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

PART 1 OF 2 - AIR

ASARCO HAYDEN PLANT SITE

TOWNS OF HAYDEN AND WINKELMAN
PINAL AND GILA COUNTIES, ARIZONA

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TABLE OF CONTENTS

Table of Contents i
List of Tables iv
List of Figures v
List of Appendices vi
Acronyms and Abbreviations viii
1.0 INTRODUCTION 1-1
1.1 Definitions 1-3
1.2 Objectives 1-3
1.3 Work Plan Organization 1-5
2.0 SITE BACKGROUND AND SETTING 2-1
2.1 ASARCO Hayden Complex 2-1
2.1.1 History of Operations 2-1
2.1.2 Current Operations 2-3
2.2 Demographics and Land Use 2-9
2.3 Physical Setting 2-9
2.3.1 Climate 2-9
2.3.2 Site Topography 2-10
2.4 Previous Investigations/Information 2-13
2.4.1 Multi-Media Investigations/Information 2-14
2.4.2 Air Quality Investigations/Information 2-16
2.4.3 Related Non-Air Quality Investigations/Information 2-23
2.5 Regulatory Framework 2-27
2.5.1 National Ambient Air Quality Standards 2-27
2.5.2 Hayden Operations as a Minor Source of HAPs (2004) 2-28
2.5.3 Air Permitting 2-28
2.5.4 Air Emissions Reporting 2-30
2.6 Remedial Investigation Areas 2-32
3.0 PRELIMINARY SITE CHARACTERIZATION 3-1
3.1 Ambient Air Data Summary 3-1
3.1.1 PM_{10} Data 3-2
3.1.2 Metals Data 3-2

3.2 Comparison of Air Quality Data to Reference Values 3-6
3.2.1 Comparison to Background Air Quality 3-6
3.2.2 Comparison to National Air Toxics Trend Sites Network 3-8
3.2.3 Comparison to Standards and Health-Based References 3-9
3.3 Comparative Analysis of Ambient Air Data 3-13
3.3.1 Data Trends 3-13
3.3.2 Correlation of Metal COPCs at the Same Monitoring Station 3-14
3.3.3 Correlation of Metal COPCs Across Monitoring Stations 3-16
3.4 Relationship of Ambient Air COPC Data and Potential Sources 3-16
3.4.1 Speciation & Particle Size Distribution – Previous Studies 3-16
3.4.2 Windrose Analysis and Potential Source Identification 3-18
3.4.3 Ambient Air Quality During Smelter Shutdowns 3-19
4.0 CONCEPTUAL SITE MODEL 4-1
4.1 Chemicals of Potential Concern 4-1
4.1.1 Chemicals of Potential Concern for Human Health Impacts 4-1
4.1.2 Chemicals of Potential Ecological Concern 4-1
4.2 Elements of the Conceptual Site Model 4-2
4.3 Relationship of CSM to RI Study Areas 4-3
4.4 RI Area Summaries 4-4
4.4.1 Area #1A and Area #1B 4-4
4.4.2 Area #2 – San Pedro Wash 4-7
4.4.3 Area #3 – Northern Waste Disposal 4-9
4.4.4 Area #4 – Lime and Filter Plants 4-13
4.4.5 Area #5 – Kennecott Avenue Wash and Tailings 4-16
4.4.6 Area #6 – Administration and Concentrator Support 4-18
4.4.7 Area #7 –Concentrate Production 4-20
4.4.8 Area #8 – Conveyor Belt Tailings 4-21
4.4.9 Area #9 – Ore Receipt and Secondary and Tertiary Crushing 4-23
4.4.10 Area #10 – Powerhouse Wash 4-25
4.4.11 Area #11 – Waste Water Treatment Plant 4-27
4.4.12 Area #12 – Concentrate Handling and Mixing 4-29
4.4.13 Area #13 – Smelter Support 4-30
4.4.14 Area #14 – Flash Smelting, Copper Converting, Anode Furnace 4-32

4.4.15 Area #15 – Reverts Crushing and Reclaim 4-34
4.4.16 Area #16 – Acid and Oxygen Plants 4-36
4.4.17 Area #17 – Slag Handling 4-37
4.4.18 Area #18A through #18D – Linear Features 4-38
4.4.19 Area #19 – Area Outside of Areas #1 - #18 4-39
5.0 PRELIMINARY APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs) 5-1
5.1 ARARS Specific to RI Tasks 5-1
5.1.1 Federal ARARS 5-1
5.1.2 Arizona State ARARS 5-3
5.1.3 Local ARARs 5-3
5.2 TBCs Specific to RI Tasks 5-3
5.2.1 Federal TBCs 5-3
5.2.2 State TBCs 5-4
5.3 ARARS Specific to FS Tasks 5-5
5.3.1 Federal ARARS 5-5
5.3.2 State ARARS 5-7
5.3.3 Local ARARS 5-7
5.4 To Be Considered –Specific to FS Tasks 5-8
6.0 WORK PLAN RATIONALE AND APPROACH 6-1
6.1 Overview 6-1
6.2 Ambient Air Quality Investigation 6-3
6.2.1 Ambient Air Monitoring 6-4
6.2.2 Laboratory Analyses of Particulate Matter Samples 6-5
6.3 Meteorological Monitoring 6-6
6.4 Source Sampling and Characterization 6-6
6.4.1 Source Profile Development 6-7
6.4.2 Characterization of Particulate Matter Samples 6-10
6.5 Source Apportionment 6-10
6.6 Risk Assessment 6-14
7.0 RI TASKS 7-1
7.1 Review of New Data and Work Plan Addendum 7-1
7.2 Procurement, Access, Permits, and Authorizations 7-1

7.2.1 Subcontractor and Consultant Procurement 7-2
7.2.2 Access Agreements 7-2
7.2.3 Regulatory Permits and Authorizations 7-2
7.3 Field Investigations 7-2
7.3.1 Ambient Air Quality Investigation 7-3
7.3.2 Emission Source Sampling 7-12
7.4 Laboratory Studies: Sample Analysis and Validation 7-14
7.4.1 Testing Methods 7-15
7.4.2 Testing Program Flowcharts 7-15
7.5 Data Analysis and Evaluation 7-18
7.5.1 Data Analysis and Source Apportionment 7-19
7.6 Process for Identification and Evaluation of Data Needs, Gaps, and Uncertainties 7-21
7.7 Risk Assessment 7-22
7.8 RI Report Preparation 7-22
8.0 FEASIBILITY STUDY 8-1
8.1 Development and Screening of Alternatives 8-1
8.2 Detailed Analysis of Alternatives 8-2
8.3 Feasibility Study Report 8-3
9.0 COMMUNITY RELATIONS 9-1
10.0 SCHEDULE 10-1
11.0 REFERENCES 11-1

LIST OF TABLES

2-1 Comparison - Half Hour Wind Direction and Speed
2-2 Summary of PM_{10} Fraction Laboratory Data from 1999 to 2001 ADEQ Hayden Jail Station
2-3 ASARCO Hayden Complex SO_2 Air Pollution Control Upgrades
2-4 Air Release Data from Toxic Release Inventory Explorer Database 2003 - 2009
3-1 Calendar Year Comparison PM_{10} and Metals at Hayden and Winkelman Stations
3-2 Air Quality Standards and Risk-Based Reference Values with Background Concentrations
3-3 Comparison Hayden and Winkelman Station Data to Phoenix and Tucson NATTS Data (2006-2007)
3-4 Calendar Year Shutdown Comparison
4-1 Chemicals of Potential Concern
5-1 ARARs and TBCs

5-2 ARAR and TBC Based Minimum Ambient Air Criteria Level
6-1 ASARCO Air Monitoring Locations and Configurations
6-2 Air-Related Soil Samples
6-3 Project Components Related to Field Monitors and Laboratory Analyses
10-1 Project Schedule

LIST OF FIGURES

2-1 ASARCO Vicinity Map
2-2 Study Area Map
2-3 Key Features of Study Area
2-4 Key Features of Study Area with Topographic Contours
2-5 Wind Roses for Selected Air Monitoring Stations in Hayden Area
2-6 Overview of RI Areas
3-1 24-Hour Ambient Air PM_{10} Results – Hayden Station
3-2 24-Hour Ambient Air PM_{10} Results – Winkelman Station
3-3 24-Hour Ambient Air Arsenic Results – Hayden Station
3-4 24-Hour Ambient Air Arsenic Results – Winkelman Station
3-5 24-Hour Ambient Air Lead Results – Hayden Station
3-6 24-Hour Ambient Air Lead Results – Winkelman Station
3-7 24-Hour Ambient Air Copper Results – Hayden Station
3-8 24-Hour Ambient Air Copper Results – Winkelman Station
3-9 24-Hour Ambient Air Cadmium Results – Hayden Station
3-10 24-Hour Ambient Air Cadmium Results – Winkelman Station
3-11 24-Hour Ambient Air Chromium Results – Hayden Station
3-12 24-Hour Ambient Air Chromium Results – Winkelman Station
3-13 Winkelman Station Wind Rose – Arsenic, Copper, and Lead
3-13A Winkelman Station Wind Rose – High Arsenic, Copper & Lead
3-13B Winkelman Station Wind Rose – Low Arsenic, Copper & Lead
3-14 Hayden Station Wind Rose – Arsenic, Cadmium, Chromium, Copper, and Lead
3-14A Hayden Station Wind Rose – High Arsenic, Copper, Cadmium & Chromium
3-14B Hayden Station Wind Rose – High Arsenic, Copper & Lead
3-14C Hayden Station Wind Rose – Low Arsenic, Copper & Lead 11/22/2010
3-14D Hayden Station Wind Rose – Low Arsenic, Copper & Lead 02/07/2010
3-15 Idealized ambient size distribution showing formation mechanisms and chemical components associated with different regions.
3-16 Hayden Station Wind Rose - Top 10 Days: Arsenic, Cadmium, Chromium, Copper, and Lead
3-16A Hayden Station Wind Rose – Top 10 High Arsenic Days
3-16B Hayden Station Wind Rose – Top 10 High Copper Days
3-16C Hayden Station Wind Rose – Top 10 High Cadmium Days
3-16D Hayden Station Wind Rose – Top 10 High Lead Days
3-16E Hayden Station Wind Rose – Top 10 High Chromium Days
3-16F Hayden Station Wind Rose – Top 10 High PM_{10} Days

3-17 Winkelman Station Wind Rose – Top 10 Days: Arsenic, Cadmium, Chromium, Copper, and Lead
3-17A Winkelman Station Wind Rose – Top 10 High Arsenic Days
3-17B Winkelman Station Wind Rose – Top 10 High Chromium Days
3-17C Winkelman Station Wind Rose – Top 10 High Cadmium Days
3-17D Winkelman Station Wind Rose – Top 10 High Lead Days
3-17E Winkelman Station Wind Rose – Top 10 High Copper Days
3-17F Winkelman Station Wind Rose – Top 10 High PM_{10} Days
4-1 Conceptual Site Model Diagram for Human Exposures
4-2A Features of Area #1A, Tailings Impoundment D
4-2B Features of Area #1B, Tailings Impoundment AB/BC
4-3 Features of Area #2, San Pedro Wash
4-4 Features of Area #3, Northern Waste Disposal
4-5 Features of Area #4, Lime and Filter Plants
4-6 Features of Area #5, Kennecott Avenue Wash and Tailings
4-7 Features of Area #6, Administration and Concentrator Support
4-8 Features of Area #7, Concentrate Production
4-9 Features of Area #8, Conveyor Belt Tailings
4-10 Features of Area #9, Ore Receipt and Secondary and Tertiary Crushing
4-11 Features of Area #10, Powerhouse Wash
4-12 Features of Area #11, Waste Water Treatment Plant
4-13 Features of Area #12, Concentrate Handling and Mixing
4-14 Features of Area #13, Smelter Support
4-15 Features of Area #14, Flash Smelting, Copper Converting, and Anode Furnace
4-16 Features of Area #15, Reverts Crushing and Reclaim
4-17 Features of Area #16, Acid and Oxygen Plants
4-18 Features of Area #17, Slag Handling
4-19AB Features of Area #18A and Area#18B, Kennecott Avenue and Hayden Junction Railroad Segment
4-19CD Features of Area #18C and Area #18D, Smelter Hill and Winkelman Railroad Segment
6-1 Air Investigation Approach
6-2 Ambient Air Monitoring Stations and Key Features of Site Vicinity
6-3 Source Sampling Locations and Key Features of Site Vicinity
6-4 Proposed Mobile SODAR Locations and Surface Sampling Locations
7-1 Monitor and Filter Flowchart
7-2 MiniVol Sampling and Analysis Configuration

LIST OF APPENDICES

A Human Health Risk Assessment (HHRA) Work Plan
B Sampling and Analysis Plan – Ambient Air and Source Characterization
1. Quality Assurance Project Plan (QAPP)
2. Field Sampling Plan
C Network Design Plan

D Quality Management Plan (QMP)
E Site-Specific Health & Safety Plan (SHSP)
F Standard Operating Procedure: Sample Tracking and Electronic Data Management
G Community Involvement Plan (CIP)

ACRONYMS AND ABBREVIATIONS

^{o}F	Degrees Fahrenheit
AAC	Arizona Administrative Code
ACAAC	Arizona Ambient Air Concentration Standard
ACR	Amarillo Copper Refinery
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
AMTIC	Ambient Monitoring Technology Information Center
AOC	Administrative Order on Consent
ARARs	applicable or relevant and appropriate requirements
ARS	Arizona Revised Statutes
ASARCO	ASARCO LLC
ATSDR	Agency for Toxic Substances and Disease Registry
B&C	Brown and Caldwell
BAAQMD	Bay Area Air Quality Management District
BACT	Best Available Control Technology
bgs	below ground surface
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CIP	Community Involvement Plan
CO	carbon monoxide
COC	chemical of concern
COPC	chemical of potential concern
COPEC	chemical of potential ecological concern
CSM	Conceptual Site Model
CSMA	Conceptual Site Model-Air
CV	Comparison Values
CWA	Clean Water Act
DQO	data quality objective
DRI	Desert Research Institute
E&E	Ecology and Environment, Inc.
EC	exposure concentration
EDX	energy dispersive X-ray
ELCR	excess lifetime cancer risk
EPA	United States Environmental Protection Agency
EPC	exposure point concentration
EPCRA	Emergency Planning and Community Right-to-Know Act
ER	Emergency Response
ERA	Ecological Risk Assessment
ESI	Expanded Site Inspection

E-SI	Engineering-Science, Inc.
FEM	Federal Equivalent Method
FRM	Federal Reference Method
FS	Feasibility Study
FSP	Field Sampling Plan
GRA	general response action
HAP	hazardous air pollutant
HHRA	Human Health Risk Assessment
HI	hazard index
ILCR	incremental lifetime cancer risk
IMPROVE	Interagency Monitoring of Protected Visual Environments
IUR	inhalation unit risk
Kennecott	Kennecott Copper Corporation
LAER	Lowest Achievable Emission Rate
LCS	Laboratory Control Samples
MACT	Maximum Achievable Control Technology
MDL	method detection limit
MET	meteorological
mg/kg	milligrams per kilogram
mg/m^3	milligrams per cubic meter
MPRSA	Marine Protection Research and Sanctuaries Act
msl	mean sea level
NAAQS	National Ambient Air Quality Standard
NCCC	Nevada Consolidated Copper Company
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NESHAPs	National Emissions Standards for Hazardous Air Pollutants
NOX	nitrogen oxides
NPL	National Priorities List
NSPS	New Source Performance Standards
NSR	New Source Review
Organ Pipe	Organ Pipe National Monument
OSHA	Occupational Safety and Health Administration
PA	Preliminary Assessment
Pb	lead
PCAQCD	Pinal County Air Quality Control District
PEF	particulate emission factor
PHA	Public Health Assessment
PM	particulate matter
$PM_{2.5}$	particulate matter less than 2.5 microns)
PM_{10}	particulate matter of ten micrometers or less
ppm	parts per million
PQL	practical quantitation limit
PRG	preliminary remediation goal
QA	quality assurance
QAPP	Quality Assurance Project Plan

QC	quality control
R&R	reverberatory furnace and roaster
RA	Remedial Action
RAO	remedial action objective
RCCC	Ray Consolidated Copper Company
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design
REL	Relative Exposure Limit
RfC	reference concentrations
RFQ	request for quotation
RI/FS	Remedial Investigation/Feasibility Study
RME	reasonable maximum exposure
R-SRL	Residential Soil Remediation Level
RSL	Regional Screening Level
SAP	Sampling and Analysis Plan
SAS	source apportionment study
SDWA	Safe Drinking Water Act
SEM	scanning electron microscope
SHSP	Site-Specific Health & Safety Plan
SI	Site Inspection
SIP	State Implementation Plan
Site	ASARCO Hayden Plant Site, Hayden, Arizona
SLERA	Screening-Level Risk Assessment
SO_2	sulfur dioxide
SODAR	SOnic Detection and Ranging
SOP	standard operating procedure
SOW	Statement of Work
SVOC	semivolatile organic compound
SWDA	Solid Waste Disposal Act
TAL	Target Analyte List
tpd	tons per day
tpy	tons per year
TRI	Toxic Release Inventory
TSCA	Toxic Substances Control Act
TSP	total suspended particulates
UCL	upper confidence limit
ug/m^3	micrograms per cubic meter
um	micron
VOC	volatile organic compound
WP	Work Plan
XRF	X-ray fluorescence

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1.0 INTRODUCTION

This Work Plan details procedures for conducting the air portion of the Phase II Remedial Investigation and Feasibility Study (RI/FS) at the ASARCO Hayden Plant Site (Site) in Hayden, Arizona. The work outlined in this Work Plan is to be performed to satisfy the requirements of the April 2008 Administrative Settlement Agreement and Order on Consent (Settlement Agreement or AOC; EPA, 2008a) between ASARCO LLC (ASARCO), the U.S. Environmental Protection Agency (EPA), and the Arizona Department of Environmental Quality (ADEQ) related to the investigation of sources of air pollution from the Site. This Work Plan is Part 1 of two parts that make up the entire Phase II RI/FS Work Plan for the ASARCO Hayden Plant Site. Part 2 of 2 will evaluate the nature and extent of contamination in soil, surface water, groundwater, and sediment. The RI/FS Work Plan has been broken up into two documents to facilitate implementation of each component and to expedite the overall completion of the RI/FS.

The ASARCO Hayden Plant Site is defined for the 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 nearly two 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).

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.

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.

