FINAL PHASE II REMEDIAL INVESTIGATION/ FEASIBILITY STUDY (RI/FS) WORK PLAN

PART 2 of 2: SOIL, WATER, AND SEDIMENT

ASARCO HAYDEN PLANT SITE

TOWNS OF HAYDEN AND WINKELMAN
PINAL AND GILA COUNTIES, ARIZONA

EPA CONTRACT NO. EP-S9-08-03
EPA TASK ORDER NO. 0019
ITSI PROJECT NO. 07163.0020
DCN: 07163.0020.0145

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March 2012

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LIST OF ACRONYMS

^{o}F	degrees Fahrenheit
A&Ww	Aquatic and Wildlife–warm water
AAC	Arizona Administrative Code
AAWWQC	Arizona Aquatic and Wildlife Water Quality Criteria
ADEQ	Arizona Department of Environmental Quality
ADHS	Arizona Department of Health Services
ADOC	Arizona Department of Commerce
ADWR	Arizona Department of Water Resources
AGFD	Arizona Game and Fish Department
AL	Alert Level
AOC	Administrative Settlement Agreement and Order on Consent
APP	Aquifer Protection Permit
ARAR	applicable or relevant and appropriate requirement
ASARCO	ASARCO LLC
ATSDR	Agency for Toxic Substances and Disease Registry
AWC	Arizona Water Company
BERA	baseline ecological risk assessment
bgs	below ground surface
BHHRA	baseline HHRA
CDC	Centers for Disease Control and Prevention
CEM	conceptual exposure model
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
CGMP	Current Good Manufacturing Practices
CIC	(EPA) Community Involvement Coordinator
CLP	(EPA) Contract Laboratory Program
cm^2	square centimeter(s)
cm/sec	centimeters per second
COC	chemicals of concern
COPC	chemical of potential concern
CSM	Conceptual Site Model
CV	comparison value
CWA	Clean Water Act
DQO	data quality objective
E&E	Ecology & Environment, Inc.
EPA	United States Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ER	Emergency Response
ERA	Ecological Risk Assessment
ESI	Expanded Site Inspection
FS	Feasibility Study

FSP	Field Sampling Plan
FWQC	federal water quality criteria
GPL	groundwater protection level
gpm	gallons per minute
GRA	general response action
HHRA	Human Health Risk Assessment
ITSI	Innovative Technical Solutions, Inc.
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
MDL	method detection limit
mg/kg	milligrams per kilogram
mg/kg-day	milligrams per kilogram per day
mg/L	milligrams per liter
msl	mean sea level
NAAQS	National Ambient Air Quality Standard
NCCC	Nevada Consolidated Copper Company
NELAC	National Environment Laboratory Accreditation Conference
NELAP	National Environmental Laboratory Accreditation Program
NPL	National Priorities List
ORP	Oxidation-Reduction Potential
OSC	On-Scene Coordinator
OSWER	Office of Solid Waste and Emergency Response
PA	Preliminary Assessment
PCE	tetrachloroethene
PHA	Public Health Assessment
PM	particulate matter
$PM_{2.5}$	particulate matter less than 2.5 microns in diameter
PM_{10}	particulate matter less than 10 microns in diameter
POC	Point of Compliance
ppm	parts per million
PRG	preliminary remediation goal
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
R&R	reverberatory furnace and roaster
RA	Removal Assessment
RAO	remedial action objective
RCCC	Ray Consolidated Copper Company
RCRA	Resource Conservation and Recovery Act
REL	Relative Exposure Limit
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RL	reporting limit
RPD	relative percent difference
RSL	regional screening level

R-SRL	(Arizona) residential soil remediation level
RPD	Relative Percent Difference
SAP	Sampling and Analysis Plan
SHB	SHB–AGRA Earth & Environmental, Inc.
SI	Site Inspection
Site	ASARCO Hayden Plant Site
SHSP	Site-Specific Health and Safety Plan
SLERA	Screening-Level Risk Assessment
SIP	State Implementation Plan
SO_2	sulfur dioxide
SOP	standard operating procedure
SOW	Statement of Work
State	State of Arizona
SVOC	semivolatile organic compound
SWPPP	stormwater pollution prevention plan
SWQS	(Arizona) Surface Water Quality Standard
TAL	Target Analyte List
TCE	trichloroethene
TDS	total dissolved solids
tpd	tons per day
TPH	total petroleum hydrocarbons
tpy	tons per year
TRI	Toxic Release Inventory
TSS	total suspended solids
UCL	upper confidence limit
ug/m^3	micrograms per cubic meter
USC	United States Code
USGS	United States Geological Survey
UST	underground storage tank
VOC	volatile organic compound
WQC	Water Quality Criteria
XRF	X-ray fluorescence

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1.0 INTRODUCTION AND OBJECTIVES

This Work Plan details procedures for conducting a Phase II Remedial Investigation and Feasibility Study (RI/FS) at the ASARCO Hayden Plant Site (Site), as required by the April 2008 Administrative Settlement Agreement and Order on Consent (AOC) between ASARCO LLC (ASARCO), the U.S. Environmental Protection Agency (EPA), and the Arizona Department of Environmental Quality (ADEQ) (EPA, 2008a). The Work Plan has been developed consistent with *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA, 1988).

This Work Plan is Part 2 of two parts that constitute the entire Phase II RI/FS Work Plan for the ASARCO Hayden Plant Site. Activities performed under Part 2 of the RI/FS will evaluate the nature and extent of contamination in surface soils, groundwater, surface water, stormwater runoff, process water, and sediments; identify migration pathways of the contaminants; and assess potential human health and ecological risks. Part 1 of the Phase II RI/FS, which is covered under a separate work plan, will evaluate the nature and extent of contamination in ambient air and assess source apportionment and potential exposure risks via air pathways (ITSI, 2012).

The ASARCO Hayden Plant Site is defined for purposes of this RI/FS to include the ASARCO Hayden smelter and associated facilities owned or operated by ASARCO, and any areas where hazardous substances from those facilities have come to be located. ASARCO continues to operate the active copper smelter, conducting copper ore processing operations to the north, west, east, and south of the community of Hayden, Arizona, and to the north and west of the community of Winkelman, Arizona. These operations include ore crushing, concentrating, and smelting, as well as tailings disposal. The Site also includes the location of the former ASARCO-owned Kennecott smelter, which operated from 1958 to 1982.

The Phase II RI follows the Phase I RI completed by EPA in 2008 (CH2M HILL, 2008a). The Phase I RI included an evaluation of the nature and extent of contamination in residential soils and indoor dusts; a limited investigation of contamination in non-residential soils and in the perimeter areas of active and historical smelter activities; an investigation of the nature and extent of groundwater contamination, and of surface water and sediment contamination in potentially impacted sections of the Gila and San Pedro Rivers; and a preliminary investigation of air contamination in the vicinity of the ASARCO Hayden smelter. In particular, the following activities were performed as elements of the Phase I RI:

- Sampling in residential areas in the towns of Hayden and Winkelman (residential yard soil sampling at 130 habitable homes, and interior dust sampling in 18 homes);

- Sampling of soil in non-residential areas (sampling at 270 locations within and outside the towns of Hayden and Winkelman, including ephemeral washes adjacent to the Hayden Complex that are tributaries to the Gila River, ASARCO property, the Winkelman school complex, Hayden public areas and golf club, and upland and surrounding areas);
- Sampling of surface water and in-stream sediment at 11 locations along the Gila River and at two locations along the San Pedro River, and sampling of stable and unstable riparian sediment at 19 locations along the Gila and San Pedro Rivers;
- Installation and sampling of five new groundwater monitoring wells, and sampling of 18 selected existing monitoring wells and five existing drinking water production wells;
- Collection of 24-hour air samples at monitoring stations in Hayden and Winkelman every six days for three years;
- Ecological investigation to characterize the terrestrial and aquatic organisms and habitats present within the project area and in a reference area; and
- Limited geotechnical evaluation of Tailings Impoundments AB/BC and D.

Based on the data collected, EPA prepared a draft Baseline Human Health Risk Assessment (BHHRA, CH2M HILL, 2008b) and a Screening Level Ecological Risk Assessment (SLERA; CH2M HILL, 2008c).

As required by the AOC, NewFields Companies, LLC (NewFields), on behalf of ASARCO, prepared and submitted a draft Phase II RI/FS work plan to EPA in October 2008 (NewFields, 2008a) to fill the data gaps identified in the Phase I RI. After receiving comments from EPA regarding the draft RI/FS work plan, ASARCO submitted a revised Phase II RI/FS work plan in April, 2011 (Brown & Caldwell, 2011). Subsequent to the receipt of this revised RI/FS work plan, EPA issued a letter to ASARCO, dated July 27, 2011, in which EPA stated that ASARCO's revised RI/FS work plan was unacceptable and that EPA was taking over the task of preparing a Phase II RI/FS work plan for the Site.

Based on the findings of the draft Phase I RI Report and HHRA, EPA identified a high-priority need for the removal of contaminated soil from residential properties in the vicinity of the ASARCO Hayden smelter. From March through June 2008, ASARCO completed a removal action at 15 residential properties identified by EPA as high priority. As described in the *Revised RI/FS Work Plan for ASARCO Hayden Plant Site* (Brown and Caldwell, 2011), from December 2008 through October 2009, ASARCO performed soil removals at 251 additional properties under EPA oversight.

The Phase II RI/FS Work Plan (Part 2) identifies additional data to be collected to characterize site conditions and related human health and ecological risks more completely in support of the identification and evaluation of appropriate response actions in the FS. Consistent with the requirements of the AOC Statement of Work (SOW), this Work Plan includes a summary and interpretation of all Site data related to soil, water and sediment media available to EPA at the time of preparation of this document. Relevant information from the Phase I RI Report, BHHRA, and SLERA, as well as the draft and revised RI/FS Work Plans from ASARCO, was considered in the development of this Phase II Work Plan and, where appropriate, is presented in this Work Plan. This Work Plan also considers data from various Site operating permits, where available.

1.1 Definitions

The AOC contains several definitions that are used with specific meanings in this document:

- **Site** – The ASARCO Hayden smelter and associated facilities owned or operated by ASARCO in Hayden, Arizona, and any areas where hazardous substances from those facilities have come to be located. The boundaries of the Site are not currently defined, and will be determined by the RI/FS process.
- **Hayden Complex** – Property owned by ASARCO or its subsidiaries on which the Hayden smelter and concentrator and associated operations are located, including associated tailings piles and those areas formerly part of the Kennecott Smelter.

In addition, the following definition is used for purposes of the Phase II RI:

- **Study Area -** The investigation area for the Phase II RI (encompassing the Site as defined above), including the towns of Hayden and Winkelman, ASARCO-owned lands, the area surrounding the confluence of the Gila River and San Pedro River, portions of the Gila River and San Pedro River upstream and downstream of their confluence, tributaries of the Gila River in the vicinity of the Hayden Complex, and select background sample locations.

1.2 Objectives

The ultimate goal of the Phase II RI is to collect sufficient data to characterize the Site adequately so that the human health and environmental risks can be quantified and EPA can select a remedy that is protective of human and ecological receptors. Specific objectives of the RI, which conform to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) RI/FS guidance document (EPA, 1988) and the AOC SOW, include the following:

- Collect sufficient data to address the data gaps identified during the Phase I RI and to meet the AOC requirements to characterize contributions of hazardous substances to the environment from both historic and active smelter operations and to assess human and ecological risks.
- Evaluate the nature and extent of contamination at or from the Site, as well as any ongoing sources of contamination or potential sources of future contamination.
- Characterize the distribution of the chemicals of potential concern (COPCs) in the Study Area in media such as non-residential soils, sediments, surface water, stormwater runoff, process water, and groundwater, as well as any connections (fate and transport) between such media.
- Identify those COPCs that may pose unacceptable risk to human health and the environment.
- Assess background or baseline environmental conditions as a point of reference for comparison to current Site conditions.
- Identify remedial action objectives (RAOs) and preliminary remedial alternatives to prevent, mitigate, or otherwise respond to or remedy the release or threatened release of hazardous substances, pollutants, or contaminants at or from the Site.
- Conduct treatability testing as necessary to evaluate the potential performance and cost of the treatment technologies that are being considered.

The Phase II RI/FS Work Plan includes a sampling program designed to satisfy the data quality objectives and to meet the future needs of the HHRA, ecological risk assessment, and FS. The sampling design was developed within the framework of 19 distinct RI Areas intended to address historic and possibly continuing sources of contamination, environmental pathways to human and environmental receptors, and the receptors themselves. These19 RI Areas are identified in Section 2.6, and detailed summaries of each area are described in Section 4.0 (Site Conceptual Model). These areas include smelter and concentrator areas, former Kennecott Smelter areas, tailings piles, material handling and transport areas, portions of the Gila and San Pedro Rivers and their tributary washes, historically contaminated areas, and other areas where hazardous substances have come to be located.

Progressive study findings may identify additional data gaps that will require iterative rounds of RI sampling and related investigations to refine EPA's understanding of the nature and extent of contamination in the Study Area to the degree required to provide full support for the risk assessment and FS. To the extent practicable, the RI and FS will be conducted concurrently to accommodate the timely identification of any additional data needed for the development and evaluation of remedial alternatives in the FS phase.

The ultimate goal of the FS is to ensure that appropriate remedial alternatives are developed and evaluated in accordance with CERCLA guidance, leading to the selection of the most efficient remedies for cleanup that balance effectiveness, protectiveness, cost, compliance with applicable or relevant and appropriate requirements (ARARs), and public acceptance. The FS is further addressed in Section 8.0 (Feasibility Study) of this Phase II RI/FS Work Plan.

1.3 Work Plan Organization

This RI/FS Work Plan is organized as follows:

- *Section 1 – Introduction:* Provides a general description of the project history, definitions, RI/FS objectives, and Work Plan organization.
- *Section 2 – Study Area Background and Setting:* Describes the Site history and physical setting, and provides a summary of data collected to date and an analysis of the suitability of the data for use in making project decisions.
- *Section 3 – Initial Site Evaluation:* Presents a general discussion of existing Site conditions based on the previously collected data.
- *Section 4 – Conceptual Site Model:* Discusses sources of contamination, primary release mechanisms, transport pathways for COPCs, and potential points of exposure. Also included is a summary description of the 19 RI Areas used to support the rationale and scope of the sampling program.
- *Section 5 – Applicable or Relevant and Appropriate Requirements (ARARs):* Discusses the preliminary ARARs identified for the Site.
- *Section 6 – Work Plan Rationale and Approach:* Documents the data gaps identified in the draft Phase I RI Report and the data requirements for both the risk assessment and the alternatives evaluation identified during the formulation of the project data quality objectives (DQOs), and presents how the RI activities will satisfy those data requirements.
- Section 7 – RI Tasks: Presents the tasks to be performed during the RI. This description incorporates RI site characterization tasks identified in the Quality Assurance Project Plan (QAPP) and the Field Sampling Plan (FSP) for the project, the data evaluation methods identified during the process of data analysis and evaluation, and the preliminary determination of tasks to be conducted after site characterization.
- *Section 8 – Feasibility Study:* Discusses the general approach to the FS.
- *Section 9 – Community Relations:* Summarizes the planned community relations activities.

- *Section 10 – Schedule:* Presents the planned schedule for the completion of the RI/FS activities for the Site.
- *Section 11 – References:* Identifies the documents referenced in the Work Plan.

2.0 STUDY AREA BACKGROUND AND SETTING

This section provides a description of the background and setting of the Study Area for the RI/FS. It incorporates pertinent information from the Phase I RI Report and relevant updates based on events that have occurred since the completion of the Phase I RI.

The Site and the town of Hayden are located approximately 100 miles southeast of Phoenix and 50 miles northeast of Tucson, Arizona. Winkelman is located approximately one mile southeast of Hayden (see Figure 2-1). The Study Area for the RI/FS (shown on Figure 2-2) generally encompasses the towns of Hayden and Winkelman, the area encompassing the ASARCO-owned and operated ore processing operation (including the Hayden Complex), the area surrounding and including the portions of the Gila River and San Pedro River near the Hayden Complex, and background sample locations.

The active portion of the Site consists of ASARCO's crusher, concentrator, smelter, and tailings impoundment areas. The crusher, located on the north side of State Route 177, crushes ore brought from the Ray Mine (and from other potential sources) via the Copper Basin Railway. An overland conveyor (Conveyor 9), approximately 2,000 feet long, transports ore from the crusher to the mill building at the concentrator facility (Figure 2-3). A portion of Conveyor 9 (approximately 400 feet long) extends over residential streets in Hayden. From the concentrator, the copper-rich concentrate, which contains about 25 to 30 percent copper, is transported to the ASARCO Hayden smelter.

Pipelines conveying tailings slurry extend from the concentrator area next to the town of Hayden swimming pool, southwest to Tailings Impoundment AB/BC, located on the northeast side of the Gila River, and to Tailings Impoundment D, located on the southwest side of the Gila River (Figure 2-3).

Hayden's drinking water is supplied by a wellfield, operated by ASARCO, located near the southeastern end of Tailings Impoundment AB/BC, approximately one mile south of Hayden, and by two additional drinking water production wells located at PZ Ranch, approximately eight miles south of Hayden. Winkelman's drinking water currently is supplied by two wells operated by the Arizona Water Company. The wells are located east of town within the community park adjacent to the Gila River, as described in the *Expanded Site Inspection Report: ASARCO, Inc., Hayden Plant* (ADEQ, 2003).

2.1 Hayden Complex Operational History

This section addresses the historical and current operational history of the Hayden complex.

2.1.1 History of Operations

The Ray Mine has been mined for copper since approximately 1880, and has been a primary source of materials for the Hayden Complex. One of the first owners of the mine was Ray Copper Company. This company transitioned to Ray Consolidated Copper Company (RCCC) with the acquisition of Globe Mines Exploration Company, Ltd., and Gila & Ray Copper Mines in 1898 and 1906, respectively. The Town of Winkelman was founded in 1887. Hayden was founded in 1909 as a company town to provide housing for workers supporting the mining and smelting operations, as described in the *Aerial Photographic Analysis of ASARCO Hayden Study Area, Gila and Pinal Counties, Arizona* (EPA, 2004a). ASARCO constructed its Hayden smelter facility in 1911 and began operations to process ore from the Ray Mine in 1912. A 300-foot stack was built in 1912 to handle reverberatory furnace and roaster (R&R) emissions, and a 250-foot stack was built in 1918 to discharge converter gases from the copper smelter.

In 1933, Kennecott Copper Corporation (Kennecott) bought the Ray Mine from Nevada Consolidated Copper Company (NCCC). The ASARCO Hayden smelter stopped receiving ore from the Ray Mine in 1958, at which time Kennecott began operation of its own smelter, which included construction of a 600-foot stack. As a result of the development of a new type of concentrate haulage car in conjunction with the Southern Pacific Railroad, the ASARCO Hayden smelter began receiving concentrates from the Pima, Duval, Bagdad, Cyprus, Silver Bell, and Mission mines in 1958.

In 1974, a 1,000-foot double-shell concrete stack was built by ASARCO to discharge exhaust gases from the smelter complex, replacing the 300-foot R&R stack and 250-foot converter stack. Operations at the Kennecott smelter ceased in 1982, and processing of ore from the Ray Mine was resumed at ASARCO's Hayden smelter in 1983. ASARCO bought the Ray Mines Division from Kennecott in 1986, and has demolished a number of structures associated with the Kennecott smelter. In 1984, ASARCO completed certain upgrades to its Hayden smelter, which included installation of an INCO oxygen flash smelting furnace; construction of an oxygen plant to produce oxygen for the new furnace; construction of a second sulfuric acid plant to capture and reuse sulfur dioxide (SO_2) produced during smelting; and construction of a water treatment plant to recover process water from the sulfuric acid plant for reuse. In 1996, a series of upgrades to the Hayden concentrator was completed (ADEQ, 2003).

Tailings disposal in the area now known as Tailings Impoundment AB/BC started in 1910 at a rate of approximately 4,000 tons per day (tpd). The rate increased to approximately 16,000 tpd

by 1952, and to 21,000 tpd in 1960. A single-point discharge system was used initially for tailings disposal. By 1958, individual basins separated by berms were present.

A geotechnical evaluation reported excess seepage at the contact between coarser grained materials and finer grained materials previously deposited by the single-point discharge system. The tailings seepage was evident mainly along the western half of the tailings impoundments. The slope eventually failed (in an area 500 feet across and 30 to 50 feet deep) at the coarse/fine grained interface in 1972. Another failure occurred in 1973, when water was seeping out of failed portions of the impoundment and seepage springs were observed (Dames & Moore, 1990). In 1993, a breach caused by a flood event in the southern portion of Tailings Impoundment AB/BC resulted in the release of an estimated 292,000 tons of tailings into the Gila River. This event was observed directly, and samples were collected as far as 11 miles downstream of the tailings impoundments. Sediment samples collected following this discharge along the Gila River indicated that copper and zinc concentrations in the discharged sediment were elevated (ADEQ, 2003; referenced in CH2M HILL, 2008a).

Construction of Tailings Impoundment D began in 1982 with a starter dike 8,700 feet long by 48 feet high. After 29 weeks of tailings disposal behind the dike, settlement cracks and tailings seepage were observed by mine employees. The cracks and seepage apparently were caused by differential settlement between coarse- and fine-grained materials, and reportedly were addressed by ASARCO (Brown & Caldwell, 2011).

As previously mentioned, the former Kennecott smelter area on the north edge of Hayden, north of the concentrator facility, underwent demolition work beginning in 2002. This area currently consists of storage tanks, foundations, debris, and a slag dump northwest of the former smelter. The former Kennecott smelter stack was not demolished. The lime and filter plant facilities remain in place and are used in current operations.

2.1.2 Current Operations

Sulfide ore undergoes primary crushing at the Ray Mine and subsequently is transported by rail to the 27,400 tpd Hayden concentrator at the Hayden Complex. The ore is offloaded at the track hopper and passed through secondary and tertiary crushing processes, where it is reduced in size. The ore is then transported by Conveyor 9 to rod mills and ball mills, where it is pulverized to sand or a finer grain size, and converted to slurry. The ore slurry is directed to froth flotation cells, where the copper-containing minerals are separated from the gangue, or barren material. The tailings from the froth flotation process are sent to thickeners, and then transported as slurry in the tailings pipeline and deposited on Tailings Impoundments AB/BC and D. The resulting copper-rich concentrate, which contains about 25 to 30 percent copper, is transported to the

720,000 tons per year (tpy) Hayden smelter, located approximately 2,000 feet east-northeast of Hayden. The smelter also receives concentrates directly from operations at the Ray Mine, as well as other sources such as ASARCO's Mission Mine and other facilities based on market conditions.

Although the activities are closely related, ASARCO manages the concentrator and smelter operations separately, with each operation having a separate entrance. The smelter facility consists of an oxygen flash furnace, converters, anode casting, an oxygen plant, and an acid plant (NewFields, 2008a). At the smelter, the concentrates are unloaded and blended with fluxes, then transferred to fluid bed dryers where they are dried before being introduced into the oxygen flash furnace. The copper concentrates ignite, melt, and separate to produce matte (approximately 55% copper) and slag. During this process, sulfur from the ore is oxidized to form sulfur dioxide (SO_2) gas. The matte from the flash furnace is subsequently processed in converter furnaces to remove additional impurities and produce blister copper (approximately 98.5% copper). Finally, the blister copper is further processed in anode furnaces to produce copper anodes that are 99% pure. The anodes are shipped off site for final processing.

The smelter facility includes several waste management activities. The active smelter building is approximately 11 stories tall, and a portion of the air emissions is released to the atmosphere through the 1,000-foot-tall stack. During the smelting process, sulfur from the ore is oxidized to form SO_2 gas, which is converted to sulfuric acid in the sulfuric acid plant. Slag from the smelter operations is transferred to an active slag handling area located immediately southeast of the smelter building (Figure 2-3). Treated wastewater and other process waters are routed to containment pond CP-1, located east of the smelter. Decant water from the tailings impoundments is routed to reclaim ponds located east of Tailings Impoundment AB/BC, where it is recycled back into process operations.

Management facilities for process water and stormwater consist of several drainages and surface water impoundments located throughout the concentrator and smelter areas. These facilities include the Powerhouse Wash (which separates the active smelter area from the concentrator and the residential areas of Hayden), emergency overflow and pump-back ponds located south-southeast of Tailings Impoundment AB/BC, a large retention pond (Last Chance Basin) at the northwestern edge of Tailings Impoundment AB/BC, and containment berms in select locations within the tailings impoundment areas (Figure 2-3). Other drainages and surface water impoundments are identified in the descriptions of the 19 RI Areas in Section 4.3.

The tailings impoundments are managed as part of the concentrator operations. Tailings Impoundment AB/BC, located south of State Route 177 and northeast of the Gila River, extends for approximately 2.5 miles to the confluence of Keystone Canyon Wash and the Gila River,

with a maximum width of one mile and a maximum height of 200 feet. Tailings Impoundment AB/BC is bounded on the north by the Copper Basin Railway tracks and on the south by the Gila River flood plain. The eastern boundary is adjoined by the Hayden Golf Club (Figure 2-2). Tailings Impoundment D, located southwest of the Gila River, extends for a length of approximately two miles, with a maximum width of 1,500 feet and a maximum height of 150 feet. It is bounded on the south by the Tortilla Mountains.

2.2 Demographics and Land Use

Hayden has a population of approximately 662 residents according to 2010 census data published by the U. S. Census Bureau (http://2010.census.gov, accessed on March 1, 2012). ASARCO operations surround the Hayden community on all sides. Residential areas are bounded on the west edge of town by the San Pedro Wash and are bisected by the Kennecott Wash. Public areas, including a library, playground, and swimming pool, are located adjacent to and west of ASARCO's concentrator facilities (Figure 2-3). A 2007 reconnaissance conducted as part of the Phase I RI estimated that there were 383 structures in the town of Hayden at the time. Of this total, 301 of the structures were occupied habitable homes, 52 were uninhabitable homes, and 30 were government or commercial structures.

Winkelman has a population of approximately 353 people according to 2010 census data published by the U. S. Census Bureau (http://2010.census.gov, accessed on March 1, 2012), and is primarily a residential area, with a school complex for the towns of Hayden and Winkelman on the northern edge of town, commercial development along State Route 177, and a community park along the Gila River on the eastern edge of town. The school complex is located south of the ASARCO smelter operation area, approximately 1,200 feet south of the active slag pile. Winkelman has a total of 215 structures, including 156 homes (146 of which are habitable), and 59 government and commercial structures.

2.3 Physical Setting

This section provides information on site topography and drainage, climate, geologic setting, hydrogeologic setting, water supply, surface water, and ecological and biological resources of the Study Area.

2.3.1 Site Topography and Drainage

The Study Area is located near the western edge of the Mexican Highland portion of the Basin and Range physiographic province. This province is characterized by north-northwest trending mountain ranges separated by sediment-filled valleys derived from erosion of the adjacent ranges. Major fault systems typically parallel the length of the uplifted mountain blocks.

The Tortilla Mountains, located several miles to the west of Hayden, form the western border of the Gila River Valley. Topographic relief is moderately gentle on the west side of the Study Area, transitioning to moderately steep slopes farther west in the Tortilla Mountains. The Dripping Spring Mountains are located immediately north-northeast of the Site and contain Tornado Peak, which extends to 4,484 feet above mean sea level (msl). From Tornado Peak to the south-southwest, elevations decrease to approximately 1,900 feet above msl along the Gila River in the southwestern corner of the Study Area (Figure 2-4). An alluvial surface gently slopes northeastward from the Tortilla Mountains to the Gila and San Pedro Rivers. The area east of the Gila and San Pedro Rivers is characterized by a dissected upland that drains to the west.

The Town of Hayden and the Hayden Complex are located on the southwestern flank of the Dripping Spring Mountains, adjacent to and elevated above the flood plain of the Gila River. Hayden is positioned downgradient and at lower elevations relative to most active operation areas. Elevations at the Hayden Complex range from approximately 2,000 feet above msl near State Route 177 to approximately 2,300 feet msl near the process water tank located north of the former Kennecott smelter area (Figure 2-3). Past reviews of topographic maps and historical aerial photographs of the Study Area (EPA, 2004a) indicate that several drainages are located north of the Hayden Complex. Prior to industrial development in the area and associated topographic modification, these drainages continued past current operation areas and linked with drainages located in Hayden. San Pedro Wash, Kennecott Wash, and Powerhouse Wash currently direct surface water runoff from the area of the Hayden Complex to the Gila River.

The topography of Winkelman is relatively flat, with a gradual decrease in elevation toward the northern boundary of the Gila River flood plain. The southernmost part of Winkelman is located within the flood plain of the Gila River. In 1926, one of the worst floods in local history was recorded. The flood destroyed crops, damaged a large area of farm land, and flooded lower Winkelman, also known as Winkelman Flats. Additional large flood events occurred in 1983 and 1993.

The Hayden Complex employs a system of man-made channels, pipes, surface impoundments, and dikes to control surface water flows and sediment transport. ASARCO personnel have indicated that all stormwater runoff from the Hayden concentrator and part of the smelter area is captured by this system to keep it from entering the Gila River (ASARCO, January 2005; referenced in CH2M HILL, 2008a). A portion of the Hayden Complex stormwater flow travels through residential areas in the city of Hayden. Most stormwater originating from the Hayden concentrator and portions of the Hayden smelter is captured by the stormwater containment system, which includes emergency ponds, pump-back ponds, and the Last Chance Basin.

The Hayden Concentrator Stormwater Pollution Prevention Plan (SWPPP) indicates that a few selected areas are outside of the containment systems. This includes an area outside of the series of berms along the Gila River on the south side of the reclaim ponds and the perimeter road around Tailings Impoundment AB/BC (ASARCO Consulting LLC, 2004). Runoff from the downstream edge of the berm/dike containing Tailings Impoundment AB/BC has been observed to flow directly into the Gila River (Figure 2-3). Runoff from portions of the smelter area is contained in impoundments below the operating slag piles, where it is allowed to infiltrate into the subsurface. Reclaim ponds are situated east of Tailings Impoundment AB/BC and south of Hayden. These reclaim ponds receive decant water from the tailings ponds located on top of the tailings impoundments (ASARCO Consulting LLC, 2004), and this water is recycled into concentrator process operations.

Stormwater in the smelter vicinity drains primarily to CP-1 (formerly known as Louie's Lagoon and also known as "run-on and containment pond" [see Figure 2-3]). CP-1 is a detention pond that collects runoff from storm drains, blow-down (process water discharge) from the anode cooling tower, treated process effluent from various treatment plants, process machinery cooling water, and air conditioner and swamp cooler water. CP-1 originally was unlined and likely remains unlined today. Excess water from this pond historically was pumped to the three Terrace Ponds, the seven North Ponds, and Wimpy's New Pond located further to the north. Sediments from the aforementioned upper ponds were removed at the time of CP-1 construction (ASARCO, 2005b; referenced in CH2M HILL, 2008a). All of these ponds continue to receive stormwater runoff from other site areas. A concrete-lined sump is located at the southwestern corner of CP-1.

Unlined depressions that collect stormwater are located downstream of the active ASARCO and former Kennecott smelter area slag piles. At the ASARCO slag pile, these depressions are referred to as Containment Ponds 1-4. Containment Ponds 1, 2, and 4 primarily collect stormwater runoff from the slag pile and adjacent areas, and Containment Pond 3 collects overflow from Containment Ponds 1, 2, and 4, and is typically dry. The unlined depression downstream (south) of the former Kennecott smelter area slag pile collects runoff from the slag pile, the lime plant, and most of the former smelter area.

2.3.2 Climate

From a review of information provided by the Western Regional Climate Center (www.wrcc.dri.edu), the Winkelman, Arizona, Cooperative Observer Station is a representative source of climatological information for the area. Based on the 1971–2002 period of record for this station, the area has an annual average precipitation of about 14 inches, and temperatures ranging from an average winter low of 31 degrees Fahrenheit (^{o}F) to an average summer high of

99 ^{o}F. The annual average low temperature is 46 ^{o}F and the annual average high temperature is 84 ^{o}F. Precipitation occurs primarily during the winter (December to March) and during the summer and fall (July to October), with highest precipitation levels occurring during the North American Monsoon in July and August.

2.3.3 Geologic Setting

Geologic units exposed in the Study Area consist of a basement complex of older Precambrian through Paleozoic sedimentary rocks and minor igneous intrusives. Older Quaternary deposits such as alluvial fans and younger Quaternary alluvium are present along stream and river channels (SHB–AGRA Earth & Environmental, Inc. [SHB], 1994). The dominant feature in the Study Area is the alluvial basin formed by the confluence of the Gila River and San Pedro River, which generally trends in a southeast-to-northwest direction. On the Hayden side of this basin, adjacent to the Dripping Spring Mountains, are Tertiary bedrock formations with locally variable amounts of Holocene alluvium and colluvium. Descriptions of these units (shown on Figure 2-5) are provided below, listed from youngest to oldest.

- Fill Material (**Fd**). Consists primarily of mill tailings. Includes Tailings Impoundments AB/BC and D and older tailings deposits in lower Kennecott Wash and west of the Powerhouse Wash.
- Quaternary Alluvium (**Qal**). Consists of unconsolidated silt, sand, and gravel along washes and river channels such as the Gila River, San Pedro River, San Pedro Wash, and Powerhouse Wash.
- Older Quaternary Deposits (**Qo**). Present along stream terraces and alluvial fans, including nearly all of the Winkelman residential areas and other terrace areas (particularly adjacent to the west side of Tailings Impoundment D). Small portions of Hayden are located on this unit.
- Tertiary Sedimentary Rocks (**Ts**). Consists primarily of volcanic tuffs and conglomerates. Deposits are present in all Hayden residential areas located hydraulically above local washes, and extend into the far northwestern portion of Winkelman. The active concentrator, smelter, and most of the former Kennecott smelter area also are located on this unit.
- Cretaceous/Tertiary Intrusives and Volcanic Rocks (**KTi**). Consists of intrusive and volcanic rock. Formations are located in the higher elevations north and east of Hayden, and are adjacent to the reaches of the Gila River upstream of Winkelman.
- Paleozoic Sediments (**Ps**). Consists of limestone located primarily in a northeast to southwest trending band in the upland area north of Hayden, and adjacent to the Gila River upstream of Winkelman.

2.3.4 Hydrogeologic Setting

The Site is located within the Upper San Pedro groundwater basin. The major components of this system are the water-bearing sands and gravels of the Gila River and San Pedro River flood plains that are recharged by the two rivers and from groundwater flows within smaller tributary stream alluvium. Bedrock seepage may contribute a small amount of inflow in certain areas. Water level measurements in wells located along the San Pedro and Gila Rivers indicate that the depth to groundwater generally is within tens of feet below the channel elevation (SHB, 1994).

The locations of Site monitoring wells and drinking water production wells are shown on Figure 2-6. Groundwater elevation contour maps (Figures 2-7 and 2-8) were prepared by CH2M HILL based on groundwater elevation measurements from February and October 2006 (CH2M HILL, 2008a). The regional groundwater flow within Hayden and Winkelman is in a southerly direction, toward the Hayden wellfield and the Gila River and San Pedro River confluence. The groundwater flow gradient is relatively high in the Hayden area, and is considerably lower in the Gila River flood plain. The groundwater flow direction between the two tailings impoundments is generally northwesterly, consistent with the surface water flow direction of the Gila River in that area. The tailings impoundments do not appear to be causing large mounding of the water table, but the relatively low gradient in the vicinity is likely the result of recharge from Gila River surface water losses and drain-down from the tailings impoundments.

Local groundwater systems at the Site are generally separated into the following three systems.

- **Gila River/San Pedro River Alluvial Aquifer**: This uppermost aquifer is composed of approximately 100 feet of alluvial sands and gravels (Qal geologic unit) within the Gila River and San Pedro River flood plains. Groundwater monitoring wells GW-03, H-1, H-2A, H-3, H-4, H-5, H-6, H-10, H-11, S-4A, most of the ARU series monitoring wells, and all Hayden and Winkelman drinking water production wells are screened in this aquifer. As would be expected, fluctuations in water levels within this aquifer are controlled primarily by fluctuations in the river stage. Yields from production wells completed in this aquifer are generally high (200 to 1,200 gallons per minute [gpm]), and the aquifer is the area's major water supply source. The hydraulic conductivity for this aquifer, as obtained from Aquifer Protection Permit (APP) field tests (SHB, 1994), is approximately 0.1 centimeters per second (cm/sec).
- **Wash Alluvial Aquifers**: These disconnected aquifers are associated with the older alluvium/colluvium (Qo unit) found within upper reaches of the local Site drainages. While several wells are located within the boundaries of the washes, only the upper screened intervals of existing monitoring well SM-2 (61.5-70 feet bgs) and monitoring well GW-02 (11-28 feet bgs) are screened within the wash alluvial aquifer. Borings completed during prior Site studies indicate that these aquifers may be dry most of the

year, and flow only when there is significant precipitation or other recharge (i.e., from ponds or storage basins). The limited field tests of hydraulic conductivity (SHB, 1994) performed on wash alluvial aquifer wells yielded an approximate value of 10^{-4} cm/sec.

- **Bedrock Aquifer**: Wells completed in bedrock are located in the Ts formation (also referred to as the Big Dome Formation, [SHB, 1992]). These bedrock aquifer wells include existing monitoring wells GW-01R, GW-06, H-7, H-8, H-9, LC-1, and GW-02 (bottom portion of screened interval, or 28-31 feet below ground surface [bgs]), and SM-2 (bottom portion of screened interval, or 70-91.5 feet bgs). The hydraulic conductivity for this aquifer, as obtained from APP field tests (SHB, 1994), is considerably lower than the alluvial aquifer, at approximately 10^{-5} cm/sec.

2.3.5 Water Supply

Water supply at the Site is discussed below in the context of the Winkelman and Hayden water supplies.

2.3.5.1 Winkelman Water Supply

The Winkelman wellfield is located in the Winkelman Flats Public Park on the east side of State Route 77, and is operated by the Arizona Water Company (AWC), a private utility. AWC services 192 connections in Winkelman and several connections in Hayden. The wells are run daily and alternate in pumping operation. Water pumped from the wellfield is directed to a 100,000-gallon reservoir on the hillside west of the wellfield. AWC conducts quarterly sampling of the wells for metals, volatile organic compounds (VOCs), and semivolatile organic compounds (SVOCs), and conducts complimentary residential tap sampling for lead and copper.

The AWC provided the following details on the wellfield, which is contained within a fenced enclosure at the north end of the park (see Figure 2-6):

- Well WM-3 (also known as GWF-618) is the northernmost well.
- Well WM-4 is the southernmost well and has a discharge water quality characterized by high turbidity (dirt and rust). At the time, AWC was evaluating treatment alternatives such as a flush-out system.
- Well WM-2 (the westernmost well) is no longer in service (not shown on Figure 2-6).

2.3.5.2 Hayden Water Supply

The Hayden wellfield is located in the Gila River flood plain, east of Tailings Impoundment AB/BC, and is operated by ASARCO. ASARCO provides water free of charge to the residents

of Hayden. The exact number of residential connections is uncertain. The following details are available on the Hayden wellfield (ASARCO, January 2005a), which is shown on Figure 2-6:

- Nineteen (19) production wells are located in the main wellfield, although not all wells are operational at all times.
- Most of the production wells have taps for collection of water-quality samples.
- Two additional production wells are located at PZ Ranch, about eight miles south of Hayden.
- The smelter also uses two production wells at Robinson Ranch, located about two miles south of Hayden.
- The main freshwater pump house, located south of State Route 177, collects water from the various production wells via manifolding, and pumps water to three end users (Town of Hayden, ASARCO Hayden Plant, and the Ray Mine).
- Water for Hayden residential use is pumped to a large, rectangular, concrete-lined reservoir on the hillside near the active smelter, while another tank provides storage for ASARCO plant use. Water for Ray Mine operations is pumped from a station located near State Route 177 using two large pumps.

