confidently estimated. The maximum detected concentration was therefore used as the EPC for these data sets. The 95%UCLs for Background Soil Type 1 are presented in Table 5.

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TABLES

TABLE 1
BACKGROUND SOIL TYPE 1

CAS Number	Chemical	Maximum Detected Concentration	Maximum Detected Qualifier	Units	Detection Frequency	Average Detected Concentration
7429-90-5	ALUMINUM	2.49E+04		mg/kg	39 / 39	1.67E+04
7440-36-0	ANTIMONY	1.00E+00	J	mg/kg	39 / 9	8.61E-01
7440-38-2	ARSENIC	6.63E+01		mg/kg	39 / 39	3.78E+01
7440-39-3	BARIUM	3.73E+02		mg/kg	39 / 39	2.08E+02
7440-41-7	BERYLLIUM	8.60E-01		mg/kg	39 / 32	4.44E-01
7440-43-9	CADMIUM	2.60E+00		mg/kg	39 / 30	1.64E+00
7440-70-2	CALCIUM	6.89E+04		mg/kg	39 / 39	1.19E+04
7440-47-3	CHROMIUM	5.77E+01		mg/kg	39 / 39	2.77E+01
7440-48-4	COBALT	1.98E+01		mg/kg	39 / 39	1.41E+01
7440-50-8	COPPER	1.09E+02	J-	mg/kg	39 / 39	5.84E+01
57-12-5	CYANIDE	2.70E-01	J		39 / 1	2.67E+00
7439-89-6	IRON	3.73E+04		mg/kg	39 / 39	2.95E+04
7439-92-1	LEAD	5.82E+01		mg/kg	39 / 39	2.32E+01
7439-95-4	MAGNESIUM	1.35E+04		mg/kg	39 / 39	7.52E+03
7439-96-5	MANGANESE	2.47E+03		mg/kg	39 / 39	8.58E+02
7439-97-6	MERCURY	1.70E-01		mg/kg	39 / 19	9.91E-02
7440-02-0	NICKEL	5.29E+01		mg/kg	39 / 39	2.78E+01
7440-09-7	POTASSIUM	4.00E+03		mg/kg	39 / 39	2.45E+03
7782-49-2	SELENIUM	1.20E+00	J	mg/kg	39 / 23	7.01E-01
7440-22-4	SILVER	1.30E+00		mg/kg	39 / 14	4.31E-01
7440-23-5	SODIUM	9.84E+01	J	mg/kg	39 / 37	4.84E+01
18785-72-3	SULFATE	8.60E+01			30 / 19	1.78E+01
7440-28-0	THALLIUM	6.10E+00	J	mg/kg	39 / 25	2.41E+00
7440-62-2	VANADIUM	8.34E+01		mg/kg	39 / 39	6.01E+01
7440-66-6	ZINC	2.32E+02		mg/kg	39 / 39	9.54E+01

Notes:
J = The analyte was positively identified; the quantitation is estimated.
mg/kg = Milligrams per kilogram.

TABLE 2
BACKGROUND SOIL TYPE 2

CAS Number	Chemical	Maximum Detected Concentration	Maximum Detected Qualifier	Units	Detection Frequency	Average Detected Concentration
7429-90-5	ALUMINUM	2.97E+04		mg/kg	10 / 10	1.94E+04
7440-36-0	ANTIMONY	2.20E+00	J	mg/kg	1 / 10	2.20E+00
7440-38-2	ARSENIC	2.27E+01		mg/kg	10 / 10	1.29E+01
7440-39-3	BARIUM	5.35E+02		mg/kg	10 / 10	1.98E+02
7440-41-7	BERYLLIUM	9.60E-01		mg/kg	8 / 10	5.65E-01
7440-43-9	CADMIUM	4.60E-01	J	mg/kg	1 / 10	4.60E-01
7440-70-2	CALCIUM	1.06E+04		mg/kg	10 / 10	6.82E+03
7440-47-3	CHROMIUM	2.62E+01		mg/kg	10 / 10	1.58E+01
7440-48-4	COBALT	3.99E+01		mg/kg	10 / 10	2.49E+01
7440-50-8	COPPER	4.24E+02	J	mg/kg	10 / 10	9.46E+01
7439-89-6	IRON	8.67E+04		mg/kg	10 / 10	5.20E+04
7439-92-1	LEAD	1.83E+01		mg/kg	10 / 10	1.03E+01
7439-95-4	MAGNESIUM	1.35E+04		mg/kg	10 / 10	8.58E+03
7439-96-5	MANGANESE	2.54E+03		mg/kg	10 / 10	1.19E+03
7439-97-6	MERCURY	5.10E-02	J	mg/kg	2 / 10	3.55E-02
7440-02-0	NICKEL	2.52E+01		mg/kg	10 / 10	1.61E+01
7440-09-7	POTASSIUM	1.16E+03		mg/kg	10 / 10	5.66E+02
7782-49-2	SELENIUM	1.60E+00	J	mg/kg	9 / 10	7.41E-01
7440-22-4	SILVER	2.60E+00		mg/kg	6 / 10	1.97E+00
7440-23-5	SODIUM	1.29E+02	J	mg/kg	10 / 10	8.18E+01
7440-28-0	THALLIUM	5.90E+00		mg/kg	9 / 10	3.31E+00
7440-62-2	VANADIUM	2.34E+02		mg/kg	10 / 10	1.28E+02
7440-66-6	ZINC	1.26E+02		mg/kg	10 / 10	8.99E+01

Notes:
J = The analyte was positively identified; the quantitation is estimated.
mg/kg = Milligrams per kilogram.

TABLE 3
BACKGROUND SOIL TYPE 3

CAS Number	Chemical	Maximum Detected Concentration	Maximum Detected Qualifier	Units	Detection Frequency	Average Detected Concentration
7429-90-5	ALUMINUM	4.82E+04		mg/kg	12 / 12	3.39E+04
7440-36-0	ANTIMONY	1.50E+00	J	mg/kg	1 / 5	1.30E+00
7440-38-2	ARSENIC	1.97E+01		mg/kg	12 / 12	1.23E+01
7440-39-3	BARIUM	2.02E+03	J	mg/kg	12 / 12	7.67E+02
7440-41-7	BERYLLIUM	1.30E+00		mg/kg	12 / 12	9.03E-01
7440-43-9	CADMIUM	3.50E-01	J	mg/kg	2 / 12	2.42E-01
7440-70-2	CALCIUM	2.63E+04		mg/kg	12 / 12	1.59E+04
7440-47-3	CHROMIUM	1.34E+02		mg/kg	12 / 12	6.10E+01
7440-48-4	COBALT	4.21E+01		mg/kg	12 / 12	2.97E+01
7440-50-8	COPPER	1.42E+02		mg/kg	12 / 12	8.63E+01
7439-89-6	IRON	4.22E+04		mg/kg	12 / 12	3.13E+04
7439-92-1	LEAD	2.29E+01	J	mg/kg	12 / 12	1.34E+01
7439-95-4	MAGNESIUM	4.62E+04		mg/kg	12 / 12	2.44E+04
7439-96-5	MANGANESE	1.07E+03		mg/kg	12 / 12	7.95E+02
7439-97-6	MERCURY	9.80E-02		mg/kg	4 / 12	4.28E-02
7440-02-0	NICKEL	2.66E+02	J	mg/kg	12 / 12	1.87E+02
7440-09-7	POTASSIUM	2.86E+03		mg/kg	12 / 12	1.41E+03
7782-49-2	SELENIUM	1.40E+00	J	mg/kg	11 / 12	6.75E-01
7440-22-4	SILVER	2.30E+00		mg/kg	10 / 12	1.52E+00
7440-23-5	SODIUM	5.99E+03		mg/kg	12 / 12	2.01E+03
7440-28-0	THALLIUM	4.30E+00		mg/kg	11 / 12	2.22E+00
7440-62-2	VANADIUM	9.85E+01		mg/kg	12 / 12	6.24E+01
7440-66-6	ZINC	9.65E+01		mg/kg	12 / 12	6.78E+01