This Phase II RI/FS Work Plan (Part 1 of 2) identifies additional data to be collected to characterize ambient air conditions and source emissions and related human health 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 pertinent and available Site data related to air, and identifies additional air data to be collected to fill gaps needed for full site characterization and to

support the risk assessment, a source apportionment study, and the identification and evaluation of appropriate response actions in the FS. This Work Plan also considers data from various operating permits, where available.

1.1 Definitions

The AOC contains several definitions of terms that are used with the following specific meanings in this document:

> **Site**: "the ASARCO Hayden Plant Site, which includes the ASARCO Hayden Smelter and associated facilities owned or operated by Respondent [ASARCO] in Hayden, Arizona, and any areas where hazardous substances from those facilities have come to be located." The boundaries of the Site will be determined by the RI/FS process, and thus are not currently defined.
>
> **Residential Site:** "all areas within the Site that are not owned by Respondent [ASARCO], including, but not limited to, residences, public areas, and vacant lots in Hayden and Winkelman."
>
> **Hayden Complex:** "property owned by Respondent [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 in this Work Plan as it applies to the overall 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 Phase II 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.
- Identify those chemicals of potential concern (COPCs) that may pose unacceptable risk to human health and the environment.
- Characterize the distribution of COPCs in the Study Area in media such as air, non-residential soils, sediments, surface water, stormwater runoff, process water, and groundwater, as well as any connections (fate and transport) between such media.
- 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.

At their highest level, the scope and objectives of the proposed air quality investigations can be defined as follows:

- Investigation of the particulates suspended in ambient air within the Study Area toward the objective of identifying what COCPs are present and at what concentrations, to enable the evaluation of exposure risk in the HHRA; and
- Characterization of the potential sources of particulate releases into air both as a primary input into the evaluation of alternative remedies in the FS and as a key component of the source apportionment study.

As indicated, a primary endpoint use of the ambient air quality monitoring data will be to support the assessment of potential risk to human receptors in the HHRA. The HHRA for the air exposure pathway will be based on the COPCs to which potential receptors are being exposed in ambient air, regardless of the source(s) of those COPCs within the ASARCO Hayden Complex. The need to relate ambient air data and associated exposure risks to specific emission sources will be of primary importance to the evaluation of alternative remedial actions in the FS. The vehicle that will be used to determine the contribution that potential emission sources make to

the ambient airborne particulates and COPCs measured at receptor locations within the Study Area is the source apportionment study to be performed as part of the Phase II RI.

Input to the source apportionment study will include three primary elements: (1) the chemical and physical characteristics of particulate matter collected at the ambient air quality monitoring stations; (2) an understanding of the local meteorological conditions as a determinant of the likelihood that particulates released from a particular source could reach a given receptor location; and (3) the potential of a particular source to emit particulate matter into the air and the chemical and physical characteristics of the particulates released. The scope of Part 1 of 2 of the RI (Air) focuses on these three inputs to the source apportionment study as the basic building blocks to meet the ultimate study objectives in the HHRA and FS.

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.

1.3 Work Plan Organization

This RI/FS Work Plan, Part 1 of 2, is organized as follows:

Section 1.0, Introduction: Provides a brief history of previous environmental work at the Site, definitions, and Work Plan organization.

Section 2.0, Site Background and Setting: Provides a description of the operational history of the Site and the background and setting for the Phase II RI/FS. It incorporates pertinent information from the draft Phase I RI Report and relevant updates based on events that have occurred since the completion of the draft Phase I RI Report.

Section 3.0, Preliminary Site Characterization: Presents a summary of the results of previous investigations of air quality conducted at the Site. Based on these results, a preliminary characterization of Site air quality is presented.

Section 4.0, Conceptual Site Model: Presents a discussion of the initial evaluation of chemicals of potential concern (COPCs) and the likely sources of the COPCs present in the air at the Site. Based on currently available data and information, a Conceptual Site Model (CSM) is presented that depicts potential sources, release mechanisms, exposure pathways and routes, and the human receptors. Summaries of 19 RI Areas that form the basis of the overall Phase II RI are also included in Section 4.0.

Section 5.0, Preliminary Applicable or Relevant and Appropriate Requirements (ARARs): Presents a preliminary identification of ARARs. Preliminary ARARs are identified as federal, state or local. Pertinent guidance, policy or local requirements that do not meet the criteria for ARARs are also listed within the To Be Considered (TBC) category.

Section 6.0, Work Plan Rationale and Approach: Provides an explanation of the data quality objectives (DQOs) for this project and how these DQOs will be addressed in the Phase II RI. Data gaps and the type, quantity, and quality of data necessary to fill these data gaps are identified.

Section 7.0, RI Tasks: Provides a summary description of the tasks to be completed as part of the Phase II RI, including source characterization and ambient air monitoring; sample analysis and validation; data evaluation; source apportionment; risk assessment; and report preparation.

Section 8.0, Feasibility Study: Provides a description of the overall approach for the FS that will be performed in conjunction with the Phase II RI. The purpose of the FS is to identify and evaluate a range of response alternatives to complement those removal actions that have been conducted at the Site.

Section 9.0, Community Relations: Summarizes the planned community relations activities and the associated responsibilities.

Section 10.0, Schedule: Presents the planned schedule for the completion of the RI/FS activities for the Site.

Section 11.0, References: Identifies the documents referenced in Part 1 of 2 the Phase II RI Work Plan.

2.0 SITE BACKGROUND AND SETTING

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

The ASARCO Hayden Complex is located approximately 100 miles east-southeast of Phoenix and 50 miles northeast of Tucson. ASARCO conducts copper ore processing operations to the north, west, east, and south of Hayden, Arizona, and to the north, west, and southwest of Winkelman, Arizona (Figure 2-1). The Study Area for the RI/FS generally encompasses the towns of Hayden and Winkelman, the ASARCO-owned and operated ore processing operations including the former Kennecott smelter, and the area surrounding and including the confluence of the Gila River and San Pedro River (Figure 2-2). Background sample locations not included on Figure 2-2 are also considered to be part of the Study Area.

2.1 ASARCO Hayden Complex

This section addresses the historical and current operational history of the ASARCO 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. in 1898, and then to Gila & Ray Copper Mines in 1906. During this period, the towns of Winkelman and Hayden were founded. 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, referenced in CH2M Hill, 2008a). 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 reverberator 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 when Kennecott began operation of its own Hayden smelter, which included construction of a 600-foot stack. As a result of the development of a new type of concentrate haulage cars in conjunction with the Southern Pacific Railroad, the ASARCO

Hayden smelter was able to receive concentrates from the Pima, Duval, Bagdad, Cyprus, Silver Bell, and Mission mines starting in 1958.

The existing 1,000-foot double-shell concrete stack was built by ASARCO in 1974 to discharge exhaust gases from the smelting complex, replacing the 300-foot R&R stack and 250-foot converter stack. Processing of ore from the Ray Mine was resumed at ASARCO"s Hayden smelter in 1983 following the cessation of operations at the Kennecott smelter in the previous year. ASARCO bought the Ray Mines Division from Kennecott in 1986, which included the Kennecott smelter, and has since demolished a number of structures associated with the Kennecott smelter. In 1984, ASARCO completed modernization of 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 waste water treatment plant to recover process water from the sulfuric acid plant for reuse. Modernization of the Hayden concentrator was completed in 1996 (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 disposal rate had increased to approximately 16,000 tpd by 1952, and to 21,000 tpd in 1960. A single-point discharge system initially was used 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. Tailings seepage was evident mainly along the western half of the tailings impoundments. The slope eventually failed (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, 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 ASARCO 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 Kennecott lime and filter plant facilities also remain in place, and are used in current operations.

2.1.2 Current Operations

Currently, sulfide ore undergoes primary crushing at the Ray Mine and is subsequently transported by rail to the Hayden Complex. The ore is offloaded at the track hopper and passed through secondary and tertiary crushing processes, located near the rail unloading facility, where it is further reduced in size. The ore is then transported by Conveyor 9 to rod mills and ball mills located at the 27,400 tpd Hayden concentrator complex, 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, containing about 25% to 30% copper, is dewatered and then transported to the 720,000 tons per year (tpy) Hayden smelter, located approximately 2,000 feet east-northeast of Hayden.

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 Inco flash furnace, converters, anode casting, an oxygen plant, and an acid plant (NewFields, 2008). 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 Inco flash furnace. Copper concentrates produced at the Ray Mine and other locations (such as Mission North, Robinson, Chino, and Montana Resource Mines) also arrive at the Hayden Complex for smelting based on market conditions. 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 SO_2 gas. The matte from the flash furnace is subsequently processed in converter furnaces to remove additional impurities and produce blister copper (approximately 95% copper). Finally, the blister copper is 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 either a slag reclaim area or to an open deposition area located immediately southeast of the smelter building (Figure 2-3) depending on the slag copper content. High copper slag is cooled, crushed, and reintroduced into the smelting process to recover additional copper. 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 retention ponds located east of Tailings Impoundment AB/BC, from which it is recycled for reuse in 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 Power House 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, or K-Pond) at the northwestern edge of Tailings Impoundment AB/BC, and containment berms in select locations within the tailings impoundment areas (Figure 2-3). 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 a length of approximately 2.5 miles, with a maximum width of one mile and a maximum height of 200 feet. 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.

The following descriptions of ASARCO‟s Hayden operations provide a more detailed explanation of the operations and are based on information in the Draft RI/FS Study Work Plan (NewFields, 2008), the Revised RI/FS Work Plan (Brown and Caldwell, 2011), the proposed ASARCO air quality permit, and other sources.

Ore Receipt and Secondary Crushing Operations

Copper-containing sulfide ore is mined and crushed at ASARCO‟s Ray Mine facility, located approximately 15 miles northwest of Hayden. Approximately 30,000 tons of crushed ore are delivered each day by rail to the Hayden Complex track hopper, where the ore is unloaded and conveyed via underground conveyor belts to the crusher building for further size reduction. The secondary crushing process reduces the ore to approximately 4-inch-sized pieces, while the tertiary crushing process further reduces the ore down to pieces between 0.5 inches and 0.75 inches. Conveyor belts transport the ore in the crushing circuit, which includes a Transfer House adjacent to the Crusher Building. Screens are used to size the material, returning the larger pieces to the crushing circuit. The crushed ore is conveyed overland on a covered beltline (Conveyor 9) to the Fine Ore Building.

The Fine Ore Building serves as a storage area for the fine ore produced by the crusher. The storage area is covered by a roof and has metal walls on two sides. The other two sides are covered by plastic flaps. The Conveyor 9 belt that transports the material from the Crusher Building drops the material onto the enclosed storage pile.

The material that is delivered to and processed at Hayden is, in general, a sulfide ore that may contain some or all of the following minerals:

- Chalcopyrite ($CuFeS_2$)
- Bornite (Cu_5FeS_4)

- Chalocite (Cu_2S)
- Covellite (CuS)
- Pyrite (FeS_2)
- Arsenopyrite ($FeAsS$).

Some oxide minerals, including the following, also may be present:

- Malachite ($CuCO_3.Cu(OH)_2$)
- Chrysocolla ($CuSiO_3.2H_2O$)
- Cuprite (Cu_2O)
- Azurite ($Cu_3(CO_3)_2(OH)_2$).

Sulfides and oxides of other metals (i.e., antimony, lead, cadmium, and zinc) also may be present.

Assay information provided by ASARCO indicates that the ore received from the Ray Mine contains approximately 0.55% to 0.69% copper, 55% silicates, 65% iron, and 1.5% to 2% sulfur by weight. The ore also contains arsenic at about 13 parts per million by weight (ppm), cadmium at less than 1 ppm, chromium at about 125 - 150 ppm, and lead at about 17 ppm. These concentrations of metals in ore are about an order of magnitude lower than those in concentrates and almost two orders of magnitude lower than those in the dusts collected by the electrostatic precipitator within the smelting operation.

Copper Concentrate Production

After the fine ore is delivered to the concentrator by conveyor, the copper ore is further ground through two successive mills. The first grinding circuit consists of rod mills, which consist of cylindrical metal rods placed on trunnions to allow rotation. The ore is placed inside these mills along with water, chemical reagents, and milk of lime. This grinding reduces the size of the ore to less than one-tenth of an inch. The resulting slurry is transported to the next step in the grinding circuit, the ball mills, which are charged with metal balls. The tumbling action of the mill grinds the ore particles to the size of very fine sand. As the slurry leaves the ball mills, it passes through a cyclone for size separation. All oversized particles are returned to the ball mills for further grinding.

Slurry that successfully passes through the cyclone is pumped to the flotation area. Reagents added to the grinding process prepare the slurry for the flotation process. Flotation cells are agitated to keep the slurry in suspension. Air is injected into the cells as small bubbles, and a collector is added to the slurry, causing the surface of the copper-bearing mineral particles to

stick to the air bubbles. Particles rise through the slurry and collect as a layer of foam on the surface (froth). A frothing reagent is added to give the bubble a tough surface. The froth that is skimmed from the top of the cells is the copper-bearing concentrate.

The tailings that were not affected by the frothing reagent and did not come off as copper-bearing concentrate in the flotation cells are pumped from the flotation cells into thickeners, and then via pipeline to Tailings Impoundments AB/BC and D located south of the ASARCO concentrator. Water from the tailings impoundments is pumped to the reclaim water pond, located east of Tailings Impoundment AB/BC. The chemical composition of tailings is similar to the original ore, except that the copper concentration is reduced (from 0.69 percent to 0.23 percent).

The concentration process fundamentally changes the chemical composition of the copper ore. Concentrate produced at the Hayden Complex typically contains about 26% copper by weight. Concentrations of most metals have also increased (e.g., arsenic is present at approximately 264 ppm, cadmium at 45 ppm, and lead at 590 ppm). The chromium concentration typically has decreased to 84 ppm.

Copper Concentrate Handling and Mix Production

This concentrate from the frothing process is sent as a slurry to the filter press where it is dewatered, leaving a filter cake. The filter cake is then conveyed to the concentrate storage area where it is allowed to dry before shipment to the smelter. Once the wet concentrate has air dried, it is either placed in temporary storage or loaded directly onto railcars for transport to the smelter. Upon delivery to the smelter, the concentrate loads are weighed and sampled for assay at the Sample Building. Next, the concentrate is either offloaded to concentrate overflow hoppers or unloaded into track hoppers and conveyed to the Bedding Plant. At the Bedding Plant, the concentrate is fed by a tripper conveyor to outdoor storage bins, where it is mixed with other copper-rich materials (e.g. crushed reverts, slag shells, and matte shells) and flux materials (e.g., silica) to create a copper concentrate mix.

Copper concentrate, and especially concentrate mix, contain higher levels of metals than the copper ore: with arsenic at about 1,100 ppm, cadmium at about 124 ppm, and lead at about 2,670 ppm. The concentration of chromium is reduced to about 30 ppm.

Flash Smelting, Copper Converting, and Anode Furnace Operations

Copper concentrates, fluxes, by-products, and coke are delivered to the smelter in rail cars and trucks. These incoming materials, also referred to as concentrate mix, are stored in four outside storage bins. Feed from the bins is screened, and oversized material is sent to the crusher for size reduction and then recycled to the screens. The undersized material passes through a hammer mill for de-lumping and is then stored in 200-ton Inco flash furnace wet feed bins.

The concentrate mix is dried in a natural gas-fired fluid-bed dryer, with any dried feed that is carried out as particulates with the exhaust gases from the tops of the dryers collected by a product baghouse. The dried feed is then stored in dry feed bins. The off gas from the dryer baghouse is routed to the R&R Cottrells (ESPs) for particulate removal and then to the annulus of the 1,000 foot stack.

Flash Smelting: The dried feed is fed into the Inco flash furnace where it is introduced into the burner with combustion oxygen. The concentrates ignite, melt, and partition into a heavy matte layer (approximately 56% copper) and a lighter slag layer (primarily iron silicates). The matte is tapped from the furnace and runs down ventilated launders into 17- to 20-ton ladles below the furnace floor. The filled ladles are then transported to the converter floor by rail. The slag is skimmed from the bath through a ventilated port, laundered into a ladle, and delivered to the slag cooling area. Hoods are located over the slag and matte tapping holes to collect secondary emissions. Secondary gas from these hoods is routed to the R&R Cottrells (ESPs) for particulate removal and then to the annulus of the 1,000 foot stack for discharge to the atmosphere.

Reverts consist primarily of matte and slag shells that form on the relatively cool surfaces of the ladles used to transfer liquid metal and slag in the converter aisle, with minor amounts of brick and silica flux. Reverts as large as 24 inches are charged to the reverts crushing system, consisting of a primary jaw crusher and a screen. The reverts crushing system is designed to crush reverts to a size less than one inch. The undersized material is transferred to storage, while the oversize material is crushed in a secondary cone crusher before being sent to storage. Some reverts are crushed at the South Reverts Crusher, operated by an independent contractor. According to the ASARCO Title V Permit Application (2009), the reverts crusher baghouse is a source of Particulate Matter (PM-1.98 tpy) and Hazardous Air Pollutant (HAP) emissions.

Copper Converting: The converter building is equipped with five Pierce-Smith converters and two anode furnaces. The converters receive matte from the oxygen flash furnace. An idle converter is heated and charged with molten matte. After charging is complete, oxygen-enriched air is blown (slag blowing) through the converter, which further reduces the sulfur content of the molten copper.

After the first slag blowing cycle, slag is skimmed from the bath and additional matte and some flux are added to the converter. This is followed by the second slag blowing cycle. Copper-containing reverts are added to regulate the temperature in the converters. Slag from the converters is returned to the flash furnace. The converter product is called blister copper (approximately 95% copper). Blister copper is transferred to the anode furnace by a bridge crane.

During the blowing cycles, gases from the converters are collected in primary hoods and routed to the gas cleaning system, then to the air plant and discharge via the 1,000-foot stack. During

charging and pouring, secondary gas is collected using secondary hoods. Gas collected in these hoods is routed to a baghouse for particulate removal and then to the annulus of the 1,000 foot stack for discharge to the atmosphere (ASARCO Title V Permit Application- 2009). Process fugitive emissions not captured by the primary and secondary hoods are a source of PM, SOx, and HAPs emissions.

Anode Furnaces: The last step in the copper smelting process is fire-refining in anode furnaces. The anode furnaces are charged with blister copper. The charge is oxidized by blowing air, followed by slag skimming. After that, natural gas is introduced into the anode furnace to consume the oxygen retained (primarily as copper oxide) in the blister copper. The charge (now approximately 99% copper) is then tapped into launders and poured into copper molds for shipment to ASARCO‟s refinery in Amarillo, Texas.