Treated wastewater from Hayden residents is currently mixed with the Site tailings water (100:1 dilution), and is directed to the tailings impoundments. However, the town of Hayden plans to build a wastewater treatment plant to treat the effluent to a B+ class (Arizona Administrative Code R-18-11-305), and it is planned that the treated effluent will be discharged to Tailings Impoundment AB/BC and eventually will become part of process water. The design work for the treatment plant has been finished; however, a construction schedule has not yet been confirmed.

2.3.6 Surface Water

The Site is located in the vicinity of two rivers, the Gila River and the San Pedro River. The Gila River flows southwestward from the San Carlos Reservoir (created by the Coolidge Dam, about 30 miles upstream, which was completed in 1928) through the Mescal Mountains and the southern portion of the Dripping Spring Mountains, turns northwestward at Hayden, and flows through the valley between the Dripping Spring Mountains and the Tortilla Mountains. The San Pedro River flows northwestward from southeastern Arizona and Mexico, and empties into the Gila River approximately one-half mile southeast of Hayden. This area is referred to as the Middle Gila Watershed by the Arizona Department of Water Resources (ADWR, 2009).
The area north and west of the Gila River is drained by a series of intermittent streams that are unnamed on U.S. Geological Survey (USGS) topographic quadrangle maps. The boundaries of

the watershed, in which the Hayden area is situated, were delineated using USGS 7-½ minute topographic quadrangle maps for Hayden and Winkelman (SHB, 1992, referenced in CH2M HILL, 2008a).

USGS stream flow records are available for gauges on the Gila River above and below Coolidge Dam. The closest upstream gauging station, the Coolidge gauging station (located approximately 28 miles upstream from the Site), measures discharge released from the Coolidge Dam into the Gila River. The Kelvin station, located approximately 18 miles downstream of the confluence of the Gila and San Pedro Rivers, measures flows through the reach downstream from the Site. In the period from 1901 to 2010, the minimum, mean, and maximum annual flows at the Coolidge station were 38, 367, and 2,333 cubic feet per second (cfs), respectively. In the period from 1912 to 2010, the minimum, mean, and maximum annual flows at the Kelvin station were 69, 505, and 3,278 cfs, respectively.

For the period from 1911 to 2010, discharges reported at the Kelvin station generally were higher than those reported at the Coolidge station for most monthly periods. However, this relationship is variable and is dependent on the contributions from stormwater inflow and groundwater recharge along this reach of the Gila River. The flows at these two stations are generally closest during the dry months (April to June), indicating that the dam releases are the major source of water in the Gila River. The flow at the Kelvin station is considerably higher in the winter rainy season (January to March) and summer monsoon season (July to September), during which periods contributions from the Coolidge Dam typically are reduced while contributions from local stormwater runoff increase. The three highest historical flood crests for the area occurred in 1932, 1993, and 1997.

2.3.7 Ecological and Biological Setting

Descriptions of the terrestrial and aquatic systems in the Study Area are derived from the literature, ecological studies in the region, and reports from a site visit by CH2M HILL personnel in 2006. General information on the terrestrial habitat in the area was obtained from *Biotic Communities: Southwestern United States and Northwestern Mexico* (Brown, 1994; referenced in CH2M HILL, 2008a). More site-specific descriptions of both terrestrial and aquatic habitats (primarily the associated riparian areas) were obtained from the site visit and ecological studies conducted along the Gila and San Pedro Rivers, ranging from southeast of Winkelman along the San Pedro River to northwest of Hayden past Kelvin along the Gila River. Prior information and data collected during the CH2M HILL Phase I RI are summarized in the Screening-Level Risk Assessment (SLERA), which is a companion document to the CH2M HILL Phase I RI Report (CH2M HILL, 2008a). A detailed summary of the SLERA procedures and findings is presented in Section 5.2 of the Phase I RI Report.

A list of special status species (including plants, invertebrates, fish, amphibians, reptiles, birds, and mammals) that have been documented in the project area was provided by the Arizona Game and Fish Department (AGFD, 2006; referenced in CH2M HILL, 2008a) and is presented in Table 2-2 of the Phase I RI Report. A more detailed description of terrestrial and aquatic communities within the Middle Gila watershed is provided in the SLERA (CH2M HILL, 2008c).

2.3.7.1 Terrestrial Biota

The Study Area is located in the northeastern corner of the Sonoran Desert scrub biome. This biome represents a large arid region that encompasses most of the Baja California Peninsula, the western half of the State of Sonora, Mexico, and large areas in southeastern California and southwestern Arizona (Brown, 1994; referenced in CH2M HILL, 2008a). The Sonoran Desert has a bimodal rainfall pattern (rains in winter and summer), which allows it to have a greater structural diversity (i.e., large cacti and succulent plants in most regions, and trees, tall shrubs, and succulents along drainages) than any of the other North American deserts. Brown (1994) presents six subdivisions of this biome, with the Study Area located in habitat characterized as Arizona Upland. About 90% of this subdivision is on slopes, broken ground, and multi-dissected sloping plains. It is the best-watered and least desert-like desert scrub habitat in North America. These upland communities are dominated by paloverde (*Cercidium spp*.) and cacti (*Opuntia spp*.) desert associations. Other plant species associated with these communities include saguaro cactus (*Carnegiea gigantea*), jojoba (*Simmondsia chinensis*), crucifixion-thorn (*Canotia holocantha*), and creosotebush (*Larrea spp.*) (Brown; 1994, referenced in CH2M HILL, 2008a).

Large mammals found in the region include desert mule deer (*Odocoileus hemionous crookz*), javelina (*Pecari tajacu*), coyote (*Canis latrans*), and gray fox (*Urocyon cinereoargenteus*). Smaller mammals in the region consist of species such as the black-tailed jackrabbit (*Lepus californicus*), desert cottontail (*Sylvilagus audubonii*), Arizona pocket mouse (*Perognathus amplus*), and the endemic Harris antelope squirrel (*Ammospermophilus harrissiz*).

Avian species include Swainson's hawk (*Buteo swainsonii*), turkey vulture (*Cathartes aura*), Harris' hawk (*Parabuteo unicinctus*), the federally endangered southwestern willow flycatcher (*Empidonax traillii extimus*), phainopepla (*Phainopepla nitens*), red-winged blackbird (*Agelaius phoeniceus*), cliff swallows (*Petrochelidon pyrrhonota*), white-winged dove (*Zenaida asiatica*), Inca dove (*Columbina inca*), elf owl (*Micrathene whitneyi*), cactus wren (*Campylorhynchus brunneicapillus*), curve-billed thrasher (*Toxostoma curvirostre*), cactus woodpeckers (*Melanerpes uropygialis, Colaptes chrysoides,*and *Picoides scalaris*), and the Wied's crested flycatcher. Avian species supported by the riparian habitat along the Gila River include the federally endangered southwestern willow flycatcher, as well as other riparian species such as the yellow-billed cuckoo, common snipe, belted kingfisher, and various warblers. The

southwestern willow flycatcher and bald eagle (*Haliaeetus leucocephalus*) have been documented in the Study Area vicinity (ADEQ, 2003; referenced in CH2M HILL, 2008a).

Reptiles, especially lizards and snakes, are a common component of desert ecosystems. Within the Arizona Upland subdivision, there are many Sonoran and other desert reptiles, including the regal horned lizard (*Phrynosoma solare*), western whiptail (Cnemidophorus tigris gracilis), Gila monster (Heloderma suspectum), Arizona glossy snake (Arizona elegans noctivaga), Arizona coral snake (Micruroides euryxanthus), tiger rattlesnake (Crotalus tigris), and diamondback rattlesnake (Crotalus atrox) (Brown, 1994, referenced in CH2M HILL, 2008a).

2.3.7.2 Aquatic Biota

The Gila River and its tributaries, including the San Pedro River, are major lotic waters (i.e., actively moving) in the area and provide riparian habitat for wildlife in southeastern Arizona (Andrews and King, 1997: referenced in CH2M HILL, 2008a). Paxton, et al. (1997) described both rivers as perennial (i.e., containing water year round); although both have been dry during extremely low rain periods (ADEQ, 2003; referenced in CH2M HILL, 2008a). The Gila River is considered a fishery, with flow rates from 100 to 1,000 cubic feet per second (cfs) (ADEQ, 2003; referenced in CH2M HILL, 2008a).

Flow in the Gila River between Coolidge Dam and the Ashurst-Hayden Diversion Dam is controlled by releases from the San Carlos Reservoir (ADWR, 2009). Both the Gila and San Pedro Rivers are classified as A&Ww (Aquatic and Wildlife–warm water). Annual fish monitoring on both the Gila and San Pedro Rivers from 1995 to 2006 indicates that from three to eleven species have been collected at various times. Up to nine fish species have been found in the San Pedro River near the Study Area, and up to eleven species of fish have been found in the Gila River near the Study Area. There are several special status fish species in the Middle Gila River, including the Gila topminnow (*Poecilliopis occidentalis*).

The SLERA summarizes the following regarding fish populations:

- The diversity (i.e., number of species) of native and non-native species does not appear to vary appreciably across five monitoring stations, though it does appear that diversity may be declining from 1995 to 2006. Marsh and Kesner (2006) noted this decline in native species and suspect that drought is a possible factor. In fact, none of the five stations could be sampled in 2004 because the streambeds were dry, and the on-site station along the San Pedro River was dry for three consecutive years (2002 to 2004).
- The number of fish collected appears to vary greatly by both location and year. In a five-year analysis of the 1995 to 1999 data, Marsh and Kesner (2004) stated that the individual sample sizes (number of fish) are highly variable in time and space, and are

often small, even for relatively abundant species. Specifically, the number of species collected at each site and the number of those that are native fish species does not appear to have a pattern of variation across the sampling stations. They report that this finding is consistent with other studies of fish communities in the arid southwest and that this is a recognized complicating factor in analyzing sample data from these areas.

The riparian area near the confluence of the Gila and San Pedro Rivers consists of mixed exotic and native vegetation. Riparian areas along the confluence of these rivers have been described as varying from monotypic tamarisk (also known as saltcedar) to stands of native Goodding's willow (*Salix gooddingii*) and Fremont cottonwood (*Populus fremontii*), with average canopy heights between 4 and 15 meters, as described by Smith, et al. (2004). These riparian areas are surrounded by the Arizona Upland subdivision vegetation as described above, though agricultural fields border the riparian habitat along some portions of the San Pedro River (Andrews and King, 1997; referenced in CH2M HILL, 2008a).

2.4 Previous Studies

Several investigations have been conducted at the Site by EPA and ADEQ. In addition, the Arizona Department of Health Services (ADHS) joined with the Agency for Toxic Substances and Disease Registry (ATSDR) to prepare the *Public Health Assessment, ASARCO Hayden Smelter Site, Hayden, Gila County, Arizona* (ATSDR, 2002). The subsections below summarize the investigations and other information relevant to the RI/FS at the Site.

2.4.1 Preliminary Assessment (1988)

EPA conducted a Preliminary Assessment (PA) of the Site in 1988 to determine if there were releases of hazardous substances and whether the Site was eligible for placement on the National Priorities List (NPL) (EPA, 1988; referenced in CH2M HILL, 2008a). Following the PA, a Site Inspection (SI) was recommended for the Hayden Complex (ADEQ, 2003; referenced in CH2M HILL, 2008a).

2.4.2 Site Inspection (1991)

ADEQ conducted a non-sampling SI at the Site in 1991 and concluded that, based on documented releases to the air and soil, the Hayden Complex qualified for further consideration under CERCLA (ADEQ, 1991; referenced in CH2M HILL, 2008a). EPA later decided that an Expanded Site Inspection (ESI) was needed (ADEQ, 2003).

2.4.3 Public Health Assessment (1999)

In conjunction with ATSDR, ADHS conducted a Public Health Assessment for the Study Area, which included the collection of ten environmental soil samples within Hayden and Winkelman to evaluate levels of contamination. From June to October 1999, public health surveys were conducted of the residents of Hayden and Winkelman. Blood lead levels were evaluated for children aged 6 to 72 months, and urinary arsenic levels were checked in adults and children. The survey did not report any other indicators of exposures.

The Public Health Assessment reported that the average concentrations of metals in soils were not above ATSDR Comparison Values (CVs) except for lead. The CVs are concentrations of a chemical below which adverse health effects are unlikely to occur. The CVs are not used to define specific adverse health effects from exposure, but instead to help determine if additional contaminant-specific investigation is needed. While only lead was shown to exceed the CV, the sample locations were not specified, only ten samples were collected, and the sampling depth (0-6 inches below ground surface [bgs]) may not be fully indicative of surface soil impacts (0-2 inches bgs).

Elevated urinary arsenic levels were found in a limited number of residents. The average urinary total arsenic concentration of individuals tested in Hayden and Winkelman was 13.7 micrograms per liter (ug/L), which is substantially less than the study reference level of 30 ug/L. All 14 children tested in Hayden and Winkelman had blood lead concentrations below the Centers for Disease Control and Prevention (CDC) intervention level of 10 micrograms per deciliter (ug/dL), with an average blood lead concentration of 3.6 µg/dL. No evidence of excessive environmental lead exposure was found in the study participants.

The study also summarized air quality data obtained from 1991–1998 from the dichot particulate monitoring station maintained by ADEQ at the Hayden Jail location, and compared this data against the ATSDR CV for arsenic (0.0002 micrograms per cubic meter [ug/m^3]), the National Ambient Air Quality Standard [NAAQS] for lead (1.5 µg/m^3 for a quarterly period, which has since been reduced to 0.15 ug/m^3), and the ATSDR CV for SO_2 (25 ug/m^3 for a 3-hour period). The Public Health Assessment did not include an evaluation of other metals such as chromium, cadmium, or copper.

The arsenic CV was exceeded in outdoor air, based on ADEQ data from the Hayden Jail, for each year from 1991 to 1998, while the NAAQS for lead was not exceeded based on ADEQ data from 1993 to 1997. The SO_2 CV was exceeded on occasion. The Public Health Assessment concluded that air quality in the Hayden and Winkelman area generally meets all federal and state air quality standards for criteria air pollutants, although some exceedances of arsenic and SO_2 CVs were reported. Brief episodes of elevated SO_2 in air are unlikely to cause respiratory

symptoms in persons without pre-existing respiratory conditions, but may cause short-term respiratory symptoms for sensitive asthmatics a few times per month. The report noted that conclusions drawn were based on data available at the time the document was released, and that conclusions could change if data indicate that exposure has increased or decreased based on further environmental investigation (ATSDR, 2002). The report noted that conclusions drawn were based on data available at the time the document was released, and that conclusions could change if data from further environmental investigations indicate that exposure has increased or decreased (ATSDR, 2002; referenced in CH2M Hill, 2008a). Importantly, any conclusions presented in the PHA were preliminary since the PHA relied on air quality data acquired from a single sampling location (the Hayden Jail) and did not include any sampling or analysis for $PM_{2.5}$.

2.4.4 RCRA Inspection (2000)

On September 20, 2000, EPA performed a Resource Conservation and Recovery Act (RCRA) inspection at the Hayden Complex, which included the collection of 12 solid material samples from the concentrator and smelter areas for analysis of the 23 Target Analyte List (TAL) metals by the EPA Region 9 laboratory.

Some samples exhibited elevated concentrations of arsenic, cadmium, chromium, copper, and lead above their respective Arizona residential soil remediation levels (R-SRLs). Other metals, including mercury, vanadium, and zinc, also were detected occasionally above their respective R-SRLs (EPA, 2000; referenced in CH2M HILL, 2008a). (Note: Arizona Administrative Code, Title 18, Chapter 7, includes Soil Remediation Standards, including R-SRLs, for remedial actions. These standards are subject to administrative change from time to time. The Soil Remediation Standards were last modified in 2007.)

2.4.5 Expanded Site Inspection (2002)

ADEQ, on behalf of EPA, performed an Expanded Site Inspection (ESI) in 2002, which primarily involved soil sampling around Conveyor 9 and other nearby areas in Hayden, and included groundwater, surface water, and sediment sampling. Soils from residential areas were sampled to assess the potential for the finer material on the conveyor belt that runs through town to be dispersed by wind into residential yards (ADEQ, 2003; referenced in CH2M HILL, 2008a).

Results of analyses revealed the following exceedances of the Arizona R-SRLs in surficial soils:

- Arsenic levels exceeded the R-SRL of 10 milligrams per kilogram (mg/kg) at 26 of the 36 locations sampled (to a maximum concentration of 67.4 mg/kg).

- Copper levels exceeded the then-current R-SRL of 2,800 mg/kg at 24 locations (to a maximum of 55,100 mg/kg). The R-SRL for copper was increased to 3,100 mg/kg in 2007.
- Lead levels exceeded the R-SRL of 400 mg/kg at three locations (to a maximum of 851 mg/kg).

Cadmium, mercury, and zinc levels in several samples were reported as elevated compared to average background concentrations, but were not detected above their respective R-SRLs.

The ESI concluded that the elevated concentrations of metals were the result of ASARCO operations. Arsenic, cadmium, copper, and mercury in surficial soil samples met the criteria of "observed contamination" (i.e., they were detected at concentrations exceeding three times the average background soil concentration). Lead did not meet the criteria of "observed contamination," even though three of 36 surface soil samples exceeded the R-SRL of 400 mg/kg. The ESI further concluded that contamination is potentially attributable to sources including, but not limited to, dispersal of crushed ore from the conveyor belt, deposition of aerosols from smelting operations, sediment transported by surface water runoff from the concentrator operation, and re-deposition of tailings from wind events. Sediment samples from containment pond CP-1 (which collects stormwater, wastewater, and process waters from the ASARCO smelter area) exhibited elevated concentrations of arsenic, cadmium, chromium, copper, lead, mercury, and zinc.

2.4.6 Removal Assessment (2004)

Based on the results of the ESI, the EPA performed a Removal Assessment that was focused on defining levels of metals contamination in soils within residential, public, and commercial areas in the towns of Hayden, Kearney, and Winkelman to further evaluate impacts from Site operations (ASARCO Hayden Removal Assessment; Final Report, Ecology & Environment, Inc. [E&E], 2004; referenced in CH2M HILL, 2008a). Background samples were collected at six locations along State Route 177 south of Winkelman. Soil samples collected in Kearney, which is approximately nine miles to the west of Hayden, did not contain elevated levels of contamination.

The total metals analyses revealed levels of at least one TAL metal above its respective R-SRL at 40 of 51 locations in the Hayden area. Exceedances included the following:

- Arsenic levels exceeded the R-SRL of 10 mg/kg at 40 locations (to a maximum concentration of 91 mg/kg);
- Copper levels exceeded the then-applicable R-SRL of 2,800 mg/kg at 29 locations (to a maximum of 11,400 mg/kg); and

- Lead levels exceeded the R-SRL of 400 mg/kg at one location (at 463 mg/kg).

In Hayden, samples with elevated copper and lead concentrations generally coincided with locations showing high arsenic concentrations, with the highest concentrations typically found close to ASARCO facilities, including particularly the Conveyor 9 area, east of the Conveyor 9 area near the Powerhouse Wash, and to the north of Hayden adjacent to concentrator operations and the former Kennecott smelter area.

For the 69 samples collected in the Winkelman area, the total metals analyses revealed the following exceedances of R-SRLs:

- Arsenic levels exceeded the R-SRL of 10 mg/kg at 16 locations (to a maximum concentration of 320 mg/kg);
- Copper levels exceeded the then-applicable R-SRL of 2,800 mg/kg at seven locations (to a maximum of 19,000 mg/kg); and
- Lead levels exceeded the R-SRL of 400 mg/kg at three locations (to a maximum of 485 mg/kg).

In Winkelman, elevated arsenic levels generally were reported for sample locations along and south of State Route 177. In addition, beryllium and thallium were also detected at concentrations above their R-SRLs in several samples. Antimony exceeded the R-SRL at only one location. (Through data validation, it was determined that the beryllium and thallium concentrations were likely biased high, which may have resulted in incorrect assignment of R-SRL exceedances.)

An analysis of the background samples revealed that concentrations of metals above their respective R-SRLs were not naturally occurring.

The Removal Assessment concluded that elevated concentrations of metals in surficial soils are present in Hayden and Winkelman, and that the observed soil contamination throughout Hayden was likely the result of contamination dispersed from ASARCO operations. Elevated concentrations of metals in Winkelman were presumed to be the result of close proximity to ASARCO operations (exceedances in the northern portion of town), proximity to tailings disposal areas, and aerial dispersion from ore-hauling vehicles traveling along State Route 177 and from rail cars from Ray Mine carrying ore on tracks southwest of the town.

2.4.7 EPA Focused Sampling Event (2004)

In October 2004, in conjunction with the Removal Assessment, soil samples were collected by EPA at five locations focused at the Hayden public swimming pool and play area and at six

locations within the Winkelman school yards. The results from the 2004 EPA samples collected from the school and playground areas indicated that surficial soil contamination was present in areas where public activities are concentrated, particularly in Hayden.

The total metals analyses revealed the following exceedances of R-SRLs in surficial soils for these 11 samples:

- Arsenic levels exceeded the R-SRL of 10 mg/kg at five locations, including four locations in Hayden and one in Winkelman (to a maximum concentration of 66.8 mg/kg);
- Copper levels exceeded the then-applicable R-SRL of 2,800 mg/kg at all five locations in Hayden (to a maximum concentration of 16,900 mg/kg);
- Lead levels exceeded the R-SRL of 400 mg/kg at one location in Hayden and one in Winkelman (to a maximum concentration of 485 mg/kg).

Samples from Hayden with contaminants exceeding R-SRLs were collected at locations in the vicinity of the public swimming pool and play structures west of and adjacent to the concentrator facility. The sample from Winkelman that contained arsenic above the R-SRL was collected at a culvert near the high school indoor swimming pool.

2.4.8 Air Quality Monitoring (early 1970s-present)

Since the early 1970s, EPA, the State of Arizona (State), and ASARCO have collected ambient air monitoring data for SO_2 and particulate matter less than 10 microns in diameter (PM_{10}) at various locations in the Hayden area. Selected PM_{10} samples have been analyzed for chemical makeup of the particles. Details are provided in the Phase II RI/FS Work Plan, Part 1 of 2 (Air), and are therefore not included this work plan.

2.4.9 Remedial Investigation (2005-2008)

The Phase I RI was conducted from 2005 through 2008, with the results presented in the draft Phase I RI Report (CH2M HILL, 2008a). As stated in the draft Phase I RI Report, the overall purpose of the RI was to identify the nature and extent of chemicals of potential concern (COPCs), migration pathways of the COPCs, and potential threats to human and ecological receptors in the Study Area. The focus of the investigation was on conditions outside of the Hayden Complex, and on sources associated with the Hayden Complex that contribute COPCs to areas of the Site external to the Hayden Complex.

The Phase I RI included collection and review of data for the following media: air, surface water and sediment, groundwater, non-residential soil, residential soil, interior dust, and aquatic and terrestrial biota. A summary of the scope of these investigations is provided in the sections

below. A draft SLERA and a draft Baseline Human Health Risk Assessment (BHHRA) were also developed with the draft Phase I RI Report. Results from the Phase I RI and risk assessments are presented as part of the Site characterization and evaluation (Section 3.0) and the conceptual site model (Section 4.0).

2.4.9.1 Residential Soil

Both surface soil (0~2 inches bgs) and subsurface soil (10~12 inches bgs) samples were collected from 99 residential parcels in Hayden and 31 residential parcels in Winkelman. In total, 1,447 individual residential soil samples (including quality control [QC] samples) were collected during the Phase I RI. The residential soil sampling activities were conducted between January 30, 2006, and February 17, 2006. All soil samples were analyzed for metals using a field portable X-ray fluorescence (XRF) instrument, and approximately 10% of samples were submitted for Contract Laboratory Program (CLP) (EPA, 2004b) laboratory analysis for the 23 TAL metals.

2.4.9.2 Non-residential Soil

The non-residential soil sampling activities consisted of two events designated as Phase I and Phase II. The Phase I event was conducted from November 15 through November 18, 2005, and included collection of 17 samples within the San Pedro Wash and 15 samples within the Powerhouse Wash. All samples were analyzed using a field portable XRF instrument, and were also submitted for laboratory (CLP) analysis of TAL metals. A good correlation between the XRF metals data and the CLP metal analysis results was found for the collected soil samples.

The Phase II event was conducted from February 20 through March 10, 2006, and included collection of samples at 238 locations within the towns of Hayden and Winkelman, including samples from ASARCO properties located outside of residential areas in the two towns. All samples were analyzed for metals using a field portable XRF instrument, and selected samples were submitted for CLP laboratory analysis of TAL metals. Later, all non-residential soil samples not initially analyzed by the laboratory (and retained in secure storage) were submitted for laboratory analysis of arsenic, copper, and lead.

The Phase I RI Report concluded that levels of arsenic, copper, and lead in non-residential soil samples are markedly influenced by ASARCO operations. This was evidenced by the fact that soils at ASARCO facilities (particularly the perimeter of the concentrator and former Kennecott smelter areas) generally contained the highest concentrations, while non-residential soils on non-ASARCO properties, including the Winkelman and upland areas, contained the lowest concentrations. The Phase I RI Report also reported that washes located near ASARCO operations (especially Powerhouse Wash) appear to be affected directly by contamination from ASARCO operations.

2.4.9.3 Groundwater

During the Phase I RI, two rounds of water level measurements and water quality samples were collected from 22 monitoring wells in the Study Area and from seven water supply wells and manifolds in the wellfields for the towns of Hayden and Winkelman. This sampling was conducted in February 2006 for the Town of Hayden and in October 2006 for the Town of Winkelman. The groundwater samples were analyzed for general geochemistry, radiochemistry, total metals, VOCs, and SVOCs. The major findings are summarized in Section 3.3.1.

2.4.9.4 Surface Water, In-stream Sediment, and Stable and Unstable Riparian Sediment

In the Phase I RI, CH2M HILL performed two rounds (summer and winter 2006) of surface water, sediment, and riparian sediment sampling at 13 locations, including 11 locations along the Gila River and two locations along the San Pedro River. The surface water samples were analyzed for general geochemistry, radiochemistry, total and dissolved metals, and total suspended solids (TSS).

2.5 Soil Remediation (2008-2009)

2.5.1 First Residential Soil Removal Action

From March through June 2008, ASARCO performed soil removal actions at 14 residential properties in Hayden and one residential property in Winkelman. ASARCO collected post-excavation (confirmation) samples and submitted them to an off-site laboratory for analysis of arsenic, copper, and lead using EPA Test Method 6010B. EPA deemed the soil removal to be complete when concentrations of arsenic, copper, and lead were below corresponding R-SRLs or when two feet of soil had been removed, whichever occurred first. Based on statements made in the Draft RI/FS Work Plan prepared by Brown and Caldwell, the excavated soil was replaced with clean fill, the fill was re-graded to match the area, and sod was added as a stabilizing cover (Brown & Caldwell, 2011).

According to Asarco Hayden Plant Site Phase I Yard Removal Final Report – Oct. 2008, EPA initially suggested placing the excavated material as cover over historic exposed tailings piles in various locations in the general Hayden area. EPA also suggested using the excavated material as part of plant site operations. It was eventually decided, with EPA concurrence, to transport the material to ASARCO Hayden Concentrator property with placement in one of two ASARCO-owned landfill areas – an asbestos landfill and a regular landfill located to the north of the former Kennecott smelter area. Mixing of these materials in the landfills was deemed allowable because the levels of metals in excavated residential soils were generally lower than the levels of metals in landfill materials.

2.5.2 Second Residential Soil Removal Action

Based on the results of the Phase I RI, EPA concluded that the primary soil chemicals of concern at the Site were arsenic, copper, and lead (CH2M HILL, 2008a). For the residential properties and public areas, EPA developed a site specific risk-based SRL for arsenic of 24.3 mg/kg, employed the pre-determined residential SRL for lead of 400 mg/kg, and developed a site-specific risk-based SRL for copper of 9,300 mg/kg.

From December 2008 through October 2009, ASARCO collected soil samples at 405 properties in Hayden and 142 properties in Winkelman. Generally, a minimum of nine surface soil samples (0 to 2 inches bgs) were collected at each property using procedures specified in the Removal Work Plan (NewFields, 2008b). The samples were submitted to an off-site laboratory for analysis of arsenic, copper, and lead using EPA Test Method 6010B.

ASARCO used the results of the laboratory analyses, as well as the analytical results of the Phase I RI and the confirmation sample analytical results generated in the first residential removal action (described above), to calculate the 95th percent upper confidence limits (UCLs) for arsenic and copper, and the mean concentration of lead for each property. ASARCO then compared these values to the SRLs established by EPA to determine which properties required further soil removal. A total of 212 properties in Hayden and 21 properties in Winkelman were remediated based on exceedances of the SRLs. Figures 2-9 and 2-10 show the residential properties at which a soil removal action was completed in the towns of Hayden and Winkelman, respectively.

ASARCO collected post-excavation confirmation samples at each property after the first foot of soil was removed. If the analytical results showed residual exceedances of the SRLs, then an additional foot of soil was removed and additional confirmation samples were collected. According to EPA, three residential properties remain that require further removal action work. As of this Work Plan, the resolution of these properties remains an open issue with ASARCO.

Based on statements made in the ASARCO Draft RI/FS WP (Brown & Caldwell, 2011), after the soil removal was complete, ASARCO backfilled the excavations with clean soil, re-graded the surface, and returned the landscaping of each property to its original condition. According to EPA, the suitability of backfill materials was verified via soil sampling and comparison of soil sample results to the R-SRLs. Excavated soil was transported to the Hayden Complex for disposal.

2.6 Remedial Investigation Areas

The Phase I RI segregated the overall Study Area into sub-areas for purposes of reporting and discussing the study findings. These sub-areas included the ASARCO Concentrator Area, the ASARCO Smelter Area, the Former Kennecott Smelter Area, the Tailings Piles, the Town of Hayden, and the Town of Winkelman. Because of the size of these sub-areas and the significant differences within each as regards emission sources, exposure pathways, and potential human receptors, a decision was made by EPA to further divide the Study Area into 19 RI Areas for purposes of the Phase II RI. These RI Areas include:

- Area #1 – Tailings Impoundments
  - Area #1A – Tailings Impoundment D
  - Area #1B – Tailings Impoundment AB/BC
- Area #2 – San Pedro Wash
- Area #3 – Northern Waste Disposal
- Area #4 – Lime and Filter Plants
- Area #5 – Kennecott Avenue Wash and Tailings
- Area #6 – Administration and Concentrator Support
- Area #7 – Concentrate Production
- Area #8 – Conveyor Belt Tailings
- Area #9 – Ore Receipt and Secondary and Tertiary Crushing
- Area #10 – Powerhouse Wash
- Area #11 – Waste Water Treatment Plant
- Area #12 – Concentrate Handling and Mixing
- Area #13 – Smelter Support
- Area #14 – Flash Smelting, Copper Converting, Anode Furnace
- Area #15 – Reverts Crushing and Reclaim
- Area #16 – Acid and Oxygen Plants
- Area #17 – Slag Handling
- Area #18 – Linear Features
  - Area #18A – Hayden Junction Segment
  - Area #18B – Kennecott Avenue
  - Area #18C – Winkelman Segment
  - Area #18D – Smelter Hill Segment
- Area #19 – Areas Outside of Areas 1 through 18

Figure 2-11 (Overview of RI Areas) illustrates these RI Areas. Summaries of the potential emission sources and activities conducted within each area as they relate to the soil, water, and sediment investigations are provided in Section 4.3.

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3.0 INITIAL SITE EVALUATION

This section interprets the findings of previous investigations (primarily the Phase I RI) and identifies the sources of information that were used to develop the Conceptual Site Model (CSM) for the Site, as presented in Section 4.0.

3.1 Soil

In the Phase I RI, the stated purpose of surface soil sampling was to develop a better understanding of contaminant levels, potential contaminant sources, and contaminant migration patterns in soils over a broad area. CH2M HILL generally divided the sampling area into two categories: residential soils and non-residential soils. Residential soil characterization and subsequent soil removal efforts were the focus of a series of removal actions undertaken by ASARCO under EPA oversight; therefore, they are not addressed in detail within this work plan. Non-residential soil results are discussed below, with a more refined presentation of analytical results presented in Section 4.3 for 19 distinct areas of the overall Study Area.

Non-residential soils were divided by CH2M HILL into location groups, consisting of the following:

- Washes (specifically Powerhouse Wash, San Pedro Wash, and the Kennecott Avenue Wash);
- ASARCO property (included locations within or near the ASARCO Hayden Complex);
- Winkelman school complex (included staff housing on school property);
- Hayden public areas and golf club; and
- Upland and surrounding areas.

Background soil concentrations for arsenic, copper, and lead were established for the Hayden and Winkelman areas in the Phase I RI (CH2M HILL, 2008a). Upper confidence limit (UCL) values for the background concentration datasets, which represent values that 95% of the population will fall below with 95% confidence, were used as background values. The UCL parameter provides an acceptable statistical method for determining a background value from a set of data (EPA, 2002). The background soil concentrations for evaluation of Hayden soils were determined to be 12.5 mg/kg for arsenic, 1,270 mg/kg for copper, and 47.9 mg/kg for lead (CH2M HILL, 2008a). The background concentrations for Winkelman soils were determined to be 9.1 mg/kg for arsenic, 882 mg/kg for copper, and 45.8 mg/kg for lead. For comparison, then-applicable Arizona residential soil remediation levels (R-SRLs) for arsenic, copper, and lead were 10 mg/kg, 2,800 mg/kg, and 400 mg/kg, respectively.

3.1.1 Washes

The Phase I RI efforts near the washes adjacent to the Hayden Complex included the collection and analysis of 15 surface soil samples and five subsurface soil samples from Powerhouse Wash, 10 surface soil samples from the Kennecott Avenue Wash, and 17 surface soil samples from San Pedro Wash. The samples were submitted to an EPA-approved laboratory for TAL metals analysis.

Samples from all three washes exhibited exceedances of R-SRLs for arsenic and copper, while no exceedances for lead were identified. One sample from Powerhouse Wash showed an exceedance for vanadium, and nearly all of the Powerhouse Wash and San Pedro Wash samples showed iron exceedances with compared to the EPA Region 9 Preliminary Remediation Goal (PRG). The maximum arsenic concentration occurred in a surface soil sample from Powerhouse Wash (77.4 mg/kg), and the maximum copper concentration occurred in a surface soil sample from the Kennecott Avenue Wash (13,500 mg/kg).

3.1.2 ASARCO Properties

Soil samples collected from ASARCO-owned properties were categorized as being from the ASARCO concentrator and historic Kennecott smelter property area, the ASARCO smelter area, or the ASARCO tailings impoundments.

The RI sampling efforts near the concentrator and historic Kennecott smelter included the collection and analysis of 27 surface soil samples from the concentrator area, 15 surface soil samples from the Kennecott smelter area, and seven surface soil samples from the crusher facility area. The majority of the surface soil samples collected from these areas exhibited elevated arsenic and copper concentrations, while the lead R-SRL was exceeded only in a portion of the samples from the Kennecott smelter area. The highest arsenic concentration of all non-residential soils within the ASARCO concentrator and historic smelter areas was identified in the concentrator area (1,720 mg/kg), while the lowest arsenic concentration was identified in the vicinity of the crusher facility. Molybdenum, vanadium, and iron also were observed at elevated concentrations throughout this sample set.

The RI sampling efforts targeting the active ASARCO smelter area included the collection and analysis of one surface soil sample from the perimeter of the smelter and from each slag dump area, and four surface soil samples collected downgradient of the slag dump. Elevated concentrations of arsenic, copper, lead, and iron were observed in all of the soil samples collected in these areas. The sample collected from the perimeter of the smelter showed a significantly elevated copper level of 380,000 mg/kg (i.e, 38% copper by weight).

The RI sampling efforts near the active tailings impoundments included the collection and analysis of eight surface samples from Tailings Impoundment AB/BC and four surface samples from Tailings Impoundment D. Samples were collected from the areas with the most recent depositions. All samples exceeded the R-SRL for arsenic; the maximum identified concentration for arsenic was 27.3 mg/kg. Only one sample from Tailings Impoundment AB/BC exceeded the R-SRL for copper, while two of the four samples from Tailings Impoundment D showed copper exceedances. None of the tailings impoundment samples showed elevated lead concentrations.

3.1.3 Non-ASARCO Properties

The RI efforts focusing on non-ASARCO properties included the collection and analysis of surface and subsurface soil samples from the locations identified below. Subsurface soil samples represent samples collected from 10 to 12 inches below ground surface.

- Hayden Public Areas: Nine surface soil samples and ten subsurface soil samples.
  - All samples exceeded the background concentration for arsenic, and approximately half exceeded the R-SRL for arsenic (the maximum concentration reported was 60.9 mg/kg).
  - Nine of the 19 samples collected exceeded the R-SRL for copper (the highest reported concentration was 24,400 mg/kg).
  - There were no R-SRL exceedances for lead.
- Hayden Golf Club: 33 surface soil samples and one subsurface soil sample.
  - All 23 samples from the eastern and central portions of the golf course were below the background concentration for arsenic, whereas nine out of ten samples from the western portion exceeded the R-SRL for arsenic (to a maximum concentration of 87.8 mg/kg).
  - Eight of the 33 samples exceeded the R-SRL for copper (to a maximum concentration of 14,700 mg/kg).
  - There were no R-SRL exceedances for lead.
- Areas Associated with Winkelman Schools: Winkelman School Complex - 38 surface soil samples; Winkelman School Housing Lot A - 7 surface soil samples and one subsurface soil sample; Winkelman School Housing Lot B - 9 surface soil samples and one subsurface soil sample; Winkelman School Housing Lot C - 9 surface soil samples and one subsurface soil sample.
  - For the Winkelman School Complex and Housing Lots A, B, and C, all surface and subsurface soil samples were below background concentrations for arsenic, except for

a single surface soil sample (14.9 mg/kg) collected near the northern end of the school complex.

  - No samples showed R-SRL exceedances for copper or lead, and nearly all samples were below background for copper and lead.

- State Route 177: Three surface soil samples and three subsurface soil samples.
  - Two of the three surface soil samples exceeded the background concentration for arsenic, to a maximum concentration of 39.1 mg/kg; all three subsurface soil samples exceeded the background concentration for arsenic, with a maximum reported concentration of 31.4 mg/kg.
  - The R-SRL for copper was exceeded in two subsurface soil samples (to a maximum of 8,130 mg/kg).
  - There were no R-SRL exceedances for lead.
- Upland Areas: 12 surface soil samples and 12 subsurface soil samples.
  - All samples were below the background concentration for arsenic except for samples collected in relatively close proximity to ASARCO operations; two surface samples and two subsurface samples exceeded the R-SRL for arsenic (to a maximum of 70.0 mg/kg).
  - The R-SRL for copper was exceeded in three surface samples and two subsurface samples (to a maximum of 10,200 mg/kg).
  - There were no R-SRL exceedances for lead.