Notes:
J = The analyte was positively identified; the quantitation is estimated.
mg/kg = Milligrams per kilogram.

Table 4. Exposure Point Concentration Summary for Background Soil Type 1 - Surface Soil

Chemical	Units	Number of Samples	Number of Detects	Arithmetic Detected Mean	Maximum Detected Concentration	95% UCLM	Reasonable Maximum Exposure		
							Medium EPC Value	Medium EPC Statistic	Medium EPC Rationale
ALUMINUM	mg/kg	39	39	1.67E+04	2.49E+04	1.77E+04	1.77E+04	95%UCLM-N	Regional Guidance
ANTIMONY	mg/kg	39	9	8.61E-01	1.00E+00	9.12E-01	9.12E-01	95%UCLM-KMt	Regional Guidance
ARSENIC	mg/kg	39	39	3.78E+01	6.63E+01	4.08E+01	4.08E+01	95%UCLM-N	Regional Guidance
BARIUM	mg/kg	39	39	2.08E+02	3.73E+02	2.27E+02	2.27E+02	95%UCLM-G	Regional Guidance
BERYLLIUM	mg/kg	39	32	4.44E-01	8.60E-01	4.73E-01	4.73E-01	95%UCLM-BCA	Regional Guidance
CADMIUM	mg/kg	39	30	1.64E+00	2.60E+00	1.61E+00	1.61E+00	95%UCLM-KMp	Regional Guidance
CALCIUM	mg/kg	39	39	1.19E+04	6.89E+04	2.44E+04	2.44E+04	95%UCLM-C	Regional Guidance
CHROMIUM	mg/kg	39	39	2.77E+01	5.77E+01	3.12E+01	3.12E+01	95% Modified-t UCL	Regional Guidance
COBALT	mg/kg	39	39	1.41E+01	1.98E+01	1.50E+01	1.50E+01	95%UCLM-N	Regional Guidance
COPPER	mg/kg	39	39	5.84E+01	1.09E+02	6.54E+01	6.54E+01	95%UCLM-G	Regional Guidance
CYANIDE	mg/kg	39	1	2.67E+00	2.70E-01	2.78E+00	2.70E-01	Maximum	N < 4
IRON	mg/kg	39	39	2.95E+04	3.73E+04	3.07E+04	3.07E+04	95%UCLM-N	Regional Guidance
LEAD	mg/kg	39	39	2.32E+01	5.82E+01	2.70E+01	2.70E+01	95%UCLM-L	Regional Guidance
MAGNESIUM	mg/kg	39	39	7.52E+03	1.35E+04	8.23E+03	8.23E+03	95%UCLM-G	Regional Guidance
MANGANESE	mg/kg	39	39	8.58E+02	2.47E+03	9.72E+02	9.72E+02	95%UCLM-G	Regional Guidance
MERCURY	mg/kg	39	19	9.91E-02	1.70E-01	9.52E-02	9.52E-02	95%UCLM-KMt	Regional Guidance
NICKEL	mg/kg	39	39	2.78E+01	5.29E+01	3.82E+01	3.82E+01	95%UCLM-C	Regional Guidance
POTASSIUM	mg/kg	39	39	2.45E+03	4.00E+03	2.64E+03	2.64E+03	95%UCLM-N	Regional Guidance
SELENIUM	mg/kg	39	23	7.01E-01	1.20E+00	7.64E-01	7.64E-01	95%UCLM-KMt	Regional Guidance
SILVER	mg/kg	39	14	4.31E-01	1.30E+00	5.11E-01	5.11E-01	95%UCLM-BCA	Regional Guidance
SODIUM	mg/kg	39	37	4.84E+01	9.84E+01	5.31E+01	5.31E+01	95%UCLM-KMt	Regional Guidance
SULFATE	mg/kg	30	19	1.78E+01	8.60E+01	3.41E+01	3.41E+01	97.5%UCLM-C	Regional Guidance
THALLIUM	mg/kg	39	25	2.41E+00	6.10E+00	2.51E+00	2.51E+00	95%UCLM-KMt	Regional Guidance
VANADIUM	mg/kg	39	39	6.01E+01	8.34E+01	6.35E+01	6.35E+01	95%UCLM-N	Regional Guidance
ZINC	mg/kg	39	39	9.54E+01	2.32E+02	1.07E+02	1.07E+02	95% Modified-t UCL	Regional Guidance

Definitions:

95%UCLM = 95 percent upper confidence limit of the mean

EPC = Exposure Point Concentration

mg/kg = milligrams per kilogram

USEPA = United States Environmental Protection Agency

Notes:

95%UCLM-G indicates that the 95 percent upper confidence limit on the mean is based on the approximate or adjusted gamma distribution.

95%UCLM-KMt indicates that the 95 percent upper confidence limit on the mean is based on the non-parametric Kaplan-Meier (KM) student's t-test.

95%UCLM-N indicates that the 95 percent upper confidence limit on the mean is based on the student's t-test for normal distributions.

95%UCLM-KMp indicates that the 95 percent upper confidence limit on the mean is based on the non-parametric Kaplan-Meier (KM) percentile boostrap test.

95%UCLM-L indicates that the 95 percent upper confidence limit on the mean is based on the Land (H) statistic for lognormal distributions.

95%UCLM-BCA indicates that the 95 percent upper confidence limit on the mean is based on the Kaplan-Meier (KM) Bias-Corrected Accelerated (BCA) percentile bootstrap test.

95%UCLM-C indicates that the 99 percent upper confidence limit on the mean is based on the non-parametric Chebyshev test.

97.5%UCLM-C indicates that the 99 percent upper confidence limit on the mean is based on the non-parametric Chebyshev test.

N < 4 indicates that the number of detected samples is less than 4, so the maximum detected value was used.