Slag Handling, Dumping, Reclaim, and Processing

Ladles of low copper containing slag (the primary byproduct of copper smelting) are transported by truck from the flash furnaces to the slag dump, where the slag is poured onto the slag dump and cooled by air. Slag containing higher levels of copper (>1%) is transported to a different area where it is dumped and cooled by air and water sprays.. The high copper slag is reclaimed from the dump with bulldozers and placed in front-end loaders for transport to crushing and screening. Both the undersized and oversized pieces of screened slag are then delivered by haul trucks to the concentrator, where they are reintroduced to the process for recovery of the copper content. Low copper slag remains at the slag dump. The low copper slag is composed primarily of silicates (31%) and iron (38%), but also contains a variety of heavy metals (arsenic: 535 ppm, cadmium: 48 ppm, chromium: 327 ppm, and lead: 1,190 ppm).

Copper Reclaim from High-Copper Materials

In addition to copper concentrate and slag mined from the slag dump, other materials handled at the Hayden Complex that are high in copper content are reintroduced to the smelting process for their copper value. These include, but are not limited to, the contents of ladles of copper matte and ladles of slag that have been allowed to cool; high-copper materials received from off-site sources; dusts captured in baghouses and electrostatic precipitators; and converter aisle cleanup. The larger materials may be screened and crushed prior to smelting. High-copper materials may be reintroduced to the process at a number of points, including the concentrator, the bedding plant, and the copper converters, based on the nature and size of the resulting material and on its copper content.

The reverts crushing and concentrate bedding operations are the primary sources of emissions from the handling of high-copper feed materials. Locations of these activities, as well as the concentrator and the copper converters, are shown on Figure 2-3. The levels of arsenic and

chromium in reverts are similar to the levels found in copper concentrate. By far the highest concentrations of arsenic and chromium in materials handled at the plant are found in high-copper byproducts that are received occasionally from ASARCO‟s Amarillo Copper Refinery (ACR) for processing at Hayden. In particular, arsenic levels in the ACR materials recycled at Hayden can be as high as 71,500 ppm, and chromium levels can be as high as 22,400 ppm.

2.2 Demographics and Land Use

Hayden has a population of approximately 662 residents according to the 2010 census published by the U.S Census Bureau (http://2010.census.gov). ASARCO operations including the crusher, concentrator, smelter, and tailings impoundments surround the Hayden community on the northern, southern, and eastern edges. Residential areas are bounded on the west edge of town by San Pedro Wash and are bisected by 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 that 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 the 2010 census data published by the U.S. Census Bureau (http://2010.census.gov) 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. In 2007, Winkelman had a total of 215 structures, including 156 homes (146 of which were habitable). There were also 59 government and commercial structures in Winkelman.

2.3 Physical Setting

The following subsections provide information on the climate of the region, the Site topography, and their influence on local meteorology and dispersion of COPCs.

2.3.1 Climate

The regional climate of the Study Area is typical for the southwestern US region having mountainous topography. The regional meteorological information for the Study Area – consisting of temperature and precipitation data – is collected at the Winkelman, Arizona, Cooperative Observer Station. According to the Western Regional Climate Center (www.wrcc.dri.edu), this is a representative source for climatological information for the area. Based on data collected during the period 1971-2002, the Study 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°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.

2.3.2 Site Topography

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. Hayden is located on the southwestern flank of the Dripping Spring Mountains, north of the confluence of the Gila and San Pedro Rivers. The Tortilla Mountains, located several miles to the west of Hayden, form the western border of the Gila River Valley. The topography of Winkelman is relatively flat, with a gradual decrease in elevation toward the northern boundary of the Gila River floodplain.

Topographic relief is moderately gentle on the west side of the Study Area, transitioning to moderately steep slopes further 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. 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 majority of operations at the Hayden Complex are located near the base of the Dripping Spring Mountains, adjacent to and elevated above the floodplain of the Gila River. Elevations at the Hayden Complex range from approximately 2,000 feet above msl near State Route 177, to approximately 2,300 feet above msl near the process water tank located north of the former Kennecott smelter (Figure 2-4). The ASARCO tailings impoundments lie just south and west of the major portions of the Hayden Complex. Tailings Impoundment AB/BC is bounded on the north by the Copper Basin Railway tracks and on the south by the Gila River floodplain. Tailings Impoundment AB/BC extends west to the confluence of Keystone Canyon Wash and the Gila River, and the eastern boundary is adjoined by the Hayden Golf Club (Figure 2-2). Tailings Impoundment D and the surrounding Tortilla Mountains are located south of the Gila River.

2.3.2.1 Topographic Influences on Local Meteorology

It is general knowledge that certain large topographical features can influence the meteorological conditions of a region. For example, rainfall events on the windward side of mountain ranges

produce greater precipitation amounts. Temperatures also can vary between geographic locations depending on the level of protection from the sun"s rays provided by topographic features or changes in elevation. Proximity to moderate to large bodies of water also can influence temperatures of nearby land masses.

The influence of topography on a more local level is not as well defined. Local wind patterns, in particular, can be affected by multiple factors, many of which, like temperature gradients, are also influenced in some ways by the regional topography. Both Hayden and Winkelman are located in a river valley with a mountain range in close proximity to the north and east. The elevation changes to the north are 800 to 1,000 feet within ½ mile to 2 miles from the Site. Based on on-site observations and basic meteorological concepts and effects, it is known that the topography in and around the Study Area has an effect on both wind speed and wind direction. Meteorological data collected to date demonstrate this in the highly variable wind conditions that occur within a 24-hour period at and between monitoring locations. However, since this data is from a limited number of meteorological stations, it is not possible to draw a reliable picture of how topography is influencing the local meteorology. As discussed below, understanding these relationships is an important factor in understanding the dispersion of COPCs from the Site.

2.3.2.2 Local Meteorology and Dispersion of COPCs

Local meteorological conditions – specifically wind patterns – are instrumental in determining the dispersion of COPCs in ambient air. Wind speed can determine if a contaminant will become airborne, how far it may travel, and how long it may remain suspended within the ambient air. The necessity for a 1,000-foot stack at the ASARCO Complex illustrates the importance of the surrounding topography and its influence on local meteorology and pollutant dispersion.

As part of ASARCO"s *1994 Fugitive SO_2 Emissions Study*, the North American Weather Consultants/TRC Companies, Inc. (NAWC/TRC) reviewed local meteorological data in an effort to evaluate the effects of wind patterns on the dispersion of fugitive SO_2 emissions from several processes within the Hayden Complex. This study relied on a limited set of data recorded at four ambient air monitoring stations in and around the Study Area during the period 1980-1984, as well as data recorded during the period from December 1993 through March 1994 from an additional station just south of the copper smelter. Based on the *Draft Review of Existing Meteorological Data at the ASARCO Ray Complex*, dated April 1994, wind roses were generated from this dataset and used to compare both seasonal and diurnal (night /day) patterns in wind speed and direction. This evaluation concluded that low velocity, stable conditions occurred at night and winds were from a general southeasterly direction during all seasons, and that this is the most probable direction of the greatest impact from fugitive emission sources.. The review also noted that as winds flow from the southeast, there "may be some streamlining by the terrain to the north." The NAWC/TRC study recommended that a full year of meteorological data be

collected to "document a more complete picture of actual wind flows in the vicinity of the copper smelter."

Additional meteorological data has been recorded since the 1994 NAWC/TRC study. This data has found wind patterns to be similar to that shown in the earlier data, i.e. calm (typically one mile per hour or less), stable night-time conditions with highly variable daytime conditions. More recent wind patterns in the Hayden/Winkelman area are characterized by wind roses provided as Figure 2-5. The top three wind roses on Figure 2-5 were generated from wind speed and direction measurements made by ASARCO at three ambient air monitoring stations (Montgomery Ranch, Hayden Junction, and Globe Highway) from January 1, 2000, through December 31, 2004. The bottom two wind roses on Figure 2-5 were generated from measurements by EPA at the Hayden maintenance yard (the Hayden Station) and at the High School in Winkelman (the Winkelman Station) for the period of January 1, 2007, through December 31, 2010.

These five wind roses collectively provide a general characterization of dominant wind patterns throughout the Study Area. The wind roses for the Montgomery Ranch and Hayden Junction stations, located west of Hayden, show a dominant east-west wind pattern, which likely is controlled by the orientation of the Gila River valley in this area. The wind roses for the Hayden and Winkelman stations are more variable, but also generally reflect the orientation of the Gila River valley at the respective monitor locations. The dominant wind directions observed at the Hayden station are from the west and southeast, whereas the dominant winds at the Winkelman station are from the northwesterly, northeasterly, and southerly directions. The wind rose for the Globe Highway station, located about 0.5 miles north of the high school in Winkelman, shows dominant wind directions from the north-northeast and south-southwest – a flow pattern that is related to the orientation of the canyon through which the Gila River flows in this part of the Study Area.

Comparing data between monitoring stations demonstrates how wind patterns can be influenced by local topography on a micro-scale. The top three wind roses of Figure 2-5 demonstrate the substantial variability of wind conditions that existed across the area covered by three monitoring locations (Hayden Junction Station, Montgomery Ranch, and Globe Highway Station) over a five-year period (January 1, 2000, through December 31, 2004). The percentage of "calm" wind conditions (i.e., ≤1.0 mph) varies from a low of 5.1% for the Globe Station to a high of 14.5% for the Montgomery Ranch Station.

The bottom two wind roses of Figure 2-5 demonstrate the difference in wind conditions measured at the Hayden Station and the Winkelman Station (located about one mile apart) over a four-year period (January 1, 2007, through December 31, 2010). The percentage of "calm" wind conditions varies from a low of 12.7% for the Hayden Station to a high of 19.0% for the

Winkelman Station. In addition, the frequency and timing of specific wind directions at each of these locations is markedly different.

Two specific examples of the differences in localized winds are illustrated by Table 2-1, which presents a comparison of half-hour average wind directions and speeds for the Winkelman and Hayden monitoring stations, which again are only one mile apart. On August 4, 2010, the 24-hour average wind direction differed by 27 degrees between the two monitoring locations. However, during that same 24-hour period, the average half-hour wind directions differed by 60 degrees or more for 12 of the 48 measurement periods. On August 13, 2010, the 24-hour average wind direction differed by only 2.1 degrees between the two monitoring locations. However, during that same 24-hour period, the average half-hour wind directions differed by 60 degrees or more for 14 of the 48 measurement periods, and by 120 degrees or more for four measurement periods.

The wind patterns described in the paragraphs above, along with the observed increase in wind speed and shift in wind direction that occur during the daytime hours, are classic meteorological patterns for high desert areas. These macroclimate conditions, combined with the microclimate issues of the area surrounding Hayden/Winkelman, result in a complex situation that has contributed to the wide and varying distribution of COPCs released from Hayden Complex operations on the surrounding area, and thus the widespread exposure to these COPCs.

No reliable daily precipitation data are available for the Site. Precipitation would be expected to reduce or deplete the particulate matter in ambient air, and damp soil would limit ground-level fugitive dust emissions. However, other factors also can affect the particulate matter (PM) and metal concentrations at the monitoring stations and make it difficult to relate changes in the 24-hour average PM and metal concentrations to the relatively brief precipitation events.

Based upon the review of previous meteorological data, as discussed above, it is evident that there are complex influences of topography on the local meteorology and, therefore, pollutant dispersion, within the Study Area. What these are and how significant their impact is on the distribution of COPCs in ambient air are questions that remain unanswered based on the data collected to date, and that will be a focus of the Phase II RI air investigations.

2.4 Previous Investigations/Information

A number of investigations, inspections, or remedial actions have been conducted at the Site by EPA, ADEQ, and/or ASARCO. These have involved both air-related activities and investigations and response actions pertaining to soil, surface water, groundwater, and sediment. The subsections below summarize these investigations as well as additional sources of information relevant to the Phase II RI/FS at the Site.

2.4.1 Multi-Media Investigations/Information

Preliminary Assessment (1988)

A Preliminary Assessment (PA) was conducted by ADEQ in 1988 to determine if there had been releases of hazardous substances from the ASARCO Hayden Complex and to evaluate eligibility of the Site for placement on the National Priorities List (NPL) (*Preliminary Assessment/Site Inspection Report* [ADEQ 1991]; referenced in CH2M Hill, 2008a). A follow-on site inspection was recommended.

Site Inspection (1991)

ADEQ conducted a non-sampling Site Inspection (SI) in 1991 and concluded that, based on documented releases to the air and soil, the Site qualified for further consideration as a potential NPL site under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA; ADEQ, 1991; referenced in CH2M Hill, 2008a).

Public Health Assessment (1999)

In conjunction with the US Agency for Toxic Substances and Disease Registry (ATSDR), the Arizona Department of Health Services (ADHS) conducted a Public Health Assessment (PHA) for the Study Area (*Public Health Assessment, ASARCO Hayden Smelter Site, Hayden, Gila County, Arizona;* ATSDR, 2002; referenced in CH2M Hill, 2008a). The PHA consisted of obtaining ten environmental soil samples within Hayden and Winkelman to evaluate levels of contamination, and conducting public health surveys of the residents of Hayden and Winkelman. The PHA reported that the average concentrations of metals in soils were not above ATSDR Comparison Values (CVs) except for lead. However, the report noted that limited samples were collected from random locations and may not have been representative of surface soil contamination throughout the area.

The study also summarized air quality data obtained from 1991 to 1998 from the dichot particulate monitoring station maintained by ADEQ at the Hayden Jail location, and compared these data against ATSDR Comparison Values (CVs) for arsenic (0.0002 micrograms per cubic meter [ug/m^3]), sulfur dioxide (SO_2; 25 ug/m^3 for a 3-hour period), and lead (using the National Ambient Air Quality Standard [NAAQS] applicable at the time of 1.5 ug/m^3 for a quarterly period). The CVs are concentrations of a chemical below which ATSDR considers that adverse health effects are unlikely to occur. The CVs are not used to define specific adverse health effects from exposure, but instead are used by ATSDR to help determine if additional contaminant-specific investigation is needed.

The PHA concluded that air quality in the Hayden and Winkelman area during the period for which data were analyzed (1991–1998) generally met all federal and state air quality standards

for criteria air pollutants, although some exceedances of the CVs for arsenic and SO_2 were reported. The arsenic CV was exceeded in outdoor air for each year from 1991 through 1998, while the lead CV was not exceeded from 1993 to 1997. Compared against the updated (and current) NAAQS for lead of 0.15 ug/m^3, the standard would have been exceeded from 1994 to 1997. The CV for SO_2 was exceeded on occasion. According to the study, the brief episodes of elevated SO_2 in air may cause short-term respiratory symptoms for sensitive asthmatics a few times per month.

The PHA did not include an evaluation of other metals in ambient air (e.g., chromium, cadmium, or copper). 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 future environmental investigations indicate that exposure has increased or decreased (ATSDR, 2002; referenced in CH2M Hill, 2008a). Importantly, any conclusions presented in the PHA are limited because 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 $PM_{2.5}$.

Blood lead levels were also evaluated in some children aged 6 to 72 months as part of the PHA, and urinary arsenic levels were checked in some adults and children. 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. A recent reassessment of the acceptable blood lead standard by the CDC may result in a lower acceptable blood lead concentration.

Phase I Remedial Investigation (2005-2008)

The Phase I RI was conducted from November 2005 through November 2007, with the results presented in the draft Phase I RI Report (CH2M Hill, 2008a). 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 Draft SLERA and a draft BHHRA were developed in conjunction with the draft Phase I RI Report. In addition to the discussion in this section, results from the Phase I RI and risk assessments provide the primary source of information for the preliminary site characterization (Section 3.0) and the individual summaries of the 19 RI Areas (Section 4.4).

As stated in the draft Phase I RI Report, the overall purpose of the RI was to identify the nature and extent of 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 (property owned by ASARCO associated with active operations) and on sources associated with the Hayden Complex that contribute COPCs to areas of the Site outside the Hayden Complex.

Ambient air quality data collected from two ambient air monitoring stations, the Hayden Maintenance Yard (Hayden Station) and the High School in Winkelman (Winkelman Station) beginning in 2006 and ending in March 2008 was included in the Phase I RI Report. Ambient air monitoring consisted of the collection of 24-hour PM_{10} samples every sixth day and meteorological data recorded every 30 minutes continuously. Samples collected were submitted for analysis of PM_{10} (particulate matter less than 10 microns in diameter) and metals, including arsenic, lead, copper, cadmium, and chromium.

Metals results were found to exceed relevant health-based criteria in place at the time, such as the Arizona Chronic Ambient Air Concentrations, the EPA Preliminary Remediation Goals (PRGs), National Ambient Air Quality Standards (NAAQSs), and for comparative purposes, the California Acute Reference Exposure Level (REL). Concentrations were found to be significantly higher in the Hayden Station samples than in the Winkelman Station samples. The arithmetic mean concentrations of all metals were significantly lower at both stations during smelter shutdown periods (compared to the arithmetic mean values over the entire monitoring period).

The BHHRA results indicated that the current and former ASARCO operations have resulted in measurable impacts to soils, ambient air, and indoor dust, groundwater, surface water, and sediment. Multi-pathway cumulative risks indicated that the soil plus air cancer risks in Hayden and Winkelman were greater than the cumulative background cancer risks.

2.4.2 Air Quality Investigations/Information

Since the late 1960s and early 1970s, EPA, the ADEQ, and ASARCO have collected SO_2 and PM_{10} ambient air monitoring data at various locations within the Study Area. Some of the early sampling was designed to address regulatory requirements, such as NAAQSs as part of the ADEQ"s state-wide ambient air monitoring network, Arizona"s State Implementation Plan (SIP) pertaining to operating processes at the Site, or the facility"s air permits. Additional PM_{10} sampling was conducted as part of the Phase I RI (Phase I RI Report, CH2M Hill, 2008a), as noted above in Section 2.4.1.4. In addition to PM_{10}, these samples were also analyzed for the chemical makeup of the particles, including metals identified as chemicals of concern for the Site. Specific air quality or air emissions studies were also undertaken by ASARCO and others in support of process air emission control evaluations or in an effort to ascertain the impact of process emissions on the community.

The following subsections provide a brief summary of these previous air quality investigations and studies. A detailed description of air quality at the Site is presented in Section 3.0. That discussion provides a comparison of Site air quality data to available background data and air quality compliance standards.

2.4.2.1 Ambient Air Monitoring

Sulfur Dioxide Data (1970–Present)

As part of the development of the SO_2 SIP for all major sources of SO_2 in the state, ADEQ began SO_2 ambient air monitoring as early as 1970 in the Hayden area. Based on emission inventories, it was determined that the ASARCO copper smelter contributed 99% of the total SO_2 emissions in the Hayden nonattainment area. A more extensive SO_2 monitoring network was established in 1973-1974. The purpose of this network was to gather air quality data that would form the basis for the rule-making necessary to reduce SO_2 emissions and bring nonattainment areas into attainment.