3.2 Surface Water and Sediment

This section summarizes the major findings of the Phase I surface water, in-stream sediment, and riparian sediment sampling conducted in the Study Area. This section also summarizes the results from the analysis of Phase 1 RI samples collected from stormwater runoff and sediment in ephemeral washes.

3.2.1 Surface Water and Sediment in the Gila and San Pedro Rivers

Surface water, in-stream sediment, and riparian sediment sampling results for the Gila River and San Pedro River during the Phase I RI are summarized in the following sub-sections.

3.2.1.1 Surface Water

In the Phase I RI, CH2M HILL performed two rounds of surface water sampling at 13 locations, including 11 locations along the Gila River and two locations along the San Pedro River. Two criteria were used to evaluate the water quality data for the surface water samples in the Phase I

RI Report: Arizona Aquatic and Wildlife Water Quality (AAWWQC) standards, which are based on ecological risks; and EPA Region 9 Primary Remediation Goals (PRGs) for tap water (which have since been replaced by EPA Regional Screening Levels [SRLs]), which are based on human health risks.

The data from surface water samples collected at locations GR-SW-01 and GR-SW-02, located upstream from the Site, were considered as background concentrations for purposes of the Phase I RI. All metal concentrations except arsenic were below AAWWQC standards and EPA tap water PRGs at the background sampling locations. Total dissolved arsenic concentrations were well below the AAWWQC standard of 190 ug/l, but exceeded the PRG for tap water of 0.045 micrograms/liter (ug/L), with concentrations ranging from 2.5 ug/L to 7 ug/L.

Concentrations of several analytes were clearly higher in samples from two Gila River sampling locations (GR-SW-06 and GR-SW-07) located between the tailings impoundments than in samples collected from upstream and downstream locations. These elevated concentrations were most pronounced in samples collected during the summer sampling event (August 2006), when surface water flows were approximately four times higher than those in winter (March 2006). No AAWWQC standards or EPA tap water RSLs except for arsenic were exceeded in samples collected during the winter sampling event. In the summer sampling event, several exceedances were noted in samples collected at GR-SW-06 and /or GR-SW-07 only. These levels were also considerably above background levels. In particular, the following concentrations were found:

- Total aluminum (62,000 ug/L in GR-SW-06 and 52,000 ug/L in GR-SW-07 [duplicate]) exceeded the tap water PRG of 36,000 ug/L.
- Total arsenic (16.8 ug/L in GR-SW-06 and 13.9 ug/L in GR-SW-07[duplicate]) exceeded the tap water PRG of 0.045 ug/L.
- Dissolved copper (43.5 ug/L in GR-SW-06 and 29.9 ug/L in GR-SW-07) exceeded the AAWWQC standard of 18 ug/L.
- Dissolved lead (27.7 ug/L in GR-SW-06 and 11.6 ug/L in GR-SW-07) exceeded the AAWWQC standard of 6 ug/L.
- Total cyanide (16.2 ug/L in GR-SW-07[duplicate]) exceeded the AAWWQC standard of 9.7 ug/L.
- Total iron (34,500 ug/L in GR-SW-06 and 31,500 ug/L in GR-SW-07[duplicate]) exceeded the tap water PRG of 11,000 ug/L.
- Total manganese (3,450 ug/L in GR-SW-06 and 2,510 ug/L in GR-SW-07) exceeded the tap water PRG of 880 ug/L.
- Total selenium (2.0 ug/L in GR-SW-06) equaled the AAWWQC standard of 2 ug/L.

- Total vanadium (56.6 ug/L in GR-SW-06 and 49.2 ug/L in GR-SW-07) exceeded the tap water PRG of 36 ug/L.
- Dissolved mercury (0.076 ug/L in GR-SW-06 and 0.068 ug/L in GR-SW-07) exceeded the AAWWQC standard of 0.01 ug/L. (Background dissolved mercury concentrations reported for GR-SW-01 and GR-SW-02 during the summer event had detection limits above the AAWWQC.)

Surface water samples from San Pedro River location SPR-SW-01 displayed higher concentrations for some analytes than those reported for Gila River sampling locations. Concentrations of total and dissolved arsenic, barium, boron, calcium, chromium, cobalt, iron, magnesium, molybdenum, nickel, potassium, selenium, sodium, total copper, lead, and silver generally were greater in San Pedro River samples than in Gila River samples. Concentrations of dissolved manganese, vanadium, and zinc also were generally greater in San Pedro River samples than in Gila River samples. Dramatic seasonal differences in concentrations in the San Pedro River samples were evident for some analytes, including aluminum, barium, iron, and manganese, which were higher during the summer sampling event (although concentrations of magnesium and sodium were higher during the winter sampling event). These elevated levels in the San Pedro River samples may result from different geology or upstream mining activity.

Despite the increased concentrations observed in the San Pedro River samples and in Gila River samples GR-SW-06 and GR-SW-07, surface water samples downstream of the tailings impoundments did not show exceedances of AAWWQC standards or tap water PRGs other than for arsenic, which also was reported at concentrations exceeding the tap water PRG in background samples.

3.2.1.2 Sediment

In the Phase I RI, in-stream sediment samples were taken from the same 13 locations where surface water samples were collected. Both stable and unstable riparian samples were also collected in areas opposite those 13 locations, with an additional five stable and unstable riparian sediment samples collected at biased locations in the Gila River floodplain (between the San Pedro River and Last Chance Basin). One additional upstream Gila River location (GR-REF) also was selected for the collection of background stable and unstable riparian sediment samples.

Sampling locations in the Gila River (GR-SED-01 and GR-SED-02) were located upstream of ASARCO operations. Sampling location SPR-SED-01 was located along the San Pedro River, south of Winkelman. In-stream sediment samples collected at these three locations were not considered to be affected by ASARCO operations, and were considered as background sediment concentrations for purposes of the Phase I RI. However, GR-SED-01 and GR-SED-02 samples might be affected by upstream mining activities at the Christmas Mine or by deposition of

ASARCO stack emissions or other discharges to drainages tributary to the Gila River northeast of the Hayden facilities. To obtain representative samples for evaluation of background concentrations and to assess potential contributions from upstream sources more accurately, additional upstream sampling locations are being proposed as part of the Phase II RI investigation.

For the two Gila River background sediment sample locations, GR-SED-01 and GR-SED-02, the maximum concentrations of arsenic (4.4 mg/kg), iron (28,800 mg/kg), manganese (2,270 mg/kg), and vanadium (91.2 mg/kg) exceeded the Arizona R-SRL and/or the site-specific risk-based EPA RSL criteria, while only arsenic (maximum 2.6 mg/kg) exceeded the EPA RSL of 0.39 mg/kg in upstream San Pedro River location SPR-SED-01.

Concentrations of arsenic, iron, manganese, and vanadium reported for in-stream sediment samples collected in the vicinity and downstream of ASARCO operations generally were consistent with those in upstream samples, while concentrations of copper, lead, and chromium were slightly higher than those in upstream sediment samples.

In-stream sediment samples showed elevated metals (arsenic, lead, manganese, and vanadium) concentrations in samples collected upstream, between, and downstream of the tailings impoundments, which indicates that additional data are needed to characterize upstream contributions and the full extent of Site impacts to sediments. With few exceptions, analyte concentrations in in-stream sediment samples from the San Pedro River exhibited lower concentrations than those obtained from the Gila River sampling locations (although surface water concentrations of metals were higher in the corresponding San Pedro River samples). Large seasonal variations also were evident in the San Pedro River samples.

For the riparian sediment samples, elevated concentrations (above the Arizona R-SRL or EPA RSL for residential soil) of arsenic, lead, and vanadium were present at upstream locations. However, only arsenic concentrations exceeded these standards at locations between and downstream of the tailings impoundments. Unstable riparian sediments generally had higher and more variable concentrations than were observed in associated stable riparian sediments.

3.2.2 Stormwater Runoff and Sediment in Ephemeral Washes

No stormwater runoff samples were collected during the Phase I RI. Section 7 of the Work Plan will discuss the sample locations proposed for the Phase II RI to characterize stormwater runoff. Sediment samples from the three ephemeral washes near the Hayden Complex (San Pedro Wash, Kennecott Avenue Wash, and Powerhouse Wash) were collected, and the results for these samples are summarized in Section 3.1.1 Washes.

3.2.3 Process Water

No process water runoff samples were collected during the Phase I RI. Section 7 of the Work Plan will discuss the sample locations proposed for the Phase II RI to characterize process water.

3.3 Groundwater

This section discusses the findings of the Phase I groundwater investigation and groundwater monitoring activities under ASARCO's Aquifer Protection Permit (APP).

3.3.1 Phase I RI Results

The Phase I groundwater investigation included two sampling events (winter and summer 2006) from 22 selected monitoring wells in the Study Area and from seven water supply wells and manifolds in the wellfields for the towns of Hayden and Winkelman. The investigation confirmed that groundwater underlying the concentrator and smelter facilities generally flows toward the Gila River. The groundwater quality data showed concentrations of aluminum, antimony, arsenic, iron, copper, manganese, molybdenum, selenium, and vanadium in multiple monitoring wells exceeding EPA primary and secondary Maximum Contaminant Levels (MCLs) and tap water PRGs. Most exceedances were in groundwater samples collected from monitoring wells located near active ASARCO concentrator and smelter operations, with a limited number of exceedances from drinking water supply wells. Antimony and cadmium had exceedances in only one well (GW-2); therefore, widespread impacts from these metals were not observed.

Most of the metal constituents listed above are commonly associated with copper mining and processing activities, but they also can occur naturally in aquifers of semi-arid desert regions. An assessment of background concentrations in groundwater was not possible during the Phase I RI due to the lack of a suitable background monitoring well, but will be addressed in the Phase II RI.

Samples from seven monitoring wells were also analyzed for VOCs and SVOCs to evaluate impacts from ASARCO operations. Four of these wells had VOC concentrations exceeding the MCLs and/or PRGs for 1,2-dibromoethane, bromodichloromethane, chloroform, tetrachloroethene (PCE), and trichloroethene (TCE). The only SVOC reported at a concentration exceeding its RSL was bis(2-ethylhexyl)phthalate at monitoring well MW-4.

Samples from the wells at the Hayden wellfield generally had sulfate and total dissolved solids (TDS) concentrations greater than the secondary MCLs. Samples from the Winkelman wellfield wells generally showed only TDS concentrations above the secondary MCL.

Overall, the distribution of metal concentrations reported for the Phase I RI demonstrated that some Site-related impacts likely are present. However, the delineation of impacts from metals was not achieved during the Phase I RI due to the relatively small number of monitoring wells available and the lack of reliable background data. New monitoring wells proposed in the Phase II RI in critical locations downgradient from the ASARCO concentrator and smelter, former Kennecott smelter, and slag piles will help to identify any sources of groundwater contamination.

3.3.2 Monitoring Results for Aquifer Protection Permit (APP) Wells

An APP application for potentially discharging-to-groundwater facilities at the Hayden Complex was originally submitted to ADEQ by ASARCO in March 1994 (SBH, 1994). The final APP (P-100507) was issued in June 2009, and the amended APP was issued in August 2009 (ADEQ 2009a, 2009b).

Monitoring of groundwater quality under the APP continues to occur at Point of Compliance (POC) wells H-1, H-3, H-5, H-6, and H-8, and Alert Level (AL) wells ARU-4, H-9, and H-11. For POC and AL wells, APP requires quarterly monitoring for the following parameters: depth to water, specific conductance, temperature, field pH, total dissolved solids, sulfate, fluoride, arsenic, copper, and selenium. In addition, biennial compliance groundwater monitoring of POC wells is required by the APP for the same parameters plus the following: total alkalinity, carbonate, bicarbonate, chloride, nitrate-nitrite, calcium, magnesium, potassium, sodium, iron, antimony, barium, beryllium, cadmium, chromium, lead, manganese, mercury, nickel, thallium, zinc, cyanide, gross alpha particle activity, adjusted gross alpha particle activity, radium 226 and radium 228, uranium, VOCs, and SVOCs.

The results of the sampling and analysis conducted under the APP since June 2009 are summarized in Table 3.1 (data are cited from Brown &Caldwell, 2011). The concentrations of analytes detected in the samples were less than MCLs, with three primary exceptions: fluoride, selenium, and arsenic. Well H-3 had the highest fluoride concentrations, varying from 3.5 to 7.4 mg/L; selenium and arsenic concentrations at well H-8 are consistently above the respective MCLs of 50 ug/L and 10 ug/L, with selenium ranging from of 72 to 148 ug/L and arsenic ranging from 11 to 63 ug/L.

3.4 COCs and COPCs

This section identifies the chemicals of concern (COCs) to human health and the environment based on existing chemical data collected from the Study Area. Also presented are the chemicals of potential concern (COPCs) based on existing chemical data for the Site and a review of chemicals commonly associated with copper ore processing activities.

The primary COCs for the Site include, but are not limited to, metals (arsenic, copper, and lead) in soils and sediment; and sulfate in groundwater and surface water.

The COPCs for the Site include, but may not be limited to, the following:

- Soil & Sediment
  - Metals (aluminum, antimony, barium, beryllium, boron, cadmium, chromium, cobalt, iron, manganese, molybdenum, nickel, selenium, silver, thallium, vanadium, and zinc).
- Surface Water, Stormwater Runoff, and Process Water
  - Metals (aluminum, arsenic, copper, iron, lead, manganese, mercury, selenium, and vanadium);
  - Major anions (sulfate, chloride, nitrate/nitrite, and fluoride);
  - Cyanide;
  - Radiochemistry (gross alpha activity, gross beta activity, radium-226, radium-228, uranium-234, uranium-235, and uranium-238).
- Groundwater
  - Metals (aluminum, antimony, arsenic, copper, iron, manganese, molybdenum, selenium, and vanadium);
  - Volatile organic compounds (VOCs), including 1, 2-dibromoethane, bromodichloromethane, chlorodibromomethane, chloroform, PCE, and TCE;
  - Semivolatile organic compounds (SVOCs), including bis(2-ethylhexyl) phthalate and naphthalene;
  - Radiochemistry (gross alpha activity, gross beta activity, radium-226, radium-228, uranium-234, uranium-235 and uranium-238).

3.5 Data Gaps

This section discusses the data gaps identified during the Phase I RI and in the AOC for non-residential soils, surface water and sediments, surface water runoff and sediments in washes, process water, and groundwater.

ASARCO submits annual reports on discharges of toxic chemicals to EPA under the federal Emergency Planning and Community Right-to-Know Act (EPCRA) program, to inform communities and citizens of chemical hazards in their areas. Through EPCRA, Congress mandated that information on toxic chemical releases to the environment be collected into a database called the Toxic Release Inventory (TRI). ASARCO has this TRI information for non-air waste values for the Site. This would be an important piece of information to have in order to better understand the environmental conditions, nature of contamination, and distribution of the COPCs in soil, water, and sediment.

3.5.1 Soil

Several data gaps were identified during the Phase I RI investigation for non-residential soils (CH2M HILL, 2008a):

- Additional soil samples encompassing the former Kennecott smelter area are needed to further characterize the nature and extent of the contamination within the area, with an extensive analysis of the metals suite (including boron, molybdenum, and vanadium) to determine other COPCs.
- Additional soil samples from the active concentrator area, beyond the perimeter of public areas, are needed to characterize the nature and extent of contamination on ASARCO property, with an extensive analysis of the metals suite to determine other COPCs.
- Additional soil sampling of the active smelter area is needed to characterize the nature of and extent contamination, with an extensive analysis of the metals suite to determine other COPCs.
- Additional soil sampling of tailings impoundments and other waste material storage areas is needed to determine the nature and extent of contamination, with an extensive analysis of the metals suite to determine other COPCs.
- Additional soil sampling of other public and commercial areas within the towns of Hayden and Winkelman that were not adequately characterized in previous investigations is needed to determine the nature and extent of the contamination, with an extensive analysis of the metals suite to determine other COPCs.
- Additional soil sampling of selected upland areas is needed to address the ecological risk assessment data gaps identified in SLERA.

The soil-sampling program proposed to fill these data gaps in each of the 19 distinct areas is presented in detail in Section 7.0.

Subsequent to the Phase I RI investigation, ASARCO conducted additional soil sampling and removal activities at residential lots in Hayden and Winkelman. With the exception of three residential properties that may require further removal work, there appears to be no data gaps remaining for residential soils; however, a final determination will be made after EPA's review of the Removal Action Summary Report to be prepared by ASARCO.

3.5.2 Surface Water and Sediment

The following data gaps have been identified for surface water and sediment:

Gila River and San Pedro River

- Additional surface water samples are needed upstream from the Phase I RI background locations on the Gila and San Pedro Rivers to aid in delineating the extent of surface water impacts from smelter emissions and other facility discharges, and to assess possible contributions of upstream sources to the contamination detected at locations in the vicinity of the ASARCO Site.
- An increased density of surface water samples from areas adjacent to ASARCO properties is needed to develop an understanding of the extent of surface water impacts.
- Additional rounds of surface water sampling, including sampling following precipitation events, are needed both to assess seasonal variations in contaminant loading and to evaluate shorter-term impacts of singular events on contaminant loading to surface water.

Stormwater Runoff and Sediments in Ephemeral Washes

- No stormwater runoff samples were collected during the Phase I RI, so the nature and extent of contamination in stormwater runoff at or from the Site is unknown. Collection of stormwater runoff samples at select locations is needed to evaluate the nature and extent of contamination in stormwater runoff within or from the Site.
- Sediment samples (surface soils) were collected only from the Kennecott Avenue Wash, San Pedro Wash, and Powerhouse Wash. It is unknown whether the samples were taken from the active thalweg of the channel (deepest or lowest point) or in overbanks with developed soil and less exposure to sediment transport. Also, channels are hard to distinguish, especially in the Kennecott Avenue Wash, so it is not clear whether past samples were reflective of the wash overbank or the actual channel of the wash. Additional sediment samples from the interiors of and adjacent to the washes and drainage channels are needed to provide a more complete understanding of the extent of impacts to sediments. The surface water runoff and sediment sampling program also will be expanded to cover other, unnamed washes in the Study Area that may be impacted by past and current activities at the Hayden Complex.
- The extent of previous soil sampling adjacent to the washes was limited to areas within the Hayden Complex. Collection of additional soil samples upstream of the washes is necessary to compare sediment constituents in upstream and downstream locations/areas and to evaluate the overall impacts of soil erosion on surface water and sediment quality.

3.5.3 Groundwater

The following data gaps for groundwater have been identified:

- Additional upgradient monitoring wells are needed to characterize background groundwater quality conditions.
- There are few monitoring wells located on formerly active or currently operational ASARCO industrial properties, particularly in areas associated with the smelter, concentrator, and slag dumps. Additional wells are needed to identify possible sources of release to groundwater and the nature and extent of impacts from these potential releases.
- Installation of additional monitoring wells in the vicinity of the Gila River, including in proximity to the tailings impoundments, is needed to better assess the interaction of groundwater and surface water and the influence of the alluvial aquifer on the chemistry of the Gila River.
- Additional information on the operation of individual production wells in the Hayden wellfield, including well pumping rates, hours/frequency/continuity of pumping operations, and groundwater drawdown during pumping is needed to support a better assessment of regional groundwater flow and pumping effects. An additional monitoring well may be needed in the vicinity of the wellfield to provide the necessary data.
- Surface water samples taken from location GR-SW-04 are anomalous compared to the other sampling locations downstream of ASARCO operations. The temperature, turbidity, and total suspended solids (TSS) levels were much lower at this sampling location than at all other locations, especially during the winter sampling event. Installation of additional stream gauges and a monitoring well near the GR-SW-04 sample location is needed to evaluate possible connections between groundwater and surface water.
- Available groundwater elevation data suggest that ARU-1 is disconnected from water levels within the Gila River alluvium. Confirmation or resurveying of the top-of-casing elevation is needed. Based on additional groundwater elevation measurements, a more reliable downgradient monitoring well may be needed to assess impacts of the tailings impoundments on the Gila River alluvial aquifer.
- An independent confirmation of vertical and horizontal coordinates for the existing monitoring and production well locations was not conducted as part of the Phase I RI. An updated and accurate survey of all monitoring wells is needed to provide greater confidence in the groundwater elevation contouring. The survey will be expanded to include the proposed new groundwater wells following their installation.
- Monthly water-level monitoring and quarterly groundwater sampling are needed to evaluate temporal variations in groundwater flow conditions and contaminant loading, and to evaluate longer-term trends. A sampling term of two years is recommended, since

eight rounds of groundwater sampling is the minimum requirement for statistical analyses such as trend analysis and non-parametric analysis.

4.0 CONCEPTUAL SITE MODEL

Figure 4-1 is a schematic representation of the conceptual site model (CSM) for the ASARCO Hayden Site. The CSM shows all significant primary and secondary source(s) of chemical release(s), the associated release mechanisms, and the transport mechanisms through environmental media. It is based on the CSM developed by EPA and CH2M HILL for the Phase I RI and the accompanying Baseline Human Health Risk Assessment (BHRRA), except for modifications as to whether certain exposure routes to receptors are complete, incomplete, minor contributors to the overall risk, or not proposed for evaluation for reasons given in footnotes in Figure 4-1. The modifications were made in response to the findings of the BHRRA and the subsequent ASARCO removal actions at residential properties.

Section 4.1 explains the entries in Figure 4-1 as they relate to the overall Phase II RI/FS, including both air (Part 1 of 2 of the Phase II Work Plan) and soil, water, and sediment (Part 2 of 2 of the Phase II Work Plan) . Section 4.2 discusses the CSM as it applies only to this Part 2 of 2 of the Phase II Work Plan (soil, water, and sediment), and addresses the aforementioned division of the Study Area into 19 RI Areas as they relate to the CSM. Section 4.3 provides summaries of the RI Areas that further establish the setting of each Area in the context of the CSM. A detailed discussion of the exposure routes and human and ecological receptors is provided in the HHRA work plan and the ecological risk work plan attached as Parts 1 and 2 of Appendix A to this Work Plan, respectively.

4.1 Elements of the Conceptual Site Model

With reference to Figure 4-1, the primary sources of chemical releases that could result in human or ecological exposures within the Study Area are categorized as either the current or historic smelters or the concentrator. While not fully shown on Figure 4-1, but inherent in this categorization, is the inclusion of both the process operations and contiguous properties that are connected with ASARCO's current or historical operations. Examples are material and chemical storage areas, tailings deposits and impoundments, slag and debris piles, containment ponds, diversion channels, and other drainage modifications and similar operation-related features.

COPCs are released from the smelter and concentrator areas to outdoor air through point source emissions and fugitive emissions. As addressed in the Phase II RI/FS Work Plan, Part 1 of 2 (Air), three types of primary release mechanisms have been identified for monitoring and evaluation in the source apportionment study. These include point emission sources, fugitive emissions from process sources, and non-point area sources that discharge fugitive dust. These emissions can be transported directly to receptors as airborne particulates in ambient air, or

deposited onto soil within the limits of ASARCO property or in public and residential areas. In addition to being impacted by the deposition of air emissions, on-Facility soils also can be impacted directly from operational activities such as spills, materials storage, improper waste handling practices, or the release of process waste water.

Impacted soil, both on-Facility and off-Facility, becomes a "secondary source" in that it can be: (1) resuspended as a contaminant into ambient air, with wind dispersion serving as a secondary release mechanism that transports airborne COPCs to points of contact with human receptors; (2) released to surface water as a result of storm water runoff and transported to downstream locations; (3) a direct point of exposure to receptors; or (4) a secondary source of contaminant release to groundwater, indoor dust, or garden vegetables. While not specifically called out in Figure 4-1, a scenario similar to that for surface soils is true for sediment in drainage corridors and washes that are ephemeral in nature.

The unique position of soil (and sediment) within the CSM requires that they be incorporated into both the air and non-air portions of the Phase II RI/FS. The air investigation (Part 1 of 2) will evaluate the significance of soil resuspension as a source of particulates and COPCs being measured at ambient air monitoring locations. On the other hand, because of their potential as points of direct exposure for purposes of the HHRA, as well as their position as secondary sources of contaminant release to surface water and groundwater, soil (and sediment) are also integral parts of the non-air RI being addressed in this Work Plan (Part 2 of 2).

Process waste water in the form of surface runoff from the smelters and concentrator areas can distribute COPCs to downstream locations where exposure to human receptors becomes a higher risk. Such releases can also result in the transport of contaminated sediment to off-site areas or result in the contamination of sediment in downstream locations. This scenario is particularly applicable to the primary sources tied to tailings and slag piles or other material storage areas where waste material is subject to direct erosion and transport by storm water runoff.

Infiltration/percolation and the potential leaching of COPCs to groundwater represents another primary release mechanism tied primarily to tailings, slag, material storage areas, and impoundments associated with the smelter and concentrator operations. In this case, groundwater is the transport mechanism from the source location to the point of potential exposure.

4.2 Relationship of CSM to RI Study Areas

The CSM illustrated in Figure 4-1 is applicable to the entire Study Area. However, as introduced in Section 2.6, the sampling design for soil and sediment has been developed within the context

of 19 RI Areas. Because the intent is to also separately evaluate human health risk for each of the 19 RI Areas, it is important to place these 19 Areas into the CSM framework. The HHRA, as described in a separate work plan (Part 1 of Appendix A), will consider each of the 19 Areas as an exposure area.

The individual RI Areas are not conducive to the development of area-specific CSMs, as many of the complete source/pathway/receptor relationships span multiple Areas. Instead, the 19 RI Areas will require a mapping into the Site-wide CSM based on the primary features of each Area. A cross-referencing scheme will be used to identify which of the 19 RI Areas includes feature(s) that qualify as either a primary source or release mechanism, a secondary source or release mechanism, or an exposure pathway. The following guidelines will be used in the mapping:

- Surface water runoff will be considered as a primary release mechanism from smelter or concentrator operations where materials associated with operations may be released directly to a surface water course. An example of this is from Area #3, Northern Waste Disposal, where slag material potentially eroded from deposits is conveyed directly into the San Pedro Wash.
- Surface water impacts other than those associated with primary releases will be considered to be sourced in on-Facility or off-Facility soils and will be addressed as secondary sources. Secondary sources will be distinguished as having been impacted by primary sources prior to being released to surface waters.
- RI Areas assigned to "Surface Water Runoff" that originate from secondary sources will include only those Areas that feature defined flow paths. While all Areas associated with ASARCO operations are subject to storm water flows that entrain impacted soil, those that involve only sheet flow and lack defined points of discharge will not be considered to represent a secondary release mechanism involving surface water runoff.
- The primary release mechanism of leaching/infiltration/percolation will be applied only to those RI Areas that feature either large quantities of deposited material (tailings, slag, etc.) or wet impoundments that contain waste or otherwise impacted materials from ASARCO operations.
- An exposure point involving surface water or sediment will be assumed only for major features such as the three washes (San Pedro Wash, Kennecott Avenue Wash, and Powerhouse Wash) and open-water impoundments or ponds. Smaller drainages will not be addressed separate from area-wide soils.

- While impacted groundwater may be present in many RI Areas, the exposure point will be limited to RI Area #19 (Areas Outside of Areas #1 - #18), which includes the two municipal wellfields.

To better illustrate the strategy that will be used in mapping the RI Areas to the CSM, consider the following ways in which Area #3, the Northern Waste Disposal Area, ties into the CSM:

1. Area # 3 will be defined fundamentally as a primary source area related to the concentrator and ancillary operations.
2. Area #3 will also be assigned as a primary source tied to smelter operations due to the presence of the Kennecott slag pile, which is remnant from historical operations at the former Kennecott Smelter.
3. The Area will involve surface water runoff as a primary release mechanism due to erosion along the western slope of the tailings pile, which would directly impact sediments of the San Pedro Wash.
4. The Area will also be represented as a primary release mechanism to groundwater due to the slag pile and its potential to infiltrate and subsequently leach COPCs into groundwater.
5. Based on past sampling data, surface soils throughout Area #3 have been impacted by the deposition of air particulates or by operational practices, and therefore will be represented as a secondary source as part of the CSM.
6. Due to the known discharges from Area #3 to the San Pedro Wash to the southwest and potentially to the Powerhouse Wash to the southeast, there will be an assumed secondary release mechanism for impacted soils by entrainment within surface water runoff.
7. The existence of both the northern portion of the San Pedro Wash and other defined drainages within Area #3 will qualify surface water and sediment within the Area as potential points of direct exposure to a trespasser.
8. The widespread presence of deposited surface materials and impacted surface soils will make Area #3 an exposure area via direct contact with these materials.

4.3 RI Area Summaries

This section provides a detailed discussion of the individual features identified in each of the 19 RI Areas, and serves as the basis for the mapping shown in Figure 4-1.

4.3.1 Area #1A – Tailings Impoundment D

Area #1A, Tailings Impoundment D, comprises approximately 709 acres. Figure 4-2A displays the boundary for Area #1A, identifies the features within and adjacent to the Area, and serves as a reference for the text descriptions below. Area #1A contains Tailings Impoundment D and adjacent transportation pathways. The Area is bounded by the Gila River to the north, and by open desert in all other directions.

Tailings impoundment D was constructed in the 1980s and serves as one of two impoundments that receive tailings material from operations at the Hayden concentrator. Tailings are transported from the Hayden concentrator by a pressurized pipeline across the Gila River. Previous spills have been documented along this pipeline. Pressure relief locations, draindown, and pump stations exist along segments of the pipeline, but specific locations have not yet been documented. After tailings material reaches the impoundment, material is discharged to the inner periphery, where solids settle and liquids from the tailings form pools in the lower elevations of the impoundment. Local slope failures and spills have occurred along the face of the Tailings Impoundment D berm. Smaller berms and catch basins are located at the base of the berm in order to prevent spills from being released to the Gila River corridor.

Previous Analytical Results
Previous sampling was conducted as part of the CH2M HILL Phase I RI (2008a). Analytical results indicated minor exceedances of the Arizona residential SRL (R-RSL) for arsenic (10 mg/kg) and moderate exceedances for copper (3,100 mg/kg). The maximum reported arsenic and copper concentrations were 18.1J- mg/kg and 6,000J- mg/kg, respectively. There were no exceedances reported for lead (400 mg/kg).

Exposure Potential
Area #1A is unfenced and can be accessed by the public from the Gila River corridor and the surrounding open desert areas. Tailings Impoundment D has been an observed source of dust emissions. This provides the opportunity for the public to be exposed to contaminants associated with Area #1A. In addition, the Town of Hayden municipal well field is located to the northeast of Area #1A, and draws from groundwater resources that flow in a northeasterly direction in this location.

4.3.2 Area #1B – Tailings Impoundment AB/BC

Area #1B, Tailings Impoundment AB/BC, comprises approximately 1,350 acres. Figure 4-2B displays the boundary for Area #1B, identifies the features within and adjacent to the Area, and serves as a reference for the text descriptions below. Area #1B contains Tailings Impoundment AB/BC, which includes the adjacent reclaim, emergency, and pump-back ponds, Last Chance Basin, portions of the Copper Basin Railway and Southern Pacific railroad, and adjacent access

roads. The Area also contains storage yards and facilities related to railcar transport activities conducted in the vicinity of Hayden Junction. The Area is bounded to the south by the Gila River corridor, to the north by other ASARCO operations and open desert, to the east by the Hayden Golf Club, and to the west by open desert.

Key Features within Area #1B

Tailings Impoundment AB/BC
Tailings Impoundment AB/BC was constructed in 1911 and serves as one of two impoundments that receive tailings material from operations at the Hayden concentrator. Tailings material mixed with Town of Hayden waste water is conveyed via pressurized pipeline, and spills have been documented along the pipeline as recently as 2009 (Four Corners, 2009b). The resulting tailings/waste-water slurry is discharged to the inner periphery of the impoundment, where solids settle and liquid pools in the lower elevations of the impoundment. The exact location(s) where the pipeline discharges into Tailings Impoundment AB/BC is currently unknown.

Last Chance Basin
Located at the northwestern end of Tailings Impoundment AB/BC, Last Chance Basin was constructed to contain surface flows generated during a 100-year flood event. ASARCO's 2004 Stormwater Pollution Prevention Plan (SWPPP) states that surface flows originating from locations as far north as Area #6, Administration and Concentrator Support, ultimately will be captured by Last Chance Basin, although it is unclear exactly how flow from Area #6 could reach this basin. According to recent aerial photography, Last Chance Basin is heavily vegetated in the western and central portions, and surface features in the eastern portion of the basin appear to be impacted by earthmoving activities and sub-basin construction/modification.

Reclaim Ponds
The reclaim ponds are located south of the Hayden Golf Club, at the southeastern end of Tailings Impoundment AB/BC, and are lined. However, EPA is aware that at some time in the past, ASARCO workers compromised the liner to promote infiltration of decant water to groundwater. The reclaim ponds receive decant water from the impoundment via a pumping system. From the reclaim ponds, decant water (10%) is mixed with groundwater (90%) and the resulting solution is injected back into the process stream.

Emergency Ponds
The emergency ponds receive process and stormwater discharges via an unlined channel located along the southeastern end of Tailings Impoundment AB/BC. The unlined channel also may receive stormwater flow from several other upgradient Areas (for example, Area #10, Powerhouse Wash). The emergency ponds serve primarily to capture stormwater flows

generated during precipitation events, and according to ASARCO's 2004 SWPPP, contain one outfall location to release flow directly to the Gila River during excessive flooding events. The exact location of this outfall currently is unknown, but it is believed to be near the Southern Pacific Railroad crossing on the north side of the Gila River.

Pump-Back Ponds
The pump-back ponds receive decant water from the emergency ponds that are located adjacent to the east. Liquid collected in these ponds is pumped to the Reclaim ponds for eventual reinjection to the process stream.

Previous Analytical Results
Sampling was conducted as part of the CH2M HILL Phase I RI (2008a). Eight surface samples were collected from the top perimeter of the Tailings Impoundment AB/BC berm. All samples were analyzed for arsenic, copper, and lead, and one of the samples also was analyzed for additional metals. Analytical results exceeded the Arizona R-SRLs of 10 mg/kg for arsenic in all samples (to a maximum of 27.3J- mg/kg) and 3,100 mg/kg for copper in one sample (3,730J- mg/kg). There were no exceedances for lead. The sample analyzed for additional metals exhibited a minor exceedance of the R-SRL of 78 mg/kg for vanadium (79.4 mg/kg), and exceeded the EPA Region 9 PRG of 23,000 mg/kg for iron (36,100 mg/kg).

Exposure Potential
Area #1B can be accessed by the public from the south via the Gila River corridor; from the east via a public access road located near the Southern Pacific Railroad crossing and the Hayden Golf Club; and from adjacent areas of open desert. Tailings Impoundment AB/BC is a significant source of fugitive dust emissions during windy conditions, as observed during recent ITSI site visits. This provides the opportunity for the public to be exposed to contaminants associated with Area #1B.

4.3.3 Area #2 – San Pedro Wash

Area #2, San Pedro Wash, comprises approximately 68 acres. Figure 4-3 displays the boundary for Area #2, identifies the features within and adjacent to the Area, and serves as a reference for the text descriptions below. The Area is bounded by the town of Hayden to the east and is truncated at the north by a Copper Basin Railway line that crosses south of the former Kennecott smelter slag pile. The western boundary of Area #2 is open desert, and State Route 177 serves as the southern boundary.

Key Features within Area #2

Railroad
The Copper Basin Railway line generally runs through the central portion of Area #2, and serves as the western boundary of much of the San Pedro Wash corridor. Based on historical and recent aerial photography, areas adjacent to the railroad tracks within Area #2 show evidence of historical spill(s), slag dump(s), and non-slag ballast areas.

Undeveloped Surfaces West of San Pedro Wash
The western half of Area #2 is primarily open desert, but also contains hiking trails and former roads. Some of the trails originate from residential areas in the Town of Hayden, extend into the wash corridor, and subsequently exit the corridor and cross the Copper Basin Railway in multiple locations. Certain sections of these trails ultimately lead to the area of the slag piles and the Kennecott Last Chance Pond (K-Pond) contained within Area #3, Northern Waste Disposal, located north of Area #2.

San Pedro Wash – Lower Reach
The active channel of the San Pedro Wash originates north of the Kennecott slag pile and outside the Area #3 boundary; enters Area #3 and proceeds south along the west side of the Kennecott slag pile (potentially forming eroded cut banks in slag material); is then re-routed west of the K-Pond via a bypass channel in Area #3; and subsequently passes underneath the Copper Basin Railway via drainage structures before entering Area #2. Consequently, the upper reach of the San Pedro Wash (located upstream of the Copper Basin Railway crossing that parallels the west side of the Kennecott slag pile) continues to have the potential to be directly impacted by eroded slag constituents, and thus remains a potential source of contaminant discharge to the lower reach of San Pedro Wash within Area #2.

Surface runoff from the majority of Area #3 east of the Kennecott slag pile was historically conveyed through the San Pedro Wash corridor prior to the construction of the K-Pond between 1969 and 1983. Hence, under historical flow conditions, the lower reach of San Pedro Wash within Area #2 potentially would have been impacted by runoff that originated from major portions of Area #3. The San Pedro Wash corridor also contains many residential and potentially industrial debris piles throughout its extent.

Previous Analytical Results
The Phase I RI conducted by CH2M HILL (2008a) identified contaminants in surface soil within Area #2. Eighteen surface soil samples were collected from the wash corridor and adjacent areas and were analyzed for arsenic, copper, and lead. The majority of these samples also were analyzed for antimony, cadmium, iron, molybdenum, thallium, and vanadium. Exceedances of the Arizona R-SRLs for arsenic (10 mg/kg) and copper (3,100 mg/kg) were reported in 14 of the

18 samples, with maximum reported concentrations of 29.7J mg/kg and 12,500 mg/kg, respectively. In addition, more than half of the 18 samples exceeded the Region 9 PRG of 23,000 mg/kg for iron (maximum of 320,000 mg/kg). There were no other exceedances identified for these samples.

Exposure Potential
The San Pedro Wash Area is not fenced or otherwise controlled to prevent access by the public and potential exposure to contaminated soil and sediment. Hayden residences along the eastern boundary of the Area are open to the wash corridor. Some residential structures at lower elevations are located within the wash corridor itself. The wash corridor also can be entered freely from State Route 177.

4.3.4 Area #3 – Northern Waste Disposal

Area #3, Northern Waste Disposal, comprises approximately 235 acres. Figure 4-4 displays the boundary for Area #3, identifies the features within and adjacent to the Area, and serves as a reference for the text descriptions below. Significant portions of the Area are used for material transport and storage, landfill operations, and selective slag removal from the Kennecott slag pile to create aggregate. Area #3 also contains miscellaneous debris associated with the demolition of the former Kennecott smelter, which began in 2004.

Key Features within Area #3

Railroad
The Copper Basin Railway tracks within Area #3 are used to transport ore from Hayden Junction to the filter plant in Area #4 (Lime and Filter Plants), and to transport concentrate from the filter plant to active smelting operations located east-southeast of Area #3.

San Pedro Wash – Upper Reach
The upper reach of the San Pedro Wash is located adjacent to the west side of the Kennecott slag pile. This reach of the San Pedro Wash potentially forms eroded cut-banks along the west side of the slag pile. Surface water is routed around the K-Pond by a bypass channel, and is conveyed into Area #2, San Pedro Wash, south of the Copper Basin Railway via drainage culverts. The potential exists that slag and other materials are entrained into the surface water and sediments of the San Pedro Wash during surface flow events, thus representing both a historical and ongoing source of contaminant releases to the downstream reaches of San Pedro Wash within both Area #2 and Area #3.