Table 5. Background Threshold Values

Analyte	Number of Samples	Number of Detects	Dataset Distribution	Maximum Detected Concentration (Qualifier)		Units	95% UPL for Single Observation	95% UPL for Mean of 10 Observations
Aluminum	39	39	Normal	24,900		mg/kg	26,765	18,920
Antimony	39	9	Nonparametric	1.0	J	mg/kg	1.1	0.91
Arsenic	39	39	Normal	66		mg/kg	68	44
Barium	39	39	Lognormal	373		mg/kg	461	239
Beryllium	39	32	Nonparametric	0.86		mg/kg	0.93	0.53
Cadmium	39	30	Nonparametric	2.6		mg/kg	2.8	1.8
Calcium	39	39	Assumed Lognormal	68,900		mg/kg	84,898	11,381
Chromium	39	39	Assumed Normal	58		mg/kg	63	35
Cobalt	39	39	Normal	20		mg/kg	23	16
Copper	39	39	Lognormal	109	J-	mg/kg	169	69
Cyanide (Total)	39	1	Nonparametric	0.27	J	mg/kg	Insufficient Detects	
Iron	39	39	Normal	37,300		mg/kg	41,044	32,032
Lead	39	39	Lognormal	58		mg/kg	80	27
Magnesium	39	39	Lognormal	13,500		mg/kg	17,467	8,665
Manganese	39	39	Lognormal	2,470		mg/kg	2,585	1,008
Mercury	39	19	Nonparametric	0.17		mg/kg	0.17	0.10
Nickel	39	39	Assumed Normal	53		mg/kg	69	37
Potassium	39	39	Normal	4,000		mg/kg	4,467	2,885
Selenium	39	23	Nonparametric	1.2	J	mg/kg	1.2	0.81
Silver	39	14	Nonparametric	1.3		mg/kg	0.57	0.57
Sodium	39	37	Nonparametric	98	J	mg/kg	102	59
Sulfate	30	19	Nonparametric	86		mg/kg	64	24
Thallium	39	25	Nonparametric	6.1	J	mg/kg	5.6	2.9
Vanadium	39	39	Normal	83		mg/kg	95	68
Zinc	39	39	Assumed Lognormal	232		mg/kg	208	110

Notes:

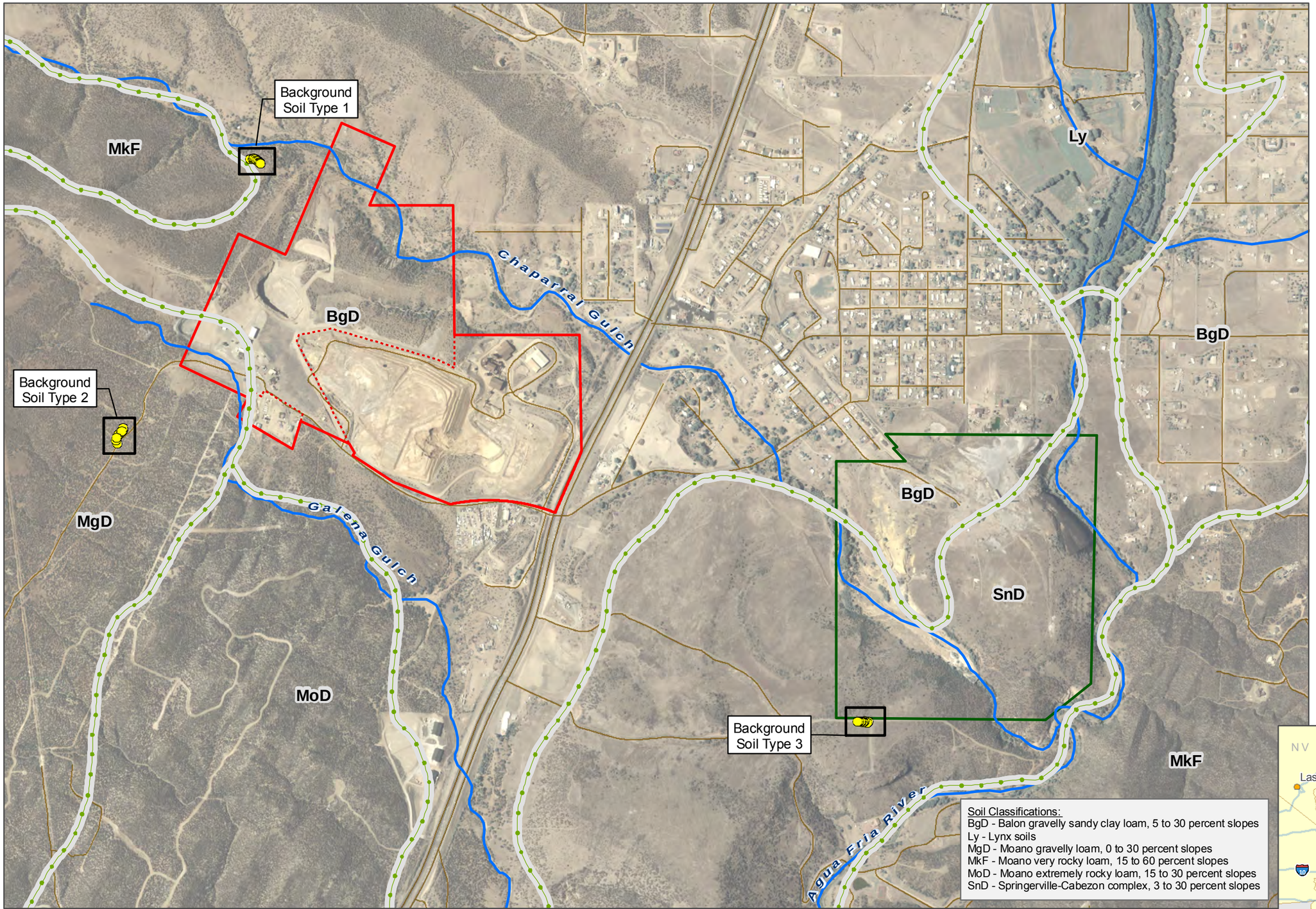
All values are presented in milligrams per kilogram (mg/kg)

UPL = Upper prediction limit

UCL = Upper confidence limit of the mean

Shaded 95% UPLs are greater than the maximum dectected concentraiton, so the maximum detected concentration will be used in the comparison.

FIGURES



Legend

- Soil Sample Location
- Waterways
  Chaparral Gulch, Galena Gulch, Agua Fria River
- Road Centerlines
- Iron King Mine
- Humboldt Smelter
- Soil Classification Area
- BgD Soil Classification Text

0 1,000
Feet

EPA Identification Number: AZ0000309013

Aerial Photo Source: Yavapai County GIS, 2007
Basemap Source: ESRI StreetMap, 2008