The SO_2 ambient air monitoring network was established by ADEQ and ASARCO, with spatial and temporal coverage intended to allow for the comprehensive evaluation of the impact of smelter emissions on ambient air conditions. More than 20 stationary and mobile monitoring sites were established throughout the area, with as many as 12 monitors operating concurrently. This ambient SO_2 network was developed to identify maximum ambient impact areas using dispersion modeling, monitored wind direction, citizen observations, and ambient SO_2 monitoring.(ADEQ,2002) Six of these monitors, Garfield Avenue, Hayden Jail (2 monitors), Hayden Junction, Montgomery Ranch, and Globe Highway remain as part of the ADEQ SO_2 monitoring network today. All monitoring for SO_2 reportedly was performed with guidance and dispersion modeling analysis from ADEQ (CH2M Hill, 2008a).

Installation of additional meteorological instrumentation at the SO_2 sites to measure wind speed and direction, air temperature, and humidity parameters further helped to define airflow and pollutant transport in the region. Use of mobile monitors allowed evaluation and verification of ambient SO_2 concentrations over a greater area. Through an iterative process, implemented jointly by ADEQ and ASARCO in accordance with EPA guidance, monitors were removed or relocated if no ambient SO_2 violations were recorded, if no SO_2 curtailment was needed due to data recorded at that monitor, or if a new site was shown to be more representative of the ambient air quality of an area. As ASARCO"s SO_2 emissions were reduced through the use of continuous control technology, the number of permanent monitors gradually was reduced to the current network of six. The six remaining sites are all high-impact monitoring sites found to be representative of the air quality of the overall area.

Based on monitoring data collected through 2001, there were no violations of the existing NAAQS for SO_2 in the Hayden area between 1995 and 2001. A subsequent request to redesignate the Hayden area to "attainment" was submitted by the ADEQ to EPA in June 2002, and is pending EPA approval. In June 2010, EPA revised the primary SO_2 standards by establishing a new 1-hour standard at a level of 75 parts per billion (ppb) and revoking the prior primary annual and 24-hour standards. ADEQ submitted the request for designation for the new 1-hour standard to EPA in May 2011, designating the Hayden area as nonattainment. EPA is to act on the State"s request by June 2012.

ADEQ Particulate Matter (PM_{10}) and Metals Data (1975-Present)

As part of the statewide ambient air monitoring network, ADEQ has operated a PM ambient air monitor at the Hayden Jail monitoring station since January 1975. Initially a Total Suspended Particulate (TSP) monitor was operated at this site; this was replaced in 1985 with a PM_{10} monitor. Data collected at this station is used in determining the Hayden area"s attainment of the NAAQS for PM_{10}. The PM_{10} NAAQS was changed in 2006 to 150 ug/m^3 as a 24-hour standard not to be exceeded more than once per year on average over a three year period. In January 2011, EPA found that the Hayden area had attained the PM_{10} NAAQS by the applicable attainment date , but was not maintaining the standard based on the most recent data. However, EPA noted that current trends indicate Hayden is likely to attain the standard in the near future.

In addition to the particulate monitoring discussed above, ADEQ has used an Anderson Dichot sampler at the Hayden Jail station to sample both particulate matter less than 2.5 microns in diameter ($PM_{2.5}$) and PM_{10} simultaneously. Some of these samples were analyzed for metals by X-ray fluorescence (XRF) at the Desert Research Institute (DRI) laboratory in Reno, Nevada. Table 2-2 presents a summary of detected concentrations over the period from 1999 to 2001 as minimum, maximum, and arithmetic mean concentrations for the period. This time period was selected to follow completion of several ASARCO air emission control projects (including anode furnace steam injection in 1994, converter secondary hoods baghouse in 1996, and furnace wet gas handling with a venturi scrubber in 1998).

Table 2-2 also shows a comparison of ambient air concentrations of metals in the ADEQ PM_{10} fraction samples with the EPA Region 9 Regional Screening Levels (RSLs) for ambient air, the ADEQ Chronic Ambient Air Concentrations (ACAACs), and/or the ADEQ Ambient Air Quality Standards. The comparison shows that annual average concentrations during this three-year period exceeded the current RSL for arsenic, cadmium, and chromium (as hexavalent chromium), and the ACAACs for arsenic and cadmium. There are no current RSLs for copper or lead. The detected annual average value for each of these metals is slightly higher than, but not dissimilar to, values detected during the period from 2007 to 2010 at the Hayden station and described in Section 3.1.2 below.

ADEQ continues to monitor for SO_2 and for PM_{10} at the Hayden Jail monitoring station; however, the PM_{10} filter samples are no longer submitted for analysis of metals.

Ambient Air Monitoring (2006–Present)

The ambient air monitoring program initiated in October 2006 as part of the Phase I RI involving the ASARCO Hayden Complex has been continued to present. EPA has maintained and operated PM_{10} monitors at the Hayden and Winkelman Stations at the Hayden Maintenance Yard and the High School, respectively. Except for sampling lapses due to periodic equipment malfunctions, ambient air samples have been collected at both monitoring locations every sixth day according to the EPA ambient air monitoring schedule. All sampled filters also are analyzed for metals by XRF at the Chester LabNet in Tigard, Oregon. See Section 3.1.2 for a discussion of the continuing ambient air monitoring results.

2.4.2.2 Air Quality and Air Emissions Studies

Source Apportionment Study (1987)

In 1987, NEA, Inc. performed a source apportionment study to determine the contribution of processes within the Hayden Complex to the concentrations of particulate matter, arsenic, cadmium, and lead detected in ambient air in Hayden (NEA, 1987). The study consisted of ambient air sampling at the Hayden Jail and the Hayden Maintenance Yard on Garfield Avenue; fugitive process source emission sampling; bulk sampling of materials and dusts; meteorological monitoring; analysis of metals on air filters; and apportionment of sources with a quantitative model. $PM_{2.5}$ and $PM_{10-2.5}$ samples were analyzed for mass by gravimetry and by XRF for 34 elements.

The investigation attributed the impacts of various sources on the concentrations found at the two monitoring stations in Hayden based on COC and PM size. Overall findings of the study included:

- The largest contributors to course (PM_{10}) dust mass were ore dust from ore crushing and conveying, and road dust.
- Although road dust and ore dust were the major sources of PM mass, they were relatively minor contributors of metals in ambient air.
- Fugitive emissions from the smelter operation were a minor source of PM_{10} mass (less than 2%), but were responsible for 80-100% of the arsenic, lead, and cadmium. The arsenic, lead, and cadmium mass in the community air were concentrated primarily in the fine ($PM_{2.5}$) particle size.
- Comparisons of source contributions during ASARCO operating and non-operating periods showed reductions during non-operating periods.

- Tailings impoundment contributions were observed only when wind speeds were high.
- Silicon (Si), at approximately 20% by mass, is the most abundant element in both fine and coarse particulates.
- Other than Si, elements most abundant in the coarse fraction were aluminum (Al), potassium (K), calcium (Ca), titanium (Ti), manganese (Mn), iron (Fe), and copper (Cu).
- Other than Si, elements most abundant in the fine fraction were sulfur (S), chlorine (Cl), zinc (Zn), arsenic (As), cadmium (Cd), antimony (Sb), and lead (Pb).
- Kennecott road dust is characterized by coarse particles rich in Al, Si, Ca, and Fe.
- Composite plant road dust is low in Ca, and high in S, Fe, Cu, and Si.
- Ore dust is high in Ti, Al, and Si, and low in S, Ca, and Cu. It has a uniquely high K to Ca ratio.
- Fugitive emissions from three components of the smelter facility (the flash smelter, the converters, and the anode furnaces) are characterized by fine particles rich in Pb, As, Zn, Cd, Sb, and K, but low in crustal elements (Al, Si, Ca, Ti).
    - Of these three components, slag skim emissions are rich in Zn, Pb, and As, as well as Cu and Fe, relative to the other two sources.
    - Matte tapping emissions are rich in As, with lower levels of Pb and Zn.
    - Secondary converter emissions are distinguished from the other two by high Pb, low As and Zn, and very low Fe.
    - Fine particulates associated with matte and slag tap emissions have very low Si levels.

These distinctive chemical signatures have guided the selection of elements to be analyzed in ambient particulates to be collected in the Phase II RI. The NEA also suggested that the apportionment study could be improved through additional source characterization. Specific recommendations included:

- Better characterization of source variability;
- Characterization of more individual fugitive dust samples, such as smelter yard and ore concentrate dust;
- Collection and analysis of replicate samples for road dust and the ore crusher; and
- Collection and analysis of individual samples of ore concentrates or other yard dust.

In addition to these recommendations, there are a number of limitations to the NEA report. Some of these were recognized by the investigators and attributed to resource and technology

constraints; others that were not identified by the investigators can be overcome with current technology or application of additional resources. These include:

- Background emissions were not characterized.
- The 24-hour samples obscured the sources and events that could have been detected with shorter-duration and/or wind direction-actuated sampling. New technology is now available to identify and sample during these events.
- The number of ambient monitoring locations, the number of source profiles, the number of days sampled and analyzed, and the particle size distributions were all limited, and did not cover the complete range of emissions and meteorological conditions required to characterize apportionment accurately. New technology and application of additional resources can eliminate these limitations.
- Only mass and element concentrations were measured, thereby limiting the specificity of source attribution. The addition of morphology, particle size distributions, and lead ion analyses coupled with mass, chemical, and wind-direction data can provide a substantially improved source apportionment result.
- Sampler siting was limited by the availability of space and power. Advances in technology have overcome many of these limitations.

Smelter Building Fugitive Emission Study (1994-1995)

ASARCO contracted for a smelter building fugitive emission study, in conjunction with an ADEQ-required SO_2 emission study, which was performed by TRC North American Weather Consultants (TRC NAWC). That fugitive emission study was undertaken during 1994-1995 to evaluate non-ducted process emissions. According to the report (TRC NAWC, 1995), samples were collected through the roof monitors near the converter and anode furnace and at other building openings, and analyzed for particulates and selected metals. They were normalized to outflow using sulfur hexafluoride (SF_6) tracer gas released over several of the operations within the building. TRC NAWC reported the following findings from the study:

- Smoke tracers demonstrated that fugitive emissions exit through the roof monitors and through other parts of the building, particularly the west wall.
- After normalization to the SF_6 and adjusting for roof monitor size and flow velocity, and based on 318 production days per year, annual metal emissions were estimated to be:
    - 1.7 tpy for antimony;
    - 33 tpy for arsenic;
    - 0.3 tpy for beryllium;
    - 1.1 tpy for cadmium;

- 0.5 tpy for chromium;
- 0.3 tpy for cobalt;
- 58 tpy for lead;
- 0.4 tpy for manganese;
- 0.6 tpy for nickel; and
- 24 tpy for selenium.

At the request of ASARCO, TRC NAWC performed a reevaluation of the study data. Using different assumptions, the reevaluation report (TRC NAWC, 1997) produced substantially reduced annual emission estimates. Using the same 318 production days per year and the same sample collection efficiency of 76%, annual metal emissions were revised to be:

- 0.25 tpy for antimony;
- 4.22 tpy for arsenic;
- 0.09 tpy for cadmium;
- 5.14 tpy for lead; and
- 2.91 tpy for selenium.

The calculation methods and the precise reasons for the differences in emission rates were not well explained by TRC NAWC in the 1997 document.

Size-Selective Sampling at the High School in Winkelman Monitoring Station (2008-2009)

As described in the technical document entitled *Metal and Metalloid Contaminants in Atmospheric Aerosols from Mining Operations* (Csavina, et al., 2010), size selective sampling was conducted by a team of scientists from the University of Arizona to determine the concentrations of metal and metalloid contaminants near the Site as a function of particle diameter, and to provide a better understanding of potential sources, transport, and human toxicity. A multiple-orifice uniform deposit cascade impactor (MOUDI), a scanning mobility particle sizer (SMPS), and a total suspended particulate collector were operated from December 2008 through November 2009 at the High School in Winkelman monitoring station. Beryllium , aluminum, arsenic, cadmium, copper, iron, magnesium, lead, and selenium were quantified on each of the MOUDI stages over 96-hour sampling periods.

Several of the samples were examined by scanning electron microscopy (SEM). Lead, arsenic, and cadmium were found preferentially in the $PM_{1.0}$ fraction, with median diameters of 0.3 to 0.5 microns. Scanning electron microscopic analysis revealed the presence of spherical sub-micron particles that contained high concentrations of lead or arsenic, typical of condensation from a hot

industrial process (smelting), while the coarse particles were mainly irregularly shaped, as is typical of fugitive dust.

This work at the High School in Winkelman monitoring station using an 11-stage MOUDI has shown that lead and arsenic are concentrated in the sub-micron fraction, that these lead- and arsenic-containing particles are spherical, and that they must have originated recently from one or more high-temperature sources that are part of the smelting operations. The coarse fraction is dominated by fragmented crystalline material characteristic of wind-blown dust. Lead and arsenic concentrations are lower in the coarse fraction.

The study suggests that the fine-particle diameters associated with maximum lead and arsenic concentrations correspond to particles produced by vapor condensation and coagulation, which would be consistent with sources related to smelting operations that include emission of high-temperature vapors. The study further indicates that the lower concentration of arsenic, lead, and cadmium in the coarse-particle size range, as well as particle morphology, was related to a traceable source or sources of windblown dust. The high correlation coefficients among arsenic, lead, and cadmium in both the fine- and coarse-particle size ranges indicate a unique source, which would be the case if windblown dust particles acquire aerosol contaminants via deposition of fine particles. Ultrafine particle concentrations measured at the High School in Winkelman showed that the highest readings occurred when the wind came from the general direction of the ASARCO smelting operations.

2.4.3 Related Non-Air Quality Investigations/Information

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 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 R-SRLs (EPA, 2000, referenced in CH2M Hill, 2008a). (Note: The sample concentrations were compared against the R-SRLs in effect in 2000 and 2008. The Soil Remediation Standards were last modified in 2007.)

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 and surface water/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). (Note that 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).

In addition, cadmium, mercury, and zinc levels in several samples were reported as elevated compared to the 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" although three of 36 surface soil samples exceeded the R-SRL of 400 mg/kg. Contamination is potentially attributable to sources including 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 during wind events. Analysis of sediment samples from containment pond CP-1 (which collects stormwater, wastewater, and process waters from the ASARCO operations smelter area) detected elevated concentrations of arsenic, cadmium, chromium, copper, lead, mercury, and zinc.

Removal Assessment (2004)

Based on the results of the ESI, EPA performed a Removal Assessment in 2004 that was focused on defining levels of metals contamination in soils within residential, public, and commercial areas of 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).

The sample analyses revealed metals contamination above R-SRLs 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. The highest concentrations were typically detected close to ASARCO facilities, including particularly the Conveyor 9 area, east of the Conveyor 9 area near Power House Wash, and to the north of Hayden adjacent to concentrator operations and the former Kennecott smelter area.

The total metals analyses of the 69 samples from the Winkelman area 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, antimony, beryllium, and thallium also were detected at concentrations above their respective R-SRLs in several samples, although antimony exceeded the R-SRL at only one location. (Through data validation, it was determined that the beryllium and thallium concentrations likely were biased high, and may have resulted in R-SRL exceedances being applied incorrectly.)

Background samples collected at six locations along State Route 177 in Kearney, approximately eight miles to the west of the Site, did not contain elevated levels of metals. Therefore, background samples revealed that concentrations of metals above their respective R-SRLs detected at other locations are not naturally occurring.

The RA concluded that surficial soil contamination is present in Hayden and Winkelman and that the elevated concentrations of metals found throughout Hayden likely are the result of contamination dispersed from ASARCO operations. Elevated concentrations of metals in Winkelman are presumed to be the result of close proximity to ASARCO operations, proximity to tailings disposal areas, and aerial dispersion from vehicles traveling along State Route 177 and rail cars on tracks southwest of the town.

EPA Focused Sampling Event (2004)

In October 2004, in conjunction with the Removal Assessment, soil samples were collected by EPA at five locations in Hayden and six locations in Winkelman, with the locations focused at the Hayden public swimming pool and play area and the Winkelman school yards. The 2004 EPA school and playground sample results revealed 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.

First Residential Soil Removal Action (2008)

In 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 and Caldwell [B&C], 2011). According to the October, 2008 Final Report on the Phase I Yard Removal, prepared by ASARCO, the excavated soil was placed on the ASARCO Concentrator property and stockpiled for cover at the facility landfill.

Second Residential Soil Removal Action (2008)

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 1 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 site-specific R-SRLs established by EPA to determine which properties required further soil removal. Those properties at which the R-SRLs were exceeded, and therefore required soil removal, included 212 properties in Hayden and 21 properties in Winkelman.

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. Based on statements made in the Draft RI/FS WP prepared by Brown and Caldwell, 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 (Brown and Caldwell, 2011). The excavated residential soil was used as cover at the asbestos landfill and disposed in the ASARCO industrial waste landfill above the former Kennecott smelter.

2.5 Regulatory Framework

The ASARCO Hayden Complex operates various air emission sources under the regulatory framework of the Clean Air Act. This section discusses those CAA requirements that are relevant to the COPCs of the Phase II RI through the regulation of emissions, application of emission controls, and/or the requirements for reporting air emission from the Site.

2.5.1 National Ambient Air Quality Standards

The Hayden area is currently designated as non-attainment for PM_{10} and SO_2. The area is attainment or unclassified for all other pollutants. According to ADEQ"s *Final Hayden Sulfur Dioxide Nonattainment Area State Implementation and Maintenance Plan*, dated June 2002, significant SO_2 process and control technology upgrades were implemented at the Hayden primary copper smelter over the years. These upgrades are listed in Table 2-3.

The ADEQ 2002 SIP is still under review by EPA. In 2010, EPA promulgated a new 1-hour SO_2 NAAQS of 75 ppb. In a May 25, 2011, letter from the Governor of Arizona to EPA, it was recommended that the Hayden area be designated as nonattainment of the 1-hour standard. SIPs for the new SO_2 NAAQS will be due to EPA beginning in 2013. ASARCO already has informed

ADEQ that additional controls will likely be necessary to comply with the new 1-hour standard. ADEQ has stated that these additional controls will also reduce HAP emissions as they will result in reductions in overall fugitive emissions from the Hayden Complex.