Kennecott Last Chance Pond (K-Pond)
The Kennecott Last Chance Pond, also referred to as the K-Pond, serves as the endpoint for surface flows generated in much of Area #3 and Area #4, Lime and Filter Plants. The K Pond is

unlined, and is identified as a discharging facility in ASARCO's 2009 Aquifer Protection Permit (APP). According to historical aerial photography, the K-Pond was constructed sometime between 1969 and 1983. Before that time, surface water runoff from the area was conveyed directly into San Pedro Wash through culverts under the railroad tracks, or impounded in other low-lying areas north of the railroad tracks.

The area immediately southwest of the K-Pond reportedly has been used to deposit material excavated from the pond. As observed during recent EPA site visits, surfaces in this location exhibit discolored soils and copper mineralization. Mineralization typically appears green or yellow, is potentially acidic, and is associated with significant salt deposits. During precipitation events, runoff from the surface of the excavated materials is conveyed into the San Pedro Wash bypass channel.

Kennecott Slag Pile
The Kennecott slag pile, located in the southwestern corner of Area #3, was formed by slag deposition initiated after 1958. According to historical aerial photography, the slag pile extended farther east than its present-day footprint. Historical aerial photos also indicate periods of slag deposition occurring after 1969, and non-slag deposition events that occurred after the shutdown of the former Kennecott smelter in 1982. Material currently is being excavated from the southeastern end of the Kennecott slag pile, crushed, then stored in a single stockpile immediately south of the Kennecott slag pile and north of the railroad line. ASARCO reportedly is using some of this material for recycling at the concentrator and for railroad base, and also is distributing material to outside parties for use as aggregate.

Breaking, crushing, and transporting the slag material provides the opportunity for metals or other contaminants within the slag to be entrained by wind and/or surface water, and increases the likelihood that contaminants are being leached to groundwater from the disturbed areas of the slag pile. The comparative leaching potential for in-place slag and disturbed slag is currently unknown, as are the concentrations of COPCs in the associated dust.

Historical Crusher and Loadout
According to ASARCO's 2004 SWPPP, a "crusher and loadout area" formerly was located immediately north of the northwestern corner of Area #4 (Lime and Filter Plants) and approximately 500 feet south of the Asbestos Landfill discussed below. Recent aerial photography in this area shows many multi-colored soil surfaces associated with various areas of disturbance. The materials that were crushed and loaded in this location are unknown.

Parts Storage
According to ASARCO's 2004 SWPPP, metallic machine parts are contained within a storage yard located north of the filter plant and directly east of the former crusher and loadout area

described above. Recent aerial photography in this area shows multiple locations of discolored soil, in addition to what appear to be stockpiles of slag-like material. Available 10-foot contour interval topography reveals that the parts storage area is located within a well-defined drainage corridor that begins north of the northern boundary of Area #3. Thus, surface flows are likely to impound or proceed through this area in a southwesterly direction during storm events, ultimately flowing to the K-Pond.

Landfills

Three landfills are located within Area #3. ASARCO's 2009 APP identifies four "solid waste landfills" as discharging facilities located within the Study Area, but provides no additional information on the locations or contents of the landfills to correlate with the landfills described below. ASARCO's 2004 SWPPP specifies the following contents for the landfills located within Area #3, but it is unclear whether other materials are contained within the landfills, and how or whether these landfills have been regulated in the past.

1. Asbestos – This landfill contains Regulated Asbestos-Containing Material (RACM) and reportedly is covered with soil as needed and as RACM is deposited. Excavated soils from residential removal actions are stockpiled in an area south and downgradient of the landfill. Previous site visits by EPA have indicated that stormwater is inadequately diverted due to the landfill being located within a primary drainage corridor, as evidenced by the observation of excessive erosion and exposed debris.
2. Municipal – This landfill primarily contains waste paper, plastics, and wood. A previous ADEQ inspection also noted that this landfill has been used for mercury lamp disposal.
3. Inert Material – According to ASARCO's 2004 SWPPP, this landfill was developed within a small detention basin and contains scrap metal, bricks, smelter floor debris, and contaminated soil, and is intermittently capped by fill material (soil). The frequency of capping is unknown. Historical aerial photography indicates that this landfill was absent in 1969, but fully established by 1983. A portion of the soils excavated during the residential removal actions was disposed in this landfill. ASARCO's 2004 SWPPP also states that "the landfill area drains to a small adjacent drainage [presumably to the west-southwest], and then to the Kennecott Smelter pad where it ultimately reports to the [K-Pond]." Thus, surface water in the landfill area has the potential to entrain surface soils and impact Area #3 and Area #4, Lime and Filter Plants.

Sumps

According to ASARCO's 2004 SWPPP, three sumps are located within Area #3. The exact locations of these sumps are currently unknown. Their approximate locations are:

- South of the municipal and inert material landfills, and north of the filter plant. This sump receives surface runoff from a portion of the landfill area, including the portion containing buried scrap metal. ASARCO's 2009 APP permit lists a "Runoff Collection

Sump" as a discharging facility, but it is unclear whether this is referring to the subject sump.

- North of the two potable water tanks located east of the filter plant. This sump retains flow from the "limited surrounding natural ground" within the vicinity of the sump, and as of 2004 was used for storage of materials and spare parts.
- Near the K-Pond. This sump collects discharge from the lime plant (in Area #4) and runoff from the surrounding area, and conveys it to the filter plant via a pump-back system. ASARCO's 2009 APP permit lists this sump as a discharging facility.

Lime Plant Discharge
Active operations at the lime plant (addressed in Area #4) result in discharges that are conveyed, via an unlined channel, to the southwestern portion of Area #3. ASARCO's 2004 SWPPP indicates that this flow then enters a sump with a pump-back system near the K-Pond. However, recent aerial photography indicates that at least a portion of sediment associated with activities at the lime plant extends into the K-Pond, likely past the location of the pump-back system.

Historical Sponge Plant
A sponge plant was constructed as part of the former Kennecott smelter operations, with the first use starting in approximately 1958. The sponge plant was used for roasting pyrite concentrate to produce sulfuric acid and hematite calcine. Excess pyrite concentrate slurry was stored in concrete bins (which currently may store hazardous waste within Area #3), or in earthen ponds. Gas from the furnace dust precipitator and cyclones from the fluid bed reactor were discharged through the 200-foot stack that is still remnant within the Area. A multicyclone installation ahead of the stack was responsible for cleaning up to 95% of the dust load (Mining World, 1959). It is unknown how waste was disposed during the former operation of the sponge plant.

Surface Disturbances
As observed in recent aerial photography, various disturbed areas are located adjacent to the Kennecott slag pile. While these disturbed areas are not visibly impacted by slag material, they clearly are related to active operations (one of which is the excavation and processing of slag material for use as aggregate, as described above). Large portions of the disturbed areas exhibit discolored soil at the surface.

Previous investigations have not accounted for surface soils in the eastern portion of Area #3. As observed in recent aerial photography, nearly the entire eastern portion has been disturbed by historical and/or current ASARCO operations. Large portions of the disturbed areas have discolored soil at the surface. According to 10-foot contour topography for the area, surface drainage within the eastern portion of Area #3 eventually discharges to the upper reach of

Powerhouse Wash within Area #3, and then passes through drainage structures at the southeastern corner of Area #3 into Area #10, Powerhouse Wash.

Previous Analytical Results

The Phase I RI conducted by CH2M HILL (2008a) identified contaminants in surface soil within Area #3. Seven surface soil samples were collected, all of which exceeded the R-SRLs of 10 mg/kg and 3,100 mg/kg for arsenic and copper, respectively. Three of the samples exceeded the SRL of 400 mg/kg for lead; five exceeded the Arizona R-SRL of 390 mg/kg for molybdenum; two exceeded the R-SRL of 78 mg/kg for vanadium; six exceeded the Region 9 PRG of 23,000 mg/kg for iron; and one exceeded the R-SRL of 5.2 mg/kg for thallium. The concentrations of arsenic (345 mg/kg in sample KS-02-SED-0) and copper (132,999 mg/kg in sample KS-09-SED-0) from Area #3 were among the highest reported for all samples collected from ASARCO-owned properties, with the highest arsenic level located south of the Kennecott slag pile just upstream from the San Pedro Wash.

Exposure Potential

The Northern Waste Disposal Area has open access from multiple directions, and the majority of the perimeter is not fenced or otherwise controlled to prevent the public from accessing the area and potentially being exposed to contaminants. As stated in the summary for Area #2, San Pedro Wash, several hiking trails and primitive roads lead to the areas of the Kennecott slag pile and the K-Pond. The Town of Hayden municipal well field is located to the southeast of Area #3, and draws from groundwater that flows southeasterly within the Area. Groundwater monitoring results from CH2M HILL's Phase I RI (2008a) indicated high concentrations of arsenic, selenium, molybdenum, sulfate, total dissolved solids (TDS), and vanadium at monitoring well LC-1, which is located immediately south of and downgradient from the K-Pond.

4.3.5 Area #4 – Lime and Filter Plants

Area #4, Lime and Filter Plants, comprises approximately 35 acres. Figure 4-5 displays the boundary for Area #4, identifies the features within and adjacent to the Area, and serves as a reference for the text descriptions below. Area #4 was used during former Kennecott smelting activities and remains an active part of current ASARCO operations. The Area contains the lime and filter plants, concentrate stockpiles, multiple materials storage yards and access roads, the former Kennecott smelter stack, and miscellaneous debris and historical foundations associated with the demolition of the former Kennecott smelter that began in 2004.

Key Features within Area #4

Railroad
The Copper Basin Railway tracks within Area #4 are used to transport concentrate from the filter plant and concentrate storage areas to active smelting operations.

Filter Plant and Concentrate Stockpiles
The filter plant is an active part of ASARCO's current operations. Concentrate produced at the filter plant goes through a material handling process and ultimately is delivered to the smelter facility via the Copper Basin Railway. The material handling process consists of the following:

1. Concentrate is belt-loaded into a single stockpile beneath the filter plant conveyor.
2. Front-end loaders remove the concentrate from this pile for stockpiling immediately west-southwest of the filter plant in one of three piles based on known copper concentrations (the exact concentration corresponding to each pile is confidential/ industry protected information).
3. Front-end loaders remove concentrate from these stockpiles according to operational needs, and load railcars located immediately south of the filter plant and east of the lime plant.
4. Concentrate is then delivered to the smelter facility by railcar.

Some of the storage piles contain concentrate from other mining operations such as the Mission Mine, and the associated levels of metals other than copper can vary. None of the activities described above are conducted under protective cover or within enclosures, leaving the potential for contaminants within the concentrate materials to be:

- Subject to wind dispersion and suspension within the air column;
- Entrained and transported as sediment load in surface water runoff during precipitation events; and
- Impacting surface soils directly due to incidental spills during the handling process.

It is known that copper concentrations of the material generated at the filter plant significantly exceed Arizona R-SRLs, given that the concentrate contains approximately 35% copper. Site visits by EPA have noted that tracked areas and piles are not always wetted according to dust suppression protocols. On several occasions, even after EPA personnel notified ASARCO staff about locations of concern that exhibited dry surfaces, the problem was not corrected on the following day.

Lime Plant
The lime plant is also an active part of ASARCO's current operations. Quicklime (CaO) is received via railcars and stored in a 150-ton silo located at the lime plant. This lime is fed to a slaker where a slurry of hydrated lime ($CaOH_2$) is produced. The hydrated lime is stored in tanks at the lime plant and pumped to various locations for the following uses:

- In the concentrator, hydrated lime is added to each of the rod mills to control the pH level during flotation. Lime is the primary pyrite depressant.
- Lime is fed to the regrind mill.
- Hydrated lime is used to adjust pH levels in Area #11, Waste Water Treatment Plant, to facilitate the precipitation of calcium sulfate and metal hydroxides.

The effectiveness of the dust controls implemented at the lime plant currently is unknown.

Former Smelter Area / Support and Storage
The remainder of Area #4 (primarily the eastern half) contains foundations and other components (cooling towers and stacks) from the former Kennecott smelter, as well as miscellaneous debris, multiple materials or parts storage areas, various unpaved access roads, and discolored surface soils.

Previous Analytical Results
The Phase I RI conducted by CH2M HILL (2008a) identified contaminants in surface soil within Area #4. Five surface soil samples were collected within the Area. Three of the five samples exceeded the Arizona R-SRL of 10 mg/kg for arsenic and all five samples exceeded the R-SRL of 3,100 mg/kg for copper, while there were no exceedances of the R-SRL of 400 mg/kg for lead. One of the five samples was analyzed for additional metals, and exceeded the R-SRL of 390 mg/kg for molybdenum (2,280J mg/kg) as well as the Region 9 PRG of 23,000 mg/kg for iron (182,000J mg/kg). The maximum arsenic and copper concentrations reported for these five samples were 106 mg/kg and 192,000 mg/kg, respectively.

Exposure Potential
The Lime and Filter Plants Area has open access from multiple directions, and the perimeter is not fenced or otherwise controlled to prevent the public from accessing the Area and potentially being exposed to contaminants.

4.3.6 Area #5 – Kennecott Avenue Wash and Tailings

Area #5, Kennecott Avenue Wash and Tailings, comprises approximately 45 acres. Figure 4-6 displays the boundary for Area #5, identifies the features within and adjacent to the Area, and serves as a reference for the text descriptions below. Portions of Area #5 were used for tailings discharge during historical ASARCO operations, and continue to receive tailings deposits

intermittently as a result of plant upsets at the Hayden concentrator. The Area contains a tailings pipeline and lift station bisecting the Area from northeast to southwest, and is bounded to the west, north, and east by Hayden residential properties. State Route 177 serves as the southern boundary of Area #5. The flow path of the Kennecott Avenue Wash is generally confined to the west side of Area #5.

Key Features within Area #5

Tailings
Tailings material has been deposited throughout a significant portion of Area #5 since the 1920s or earlier. Aerial photography from 1958 and 1964 (EPA, 2004a) indicates that tailings were deposited throughout much of Area #5, with two exceptions being the unnamed tributary in the northeastern portion of Area #5 and the undeveloped southwestern portion of Area #5. Plant upsets at the Hayden Concentrator have resulted in additional deposits of tailings material within the Kennecott Avenue Wash corridor, with incidents occurring as recently as 2009 (Four Corners, 2009b).

A tailings pipeline extending across the Area conveys tailings material from the concentrator (Area #7, Concentrate Handling) to the tailings impoundments (Area #1A, Tailings Impoundment D and Area #1B, Tailings Impoundment AB/BC). ASARCO's 2009 APP indicates that wastewater from the Town of Hayden also is injected into this pipeline. The resulting tailings and wastewater slurry is then discharged into the impoundments.

As viewed on recent aerial photography, the footprint of the tailings material within Area #5 is located within the central and southern portions of the Area; however, based on footprints visible in historical aerial photography, tailings material likely is present beneath a surface cover in areas extending beyond the present day footprint.

Kennecott Avenue Wash and Tributary
The Kennecott Avenue Wash receives surface flow from adjacent residential properties as well as local runoff generated on tailings surfaces. The main channel of the wash is located primarily along the western side of Area #5, and specific reaches of the wash are located in gullies that are eroded into the tailings deposits. In addition, process water from the ASARCO concentrator (Area #7, Concentrate Production) is discharged immediately west of the southwestern thickener tank located within Area #7, and then conveyed beneath Hayden Avenue via drainage structures to a tributary of the Kennecott Avenue Wash. Thus, the Kennecott Avenue Wash ultimately receives discharge from Area #7 via the tributary located at the northeastern corner of Area #5. The portion of the tributary above Canyon Drive and below Hayden Avenue was remediated as part of the ASARCO removal actions, but continues to receive flow from the vicinity of the thickener tanks.

Kennecott Avenue Wash Corridor – Perimeter Soils
Residential removal actions previously completed in the Town of Hayden included properties along the northern, eastern, and western boundaries of Area #5. Therefore, soils around the perimeter of Area #5 also may be impacted by the contaminants identified within these adjacent properties.

Flume
A wooden flume in the southeastern portion of Area #5 was decommissioned within the last few years. The flume originates from an underground pipeline at the concentrator, which proceeds under the Town of Hayden park and fire station, and emerges near the western end of Second Street. This flume was used in the past to transport tailings material by gravity from the concentrator to Tailings Impoundment AB/BC. It served primarily as a backup to the main line in the event the mill experienced a power failure and lacked the capacity to pump tailings through the main line. The top of the flume was open and occasionally spilled materials due to overtopping, obstructions, or vandalism. Historical spills would have flowed overland and settled in lower elevation areas within Area #5. The flume also was used by the Town of Hayden in the past to drain the Town swimming pool.

Previous Analytical Results
Two surface soil samples were collected from the tributary to the Kennecott Avenue Wash as part of the 2004 EPA removal assessment sampling effort (residential data), and two samples were collected from the main channel of the Kennecott Avenue Wash located in the northwestern portion of Area #5 (non-residential data). The Arizona R-SRLs for arsenic and copper (10 mg/kg and 3,100 mg/kg, respectively) were exceeded in all four samples, with maximum concentrations of 36.8 mg/kg and 9,380 mg/kg, respectively. There were no exceedances of the R-SRL of 400 mg/kg for lead.

Ten surface soil samples were collected from the north, central, and southern portions of Area #5 as part of the Phase I RI conducted by CH2M HILL (2008a). Three of the ten samples exceeded the R-SRL for arsenic (maximum of 22J- mg/kg), and four of the ten samples exceeded the R-SRL for copper (maximum of 13,500J- mg/kg), while there were no exceedances for lead. One of the ten samples also was analyzed for additional metals, but did not exhibit any exceedances.

At the request of the Town of Hayden, Four Corners conducted Phase I (2009a) and Phase II (2009b) environmental site assessments for a proposed waste water treatment plant to be located entirely on tailings material. Based on surface and depth sample results, Four Corners concluded that the proposed property has been impacted by copper.

Exposure Potential
The Kennecott Avenue Wash and Tailings Area has open access from multiple directions, and the perimeter is not fenced or otherwise controlled to prevent the public from accessing the Area and potentially being exposed to contaminants. Kennecott Avenue, a primary transportation corridor, extends through the center of Area #5, and is constructed on top of historical tailings deposits. Area #5 also can be accessed freely from State Route 177.

4.3.7 Area #6 – Administration and Concentrator Support

Area #6, Administration and Concentrator Support, comprises approximately 52 acres. Figure 4-7 displays the boundary for Area #6, identifies the features within and adjacent to the Area, and serves as a reference for the text descriptions below. Area #6 contains multiple structures and storage areas that support current operations at the Hayden concentrator. Structures include the administration building, warehouses, shops and garages, power house, and Salt River Project (SRP) substation. A primary materials storage yard is located in the north-central portion of Area #6. The Area is bounded on the north by the Copper Basin Railway tracks, and in the remaining directions by other ASARCO operations, residential properties, and the Powerhouse Wash corridor.

Key Features within Area #6

Railroad
Four individual spurs of the Copper Basin Railway are located within the boundary of Area #6. Tracks within Area #6 are used to transport slag, concentrate, sulfuric acid, and any other materials brought to or from the smelter and concentrator areas by rail. Some transported substances–such as smelter ventilation dust–may be hazardous, and are proposed to be addressed during the Phase II RI/FS.

Storage Yards
A primary storage yard is located adjacent to and north of the warehouse in Area #6. ASARCO's 2004 SWPPP provides the following description of this storage area: *"Materials stored in this area can include but are not limited to chlorine, acetylene, oxygen, silicon, bulk oil, anode mold wash (Dylon), soluble oil, hydraulic oil, electrical insulating oil, kerosene, anti-freeze, and GST oil.* [It] *also contains solid materials such as belt material, belt rollers, steel pipe and fittings, and spare parts."* This storage yard likely also contains additional materials not covered in the SWPPP. As observed in recent aerial photography, large portions of the storage yard have discolored soil at the surface. Aerial photography from 1958 indicates that the primary storage yard footprint at that time contained at least three railroad spurs that ultimately connected to the concentrator building. Portions of these historical tracks are remnant in subsequent aerial photography until 1983, after which they are no longer distinguishable.

A secondary storage yard is located in the northwestern corner of Area #6. ASARCO's 2004 SWPPP states that the northwestern portion of Area #6 was used to store scrap metal from the 2004 demolition of the former Kennecott smelter until buyers removed the materials at an unknown date. Before being used for scrap storage, this portion of Area #6 was utilized as part of operations at the former Kennecott smelter. Aerial photography from 2004 shows the storage area contained multiple piles of miscellaneous materials, and earlier photographs (including 1958) indicate similar usage.

Slag Area
A slag pile is located in the northeastern corner of Area #6, and appears to be an intermediate/raw materials storage location. No information has been provided to EPA on the contents of the pile or how it is used in active operations. Aerial photography from 2004 does not display this feature, indicating that deposition in this area has occurred within the last eight years. Recent EPA site visits have noted that rubber-tired loaders were depositing slag material into railcars at this location.

Previous Analytical Results
Five surface soil samples were collected in the northwestern portion of Area #6 for the Phase I RI (CH2M HILL, 2008a). All five surface soil samples exhibited exceedances of the Arizona R-SRLs for arsenic and copper (10 mg/kg and 3,100 mg/kg, respectively), while only one sample exceeded the R-SRL of 400 mg/kg for lead. Maximum arsenic, copper, and lead concentrations for these five samples were 90.7 mg/kg, 48,600 mg/kg, and 450 mg/kg, respectively. None of the five samples was analyzed for additional metals. The majority of Area #6 was not sampled as part of past investigations, so surface soil contaminants associated with this Area are largely unknown.

Exposure Potential
Residential portions of the Town of Hayden adjacent to Area #6 to the west have access to the Administration and Concentrator Support Area through existing holes in fencing and along unfenced railroad corridors. In addition, the Powerhouse Wash corridor provides a pathway to adjacent areas to the east, although it is unknown whether the eastern perimeter of Area #6 effectively prevents public access. Collectively this provides the opportunity for the public to be exposed to contaminants associated with Area #6.

4.3.8 Area #7 –Concentrate Production

Area #7, Concentrate Production, comprises approximately 21 acres. Figure 4-8 displays the boundary for Area #7 and identifies the features within and adjacent to the Area, and serves as a reference for the text descriptions below. Area #7 contains the active concentrator building, the

leach-precipitation-flotation (LPF) section building, settling ponds, two thickener tanks, a former molybdenum production area, a tailings pump station, an extensive pipeline network, and other structures and features that serve purposes that are currently unknown to EPA. Near the entrance road in the northeastern corner of the area, a drainage underpass conveys stormwater and sediment from an unknown area of the facility around the thickener tanks. Some regions in the southwestern and western portions of Area #7 were capped with decomposed granite during residential removal actions, but the thickness of this material cap is unknown. The Area is bounded to the north and east by other ASARCO operations, and to the west and south by Hayden residential and public properties.

Previous Analytical Results

A considerable quantity of historical data is available for the southern and western portions of Area #7, including data for adjacent public areas outside the Area boundary. One sample was collected as part of the 2000 Resource Conservation and Recovery Act (RCRA) inspection, and analytical results exceeded the respective Arizona R-SRLs of 10 mg/kg and 3,100 mg/kg for arsenic and copper, but did not exceed the R-SRL of 400 mg/kg for lead. Five samples were collected as part of the 2004 School and Playground study, four of which exceeded the R-SRLs for arsenic and copper (maximum concentrations of 66.8 mg/kg and 16,900J mg/kg, respectively), and none of which exceeded the R-SRL for lead.

Thirteen samples were collected within Area #7 for the CH2M HILL Phase I RI (2008a), all of which were analyzed for arsenic, copper, and lead, and four of which were analyzed for additional metals. Ten of the 13 samples exceeded the R-SRL for arsenic (maximum concentration of 81.6J- mg/kg); all 13 samples exceeded the R-SRL for copper (maximum concentration of 69,300 mg/kg); and none exceeded the R-SRL for lead. Of the four samples analyzed for additional metals, exceedances of the Arizona R-SRLs of 390 mg/kg for molybdenum (1,240 mg/kg) and 78 mg/kg for vanadium (93.3 mg/kg) were identified in one sample, while all four samples exceeded the Region 9 PRG of 23,000 mg/kg for iron (maximum concentration of 68,000 mg/kg).

Exposure Potential

Residential portions of the Town of Hayden adjacent to Area #7 to the west and south have access to the Concentrate Production Area through existing holes and other openings in fencing. In addition, the Town of Hayden swimming pool is located immediately west of Area #7, such that wind dispersion of fine-grained soils provides the opportunity for the public to be exposed to contaminants associated with Area #7.

4.3.9 Area #8 – Conveyor Belt Tailings

Area #8, Conveyor Belt Tailings, comprises approximately 13 acres. Figure 4-9 displays the boundary for Area #8, identifies the features within and adjacent to the Area, and serves as a reference for the text descriptions below. Area #8 contains the tailings deposits, associated containment ponds, and areas adjacent to the present day tailings footprint. A pipeline extends from the concentrator to the north and proceeds along the east side of the tailings within Area #8, and ultimately conveys tailings material to Area #1A, Tailings Impoundment D. Overhead conveyor #9, approximately 1,200 feet long, runs through Area #8, but is addressed separately within Area #9 (Ore Receipt and Secondary and Tertiary Crushing). Area #8 is bounded to the north and south by other ASARCO operations, and to the west and east by Hayden residential and industrial properties.

Key Features within Area #8

Tailings Deposits
Tailings material has been deposited throughout a large portion of Area #8 as a result of past discharges from the Hayden Concentrator. As viewed on recent aerial photography, the footprint of the tailings is located within the central and southern portions of Area #8. Historical aerial photography indicates that this area has experienced a number of changes since 1958, including excavations related to the construction of conveyor #9 and the reintroduction of older tailings material to the process stream. Side slopes and other areas adjacent to tailings likely have been impacted during these activities. The number and locations of containment ponds within Area #8 also have varied over time.

According to the discussion presented in ASARCO's 2004 SWPPP, Area #8 currently receives runoff from the area directly below the conveyor belt and also from Hayden residential areas. Exhibit 1 (Concentrator and Smelter Site Drainage Areas) from the SWPPP indicates that Area #8 and areas surrounding the concentrator and administration buildings to the north are contained within a single drainage area (DA-1). However, 10-foot contour topography and observations made during previous EPA site visits indicate that the DA-1 boundary displayed on Exhibit 1 is an inaccurate representation of the containment of surface flows within these areas. In addition, it is not clear how flow from the northern areas could potentially impact portions of Area #8.

Regardless of the above uncertainty, surface flows not contained by the two containment ponds in Area #8 are conveyed into Area #10, Powerhouse Wash, then beneath State Route 177 via drainage structures, and ultimately to the emergency ponds located at the southern tip of Tailings Impoundment AB/BC. These containment ponds are listed as discharging facilities on ASARCO's 2009 APP.

Areas Adjacent to Tailings

Historical aerial photography indicates that tailings were deposited primarily from the northern boundary of the present day footprint to locations to the south. The northern portion of Area #8 does not appear to have been used for tailings deposition. However, previous analytical results within this area indicate that further investigation is required to define the extent of contaminants identified (see below).

Previous Analytical Results

Four samples were collected as part of the 2002 Expanded Site Investigation (ESI) non-residential sampling effort (ADEQ, 2003). Results for all of these samples exceeded the Arizona R-SRL of 10 mg/kg for arsenic (maximum of 62.8 mg/kg), three exceeded the R-SRL of 3,100 mg/kg for copper (maximum of 12,700J mg/kg), and three exceeded the R-SRL of 400 mg/kg for lead (maximum of 851J mg/kg). Two samples were collected as part of the 2002 ESI residential sampling effort, one of which exceeded the R-SRLs for arsenic and copper (26.7J mg/kg and 5,640 mg/kg, respectively). One sample collected as part of the 2004 EPA Removal Assessment did not exhibit any exceedances (ADEQ, 2003). Five samples were collected for the CH2M HILL Phase I RI (2008a). Four of these exceeded the R-SRL for arsenic (maximum of 52.7J- mg/kg), four exceeded the R-SRL for copper (maximum of 131,000J- mg/kg), and none exceeded the R-SRL for lead. None of the previous samples were analyzed for additional metals.

Exposure Potential

Residential portions of the Town of Hayden adjacent to Area #8 on the west and east have access to the Conveyor Belt Tailings Area through existing holes in fencing. This provides the opportunity for the public to be exposed to contaminants associated with this Area.

4.3.10 Area #9 – Ore Receipt and Secondary and Tertiary Crushing

Area #9, Ore Receipt and Secondary and Tertiary Crushing, comprises approximately 24 acres. Figure 4-10 displays the boundary for Area #9 and identifies the features within and adjacent to the Area, and serves as a reference for the text descriptions below. Area #9 contains the ore receipt area where ore, slag, and other materials are received via rail and truck; the secondary and tertiary crushers that crush materials and convey them via conveyor #9; and the fine ore bin and mill building where material is further refined. All of these features were constructed between 1958 and 1964. Area #9 also contains an intermediate material stockpile and two parts storage areas. The Area is bounded to the north and south by other ASARCO operations, and to the west and east by Hayden residential properties and the Powerhouse Wash corridor.

Key Features within Area #9

Ore Receipt
The ore receipt area contains a track hopper that receives deliveries of ore by railcar, as well as slag and oversized smelter by-products by truck. These materials are deposited onto a series of feeders and belts that transport material to the secondary and tertiary crusher building located across State Route 177 to the northeast.

Secondary and Tertiary Crushing
Ore and slag received at the ore receipt area is delivered by a series of feeders and belts to the crusher building, where material is distributed through secondary and tertiary crushing processes to create a nominal ½-inch product. Crushed materials are conveyed to the fine ore bins via conveyor #9.

Conveyor #9
Conveyor #9 carries crushed materials from the secondary and tertiary crusher building in the southern portion of Area #9 to the fine ore bins located east of and adjacent to the concentrator building. The conveyor is covered to protect the integrity of materials from precipitation. However, the sides of the conveyor remain open to the environment, which results in periodic material spills and/or dispersion of materials by wind. Spilled material has been observed in the Hillcrest neighborhood of Hayden during previous EPA site visits.

Fine Ore Bins and Mill Building
Materials transported by conveyor #9 enter the fine ore bins and subsequently are belt-fed to the adjacent mill building. The mill building contains rod and ball mills to grind material to finer sizes. One section of the mill building also is equipped to feed slag into the milling process. ASARCO's 2004 SWPPP indicates that the mill building is periodically cleaned, and material that is recovered during this process is temporarily stockpiled immediately north of the fine ore bins (the "Intermediate Material Stockpile"). The stockpiled material is considered an intermediate product that eventually is incorporated back into the milling process. Two parts storage yards are located south of these two structures.

Previous Analytical Results
Two samples were collected as part of the 2000 RCRA Inspection sampling effort and analyzed for arsenic, copper, lead, cadmium, and chromium. Both samples exceeded the Arizona R-SRLs of 10 mg/kg for arsenic and 3,100 mg/kg for copper (maximum arsenic and copper concentrations of 70 mg/kg and 56,000 mg/kg, respectively), but did not exceed the R-SRLs for the other metals. Three samples were collected as part of the 2002 ESI non-residential sampling effort (ADEQ, 2003) and analyzed for arsenic, copper, and lead. All three samples exceeded the

respective R-SRLs for arsenic and copper (maximums of 47.6 mg/kg and 20,100 mg/kg, respectively), but did not exceed the R-SRL of 400 mg/kg for lead. Eighteen samples were collected within Area #9 for the 2008 CH2M HILL Phase I RI. All samples were analyzed for arsenic, copper, and lead, and 11 of the 18 samples were analyzed for additional metals. Fifteen of the 18 samples exceeded the R-SRL for arsenic (maximum of 1,720 mg/kg), 13 of the samples exceeded the R-SRL for copper (maximum of 59,700 mg/kg), and none of the samples exceeded the R-SRL for lead. Of the 11 samples analyzed for additional metals, two samples exceeded the R-SRL of 78 mg/kg for vanadium (maximum of 105 mg/kg), one sample exceeded the R-SRL of 390 mg/kg for molybdenum (1,020 mg/kg), and eight samples exceeded the Region 9 PRG of 23,000 mg/kg for iron (maximum of 162,999 mg/kg).

Exposure Potential

Residential portions of the Town of Hayden adjacent to Area #9 to the west and east have access to the Ore Receipt and Secondary and Tertiary Crushing Area through existing holes in fencing, or through portions that lack fencing. In addition, wind dispersion of ore dust and materials results in surface deposition within residential areas of the Town of Hayden. This provides the opportunity for the public to be exposed to contaminants associated with Area #9.

4.3.11 Area #10 – Powerhouse Wash

Area #10, Powerhouse Wash, comprises approximately 44 acres. Figure 4-11 displays the boundary for Area #10, identifies the features within and adjacent to the Area, and serves as a reference for the text descriptions below. Area #10 contains the lower reach of the Powerhouse Wash and adjacent wash corridor, a historical tailings deposit (partially buried), and a location exhibiting features consistent with the discharge of flow from Area #6 (Administration and Concentrator Support) and Area #9 (Ore Receipt and Secondary and Tertiary Crushing) to portions of Area #10. The Area is bounded in all directions by other ASARCO operations, with the exception of an approximate 1,500-foot extent of Hayden residential properties along the west-central boundary.

Key Features within Area #10

Powerhouse Wash

Historical aerial photography (EPA, 2004a) indicates that the Powerhouse Wash corridor has been subject to a variety of uses and is impacted by ASARCO's historical and current operations. The following uses have been documented for portions of the wash corridor within Area #10:

- Residential developments (pre-1969);
- Industrial developments;
- Tailings disposal (pre-1964); and

- Transportation corridor between various ASARCO facilities.

Aerial photography from 1958 shows the active channel of the wash had clearly defined banks and a consistent flow path from its headwaters to the north of Area #10 in Area #3, Northern Waste Disposal, to its present day intersection with State Route 177. In contrast, recent aerial photography shows defined banks and a consistent flow path only from a point near the Power House to its intersection with State Route 177. Discharges of flow from adjacent ASARCO operation areas into Powerhouse Wash were discernible throughout the years spanned by the aerial photography.

Tailings Deposits
As discussed in the summary for Area #8, Conveyor Belt Tailings, aerial photography from 1958 indicates that tailings were stored within Area #10, northeast of the secondary crusher. Aerial photography subsequent to 1958 shows that the tailings feature was modified (or possibly capped) in later years, and potentially was exposed by erosion or operations-related excavations. It is thus likely that historical tailings are still present in the subsurface (and/or potentially at the surface) in this area.

Discharge near Power House and Mill Buildings
ASARCO constructed the mill building between 1958 and 1964. Aerial photography from 1964 provides the first indication that flow was being discharged to the Powerhouse Wash corridor from the area between the Power House and mill buildings. By 1983, a sizeable flow path can be seen originating from the same location, with a channel width comparable to the downstream channel of Powerhouse Wash. This flow path appears to be more confined in recent aerial photography. Color aerial photography from 2011 shows that this flow path is composed of multiple individual flows, all of which are transporting sediments with varying hues. Flow appears to be originating from the east side of the mill building, and potentially from the south side of the Power House building. It is unclear whether this discharge is a result of local surface flows generated during storm events, or whether flow is discharged from these locations as part of ASARCO's current operations.

Previous Analytical Results
Previous data were collected as part of the 2002 ESI non-residential sampling effort (four samples; ADEQ, 2003), the 2004 EPA Removal Assessment (two samples), and the 2008 CH2M HILL Phase I RI (nine surface samples and five deeper samples). All samples were analyzed for arsenic, copper, and lead, and the majority exceeded the Arizona R-SRLs only for arsenic and copper. All fourteen of the CH2M HILL (2008) samples were analyzed for additional metals, but exhibited exceedances only of the Region 9 PRG of 23,000 mg/kg for iron in both the surface and deeper samples.

Exposure Potential

Residential portions of the Town of Hayden adjacent to the west have unfenced and open access to the Powerhouse Wash Area, and the wash corridor can be entered freely from State Route 177. This provides the opportunity for the public to be exposed to contaminants associated with Area #10.

4.3.12 Area #11 – Waste Water Treatment Plant

Area #11, Waste Water Treatment Plant, comprises approximately 42 acres. Figure 4-12 displays the boundary for Area #11, identifies the features within and adjacent to the Area, and serves as a reference for the text descriptions below. Area #11 contains spurs of the Copper Basin Railway, a waste-water treatment plant (WWTP) and related features, a calcium sulfate pond remnant from historical operations, and wet/dry bins for storage of waste generated during cleaning activities at the Hayden Complex. The Area is bounded by other ASARCO operations to the north and east, the Powerhouse Wash corridor to the west, and open desert to the south.

Key Features within Area #11

Railroad

Area #11 includes two railroad spurs of the Copper Basin Railway used for transporting multiple types of materials other than concentrate and slag to ASARCO operation areas. Typical materials include sulfuric acid, waste-water treatment filter cake, and other materials of unknown composition and use.

Waste Water Treatment Plant

The WWTP treats water from the sulfuric acid plant for re-use in the process stream. The plant was constructed in 1983. A sludge drying bed is located in the southwestern portion of the WWTP. Liquid removed from the sludge drying beds ultimately is delivered to the tailings impoundments in Areas #1A and #1B (Tailings Impoundments D and AB/BC, respectively). The remaining solids are excavated from the sludge drying beds and transported via truck or rail to Mexico for disposal or reuse. Recent aerial photography shows a dark linear feature (possibly a result of flow discharge) that proceeds from the sludge drying beds toward the calcium sulfate pond.

Calcium Sulfate Pond

The calcium sulfate pond is not used in current operations, but contains sludge that had been neutralized with lime in the past. ASARCO's 2009 APP lists the pond as a discharging facility and indicates that it is lined. The composition of the liner is unknown. Recent aerial

photography of the pond shows multiple discolorations on the surface, possibly indicating different periods of deposition.

Wet/Dry Bins
Concrete-lined bins installed in the northeastern corner of Area #11 contain materials recovered during spill-response operations conducted within the Hayden Complex. The integrity of the liners is unknown. Materials deposited in these bins typically are wet and are allowed to dry before the material is removed for disposal or reuse. In the event that the concrete-lined bins overflow, materials are conveyed into one of two ponds located immediately to the west. It is not clear whether the western ponds are lined.

Previous Analytical Results
To date, only two soil samples have been collected within Area #11, as part of the 2000 RCRA Inspection sampling event. Sample AS07 was collected from the sludge drying bed described above, and sample AS10 was collected in the northeastern corner of Area #11. The samples were analyzed for arsenic, copper, lead, cadmium, and chromium. Analytical results for both samples significantly exceeded the respective Arizona R-SRLs for all of these metals except chromium.

Exposure Potential
Area #11 can be accessed by the public from the south via hiking trails and former roads that originate from residential and public areas of Winkelman. This provides the opportunity for the public to be exposed to contaminants associated with Area #11.

4.3.13 Area #12 – Concentrate Handling and Mixing

Area #12, Concentrate Handling and Mixing, comprises approximately 19 acres. Figure 4-13 displays the boundary for Area #12, identifies the features within and adjacent to the Area, and serves as a reference for the text descriptions below. Area #12 contains spurs of the Copper Basin Railway, an auger building that samples the contents of railcars, a railcar unloading area, concentrate bedding bins, a flux storage area, and containment areas for semi-solid vacuum truck discharges. The Area is bounded by other ASARCO operations to the north, east, and south, and by the Powerhouse Wash corridor to the west.