Figure 1 – Background Sample Locations

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

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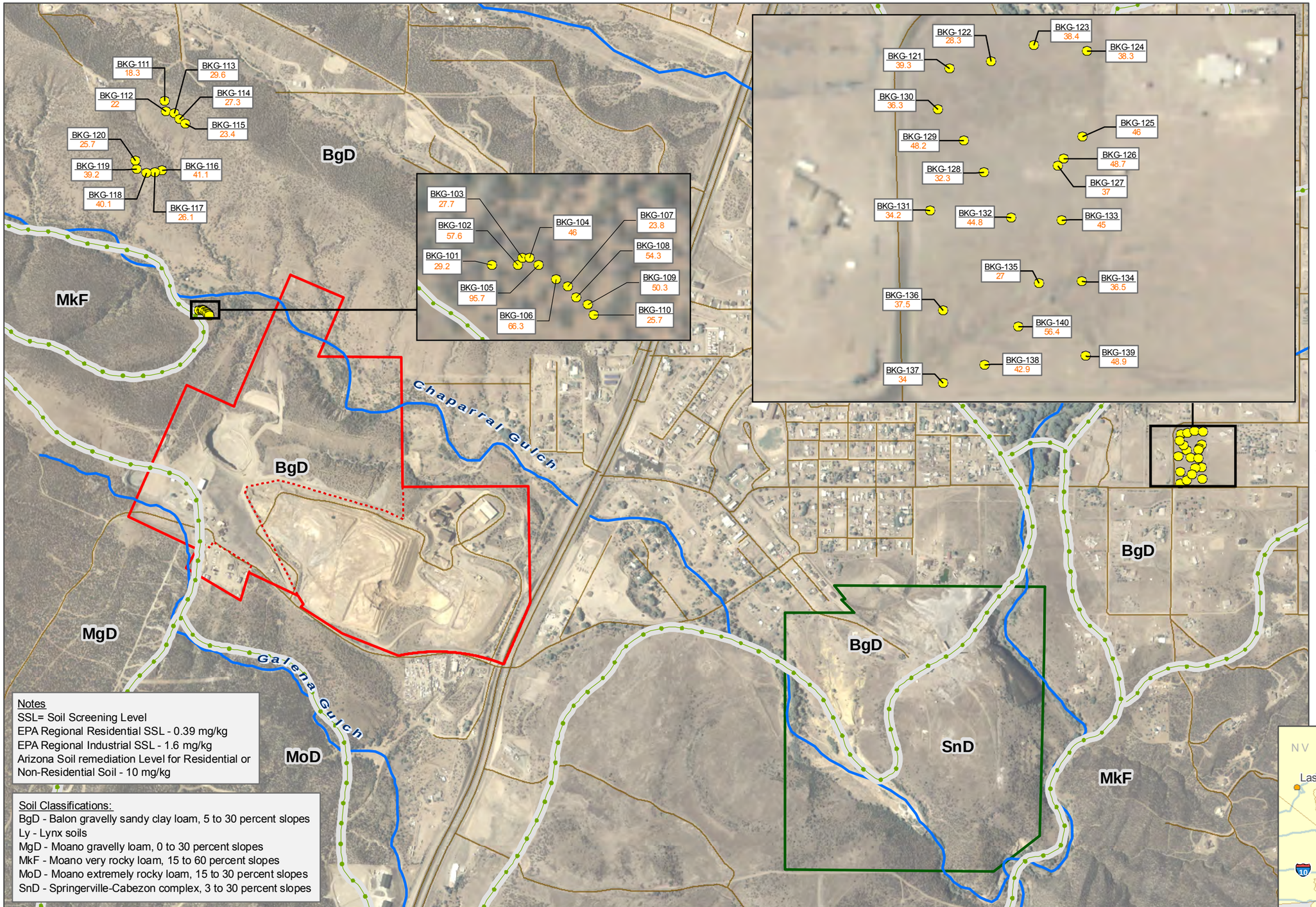

Notes
SSL= Soil Screening Level
EPA Regional Residential SSL - 0.39 mg/kg
EPA Regional Industrial SSL - 1.6 mg/kg
Arizona Soil remediation Level for Residential or Non-Residential Soil - 10 mg/kg

Soil Classifications:
BgD - Balon gravelly sandy clay loam, 5 to 30 percent slopes
Ly - Lynx soils
MgD - Moano gravelly loam, 0 to 30 percent slopes
MkF - Moano very rocky loam, 15 to 60 percent slopes
MoD - Moano extremely rocky loam, 15 to 30 percent slopes
SnD - Springerville-Cabezon complex, 3 to 30 percent slopes

Legend

Soil Sample Location

"Sample Identification"
"Concentration"

"Concentration"
units = mg/kg - milligrams per kilogram
Grey non-detect
Green < 10x Residential and Industrial SSL
Orange < 100x Industrial SSL
Red > 100x Industrial SSL

Waterways
Chaparral Gulch, Galena Gulch, Agua Fria River

Road Centerlines

Iron King Mine

Humboldt Smelter

Soil Classification Area

BgD Soil Classification Text

Notes:
The BTV (Background Threshold Value) is 91 mg/kg. 95%UCLM (Upper Confidence Limit of the Mean) is 61 mg/kg.

0 1,000
Feet

EPA Identification Number: AZ0000309013

Aerial Photo Source: Yavapai County GIS, 2007
Basemap Source: ESRI StreetMap, 2008

Figure 2 - Background Arsenic Concentrations, Soil Type 1

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

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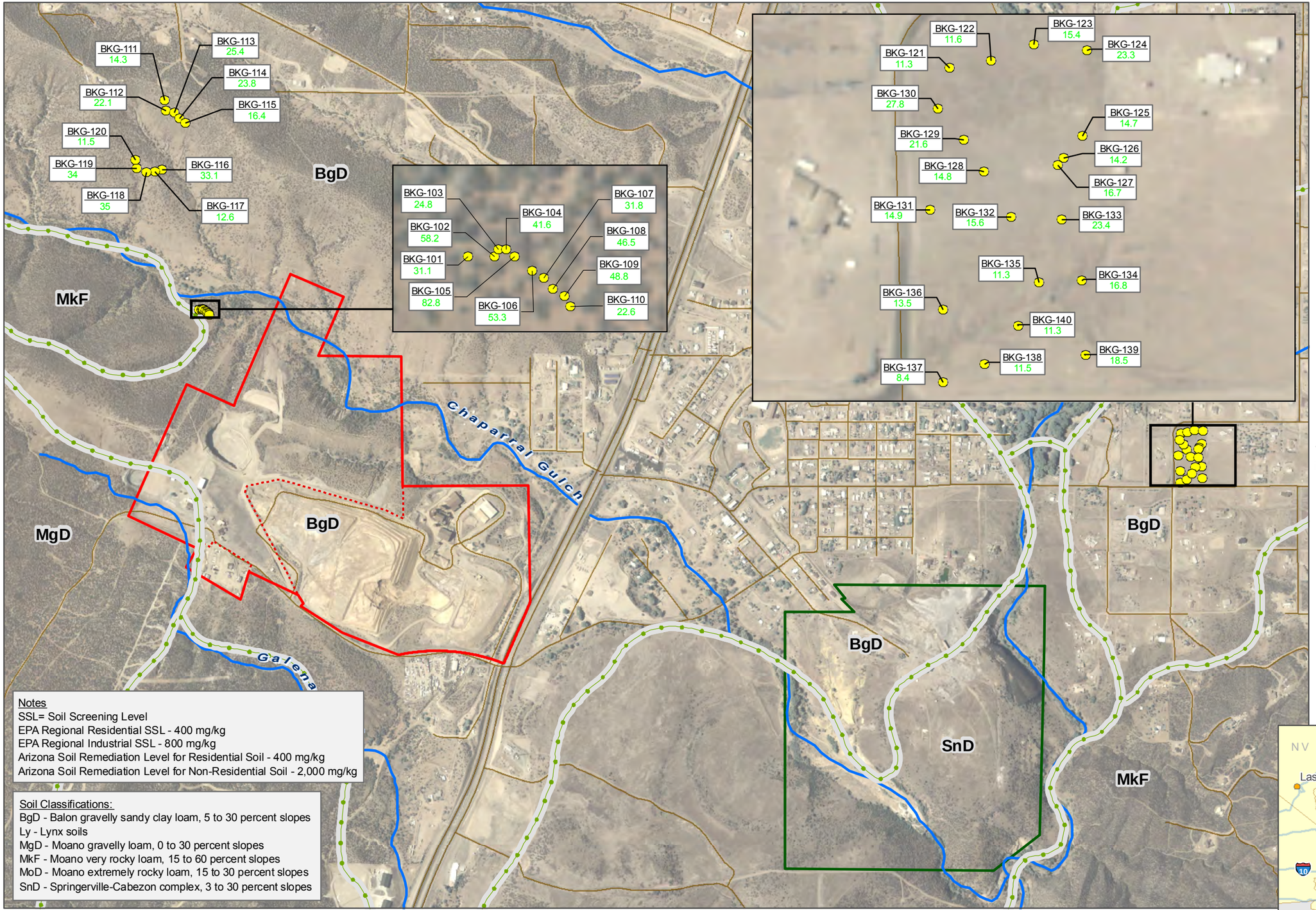