2.5.2 Hayden Operations as a Minor Source of HAPs (2004)

On June 12, 2002, EPA promulgated within 40 CFR Part 63 Subpart QQQ the National Emission Standard for Hazardous Air Pollutants (NESHAP) for Copper Smelters at major sources of HAPs emissions, i.e. those sources whose potential to emit (PTE) is greater than 10 tons per year of a single HAP or 25 tons per year of combined HAPs. In response to the promulgation of this NESHAP, ASARCO submitted a request for an applicability determination stating that they believed the facility to be a minor source of HAPs, and therefore not subject to the NESHAP. In response to discussions with ADEQ, ASARCO submitted a report, *Documentation that Hayden Operations is a Minor Source of HAPS*, dated November 16, 2004, to support their claim to be a minor source of HAPS.

The ASARCO report provided an assessment of the facility-wide PTE HAPs. The report described the HAP emitting processes, material throughputs, and feed stocks. A summary of the methodology used to determine the PTE from each process also was provided to establish the basis for the PTE HAPs calculations. The report concluded that the PTE HAPs were all less than 50% of the major source thresholds, and the facility-wide PTE was 12.4 tons per year. ASARCO concluded that the PTE demonstration substantiated the minor source claim.

This ASARCO study has undergone considerable review since 2004 by the ADEQ. In 2009–2010, ADEQ performed additional material balance calculations using information from ASARCO. These calculations indicated that a substantial amount of lead emissions were unaccounted for in ASARCO"s PTE demonstration. As a result of follow-up communications between ASARCO and the ADEQ during 2011, ADEQ was unable to conclusively determine the Hayden Operations status with regard to the major source NESHAP. ADEQ addressed this issue again in the November 2011 draft Class I Operating Permit Renewal. This permit is discussed in Section 2.5.3 below.

2.5.3 Air Permitting

Current Effective Class I/Title V Air Permit(s)

The ASARCO Hayden Complex operates under authority from ADEQ through two Class I (Title V) Operating Permits. These permits split the facility"s operations under the Hayden Concentrator, Permit No. M070399P1-99, issued May 30, 2001, and the Hayden Smelter, Permit No. 1000042, issued October 9, 2001. The Class I Operating Permits address both point sources

and fugitive sources of air pollutants and the air pollution control measures or devices associated with these sources.

The Class I Operating Permits identify all applicable emission regulations at the time, as well as the compliance methods required to demonstrate that the facility maintains ongoing compliance with these regulations. The current Class I Operating Permits expired in 2006; however, ASARCO has maintained its authority to operate through the timely submittal of permit renewal applications. ASARCO submitted updated permit renewal applications for the Concentrator and Smelter to ADEQ dated November 5, 2005, and April 7, 2006, respectively. These applications have been under ADEQ review since they were submitted.

Draft Class I/Title V Renewal Permit

On November 22, 2011, ADEQ issued for public comment a Draft Class I/Title V Operating Permit Renewal that combines the Concentrator and Smelter operations under a single permit (Permit No. 39948). ADEQ had determined that the renewal applications for both the operations should be processed in a single permit in December 2007, as the two sources are categorized as a single "stationary source" in accordance with A.A.C. R18-2-101(113).

A Class I Operating Permit Renewal must include all new applicable regulations that have become effective since the issuance of the previous permits. However, as noted in Section 2.4.2.2, ADEQ was unable to determine the facility"s HAPs PTE conclusively. As a result, ADEQ processed the Draft Class I Permit as a minor source permit for HAPs, incorporating the requirements of the NESHAP for Primary Copper Smelters at Area Sources, 40 CFR Part 63 Subpart EEEEEE, promulgated by EPA on January 23, 2007, as a new applicable regulation. The NESHAP regulates the emissions of arsenic, cadmium, chromium, lead, and nickel through the regulation of particulate matter emissions from various processes in the Hayden Complex. In accordance with the regulations, the permit contains conditions for demonstrating ongoing compliance with the NESHAP particulate emission limitations, such as monitoring, recordkeeping, and testing from the dryers, secondary capture systems for converters, and capture system for furnace slag and matte tapping hoods.

The permit also incorporates the August 23, 2011, Class I Operating Permit Revision authorizing the installation and operation of a baghouse along with associated hoods, ductwork, and fans to control and minimize particulate matter and HAPs emissions, including arsenic and lead, from the anode furnaces. The requirements for the operation and maintenance of this control equipment are included within the draft renewal permit terms and conditions for the anode furnaces.

The Draft Class I Permit requires ASARCO to reassess the facility-wide PTE HAPs during the five-year permit term to confirm that the facility is not emitting HAPs at a greater level than the

major source thresholds of 10/25 tons per year. If the PTE is found to exceed these levels, either the permit existing at the time would be required to be re-opened to include the requirements within the NESHAP for Primary Copper Smelters at major sources, 40 CFR PART 63 Subpart QQQ (instead of Subpart EEEEEE), or the major source NESHAP would be included at the time of permit renewal, depending on the remaining effective years of the permit. If applicable, the major source NESHAP would impose additional requirements and emission limitations on the Hayden Complex, further reducing HAPs emissions.

The Phase I RI/FS ambient air data, discussed in Section 2.4.1 and Section 3.0, was collected subsequent to the emission control improvements noted in Section 2.5.1 above, which were installed pursuant to regulatory requirements prior to the 2011 permit revision as incorporated into the draft Class I Operating Permit Renewal. Therefore, reductions made in HAPs emissions as a result of these earlier controls are reflected in the existing ambient air data. Any additional reductions in ambient air HAPs concentrations would be realized only from those additional controls required by the August 2011 permit revisions, and would likely not be realized for a number of years pending the implementation of any new controls..

Although the additional control systems are expected to reduce HAP emissions further by collecting and controlling fugitive emissions from specific processes at the anode furnaces, it is uncertain how much these processes currently contribute to the overall HAPs concentrations in ambient air within the Study Area. The 1987 Source Apportionment Study, discussed in Section 2.4.2.2, concluded that almost all of the arsenic and cadmium, and 80% of the lead, originated from fugitive emissions from within the smelter with no differentiation of specific processes. Because the additional controls included in the 2011 permit revision will address only a portion of the smelter processes, the degree to which the controls will impact air quality in the Study Area remains uncertain.

2.5.4 Air Emissions Reporting

The ASARCO Hayden Complex annually reports air emissions to the EPA and ADEQ under two programs, the Emergency Planning and Community Right-to-Know Act of 1986 (EPCRA) and the 40 CFR Part 70 - Title V Operating Permit program. These reports are discussed in the following sections.

2.5.4.1 Toxic Release Inventory

The Toxic Release Inventory (TRI) is a database that contains information concerning specific toxic chemical releases, transfers, and waste management and pollution prevention activities from manufacturing facilities throughout the United States. This inventory was established under EPCRA, which Congress passed to promote planning for chemical emergencies and to provide information to the public about the presence and releases of toxic and hazardous

chemicals in their communities. TRI does not regulate the chemical releases themselves. TRI data can be accessed at http://www.epa.gov/enviro/facts/tri/form_r_search.html.

ASARCO submits annual TRI reports that include air emissions from both point source and fugitive sources of air pollutants. TRI reports for the Hayden smelter operation have been submitted since 1987. The ASARCO Hayden operation has been one of the top sources of chemical releases in the nation. Table 2-4 presents a summary of TRI air emissions from ASARCO fugitive and point sources for the past seven years of available data (2003-2009). The following observations are made based on Table 2-4:

- The total TRI air emissions reported ranged from a low of approximately 102 tons in 2004 to a high of about 268 tons in 2003. Approximately 249 tons of TRI air emissions were reported for 2009 (the most recent year for which data are available).
- Sulfuric acid aerosol emissions (related to SO_2 in the ambient air) represented between 58 percent and 81 percent of total TRI emissions reported during the seven-year period. Approximately 186 tons of sulfuric acid aerosol emissions were reported for 2009.
- During the period 2003 through 2009, the highest reported air emissions of metals were for copper, zinc, barium, lead, and arsenic.
- A majority of the sulfuric acid, zinc, and barium was reported to be emitted through point sources, while a majority of the copper, lead, and arsenic was reported to be emitted through fugitive sources.

2.5.4.2 Annual Air Emissions Inventory

Each Class I/Title V facility must submit an annual accounting of the actual air pollutant emissions from their facility. These Annual Emissions Inventories include facility-wide actual emissions of all criteria pollutants, plus HAPs. In 2008 ASARCO reported the following SO_2 and arsenic, cadmium, chromium, copper, lead, and PM_{10} actual emissions:

	CONCENTRATOR	SMELTER
Pollutant	**Emissions (tons/year)**	**Emissions (tons/year)**
SO_2	0.0011	21,741.58
Arsenic	0.0009	2.996
Cadmium	0.0003	0.1332
Chromium	0.003	0.0552
Copper	None Reported	35.88
Lead	0.0008	4.8155
PM_{10}	18.64	195.39

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, the Study Area was divided 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 Railway Junction Segment
    - Area #18B – Kennecott Avenue
    - Area #18C – Winkelman Railway Segment
    - Area #18D – Smelter Hill Railway Segment
- Area #19 – Areas Outside of Areas #1 through #18

Figure 2-6 (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 air investigations are provided in Section 4.4.

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3.0 PRELIMINARY SITE CHARACTERIZATION

This section presents a summary of the results of various investigations of ambient air quality in the Hayden and Winkelman communities. Based on these results, a preliminary characterization of Site air quality is presented. Information relating to source apportionment, particle size distributions, and process emissions at the Site has been included where relevant to the review of air quality.

The existing ambient air monitoring program within the Study Area has involved the collection of meteorological, TSP (lead), PM_{10}, and COPC metals data from various ambient air monitors installed and operated within the Study Area. The monitoring stations include EPA Hayden and Winkelman Stations (RI/FS Phase I), and ASARCO/ADEQ Hayden Jail, Globe Highway, Montgomery Ranch, and Hayden Junction stations. A summary of the ambient air data collected by EPA at the Hayden Station from October 22, 2006 through December 31, 2010, and at the Winkelman Station from November 21, 2006 through December 31, 2010, is provided in Section 3.1. A comparison of this data to a number of reference values, including background and regulatory standards, is presented in Section 3.2. An evaluation of trends in the data, as well as a comparative analysis of the data collected at a single monitoring location and across locations, are the subject of Section 3.3. The final section (Section 3.4) evaluates both this data and other information from previous studies from the vantage point of apportioning the observed ambient air conditions to potential sources.

3.1 Ambient Air Data Summary

An evaluation of available ambient air quality data for PM_{10} and selected metals (including arsenic, lead, copper, cadmium, and chromium) for the Hayden and Winkelman air monitoring stations is provided below. Additional data collected by ADEQ and/or ASARCO, as well as other specialized sampling that has been conducted within the Study Area, are also discussed within the following sections where relevant.

All PM_{10} samples from the Hayden and Winkelman Stations were collected on pre-loaded filters for a 24-hour period (from midnight to midnight local time) according to the US EPA six-day schedule (EPA, 2008). Meteorological data, including ambient temperature, relative humidity, wind speed, and wind direction, was also collected continuously as 30-minute averages at each station. The sample filters collected were submitted to a certified laboratory for analysis of PM_{10} by gravimetric method and for metals analysis of the PM_{10} fraction by EPA Compendium Method IO-3.3 using X-ray fluorescence spectroscopy.

The PM10 and metals data set (arsenic, cadmium, chromium, lead and copper) for the Hayden and Winkelman Stations during the 2006 through 2010 periods mentioned above are summarized

in Table 3-1. This summary also incorporates the results of air samples collected during the periods from January 15 to February 5, 2007, March 10 to March 31, 2008, and May 25 to June 24, 2009, when ASARCO"s smelter facility was shut down for annual maintenance. In general, as would be expected, the concentrations of PM_{10} and metals detected at the two stations are shown to vary considerably over time due to a combination of factors, including the relative locations of the emission source(s) and the monitoring stations, variations in the emission rates from the sources, and meteorological conditions such as wind direction and speed.

3.1.1 PM_{10} Data

As indicated in Table 3-1, during the period for which monitoring data was reviewed, there were 244 available results for PM_{10} at the Hayden Station and 214 results available for the Winkelman Station. The average annual PM_{10} values for the Hayden Station ranged from 26.98 ug/ m^3 to 39.27 ug/ m^3 over this period. These values are about two times the average annual PM_{10} values at the Winkelman Station, which ranged from 13.46 ug/ m^3 to 21.42 ug/ m^3. (NOTE: Because 2006 data consisted of less than three months of monitoring, these data were not considered sufficient for calculation of annual averages.)

Figures 3-1 and 3-2 show 24-hour ambient air PM_{10} concentrations at the two stations. In general, as would be expected based on the annual average values, PM_{10} concentrations were observed to be higher at the Hayden Station than at the Winkelman Station during most sampling events. The highest or lowest PM_{10} concentrations at both monitoring stations did not necessarily occur on days with the highest or lowest wind speeds. Historically, data has shown limited correlation between wind speed and PM_{10} concentrations.

3.1.2 Metals Data

The concentrations of metals including arsenic, lead, copper, cadmium, and chromium in the PM_{10} filters were evaluated for both the Hayden and Winkelman Stations and are shown on Figures 3-3 through 3-12, respectively. The metals results are further described below.

Arsenic Data

Of the 243 samples collected in Hayden during the reporting period and analyzed for metals, 217 samples contained arsenic at sufficient concentrations above the method detection limit (MDL) to meet the three-sigma analysis certainty criteria (99.7% confidence) for arsenic. Of the 214 samples collected in Winkelman during the reporting period and analyzed for metals, 157 samples contained arsenic at sufficient concentrations above the MDL to meet the three-sigma analysis certainty criteria (99.7% confidence) for arsenic.

Figure 3-3 presents the 24-hour average ambient air concentrations for arsenic measured at the Hayden Station during the monitoring period. As indicated in Table 3-1, the annual average

arsenic concentrations at the Hayden Station during the monitoring period ranged from 0.0214 ug/m^3 to 0.0300 ug/m^3. The maximum detected 24-hour average arsenic concentration at the Hayden Station was 0.2276 ug/m^3 on November 21, 2008.

Figure 3-4 presents the 24-hour average ambient air concentrations for arsenic measured at the Winkelman Station during the monitoring period. As indicated in Table 3-1, the annual average arsenic concentrations at the Winkelman Station during the monitoring period ranged from 0.0065 ug/m^3 to 0.0087 ug/m^3. The maximum detected arsenic concentration at the Winkelman Station (0.0389 ug/m^3) occurred on December 10, 2010.

The arsenic results from the Hayden Station were on average higher than the results from the Winkelman Station. However, on several specific days in which both stations were sampled, results for arsenic were found to be higher at the Winkelman Station than those found at the Hayden Station. The days on which elevated arsenic concentrations were reported in Hayden and Winkelman also did not coincide. The lack of correlation in arsenic concentrations between the two stations is not unexpected given: (1) the two stations have different spatial relationships with the Hayden Complex operations; and (2) the two stations exhibit different wind patterns, as previously discussed in Section 2.3.2.2. The significance of these results is discussed in Section 3.3 below.

Lead Data

Of the 243 samples collected at the Hayden Station during the reporting period and analyzed for metals, 240 samples contained lead at sufficient concentrations above the MDL to meet the three-sigma analysis certainty criteria (99.7% confidence) for lead. Of the 214 samples collected in Winkelman during the reporting period and analyzed for metals, 191 samples contained lead at sufficient concentrations above the MDL to meet the three-sigma analysis certainty criteria (99.7% confidence) for lead.

Figure 3-5 presents the 24-hour average ambient air concentrations for lead measured at the Hayden Station during the monitoring period. As indicated in Table 3-1, the average annual lead concentrations at the Hayden Station during the monitoring period ranged from 0.0740 ug/m^3 to 0.1128 ug/m^3. The maximum detected 24-hour average lead concentration was 0.984 ug/m^3 on November 21, 2008.

Figure 3-6 presents the 24-hour average ambient air concentrations for lead measured at the Winkelman Station during the monitoring period. As indicated in Table 3-1, the average annual lead concentrations at the Winkelman Station during the monitoring period ranged from 0.0160 ug/m^3 to 0.0276 ug/m^3. The maximum detected 24-hour average lead concentration was 0.2067 ug/m^3 on January 12, 2008.

As with the arsenic results, the lead readings for the Hayden Station were on average significantly higher than those for the Winkelman Station. However, on some sample days, lead readings were higher at the Winkelman Station than those at the Hayden Station. Elevated concentrations of lead at the two stations did not occur on many of the same dates. The significance of the results is discussed in Section 3.3 below.

Copper Data

Of the 243 samples collected in Hayden during the reporting period and analyzed for metals, 242 samples contained copper at sufficient concentrations above the MDL to meet the three-sigma analysis certainty criteria (99.7% confidence) for copper. Of the 214 samples collected in Winkelman during the reporting period and analyzed for metals, 212 samples contained copper at sufficient concentrations above the MDL to meet the three-sigma analysis certainty criteria (99.7% confidence) for copper.

Figure 3-7 presents the 24-hour average ambient air concentrations for copper measured at the Hayden Station during the monitoring period. As indicated in Table 3-1, the annual average copper concentrations reported for the Hayden Station during the reporting period ranged from 0.3738 ug/m^3 to 0.6957 ug/m^3. The maximum 24-hour ambient air copper concentration detected at the Hayden Station during the monitoring period was 3.997 ug/m^3 on November 21, 2006.

Figure 3-8 represents the 24-hour average ambient air concentrations for copper measured at the Winkelman Station during the monitoring period. As indicated in Table 3-1, the average annual copper concentrations at the Winkelman Station during the reporting period ranged from 0.1257 ug/m^3 to 0.3101 ug/m^3. The maximum 24-hour ambient air copper concentration detected at the Winkelman Station during the monitoring period was 1.39 ug/m^3 on November 9, 2008.

As shown on Figures 3-7 and 3-8, the copper results for the Hayden Station were on average significantly higher than those for the Winkelman Station. The maximum copper concentration detected at the Winkelman Station was about one-third the maximum value recorded at the Hayden Station. The 24-hour ambient air concentrations for copper detected in samples collected at the Hayden and Winkelman Stations display patterns very similar to those for arsenic and lead, as discussed above. The significance of the results on these days is discussed in Section 3.3 below.