Key Features within Area #12

Railroad
Area #12 includes eastern and western railroad spurs of the Copper Basin Railway. The eastern spur is used to transport concentrate, and potentially flux or other bedding material. The western spur supports other areas of the smelter and transports sulfuric acid and other unknown materials.

Auger Building
The auger building and surrounding switching yard are used to sample railcar loads and determine the chemistry of the material before it is delivered to the bedding area. Augers bore into the material in each car, collect samples for testing, and subsequently deposit the test material on adjacent surface soils.

Railcar Unloading Area
Bottom-dump railcars loaded with concentrate are emptied into a sub-grade bin before distribution to the concentrate bedding. After the railcars are unloaded, they are shaken to loosen any residual material.

Flux Storage Area
Within the flux storage area, flux is loaded into the rail concentrate unloading bin and is then applied to the bedding area by rubber-tired loaders.

Concentrate Bedding Bins
There are four concentrate bedding bins, and each is layered with concentrate, flux, and materials composed predominantly of metals. Bins are unloaded by rubber-tired loaders and material is distributed to a conveyor belt that directs material to the smelter building.

Vacuum Truck Discharge
The contents of vacuum trucks used for cleaning roadways and facility surfaces are emptied into a containment area in the southern portion of Area #12. Whether the containment is lined is unknown. Material from the containment area is dumped into the rail unloading area for distribution to the concentrate bedding bins.

Remaining Portions of Area #12
The majority of surface soils within Area #12 have not been characterized. Characterization is merited due to discolored soils in various locations, a single slag pile in the south-central portion of the Area, and areas where concentrate additives are stored and managed.

Previous Analytical Results

To date, only two historical soil samples have been collected within Area #12. Samples AS05 and AS11 were collected as part of the 2000 RCRA Inspection sampling event. Both samples were analyzed for arsenic, copper, lead, cadmium, and chromium, and both samples significantly exceeded the Arizona R-SRLs for arsenic, copper, and lead.

Exposure Potential

Area #12 can be accessed by the public from the west via the Powerhouse Wash corridor. Fine-grained material and extensive handling result in fugitive dust emissions that potentially impact adjacent Areas. This provides the opportunity for the public to be exposed to contaminants associated with Area #12.

4.3.14 Area #13 – Smelter Support

Area #13, Smelter Support, comprises approximately 113 acres. Figure 4-14 displays the boundary for Area #13, identifies the features within and adjacent to the Area, and serves as a reference for the text descriptions below. As its name implies, Area #13 serves to support operations at the Hayden smelter. The Area contains nine containment ponds, a railcar maintenance facility and related storage yards, additional storage yards, a flux crushing area, a former limestone quarry, and various unpaved roadways and surface disturbances. The Area is bounded by other ASARCO operations in all directions with the exception of the eastern boundary, which is adjacent to highlands composed of Paleozoic-age rock.

Key Features within Area #13

Containment Ponds

Containment ponds are visible in aerial photography as early as 1983. ASARCO currently maintains a series of nine containment ponds within Area #13. The southernmost containment pond (CP-1 in ASARCO's 2004 SWPPP) is listed as a discharging facility on ASARCO's 2009 APP, and is lined. CP-1 receives flow from smelter activities and related areas, but the exact locations and methods used to distribute flow to this pond are unknown. The remaining eight ponds, located further north, are unlined, and appear to be used to manage flow that originates from upland locations. However, based on color variation from surrounding regions observed in recent aerial photography, the ponds may contain fine-grained materials or may be utilized for material storage. ASARCO is believed to have updated their SWPPP, which may address the usage of the containment ponds, but the document was not available for review during the time this work plan was developed.

Railcar Maintenance Facility and Storage Yards
ASARCO maintains a railcar maintenance facility in the west-central portion of Area #13. This facility is used for railcar repair and engine rebuilds for ASARCO-owned rolling stock. Storage yards are located immediately east and southeast of the railcar maintenance facility, and contain items that support maintenance activities. According to historical aerial photography, this facility was constructed between 1983 and 1992.

Additional Storage Areas
Two other storage yards are located within Area #13 near the southern and eastern boundaries. Exact usage of these yards is currently unknown. Recent aerial photography shows variations in soil color within the storage yards.

Flux Crushing
A contractor operates a flux crushing area located within the central portion of Area #13. Recent aerial photography shows a bermed storage area located adjacent to the crushing activities. Surface soils in the area vary in color from pink to tan and black, indicating likely variations of chemical composition.

Previous Analytical Results
To date, only one soil sample has been collected within Area #13. Sample AS06 was a three-part composite sample of CP-1 sediments, and was collected as part of the 2000 RCRA Inspection sampling event. The sample was analyzed for five metals, and results showed significant exceedances of the Arizona R-SRLs of 10 mg/kg for arsenic (3,700 mg/kg), 3,100 mg/kg for copper (98,000 mg/kg), 400 mg/kg for lead (7,200 mg/kg), 39 mg/kg for cadmium (340 mg/kg), and 35 mg/kg for chromium (46 mg/kg).

Exposure Potential
Area #13 can be accessed by the public from the east via former roads and hiking trails. This provides the opportunity for the public to be exposed to contaminants associated with Area #13.

4.3.15 Area #14 – Flash Smelting, Copper Converting, Anode Furnace

Area #14, Flash Smelting, Copper Converting, Anode Furnace, comprises approximately 14 acres. Figure 4-15 displays the boundary for Area #14, identifies the features within and adjacent to the Area, and serves as a reference for the text descriptions below. Area #14 contains the smelter building, which contains the Inco flash furnace, converters, and anode furnace. The Area is bounded by other ASARCO operations in all directions.

Previous Analytical Results

No soil samples have been collected within Area #14. However, one soil sample was collected from Area #11, Waste Water Treatment Plant, just outside the southwestern corner of Area #14. Sample AS10 was collected as part of the 2000 RCRA Inspection sampling event. As discussed in the summary for Area #11, results for this sample significantly exceeded the Arizona R-SRLs for arsenic, copper, lead, and cadmium, suggesting that contaminants may have been derived from upgradient locations within Area #14.

Exposure Potential

Authorized access to Area #14 is limited to ASARCO personnel. However, fugitive dust generated from operational activities, as well as any originating surface flows, ultimately may impact nearby residential areas. This provides the opportunity for the public to be exposed to contaminants associated with Area #14.

4.3.16 Area #15 – Reverts Crushing and Reclaim

Area #15, Reverts Crushing and Reclaim, comprises approximately 27 acres. Figure 4-16 displays the boundary for Area #15, identifies the features within and adjacent to the Area, and serves as a reference for the text descriptions below. Area #15 contains the reverts crushing and reclaim operations, adjacent storage areas, and Copper Basin Railway spurs. The Area is bounded by other ASARCO operations to the north and west, and primarily by open desert to the east and south.

Key Features within Area #15

Railroad

Two railroad spurs of the Copper Basin Railway are located within the boundary of Area #15. Tracks within Area #15 are used to transport sulfuric acid, crushed reverts, flux, and other materials used in conjunction with reverts system and smelter related processes.

Materials Storage and Handling

This portion of Area #15 is used as a temporary storage location for various materials of known (flux) and unknown composition. Materials are also potentially transported from Area #11, Waste Water Treatment Plant, for possible loading onto rails cars or other types of transportation vehicles. Aerial photography shows multiple discolored surfaces and depositional patterns indicative of material that has been spread around, some of which has moved to lower elevations along the side slope.

Reverts Crushing Yards (North and South)
Reverts material is crushed and potentially stockpiled within the north-central and southern portions of Area #15. Recent aerial photography shows multiple areas of soil discolorations within the north and south reverts crushing yards. A portion of surface flows generated within the south yard are directed westward into one of two small drainage channels that form a confluence approximately 200 feet west of the western boundary of the south yard. Flow within the merged channel is then captured by a small settling pond in the southwestern corner of Area #15. The remainder of surface flows within the south yard travel to the south and east, and are ultimately captured by settling ponds near the high school gym, but exact paths are currently unknown. It is unknown how surface flows generated in the north yard are managed.

Reverts Reclaim
This portion of Area #15 has been traditionally used to crush reverts originating from the Hayden smelter and the Amarillo Copper Refinery (ACR). Reverts material is crushed in one of two crusher systems and then delivered to the concentrator or smelter for reclaim and feed into the smelting process. Recent EPA site visits have indicated that this feature may be infrequently used but could be restarted at any time.

Previous Analytical Results
Two surface soil samples were collected as part of the 2000 RCRA Inspection and the 2008 CH2M HILL Phase I RI (one sample each). Analytical results showed significant exceedances of the Arizona R-SRLs for arsenic, copper, lead, cadmium, chromium, and antimony, and exceedance of the Region 9 PRG for iron.

Exposure Potential
Area #15 can be accessed by the public from the south via former roads and hiking trails, some of which originate in the vicinity of the high school. ASARCO staff has identified trespassing issues within the area. This provides the opportunity for the public to be exposed to contaminants associated with Area #15.

4.3.17 Area #16 – Acid and Oxygen Plants

Area #16, Acid and Oxygen Plants, comprises approximately 33 acres. Figure 4-17 displays the boundary for Area #16, identifies the features within and adjacent to the Area, and serves as a reference for the text descriptions below. Area #16 contains the sulfuric acid and oxygen plants, adjacent storage areas, and Copper Basin Railway spurs. The Area is bounded by other ASARCO operations to the north and east and primarily by open desert to the west and south, and is bisected in a general north-south direction by a segment of the Copper Basin Railway.

The smelter slag pile abuts most of the eastern boundary, and is addressed separately as Area #17, Slag Handling.

Key Features within Area #16

Railroad
One railroad spur of the Copper Basin Railway is located within the boundary for Area #16. Tracks within Area #16 are used to transport copper anodes, sulfuric acid, waste water treatment plant sludge, copper concentrates, and reverts. Other materials also may be stored or transported within the area.

Acid Plant
The acid plant consists of a gas cleaning system followed by a double-contact acid plant that converts sulfur dioxide gas produced during the smelting process into 93 or 98 percent commercial grade sulfuric acid. The resulting product is then sold to outside parties.

Oxygen Plant
The oxygen plant separates oxygen and nitrogen from ambient air and produces a higher-concentration oxygen gas that is used at the smelter to facilitate continuous combustion of the sulfur that is resident in concentrate.

Remaining Portions of Area #16
Surface soils within Area #16 have not been characterized. Multiple locations of high and intense soil color variation indicate potential impacts from contaminants.

Previous Analytical Results
To date, no investigations have included the collection of soil samples within Area #16.

Exposure Potential
Portions of Area #16 can be accessed by the public from the south via hiking trails. This provides the opportunity for the public to be exposed to contaminants associated with Area #16.

4.3.18 Area #17 – Slag Handling

Area #17, Slag Handling, comprises approximately 61 acres. Figure 4-18 displays the boundary for Area #17, identifies the features within and adjacent to the Area, and serves as a reference for the text descriptions below. Area #17 contains the active slag pile, a slag crushing area, and a series of containment ponds located at the southern and eastern ends of the slag pile. The Area is

bounded by other ASARCO operations to the north and west, by State Route 177 to the east, and by open desert to the south.

Key Features within Area #17

Containment Ponds
ASARCO maintains four containment ponds south/southeast and downgradient of the slag pile. Containment ponds 1, 2, and 3 receive flow generated from the slag pile, while the easternmost pond (4) receives runoff generated from off-site areas to the northeast. Recent aerial photography indicates that containment ponds 1, 2, and 3 contain significantly less vegetative growth than containment pond 4. The difference between these basins may be attributable to the effects of differing water chemistries or may be a result of pond maintenance (i.e., removing vegetative growth). Historic aerial photography shows that containment ponds 1, 2, and 3 were constructed prior to 1983, while containment pond 4 was constructed prior to 1992. These ponds are listed as discharging facilities on ASARCO's 2009 APP permit.

Slag Pile
The present day slag pile contains two primary areas where slag is dumped into chutes based on known copper concentrations. Slag with relatively low copper concentrations currently is dumped at the southern end of the slag pile, while slag with relatively high copper concentrations is dumped in the central portion of the slag pile.

Slag Crushing
A slag crushing area is located immediately east of the high copper concentration slag dump area. The crushing activity processes the higher copper concentration slag into a finer size for subsequent recycling into the copper extraction process. The low copper concentration slag is considered waste material and is not recycled.

Previous Analytical Results
CH2M HILL (2008a) collected one surface sample from within containment pond 1 and three surface samples immediately south and downgradient of containment pond 2 as part of the Phase I RI. Analytical results indicated all four samples exceeded the Arizona R-SRLs of 10 mg/kg for arsenic (to a maximum concentration of 361 mg/kg) and 3,100 mg/kg for copper (to a maximum concentration of 27,000 mg/kg), while there were no exceedances of the R-SRL of 400 mg/kg for lead. Three of the four samples were analyzed for additional metals. All of the samples exceeded the Region 9 PRG of 23,000 mg/kg for iron (to a maximum of 64,200 mg/kg), and two exceeded the R-SRL of 39 mg/kg for cadmium (to a maximum of 94.7 mg/kg).

Exposure Potential

Area #17 can be accessed by the public from the east via state route 77 due to the lack of fencing before the guard shack located near the southwestern portion of the Area. Access also can be obtained via hiking trails that originate from the vicinity of the high school, or from the Town of Winkelman. This provides the opportunity for the public to be exposed to contaminants associated with Area #17.

4.3.19 Area #18A through #18D – Linear Features

Area #18A through Area #18D, Linear Features, collectively comprise approximately 55 acres. Figures 4-19AB and 4-19CD display the boundaries for Areas #18A and #18B, and Areas #18C and #18D, respectively, and serve as references for the text descriptions below. The linear features represented under Areas #18A through #18D include three segments of railroad tracks (Copper Basin Railway and Southern Pacific Railroad) and one segment of roadway (Kennecott Avenue).

Previous Analytical Results

To date, no surface samples have been collected within Area #18A (Hayden Junction Railway Segment), #18B (Kennecott Avenue), or #18D (Smelter Hill Railway Segment). One surface sample was collected from the southern end of Area #18C (Winkelman Railway Segment) as part of the 2004 Removal Assessment (Sample W-150). This sample exceeded the Arizona R-SRLs for arsenic, copper, and lead.

Exposure Potential

The majority of Area #18 is located within open desert, serves as or is adjacent to a transportation corridor, or is crossed by former roads and hiking trails. Therefore, the opportunity is provided for the public to be exposed to contaminants associated with Area #18.

4.3.20 Area #19 – Area Outside of Areas #1 - #18

Area #19, Area Outside of Areas #1 through #18, consists of the remaining portions of the Study Area that have not been included in other RI Area designations. For the purposes of the soil investigation, three regions of Area #19 are addressed below and are identified in Figure 7-19.

Region 1

The portion of the Study Area located west of Area #2, San Pedro Wash, and north of the Copper Basin Railway is identified as the location for background soil sampling and the first area for ecological sampling. The region is primarily undeveloped open desert, but also contains former roadways and hiking trails.

Region 2

The portion of the Study Area located south of Smelter Hill and west of the Hayden High School is identified as the second area of ecological sampling, and also contains additional Area #19 soil and sediment sample locations. The region is primarily undeveloped open desert, but also contains former roadways and hiking trails.

Region 3

The portion of the Study Area located northeast of Area #13, Smelter Support, and on top of the Paleozoic highlands contains the third area for ecological sampling within undeveloped mountain terrain.

5.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS)

This section preliminarily identifies applicable or relevant and appropriate requirements (ARARs) and other standards, criteria, and guidance "to be considered" (TBC) for activities at the Site. A preliminary identification of ARARs and TBCs is helpful in guiding remedial investigation efforts and assessing the feasibility of remedial action alternatives; however, ARARs and TBCs are identified iteratively throughout the RI/FS.

Applicable requirements are those substantive mandatory environmental regulations or standards that are promulgated under federal or state laws that specifically address contaminants or hazardous substances and remedial actions at the Site. Even if a requirement is not legally applicable, it may be relevant and appropriate. Relevant and appropriate requirements are those substantive environmental regulations or standards that are promulgated under federal or state laws that do not completely address site conditions, but would involve similar problems or situations encountered at CERCLA sites.

TBCs are non-promulgated federal or state advisories, guidance, or proposed rules that are not legally binding and do not have the status of an ARAR, but are useful in determining the necessary level of cleanup for protection of human health and the environment if ARARs are unavailable.

ARARs and TBCs are divided into three categories:

- *Chemical-Specific ARARs* are typically health- or risk-based numerical values or methodologies which, when applied to site-specific conditions, are expressed as numerical values that represent cleanup standards (i.e., the acceptable concentration of a chemical at the site). Examples of chemical-specific ARARs include non-zero maximum contaminant level goals (MCLGs) and maximum contaminant levels (MCLs) established under the Safe Drinking Water Act, and federal water quality criteria (FWQC) established under the Clean Water Act (CWA). As a general rule, if more than one chemical-specific ARAR exists for a particular contaminant, the most stringent should be applied.
- *Action-Specific ARARs* are generally technology- or activity-based requirements or limitations on actions or conditions taken with respect to specific hazardous substances. An example is the treatment of extracted groundwater to MCLs prior to discharge to comply with the CWA and the Arizona State Water Quality Standards for Surface Waters. Action-specific ARARs do not determine the remedial alternative; rather, they

indicate how a selected alternative must be implemented or achieved. RCRA and the Clean Water Act provide the majority of action-specific ARARs.

- *Location-Specific ARARs* are restrictions on the concentrations of hazardous substances or the conduct of activities in environmentally sensitive areas. An example of a location-specific restriction on the concentrations of hazardous substances are the RCRA land disposal restrictions (LDRs) prohibiting hazardous waste placement into or onto the land (e.g., landfills and salt domes) until waste-specific treatment standards have been met. Restrictions on the conduct of activities would apply, for example, to work in environmentally sensitive areas such as floodplains, wetlands, and locations where endangered species or historically significant cultural resources are present.

Potential chemical-specific and location-specific ARARs and TBCs for the Site have been identified on the basis of existing site data and are outlined below. These ARARs and TBCs will be updated based on progressive RI findings. Potential action-specific ARARs and TBCs will be based on the remedial action alternatives to be developed in the Feasibility Study (FS). A preliminary set of action-specific ARARs and TBCs is presented below; a more detailed list will be presented in the FS once the alternatives to be evaluated are identified.

If both federal and state laws that are applicable, appropriate, and relevant address the same issue, the more stringent or specific one is cited below to reduce redundancy. In addition, many regulations refer to other regulations for specific guidance. In these cases, the substantive guidance has been cited.

5.1 Chemical-Specific ARARs and TBCs

5.1.1 ARARs

Federal and state chemical-specific ARARs and TBCs will be used to conduct a preliminary screening for COPCs in all media at the Site. The following factors are important to note with respect to the chemical-specific ARARs:

(1) The Federal Safe Drinking Water Act, 42 United States Code (USC) 300(g-1), 40 Code of Federal Regulations (CFR) 141.161 establishes MCLs for public drinking water supplies for a number of common organic and inorganic contaminants. The selected remedy must comply with these requirements.

(2) An Arizona Aquifer Protection Permit (AAC 18-9) establishes the criteria of water quality and requirements of compliance monitoring for facilities that discharge to aquifers. All aquifers in Arizona are classified for drinking water protected use.

(3) The Clean Water Act (CWA), 33 U.S.C 1311-1387 establishes the water quality criteria for surface water. The FWQC are designed to protect aquatic life (marine and freshwater). These criteria are expressed on the basis of acute and chronic toxicity levels. The selected remedy must comply with these criteria. Any treated groundwater discharged to a surface water body must also meet the FWQC.

(4) Clean Water Act 40 CFR 402, 405-471; 40 CFR 125; AAC Section 18-9-A901 establishes the National Pollutant Discharge Elimination System (NPDES) permit program. The NPDES permit program regulates discharges into "waters of the United States" by establishing numeric limits and monitoring requirements for such discharges.

(5) Surface Water Standards have been established by the State of Arizona for surface waters in the State. The Arizona Aquatic and Wildlife Water Quality Criteria (AAWWQC) are the main standards used in evaluating the surface water quality in rivers and streams in the State.

(6) Cleanup levels for hazardous substances in soil are governed by either: (a) pre-determined Soil Remediation Levels (SRLs) for residential and non-residential soils that are specified in Arizona Administrative Code (AAC) R-1-7 Appendix A; or (b) site-specific risk-based SRLs developed in accordance with AAC Section R-18-7-206 such that the levels of contaminants in the soils are shown, through a site-specific HHRA, to result in a cumulative excess lifetime cancer risk (CELCR) no greater than1 x 10^{-4} to 1 x 10^{-6} and a hazard index (HI) no greater than 1 for each group of contaminants having similar health affects (EPA, 1989), based on appropriate exposure assumptions.

If contaminants are found to be present in soils at concentrations in excess of the pre-determined SRLs or site-specific SRLs, then the corresponding FS or further response action planning will be applied to the soils in a manner that satisfies AAC Section R18-16-407(C). In particular, the response actions evaluated will involve removal or remediation of the soils to: (a) pre-determined SRLs under AAC Section R18-7-205; (b) site-specific SRLs under AAC Section R18-7-206; (c) minimum or site-specific groundwater protection levels (GPLs) developed to address the requirements of AAC Section R18-2-703(B)(1); and/or (d) alternative SRLs protective of ecological receptors under AAC Section R18-2-703(B)(3).

5.1.2 TBCs

Tables developed by EPA entitled "Regional Screening Levels for Chemical Contaminants at Superfund Sites" (EPA, 2011) represent a preliminary TBC that may be applicable to a remedial action at the Site. These tables provide risk-based screening levels, calculated using default exposure assumptions, physical and chemical properties, and the most recent toxicity values. These regional screening levels have been used in other studies as TBCs for soil and water, but

are not location-specific. The residential soil risk-based concentrations from the EPA tables have been identified as potential TBCs for soils for the RI/FS.

5.1.3 Project Decision Limit (PDL)

Tables 5-1 through 5-3 present the decision limit hierarchy for the project. The ARARS and TBCs, screening levels, have been tabularized and the tables reviewed to determine the lowest of the value to use as the PDL. If the screening level is below the laboratory method detection limit (MDL), the MDL will be used for the PDL. If no screening level exists for the compound, the PDL will be the laboratory reporting limit (RL). The highlighted values in the Tables 5-1 through 5-3 represent the laboratory MDL and RLs. The laboratory will report concentrations down to the MDL in order to meet the sensitivity objectives of the project.

5.2 Action-Specific ARARs and TBCs

This section discusses the preliminary action-specific ARARs and TBCs related to the development and evaluation of remedial alternatives.

5.2.1 ARARS

The following two action-specific ARARs are generally applicable to the development and evaluation of alternatives for Superfund sites. As indicated above, a final list of action-specific ARARs will be developed in the FS once the full range of remedial action alternatives is known.

(1) 40 CFR Part 300 (National Contingency Plan), including 300.420 (remedial site evaluation), 300.425 (establishing remediation priorities), 300.430 (remedial investigation/feasibility study and selection of remedy), 300.435 (remedial design/remediation action, operation and maintenance), and 300.440 (procedures for planning and implementing off-site response actions).

(2) The requirements of AAC R-18-16 Article 4 (Site Remedy Selection), specifically R-18-16-406 (remedial investigations), R-18-16-407 (feasibility study), and R-18-16-408 (proposed remedial action plan).

5.2.2 TBCs

No action-specific TBCs have been identified.

5.3 Location-Specific ARARs and TBCs

Potential location-specific ARARs are identified and discussed in this section. The discussions are presented based on various resources potentially affected by the remedial actions at the Site.

In particular, these resources include: cultural resources, wetlands protection, floodplain management, hydrological resources, biological resources, other natural resources, and geological characteristics.

5.3.1 ARARS

(1) The Endangered Species Act (16 USC. 1531-1544; 50 CFR Part 200 and 50 CFR Part 402) protects critical habitats upon which endangered species or threatened species depend. These regulations require action to conserve endangered species or threatened species, including consultation with the Department of Interior and the Fish and Wildlife Service. Avian species supported by the riparian habitat along the Gila River include the federally endangered southwestern willow flycatcher.

(2) The following are potential ARARs related to cultural resources: National Historical Preservation Act of 1996, as amended (16 USC §§ 470-470x-6, 36 CFR pt. 800, 40 CFR§ 6.301[b], and the Archaeological and Historical Preservation Act (16 USC § 469-469c-1, 40 CFR § 6.301[c]).

(3) Floodplain Management 40 CFR 6.302(b) Executive Order 11988 requires that federal agencies proposing actions to be located in a floodplain must first evaluate the potential adverse effects those actions might have on the natural and beneficial values served by the floodplain.

(4) Protection of Wetlands 40 CFR 6.302(a) Executive Order 11900 directs federal agencies to avoid construction located in wetlands unless the agency head finds: (1) no practical alternative to such construction, and (2) the proposed action includes all practical measures to minimize harm to wetlands which might result from such use.

5.3.2 TBCs

No location-specific TBCs have been identified.

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6.0 WORK PLAN RATIONALE AND APPROACH

Section 3 of this Work Plan identified data gaps based on an evaluation of existing data. The primary objective of the additional investigations described herein is to collect data of sufficient quality and quantity to address these data gaps in order to provide a better understanding of the sources of contamination and the distribution of COPCs in media such as non-residential soils, sediment, surface water, stormwater runoff, process water, and groundwater. Further objectives are to establish any connections between such media and to identify the RAOs and preliminary remedial alternatives for the Site.

6.1 Project Data Quality Objectives

The rationale for the sampling strategy is premised on the data quality objectives (DQOs) for the project (in accordance with EPA, 1988). The DQO process (EPA, 2006) is a seven-step iterative planning approach used to prepare plans for environmental data collection activities, and is intended to help plan to collect data of the right type, quality, and quantity to support defensible site decisions. The seven steps of the DQO process are:

- Step 1: State the Problem – Summarize the contamination problem that will require new environmental data and identify the resources available to resolve the problem. Updating the Conceptual Site Model, as necessary, is a part of Step 1.
- Step 2: Identify the Goals of the Study – Identify the decision(s) that require new environmental data to address the contamination problem.
- Step 3: Identify Information Inputs – Identify the information needed to support the decision(s) and specify which inputs require environmental measurements.
- Step 4: Define the Study Boundaries – Specify the spatial and temporal aspects of the environmental media that the data must represent to support the decision.
- Step 5: Develop a Decision Rule – Develop a logical "if…then …or else" statement that defines the conditions that would cause the decision makers to choose among alternative actions.
- Step 6: Specify Limits on Decision Errors – Specify the decision maker's acceptable limits on decision errors, which are used to establish performance goals for limiting uncertainty in the data.
- Step 7: Optimize the Design for Obtaining Data – Identify the most resource-effective sampling and analysis for generating data that are expected to satisfy the DQO.

Four DQOs have been developed to address the data gaps identified in the previous studies:

- DQO#1: Characterize the sources of chemicals of potential concern (COPCs) within the ASARCO Hayden Complex.
- DQO#2: Understand the nature and define the extent of COPCs in soil, water, and sediment media.
- DQO#3: Collect sufficient data to support the Human Health Risk Assessment (HHRA).
- DQO#4: Collect sufficient data to support the Ecological Risk Assessment (ERA).

The aforementioned seven steps of the DQO process developed for each of the four DQOs is presented in the Quality Assurance Project Plan (QAPP), which is included as Part 1 of Appendix B of this Work Plan. The development of acceptance criteria for the data consistent with these DQOs is discussed in the QAPP. The Field Sampling Plan (FSP; Part 2 of Attachment B of this Work Plan) discusses the sampling and data-gathering methods to be used in the project. .

6.2 Objectives of Phase II RI/FS Data Collection

For the Phase II RI, the AOC SOW requires that: "further investigative work will be scoped to characterize contributions of hazardous substances to soils, air, surface water, and groundwater from both historical and active smelter activities."

The AOC SOW for the soil investigation is to "evaluate and sample the nature, extent, and degree of contamination as needed of potential sources of contamination identified in EPA's draft Phase I RI including, but not limited to, currently active smelter and concentrator areas, tailings, material handling and transport areas, historically contaminated areas and other areas where hazardous substances have come to be located. The specific locations and distribution of sample points must be enough to define and delineate fully such sources areas and the fate and transport of hazardous substance from them."

For the groundwater/surface water investigation, the tasks established in the AOC Statement of Work are to "collect additional groundwater and surface water samples at appropriate locations based upon available data including EPA's draft Phase I RI and characterize groundwater and surface water impacts on the downgradient boundary of the current and historical smelter facilities. Collect surface water runoff samples at appropriate locations within and near the towns of Hayden and Winkelman."

6.3 Rationale and Investigation Approach

This section summarizes the rationale and investigation approaches for the soil, surface water, stormwater runoff, sediment, and groundwater media for the Phase II RI in response to the AOC requirements. The rationale for the selection of specific numbers and locations of samples is presented in Section 7.0 within the framework of a much more detailed presentation of the scope of each RI task. In the case of soils, individual sampling programs have been developed for each of the 19 RI Areas defined and summarized in Section 4.3 of this Work Plan. The details of each of these 19 sampling programs are presented by RI Area in Section 7.2.1.1.

6.3.1 Soil

The results of previous soil investigations performed at the Site have been reviewed to identify areas where soil characterization has not yet been performed or where additional characterization is required. In order to address the sources of the COPCs and to characterize the nature of soil contamination in the Study Area, the Study Area was divided into 19 RI Areas based on past and current activities, geography, and historical investigation results (Section 2.6). Soil sampling will be conducted within each RI Area to address DQO #1 and DQO #2, as well as to support the exposure evaluations under DQO #3 and DQO #4. Data generated from soil sampling will be evaluated to identify transport pathways from COPC sources into the surrounding areas and to establish levels of COPCs in soils to which a receptor may be exposed. The focus of the soil investigation will be on surface soils (0 to 2 inches bgs), as the results of previous sampling documented in the Phase I RI Report showed that the subsurface soils (10-12 inches bgs) in general have much lower concentrations of COPCs. Surface soils also are of primary importance to the exposure scenarios to be evaluated in the HHRA and ERA.

It is noted that the soil sampling program includes the collection of samples other than native soils. Also included is the sampling tailings, slag, stored materials, and other materials that appear as discolored surface soil in aerial photographs of various materials deposited on the ground surface as a result of ASARCO operations, including (but not limited to). Also included under the soil sampling program is the sampling of sediments in the three primary ephemeral washes, various ponds and impoundments located throughout ASARCO operational areas and the Study Area as a whole, and other surface drainages for stormwater runoff.

A necessary part of the investigation is the establishment of background soil conditions. A representative upland area, assumed not to be impacted by the Hayden Complex operations, will be selected for the background soil investigation. This new background data will augment the currently existing soil background data in the Study Area, and will provide a baseline to which soil samples from impacted areas can be compared to ascertain the nature of COPC contamination at or from the Site.

6.3.2 Surface Water

Phase I RI results indicated that the surface water in the Gila and San Pedro Rivers showed seasonal variations for various COPCs and general geochemical compositions. COPC concentrations also varied spatially, especially in the Gila River. Surface water had much higher copper, iron, aluminum, and total suspended solids (TSS) in two locations of the Gila River between the Tailings Impoundments during the summer 2006 sampling event, when compared to both upstream and downstream locations.

In addition, the Screening Level Ecological Risk Assessment (SLERA) performed during the Phase I RI showed that multiple chemicals exceeded surface water screening values for aquatic organisms and soil screening values for plants and soil invertebrates. Based on the SLERA, possible risks within the aquatic portions of the Study Area are primarily related to exposures of aquatic plants, water-column invertebrates, fish, and amphibians to COPCs in surface water.

The additional surface water investigation in the Gila and San Pedro Rivers will focus mainly on the following aspects: (1) evaluation of the seasonal variations of COPCs in surface water, especially in the Gila River; (2) evaluation of the causes of the elevated concentrations of selected COPCs and TSS at the Gila River sampling locations between the Tailings Impoundments, as related to the potential impacts of the Tailings Impoundments on the surface water quality in the Gila River; and (3) investigation (along with groundwater investigation) of the interaction between groundwater and surface water in the rivers.

Four additional rounds of sampling and analysis of surface water in the Gila and San Pedro Rivers in the vicinity of the Hayden Complex will be conducted for the purposes specified in DQO #2, DQO #3, and DQO #4, and in the rationales presented above. Two additional rounds of surface water sampling will be conducted in March, to be representative of winter flow conditions; and two will be conducted in late August, to be representative of summer flow conditions. The sample parameters to be analyzed are those specified in Section 7.0 of this Work Plan. Additional surface water sampling needs will subsequently be determined if standards or criteria are exceeded (for example, if higher concentrations in summer sample events are detected immediately following local rain events).

6.3.3 Stormwater Runoff and Sediment

Stormwater runoff and sediment samples will be collected from the selected ephemeral washes near the Site and in the towns of Hayden and Winkelman for the purposes specified in DQO #2. The sample parameters to be analyzed are those specified in Section 7.0 of this Work Plan.

6.3.4 Process Water

Process water will be collected from the Tailings Impoundments, reclaim ponds, discharge points of the facilities, and seepage from the Tailings Impoundments to evaluate the nature of the contamination and the potential impact of the process water on groundwater in the alluvial aquifer and surface water in the Gila River.

6.3.5 Groundwater

The groundwater investigation will include installation of six new groundwater monitoring wells, and eight rounds of quarterly groundwater monitoring at the network of monitoring wells (including the new wells) and water supply wells used in the Phase I RI. All groundwater monitoring wells in the proposed monitoring network will be re-surveyed to a consistent horizontal and vertical datum. Additional groundwater samples will also be collected using direct push technology for characterization of Tailings Impoundments AB/BC and D and the reclaim ponds.

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7.0 RI TASKS

The section presents the tasks that will be performed during the Phase II RI/FS.

7.1 Procurement, Access, Permits, and Authorizations

Before conducting any work at the Site, ITSI will ensure that all preliminary activities have been completed, and that field and project management personnel have the appropriate access and authorizations. These activities may include:

- Procurement of subcontractors.
- Establishment of access agreements.
- Procurement of regulatory and local authority permits and authorizations.

These activities are discussed further in the subsections below.

7.1.1 Subcontractor Procurement

ITSI will require the assistance of subcontractors in order to implement the RI tasks described in this Work Plan. As soon as ITSI has received written authorization from EPA to conduct these tasks, ITSI will begin to procure the services of the following subcontractors:

- Drilling subcontractors (to collect subsurface soil samples and install monitoring wells).
- Arizona Registered Land Surveyor (to survey existing and new wells).
- Analytical laboratory(ies), including coordination with the U.S. EPA Region 9 Laboratory and Quality Assurance Office.

7.1.2 Access Agreements

As part of the planning stages for the field work, ITSI will work with the EPA RPM to identify, negotiate, and secure access to all public and private properties where samples will be collected or equipment will be installed. It is expected that the EPA Office of Regional Counsel for Region 9 will assist in obtaining property access agreements similar to those that were obtained as part of previous EPA investigations or oversight activities. It is understood that all access information provided will need to be verified.

7.1.3 Regulatory Permits and Authorizations

In accordance with Office of Solid Waste and Emergency Response (OSWER) Directive 9355.7-03, dated February 19, 1992, by law CERCLA response actions are exempted from obtaining federal, state, or local permits related to any activities conducted completely within the Site. However, compliance with CERCLA will require ITSI to meet the substantive provisions

of permitting regulations that are applicable or relevant and appropriate requirements (ARARs). An example is meeting the substantive requirements of local permitting for working in right of ways.

In addition, ITSI will secure any required authorizations and process any necessary notifications. For example, ITSI will obtain a Notice of Intent to Drill a groundwater monitoring well for any soil boring that may intercept the water table.

7.2 Field Investigations

Table 7-1 lists the proposed sample locations and the analytical parameters for soil, water, and sediment for the Phase II RI. All sampling and other field activities will be conducted in accordance with the following plans and procedures:

- Sampling and Analysis Plan (SAP) included as Appendix B, which is comprised of the Quality Assurance Project Plan (QAPP) and the Field Sampling Plan (FSP). The QAPP describes the data quality objectives (DQOs) for the RI, the QA goals, requirements for sampling and analysis activities, and the field and laboratory documentation requirements. The FSP provides the sampling locations and frequency, sampling procedures, and sample handling and analysis guidelines for use by field personnel. Site-specific Standard Operating Procedures (SOPs) are provided as an attachment to the FSP.
- Site-Specific Health and Safety Plan (SHSP) included as Appendix C, which identifies, evaluates, and prescribes control measures for site-specific health and safety hazards, and describes emergency response procedures for the proposed work within the Study Area.
- Quality Management Plan (QMP) included as Appendix D, which describes the policies and procedures to be applied to ensure that all environmental data developed or used by ITSI is scientifically valid, defensible, and of known and documented quality.
- Standard Operating Procedure for Sample Tracking and Electronic Data Management included as Appendix E, which describes the requirements and procedures for tracking environmental samples and data from the field to the laboratory, and ultimately to the electronic data management system.

7.2.1 Task 1: Soil Investigation

Key purposes of the Phase II soil investigation are to:

1. Characterize the chemical and physical nature of impacted soils in those portions of the 19 RI Areas designated as potential sources of contamination (see Section 4.3).

2. Characterize the nature and begin to define the extent of soil contamination in the Study Area in areas beyond the potential source areas that resulted from both historic and active operations at the ASARCO Hayden Complex.
3. Evaluate additional background concentrations of COPCs in soils within the Study Area. Background concentrations for only arsenic, copper, and lead were established in the Phase I RI.
4. Develop vertical profiles of soil contamination in areas (e.g., tailings piles) where waste material has been deposited over time and represents a potential source of contaminant release to groundwater.

7.2.1.1 Proposed Soil and Sediment Sample Locations

Before reading the discussions of proposed soil and sediment sampling presented below, the reader should be familiar with the RI Area summaries provided in Section 4.3. The RI Area summaries set the context for the identification of and justification for the proposed soil and sediment sample locations by RI Area. It is also recommended that the reader have both the summary figures (Figures 4-2A through 4-20) and the proposed soil and sediment sample figures (Figures 7-1A through 7-19) available for reference while reading the discussions presented below.

Sample Design

The sample designs for RI Areas 1-19 were established through an iterative process that began with a statistical approach utilizing Visual Sample Plan (VSP) software to identify optimum sample locations. VSP-generated points were subsequently modified by the application of professional judgment and ITSI's and EPA's knowledge of the Study Area. Professional judgment was augmented by previous Site investigations, including analytical results from 2000, 2002, 2004, and 2008; other related documents (such as ASARCO's 2004 Hayden Concentrator Stormwater Pollution Prevention Plan [SWPPP]); and recent and historical aerial photography. Additional details of the applied sample design are provided in Section 4.1 of the accompanying FSP.

X-Ray Fluorescence (XRF) Device

An XRF device is proposed for use during field activities in each RI Area to confirm whether proposed soil/sediment sample locations (as discussed below) sufficiently represent surface contaminant concentrations within the immediate vicinity of the currently designated locations. The device will also be used to identify preliminary surface contaminant trends in the event that hotspots are encountered during field activities. Both of these purposes are applicable to all RI Areas. In the event an XRF analysis is proposed for a purpose that is specific to an individual RI Area, the proposed use is described with respect to that Area. Operation of the XRF device is

described in detail within Section 5.2 of the accompanying FSP, and the project decision limits related to XRF use are addressed in the accompanying QAPP.