Legend

- Soil Sample Location
- "Sample Identification" "Concentration"

"Concentration"
units = mg/kg - milligrams per kilogram
Grey non-detect
Green less than Residential SSL
Orange less than Industrial SSL
Red greater than Industrial SSL

- Waterways: Chaparral Gulch, Galena Gulch, Agua Fria River
- Road Centerlines
- Iron King Mine
- Humboldt Smelter
- Soil Classification Area
- BgD Soil Classification Text

Notes:
The BTV (Background Threshold Value) is 79 mg/kg. 95%UCLM (Upper Confidence Limit of the Mean) is 55 mg/kg.

0 1,000
Feet

EPA Identification Number: AZ0000309013

Aerial Photo Source: Yavapai County GIS, 2007
Basemap Source: ESRI StreetMap, 2008

Figure 3 – Background Lead Concentrations, Soil Type 1

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

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Appendix B

Ecological Preliminary Cleanup Levels

ECOLOGICAL PRELIMINARY CLEANUP LEVELS

An ecological risk assessment (ERA) was conducted for the Iron King Mine – Humboldt Smelter Superfund Site (Site) located in Dewey-Humboldt, Yavapai County, Arizona (EA 2010). The Baseline Ecological Risk Assessment (BERA) represents the culmination of Steps 1 through 7 of the USEPA ERA guidance (USEPA 1999a). Step 8 of the USEPA guidance pertains to risk management. Receptor-specific thresholds of effects for preliminary chemicals of concern (COCs) are provided to aid in risk management decisions.

In accordance with USEPA Risk Management Guidance (USEPA 1999b), the following sections address the four main topics discussed in risk management: the ecological receptors that should be protected, unacceptable risks at the Site, natural resources that would be damaged during remediation, and Preliminary Cleanup Levels.

1.0 RECEPTORS AT RISK: ECOLOGICAL RISK ASSESSMENT SUMMARY

The West Exposure Grouping comprises the Iron King Mine and western portions of Chaparral Gulch and Galena Gulch. The East Exposure Grouping comprises the Humboldt Smelter and eastern portions of Chaparral Gulch and Galena Gulch (EA 2010). The Agua Fria River Exposure Grouping comprises the Agua Fria River as well as eight samples from outfalls located immediately adjacent to the river. In the ERA

In the BERA, ecological risks were estimated for terrestrial receptors exposed to soil and surface water, and for aquatic and benthic receptors exposed to sediment and surface water. The assessment found that highly elevated concentrations of metals from mine tailings posed unacceptable risks to all receptor groups.

A Biological Evaluation (Envirosystems Management, Inc. 2009) was performed as a part of the ERA. It identified the rare, threatened, and endangered species that may be present at the Site. The evaluation of the special status species established that there is no potential for adverse effects on any of the special status species or their habitats except for the Arizona toad. The Arizona toads are known to occur three miles from the Site; although, suitable habitat exists along the Agua Fria River and the Chaparral Gulch.

Using information from the Biological Evaluation (Envirosystems Management, Inc. 2009), observations made during Site visits, and other literary resources, receptor species were identified. Evaluation criteria included: (1) the likelihood of a species to utilize the Site and the area immediately surrounding the Site, (2) the potential for exposure to site-related contaminants based on the feeding habits, and (3) the life history of the organisms/guild represented by the receptor species. The ERA evaluated the following receptor species: plants, invertebrates, aquatic and benthic organisms, herbivorous mammals (pocket gopher), herbivorous birds (song sparrow), insectivorous mammals (desert shrew), insectivorous birds (greater roadrunner), insectivorous reptiles (black-necked garter snake), predatory mammals (coyote), predatory birds (red-tailed hawk), predatory reptiles (gopher snake), and piscivorous birds (great blue heron) as receptors.

The specific Preliminary COCs are identified for each receptor as follows:

- **Terrestrial plants** - Aluminum, antimony, arsenic, chromium, cobalt, copper, lead, manganese, mercury, nickel, selenium, thallium, vanadium, and zinc in soil.
- **Terrestrial invertebrates** - Arsenic, chromium, copper, manganese, mercury, selenium, and zinc in soil.
- **Aquatic and benthic organisms** – Combined effects from multiple metals, with arsenic, copper, lead, and zinc in sediment and surface water.
- **Mammals** – Aluminum, antimony, arsenic, cadmium, copper, lead, selenium, thallium, zinc, and PCBs in soil and ingested surface water.
- **Birds** - Arsenic, copper, lead, selenium, zinc and butylbenzylphthalate in soil; arsenic, copper, lead, selenium and zinc in sediment; the same chemicals in ingested surface water.
- **Reptiles** - Metals and butylbenzylphthalate based on exceedances for other organisms.

The In-Town West Exposure Grouping comprises commercial or residential parcels north of the Chaparral Gulch. The In-Town East Exposure Grouping comprises commercial or residential parcels north, east, and west of the Humboldt Smelter. Soil from these areas was sampled to determine whether metals were impacted from historic site activities via storm water or air particulate migration pathways. Risks were assessed for terrestrial receptors exposed to soil and surface water. The BERA found that concentrations of metals were somewhat elevated and may pose unacceptable risks to several receptor groups; however, it also determined that the exposure areas are developed and provide poor habitat; in addition, the concentrations of several metals are similar to background values, greatly reducing the risk potential from those metals. The specific Preliminary COCs are identified for each receptor as follows:

- **Terrestrial plants** - Aluminum, antimony, arsenic, chromium, cobalt, copper, lead, manganese, mercury, selenium, thallium, vanadium, and zinc in soil.
- **Terrestrial invertebrates** - Chromium, copper, manganese, mercury and zinc in soil.
- **Mammals** – Aluminum, arsenic, selenium, and thallium in soil and ingested surface water.
- **Birds** - No chemicals retained as Preliminary COCs.
- **Reptiles** – Metals, particularly arsenic and aluminum, based on exceedances for other organisms.