Cadmium Data

Of the 243 samples collected in Hayden during the reporting period and analyzed for metals, 45 samples contained cadmium at sufficient concentrations above the MDL to meet the three-sigma analysis certainty criteria (99.7% confidence) for cadmium. Of the 214 samples collected in Winkelman during the reporting period and analyzed for metals, 11 samples contained cadmium

at sufficient concentrations above the MDL to meet the three-sigma analysis certainty criteria (99.7% confidence) for cadmium. The relatively low number of samples satisfying the 99.7% confidence level for cadmium indicates that most of the samples exhibited cadmium concentrations close to or below the MDL. Those below the MDL were assigned a value equal to the MDL and were appropriately qualified during the data validation process. This explains the occurrence of the same value for several consecutive sampling periods in Figures 3-9 and 3-10.

Figure 3-9 presents the 24-hour average ambient air concentrations for cadmium measured at the Hayden Station during the monitoring period. As indicated on Table 3-1, the average annual cadmium concentrations reported for Hayden during the monitoring period ranged from 0.0017 ug/m^3 to 0.0069 ug/m^3. The maximum 24-hour ambient air cadmium concentration detected at the Hayden Station during the monitoring period was 0.0351 ug/m^3 on November 21, 2006.

Figure 3-10 represents the 24-hour average ambient air concentrations for cadmium measured at the Winkelman Station during the monitoring period. As indicated on Table 3-1, the average annual cadmium concentrations reported for Winkelman during the monitoring period ranged from 0.0006 ug/m^3 to 0.0021 ug/m^3. The maximum 24-hour ambient air cadmium concentration detected at the Winkelman Station during the monitoring period was 0.0049 ug/m^3 on December 10, 2010.

As shown on Figures 3-9 and 3-10, the average cadmium concentration found in the Hayden Station data was higher than the average concentration in the Winkelman Station data. The maximum cadmium concentration detected at the Winkelman Station was almost an order of magnitude lower than the maximum value recorded at the Hayden Station. The 24-hour ambient air concentrations for cadmium detected in samples collected at the Hayden and Winkelman Stations display patterns very similar to those for other metals, as discussed above. The significance of the results on these days is discussed in Section 3.3 below.

Chromium Data

Of the 243 samples collected in Hayden during the reporting period and analyzed for metals, 112 samples contained chromium at sufficient concentrations above the MDL to meet the three-sigma analysis certainty criteria (99.7% confidence) for chromium. Of the 214 samples collected in Winkelman during the reporting period and analyzed for metals, 29 samples contained chromium at sufficient concentrations above the MDL to meet the three-sigma analysis certainty criteria (99.7% confidence) for chromium.

Figure 3-11 presents the 24-hour average ambient air concentrations for chromium measured at the Hayden Station during the monitoring period. As indicated in Table 3-1, the average annual chromium concentrations reported for the Hayden Station over the monitoring period ranged

from 0.0012 ug/m^3 to 0.0022 ug/m^3. The maximum 24-hour ambient air chromium concentration detected at the Hayden Station (0.0149 ug/m^3) was reported on October 29, 2010.

Figure 3-12 presents the 24-hour average ambient air concentrations for chromium measured at the Winkelman Station during the monitoring period. As indicated in Table 3-1, the average annual chromium concentrations reported over the monitoring period ranged from 0.0006 ug/m^3 to 0.0014 ug/m^3. The maximum 24-hour ambient air chromium concentration detected at the Winkelman Station (0.0056 ug/m^3) was reported for March 27, 2007.

As shown on Figures 3-11 and 3-12, the concentration patterns for chromium in the Hayden and Winkelman samples do not display patterns similar to those for other metal COPCs, with the elevated chromium concentrations occurring on days that did not coincide with the days of elevated concentrations of other metals. Potential reasons for this observed change in observed patterns are presented in Sections 3.2.1 and 3.4.2.

3.2 Comparison of Air Quality Data to Reference Values

In Section 3.2, the observed concentrations of PM_{10} and metal COPCs at the Hayden and Winkelman Stations will be put into regional and regulatory perspective by comparing the concentrations to background conditions, to data from similar monitoring stations in Arizona and elsewhere, and to various applicable regulatory standards.

3.2.1 Comparison to Background Air Quality

A background air monitoring station was not installed as part of the Phase 1 RI. Rather, data from several remote monitoring locations in Arizona with minimal anthropogenic (caused or influenced by human activities) contributions were reviewed to identify appropriate datasets for an area similar to Hayden, Arizona. Based on this review, PM_{10} filter samples from the Organ Pipe National Monument (Organ Pipe, part of the Interagency Monitoring of Protected Visual Environments [IMPROVE] network), were selected for use as background concentrations. A selected number of samples collected at the Organ Pipe Station during CY 2006 were submitted to Chester LabNet for analysis of PM_{10} and metals using the same EPA methodology used for analysis of samples from the Phase I RI locations. The annual mean, minimum, and maximum values for PM_{10} and selected metals (arsenic, cadmium, copper, lead, and chromium) from the Organ Pipe Station are summarized in Table 3-2.

The concentrations of arsenic were non-detect in the ambient air samples from the Organ Pipe background station. The MDL for arsenic (0.0003 ug/m^3) was below the arsenic ambient air risk-based screening level (RSL) of 0.00057 ug/m^3, except for five samples that had an arsenic MDL of 0.0006 ug/m^3, only slightly above the RSL. Cadmium was also non-detect in the ambient air samples from the Organ Pipe Station, with an MDL of 0.0006 ug/m^3. The arithmetic

mean concentrations of chromium, copper, and lead in background samples were 0.00049 ug/m^3, 0.00142 ug/m^3, and 0.00133 ug/m^3, respectively. Only the chromium concentration exceeded a standard or health-based reference value, i.e. the RSL of 0.000011 ug/m^3. Again, however, the RSL for chromium is based on the concentration of hexavalent chromium, whereas total chromium is reported for the background samples.

Based on these 2006 background levels, the following observations are made for the samples collected at the Hayden and Winkelman Stations for the period 2006-2010:

- All samples collected at the Hayden and Winkelman Stations were above the background concentration for arsenic. The annual average concentrations for arsenic exceeded the background level by at least an order of magnitude.
- The range of annual average concentration values for lead detected in the Hayden Station samples was 56 to 85 times higher than the background annual average concentration at the Organ Pipe Station of 0.00133 ug/m^3. The range of annual average concentration values for lead at the Winkelman Station was 12 to 21 times higher than the average background value.
- Of the 242 samples and 212 samples collected at the Hayden and Winkelman Stations, respectively, that exceeded the MDL for copper, 100% exceeded the Organ Pipe copper ambient air background arithmetic mean concentration of 0.000142 ug/m^3. The range of annual average concentration values for copper at the Hayden station was 263 to 490 times higher than the Organ Pipe Station average background concentration. The range of annual average copper concentrations at the Winkelman Station during the reporting period was 88 to 218 times the average background copper concentration.
- The average annual cadmium concentrations reported for Hayden, as shown in Table 3-1, were all above the Organ Pipe Station average background value (MDL of 0.0006 to 0.0009 ug/m^3). The Winkelman Station average annual concentrations for cadmium were also above the average background value in CY 2007-2008, but fell to levels consistent with background in subsequent years.
- As shown in Table 3-1, the Hayden Station average annual chromium concentrations over the monitoring period ranged from 0.0012 ug/m^3 to 0.0022 ug/m^3, or about 3.5 times higher than background on average when compared to 0.00049 ug/m^3 at the Organ Pipe Station. The average annual chromium concentrations reported over the monitoring period for the Winkelman Station ranged from 0.0006 ug/m^3 to 0.0014 ug/m^3, or only slightly higher than background at the Organ Pipe Station.

3.2.2 Comparison to National Air Toxics Trend Sites Network

The National Air Toxics Trend Sites (NATTS) network was designed to monitor and record the concentrations of certain air toxics on a national scale. As part of the National Air Toxics Assessment (NATA) process, data from EPA"s national monitoring activities are used to estimate national average concentrations for air toxics and to assess the national toxics inventory and hazardous air pollutant (HAP) trends. Using this information, EPA, the States, and local agencies can estimate changes in the risks of human exposure.

The ADEQ accepted federal funding and responsibility for the NATTS program in Arizona in 2003. The ADEQ JLG Supersite is the designated NATTS site for the Phoenix metropolitan area. Additional ambient air monitoring of air toxics is conducted by the ADEQ in Tucson. Table 3-3 shows the range (minimum to maximum detected concentrations) of the 24-hour ambient air concentrations of arsenic, cadmium, and chromium collected at both the ADEQ Phoenix and Tucson NATTS stations during the period 2006 through 2007 compared to the range of concentrations measured in the unqualified data for the Hayden and Winkelman air monitoring stations during the same sampling period (2006-2007). No NATTS data from Phoenix and Tucson was available for copper or lead. The following comparison is made:

- The range of 24-hour concentrations of arsenic at the Hayden Station was greater than levels found in either Phoenix or Tucson. The range of 24-hour concentrations of arsenic at the Winkelman Station was also greater than levels found in either Phoenix or Tucson.
- The range of 24-hour concentrations of cadmium at the Hayden Station was greater than the levels found in Phoenix or Tucson; however, the degree to which these were exceeded was far less than observed for arsenic. Statistical analysis would be necessary to determine the significance of the levels above the NATTS monitoring results for cadmium. The range of 24-hour concentrations of cadmium at the Winkelman Station was similar to levels found in the Phoenix and Tucson areas.
- The 24-hour concentrations of chromium at both the Hayden and Winkelman Stations were within the range of levels found in the Phoenix and Tucson areas, but elevated above background values detected at Organ Pipe National Monument.

The evidence of concentrations of arsenic significantly above the NATTS data strongly supports a conclusion that a local source of arsenic is impacting air quality in the Hayden and Winkelman communities. The relative concentrations of arsenic to cadmium coincides with the ambient air data collected as part of the 1987 *Source Apportionment of Suspended Particles and Toxic Elements in Hayden Arizona*, see Section 2.4.2.2. Both the Phase I RI and the 1987 study found cadmium concentrations in ambient air to be significantly lower than arsenic concentrations. The NATTS data, however, does not reflect this same distribution, but rather found very similar concentrations of arsenic and cadmium. The much higher proportion of arsenic to cadmium

found in ambient air in the Hayden area likely reflects source contributions from operations at the Hayden Complex. A more detailed source apportionment study, as proposed for the Phase II RI, is necessary to differentiate the contributing sources.

The fact that chromium concentrations in the Hayden and Winkelman Station data are similar to those found in the NATTS data for Phoenix and Tucson indicates that there are other, perhaps more ubiquitous sources of chromium in the regional area that may not be tied to the ASARCO Hayden operations. This supposition is further supported by the detection of chromium within the ambient air background data (see Section 3.2.1).

3.2.3 Comparison to Standards and Health-Based References

Regional Screening Levels (RSLs) were developed by EPA for individual contaminants in air, drinking water, and soil to provide a tool to assist in the evaluation of the significance of site-specific contaminant levels (i.e., a "screening" tool). The RSLs are calculated using the latest toxicity values, default exposure assumptions, and physical and chemical properties of the specific contaminants in a given medium. RSLs are default screening levels that can assist decision makers in determining if sites warrant further investigation and/or clean-up. Chemical-specific RSLs correspond to either a 10^{-6} risk level for carcinogens or a Hazard Quotient (HQ) of 1 for non-carcinogens. All air RSLs are based upon a 24-hour average concentration in ug/m^3. The RSLs replaced previous EPA Preliminary Remediation Goals (PRGs), which were used to evaluate ambient air data at the time of the Phase I RI.

Ambient air data for arsenic, cadmium, and chromium collected at the Winkelman and Hayden Stations were compared to the most recent RSLs. RSLs are not available for copper, lead, or PM_{10}, so these parameters were compared to other relevant reference values or standards. These include the NAAQSs for PM_{10} and lead, and the California Office of Environmental Health Hazard Assessment and Air Resources Board Approved Risk Assessment Health Values - Acute Reference Exposure Level (CA Acute REL) for copper. Table 3-2 compares the air quality standards and risk-based reference values to the annual average concentration values for the Hayden and Winkelman Stations.

The Arizona Hazardous Air Pollutant Program was also reviewed for relevant health-based standards for the COPCs. This program, documented in Arizona Administrative Code (AAC) R18-2-1708 - *Risk Management Analysis*, Table 3, includes Acute and Chronic Ambient Air Concentrations (AACs) for arsenic, cadmium, and chromium VI. With the exception of chromium VI, the Arizona Chronic AAC for these COPCs is very close to the RSLs, as shown below

COPC	RSL (ug/m^3)	AZ ACC (ug/m^3)
Arsenic	5.66×10^{-4}	4.41×10^{-4}
Cadmium	1.4×10^{-3}	1.05×10^{-3}
Chromium VI	1.1×10^{-5}	1.58×10^{-4}

A direct comparison of individual sample results to the corresponding RSL or AZ ACC values would be a preferred approach for documenting the percentage of all samples meeting or exceeding the reference values. However, because the reference values for the COPC metals are below or within the 99.7% confidence level of the MDLs, and the actual concentrations for any sample not exceeding the 99.7% confidence level cannot be stated without qualification, it is not possible to determine whether or not those samples not meeting the 99.7% confidence level exceed the RSL or AZ ACC. On the other hand, every sample that did exceed the 99.7% confidence level exceeded the RSL or AZ ACC. Therefore, to use only qualified data for comparison to the RSL or AZ ACC was found to provide no discrimination of the data given that all of the corresponding samples exceeded the RSL or AZ ACC. As a result, the percent of exceedances can only be qualitatively presented by indicating the regulatory standard on Figures 3-3 through 3-12 for comparison to the spread of the data. The following sections provide alternative methods of comparison of the sampling results to the standards.

PM_{10} Compared to NAAQS

The highest detected concentration of PM_{10} at the Hayden Station (177.2 ug/m^3) occurred on November 9, 2008. This was the only sample collected at either of the two stations during the four-year period that exceeded the NAAQS 24-hour PM_{10} value of 150 ug/m^3. The highest concentration of PM_{10} at the Winkelman Station (91.9 ug/m^3) occurred on March 26, 2009, and was below the NAAQS.

Arsenic Compared to RSL

The annual average concentration ranges for arsenic shown in Table 3-1 are about 37 to 53 times higher than the RSL. Arsenic concentrations were detected at values that exceeded 100 times the RSL (i.e., 0.057 ug/m^3) on 24 days during the 2006-2910 monitoring period. The maximum detected 24-hour average arsenic concentration at the Hayden Station of 0.2276 ug/m^3 is about 400 times the ambient air RSL.

The maximum detected arsenic concentration at the Winkelman Station of 0.0389 ug/m^3 is about 68 times the ambient air RSL. The annual average concentration ranges shown for the Winkelman Station in Table 3-1 are about 11 to 15 times higher than the RSL.

The levels of arsenic found at both the Hayden and Winkelman Stations since 2008 that are significantly above the health-based RSL, as noted above, are indications of the potential impact that sources of arsenic at the Site continue to exert on ambient air quality in both communities. The *Baseline Human Health Risk Assessment for the ASARCO Hayden Plant* (CH2M Hill, 2008b) found that, of the total cancer risk from exposure to ambient air in Hayden, 80% of the risk contribution was from arsenic. The risk contribution of arsenic to the total risk from exposure to ambient air in Winkelman was 64%.

Lead Compared to NAAQS

It is important to note that the monitors used at the Hayden and Winkelman Stations do not meet the requirements for use in determining NAAQS compliance. Lead-related data used to determine compliance with the NAAQS for lead must be collected and analyzed using a Federal Reference Method (FRM) or Federal Equivalent Method (FEM) for lead. The current FRM for lead sampling is based on the use of a high-volume total suspended particulate (TSP) sampler, and use of Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) for the analysis for lead (40 CFR 50, Appendix G). All other approved FEMs also are based on the use of high-volume TSP samplers. Although the current monitors do not meet these requirements, the sampling results are believed to be reliable indicators of ambient air lead concentrations and suitable for use in this preliminary evaluation of site conditions.

The lead NAAQS at the time of the Phase I RI was 1.5 ug/m^3 as a rolling three-month average. Ambient air data collected prior to the drafting of the RI Phase I Report was compared to this standard and levels were found to be below the standard at that time. However, EPA revised the lead NAAQS in 2008 to 0.15 ug/m^3 as a rolling three-month average. This summary review compares the ambient air data from the Phase I RI to the current NAAQS for lead (0.15 ug/m^3).

As shown on Figure 3-5, on three days over the period from September 30, 2008, to February 4, 2009, the 24-hour average ambient air concentration of lead as PM_{10} at the Hayden Station exceeded 0.9 ug/m^3. During that same period, the three-month rolling average concentration of lead as PM_{10} equaled or exceeded the current lead NAAQS of 0.15 ug/m^3. In comparison, the three-month rolling average lead concentration at the Winkelman Station did not approach the lead NAAQS throughout the monitoring period.

In addition, ADEQ installed and began sampling operations of a Pb-TSP monitor on October 5, 2010, just west of the Hayden Complex along the Globe Highway. Starting April 9, 2011, the three-month rolling average of sampling results (using three months of data from January 19, 2011 forward) exceeded the lead NAAQS (0.15 ug/m^3) determined as a rolling three-month average. This exceedance continued without interruption through August 24, 2011 (using three months of data including data from August 19, 2011).

Copper Compared to CA Acute REL

Since no chronic health-based reference value or NAAQS is available for copper, the ambient air concentrations found at the Hayden and Winkelman Stations were compared to the CA Acute REL. An acute concentration would represent the concentration in ambient air above which the general population, including susceptible populations, could experience acute (sudden) adverse health effects. The CA Acute (one hour) REL for copper is 100 ug/m^3. None of the 24-hour ambient air samples collected during the sample period at either the Hayden or Winkelman Stations contained copper concentrations above the CA Acute REL.

Cadmium Compared to RSL

The annual average concentrations of cadmium at the Hayden Station (2007-2010) exceeded the RSL in all years. On 13 days during the monitoring period, cadmium concentrations were unusually elevated and were detected at values that exceeded 0.010 ug/m^3, or approximately an order of magnitude above the RSL and the chronic AZ Chronic AAC of 0.00105 ug/m^3. The annual average concentrations at Winkelman exceeded the RSL for cadmium only for CY 2007-2008, with annual averages in subsequent years being below the RSL. Because of the MDL issue discussed above, it is difficult to determine exactly how many days the cadmium concentrations exceeded the RSL or the AAC.

Chromium Compared to RSL

The RSL for chromium (0.000011 ug/m^3) and the AZ Chronic AAC (0.000158 ug/m^3) are specific for hexavalent chromium. Because the Hayden and Winkelman samples were not collected and analyzed to obtain concentrations of hexavalent chromium, the total chromium concentrations were conservatively used for comparison purposes to the RSL and AZ Chronic AAC. The annual average concentrations of total chromium at the Hayden and Winkelman stations (2007-2010) exceeded the RSL and AZ Chronic ACC for chromium VI in all years.