UCL Maps

EPA requested upper confidence limit (UCL) maps for arsenic, copper, and lead from CH2M HILL to support the sample design for the Phase II RI. These maps were recently provided to EPA and ITSI, and are included as Appendix F to this Work Plan. The maps were developed based on data obtained during the removal actions previously described (see Section 2.4), and indicate which parcels were previously remediated as a result of exceedances of Arizona R-SRLs for arsenic, copper, lead, or a combination of these metals. The information presented in the figures was used for the purpose of determining whether surface soils within certain RI Areas immediately adjacent to the previously remediated parcels may have been similarly impacted by COPCs.

Sample Type Designations

All samples being proposed for collection under the soil and sediment sampling program have been broadly classified into the following three categories:

1. *Soil Samples:* Soil samples include both surface samples and subsurface samples that generally consist of native soils. While a large percentage of soil samples will be made up solely of native soils, there may be cases where materials other than native soils are commingled in the sample. In general, unless the surface appears to be composed predominantly of non-native materials, the corresponding sample will be categorized as a soil sample.
2. *Sediment Samples:* Sediment samples include any sample from the three major washes within the Study Area or any sample from containment ponds or impoundments with free-standing water. Samples from the more significant diversion channels and drainages are also considered to be sediment samples, whereas samples from minor drainages and swales are classified as soil samples. Case-specific examples are evident in the following sections based on the sample number designator.
3. *Surface Sample:* The generic terminology of "surface sample" will be used in those cases where neither soil nor sediment is an applicable descriptive term. Examples would include samples of tailings, slag, stored materials, and other materials that appear as discolored surface soil in aerial photographs.

This terminology is in contrast to the Phase I RI, where all samples were designated as sediment samples (using 'SED' as the sample number designator for all samples).

Background Soil Samples

For the Phase I RI, CH2M HILL (2008a) established soil background concentrations for arsenic, copper, and lead. Background determinations are addressed in CH2M HILL's November 30, 2007, technical memorandum, *Evaluation of Background Metal Concentrations in Soil for the ASARCO LLC Hayden Plant Site,* and conformed to EPA's 2002 guidance document, *Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites*.

For the Phase II investigation, establishment of background concentrations for additional metals beyond arsenic, copper, and lead is proposed. Previous analytical results from the CH2M HILL background study included the concentrations of additional metals for some samples. As a result, some of this previous data will be used to determine background concentrations for the additional metals. To augment this data, the collection of 12 additional background soil samples is proposed for Area #19 (Area Outside of Areas 1-18), and is addressed below in the section corresponding to Area #19.

Area #1A, Tailings Impoundment D

The rationale for each group of surface/soil and sediment samples proposed for Area #1A, Tailings Impoundment D, is addressed below. Figure 4-2A displays the boundaries for Area #1A and identifies the features within and adjacent to the Area, and Figure 7-1A displays the locations and corresponding identification numbers (TID##) for the proposed samples.

CH2M HILL (2008) collected four surface samples from the top of the west, north, and east berms of Tailings Impoundment D as part of the Phase I RI (TPD-01-SED-0 through TPD-04-SED-0). Minor exceedances of the Arizona R-SRL of 10 mg/kg were exhibited for arsenic (at 11.6J- mg/kg, 10J- mg/kg, 10.1J- mg/kg, and 18.1J- mg/kg), and two exceedances of the R-SRL of 3,100 mg/kg were exhibited for copper (at 3,920J- mg/kg and 6,000J- mg/kg). No exceedances were identified for lead, and no other metals were analyzed for these samples. These data collectively indicate that Tailings Impoundment D has been impacted primarily by copper, and that further investigation is warranted.

Surface Samples TID01 through TID12 –Twelve surface samples are proposed for Tailings Impoundment D. Samples TID08 through TID12 are intended to characterize different elevations of the northern berm, and are spaced evenly to facilitate an understanding of how contaminant concentrations may vary along the surfaces of the berm. Samples TID01, TID02, and TID05 are intended for the first lift of tailings above the starter dike. Analytical results will be used to determine typical contaminant impacts derived from the side slopes of Tailings Impoundment D. Samples TID03, TID04, TID06, and TID07 are located within disturbed areas and smaller containments located at the base of the northern berm, and are intended to gage potential surface impacts associated with historical berm failures.

Sediment Samples TID13 through TID17 – Five sediment samples are proposed within Tailings Impoundment D. Exact locations of samples will be field established based on accessibility and the avoidance of standing water. Analytical results will be used to determine contaminant concentrations within recently deposited tailings material on a given day, and provide insight into potential impacts to groundwater from this location.

Area #1B, Tailings Impoundment AB/BC

The rationale for each group of surface/soil and sediment samples proposed for Area #1B, Tailings Impoundment AB/BC, is addressed below. Figure 4-2B displays the boundaries for Area #1B and identifies the features within and adjacent to the Area, and Figure 7-1B displays the corresponding locations and identification numbers (TIA##) for the proposed samples.

Railroad

Soil Samples TIA01 through TIA18 – Eighteen surface soil samples are proposed adjacent to the Southern Pacific Railroad and the Copper Basin Railway within Area #1B to evaluate impacts to soils resulting from historical and current ore transportation and related spills.

Tailings Impoundment AB/BC

CH2M HILL (2008a) collected eight surface samples from the top perimeter of the Tailings Impoundment AB/BC berm as part of the Phase I RI (TPA-01-SED-0 through TPA-08-SED-0). The maximum exceedance of the Arizona R-SRL of 10 mg/kg for arsenic was in sample TPA-03-SED-0 (21.8J- mg/kg). Sample TPA-06-SED-0 exhibited the only exceedance of the R-SRL of 3,100 mg/kg for copper (3,730J- mg/kg); while there were no exceedances identified for lead (400 mg/kg). Sample TPA-07-SED-0 was the only sample analyzed for additional metals, and exhibited an exceedance of the Region 9 PRG of 23,000 mg/kg for iron (36,100 mg/kg), and a minor exceedance of the R-SRL of 78 mg/kg for vanadium (79.4 mg/kg).

CH2M HILL (2008) also collected 33 surface samples from the Hayden Golf Course located immediately southeast of Tailings Impoundment AB/BC. Within these 33 samples, concentrations for arsenic and copper generally increased with proximity to the tailings impoundment. Exceedances of the Arizona R-SRLs for arsenic and copper were limited primarily to those samples located closest to the tailings impoundment. There were no exceedances identified for lead. Four of the 33 samples were analyzed for nine metals, and the two samples located closest to the tailings impoundment exhibited exceedances of the Region 9 PRG for iron (26,900 mg/kg and 49,600 mg/kg), and one of the two located closest to the tailings impoundment exhibited an exceedance of the R-SRL for vanadium (105J mg/kg).

This data indicates that portions of Tailings Impoundment AB/BC and adjacent areas to the southeast have been impacted by arsenic, copper, iron, and vanadium, and that further investigation is warranted.

Surface Samples TIA19 through TIA74 – A total of 56 surface samples are proposed for Tailings Impoundment AB/BC. Sample locations account for areas not sampled during previous investigations and are distributed on top of the tailings impoundment berm, on side slopes, within adjacent ponds, and within adjacent operation areas (for example, near Hayden Junction). In addition, surface samples are clustered in three side-slope locations (samples TIA20 through TIA33) to facilitate an understanding of how contaminant concentrations vary within side slopes from top to bottom. Analytical results for all the proposed samples will be used to determine typical contaminant concentrations associated with Tailings Impoundment AB/BC.

Sediment Samples TID75 through TID96 – A total of 22 sediment samples are proposed within Tailings Impoundment AB/BC, within the drainage channel located at the east side, or within the emergency, pump-back, and overflow ponds located at the southern tip of the impoundment; Last Chance Basin, located at the northwestern end of the impoundment; and the reclaim ponds located at the eastern tip of the impoundment. Exact locations of samples will vary based on access and the avoidance of standing water. Analytical results will be used to determine contaminant concentrations within recently deposited tailings material, and will provide insight into potential impacts to groundwater from this location.

Area #2, San Pedro Wash

The rationale for each group of soil and sediment samples proposed for Area #2, San Pedro Wash, is addressed below. Figure 4-3 displays the boundary for Area #2 and identifies the features within and adjacent to the Area, and Figure 7-2 displays the corresponding locations and location identification numbers (SPW##) for the proposed samples.

Railroad

CH2M HILL (2008) collected two surface soil samples near the northern extent of the tracks located within Area #2. The samples were collected from a former pond/spill feature. One of the samples (SPW-SED-16AS) was analyzed for arsenic, copper, lead, antimony, cadmium, iron, molybdenum, thallium, and vanadium, while the second sample (SPW-SED-17AS) was analyzed only for arsenic, copper, and lead. Sample SPW-SED-16AS exhibited exceedances of the Arizona R-SRLs of 10 mg/kg for arsenic (28 mg/kg) and 3,100 mg/kg for copper (5,160 mg/kg), as well as a significant exceedance of the Region 9 PRG of 23,000 mg/kg for iron (320,000 mg/kg). Sample SPW-SED-17AS exceeded the R-SRL only for copper (7,250 mg/kg). These data indicate that areas along the railroad tracks have been impacted by arsenic, copper, and iron, and that further investigation is warranted.

Soil Samples SPW01 through SPW07 – Seven surface soil samples are proposed adjacent to the Copper Basin Railway within Area #2 to provide additional delineation of the impact to surface soils resulting from historical and/or current ore transportation and related spills and/or resulting from surface runoff that is diverted along the tracks. Samples SPW05 through SPW07 are intended to support further characterization of the pond/spill area described above.

In addition, intermediate portions of the corridor between the proposed sample locations will be assessed with an XRF device. The first reading will be taken approximately 200 feet from the railroad tracks, and additional surface soil readings will be taken at intervals of approximately 25 feet along a transect perpendicular to and advancing toward the tracks, to facilitate identification of potential contaminant trends as proximity to the railroad tracks increases. The number of transects will vary based on field observations, but a minimum of two transects are proposed for the intermediate areas on each side of the tracks within Area #2 (four total transects).

Undeveloped Surfaces West of San Pedro Wash

One previous surface soil sample was collected by CH2M HILL (2008a) from undeveloped surfaces located west of the San Pedro Wash. Sample UPA-08-SED-0 was located northwest of the Copper Basin Railway tracks near the southern portion of Area #2, and was analyzed for arsenic, copper, and lead. Analytical results indicated exceedances of the Arizona R-SRLs for arsenic (27.2J- mg/kg) and copper (6,310J- mg/kg), while there were no exceedances identified for lead. These data indicate that a portion of the western surfaces has been impacted by arsenic and copper, and that further investigation is warranted.

Soil Samples SPW08 through SPW15 – Eight surface soil samples are proposed in the portions of Area #2 west of the San Pedro Wash corridor. All eight samples will be collected from the western portion of Area #2 to determine whether surface soils have been impacted by contaminants, and are intended to determine the potential impact to surface soils by wind-blown contaminants originating from ASARCO operation areas and/or from fugitive emissions from railcars during ore transport.

Sediment Sample SPW41 – This sample is intended to assess the potential impact to sediment in a tributary drainage to the west of San Pedro Wash resulting from surface water runoff originating on the south side of the Copper Basin Railway alignment. Sample SPW41 also will serve as a comparison with San Pedro Wash sediment results, as it is located outside the impact zone created by surface flows originating from Area #3.

San Pedro Wash – Lower Reach

CH2M HILL (2008) collected nine sediment samples from the San Pedro Wash as part of the Phase I RI. All nine samples were analyzed for arsenic, copper, lead, antimony, cadmium, iron,

molybdenum, thallium, and vanadium. Exceedances of the Arizona R-SRLs for arsenic and copper were reported for all nine samples, with maximum reported concentrations of 29.7J mg/kg and 12,500 mg/kg, respectively. In addition, seven of the nine samples exceeded the Region 9 PRG for iron (maximum of 36,200 mg/kg), while there were no exceedances reported for the other metals. These data indicate that sediments of the San Pedro Wash have been impacted by arsenic, copper, and iron, and that further investigation is warranted.

Sediment Samples SPW32 through SPW40 – Nine sediment samples are proposed in the San Pedro Wash. Sample locations are spatially balanced with CH2M HILL historical sample locations for the purpose of developing a better understanding of contaminant concentrations along the San Pedro Wash. The data will be used to assess the impacts associated with eroded slag and contaminant transport originating from Area #3, as well as the side slopes just west of the previously remediated parcels that form the eastern boundary of Area #2. All nine of the proposed sample locations are intended for the San Pedro Wash thalweg, or lowest elevation point within the wash corridor. SPW40 is specifically intended to characterize sediment as the wash enters Area #2 from Area #3.

Soil Samples SPW16 through SPW31 – Sixteen surface soil samples are proposed along the eastern side slopes of the San Pedro Wash corridor, just west of the previously remediated parcels. Sample results will provide data for the assessment of potential side-slope contributions of contaminants to the San Pedro Wash corridor during storm events.

Area #3, Northern Waste Disposal

The rationale for each group of soil and sediment samples proposed for Area #3, Northern Waste Disposal, is addressed below. Figure 4-4 displays the boundary for Area #3 and identifies the features within and adjacent to the Area, and Figure 7-3 displays the corresponding locations and identification numbers (NWD##) for the proposed samples. Both figures serve as references for the text descriptions provided below.

Railroad

Two surface soil samples (KS-03-SED-0 and KS-04-SED-0) were collected by CH2M HILL (2008) in the vicinity of the two railroad spurs located in the southwestern corner of Area #3. These samples exhibited arsenic concentrations of 140J mg/kg and 99.4J- mg/kg, respectively, and copper concentrations of 56,700 mg/kg and 68,200 mg/kg, respectively, well above the corresponding Arizona R-SRLs for arsenic and copper (10 mg/kg and 3,100 mg/kg, respectively). These elevated levels of soil contaminants indicate that surface soils in the vicinity of the railroad tracks have been impacted by historical and/or current operations, and that further investigation is warranted.

Soil Samples NWD01 through NWD08 – Based on this information, eight surface soil samples are proposed adjacent to the Copper Basin Railway within Area #3 to support further delineating the impact to surface soils resulting from historical and current ore transportation and/or resulting from surface runoff that is diverted along the tracks.

San Pedro Wash – Upper Reach

Sediment Samples NWD70 through NWD78 – Nine sediment samples are proposed along the upper reach of San Pedro Wash to determine the extent to which sediments have been impacted by slag or other material. Sample results will be used to provide an indication of the potential downstream impacts to the lower reach of the San Pedro Wash (in Area #2, San Pedro Wash). Proposed samples NWD77 and NWD78 may serve as local background samples, as they are located upstream of the eroding segment of the slag pile. Sample NWD70 is intended to characterize sediment immediately prior to the point of flow conveyance into Area #2. All nine of the proposed samples are intended to be collected in the San Pedro Wash thalweg, or lowest elevation point within the wash corridor.

Kennecott Last Chance Pond

Two surface soil samples (KS-01-SED-0 and KS-02-SED-0) were collected by CH2M HILL (2008) within and just west of the K-Pond, respectively. Elevated levels of arsenic (224J+ mg/kg and 345J mg/kg, respectively), copper (56,200 mg/kg and 18,400 mg/kg, respectively), and lead (547J mg/kg for sample KS-02-SED-0) were identified. Thus, surface soils within and in the vicinity of the K-Pond have been impacted by contaminants associated with historical and/or active operations in Area #3, and further investigation is warranted.

Surface Samples NWD09 through NWD16 – Eight surface samples are proposed within the K-Pond and in its vicinity for the purpose of more completely defining the extent of previously identified soil contamination. In addition, the two sample locations within the K-Pond (NWD13 and NWD14) are proposed to be sampled at approximate six-inch depth intervals to a total depth of five feet (10 deeper samples from each location) for the purpose of defining the vertical extent of contaminants and providing further data that may indicate potential impacts to groundwater from this location.

Kennecott Slag Pile

Surface Samples NWD17 through NWD24 – Eight surface samples are proposed to address the slag pile removal and reuse operation in the southern portion of the Kennecott slag pile. Six of the proposed samples (NWD19 through NWD24) will serve to characterize contaminants in the area of active disturbance, and two (NWD17 and NWD18) will serve to characterize the slag aggregate stockpile located immediately southeast of the disturbed area. In addition, toxicity characteristic leaching procedure (TCLP) and synthetic precipitation leaching procedure (SPLP)

tests are proposed for the slag material located in the active area of disturbance. The leachability tests will assist in determining whether leaching to groundwater is a plausible contaminant transport mechanism in this portion of Area #3, and will support the evaluation of potential contaminant contributions to groundwater. The tests also will indicate if the ballast is a potential source of contaminants.

Surface Samples NWD25 through NWD29 – As previously described for Area #2, the upper reach of the San Pedro Wash forms eroded cut banks along the west side of the Kennecott slag pile, and surface flows along San Pedro Wash thus may entrain slag pile constituents. Therefore, five surface samples of slag are proposed along the western side of the slag pile for the combined purpose of characterizing the slag pile and achieving a basic understanding of the levels of contaminants that may be influencing surface water and sediment associated with the San Pedro Wash.

Historical Crusher and Loadout

CH2M HILL (2008) conducted surface soil sampling at two locations within the historical crusher and loadout area (samples KS-08-SED-0 and KS-09-SED-0), and samples were analyzed for nine metals. Both samples exhibited exceedances of the Arizona R-SRLs for arsenic (114J mg/kg and 91.6J mg/kg, respectively), copper (92,800 mg/kg and 132,999 mg/kg, respectively), lead (539J mg/kg and 552J mg/kg, respectively), and the R-SRL of 390 mg/kg for molybdenum (1,490J mg/kg and 2,060J mg/kg, respectively). Both samples exceeded the Region 9 PRG for iron (146,000J mg/kg and 141,999J mg/kg, respectively). Sample KS-09-SED-0 also exceeded the R-SRL of 5.2 mg/kg for thallium (5.9 mg/kg). There were no other exceedances identified for either sample. Thus, surface soils within this area have been impacted by historical and/or current operations and further investigation is warranted.

Soil Samples NWD30 through NWD32 – Three additional surface soil samples are proposed to define the extent of contamination in this area more clearly.

Parts Storage

Soil Samples NWD33 and NWD34 – Two surface soil samples are proposed within the parts storage area, at locations that specifically target discolored soil, to characterize a portion of the soils within the parts storage area and to provide additional data for the study of potential contaminant transport across Areas #3 and #4.

Landfills

Asbestos Landfill

Groundwater Well H-7 is located immediately south and down gradient of the asbestos landfill. CH2M HILL (2008) reported that in August 2006, Well H-7 exhibited the highest concentrations

of arsenic (231 micrograms per liter [ug/L]) and vanadium (598 ug/L) reported in any well sampled during the Phase I RI. These concentrations indicate either an impact from an upgradient source (potentially the landfill), an impact due to leaching of contaminants from overlying soils, or a combination of both.

Soil Samples NWD35 through NWD38 – As part of the soil investigation in this area, four surface soil samples are proposed in the vicinity of groundwater Well H-7. Three soil samples (NWD35 through NWD37) are positioned to characterize disturbed soils surrounding Well H-7, and one soil sample (NWD38) is designed to characterize undisturbed soil to the east. No soil samples are proposed for the asbestos landfill itself, given that it is capped.

Sediment Samples NWD79 and NWD80 – The asbestos landfill is located within a defined drainage corridor that proceeds from the north, such that surface flow originates in the vicinity of the landfill and proceeds south along the drainage corridor that also serves as a landfill access road. Two sediment samples are proposed to characterize the sediment being transported from this location during flow events and to provide additional insight into the high arsenic values observed in groundwater Well H-7.

Municipal Landfill and Inert Material Landfill
Soil Samples NWD39 through NWD45 – As no specific documentation has been provided for either of these landfills, it is unknown whether they contain hazardous materials, whether they are lined, or how (or whether) they have been regulated in the past. Because of this data gap, seven surface soil samples are proposed within the boundaries of the two landfills to characterize the landfills more clearly and to determine whether they are potential sources of contaminants.

Sumps
Sediment Samples NWD81 through NWD83 – Sediment samples NWD81 through NWD83 are intended to sample sediment in the three sumps described in the Area summary. However, it is not clear exactly where these sumps are located, so reconnaissance will need to be conducted prior to the sampling effort. The proposed sediment samples from the bottom of the sumps are intended to:

- Characterize the materials being drained from significant portions of the landfill area and assist in determining whether the landfills are a source of contaminants.
- Provide an indication of contaminant concentrations that ultimately influence the character of sediment in downstream locations in the event the sumps that lack pump-back systems overflow.

Lime Plant Discharge

Sediment Samples NWD84 and NWD85 – Two sediment samples are proposed within the unlined channel that originates near the Lime Plant in Area #4 to determine contaminant concentrations resulting from discharges at the Lime Plant.

Historical Sponge Plant

Soil Samples NWD63 through NWD69 – Seven surface soil samples are proposed within the footprint of the former sponge plant and adjacent areas to characterize contaminant concentrations resulting from past operations.

Surface Disturbances

Soil Samples NWD46 and NWD47 – Two surface soil samples are proposed within the disturbed areas located at the north end of Area #3 to characterize contaminant concentrations resulting from current operations.

Soil Samples NWD43 through NWD53 – Six surface soil samples are proposed in the vicinity of the disturbed areas north and east of the slag pile to characterize surface soils in this area as a potential source of contaminants within Area #3.

Soil Samples NWD54 through NWD62– Nine soil samples are proposed within the eastern portion of Area #3 to characterize surface soils in this area as potential sources of both contamination within Area #3 and potential downstream impacts to Area #10, Powerhouse Wash (located south of the southeastern corner of Area #3). Most of the samples will target discolored soil locations, with the remainder of the samples spatially balanced with other sample locations to facilitate a comprehensive assessment of the surface soils across the area.

Sediment Sample NWD86 – As the upper reach of Powerhouse Wash receives surface flow from the eastern portion of Area #3, one sediment sample is proposed immediately upstream of the drainage structures that pass surface flow from Area #3 into Area #10, Powerhouse Wash. The purpose of this sample is to characterize the sediment mobilized from this area and to provide an indication of the potential for contaminant transport to Area #10.

Area #4, Lime and Filter Plants

The rationale for each group of soil and sediment samples proposed for Area #4, Lime and Filter Plants, is addressed below. Figure 4-5 displays the boundary for Area #4 and identifies the features within and adjacent to the Area, and Figure 7-4 displays the corresponding locations and identification numbers (LFP##) for the proposed samples.

Railroad

One surface soil sample (KS-06-SED-0) was collected by CH2M HILL (2008) in the vicinity of the railroad spurs located in the southwestern corner of Area #4. This sample did not exceed the Arizona R-SRLs for arsenic or lead (10 mg/kg and 400 mg/kg, respectively), but exhibited one of the highest copper concentrations of all surface samples collected during the Phase I RI (192,000 mg/kg, over 60 times the R-SRL of 3,100 mg/kg). An exceedance of the a R-SRL of 390 mg/kg for molybdenum was also reported for this sample (2,280J mg/kg), as was an exceedance of the Region 9 PRG of 23,000 mg/kg for iron (182,000J mg/kg). These elevated levels of soil contaminants indicate that surface soils in the vicinity of the railroad tracks have been impacted by historical and/or current operations, and that further investigation is warranted.

Soil Samples LFP01 through LFP10 – Based on this information, ten surface soil samples are proposed adjacent to the Copper Basin Railway within Area #4 for the purpose of further delineating the impact to surface soils resulting from historical and/or current ore transportation and concentrate handling. Soil samples LFP01 and LFP02 are intended to characterize the area adjacent to the CH2M HILL sample described above. Soil samples LFP06 through LFP10 are intended to characterize the area where concentrate is loaded into railcars, and soil samples LFP03 through LFP05 are positioned at other locations along the main railroad spurs in Area #4.

Filter Plant and Concentrate Stockpiles

Five surface soil samples were collected by CH2M HILL (2008) south and down gradient of the filter plant and related material handling areas. Although the Arizona R-SRL for arsenic was exceeded in only four of the five samples (with two of the four concentrations being minor exceedances), the R-SRL for copper was exceeded in all four samples (maximum of 192,000 mg/kg). This collectively indicates that copper impacts to surface soils in this area may have been (or are currently) derived from activities at the filter plant or concentrate handling areas; that the filter plant and related material handling areas are a potential source of contaminants within Area #4; and that further investigation is warranted.

Soil Samples LFP11 through LFP23 – Based on this information, thirteen surface soil samples are proposed within the materials handling area located west-southwest of and adjacent to the filter plant in Area #4. All thirteen samples are intended to characterize surface soils and to assess the extent to which soils are being impacted by metals, with specific focus on copper. These samples also will provide data that will be used to assess whether the filter plant and related activities are a source of contaminants within Area #4.

Lime Plant

Two surface soil samples were collected by CH2M HILL (2008) in the vicinity of the lime plant (KS-05-SED-0 and KS-07-SED-0). Both samples exhibited minor exceedances of the Arizona

R-SRL for arsenic (13.4J- mg/kg and 12.4J- mg/kg, respectively) and both exceeded the R-SRL for copper (7,710J- mg/kg and 7,400J- mg/kg, respectively). There were no exceedances of lead in either sample, and no other metals were analyzed for the two samples.

Soil Samples LFP24 through LFP29 – Based on this information, six surface soil samples are proposed in the vicinity of the lime plant. All six proposed locations are spatially balanced with the two CH2M HILL (2008) sample locations for the purpose of developing a better understanding of contaminant concentrations in the vicinity of the lime plant.

Sediment Samples LFP47 and LFP48 – As discussed in the rationale for Area #3 (NWD), operations at the lime plant result in the discharge of flow through an unlined channel into the southwestern portion of Area #3. Two sediment samples are proposed within the unlined channel in Area #4 to determine contaminant concentrations resulting from discharges at the lime plant.

Former Smelter Area / Support and Storage

To date, surface soils in the eastern portion of Area #4 have not been characterized. Given that the area encompasses a formerly active smelter, currently is used for other industrial purposes, and has multiple discolored soil locations, the absence of soil samples in this area is considered to be a significant data gap.

Soil Samples LFP30 through LFP46 – Based on the lack of historical data, seventeen surface soil samples are proposed in the eastern half of Area #4 to characterize surface soils in this area as potential sources of contamination. Most of the samples target discolored soil locations, with the remainder of the samples evenly distributed to facilitate a more comprehensive assessment of the surface soils across the area.

Area #5, Kennecott Avenue Wash and Tailings

The rationale for each group of soil and sediment samples proposed for Area #5, Kennecott Avenue Wash and Tailings, is addressed below. Figure 4-6 displays the boundary for Area #5 and identifies the features within and adjacent to the Area, and Figure 7-5 displays the corresponding locations and identification numbers (KWT##) for the proposed samples.

Tailings

The Town of Hayden requested that Four Corners Environmental, Inc. (Four Corners) conduct a Phase I Environmental Site Assessment (ESA) for an approximate 1.75-acre portion of the tailings area for the possible construction of a new waste-water treatment plant (WWTP). After reviewing the CH2M HILL draft Phase I RI (2008), Four Corners observed that historical analytical results near the proposed property showed Arizona R-SRL exceedances for arsenic

and copper (addressed in detail below). In addition, they observed that groundwater Well GW-01R, located within the proposed WWTP footprint and within the central portion of the tailings footprint, historically has exhibited aluminum and manganese concentrations exceeding EPA Maximum Concentration Limits (Four Corners, 2009a).

As a result, a Phase II ESA (also conducted by Four Corners, 2009b) was scoped to include three deep borings (B-1 through B-3) into the tailings material and four surface samples (B-4 through B-7; 0-6 inches depth). Boring and surface sample locations were chosen to be consistent with the locations of the proposed WWTP facilities. With reference to Figure 4-6, borings B-1 and B-2 were located within the east-central portion of the tailings footprint, boring B-3 was located within the central portion of the footprint, and the surface samples were located within the central and east-central portions of the footprint.

Twenty-two samples of the tailings material were collected between the ground surface and 40.5 feet below ground surface (bgs) and analyzed for arsenic, copper, lead, aluminum, and manganese. The Arizona R-SRL of 3,100 mg/kg for copper was exceeded in one surface sample and four deeper samples across all three borings. No exceedances of the R-SRLs for arsenic, lead, aluminum, or manganese were reported in any of the 22 samples. Boring logs collectively indicate that tailings material was observed from ground surface to approximately 37 feet bgs before native soil was encountered. Four Corners concluded that portions of the subject property and the subsurface have been impacted by copper.

Ten surface samples of the tailings material also were collected by CH2M HILL (2008) in the northern, central, and southern portions of the tailings footprint. Three of the ten samples exceeded the R-SRL of 10 mg/kg for arsenic (maximum of 22J- mg/kg) and four exceeded the R-SRL value for copper (maximum of 13,500J- mg/kg), while there were no exceedances for lead. One of the ten samples also was analyzed for antimony, cadmium, iron, molybdenum, vanadium, and thallium, but did not exhibit any exceedances.

Surface Samples KWT01 through KWT29 - Based on the historical investigations discussed above, 29 additional surface samples are proposed within the tailings footprint in order to:

- Characterize the surface contaminants associated with tailings material more fully; and
- Determine the potential for the tailings area to be a source of contaminant release either to surface waters through stormwater runoff or to groundwater as a result of leaching and vertical migration through the tailings piles.

Kennecott Avenue Wash and Tributary

Two soil samples were collected from the tributary as part of the EPA removal assessment (2004). One sample was collected from the north end of the tributary, and a second sample was collected near the confluence of the tributary with the Kennecott Avenue Wash. Analytical results indicated exceedances of the Arizona R-SRLs for arsenic (36.8 mg/kg and 29 mg/kg, respectively) and copper (9,380 mg/kg and 5,670 mg/kg, respectively), while there were no exceedances identified for lead. Two soil samples also were collected from the Kennecott Avenue Wash as part of the Removal Assessment (2004). Both samples were located within the northern extent of the Kennecott Avenue Wash in Area #5. Analytical results indicated exceedances of the R-SRLs for arsenic (16.4 mg/kg and 30.1 mg/kg, respectively) and copper (3,110 mg/kg and 8,740 mg/kg, respectively), while there were no exceedances identified for lead.

These results collectively indicate that the tributary which originates from Area #7, Concentrate Production, is a potential source of contaminant releases to the Kennecott Avenue Wash. The wash also would be the receptor of any impacted surface water runoff from the tailings through which it travels.

Sediment Samples KWT70 through KWT76 – Seven sediment samples are proposed within the Kennecott Avenue Wash and the northeast tributary. Three samples (KWT70 through KWT72) will serve to characterize the sediments in the reaches of Kennecott Avenue Wash located adjacent to or downgradient of tailings surfaces. Three samples (KWT73 through KWT75) will serve to characterize sediment derived from the northeast tributary. These six samples will be collected from the thalweg, or lowest elevation point within the wash corridor. Sample KWT76 is located within a pond feature downgradient of the tailings footprint.

Kennecott Avenue Wash Corridor - Perimeter Soils

Soil Samples KWT30 through KWT44 – Fifteen surface soil samples are proposed along the eastern and western side slopes of the Kennecott Avenue Wash corridor, adjacent to previously remediated parcels. Sample results will provide data for assessing whether impacted soils in these accessible areas represent either a direct exposure risk or a potential source of contaminant release to Kennecott Avenue Wash as a result of surface water runoff during storm events.

Flume

Soil Samples KWT45 through KWT50 – Six surface soil samples are proposed adjacent to and down-slope of the flume in the southeastern corner of Area #5 to determine if soils have been impacted by contaminants as a result of historical releases from the flume.

Remaining Areas

Soil Samples KWT51 through KWT69 – This group of 19 surface soil samples is intended to characterize surface soils within the remaining portions of Area #5.

Area #6, Administration and Concentrator Support

The rationale for each group of soil samples proposed for Area #6, Administration and Concentrator Support, is addressed below. No sediment samples are proposed for Area #6. Figure 4-7 displays the boundary for Area #6 and identifies the features within and adjacent to the Area, and Figure 7-6 displays the corresponding locations and identification numbers (ACS##) for the proposed samples.

Railroad

One historical surface soil sample (KS-12-SED-0) was collected by CH2M HILL (2008) in the vicinity of the railroad spurs located in the northwestern corner of Area #6. This sample exhibited arsenic concentrations of 54.2 mg/kg, and copper concentrations of 31,400 mg/kg, each of which exceeds the respective Arizona R-SRLs of 10 mg/kg and 3,100 mg/kg. The sample did not exceed the R-SRL for lead (400 mg/kg). The sample was not analyzed for other metals. These elevated levels of soil contaminants indicate that surface soils in the vicinity of the adjacent railroad spur have been impacted by past and/or current operations, and that further investigation is warranted.

Soil Samples ACS01 through ACS11 – Based on the documented exceedances of R-SRLs at one location and the overall lack of historical data for the railroad spurs, eleven surface soil samples are proposed within/adjacent to the Copper Basin Railway spurs within Area #6. These samples will support the delineation of impacts to surface soils resulting from past and current ore transportation, and possibly from surface runoff that is diverted along the tracks.

Storage Yards

Three historical surface soil samples (KS-13-SED-0, KS-14-SED-0, and KS-15-SED-0) were collected by CH2M HILL (2008) within the northwestern storage yard. Samples exhibited arsenic concentrations of 38.5 mg/kg, 90.7 mg/kg, and 70.2 mg/kg, respectively; copper concentrations of 9,420 mg/kg, 48,600 mg/kg, and 19,800 mg/kg, respectively; and a lead concentration of 450 mg/kg in one sample (KS-14-SED-0). No other metals were analyzed. These levels of soil contaminants exceed the respective R-SRLs, indicating that surface soils within this area have been impacted by historical and/or current operations. Further investigation, therefore, is warranted.

To date, surface soils within the primary storage yard have not been investigated. As observed in recent aerial photography, large portions of the storage yard have discolored soil at the surface.

ASARCO's Hayden Concentrator SWPPP indicates that some of the surface flows within this portion of Area #6 enter drainage grates located in front of the warehouse and behind the service garage. Flow is then conveyed to the settling ponds within Area #7, Concentrate Production, located northwest of the carpenter shop for subsequent recycling back into the process stream.

Soil Samples ACS12 through ACS18 – Based on the R-SRL exceedances in the northwestern portion of Area #6, seven surface soil samples are proposed within the former scrap metal storage area to support further delineation of the impact to soils resulting from past or current uses of this area.

Soil Samples ACS19 through ACS34 – Based on the information above, 16 surface soil samples are proposed within the primary storage yard for the purpose of delineating impacts to soils resulting from material storage and handling practices.

Slag Area

Surface Samples ACS35 through ACS37 – The lack of information as to the levels of contaminants associated with the slag pile in the northeastern corner of Area #6 is considered to be a data gap. Three surface samples are proposed in the vicinity of the slag pile. Two samples (ACS35 and ACS37) will serve to characterize surface soils adjacent to the slag pile, and one sample (ACS36) is intended to characterize the slag material.

Remaining Portions of Area #6

Soil Samples ACS38 through ACS50 – This group of 13 soil samples is intended to characterize surface soils within the remaining portions of Area #6, with the exception of the administration building and its immediate vicinity. To date, historical investigations have not accounted for surface soils in these areas. Thirteen surface soil samples are proposed, primarily within the southern portion of Area #6, with the majority targeting exposed soils around the Power House and the shops to the northwest.

Area #7, Concentrate Production

The rationale for each group of soil sediment samples proposed for Area #7, Concentrate Production, is addressed below. Figure 4-8 displays the boundary for Area #7 and identifies the features within and adjacent to the Area, and Figure 7-7 displays the corresponding locations and identification numbers (CNP##) for the proposed samples.

CH2M HILL (2008) conducted surface soil sampling within the western and southern portions of Area #7 as part of the Phase I RI. Nine samples were collected from the southern portion of Area #7, immediately south of the concentrator building. Six of the nine samples exhibited arsenic concentrations exceeding the Arizona R-SRL of 10 mg/kg, with a maximum arsenic

concentration of 81.6J- mg/kg. Copper levels exceeded the R-SRL of 3,100 mg/kg in all of the samples, with a maximum concentration of 69,300 mg/kg. Iron concentrations exceeded the Region 9 PRG of 23,000 mg/kg in half of the samples, to a maximum of 68,000 mg/kg. One sample obtained from the southern portion of Area #7 exhibited exceedances of the R-SRLs of 390 mg/kg for molybdenum and 78 mg/kg for vanadium (results of 1,240 mg/kg and 93.3 mg/kg, respectively). No exceedances of the R-SRL for lead were identified. Surface soils within the southern portion of Area #7 are considered to be sufficiently characterized to meet the needs of the RI/FS, and therefore no additional sampling is proposed.

Three surface soil samples (PCON-01-SED-0, PCON-02-SED-0, and PCON-28-SED-0) were also collected by CH2M HILL (2008) from the northwestern quadrant of Area #7, within the vicinity and down gradient of the thickener tanks and the LPF section building. All three samples exceeded the Arizona R-SRL for arsenic (30.1 mg/kg, 24.6 mg/kg, and 17.9J- mg/kg, respectively), and copper concentrations exceeded the R-SRL in samples PCON-01-SED-0 and PCON-02-SED-0 (7,170 mg/kg and 41,100 mg/kg, respectively). No exceedances were reported for lead, and no other metals were analyzed for these samples.

CH2M HILL (2008) also collected four surface soil samples (HPUB-02-SED-0, PCON-03-SED-0, PCON-04-SED-0, and PCON-27-SED-0) north and east of the Town of Hayden swimming pool, in the area immediately west of the concentrator building. All four samples exceeded the Arizona R-SRLs for arsenic (50J- mg/kg, 65.4 mg/kg, 43.5 mg/kg, and 32.6J- mg/kg, respectively) and copper (19,000J- mg/kg, 19,100 mg/kg, 20,700 mg/kg, and 26,100J- mg/kg, respectively). These samples are located immediately adjacent to the western boundary of Area #7, but are not included in Area #7.

These results collectively indicate that surface soils within the northwestern portion of Area #7 and south and west of the concentrator building have been impacted by arsenic and copper, and that further investigation is warranted.

Soil Samples CNP01 through CNP14 – Based on the information above, 14 surface soil samples are proposed within the northern half of Area #7 to support further delineation of the impact to surface soils resulting from historical and/or current operations in this area. CNP08 is intended to be an additional data point located between samples PCON-01-SED-0 and PCON-02-SED-0 that reported exceedances of the Arizona R-SRLs for arsenic and copper. CNP09 through CNP14 are intended to be additional data points between the Town of Hayden swimming pool and the concentrator and LPF section buildings. The remaining samples are spatially balanced to facilitate a better understanding of contaminant concentrations across Area #7, with emphasis on the northern portion of the Area.

Sediment Samples CNP14 and CNP15 – Based on the lack of information for the two flow paths located at the northern end of Area #7, two sediment samples are proposed to fill this data gap.

Area #8, Conveyor Belt Tailings

The rationale for each group of soil and sediment samples proposed for Area #8, Conveyor Belt Tailings, is addressed below. Figure 4-9 displays the boundary for Area #8 and identifies the features within and adjacent to the Area, and Figure 7-8 displays the locations and corresponding identification numbers (CBT##) for the proposed samples.

Conveyor Belt Tailings

One surface sample was collected from the southern third of the tailings feature as part of the 2002 ESI non-residential sampling effort, and a second sample was collected from the northern third of the tailings feature in 2004 as part of the EPA Removal Assessment. Both samples were analyzed for arsenic, copper, and lead. The 2002 sample exhibited a minor exceedance of the Arizona R-SRL of 10 mg/kg for arsenic (12.5J mg/kg). No other exceedances of the three metals were reported in these samples.