2.0 UNACCEPTABLE RISK: PRIMARY RISK DRIVERS

The Preliminary COCs are based on mean case scenario exceedances of low-effects benchmarks and background mean doses. Given the high concentrations of metals, other metals may also cause risks in localized areas of high concentrations at their maximum exceedances. For the West Exposure Grouping, the highest concentrations are associated with the Iron King Mine Proper Area, the Iron King Mine Operations Area, the Iron King Mine Former Fertilizer Plant, the Galena Gulch, and the Chaparral Gulch. In the East Exposure Group, the highest metal concentrations are associated with the tailings (e.g., Humboldt Smelter Tailings Pile and the Lower Chaparral Gulch), the Humboldt Smelter Ash Pile, the Humboldt Smelter Slag Pile, and scattered localized areas of high concentrations of tailings, ash, and slag. For the Agua Fria Exposure Group, high concentrations of metals may cause unacceptable risks in localized areas

of high concentrations. The highest concentrations are associated with the outfall areas and sediments downstream of the confluence with Chaparral Gulch. In-Town East and West metals maxima may also cause risks in localized areas of high concentrations.

All of the Preliminary COCs listed above may contribute to an increase in toxicity to ecological receptors. Of these Preliminary COCs, arsenic and lead are noted as primary risk drivers. Elevated concentrations of arsenic and lead are known to be related to source materials (e.g., tailings, ash, slag, etc.) and are typically co-located with elevated concentrations of other metals. Therefore, even though all Preliminary COCs may contribute to toxicity, it is recommended that arsenic and lead are the focus of risk management decisions.

3.0 CLEANUP IMPACTS: HABITAT QUALITY

For the East and West Exposure Groupings, concentrations are highly elevated over large spatial scales and the contaminants are potentially bioavailable. Current habitat within these groupings is disturbed by past commercial/industrial activities. However, higher quality habitat is immediately adjacent to these areas (e.g., Waterway AOI). Also, portions of the Site may be returned to a more natural state in the future. Future land use will determine whether risk management is necessary. If the Site remains developed after remediation, and habitat quality remains poor, potential unacceptable ecological risks may not be relevant. Because high quality habitats are adjacent to areas of highly elevated chemical concentrations (e.g., Waterway AOI), and because future conditions are uncertain, habitat evaluation for the East and West Exposure Groupings suggests that risk management considerations should include the potential for unacceptable ecological risk.

The aquatic habitat in the Chaparral and Galena Gulches is of variable quality due to the fact that these gulches are dry except during high rain events; at this time they are subject to physical disturbance (i.e. scouring) by periodic flash flooding. However, riparian habitats associated with areas where water may collect (i.e. the area behind the Chaparral Gulch dam) are likely to be an important resource for local wildlife. Given the concentrations in these areas, risk managers should consider whether remediation is required in riparian and aquatic habitats or whether remediation would lead to more habitat destruction than that posed by the chemicals.

Aquatic habitat in the Agua Fria River is of high quality. Concentrations of Preliminary COCs were elevated within the Agua Fria River; in general, concentrations are less than those in the other waterways, and produce fewer benchmark exceedances. Risk managers should consider whether attempting to eliminate localized areas of high concentrations in the Agua Fria through remediation may cause more harm to ecosystems than good. Currently, there are stable aquatic and benthic populations within the Agua Fria River. Attempting to eliminate localized areas of high concentrations may mobilize chemicals, disturbing local habitats and populations. Periodic disturbance by flooding, when additionally coupled with remediation efforts, may damage the ecosystem further. Remediation at the outfalls in the Agua Fria River would most likely not prove to be beneficial because their physical conditions only provide lower quality habitats. Finally, if upgradient sources are remediated, it is likely that the metals concentrations within these important ecological habitats would decrease over time due to surface water migration; this decrease in concentrations would ameliorate the unacceptable ecological risk over time.

The In-Town East and West Exposure Groupings provide poor habitat because these are public, residential, or commercial/industrial properties in a developed area. Wildlife may still be found within residential developments, however, compaction due to development, disturbance from humans and pets, and alteration of natural resources (i.e. plants) in these areas may produce greater effects on wildlife than metal contamination, and would certainly decrease expected exposures. Therefore, it is recommended that risk managers consider that remediation targeting ecological risks is unlikely to make these areas suitable habitat for wildlife. Area use factors were not included in the risk assessment; it is likely that the area used by wildlife would be less than 100% due to disturbance.

4.0 PRELIMINARY CLEANUP LEVELS: THRESHOLDS OF EFFECTS

To aid in risk management decisions, thresholds of effects were developed for ecological receptor exposures to Preliminary COCs. Thresholds of effects were developed using generic exposure models for wildlife and benchmarks available from guidance for lower trophic organisms. Site-specific thresholds were developed for wildlife based on site-specific data regarding chemical bioavailability of arsenic and lead; data were too limited to develop site-specific thresholds for other chemicals or organisms. As discussed above, it is recommended that ecological risk management decisions focus on the West and East exposure groupings. Therefore, Preliminary COCs for only these groupings were developed.

4.1 Benchmarks for Lower Trophic Level Organisms

The ERA concluded that chemicals detected in soil, sediment, and surface water may potentially impact lower trophic level organisms such as plants, insects, and aquatic or benthic organisms in the East and West Exposure Groupings. It is recommended that risk management decisions consider the range of chemicals detected, focusing on arsenic and lead as indicators of mining-related impacts.

To aid in risk management decisions, benchmarks that represent thresholds of effects are summarized in Tables 1 to 4. Literature-based benchmarks for soil, sediment, and surface water are available from a number of literature-based sources; sources for these are included in the risk management tables and are more fully documented in Tables 7-9 through 7-11 in the ERA (EA 2010).

It is important to note that these thresholds of effect are based on highly conservative benchmarks and are not site-specific. Given their conservative nature, it is recommended that thresholds with less inherent uncertainty – such as site-specific wildlife thresholds of effects for arsenic and lead in soil, or statistically pertinent background concentrations, be used as Preliminary Cleanup Levels.

4.2 Benchmarks for Wildlife

The conclusion of the ERA was that mammals and birds have potential unacceptable risk from several metals in the soil; however it is recommended that risk management decisions focus on arsenic and lead as indicators of mining-related impacts.