Sulfur Dioxide (SO_2) and Other Metals in Hayden and Winkelman

Although not a focus of the Phase 1 RI or the continuing air monitoring at the Hayden and Winkelman Stations, concentrations of SO_2 in ambient air in the Hayden area have been studied since the early 1970s, when ADEQ began collecting ambient SO_2 monitoring data (ADEQ, 2002). An extensive network of 20 mobile and stationary monitors had once been deployed to measure the ambient impacts of smelter emissions of SO_2 throughout the Hayden area continuously. Over time, based on joint decisions by ADEQ and ASARCO, the number of permanent monitors in service was reduced to six at five locations found to be representative of the locations of maximum SO_2 concentrations in the area: the Globe Highway site, the Garfield Avenue site, the Montgomery Ranch site, the Hayden Junction Site, and two monitors at the Hayden Jail site (ADEQ, 2007). The data from these monitors, as reported on EPA‟s AirData website (www.epa.gov/air/data) since 1998, show no exceedances of the 24-hour NAAQS for

SO_2 (0.140 ppm not to be exceeded more than once per year) or the annual mean NAAQS for SO_2 (0.030 ppm annual mean) in the Hayden area.

3.3 Comparative Analysis of Ambient Air Data

A qualitative comparative review of the ambient air data was performed comparing COPC concentrations at a given station over time; concentrations of different metals at the same location; and COPC concentrations at one monitoring station against those at another station. The purpose was to extract information from the comparisons in support of the Phase II planning process toward the goal of filling data gaps for source apportionment and the HHRA.

3.3.1 Data Trends

In evaluating trends within the ambient air data collected at both the Hayden and Winkelman Stations, care must be exercised in the interpretation of observed short-term changes. For example, a review of the average concentration of COPCs at the Hayden Station calculated as a mathematical average over the period January through June 2010, as compared to the average concentration measured from July through December 2010, found concentrations to be higher for all COPCs in the second half of the calendar year. This short-term increase may be indicative of a seasonal change in climate and/or operations at potential sources at the Hayden Complex, and may not represent a "trend" of any significance. It is more appropriate, therefore, to compare concentrations of COPCs over a longer period of time.

Hayden Station

A comparison of the annual average concentration of COPCs at the Hayden Station in CY 2010 against the CY 2009 concentrations indicates that the concentrations of all COPCs were higher in CY 2010. For example, the 2009 annual average concentrations for arsenic, copper and lead were 0.0214 ug/m^3, 0.3738 ug/m^3, and 0.0740 ug/m^3, respectively, whereas the annual average concentrations for CY2010 were 0.0300 ug/m^3, 0.5795 ug/m^3, and 0.0833 ug/m^3. However, when compared over the full CY 2007 through 2010 sampling period, the CY 2010 annual average concentrations of most COPCs were within the range of annual concentrations measured. Only the 2010 arsenic and lead concentrations were among the highest annual average concentrations throughout the sampling period.

This recent increase in arsenic and lead would seem to reverse a slight downward trend in these COPCs shown in the data prior to CY 2010 at the Hayden Station. One possible theory is that the increases in ambient concentrations of arsenic and lead result from changes at potential sources within the Hayden Complex, i.e. raw material inputs, production rates, operating schedules, emission collection efficiency, emission control equipment performance, etc.

Winkelman Station

In looking at the *annual* average concentration of COPCs at the Winkelman Station in CY 2010 as compared to CY 2009, concentrations of arsenic, lead, chromium and copper were found to be higher in 2010. However, the CY 2010 annual average concentrations of most COPCs were within the range of annual concentrations measured throughout the CY2007 through 2010 full sampling period, with only the CY 2010 lead and arsenic concentrations again among the highest annual average concentrations throughout the full sampling period. As noted above, this could indicate production changes at potential sources as the basis for these increases in measured concentrations in ambient air.

3.3.2 Correlation of Metal COPCs at the Same Monitoring Station

Ambient air data collected during CY 2009-2010 was further reviewed to identify sample days on which results for multiple metal COPCs were all high or all low, indicating a possible correlation and relationship to specific sources or meteorological events. As discussed previously, the metals results from the Hayden Station were on average higher than the results from the Winkelman Station. However, there were days during the sampling period in which the Winkelman Station results were higher than those found at the Hayden station. There were several days in which the concentrations of arsenic, copper, lead, and cadmium and/or chromium were all higher at the Winkelman Station.

Abnormally high concentrations of arsenic, copper, lead and cadmium were observed at the Winkelman Station on eight sampling days in CY 2010 (January 14, February 7, February 13, March 21, September 23, November 22, December 10 and December 28; see Figure 3-13A). In addition, it was noted that the lowest levels of arsenic, copper and cadmium were also found to occur on the same day during the sampling period (August 24); see Figure 3-13B.

In contrast, a high correlation of high or low concentrations of metals was found less frequently at the Hayden Station. Abnormally high concentrations of arsenic, copper, and cadmium and/or chromium were all found on only two sampling dates during CY 2010 (July 1 and October 29), Figure 3-14A. Abnormally high levels of arsenic, copper and lead were all detected on only one sampling date (January 8), Figure 3-14B. None of these dates correspond to the dates of concurrent high readings at the Winkelman Station. The lowest concentrations of arsenic, lead, copper, and/or cadmium were concurrently detected at the Hayden Station on the same day only twice during CY 2010 (February 7 and November 22), Figure 3-14C and Figure 3-14D, respectively. Interestingly, both the February 7 and November 22 dates coincide with the concurrent detection of the highest levels of these metals at the Winkelman Station, as noted above.

Windroses for each of the sampling dates noted above illustrate the predominant wind patterns during these events. As shown on Figures 3-14A and 3-14B, the windroses for the days with a high correlation of high metal readings at the Hayden Station show wind direction from the northeast, or from the general Hayden Complex area. The windroses shown in Figures 3-14C and Figure 3-14D, representing the sampling dates with a high correlation of low metal concentrations at Hayden, illustrate wind directions from the west or southeast that would be from the general area of ASARCO material handling operations or tailings impoundments.

As shown on Figure 3-13A, the windroses for the days with a high correlation of high metal readings at the Winkelman Station show a general wind direction from the northwest, or from the Hayden Complex area, although less predominant than seen in the Hayden station data. The windrose in Figure 3-13B, representing the sampling dates with a high correlation of low metal concentrations for the Winkelman Station, illustrate wind directions from the south or southeast. There are no known Hayden Complex sources in these directions from the Winkelman Station. The low concentrations may be the result of windblown fugitive dust that contains concentrations of COPCs from historical deposition.

The 1987 Source Apportionment Study, see Section 2.4.2.2, concluded that fugitive emissions from the Hayden Complex smelter contributed "almost all of the arsenic and cadmium and 80% of the lead" to ambient air concentrations. In addition, the Smelter Building Fugitive Emissions Study, see Section 2.4.2.2, found that emissions of arsenic, copper and lead represented the largest percentage of process fugitive emissions. These studies clearly demonstrated that there was a strong correlation among arsenic, copper, and lead concentrations, and to a lesser degree cadmium and iron concentrations, indicative of process fugitive emissions from the Hayden Complex.

In all the data collected during the sampling period, no clear and consistent correlation of PM_{10} concentrations with the metal COPCs was evident. Sample results with high metals concentrations did not regularly include correspondingly high concentrations of PM_{10}, although the metal COPCs are all a component of the PM_{10} sample. There were some exceptions, as evidenced by both a high chromium and high PM_{10} level on several occasions. However, even this pattern was not consistently observed throughout the period of record.

A review of a subset of the 2007 ambient air data by ADEQ found that of the total PM_{10} mass, copper represented only 8.2% to 9.3% by weight, lead 1.3% to 1.8%, and arsenic approximately 0.5%. This was further shown in the 1987 Source Apportionment Study, in which fine, course and PM_{10} samples were collected. Results from this study found that arsenic, cadmium, and lead were most abundant only in the fine particle fraction. The study further found that the ratio of fine to course particles was lowest on high wind speed days and on days with highest PM_{10} values. Sample days with low wind speeds found the highest ratios of fine to course particles.

This information supports the low correlation of PM_{10} results with the metal COPCs found in the ambient air data during the sampling period.

3.3.3 Correlation of Metal COPCs Across Monitoring Stations

The observed relationship between the concentrations measured at the Hayden Station and those measured at the Winkelman Station on the same sampling days, as noted within Section 3.1.2, also provides insight into the potential impact of source operations on ambient air quality. Particularly significant are those dates on which the concentrations measured at the Winkelman Station were higher than those measured at the Hayden Station. The days on which this aberrant relationship of arsenic, copper and lead levels at the Winkelman Station versus the Hayden Station occurred were found to have similar meteorological conditions, thereby suggesting a correlation with a particular source or group of sources.

However, there were other sampling days during the same sampling period, e.g. October 23, 2010, on which the concentrations of COPCs at the Winkelman Station were lower than those at the Hayden Station under the same meteorological conditions. This may indicate that changes in operations at the Hayden Complex on a given day may also have to be considered to explain the observed patterns fully. As noted above, the Phase II source apportionment study will shed more light on the significance of these observations.

3.4 Relationship of Ambient Air COPC Data and Potential Sources

The combination of the preliminary data analysis reported in the previous sections and the findings and conclusions of several previous studies provides considerable insight into the potential sources of COPC metals in ambient air in the Study Area. Three particular sources of evidence linking sources and ambient air observations are discussed below.

3.4.1 Speciation & Particle Size Distribution – Previous Studies

Air pollutants from the ASARCO copper ore handling and refining operations are released to ambient air by process point sources through emissions from vents and ducts; by process sources in the form of uncontrolled fugitive emissions; and by area sources such as paved and unpaved roads, disturbed surfaces, tailing piles, and depositional areas in the form of fugitive dust emissions from wind and mechanical activities.

Ambient particulate matter consists of primary particles (direct emissions) as well as secondary particles (formed from directly emitted gases). Particulate matter spans a large range of particle sizes from 0.001 to ~100 microns in aerodynamic diameter, and the size distribution changes owing to evaporation, condensation, and deposition between source and receptor. This

differentiation of size and composition constitutes "fingerprints" that can define the "source profile" and allow the estimation of source contributions to specific receptor locations.

Figure 3-15 illustrates an idealized ambient air relative mass concentration versus particle size distribution. Formation mechanisms and chemical components associated with different regions of the distribution are illustrated. Coarse mode particles (2.5 microns and larger) present in ambient air frequently result from mechanical action such as windblown dust, grinding operations, and vehicular movement. The formation of accumulation mode particles (0.1 microns to 2.5 microns) in ambient air is almost exclusively the result of condensation of hot gases and coagulation of ultrafine particles, but not from mechanical action. Windblown dust contains a relatively low mass concentration of fine and ultrafine particles because: a) these particles adhere very strongly to coarse particles (by van der Waal‟s forces) and cannot be separated from them by wind action; and b) the mass of a particle is proportional to the cube of its diameter, such that the mass concentration ($\mu g/m^3$) of an aerosol sample can be dominated by the presence of relatively few coarse particles.

Previous source apportionment studies have shown that the primary metal COPCs found in ambient air are arsenic, lead, and copper. A finding of the 1987 Source Apportionment Study was that arsenic and lead are found in the finer fraction of particulate matter emitted by sources at the Hayden Complex. Copper, on the other hand, was reported to be primarily within the coarse fraction. In a later 2010 study by Csavina et al *(Metal and Metalloid Contaminants in Atmospheric Aerosols from Mining Operations* [Csavina, et al., 2010]), it was stated that the fine particulate fraction that results from smelting operations may disperse more readily into the environment than coarser particulates, such as those found in mine tailings dust. According to Csavina et. Al, fine particulates are associated with high temperature processes, such as smelting and refining operations. Fine particulates travel greater distances before depositing on the ground. Coarse fraction pollutants would have more impact closer to the source.

In data collected in Hayden during 2008-2009 as part of the Csavina study, arsenic and lead were found to be higher than at other sites in southeast Arizona. This was also shown in the comparison with the NATTS in Section 3.2.2. The study data further found that the fine fraction of particulates represented "the most important contribution of these contaminants to atmospheric air at the site." This study concluded that the "High correlation coefficients among contaminants (As, Cd, and Pb) in both the fine- and coarse-particle size ranges indicates a unique source, which would be the case if windblown dust particles acquire aerosol contaminants via deposition of fine particles."

In the 1987 Source Apportionment Study, the differentiation between sources of the metal COPCs was also based primarily upon particle size. In this study, the speciated particulate matter emissions found that fugitive smelter source emissions are "easily distinguished" from other material handling operations and road dust based upon particle size.

The Phase I RI study results that provide the most current ambient air data are limited to PM_{10} data and do not, therefore, allow the differentiation of COPCs based upon particle size. However, the apparent correlation of arsenic, lead and other metal COPCs would suggest specific sources at the Hayden Complex are impacting air quality in the Study Area more than others.

3.4.2 Windrose Analysis and Potential Source Identification

Using ambient air data collected in CY 2010, the ten highest concentration sample days were identified for each metal COPC and PM_{10}. The meteorological data for each of the ten days was then compiled into a single windrose for each metal COPC and PM_{10}. This overlapping of individual sampling events using a windrose illustrates the predominant wind direction that contributed to the observed COPC concentrations.

In the corresponding windrose for each of the four metals (arsenic, copper, cadmium, and lead) at the Hayden Station, Figures 3-16A 3-16B, 3-16C and 3-16D, respectively, winds primarily came from a northeasterly direction with average wind speeds around 8 mph. Potential sources of emissions in that direction would include process fugitive and point sources from the smelter and concentrator buildings. The wind pattern shown in the ten-day windroses for arsenic, copper, cadmium, and lead were also displayed in the windroses representing the sample days in which concentrations of multiple COPCs were abnormally elevated, Figures 3-14A and 3-14B, as discussed in Section 3.3.2.

The windrose representing the high concentration sample days for chromium at the Hayden Station, Figure 3-16E, shows a slightly more varied and broader wind direction pattern, although average wind speed is approximately the same. This suggests the possibility of other sources of chromium in the Study Area not related to a process gas stream, as for example a crushing operation.

A more evident contrast in wind pattern from that shown in the windroses for the metal COPCs is displayed in the windrose representing the high PM_{10} concentration sample days (Figure 3-16F). The wind direction is highly variable. This further supports the lack of any significant correlation between PM_{10} and metal COPCs, and the potential for multiple fugitive dust sources contributing to the PM_{10} concentrations in ambient air.

The concentrations of COPCs detected at the Winkelman Station are generally much less than those found in the Hayden Station samples for the same sample day. The consolidated windroses for the ten days of highest arsenic, chromium, cadmium and lead readings at the Winkelman Station (Figures 3-17A, 3-17B, 3-17C, and 3-17D, respectively) display a similar wind pattern, with winds somewhat varied, but with stronger wind speeds and a higher proportion of winds from the Hayden Complex to the northwest. The high copper and high PM_{10} sample days,

Figures 3-17E and 3-17F, show a more prominent northwest pattern with higher wind speeds. This apparent consistency in the wind patterns for high concentrations of all of these COPCs suggests the influence of sources at the Hayden Complex. These sources have been found to have emissions of fine fraction particulate with significant levels of arsenic, cadmium and lead, as well as coarse fraction particulate (PM_{10}) that has been shown to include higher levels of copper. This pattern is also indicated by the windrose representing high concentrations of arsenic, copper and lead on the same day (Figure 3-13A), which again displays a stronger northwesterly wind direction pattern.

Although existing data indicates that there are general areas within the Site that are affecting air quality in the Hayden and Winkelman communities, the data is inconclusive as to the exact source(s) and their relative contribution to ambient air. Additional analysis of the COPCs detected in ambient air and source emissions, along with a more complete meteorological data set, will further define the potential source(s) I and their apportionment n the Phase II RI.

3.4.3 Ambient Air Quality During Smelter Shutdowns

During the Phase I RI monitoring period, the ASARCO smelter was shut down for annual maintenance from January 15 to February 5, 2007, and again from March 10 to March 31, 2008. However, the ASARCO concentrator facilities continued to operate during both of these periods of smelter shutdown. ASARCO also notified the ADEQ of its intent to shut down during the period of May 18 to June 28, 2009. ASARCO notified EPA in a 2009 e-mail that it "suspended operations on May 18 for the maintenance outage and restarted on June 29 following a three-day heat up period". However, because exactly when the suspension occurred on May 18, 2009, is unclear and because Hayden Station monitoring that occurred on May 19, 2009, detected high arsenic, copper, and lead concentrations, only data from May 25 to June 24, 2009, was considered for this discussion in relation to the third smelter shutdown. Once ASARCO provides EPA with precise production/operation records, the shutdown analysis can adjusted to reflect the exact shutdown period. This section briefly evaluates the changes in concentrations observed during periods when the smelter was not operating. It should be noted that the shutdown periods included only a limited number of samples; and any impacts from wind direction, wind speed, and precipitation are not evaluated in this discussion.

Table 3-4 presents the annual and shutdown period ambient air data summaries for PM_{10} and metals for the Hayden and Winkelman Stations. As shown in Table 3-4, the maximum and average measured concentrations of PM_{10} at the Hayden and Winkelman Stations were significantly lower during the smelter shutdown periods than the maximum concentrations and annual average concentrations for the associated years. The maximum and average measured concentrations of arsenic, copper, and lead at the Hayden and Winkelman Stations also were significantly lower during the smelter shutdown periods than the maximum and annual averages

for the associated years. The maximum and average measured concentrations of cadmium and chromium at the Hayden and Winkelman Stations generally were lower during the smelter shutdown periods than the maximum and annual averages for the associated years; however, the significance of the decreases was more subtle because of the relatively low concentrations of these COPCs.

For the Hayden Station, PM_{10} average values during the shutdowns exhibited reductions of 67%, 27%, and 23% when compared to the yearly averages for the respective years of 2007, 2008, and 2009. Average values for arsenic, copper, and lead at the Hayden Station during the shutdowns exhibited reductions of 82%, 84%, and 89% for arsenic; 75%, 45%, and 57% for copper; and 94%,79 %, and 92% for lead when compared to the yearly averages for the respective years of 2007, 2008, and 2009. Cadmium reductions of 26 % and 41% were also shown in the average concentrations at the Hayden Station in the 2007 and 2008 shutdown events. Cadmium concentrations were non-detect during the 2009 shutdown event. Average values for chromium exhibited reductions during the 2007 and 2009 shutdowns of 41% and 25%, respectively. However, during the 2008 shutdown, the average concentration of chromium was 89% greater than the annual average for that year.