CH2M HILL (2008) subsequently conducted surface sampling in five locations within the tailings. Four of the five soil samples (CF-03-SED-0, CF-04-SED-0, CF-06-SED-0, and CF-07-SED-0) exceeded the Arizona R-SRL for arsenic (31.6J- mg/kg, 42.4J- mg/kg, 33J- mg/kg, and 52.7J- mg/kg, respectively), as well as the R-SRL of 3,100 mg/kg for copper (29,000J- mg/kg, 57,600J- mg/kg, 131,000J- mg/kg, and 21,200J- mg/kg, respectively). There were no exceedances of the lead R-SRL (400 mg/kg), and no additional metals were analyzed for these samples. These data indicate that surface soils associated with the tailings feature have been impacted by arsenic and copper.

Surface Samples CBT05 through CBT15 – Based on the information provided above, 11 additional surface samples are proposed within the tailings footprint in order to characterize the contaminants present, and to provide an indication of the potential for contaminants to be conveyed to downstream locations via stormwater runoff.

Sediment Samples CBT24 and CBT25 – One sediment sample is proposed from the bottom of each of the two stormwater collection ponds located within the tailings area. These data will be used to determine contaminant concentrations associated with pond sediments as a potential source of contaminant release to groundwater.

Areas Adjacent to Tailings

During the 2002 ESI non-residential sampling effort, three soil samples were collected from the portion of Area #8 located north-northeast of the tailings footprint. Sample results indicated

exceedances of the Arizona R-SRL for arsenic in all three locations (53.4J mg/kg, 57.6 mg/kg, and 62.8 mg/kg); for copper in all three locations (10,900 mg/kg, 11,800J mg/kg, and 12,700J mg/kg); and for lead in two of the three locations (538J mg/kg and 851J mg/kg). One sample was also collected from the area north-northeast of the tailings footprint as part of the 2002 ESI residential sampling effort, but did not exhibit any exceedances for arsenic, copper, or lead.

These data collectively indicate that surface soils upgradient of the tailings feature have been impacted by arsenic, copper, and lead, and that further investigation is warranted.

Soil Samples CBT01 through CBT04 and CBT23 – To augment the historical information provided above, four surface soil samples are proposed in areas upgradient of the tailings footprint. A fifth sample (CBT23) will serve to characterize surface soil southwest of the tailings footprint.

Soil Samples CBT16 through CBT22 – Seven surface soil samples are also proposed along the western side slopes of Area #8, adjacent to previously remediated residential parcels. No samples are proposed along the eastern side slopes due to the proximity of the overhead conveyor addressed in Area #9. Western side-slope sample results will provide data for assessing whether impacted soils in these accessible areas represent either a direct exposure risk or a potential source of contaminant release from Area #8 as a result of wind dispersion or surface water runoff during storm events.

Area #9, Ore Receipt and Secondary and Tertiary Crushing

The rationale for each group of soil and sediment samples proposed for Area #9, Ore Receipt and Secondary and Tertiary Crushing, is addressed below. Figure 4-10 displays the boundary for Area #9 and identifies the features within and adjacent to the Area, and Figure 7-9 displays the locations and corresponding identification numbers (STC##) for the proposed samples.

Ore Receipt

Soil Samples STC01 through STC04 - Given the fact that materials being handled in the ore receipt area are known to contain elevated levels of metals, the absence of previous data in this portion of Area #9 is considered a data gap. Four surface soil samples are proposed within the ore receipt area for the purpose of determining whether it is a source of contaminants. Sample STC01 is intended to sample surface soils from the location where trucks unload slag material and smelter by-products. Sample STC03 is intended to sample surface soils where ore is off loaded from railcars. The remaining two sample locations are placed at locations adjacent to the ore receipt structure. Given the proximity of the railroad, sample results also may be used to augment data on contaminants associated with the railroad corridor.

Secondary and Tertiary Crushing

Gila County parcel 101-09-080C is located northwest of the crusher building and was sampled as part of the 2004 Removal Investigation. Thirty surface soil samples were collected from the parcel and were analyzed for arsenic, copper, and lead. The majority of the samples did not exceed Arizona R-SRLs for arsenic and copper, and there were no exceedances of the R-SRL for lead. Given the large amount of historical data, surface soils within this portion of Area #9 are considered to be sufficiently characterized to meet the needs of the RI/FS, and therefore no additional sampling is proposed in this area.

CH2M HILL (2008) collected three surface soil samples from areas adjacent to the crusher building as part of the Phase I RI Investigation. All three samples were analyzed for nine metals, and exhibited exceedances of the Arizona R-SRLs for arsenic in one sample (10.4 mg/kg), for copper in two samples (maximum concentration of 6,670 mg/kg), the R-SRL of 78 mg/kg for vanadium in one sample (79.8 mg/kg), and the Region 9 PRG of 23,000 mg/kg for iron in all three samples (maximum concentration of 35,000 mg/kg). These data indicate that surfaces adjacent to the crusher building have been moderately and primarily impacted by copper and iron.

Soil Samples STC05 through STC10 – To facilitate characterization of soils within this portion of Area #9, six additional soil samples are proposed at locations within the more active areas adjacent to the crusher building.

Sediment Sample STC46 – According to recent aerial photography, process water from the secondary crushing operation is discharged from the northwestern portion of the structure, conveyed to Powerhouse Wash, passed underneath State Route 177, and ultimately conveyed to the emergency ponds at the southern tip of Tailings Impoundment AB/BC (Area #1B). One sediment sample (STC46) is proposed within the unlined channel that conveys flow from the northwestern portion of the secondary crusher building. Results will be used to evaluate chemical contributions to downstream sediments from this location.

Conveyor #9

Two soil samples were collected during the RCRA Inspection (2000) from just west of the northern portion of conveyor #9. Samples AS02 and AS03 were analyzed for arsenic, copper, lead, cadmium, and chromium, and exceeded the Arizona R-SRLs only for arsenic (40J mg/kg and 70 mg/kg, respectively) and copper (12,000 mg/kg and 56,000 mg/kg, respectively).

CH2M HILL (2008) collected five surface soil samples beneath conveyor #9 as part of the Phase I RI Investigation. One sample was located near the southern portion of the conveyor, two samples were located near the central portion of the conveyor, and two samples were located

west of the northern portion of conveyor #9. The southern sample (PHW-SED-13AS) did not exceed the Arizona R-SRLs for any of the nine metals analyzed. The central samples (CF-01-SED-0 and CF-02-SED-0) exhibited exceedances of the R-SRLs for arsenic (27.6J- mg/kg and 45.8J- mg/kg, respectively) and copper (12,000J- mg/kg and 23,300J- mg/kg, respectively), while there were no exceedances for lead. No other metals were analyzed for these samples. The northern samples (PCON-16-SED-0 and PCON-17-SED-0) exhibited minor exceedances of the R-SRL for arsenic (13.4 mg/kg and 12.9 mg/kg, respectively) and exceedances for copper (9,510 mg/kg and 7,530 mg/kg, respectively), while there were no exceedances for lead. No other metals were analyzed for these samples.

The majority of the residential properties located beneath or immediately adjacent to conveyor #9 were remediated by ASARCO due to R-SRL exceedances for arsenic, copper, lead, or a combination of these metals. These impacts to residential properties, as well as other documented surface soil contamination discussed above, may be attributable at least in part to spills and/or airborne emissions from conveyor #9. These data collectively indicate that surface soils beneath conveyor #9 have been impacted by arsenic and copper, and that further investigation is warranted.

Soil Samples STC11 through STC25 – Based on this historical information, fifteen surface soil samples are proposed within the area below and immediately adjacent to Conveyor #9 in order to support further characterization of surface soil impacts and to determine whether Conveyor #9 is a source of contaminants within Area #9.

Fine Ore Bin and Mill Building

CH2M HILL (2008) collected one surface soil sample (PCON-25-SED-0) either adjacent to or within the intermediate material stockpile located north of the fine ore bins. CH2M HILL figures identify this sample as within the material stockpile, but no description within the text explicitly states the sample location. The sample was analyzed for nine metals and exhibited exceedances of the Arizona R-SRLs for arsenic (18.1 mg/kg), copper (59,700 mg/kg), and molybdenum (1,020 mg/kg). The sample also exceeded the Region 9 PRG for iron (162,999 mg/kg). An additional sample (PCON-24-SED-0) was collected immediately east of the mill building. Sample results indicate exceedances of the R-SRLs for arsenic (23.3J- mg/kg) and copper (10,400J- mg/kg) and the PRG for iron (52,900 mg/kg). Additional metals were analyzed in this sample but did not exhibit exceedances.

These data collectively suggest that the intermediate material stockpile is a source of contamination within Area #9. Because the stockpile is exposed during precipitation events, the associated contaminants may be migrating downgradient via surface flow towards portions of

Area #6 (Administration and Concentrator Support) and Area #10 (Powerhouse Wash). Therefore, further investigation is warranted.

Two storage areas are located directly south of the mill building and adjacent to the Powerhouse Wash corridor, and are divided by an unpaved access road that extends into the lower elevations within Area #10, Powerhouse Wash. Non-residential sampling was conducted at three locations (CB-SS-01, RH-SS-01, and RH-SS-02) in the storage area located west of the access road (ESI, 2002). Sample results exhibited exceedances of the Arizona R-SRLs for arsenic (43.9 mg/kg, 47.6 mg/kg, and 43.3 mg/kg, respectively) and copper (20,100 mg/kg, 18,200J mg/kg, and 13,600J mg/kg, respectively), while no exceedances of lead were identified.

CH2M HILL (2008) collected six soil samples (PCON-18-SED-0 through PCON-23-SED-0) from surfaces within the storage areas. Sample results exhibited exceedances of the Arizona R-SRLs for arsenic and copper in all samples, with the highest detected arsenic concentration of 1,720 mg/kg (PCON-20-SED-0) and the highest detected copper concentration of 35,000 mg/kg (PCON-21-SED-0). Both of these samples were collected in the eastern storage area. Some of the six samples also exceeded the R-SRLs of 31 mg/kg for antimony (one sample) and 78 mg/kg for vanadium (one sample), and the PRG for iron (majority of samples with a maximum concentration of 150,000 mg/kg).

These data collectively indicate significant impacts to surface soils within the storage areas, potentially a source of contaminants within Area #9 and/or nearby residential properties. Releases from these storage areas ultimately may impact downgradient portions of Area #10, Powerhouse Wash, to the south via the unpaved access road or to the south- and east-facing adjacent side slopes. Further investigation is, therefore, warranted.

Surface Samples STC26 through STC45 – Based on the existing data, 20 surface samples are proposed within the northern portion of Area #9. Samples STC26 and STC27 are intended to sample the intermediate material stockpile and the surface soils immediately west of the stockpile. Samples STC28 through STC34 are intended to sample surface soils in the vicinity of the fine ore bins and mill building. Samples STC35 through STC45 are intended to sample the two storage areas and are positioned relative to previous sample locations. The purpose of all samples is to support further delineation of previously identified impacts to soil, to refine the understanding of surface contaminants in this portion of Area #9, and to provide additional insight into potential contaminant contributions to downgradient locations.

Area #10, Powerhouse Wash

The rationale for each group of soil and sediment samples proposed for Area #10, Powerhouse Wash, is addressed below. Figure 4-11 displays the boundary for Area #10 and identifies the

features within and adjacent to the Area, and Figure 7-10 displays the corresponding locations and identification numbers (PHW##) for the proposed samples.

Powerhouse Wash

Three historical investigations resulted in the collection of soil samples within Area #10. These investigations are addressed below in the order of occurrence.

In the earliest study, four samples (RH-SS-03, RH-SS-04, RH-SS-05, and RH-SS-16) were collected as part of the ESI non-residential sampling event (2002). Samples were collected from the western side slopes in the southern half of Area #10, approximately 50 feet east of residential property. All four samples exceeded the Arizona R-SRL of 10 mg/kg for arsenic (29.3 mg/kg, 46.9 mg/kg, 39 mg/kg, and 23.1 mg/kg, respectively), and the R-SRL of 3,100 mg/kg for copper (5,900J mg/kg, 8,140J mg/kg, 8,120J mg/kg, and 3,920 mg/kg, respectively). There were no exceedances for lead.

Two samples were collected during the Removal Assessment (2004). Samples were collected along the west side of the southern half of Area #10. One sample (H-206) was located on the access road that leads from the secondary crusher to the mill building. The second sample (H-220) was located on the western side slope of the corridor, approximately 50 feet east of residential property. Sample results indicated exceedances of the Arizona R-SRL for arsenic in both samples (29.1 mg/kg and 21.2 mg/kg, respectively), and one exceedance for copper (4,030 mg/kg in sample H-220). There were no exceedances for lead in either sample.

CH2M HILL (2008) collected nine surface sediment samples (PHW-SED-01AS through PHW-SED-09AS) from the main channel of Powerhouse Wash, and collected an additional subsurface sediment sample from 10 to 12 inches bgs at five of the nine locations. Sample locations extended upstream from State Route 177 to the approximate middle of Area #10. All samples were analyzed for nine metals. All nine surface sediment samples exceeded the Arizona R-SRL for arsenic (with concentrations ranging from 16.5 mg/kg to 77.4 mg/kg) and for copper (with concentrations ranging from 4,650 mg/kg to 12,200 mg/kg). All samples also exceeded the Region 9 PRG of 23,000 mg/kg for iron (concentrations ranging from 33,700 mg/kg to 63,300 mg/kg), while there were no exceedances of R-SRLs for any other metals analyzed (including lead).

The deeper sediment samples similarly exceeded R-SRLs for arsenic and copper (with arsenic concentrations ranging from 13.3 mg/kg to 37.9J mg/kg and copper concentrations from 6,270 mg/kg to 11,100 mg/kg), and the Region 9 PRG for iron (ranging from 31,000 mg/kg to 58,900 mg/kg). There were no exceedances of R-SRLs for any other metals analyzed for the deeper samples.

The data addressed above collectively indicate that surface soils within the southern half of Area #10 have been impacted by arsenic, copper, and iron, and that surface and subsurface sediments within Powerhouse Wash have been impacted by the same metals. Therefore, further investigation is warranted.

Soil Samples PHW01 through PHW22 – Based on the historical soil results addressed above and the lack of data for the northern portion of Area #10, 22 surface soil samples are proposed within Area #10 to support further delineation of impacts to surface soils along the side slopes of the Powerhouse Wash corridor. Sample PHW17 is intended to sample the unpaved access road leading from the secondary crusher to the mill building.

Sediment Samples PHW33 through PHW45 – Based on the historical sediment results addressed above, and the lack of data for the northern portion of Powerhouse Wash, 13 sediment samples are proposed within the Powerhouse Wash. All of the proposed sample locations are intended for the Powerhouse Wash thalweg, or lowest elevation point within the wash corridor. These sediment sample locations are spatially balanced with CH2M historical sample locations for the purpose of developing a better understanding of contaminant concentrations along the entire length of the Powerhouse Wash thalweg.

Historical Tailings

Soil Samples PHW23 through PHW29 – Based on the location of historical tailings deposition observed in 1958 and 1964 aerial photography, four soil samples are proposed within the area that historically contained tailings to determine whether there are any surface contaminants associated with this historical feature. Two of the four sample locations (PHW24 and PHW29) are proposed to be sampled at intervals of approximately six inches to a total depth of five feet (10 deeper samples from each location) to determine whether tailings material is present in the subsurface and to determine associated contaminant concentrations.

Discharge near Power House and Mill Buildings

Soil Samples PHW30 through PHW32 – Based on the prevalence of flow paths originating from the east side of the mill building, three soil samples are proposed within the discharge area. These samples are positioned outside of the visible flow paths and are intended to characterize adjacent soils.

Sediment Samples PHW46 through PHW50 – Also based on the historical findings, five sediment samples are proposed within the discharge flow paths that originate near the Power House and mill building to determine if discharges are a source of contamination within Area

#10. Samples are intended to be located within flow paths that exhibit differing discolorations, as observed during future field efforts.

Area #11, Waste Water Treatment Plant

The rationale for each group of soil and sediment samples proposed for Area #11, Waste Water Treatment Plant (WWTP), is addressed below. Figure 4-12 displays the boundary for Area #11 and identifies the features within and adjacent to the Area, and Figure 7-11 displays the corresponding locations and identification numbers (WTP##) for the proposed samples.

Railroad

Soil Samples WTP01 through WTP03 – Three surface soil samples are proposed adjacent to the Copper Basin Railway spurs to evaluate the extent to which fugitive emissions from railcars are impacting adjacent soils, and whether contaminated runoff is being directed toward and then trapped by the tracks.

Waste Water Treatment Plant

To date, only two surface samples have been collected within Area #11. Sample AS07 was collected as part of the 2000 RCRA Inspection sampling event from the sludge drying beds located within the southwestern portion of the WWTP. The sample was analyzed for arsenic, copper, lead, cadmium, and chromium, all of which, except for chromium, significantly exceeded the Arizona R-SRLs. Arsenic was reported at 32,000 mg/kg (>1,000 times the R-SRL), copper at 350,000 mg/kg, lead at 32,000 mg/kg, cadmium at 5,200 mg/kg, and chromium at 9 mg/kg. Sample AS10 was collected from the northeastern corner of the Area and was analyzed for the same five metals. Analytical results again showed exceedances of the R-SRLs for each metal except chromium. Concentrations were 2,400 mg/kg, 210,000 mg/kg, 6,600 mg/kg, 240 mg/kg, and 27 mg/kg, respectively.

Surface Samples WTP04 through WTP16 – Based on the historical results above, contaminants associated with activities at the WWTP have impacted surface soils. To augment these findings, thirteen surface samples are proposed within and downgradient from the WWTP in order to support characterization of the extent of the contaminants previously observed at high levels. In particular, samples WTP04 and WTP05 are intended to sample material from the sludge drying beds, and surface soil samples WTP06 through WTP16 are positioned downgradient from the WWTP.

Sediment Samples WTP39 and WTP40 – Recent aerial photography shows that flow is discharged to the southwest from the southern corner of the WWTP. Two sediment samples are proposed immediately downstream of the discharge location for the purposes of source identification and sediment characterization in this area.

Soil Samples WTP27 through WTP30 – Also based on the historical results above, four surface soil samples are proposed in the vicinity of Sample AS10 to characterize the extent of the contaminants previously observed at high concentrations at this sampling location.

Calcium Sulfate Pond

Surface Samples WTP17 through WTP26 – Ten surface samples are proposed within and immediately adjacent to the calcium sulfate pond. Samples WTP18 through WTP23 are intended to characterize surface materials contained within the pond, which may represent the uppermost layer of deposited calcium sulfate sludge. Any significant exceedances of Arizona R-SRLs likely will result in the need for deeper sludge samples to confirm if any release to groundwater from the calcium sulfate pond has occurred. Samples WTP17 and WTP24 through WTP26 are intended to sample surface soils at locations around the outer perimeter of the pond.

Wet/Dry Bins

Sediment Samples WTP31 through WTP37 – Seven sediment samples are proposed for the material storage bins and the western ponds. Sample results will be used to determine whether the wet/dry bins or the ponds could be a source of contamination within Area #11, although it is recognized that the types of materials in the bins may vary over time.

Area #12, Concentrate Handling and Mixing

The rationale for each group of soil and sediment samples proposed for Area #12, Concentrate Handling and Mixing, is addressed below. Figure 4-13 displays the boundary for Area #12 and identifies the features within and adjacent to the Area, and Figure 7-12 displays the corresponding locations and identification numbers (CHM##) for the proposed samples.

Previous Analytical Data

To date, only two soil samples have been collected within Area #12. Samples AS05 and AS11 were collected as part of the RCRA Inspection sampling event (2000). Both samples were analyzed for arsenic, copper, lead, cadmium, and chromium. Sample AS05 was collected from the northwestern portion of Area #12, west of the Copper Basin Railway spur, and exceeded the Arizona R-SRLs for arsenic (720 mg/kg), copper (230,000 mg/kg), and lead (1,100 mg/kg) by nearly two orders of magnitude. Sample AS11 was collected near the end of the easternmost spur of the Copper Basin Railway, north of the railcar concentrate unloading building. This sample also greatly exceeded the R-SRLs for arsenic (310 mg/kg), copper (230,000 mg/kg), and lead (1,100 mg/kg).

This data collectively indicates that surface soils within portions of Area #12 have experienced significant impacts from arsenic, copper, and lead, and that further investigation is warranted.

Soil Samples CHM01 through CHM09 – Based on this information, nine surface soil samples are proposed to evaluate the extent of soil contamination in the vicinity of the two prior samples. Four of the proposed samples (CHM01 through CHM04) are located within the general vicinity of Sample AS05, and the other five samples (CHM05 through CHM09) are located within the vicinity of Sample AS11.

Railroad

Soil Samples CHM10 through CHM16 – Seven surface soil samples are proposed adjacent to the two Copper Basin Railway spurs within Area #12. These samples will be used to evaluate whether fugitive emissions or spills from railcars are impacting adjacent soils and whether contaminated runoff is being directed toward and then trapped by the tracks. Analytical results from other proposed samples located close to the railroad tracks also may be used to assess these impacts.

Vacuum Truck Discharge

Sediment Samples CHM28 through CHM33 – Six sediment samples are proposed within the vacuum truck discharge containment area. Sample results will be used to determine whether the vacuum truck discharges could be a source of contamination within Area #12, although it is recognized that the types of materials may vary over time.

Remaining Portions of Area #12

Surface Samples CHM17 through CHM27 – Eleven additional surface samples will be located to target discolored soils and other specific features of the Area, such as the slag pile (Surface Sample CHM25).

Area #13, Smelter Support

The rationale for each group of soil and sediment samples proposed for Area #13, Smelter Support, is addressed below. Figure 4-14 displays the boundary for Area #13 and identifies the features within and adjacent to the Area, and Figure 7-13 displays the corresponding locations and identification numbers (SMS##) for the proposed samples.

Previous Analytical Data

To date, only one soil sample has been collected within Area #13. Sample AS06 was a three part composite sample of CP-1 sediments, and was collected as part of the 2000 RCRA Inspection sampling event. The sample was analyzed for arsenic, copper, lead, cadmium, and chromium, and results showed significant exceedances of the Arizona R-SRLs for all five metals, with arsenic reported at 3,700 mg/kg, copper at 98,000 mg/kg, lead at 7,200 mg/kg, cadmium at 340 mg/kg, and chromium at 46 mg/kg.

These data indicate that portions of Area #13 may have been impacted by arsenic, copper, lead, cadmium, and chromium, and that further investigation is warranted.

Soil Samples SMS01 through SMS07 – Based on this information, six surface soil samples are proposed within the vicinity of CP-1 in order to evaluate the extent of impacts to soil in this area.

Containment Ponds
Sediment Samples SMS37 through SMS45 – One sediment sample is proposed from each of the nine existing containment ponds in Area #13. Samples will be collected from the bottom of the ponds. Based on the results, additional sediment sampling may be warranted in order to evaluate the potential for pond contaminants to leach into groundwater.

Railcar Maintenance Facility and Storage Yards
Soil Samples SMS08 through SMS10 – Three surface soil samples are proposed within the storage yards located east of the railcar maintenance building. Sample locations were chosen based on areas of discolored soil within the storage yards.

Storage Area #1
Soil Samples SMS11 and SMS12 – Two surface soil samples are proposed for the storage yard located southwest of the former limestone quarry. Sample locations will target areas of discolored soil within the storage yard.

Storage Area #2
Soil Samples SMS13 through SMS15 – Three surface soil samples are proposed for the storage yards located south-southeast of the railcar maintenance facility. Sample locations will target discolored soil and low elevation points within the storage yards.

Flux Crushing
Soil Samples SMS16 and SMS17 – Two surface soil samples are proposed for the flux crushing area located in the central portion of Area #13. Sample locations were chosen based on two distinctive surface discolorations associated with the area, visible in recent aerial photography.

Remaining Portions of Area #13
Soil Samples SMS18 through SMS36 – The remaining 19 surface soil sample locations target either features such as discolored surfaces north of the flux crushing area, or are placed to facilitate a broader understanding of the nature and extent of surface soil impacts throughout Area #13.

Area #14, Flash Smelting, Copper Converting, Anode Furnace

The rationale for each group of surface soil samples proposed for Area #14, Flash Smelting, Copper Converting, Anode Furnace, is addressed below. No sediment samples are proposed for this Area. Figure 4-15 displays the boundary for Area #14 and identifies the features within and adjacent to the Area, and Figure 7-14 displays the locations and corresponding identification numbers (FCA##) for the proposed samples.

Previous Analytical Data

To date, no surface soil samples have been collected within Area #14. However, sample AS10 was collected immediately southwest of the southwestern corner of the Area as part of the 2000 RCRA Inspection sampling event. The sample was analyzed for arsenic, copper, lead, cadmium, and chromium. Analytical results showed exceedances of the R-SRLs for arsenic (at 2,400 mg/kg), copper (at 210,000 mg/kg), lead (at 6,600 mg/kg), and cadmium (at 240 mg/kg).

These data indicate that surface soils within a portion of Area #14 have experienced significant impacts from arsenic, copper, lead, and cadmium, and that further investigation is warranted.

Soil Samples FCA01 through FCA05 – Based on this information, five surface soil samples located near Sample AS10 are proposed in order to evaluate whether the surface soil impacts exhibited by the 2000 RCRA sample were derived from activities conducted within Area #14. Additional soil samples in the region immediately surrounding Sample AS10 are being collected as part of the sampling design for Area #11, Waste Water Treatment Plant.

Soil Samples FCA06 through FCA20 – The remaining 15 surface soil sample locations target discolored surfaces or are placed to facilitate a broader understanding of the extent of soil impacts throughout Area #14.

Area #15, Reverts Crushing and Reclaim

The rationale for each group of soil and sediment samples proposed for Area #15, Reverts Crushing and Reclaim, is addressed below. Figure 4-16 displays the boundary for Area #15 and identifies the features within and adjacent to the Area, and Figure 7-15 displays the corresponding locations and identification numbers (RCR##) for the proposed samples.

Railroad

Soil Samples RCR01 through RCR05 – Five surface soil samples are proposed adjacent to the Copper Basin Railway within Area #15. These samples will be used to evaluate the extent to which fugitive emissions or spills from railcars are impacting adjacent soils or if contaminated runoff is being directed toward and then trapped by the tracks. Analytical results from other proposed samples located near the railroad tracks also may be used to assess these impacts.

Materials Storage and Handling

One soil sample was collected at one location in Area #15 as part of the 2000 RCRA Inspection sampling event. Sample AS09 was located along the western side slopes near the central portion of Area #15, and was analyzed for arsenic, copper, lead, cadmium, and chromium. Analytical results showed notable exceedances of the Arizona R-SRL for each metal (at concentrations of 750 mg/kg, 160,000 mg/kg, 3,700 mg/kg, 80 mg/kg, and 380 mg/kg, respectively), indicating that contaminants have significantly impacted surface soils located downgradient of operations within this portion of Area #15.

Soil Samples RCR06 through RCR22 – Based on this information, 17 surface soil samples are proposed along the western side slopes in the vicinity and south of the previous sample location. Sample results will be used to evaluate the extent of contaminant impacts to surface materials near this location, and will provide insight as to the potential levels of contamination that may be transported westward into Area #11, Waste Water Treatment Plant, during flow events. Samples RCR06 through RCR08 are intended to sample the roadway used to transport materials.

Reverts Crushing – South Yard

CH2M HILL (2008) collected one surface sample from the north side of the southernmost reverts crushing yard (sample PSMT-01-SED-0). The sample was analyzed for nine metals. Analytical results showed exceedances of the Arizona R-SRLs for arsenic, copper, and lead, at concentrations of 121 mg/kg, 380,000 mg/kg, and 1,230 mg/kg, respectively, and a minor exceedance of the R-SRL of 31 mg/kg for antimony (at 36.8J mg/kg). The sample also exceeded the Region 9 PRG of 23,000 mg/kg for iron (at 108,000 mg/kg). The sample appears to have been collected from a material stockpile that showed as a pale pink color on recent aerial photography.

Based on 10-foot contour interval topography and recent aerial photography, surface flows generated within the south reverts crushing yard proceed east or west via small drainage channels. The largest of these channels are located west of the yard, from which flow is captured by a small containment pond in the southwestern corner of Area #15.

Surface Samples RCR23 through RCR31 – Based on this historical information, one surface sample and eight soil samples are proposed within the south reverts crushing yard. Sample RCR27 is intended to characterize the dark-colored stockpile located in the northwestern corner of the yard, and samples RCR26 and RCR28 are intended to characterize surface soils immediately upstream of the two small drainage channels. The remaining soil samples are placed at coordinated locations within the yard to facilitate a broader understanding of the extent of soil impacts within this area as a whole. Sample results also will provide an indication of the potential for contaminants to be transported by wind or surface flow.

Sediment Samples RCR53 through RCR56 – Four sediment samples are proposed within Area #15. One sediment sample will be collected from each of the two drainages described above (\samples RCR55 and RCR56), one from the combined channel immediately upstream of the containment pond (sample RCR54), and one from the containment pond itself (sample RCR53). Collection of samples from the drainage channel located further to the east is proposed for Area #19, Area Outside of Areas #1 - #18

Reverts Crushing – North Yard

Soil Samples RCR32 through RCR42 - Eleven surface soil samples are proposed within the northernmost reverts crushing yard to determine if operations within or in the vicinity of the north yard have resulted in the contamination of surface soils. A comparison will be made between the types and levels of contamination observed in the north and south reverts crushing yards. The transient nature of crushing operations will require adjustments to the sampling design during field work, and it is recognized that results will be representative of a limited time frame.

Reverts Reclaim

Soil Samples RCR43 through RCR47 – Five surface soil samples are proposed within the reverts reclaim area at the northern end of Area #15. Sample locations will be spatially biased to address discolored surfaces, as observed in recent aerial photography, or will be based on site observations during field activities.

Remaining Portions of Area #15

Soil Samples RCR48 through RCR52 – Sample RCR52 will be located within the loading/unloading area adjacent to the backup crushing facility. The remaining four soil sample locations will facilitate a broader understanding of the extent of soil impacts within Area #15.

Area #16, Acid and Oxygen Plants

The rationale for each group of soil samples proposed for Area #16, Acid and Oxygen Plants, is addressed below. No sediment samples are proposed for this Area. Figure 4-17 displays the boundary for Area #16 and identifies the features within and adjacent to the Area, and Figure 7-16 displays the corresponding locations and identification numbers (AOP##) for the proposed samples.

To date, no historical investigations have been conducted within Area #16.

Railroad

Soil Samples AOP01 through AOP04 – Four surface soil samples are proposed adjacent to the Copper Basin Railway within Area #16. These samples will be used to evaluate the extent to

which fugitive emissions or spills from railcars are impacting adjacent soils or if contaminated runoff is being directed toward and then trapped by the tracks.

Remaining Portions of Area #16

Soil Samples AOP05 through AOP20 – The remaining 16 surface soil sample locations either target variously colored surfaces or have been placed to facilitate a broader understanding of the extent of soil impacts within Area #16.

Area #17, Slag Handling

The rationale for each group of soil and sediment samples proposed for Area #17, Slag Handling, is addressed below. Figure 4-18 displays the boundary for Area #17 and identifies the features within and adjacent to the Area, and Figure 7-17 displays the corresponding locations and identification numbers (SLH##) for the proposed samples.

Containment Ponds

CH2M HILL (2008) collected surface samples from within containment pond 1 and immediately south and downgradient of containment pond 2 as part of the Phase I RI. Sample SDD-01-SED-0, a sediment sample collected from within containment pond 1, was analyzed for nine metals and exhibited exceedances of the Arizona R-SRLs for arsenic (361 mg/kg versus 10 mg/kg), copper (12,100 mg/kg versus 3,100 mg/kg), and cadmium (94.7 mg/kg versus 39 mg/kg). There was also an exceedance of the Region 9 PRG of 23,000 mg/kg for iron (at a concentration of 64,200 mg/kg). The three downgradient surface soil samples (SDD-02-SED-0 through SDD 04-SED-0) were analyzed for arsenic, copper, and lead, and two of these samples were analyzed for additional metals. All the samples exhibited exceedances of the R-SRLs for arsenic (to a maximum of 232 mg/kg) and copper (to a maximum of 27,000 mg/kg), and one of the three samples exceeded the R-SRL for cadmium (82.4 mg/kg). The Region 9 PRG for iron also was exceeded in two of the three samples (to a maximum of 53,000 mg/kg).

These analytical results collectively indicate that sediments within the containment ponds and adjacent soils have been impacted by arsenic, copper, cadmium, and iron, and that further investigation is warranted.

Soil Samples SLH01 through SLH04 – Four additional surface soil samples are proposed within the vicinity of the three historical soil samples located south of containment pond 2 to support further characterization of impacts to soil in this area.

Sediment Samples SLH25 through SLH33 – Sediment samples from nine locations are proposed within the eastern portion of Area #17. Two locations within containment pond 1 (previously sampled by CH2M HILL) are proposed to be sampled at approximate six-inch depth intervals to

a total depth of five feet (10 deeper samples from each location) for the purpose of defining the vertical extent of contaminants and to inform potential impacts to groundwater from this pond. Samples SLH28 through SLH32 are intended to characterize sediments at the bottom of each of the other three containment ponds. Samples SLH30 and SLH31 are located within containment pond 4, which captures runoff generated from off-site areas northeast of the existing Area #17 boundary. Data from these samples will be compared to sediment data from other ponds that receive runoff from the slag pile. Sample SLH33 is intended to characterize sediments in the constructed channel used to convey flow from containment pond 4 to downgradient locations within and beyond Area #17. An additional sample (Sample SLH25) is intended to characterize sediments within a drainage that runs southeasterly along the contact between slag material and the adjacent Paleozoic age deposits to the east.

Slag Dumps

Surface Samples SLH05 through SLH12 – Eight surface samples of slag are proposed within the lower and higher copper concentration areas of the slag dumps. Analytical results will be used to evaluate the nature of contamination within the slag deposits and indicate the potential for contaminants to be leached to groundwater from the slag pile.

Surface Samples SLH13 through SLH21 – Nine additional surface sample locations are placed to facilitate a broader understanding of the extent of contamination along roadways and within storage yards located on top of the slag pile.

Slag Crushing

CH2M HILL (2008) collected one surface sample from within the slag crushing area as part of the Phase I RI. Sample SD-01-SED-0 was analyzed for nine metals and exhibited the following exceedances of the Arizona R-SRLs: arsenic at 24.7 mg/kg, copper at 47,200 mg/kg, lead at 468 mg/kg, and molybdenum at 1,060 mg/kg. The Region 9 PRG for iron also was exceeded (at a concentration of 186,000 mg/kg).

Surface Samples SLH22 through SLH24 – Three surface samples are proposed within the slag-crushing region of Area #17 in order to further delineate associated contaminant concentrations.

Area #18A-D, Linear Features

The rationale for each group of surface/soil samples proposed for Areas #18A through #18D, Linear Features, is addressed below. No sediment samples are proposed for these Areas. Figures 4-19AB and 4-19CD display the boundaries for Areas #18A through #18D and identify the features within and adjacent to the Areas, and Figures 7-18AB and 7-18CD display the locations and corresponding identification numbers (LNF##) for the proposed samples.

Linear Features

To date, no surface samples have been collected within Area 18A (Hayden Junction Railway Segment), 18B (Kennecott Avenue), or 18D (Smelter Hill Railway Segment). One surface sample was collected from the southern end of Area 18C (Winkelman Railway Segment) as part of the 2004 Removal Assessment (Sample W-150). The sample exceeded the Arizona R-SRLs for arsenic, copper, and lead, with analytical results of 320 mg/kg, 19,000 mg/kg, and 403 mg/kg, respectively.

Under the proposed sampling design, an average spacing of one sample per 500 feet of track will be applied for the railway segments (except where historical data, spills, or soil disturbances were identified in intermediate zones), with sample locations on both sides of a given track segment. The same spacing will be applied to Kennecott Avenue, with one sample proposed in the middle of the roadway at each selected location.

Soil/Surface Samples LNF01 through LNF34 – A total of 34 surface samples are proposed for the linear features. Twenty-five samples will be collected along the three railroad segments (Samples LNF01 through LNF08 and LNF18 through LNF34), and nine samples will be collected along Kennecott Avenue (Samples LNF09 through LNF17). Analytical results from the railroad linear features will be used to evaluate whether fugitive emissions from railcars are impacting adjacent soils and/or if contaminated runoff is being directed toward and then trapped by the tracks. The results will be compared with those for railroad corridors in other RI Areas, such that the railroad system will be assessed as a whole after all data is collected. The sample results along Kennecott Avenue will be used to determine whether Kennecott Avenue is a potential risk exposure area for the public.

Area #19, Area Outside of Areas #1 through #18

The rationale for each group of soil and sediment samples proposed for Area #19, Area Outside of Areas #1 through #18, is addressed below. Figure 7-19 displays the regions addressed within Area #19 and the locations and corresponding identification numbers (AOA##) for the proposed samples.

Region 1

Soil Samples AOA01 through AOA12 – A grid approach was used for the sampling design within this region to establish twelve proposed sample locations. Soil samples are proposed to be collected from each location at the surface (0-2 inches bgs) and at a depth of one foot (10-12 inches). Surface sample results will be used for the ecological investigation, and deeper samples will be used to define soil background values for metals other than arsenic, copper, and lead. Background levels for arsenic, copper, and lead were previously established as part of the Phase I RI.

Region 2

Soil Samples AOA13 through AOA24 – A grid approach also was applied to the sampling design within this region to establish an additional twelve proposed surface soil sampling locations. All twelve samples will be collected at the surface (0-2 inches bgs) and will be used for the ecological investigation and to support the evaluation of the nature and extent of soil impacts within Area #19.

Soil Samples AOA37 through AOA42 – The remaining six soil sample locations within Region 2 are intended to provide additional information on the nature and extent of surface soil impacts within the remaining portions of Region 2.

Sediment Samples AOA43 through AOA50 – Eight sediment samples are proposed within the primary drainage channels that convey flow to the south-southwest within Region 2 to evaluate if any impacts to these drainage channels have occurred.

Region 3

Soil Samples AOA25 through AOA36 – A grid approach was applied to the sampling design within this region to establish an additional twelve proposed surface soil sampling locations. All twelve samples are intended to support the ecological investigation, but results will also be used to determine the extent of surface impacts resulting from stack emissions in this region.

7.2.1.2 Soil Sampling Procedures

Soil sampling will be conducted in accordance with the SOPs included in the FSP. Surface soil samples will be collected at a depth interval of 0-2 inches bgs, consistent with the Phase I RI study. Samples generally will be collected manually using a trowel or a spoon; a hand auger may be used if needed.

Soil samples will be screened in the field using portable XRF analyzers. XRF screening will optimize field sampling by providing real-time concentration data to establish the horizontal and vertical extent of COPC contamination, as explained in the introductory portion of Section 7.2.1.1. XRF procedures are listed in Section 5.2 of the FSP (Part 2 of Appendix B).

7.2.2 Task 2: Surface Water Investigation

This section presents an overview of the rationale for the surface water investigation and monitoring in the Gila and San Pedro rivers in the vicinity of the Site, and general sampling methods for surface water.

7.2.2.1 Purpose and Overview

The surface water investigation includes sections of the Gila and San Pedro Rivers in the vicinity of the ASARCO Hayden smelter. Two rounds of surface water sampling in the Gila and San Pedro Rivers were performed during the Phase I RI. Based on Phase I RI results, CH2M HILL identified several data gaps in the surface water data. Additional sample locations and additional rounds of surface water sampling are proposed in this Work Plan to help fill the data gaps.