Benchmarks that represent thresholds of effects are provided to aid in risk management decisions. Table 5 provides values that may be useful. Conservative food-web exposure models were used in the ERA to assess risks to wildlife species. The same models were used to develop risk-based Preliminary Cleanup Levels that are protective of the various wildlife species. This was done by back-calculating until a soil concentration was achieved that produced a specified benchmark. This is analogous to the method used by the USEPA to develop soil screening benchmarks (Eco-SSL) for birds and mammals (e.g., USEPA 2003-2007). Three risk-based Preliminary Cleanup Levels (soil concentrations) were developed for each COC-receptor combination: (1) a soil concentration equivalent to a food-web No Observed Adverse Effect Level (NOAEL); (2) a soil concentration equivalent to a food-web Lowest Observed Adverse Effect Level (LOAEL); and (3) a soil concentration equivalent to the midpoint between the NOAEL and LOAEL. Three risk-based Preliminary Cleanup Levels were developed to provide risk managers with a range of options over varying low levels of risk. Arsenic and lead were each shown to pose risk to at least one wildlife receptor in the ERA (EA 2010). Site-specific, risk-based Preliminary Cleanup Levels were developed for each applicable receptor – Preliminary COC combination.

It is important to note that sediment to biota uptake factors were not available for calculation of sediment preliminary risk-based Preliminary Cleanup Levels to piscivorous birds. It is recommended that the goals for wildlife exposed to soil and for benthic organisms be used in lieu of sediment goals.

4.3 Preliminary Cleanup Levels

The risk-based Preliminary Cleanup Levels for each receptor-COC combination are displayed in Table 6. The lowest risk-based Preliminary Cleanup Levels for each chemical in each medium among all receptors is also identified.

These Preliminary Cleanup Levels correspond to exposure point concentrations below which risk is unlikely to occur. For wildlife, goals should only be applied using appropriate spatial analyses and consideration of population biology, and are not intended as “not-to-exceed” concentrations on a point-by-point basis. It is recommended that a mean or 95% Upper Confidence Limit of the Mean Exposure Point Concentration be calculated for anticipated post-remedial scenarios and compared to these goals. For benthos and lower trophic level organisms, goals should be applied across areas suspected to support distinct communities. Per USEPA guidance, it is recommended that background concentrations be used as a Preliminary Cleanup Levels instead of risk-based goals when background is found to be higher than a goal.

As is, these goals do not necessarily constitute final Preliminary Cleanup Levels; rather they were developed to provide an enhanced understanding of the combined data set. Each receptor-Preliminary Cleanup Levels combination will have to be reviewed and evaluated by risk managers in light of the comparative screening benchmarks and background data, as well as other information inherent in the risk management process. Reptiles are not included in the table because exposure and toxicity data for reptiles are too limited to allow quantitative modeling.

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Table 1
Values for use in Risk Management of Plants in the On-Site East and West Exposure Groupings

Chemical	Plant Toxicity Reference Value (mg/kg)	Toxicity Reference Value Source and Notes
METALS		
ALUMINUM	5.00E+01	Efroymson et al. 1997a
ANTIMONY	5.00E+00	Efroymson et al. 1997a
ARSENIC	1.80E+01	EcoSSL, 2005b
CHROMIUM	1.00E+00	Efroymson et al. 1997a
COBALT	1.30E+01	EPA, 2005f
COPPER	7.00E+01	EPA, 2007a
LEAD	1.20E+02	EPA, 2005g
MANGANESE	2.20E+02	EPA, 2007d
MERCURY	3.00E-01	Efroymson et al. 1997a
NICKEL	3.80E+01	EPA, 2007e
SELENIUM	5.20E-01	EPA, 2007h
THALLIUM	1.00E+00	Efroymson et al. 1997a
VANADIUM	2.00E+00	Efroymson et al. 1997a
ZINC	1.60E+02	EPA, 2007i

Notes:
Values are presented in milligrams per kilogram (mg/kg).

Table 2
Values for use in Risk Management of Invertebrates in the On-Site East and West Exposure Groupings

Chemical	Invertebrate Toxicity Reference Value (mg/kg)	Toxicity Reference Value Source and Notes
METALS		
ARSENIC	6.00E+01	Efroymson et al. 1997b
CHROMIUM	4.00E-01	Efroymson et al. 1997b
COPPER	8.00E+01	EPA, 2007a
MANGANESE	4.50E+02	EPA, 2007d
MERCURY	1.00E-01	Efroymson et al. 1997b
SELENIUM	4.10E+00	EPA, 2007h
ZINC	1.20E+02	EPA, 2007i

Notes:
Values are presented in milligrams per kilogram (mg/kg).

Table 3

Values for use in Risk Management of Aquatic Organisms in the On-Site East and West Exposure Groupings

Chemical	Surface Water Toxicity Reference Value (µg/L)	Source for Surface Water TRVs
METALS		
ARSENIC	1.50E+02	National Ambient Water Quality Criteria; Value for total arsenic (EPA 1999c)
COPPER	2.90E+01	Hardness dependent criterion based on 400 mg/L hardness (EPA 1999c)
LEAD	4.70E+01	Hardness dependent criterion based on 400 mg/L hardness (EPA 1999c)
ZINC	3.80E+02	Hardness dependent criterion based on 400 mg/L hardness (EPA 1999c)

Notes:
Surface water concentrations are presented in microtgrams per liter (µg/L).

Table 4
Values for use in Risk Management of Benthic Organisms in the On-Site East and West Exposure Groupings

Chemical	Sediment Benchmarks (mg/kg)	Source for TRVs
METALS		
ARSENIC	9.79	MacDonald et al., 2000
COPPER	31.6	MacDonald et al., 2000
LEAD	35.8	MacDonald et al., 2000
ZINC	121	MacDonald et al., 2000

Notes:
Values are presented in milligrams per kilogram (mg/kg).

Table 5
Derivation of Wildlife Concentration-Based Effects Thresholds[A]
for the On-Site East and West Exposure Groupings