This task will complement the results of previous investigations and develop a better understanding of COPC levels, potential sources of COPCs, and COPC migration patterns over a broader area. The surface water sampling program has the following key purposes:

1. Include major anions (sulfate, chloride, nitrate/nitrite, and fluoride) in the chemical analyses of surface water samples. In the Phase I RI, surface water samples were not analyzed for major anions. These constituents likely will provide information as to the sources of surface water contamination and surface water - groundwater interaction.
2. Obtain background surface water samples from newly proposed upstream locations on the Gila and San Pedro Rivers.
3. Evaluate seasonal variations and longer-term trends in surface water quality.
4. Collect sufficient data to support remedial actions, if necessary, and to support the ecological risk assessment.
5. Investigate the abnormal water chemistry of previously collected surface water sample GR-SW-04 by collecting an additional sample from a point downstream of GR-SW-04, but upstream from the confluence of the Gila and San Pedro Rivers.
6. Collect additional surface water samples between the tailings impoundments, because the existing sample density is insufficient to allow evaluation of impacts of the tailings impoundments on surface water.

7.2.2.2 Surface Water Sampling Locations and Rationale

Surface water sampling in the Gila and San Pedro rivers will be conducted at 19 locations, 13 of which are identical to those sampled during the Phase I RI. Six new locations are proposed to complement the surface water sampling network from the Phase I RI. The proposed surface water sampling locations are illustrated on Figure 7-20. Four rounds of surface water sampling will be conducted, according to a schedule which corresponding to that used for the Phase I RI. Two rounds of samples will be conducted during the late monsoon period (i.e., late August) when stormwater runoff and upland erosion are mostly likely to occur. The other two rounds of samples will be collected following the winter rainy period (i.e., early March) when the water table is relatively high and groundwater discharges are most likely to affect the river.

In addition to the collection of surface water samples at the selected locations between the tailings impoundments, high-density real time conductivity, TDS, and temperature measurements of the surface water will be recorded in this section of the Gila River to identify potential inflow to the river (such as seepage from the tailings impoundments or inflow from groundwater). Field observations also will be made for any signs of acid rock drainage or salt precipitates on the outer slopes of the tailings impoundments and on the surface of riparian sediments. Based on these supplemental field observations, additional sample locations may be needed to characterize the surface water quality more fully, and to identify and fingerprint potential seepage from the tailings impoundments or groundwater inflows. If significant inflows of seepage or groundwater are identified, then a tracer study and/or synoptic surface water sampling in the Gila River in this specific area may be warranted in order to quantify the metal loading from the various inflows.

Two newly proposed upstream locations in the Gila River (GR12 and GR13) and one additional upstream location in the San Pedro River (SP03) are intended for the collection of background surface water samples. The samples taken from location GR01 in the Gila River (same location as GR-SW-01) during the Phase I RI were intended to represent background conditions, but showed elevated concentrations of various constituents, especially metals, which may represent impacts from ASARCO operations in the area.

Proposed sample location GR14 is intended to help investigate the abnormal water chemistry of previously collected surface water sample GR-SW-04 during the Phase I RI (same location as GRW04SW). Surface water samples from two other new locations, GR15 and GR16, are intended to supplement data from locations GR06 and GR07 (same locations as GR-SW-06 and GR-SW-07) that previously indicated potential impacts from the tailings impoundments on surface water. In the Phase I RI, elevated concentrations of copper, aluminum, iron, and total suspended solids were found at GR-SW-06 and GR-SW-07.

7.2.2.3 Surface Water Sampling Procedures

Surface water samples will be collected in accordance with procedures described in Section 5.5 of the FSP (Part 2 of Appendix B). Field personnel will evaluate river flow and channel conditions at each location at the time of sampling to identify a sampling point that is safe to access, has uniform flow, and appears to be well mixed along the cross-section of the location to be sampled. The sampling point should be far enough above and below confluences of stream flows or potential point sources of contamination to avoid sampling a cross section where flows are not completely mixed.

If the sampling point is safely accessible from the bank, the water sample will be grabbed directly by hand, with the sampler holding the bottle underwater with the opening facing upstream. If the sampling point is not within reach of the bank, a pond sampler or similar device

will be used to collect the sample from the main flow channel of the river. Field parameters (pH, conductivity, turbidity, dissolved oxygen [DO], and temperature) will be measured in the field for each surface water sample in accordance with procedures described in Section 5.5 of the FSP (Part 2 of Appendix B). Surface water samples will be analyzed for both total and dissolved analytes. The surface water sampled will be filtered on site for dissolved analytes.

7.2.3 Task 3: Stormwater Runoff and Ephemeral Wash Sediment Investigation

This section presents an overview of the rationale and general sampling methods for the stormwater runoff and ephemeral wash sediment investigation and monitoring.

7.2.3.1 Purpose and Overview

According to ASARCO's 2004 Hayden Concentrator SWPPP, water samples from the stormwater outfalls were to be collected and analyzed, and the analytical results of any stormwater sampling were to be retained and available on site. To date, ASARCO has not shared the stormwater data with EPA. Therefore, the nature of COPC contamination in stormwater and the potential impact of the Site activities on stormwater quality are considered to be data gaps for purposes of the Phase II RI.

7.2.3.2 Stormwater Runoff

Stormwater sampling will focus on the tributaries of the Gila River at or near the Hayden Complex, which includes San Pedro Wash, Kennecott Avenue Wash, and Powerhouse Wash. The sample locations have been selected based on Site activities and the description of potential stormwater discharge facilities and outfalls at the Site. In general, an upstream location and a downstream location were selected for each of the above-mentioned washes. Additional locations were selected where major stormwater discharge facilities or stormwater outfalls were identified along the interim reaches. The following sample locations are proposed (Figure 7-21):

- Sample location STW01 is intended to provide water quality data for stormwater in the channel northeast of Tailings Impoundment AB/BC. This channel conveys stormwater from the upland tributaries west/northwest of Hayden and surface water from the San Pedro Wash.
- Sample locations STW04 through STW06 were selected to monitor the potential impact of the former Kennecott smelter area (RI Areas #3 and #4) on stormwater quality in the San Pedro Wash.
- Sample locations STW07 through STW09 were selected to monitor the potential impact of the active concentrator area and tailings piles on stormwater quality in the Kennecott Avenue Wash.

- Sample locations STW10 and STW11 are intended to monitor the impact of the active smelter and concentrator areas on stormwater quality in the Powerhouse Wash.
- Sample location STW12 is intended to monitor potential stormwater runoff from the Run-on and Containment Pond.

In addition, four locations were selected for collection of samples to provide background stormwater quality data for evaluation of the nature of contamination in stormwater runoff at the Site. They include two locations (STW02 and STW13) within upland washes, one location (STW03) within the San Pedro Wash upstream from the former Kennecott smelter, and one location (STW14) within a tributary of San Pedro Wash. Site activities likely will have no impact on these locations, except for potential air deposition of fugitive and stack emissions under certain wind conditions.

Stormwater runoff will be collected from appropriate locations using an automatic sampler due to the unpredictable nature of rain events in Arizona. The detailed sampling procedures and automatic sampler installation procedures are discussed in Section 5.8 of the FSP (Part 2 of Appendix B).

7.2.3.3 Ephemeral Wash Sediment

The ephemeral wash sediment sampling locations and rationales were addressed in Section 7.2.1 (Soil Investigation) of this Work Plan. A stainless steel spoon or trowel will be used to collect a sample of the surficial sediment within the active channel of the wash at a depth of 0 to 2 inches. Each sediment sample will be a single scoop sample rather than a composite sample. The sampling procedures are outlined in Section 5.7 of the FSP (Part 2 of Appendix B).

7.2.4 Task 4: Process Water Investigation

This section presents an overview of the rationale and general sampling methods for the investigation and monitoring of process water.

7.2.4.1 Purpose and Overview

Process water is mainly water associated with the active concentrator and smelter operations. For purposes of this sampling program, process water includes:

- Water present in Tailings Impoundments AB/BC and D;
- Water in the reclaim pond located east of Tailings Impoundment AB/BC;
- Water flowing in the channel along the northeast and east sides of Tailings Impoundment AB/BC;

- Water present in the emergency ponds and pump-back ponds located southeast of Tailings Impoundment AB/BC;
- Seepage water in the area immediately west of the pump-back ponds along the road south of Tailings Impoundment AB/BC; and
- Water generated in the smelter area and contained in impoundment CP-1 located within the smelter support area near the active slug dump.

Figure 7-22 illustrates the locations of the 14 process water locations proposed for sampling and investigation. Six sampling locations (PW01 through PW06) are proposed for Tailings Impoundments AB/BC and D. These samples are intended to characterize the water chemistry of surface liquid samples collected from isolated pools within Tailings Impoundments AB/BC and D. Understanding the water chemistry of surface/process water in the tailings impoundments and identifying any distinctive chemistry will help fingerprint the potential impact of the tailing impoundments on groundwater and surface water.

Sample PW07 is located at the reclaim pond, and will provide information about the water quality in the pond. PW08 and PW09 are located at seepage features along the north bank of the Gila River. Water quality information obtained for these seeps will be useful in tracing the potential interaction between Tailings Impoundment AB/BC and surface water in the Gila River. Location PW12 is planned to provide data on process water before it flows into the emergency ponds, and locations PW10 and PW11 are intended to collect water quality information from the emergency ponds and pump-back ponds. A portion of the water in these ponds is expected to infiltrate into groundwater or seep into surface water in the Gila River. PW13 is intended to collect process water originating from the secondary crusher located adjacent to State Route 177.

7.2.5 Task 5: Groundwater Investigation and Monitoring

This section presents an overview of the rationale and general sampling methods for the Phase II groundwater investigation and monitoring.

7.2.5.1 Groundwater Investigation

Purpose and Overview

Based on the review of groundwater quality data from previous sampling events, especially the Phase I RI, data gaps were identified regarding the potential effects of the Site on human health and the environment via the groundwater exposure pathway. The current network of monitoring wells is insufficient to cover critical areas within the Study Area where groundwater contamination is most likely to occur. The installation and monitoring of new groundwater wells is intended to: (1) complement the existing monitoring well network in characterizing hazardous substance impacts to groundwater in the Study Area; (2) aid in the evaluation of shallow

groundwater quality impacts and groundwater flow conditions within and around the Site; and (3) obtain groundwater quality data from one or more locations representative of background conditions.

Well Location and Rationale

Six new monitoring wells are proposed to collect groundwater information to fill these data gaps (Figure 7-23). The proposed wells and justification are summarized in the following paragraphs.

There is no monitoring well located southwest (downgradient) of the slag dump to monitor the potential impact of the slag dump and other related site features on groundwater quality, and to provide water level information regarding groundwater flow direction and gradient in this area. Proposed monitoring well MWP-1 is intended to fill this data gap. The proposed location for this well is in Older Quaternary deposits, and the well most likely will be screened in bedrock based on the hydrogeology at the proposed location.

Groundwater monitoring results from the Phase I RI indicate that high concentrations of arsenic, selenium, molybdenum, sulfate, TDS, and vanadium exist at monitoring well LC-1, which is located downgradient from the former Kennecott smelter area. GW-01R, a monitoring well located within the former tailing piles near the Kennecott Avenue Wash, also exhibited high concentrations of aluminum, iron, manganese, sulfate, TDS, and vanadium in the summer 2006 sampling event. It is not known, however, if the high contaminant concentrations at well GW-01R are due to impacts from the tailing piles, from the former Kennecott smelter farther upgradient, or from the active concentrator area. In addition, the groundwater flow direction and the gradient of the bedrock aquifer in this general vicinity are not well understood due to a lack of monitoring wells. A well downgradient from (but closer to) the former Kennecott smelter area and the active concentrator and smelter areas will be of particular value in evaluating the potential source of the observed groundwater impacts. Proposed monitoring wells MWP-2 and MWP-3 are intended to supplement the existing monitoring wells to fill these data gaps.

Proposed Well MWP-4 is intended to provide information on groundwater conditions inside the former Kennecott smelter area, where smelting and related activities might impact groundwater quality. This well also will provide information on water levels to aid in the understanding of the groundwater flow direction and gradient in this area.

Proposed Well MWP-5 is proposed as a background monitoring well for the bedrock aquifer beneath the Site. Existing monitoring well H-7 was intended to be a background well for the bedrock aquifer; however, this monitoring well is apparently located immediately downgradient from an asbestos landfill, and concentrations of COPCs detected in groundwater samples collected from this well may be attributable to impacts from the landfill. Concentrations of

arsenic and vanadium in samples collected from H-7 were the highest reported in any samples obtained from monitoring wells during the Phase I RI, and thus cannot be considered as representative of background concentrations. Therefore, MWP-05 is proposed for a location farther upgradient from the asbestos landfill, but still in the same geological formation. Based on aerial photos, there appears to be no current or historical ASARCO-related activity at or upgradient from this location.

Proposed Well MWP-6 is proposed to monitor the potential impact of the historical Kennecott Avenue Wash tailing piles in RI Area #5. In 2009, the Town of Hayden retained Four Corners Environmental, Inc. (Four Corners) to conduct a Phase I and Phase II Environmental Site Assessment (ESA) for a 1.75-acre portion of the tailings area for the possible construction of a new WWTP (Four Corners Environmental, Inc., 2009a, 2009b). As part of Phase II ESA activities, three deep borings were drilled into the tailings to depths of approximately 40 feet. ITSI reviewed the analytical results reported by Four Corners, and observed that copper, aluminum, and manganese concentrations generally increased with depth in all three borings. As mentioned earlier, groundwater samples taken from monitoring well GW-01R, which was installed through the tailings pile, showed elevated concentrations of aluminum, iron, manganese, sulfate, TDS, and vanadium. In addition, downgradient monitoring well H-8 showed elevated concentrations of molybdenum and vanadium. The proposed new monitoring well (MWP-6) will be used to evaluate whether copper and/or other metals observed in the deep borings have migrated vertically into the underlying alluvial aquifer as the source of the previously observed groundwater impacts.

Monitoring Well Installation

Each groundwater monitoring well will be constructed of 4-inch-diameter, Schedule 40 polyvinyl chloride (PVC) casing and screen. Thirty feet of 0.020-inch slot, Schedule 40 PVC screen with an end cap will be placed at the bottom of each boring, followed by Schedule 40 PVC blank casing placed to three feet above ground surface. The casing and screen string will be held in suspension during placement of the annular materials. A filter pack consisting of No. 8-12 Colorado silica sand, or equivalent, will be installed via tremie pipe adjacent to the screened interval and will extend from the bottom of the well to five feet above the screened interval. A 2-foot-thick interval of fine sand (No. 60 Colorado silica sand) will be placed on top of the main filter pack, followed by placement of a 5-foot thick seal of hydrated bentonite pellets. A cement/bentonite grout slurry will be placed via tremie pipe from the top of the bentonite seal to three feet bgs. Each well will be completed by adding concrete from three feet bgs to the ground surface and embedding an above-grade 8-inch-diameter well monument with a locking cover into the concrete.

Actual well depths and screen placements and lengths may be modified depending on the groundwater levels encountered in the field. Based on historic groundwater levels in existing wells, groundwater is expected to be encountered at 25 to 30 feet bgs at MWP-1, and at 45 to 55 feet bgs at MWP-2, MWP-3, and MWP-4. The depth to groundwater at the MWP-5 and MWP-6 locations cannot be estimated reliably, but may be greater than 60 feet bgs.

Detailed procedures for formation logging; well development, surveying, and pump testing; and documentation of all new monitoring wells are provided in the FSP.

Direct Push Temporary Wells

Historical water quality data from monitoring wells H-1, H-2A, H-3, and H-5 in the vicinity of Tailings Impoundments AB/BC and D showed that groundwater in the vicinity of the tailings impoundments has been impacted by Site activities. For instance, Phase I RI results showed that downgradient monitoring wells H-1 and H-2A had high sulfate concentrations (1,600 mg/L and 1,300 mg/L, respectively) and high manganese concentrations (6,500 ug/L and 7,200 ug/L, respectively) in winter 2006. Monitoring wells H-8 and H-9, located next to but generally upgradient from Tailings Impoundment AB/BC, showed elevated concentrations of sulfate and chloride.

The water quality and general water chemistry of the groundwater in the vicinity of the Tailings Impoundments, as well as the source(s) of the observed impacts, are not well understood. In the proposed Phase II RI, groundwater samples will be collected using direct push technology in the vicinity of Tailings Impoundment AB/BC, Tailings Impoundment D, and the reclaim ponds to characterize groundwater quality near these features and to support additional evaluation of the potential connection between groundwater and surface water. A total of 12 locations are proposed, as illustrated on Figure 7-23. Ten locations are located south/southwest of Tailings Impoundment AB/BC, and four locations are located around the Reclaim Pond. The step-by-step procedure for installing and sampling the temporary wells is provided in the FSP.

7.2.5.2 Groundwater Well Resurvey

The groundwater monitoring wells at the Site were installed at different times and by different contractors. Consequently, these wells may not have been surveyed using the same horizontal and vertical datum, which may make the groundwater contouring problematic. Monitoring well ARU-1 appears to have an incorrect survey elevation, which raises concern regarding a potential datum inconsistency.

As part of the Phase II RI, all of the groundwater wells in the proposed monitoring network, including the proposed new monitoring wells and the five production wells, will be re-surveyed to a consistent horizontal datum (the North American Datum of 1983 [NAD83]) and vertical

datum (the North American Vertical Datum of 1988 [NAVD88]). This survey will ensure accuracy in the interpretation of groundwater flow directions and hydraulic gradients.

7.2.5.3 Groundwater Monitoring

The proposed groundwater monitoring network will consist of the following new and existing wells (as shown on Figure 7-23):

- Existing monitoring wells: ARU-1, ARU-4, ARU-8, ARU-9, ARU-11, ARU-12, GW-01R, GW-02, GW-03, GW-06, H-1, H-2A, H-3, H-4, H-5, H-6, H-7, H-8, H-9, H-10, H-11, LC-1, MW-2, MW-4, and SM-2.
- Existing production wells: HWF-15, HWF-21, HWF-26, WM-3, and WM-4.
- New proposed monitoring wells: MWP-1, MWP-2, MWP-3, MWP-4, MWP-5, and MWP-6.

Quarterly groundwater samples will be collected from the listed monitoring wells and production wells for a period of two years. The purpose of the proposed quarterly groundwater sampling events within the Study Area is to evaluate the nature and extent of COPC contamination in groundwater at or from the Site and to evaluate seasonal variations in groundwater quality (if any). Groundwater sampling will be performed in accordance with procedures described in Section 5.10 of the FSP (Part 2 of Appendix B). Groundwater samples from the production wells will be taken from the wellhead spigot in accordance with the sampling procedures discussed in detail in the FSP.

Groundwater levels will be gauged during each of the quarterly groundwater sampling events. The procedures followed for obtaining water level measurements will be in accordance with procedures described in Section 5.10 of the FSP (Part 2 of Appendix B). Geochemical parameters will also be collected at each of the groundwater sample locations, using a YSI model 556 multi-parameter water quality meter, or equivalent. Field parameters will include pH, conductivity, temperature, DO, and oxidation-reduction potential (ORP). The field parameter readings will be recorded once parameters have stabilized to ± 10% variation over three consecutive readings.

7.3 Sample Analysis

This section summarizes the proposed chemical analyses for soil, sediment, surface water, and groundwater.

7.3.1 Soil

Soil samples will be analyzed for the following 23 target analyte list (TAL) metals: aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, sodium, nickel, potassium, selenium, silver, thallium, vanadium, and zinc plus boron and molybdenum. Detailed analytical methods for the analyses are specified in the QAPP (Part 1 of Appendix B).

7.3.2 Surface Water

Surface water samples will be analyzed for the 23 TAL metals plus boron, cyanide, and molybdenum, in accordance with the laboratory analytical methods specified in the QAPP (Part 1 of Appendix B) for surface water. All of the analytes except for cyanide will be analyzed and reported on both a total and dissolved basis. Cyanide will be analyzed and reported on a total basis only.

Surface-water samples will also be analyzed for the following general chemistry parameters and anions: ammonia, alkalinity, sulfate, chloride, nitrate/nitrite, fluoride, total dissolved solids, total organic carbon, and total suspended solids. The laboratory analytical methods for general chemistry parameters and major anions are specified in the QAPP (Part 1 of Appendix B) for water.

7.3.3 Stormwater Runoff

Stormwater runoff samples will be analyzed for the 23 TAL metals plus boron, cyanide, and molybdenum, in accordance with laboratory analytical methods specified in the QAPP (Part 1 of Appendix B). All of the analytes listed above will be analyzed and reported on a totals basis. Stormwater runoff samples will also be analyzed for the general chemistry parameters and major anions listed in Section 7.3.2. The laboratory analytical methods for the general water quality parameters and major anions are specified in the QAPP (Part 1 of Appendix B) for water.

7.3.4 Process Water

Process water samples will be analyzed for the 23 TAL metals plus boron, cyanide, and molybdenum, in accordance with laboratory analytical methods specified in the QAPP (Part 1 of Appendix B). All of the analytes listed above will be analyzed and reported on a totals basis. Process water samples will also be analyzed for the general chemistry parameters and major anions listed in Section 7.3.2. The laboratory analytical methods for the general water quality parameters and major anions are specified in the QAPP (Part 1 of Appendix B) for water.

7.3.5 Groundwater

Groundwater samples will be analyzed for the following parameters, in accordance with laboratory analytical methods specified in the QAPP (Part 1 of Appendix B):

- Twenty-three (23) TAL metals plus boron, cyanide, and molybdenum;
- VOCs, including 1-2-dibromoethane, bromodichloromethane, chlorodibromomethane, chloroform, PCE, and TCE; and
- SVOCs, including bis(2-ethylhexyl) phthalate and naphthalene.

These analytes will be analyzed and reported on a totals basis only. Groundwater samples will also be analyzed for the following general chemistry parameters and major anions: alkalinity, sulfate, chloride, nitrate/nitrite, fluoride, and total dissolved solids. The laboratory analytical methods for the general water quality parameters and major anions are specified in the QAPP (Part 1 of Appendix B) for water.

7.3.6 Surface Water, Process Water, and Groundwater Isotopic Analysis

Two rounds (winter and summer) of both groundwater samples and surface water samples from the Gila River, the San Pedro River, Tailings Impoundment AB/BC, and Tailings Impoundment D will be analyzed for oxygen, hydrogen, sulfur isotopes, and oxygen isotope in sulfate. The groundwater collected from the direct push locations will have a one-time isotope analysis for the same parameters. The laboratory analytical methods for the isotopic analyses are specified in the QAPP (Part 1 of Appendix B).

The rationale for including the isotopic analyses in the Phase II RI is the following:

- The comparative isotopic compositions of surface water and groundwater will provide critical information on: (1) the sources of groundwater; (2) groundwater flow pathways (and thus, indirectly, information as to the sources of contamination); (3) the interaction between the bedrock and alluvial aquifers; (4) the potential connection between surface water and groundwater; and (5) the potential source(s) of water for the Hayden and Winkelman wellfields during pumping.
- It is expected that the isotopic composition of oxygen and hydrogen in the surface water in the Gila and San Pedro Rivers and ground water in the alluvial aquifer will be different in the summer season than in the winter season. Understanding seasonal variations in this data will help to understand the potential connection between surface water and groundwater in the study area.
- Because sulfate derived from weathering of sulfate evaporates has a significantly different sulfur isotope makeup than sulfate formed from the oxidation of sulfide

minerals associated with copper mines (such as the ASARCO Site), the sulfur isotopic analysis will provide information on the sources of dissolved sulfate in surface water and groundwater, and an additional line of evidence for the potential connection between the groundwater and surface water.

7.4 Data Evaluation

Data evaluation will be initiated with the validation process described in the QAPP. Validated data will be uploaded to the project database in accordance with the data management procedures described in the QAPP and the Standard Operating Procedure in Appendix E. Tabulated data will be compared to applicable federal, state, and local regulatory thresholds to identify exceedances of established screening levels or remediation criteria. Results will also be evaluated in the context of human health and ecological risk-based thresholds as described in the risk assessment work plans in Appendix A.

Data evaluation and interpretation will include, but will not be limited to, review of analytical and field data measurements; development and interpretation of maps illustrating the spatial distribution and concentration variations of COPCs; modeling; and identification of statistical, spatial, and temporal trends observed in the data. The data evaluation will also examine the correlation of COPCs in various media and evaluate the presence or potential migration of COPCs via leaching, erosion, surface water runoff, and other transport or exchange mechanisms.

The results of data evaluation and interpretation will be integrated into the CSM for further assessment of contaminant transport, potential risks to human health and the environment, and potential mitigation measures, as appropriate. Anticipated approaches to evaluating Site data are summarized in the following subsections.

7.4.1 Soil Data

Evaluation of soil data will include, but will not be limited to:

- Comparison of concentrations of COPCs site-wide against measured background concentrations.
- Comparison of concentrations of COPCs against applicable regulatory thresholds.
- Development of maps illustrating COPC distribution and concentration variations.
- Identification of potential sources of COPCs in soils.
- Evaluation of COPC migration from soils via leaching, erosion, stormwater runoff, and other transport mechanisms.

7.4.2 Surface Water Data

Evaluation of surface water data will include, but will not be limited to:

- Comparison of concentrations of COPCs against background concentrations.
- Comparison of concentrations of COPCs against regulatory thresholds.
- Evaluation of the distribution and concentration variability of COPCs relative to surface water flow, accumulation, deposition, erosion, or other transport mechanisms.
- Identification of potential sources of COPCs in surface waters.
- Evaluation of the migration potential for COPCs and existing or potential impacts downstream or downgradient of source areas.

7.4.3 Groundwater Data

Evaluation of groundwater elevations, chemistry, and other data will include, but will not be limited to:

- Comparison of concentrations of COPCs site-wide against measured background concentrations.
- Comparison of concentrations of COPCs against applicable regulatory thresholds.
- Identification of the locations of elevated COPCs and the distribution of COPCs relative to potential sources.
- Evaluation of the impact of COPCs on groundwater quality and the identification of the sources of COPCs in groundwater.
- Identification of groundwater flow directions and gradients.
- Preparation of groundwater potentiometric maps and maps illustrating the distribution of COPCs.
- Evaluation of the connectivity and interactions between the alluvial aquifer and bedrock aquifer.
- Evaluation of the connectivity and interactions between the alluvial aquifer and surface water along the Gila River in the vicinity of the Site, with particular emphasis on the area containing the tailings impoundments.
- Evaluation of the potential for COPCs in groundwater to migrate off site or downgradient of source areas.
- Evaluation of the sources of water from the Hayden and Winkelman wellfields.

7.5 Human Health Risk Assessment

The draft Baseline Human Health Risk Assessment (BHRRA) performed as part of the Phase I RI (CH2M HILL, 2008b) evaluated risks associated with the exposure of residents, recreational users, and in-town and remote trespassers to "contaminated soil, air, ground water, indoor and attic dust, and surface water and sediment." As part of the BHHRA, uncertainties associated with the risk evaluation were discussed and additional investigations to address data gaps were recommended. The investigations addressed in preceding sections are intended to fill these data gaps, in accordance with DQO #3, in order to reduce the uncertainties associated with evaluating potential health risks to residents due to exposures to COPCs emanating from the ASARCO Hayden Plant Site by way of groundwater, surface water including stormwater runoff, non-residential soil, and sediment.

The scope of the Phase II HHRA and the specific approaches, methods, and equations to be utilized are documented in a separate Non-Air Human Health Risk Assessment Work Plan attached as Part 1 of Appendix A to this Work Plan.

7.6 Ecological Risk Assessment

The Screening Level Ecological Risk Assessment (SLERA) conducted in 2008 (CH2M HILL, 2008c) concluded that multiple chemicals exceeded screening values for surface water. Uncertainties in the SLERA results were determined to include those associated with exposure estimates for birds and mammals, detection limits that exceeded screening benchmarks, and a generally limited dataset. As a result, the SLERA recommended additional investigations. As with the HHRA, the proposed investigations discussed in preceding sections are intended to fill the data gaps for the ecological risk assessment, in accordance with DQO #4.

A Baseline Ecological Risk Assessment (BERA) will be performed as part of the Phase II RI. The scope of the BERA and the specific approaches, methods, and equations to be utilized are documented within the Baseline Ecological Risk Assessment Work Plan attached as Part 2 of Appendix A to this Work Plan.

7.7 RI Report

A Phase II RI Report will be prepared to summarize the completed investigation activities. The report will be signed by an Arizona-registered geologist or engineer. The report will be organized generally as follows:

EXECUTIVE SUMMARY
1 INTRODUCTION
    1.1 Purpose of Report

1.2 Regulatory Framework
1.3 Site Background
1.3.1 Site Description
1.3.2 Site History
1.3.3 Previous Investigations
1.4 Report Organization
2 STUDY AREA INVESTIGATION
2.1 Soil Investigation
2.1.1 Tailings Impoundments
2.1.2 San Pedro Wash
2.1.3 Northern Waste Disposal
2.1.4 Lime and Filter Plants
2.1.5 Kennecott Avenue Wash and Tailings
2.1.6 Administration and Concentrator Support
2.1.7 Concentrate Production
2.1.8 Conveyor Belt Tailings
2.1.9 Ore Receipt and Secondary and Tertiary Crushing
2.1.10 Powerhouse Wash
2.1.11 Waste Water Treatment Plant
2.1.12 Concentrate Handling and Mixing
2.1.13 Smelter Support
2.1.14 Flash Smelting, Copper Converting, Anode Furnace
2.1.15 Reverts Crushing and Reclaim
2.1.16 Acid and Oxygen Plants
2.1.17 Slag Handling
2.1.18 Linear Features
2.1.19 Areas Outside of Areas 1 through 18
2.2 Surface Water and Sediment Investigation
2.3 Stormwater Runoff Investigation
2.4 Process Water Investigation
2.5 Groundwater Investigation
3 PHYSICAL CHARACTERISTICS OF THE STUDY AREA
3.1 Surface Features
3.2 Meteorology
3.3 Surface Water
3.4 Groundwater
3.5 Geology
3.6 Soils
3.7 Demographics and Land Use
3.8 Ecology
4 NATURE OF CONTAMINATION

4.1 Contaminant Sources
4.2 Soils
4.1.1 Tailings Impoundments
4.1.2 San Pedro Wash
4.1.3 Northern Waste Disposal
4.1.4 Lime and Filter Plants
4.1.5 Kennecott Avenue Wash and Tailings
4.1.6 Administration and Concentrator Support
4.1.7 Concentrate Production
4.1.8 Conveyor Belt Tailings
4.1.9 Ore Receipt and Secondary and Tertiary Crushing
4.1.10 Powerhouse Wash
4.1.11 Waste Water Treatment Plant
4.1.12 Concentrate Handling and Mixing
4.1.13 Smelter Support
4.1.14 Flash Smelting, Copper Converting, Anode Furnace
4.1.15 Reverts Crushing and Reclaim
4.1.16 Acid and Oxygen Plants
4.1.17 Slag Handling
4.1.18 Linear Features
4.1.19 Areas Outside of Areas 1 through 18
4.3 Surface Water and Sediment
4.4 Stormwater Runoff
4.5 Process Water
4.6 Groundwater
5 CONTAMINANT FATE AND TRANSPORT
5.1 Conceptual Site Model
5.2 Contaminant Mobility
5.3 Contaminant Migration
6 RISK ASSESSMENT
6.1 Human Health Risk Assessment
6.2 Baseline Ecological Risk Assessment
7 SUMMARY AND CONCLUSIONS
7.1 Summary
7.1.1 Soils
7.1.2 Surface Water and Sediment
7.1.3 Stormwater Runoff
7.1.4 Process Water
7.1.5 Groundwater
7.1.6 Data Gaps
7.2 Conclusions

7.2.1 Data Limits
7.2.2 Remedial Action Objectives
7.2.3 Preliminary Remedial Alternatives
8 REFERENCES
APPENDICES and ATTACHMENTS

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8.0 FEASIBILITY STUDY

This section provides a description of the overall approach and schedule for the FS for the non-air media. The purpose of the FS is to identify and evaluate a range of response alternatives to complement any early actions at the Site. The FS will use guidance, RI findings, risk information, and cleanup levels determined in the HHRA and ERA. The FS will include an analysis of ARARs, with consideration of related requirements applicable to ongoing facility operations that are regulated under other programs (for example, the Clean Air Act, the Arizona Aquifer Protection Permit program, and mining closure requirements).

The FS will follow the pertinent procedures outlined in *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA, 1988), as well as *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study (EPA, 2000).* The draft FS report will be submitted within 120 days after receipt of EPA approval of the RI Report. Consistent with the AOC, the final FS report will be submitted within 20 days after consolidated agency comments are received. The general FS process to be followed is summarized in the following subsections.

8.1 Development and Screening of Alternatives

The development and screening of response alternatives will consist of six general steps:

1. Based on the risk assessments and RI findings, remedial action objectives (RAOs) will be developed specifying the contaminants of concern and environmental media of interest, exposure pathways, and preliminary remediation goals (PRGs) that permit a range of response alternatives to be developed. The PRGs will be developed on the basis of chemical-specific ARARs when available, other available information, and Site-specific risk-related factors.
2. General response actions (GRAs) for each environmental medium of interest will be developed that might be implemented alone, or in combination, to satisfy RAOs. The GRAs will include, as appropriate, options as to which treatment may be used to reduce the toxicity, mobility, or volume of wastes; options involving containment with little or no treatment; options involving both treatment and containment; institutional controls; and no action.
3. Volumes or areas of environmental media to which GRAs might be applied will be determined, taking into account the requirements for protectiveness as identified in the RAOs and the chemical and physical characterization of the Site.

4. Technologies applicable to each GRA will be identified and screened to eliminate those that cannot be implemented technically at the Site.
5. Technology process options will be identified and evaluated to select a representative process or processes for each technology type retained for consideration.
6. The remaining technologies and process options will be combined into media-specific or Site-wide response alternatives. If many distinct viable options, or combinations thereof, are available and developed, alternatives will be screened to limit the number of alternatives that undergo detailed analysis so that only the most promising process options are evaluated. The alternatives will be screened on a general basis with respect to their effectiveness, implementability, and cost, as well as a consideration of the environmental effects and sustainability ("environmental footprint") of remedy implementation, to maximize the net environmental benefit of cleanup actions (EPA, 2008).

8.2 Detailed Analysis of Alternatives

A detailed analysis of the assembled initial alternatives will be performed against seven criteria in the FS, in accordance with the NCP, to ensure that the selected remedial alternative will:

- Be protective of human health and the environment;
- Be in compliance with, or include a waiver of, ARARs;
- Be cost-effective;
- Utilize permanent solutions and alternative treatment technologies, or resource recovery technologies, to the maximum extent practicable; and
- Address the statutory preference for treatment as a principal element.

The evaluation criteria are as follows:

- *Overall Protection of Human Health and the Environment:* Addresses whether or not a remedy will provide adequate protection and describes how risks posed through each pathway will be eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls. This criterion will also address whether a reduction in the overall environmental footprint of the remedy ("green remediation") will be achieved, either by using natural resources and energy efficiently, reducing negative impacts on the environment, minimizing or eliminating pollution at its source, and/or reducing waste to the greatest extent possible.

- *Compliance with Applicable Regulatory Requirements:* Addresses whether or not a remedy will meet the requirements of pertinent federal and state environmental laws and regulations, including revisions to relevant water quality standards.
- *Long-Term Effectiveness and Permanence:* Refers to the ability of a remedy to maintain reliable protection of human health and the environment over time once remedial goals have been met.
- *Reduction of Toxicity, Mobility, or Volume through Treatment:* Refers to the anticipated performance goal of the treatment technologies that a remedy may employ.
- *Short-Term Effectiveness:* Addresses the period of time needed to achieve protection, and any adverse impacts on human health and the environment that may be posed during the construction and implementation period until remediation goals are achieved.
- *Implementability:* Refers to the technical and administrative feasibility of implementing a remedy, including the availability of materials and services needed to implement a particular option.
- *Cost:* Includes estimated capital and operation and maintenance costs, and net present worth costs.

The detailed analysis of each alternative will include: (1) a technical description of each alternative that outlines the waste management strategy involved and identifies the key environmental standards associated with each alternative; and (2) a discussion that profiles the performance of that alternative with respect to each of the evaluation criteria. Once the detailed analysis is complete, the alternatives will be compared and contrasted to one another with respect to each of the evaluation criteria (the comparative analysis).

8.3 Feasibility Study Report

The results of the feasibility study will be presented in an FS Report that provides a description of remedial alternatives to address contaminant sources, identifies areas of unacceptable risk within the Study Area; presents a detailed analysis and comparison of remedial alternatives, and includes the results of any treatability studies that are conducted.

Generally, the Feasibility Study Report will follow the outline presented below:

Section 1	Introduction
Section 2	Site Characteristics
Section 3	Remedial Action Objectives
Section 4	Applicable or Relevant and Appropriate Requirements (ARARs)

Section 5 Identification and Screening of General Response Actions, Remedial Technologies, and Process Options

Section 6 Development and Screening of Alternatives

Section 7 Definition of Criteria Used in the Detailed Analysis of Retained Alternatives

Section 8 Detailed Analysis of Retained Alternatives

Section 9 Comparative Evaluation of Remedial Alternatives

Section 10 References

9.0 COMMUNITY RELATIONS

As required by Section IX of the AOC, A Community Involvement Plan for the Phase II RI/FS has been prepared by the EPA Community Involvement Coordinator (CIC) along with the ADEQ CIC. The Community Relations Plan is attached in Appendix G. This CIP, which will be implemented by EPA, describes steps that the EPA will implement to communicate information regarding planned activities to the community and to provide ways in which the community can share information with or ask questions of EPA. The CIP also provides contact information, locations of document repositories, and schedules for meetings to facilitate the exchange of information. The ITSI Project Manager will assist the EPA RPM and the EPA CIC in performing community relations activities.

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10.0 SCHEDULE

Table 10-1 presents a general schedule of events for the RI/FS activities outlined in this Work Plan. A summary of the work products that will be submitted is also included in the schedule. Agency review periods and other timeframes not otherwise specified in the AOC have been estimated. The schedule is subject to change, and may need to be updated periodically depending on field conditions and the progress of each scheduled activity.

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11.0 REFERENCES

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TABLES

FIGURES

APPENDICES

APPENDIX A

Risk Assessment Work Plans

Part 1 – Non-Air Human Health Risk Assessment
Part 2 – Non-Air Ecological Risk Assessment

APPENDIX A

Risk Assessment Work Plans

Part 1 – Non-Air Human Health Risk Assessment

APPENDIX A

Risk Assessment Work Plans

Part 2 – Non-Air Ecological Risk Assessment

APPENDIX B

Sampling & Analysis Plan

Part 1 – Quality Assurance Project Plan
Part 2 – Field Sampling Plan

APPENDIX B

Sampling & Analysis Plan

Part 1 – Quality Assurance Project Plan

APPENDIX B

Sampling & Analysis Plan

Part 2 – Field Sampling Plan

APPENDIX C

Site-Specific Health & Safety Plan

APPENDIX D

Quality Management Plan (QMP)

APPENDIX E

Standard Operating Procedure: Sample Tracking and Electronic Data Management

APPENDIX F

UCL Maps for Hayden Residential Property Soil Removal

APPENDIX G

Community Involvement Plan