Chemical	Unmodified Effects Thresholds (mg/kg)			Site Specific Effects Thresholds[B] (mg/kg)		
	NOEC	Mid	LOEC	NOEC	Mid	LOEC
Herbivorous Mammals (pocket gopher)						
ALUMINUM	2.80E+02	1.26E+03	2.80E+03	NA	NA	NA
ANTIMONY	1.19E+00	2.59E+01	5.30E+01	NA	NA	NA
ARSENIC	1.32E+02	1.50E+01	1.62E+02	2.64E+02	3.00E+01	3.24E+02
CADMIUM	5.00E+01	5.50E+02	1.15E+03	NA	NA	NA
COPPER	5.51E+02	6.52E+02	1.85E+03	NA	NA	NA
LEAD	5.94E+02	5.49E+03	1.16E+04	9.90E+02	9.15E+03	1.93E+04
SELENIUM	2.63E+00	1.52E+00	5.66E+00	NA	NA	NA
THALLIUM	1.08E+00	4.86E+00	1.08E+01	NA	NA	NA
ZINC	4.68E+03	1.25E+04	2.97E+04	NA	NA	NA
Herbivorous Birds (song sparrow)						
ARSENIC	9.10E+01	1.16E+02	3.22E+02	NA	NA	NA
LEAD	5.40E+01	2.03E+02	4.60E+02	NA	NA	NA
SELENIUM	3.51E+00	1.56E+00	6.62E+00	NA	NA	NA
ZINC	9.63E+02	7.75E+02	2.51E+03	NA	NA	NA
Insectivorous Mammals (desert shrew)						
ALUMINUM	3.90E+01	1.76E+02	3.90E+02	NA	NA	NA
ANTIMONY	2.50E-01	2.60E+00	5.45E+00	NA	NA	NA
ARSENIC	2.30E+01	2.50E+00	2.80E+01	4.60E+01	5.00E+00	5.60E+01
CADMIUM	3.70E-01	4.39E+00	9.14E+00	NA	NA	NA
COPPER	8.10E+01	1.52E+02	3.85E+02	NA	NA	NA
LEAD	4.50E+01	5.65E+02	1.17E+03	7.50E+01	9.41E+02	1.96E+03
SELENIUM	5.90E-01	5.80E-01	1.75E+00	NA	NA	NA
THALLIUM	3.30E-02	1.49E-01	3.30E-01	NA	NA	NA
ZINC	8.10E+01	1.46E+03	3.01E+03	NA	NA	NA
Total PCBs	3.65E-02	8.33E-02	2.03E-01	NA	NA	NA
Insectivorous Birds (greater roadrunner)						
ARSENIC	1.93E+02	2.63E+02	7.19E+02	NA	NA	NA
LEAD	4.20E+01	1.82E+02	4.05E+02	NA	NA	NA
SELENIUM	1.10E+01	7.50E+00	2.60E+01	NA	NA	NA
ZINC	7.52E+02	1.50E+03	3.75E+03	NA	NA	NA
BUTYLBENZYLPHTHALATE	1.25E+00	5.63E+00	1.25E+01	NA	NA	NA
Predatory Mammals (coyote)						
ALUMINUM	1.06E+03	4.76E+03	1.06E+04	NA	NA	NA
ANTIMONY	1.17E+02	1.17E+03	2.45E+03	NA	NA	NA
ARSENIC	1.92E+03	2.07E+02	2.33E+03	3.83E+03	4.13E+02	4.66E+03
CADMIUM	8.94E+02	8.14E+03	1.72E+04	NA	NA	NA
COPPER	1.01E+04	9.59E+03	2.92E+04	NA	NA	NA
LEAD	7.34E+03	7.19E+04	1.51E+05	1.22E+04	1.20E+05	2.52E+05

Table 5
Derivation of Wildlife Concentration-Based Effects Thresholds[A]
for the On-Site East and West Exposure Groupings

Chemical	Unmodified Effects Thresholds (mg/kg)			Site Specific Effects Thresholds[B] (mg/kg)		
	NOEC	Mid	LOEC	NOEC	Mid	LOEC
SELENIUM	1.34E+02	1.46E+02	4.25E+02	NA	NA	NA
THALLIUM	2.73E+00	1.23E+01	2.73E+01	NA	NA	NA
ZINC	1.42E+05	2.42E+05	6.26E+05	NA	NA	NA
Predatory Birds (red-tailed hawk)						
No COPCs identified.	NA	NA	NA	NA	NA	NA
Piscivorous Birds (great blue heron)						
ARSENIC	NA	NA	NA	NA	NA	NA
COPPER	NA	NA	NA	NA	NA	NA
LEAD	NA	NA	NA	NA	NA	NA
SELENIUM	NA	NA	NA	NA	NA	NA
ZINC	NA	NA	NA	NA	NA	NA

Notes:
Values are presented in milligrams per kilogram (mg/kg).

A - Exposure Factors used in effects threshold calculation are consistent with those used in the risk assessment.
The unmodified effects thresholds are the concentrations where the LOAEL or NOAEL was equalled or surpassed in the models used in the Ecological Risk Assessment.

B - Lead in soil is 60% bioavailable to mammals at the Site (Casteel et al. 1997)
Arsenic in soil is typically only one-half to one-tenth as bioavailable to mammals as soluble arsenic forms, for the puroposes of this document, the more conservative 50% is used (Schoof 2003).

Table 6
Summary of Effects Thresholds
for the On-Site East and West Exposure Groupings

Chemical	Soil Effects Threshold (mg/kg)								Aquatic Organism Effects Threshold (Recommended Surface Water Goal) (µg/L)	Benthic Organism Effects Threshold (Recommended Sediment Goal) (mg/kg)
	Lower Trophic Level Organisms		Higher Trophic Level Wildlife, Mid-Point					Recommended Soil Goal Based on Lowest Threshold for Wildlife		
	Plants	Invertebrates	Herbivorous Mammals	Herbivorous Birds	Insectivorous Mammals	Insectivorous Birds	Predatory Mammals			
ALUMINUM	5.00E+01	--	1.26E+03	--	1.76E+02	--	4.76E+03	1.76E+02	--	--
ANTIMONY	5.00E+00	--	2.59E+01	--	2.60E+00	--	1.17E+03	2.60E+00	--	--
ARSENIC	**1.80E+01**	**6.00E+01**	**3.00E+01**	**1.16E+02**	**5.00E+00**	**2.63E+02**	**4.13E+02**	**5.00E+00**	**1.50E+02**	**9.79E+00**
CADMIUM	--	--	5.50E+02	--	4.39E+00	--	8.14E+03	4.39E+00	--	--
CHROMIUM	1.00E+00	4.00E-01	--	--	--	--	--	--	--	--
COBALT	1.30E+01	--	--	--	--	--	--	--	--	--
COPPER	7.00E+01	8.00E+01	6.52E+02	--	1.52E+02	--	9.59E+03	1.52E+02	2.90E+01	3.16E+01
LEAD	**1.20E+02**	**--**	**9.15E+03**	**2.03E+02**	**9.41E+02**	**1.82E+02**	**1.20E+05**	**1.82E+02**	**4.70E+01**	**3.58E+01**
MANGANESE	2.20E+02	4.50E+02	--	--	--	--	--	--	--	--
MERCURY	3.00E-01	1.00E-01	--	--	--	--	--	--	--	--
NICKEL	3.80E+01	--	--	--	--	--	--	--	--	--
SELENIUM	5.20E-01	4.10E+00	1.52E+00	1.56E+00	5.80E-01	7.50E+00	1.46E+02	5.80E-01	--	--
THALLIUM	1.00E+00	--	4.86E+00	--	1.49E-01	--	1.23E+01	1.49E-01	--	--
VANADIUM	2.00E+00	--	--	--	--	--	--	--	--	--
ZINC	1.60E+02	1.20E+02	1.25E+04	7.75E+02	1.46E+03	1.50E+03	2.42E+05	7.75E+02	3.80E+02	1.21E+02
TOTAL PCBs	--	--	--	--	8.33E-02	--	--	8.33E-02	--	--
BUTYLBENZYLPHTHALATE	--	--	--	--	--	5.63E+00	--	5.63E+00	--	--

Notes:
Soil and sediment values are presented in milligrams per kilogram (mg/kg). Surface water concentrations are presented in microtgrams per liter (µg/L).
For arsenic and lead in all mammals, the value presented is the site-specific midpoint of the NOEC and the LOEC. For all other chemicals, the value is the unmodified midpoint.
For all birds, the value presented is the unmodified midpoint of the NOEC and the LOEC.
"--" = Some values were not calculated because the receptor was not determined to be at risks from the COC.