For the Winkelman Station, PM_{10} average values during the shutdowns exhibited reductions of 69%, 60%, and 30% compared to the yearly averages for the respective years of 2007, 2008, and 2009. Arsenic, copper, and lead average values for the Winkelman Station during the shutdowns exhibited reductions of 97%, 81%, and 89% for arsenic; 29%, 79%, and 60% for copper; and 74%, 88%, and 77% for lead from the yearly averages for the respective years of 2007, 2008, and 2009. Cadmium reductions of 10% were also shown in the average concentrations at the Winkelman Station in both the 2007 and 2008 shutdowns. Cadmium concentrations were non-detect during the 2009 shutdown event. Average values for chromium showed reductions during the 2008 and 2009 shutdowns of 18% and 50%, respectively. However, during the 2007 shutdown, the average concentration of chromium was 13% greater than the annual average that year.

4.0 CONCEPTUAL SITE MODEL

This section of the Work Plan provides a discussion of the initial evaluation of chemicals of potential concern (COPCs) and the likely sources of the COPCs present in the air at the Site. Based on currently available data and information, a Conceptual Site Model (CSM) is presented that depicts potential sources, release mechanisms, exposure pathways and routes, and the human receptors. The focus of the CSM discussion is air-related exposure pathways and exposure routes.

4.1 Chemicals of Potential Concern

This section outlines the COPCs based on existing chemical data collected at the Site, and based on expected chemical emissions from ongoing copper ore processing activities and other secondary sources.

4.1.1 Chemicals of Potential Concern for Human Health Impacts

For human health risk assessments, COPCs are chemicals of potential concern to human health that are Site related and for which data are of sufficient quality for use in the quantitative risk assessment (*Risk Assessment Guidance for Superfund, Human Health Evaluation Manual* (EPA, 1989). COPCs in ambient air within the Study Area were identified in the Phase I RI and included 19 metals, including all 14 metals in the TRI reports submitted by ASARCO to EPA for reporting years 2003 to 2008. Additionally, radionuclides, SO_2, sulfates, cyanide, volatile organic compounds, and semi-volatile compounds were added to the Site COPC list since they often are associated with mining and ore processing activities. The list of COPCs for the Site is presented in Table 4-1.

Ambient air monitoring and source sampling for the source apportionment study as part of the Phase II RI, as described in this Work Plan, will include particulate matter in the form of PM_{10} and $PM_{2.5}$ and COPC metals. Ambient air monitoring for SO_2 is conducted through ambient air monitoring sites within the Study Area that are operated by the ADEQ. Additional SO_2 sampling is not proposed in this Work Plan. Radionuclides, sulfates, cyanide, volatile organic compounds, and semi-volatile compounds are not included in the Phase II RI/FS air investigation because these COPCs were primarily of concern to groundwater, and because previous investigations did not identify any air-related data gaps for these COPCs.

4.1.2 Chemicals of Potential Ecological Concern

Chemicals of potential ecological concern (COPECs) are those chemicals present at the Site in concentrations that may exceed toxicity thresholds for plants and animals (ecological receptors).

The Phase I RI did not identify any COPECs for the air exposure route and, as a result, the Phase II RI for air will not include any investigation for ecological risk.

4.2 Elements of the 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.

The section 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 4.3 discusses the CSM as it applies only to this Part 1 of 2 of the Phase II Work Plan (Air), and addresses the aforementioned division of the Study Area into 19 RI Areas as they relate to the CSM. Section 4.4 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 receptors is provided in the Human Health Risk Assessment Work Plan for air, which is attached as Appendix A to this Work Plan.

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 later sections of this Work Plan, 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 exposure for 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 Part 2 of 2 of the Phase II RI/FS Work Plan.

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.

4.3 Relationship of CSM to RI Study Areas

The CSM illustrated in Figure 4-1 is applicable to the entire Study Area. However, because the overall RI program is being developed within the context of 19 distinct subareas (RI Areas), and the intent is to evaluate human health risk separately for each of those Areas, it becomes important to place the RI Areas into the CSM framework. The development of area-specific CSMs for each of the RI Areas is not feasible for air, as complete source/pathway/receptor

relationships span multiple RI Areas. Instead, the relevant RI Areas will be mapped into the Site-wide CSM (Figure 4-1) based on the primary features of each Area.

With reference to Figure 4-1, the CSM for air includes only one primary environmental pathway – ambient air. Because risk due to exposure to COPCs in ambient air will be quantified in the HHRA only where sufficient monitoring data is available, the locations of the ambient air monitoring locations within certain RI Areas becomes an important consideration. It is noted that ten of the fifteen ambient air quality monitoring locations (including the background station) are in RI Area #19 (Areas Outside of Areas #1- #18) due to the emphasis on monitoring in those areas accessible to the general population outside of the ASARCO Hayden Complex.

An important distinction across RI Areas in relation to exposure to ambient air is the classification of the exposed individual, as this dictates the selection of the exposure model and the parameters to be assigned to that individual in the HHRA. For example, a resident receptor would be exposed to COPCs in air for a much longer duration than a recreational user within the same RI Area. The types of potential receptors to be evaluated for each of the RI Areas are addressed in the HHRA Work Plan in Appendix A.

Another important differentiator across the RI Areas in relation to the CSM for air is the primary type of source(s) associated with each Area and the corresponding primary release mechanism(s). As indicated in Section 4.2, the air investigation will address three types of primary releases of COPCs to air: point source emissions, fugitive process emissions, and area fugitive dust emissions. The first two release mechanisms are necessarily limited to those RI Areas that encompass ASARCO operations. The area fugitive dust sources include areas both within ASARCO facilities and in areas outside of the controlled areas that exhibit high concentrations of COPCs susceptible to resuspension by wind. The RI Areas from which the corresponding types of samples will be collected, as well as the individual sampling locations, are addressed in Section 6.4.1.

4.4 RI Area Summaries

This section provides a detailed discussion of the individual features identified in each of the 19 RI Areas.

4.4.1 Area #1A and Area #1B

4.4.1.1 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 at 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

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. Tailings Impoundment D is an area source identified as a fugitive PM emissions source within the 2011 draft Hayden Complex Class I/Title V Renewal Permit. The permit requires the use of good management practices, such as the application of dust suppressants, enclosures, and water spray, at all facility open areas, roadways, storage piles and material handling sources.

Particulate matter emissions from this tailings area are likely to result from vehicle traffic and wind erosion of surface materials. Previous studies were inconclusive as to the contribution the tailings provided to the overall ambient air concentrations observed. Both the Csavina study and the 1987 Source Apportionment Study found that particulates from this type of source area would be predominantly in the coarse particle size.

4.4.1.2 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 are 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 the R-SRL of 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 Region 9 preliminary remediation goal (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 also 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.

Tailings Impoundment AB/BC is an area source identified as a fugitive PM emissions source within the 2011 draft Hayden Complex Class I/Title V Renewal Permit. The permit requires the use of good management practices, such as the application of dust suppressants, enclosures, and water spray, at all facility open areas, roadways, storage piles and material handling sources. Particulate matter emissions from this tailings area are likely to result from vehicle traffic and wind erosion of surface materials. Previous studies were inconclusive as to the contribution the tailings provided to the overall ambient air concentrations observed. Both the Csavina study and the 1987 Source Apportionment Study found that particulates from this type of source area would be predominantly in the coarse particle size.

4.4.2 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 on the east and is truncated to 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 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 of 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 conveyed in the past through the San Pedro Wash drainage corridor prior to the construction of the K-Pond (between 1969 and 1983 based on aerial photographs from those years). Hence, under historical flow conditions, the lower reach of San Pedro Wash within Area #2 could 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 residential areas 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. Particulate matter emissions from this area are likely to result from vehicle traffic and wind erosion of surface materials.

4.4.3 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 an 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 Aquifer Protection Program (APP) permit (2009). 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 separate 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 Hayden Concentrator SWPPP, a “crusher and loadout area” formerly was located in Area #3 immediately north of the northwestern corner of Area #4, 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 formerly 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 the discharge from the lime plant extends into the K-Pond, likely bypassing 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 Arizona 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 Arizona 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 former 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 elevated 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. Particulate matter emissions from this area are likely to result from vehicle traffic and wind erosion of surface materials.

4.4.4 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.

Open areas and roadways are addressed in the draft 2011 Class I/Title V Renewal Permit under the requirements for facility fugitive dust sources. The Lime Plant includes several fugitive sources such as lime storage and handling, and a point source, the lime receiving and transfer dust collector (baghouse). These particulate emission sources are regulated through the 2011 draft Class I/Title V Renewal permit. The draft permit includes both a PM mass emission limitation and an opacity limitation of 20% for these sources.

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 (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 rail cars located immediately south of the filter plant and east of the lime plant.
4. Concentrate is then delivered to the smelter facility by rail car.

Although there are no specific sample results for the concentrate, it is by definition high in copper and contains other COPC metals at concentrated levels greater than found in the copper ore. The ASARCO 2004 HAPs Documentation provides an analysis of smelter baghouse dust, which was proposed as representative of the metals composition of concentrate feed to the smelter. This data indicates that fugitive emissions from concentrate handling activities would be a source of both arsenic and lead in ambient air.

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 by the following day.

Lime Plant
The lime plant is also an active part of ASARCO‟s current operations. Quicklime (CaO) is received via rail cars 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 (CaOH2) 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 Arizona R-SRL of 3,100 mg/kg for copper, while there were no exceedances of the Arizona R-SRL of 400 mg/kg for lead. One of the five samples was analyzed for additional metals, and exceeded both the Arizona R-SRL of 390 mg/kg for molybdenum (2,280J mg/kg) and 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. Particulate matter emissions from this area are likely to result from process operations and vehicle traffic and wind erosion of surface materials.

4.4.5 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 surficial soil 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 some 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 that were not part of the removal actions may be impacted by the contaminants identified within the adjacent remediated 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 samples were collected from the tributary to the Kennecott Avenue Wash as part of the 2004 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 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 was 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. Particulate matter emissions from this area are likely to result from vehicle traffic and wind erosion of surface materials.

4.4.6 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 and 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 transported 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 rail cars 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. Particulate matter emissions from this area are likely to result from vehicle traffic and wind erosion of surface materials.

4.4.7 Area #7 –Concentrate Production

Area #7, Concentrate Production, comprises approximately 21 acres. Figure 4-8 displays the boundary for Area #7, 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 area of the facility around the thickener tanks. Some areas 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.

Concentrate production is an active process operation at the Site. Ore is processed through primarily mechanical means to enrich the level of copper within the feed material for the smelter, as discussed in more detail in Section 2.1.2. Concentrate production is a wet process that generates a slurry that is rich in copper, which is further processed in ball mills to reduce the ore to a fine sand consistency. The slurry is further concentrated and dried at the Filter Plant. Concentrate handling activities are performed with front-end loaders or other large material handling equipment in an open air setting. This area is subject to windblown dispersion of surface materials. These activities are likely the primary emission source in this area. The Class I/Title V permit requires the application of dust suppressants or the use of other methods to reduce or minimize fugitive emissions from Site material handling operations.

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. Particulate matter emissions from this area are likely to result from process operations and vehicle traffic and wind erosion of surface materials.

4.4.8 Area #8 – Conveyor Belt Tailings

Area #8, Conveyor Belt Tailings, comprises approximately 13 acres. Figure 4-9 displays the boundary for Area #8 and 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.

The Conveyor Belt Tailings are identified as fugitive PM emissions sources within the 2011 draft Hayden Complex Class I/Title V Renewal Permit. The permit requires the use of good management practices, such as the application of dust suppressants, enclosures, and water spray at all facility open areas, roadways, storage piles and material handling sources such as depositional tailings material along the conveyor belt line in Area # 8. In addition, this fugitive source must also meet a 40% opacity limitation.

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 have also 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) in 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 samples 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 was 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. Particulate matter emissions from this area are likely to result from process operations and vehicle traffic and wind erosion of surface materials.

4.4.9 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, 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.

Several emission points within these operations are controlled through add-on controls consisting of several wet scrubber systems. The draft 2011 Class I/Title V Renewal Permit limits PM emissions from these sources through PM mass emission limits of 0.05 grains/dry standard cubic foot (gr/dscf) and opacity limits for each scrubber stack. Work practice standards consisting of the use of water sprays, enclosures and other housekeeping measures to minimize the generation of fugitive dust are required for conveyors and other non-point sources.

These operations have been shown through previous studies conducted by Csavina, et al to be primary sources of large particle size contaminants to ambient air. The results from source sampling during the 1987 Source Apportionment Study conducted for ASARCO have shown that these operations were the largest source of coarse PM_{10} mass at the ambient air monitoring stations used in the study. These coarse particles have been found in previous studies to contain largely copper among the trace metals, with much lower concentrations of other metals than found in concentrate. Given these low concentrations, the ore receipt/crushing operations may be contributing to the copper and PM_{10} concentrations detected in ambient air with only limited contribution of other metals.

Key Features within Area #9

Ore Receipt
The ore receipt area contains a track hopper that receives deliveries of ore by rail car, 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 a secondary and tertiary crushing process 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 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 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. Particulate matter emissions from this area are likely to result from process operations and vehicle traffic and wind erosion of surface materials.

4.4.10 Area #10 – Powerhouse Wash

Area #10, Powerhouse Wash, comprises approximately 44 acres. Figure 4-11 displays the boundary for Area #10 and 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 Areas #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 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 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 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 below a surficial soil cover (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 14 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. Particulate matter emissions from this area are likely to result from vehicle traffic and wind erosion of surface materials.

4.4.11 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 cleanup 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.

The Waste Water Treatment plant is not included in the 2011 draft Class I/Title V Renewal Permit and is not considered as having air emission sources.

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 surface 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. Particulate matter emissions from this area are likely to result from vehicle traffic and wind erosion of surface materials.

4.4.12 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.

Concentrate handling activities are performed with front-end loaders or other large material handling equipment in an open air setting. This area is subject to windblown dispersion of surface materials. These activities would be a primary emission source in this area. The Class I/Title V permit requires the application of dust suppressants or the use of other methods to reduce or minimize fugitive emissions from Site material handling operations.

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 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
Most 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. Particulate matter emissions from this area are likely to result from process operations and vehicle traffic, as well as wind erosion of surface materials. This provides the opportunity for the public to be exposed to contaminants associated with Area #12.

4.4.13 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. The Area includes 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.

The sources within the smelter support area are uncovered and present the potential for contaminants being captured as windblown dust and impacting ambient air within the Study

Area. These emission sources would be addressed under the facility-wide requirements for facility fugitive dust sources within the 2011 draft Class I/Title V Renewal Permit.

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 at 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 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 sample has been collected within Area #13. Sample AS06 was a composite of three CP-1 sediment samples, 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. Particulate matter emissions from this area are likely to result from vehicle traffic and wind erosion of surface materials.

4.4.14 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 and 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.

Flash Smelting:

The flash furnace building contains several point sources and fugitive sources of PM. Dryers that dry smelter feed material from wet feed bins are controlled by a product baghouse. The baghouse dust is stored within dry feed bins. The dry feed bin PM emissions are also controlled by a baghouse. The exhaust from the baghouse is then controlled through an electrostatic precipitator (ESP).

The flash furnace building also houses the Inco flash furnace and process operations associated with matte tapping and slag skimming. Exhaust gas from the Inco flash furnace is captured by a primary hood system and is then exhausted through the Acid Plant. The 2011 draft Class I/Title V Renewal Permit contains PM mass emission, opacity limitations, and SO_2 mass emissions limitations for the Inco flash furnace.

Emissions from the matte tapping and slag skimming are collected by hoods, directed to the electrostatic precipitator, and exhausted through the 1,000-foot smelter stack. Assay of the electrostatic precipitator dust indicates the degree to which the smelting process concentrates metals: arsenic at 8,140 ppm, cadmium at 1,080 ppm, and lead at 13,500 ppm. On the other hand, levels of chromium in the electrostatic precipitator dust are approximately 64 ppm.

Emissions that are not captured by the various control systems have been found to be a source of COPCs in ambient air. The 1987 Source Apportionment Study concluded that smelter fugitive emissions, including these operations, were primarily responsible for the arsenic, cadmium, and

lead concentrations found in ambient air samples during the study. Although this study did not fully assess all sources that may contribute to ambient air concentrations of COPCs, the emissions from these operations would be expected to impact ambient air by their contribution of arsenic and lead. The 2011 draft Class I/Title V Renewal Permit addresses the furnace building fugitive emissions by limiting any plume or effluent to 20% opacity.

Copper Converting:
The batch converters convert copper matte to blister copper. After blister copper is transferred to the anode furnaces, emissions continue to evolve from the converter vessels. The majority of these emissions is captured by secondary hoods, directed to a baghouse, and then exhausted through the 1,000-foot stack. However, the hood doors must be retracted during materials transfer, which allows a portion of the emissions to escape to the atmosphere as fugitive emissions, primarily through the converter building roof monitors. As with the flash furnace building fugitive emissions, the 2011 draft Class I/Title V Renewal Permit addresses the converter building fugitive emissions by limiting any plume or effluent to 20% opacity. The permit also includes a limitation on the arsenic charging rate to the converters of 75 kg/hr. Due to the significant concentrations of arsenic, cadmium, and lead in the converter emissions, they have the potential to be a significant contributor to elevated levels of these metals in ambient air, as noted in the 1987 Source Apportionment Study.

Because the 1,000-foot stack vents emissions captured by the flash furnace hoods and the converter secondary hoods, it is also a potential source of emissions of arsenic, cadmium, and other metals to the atmosphere. The impact of these emissions on local ambient air conditions is unknown.

Anode Furnaces:
Emissions from the anode furnaces are released to the atmosphere through building openings. The 1994 and 1995 Fugitive Particulate Emissions Study found that the fugitive emissions from the furnaces contained significant concentrations of arsenic, cadmium, and lead, with chromium and other metals found below the method detection limits. Fugitive emissions from this source have been shown to have a significant contribution to the levels of arsenic and lead in the ambient air samples collected during the 1987 Source Apportionment Study. Currently the anode furnaces have no emission control system. However, a new capture system and baghouse are to be installed in 2012 to control and minimize PM and Hazardous Air Pollutant (HAP) emissions from the anode furnaces. The impact of this source on ambient air quality following installation of these new controls will be evaluated in the Phase II RI.

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 up gradient 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. Particulate matter emissions from this area are likely to result from process operations and vehicle traffic and wind erosion of surface materials.

4.4.15 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.

As discussed in Section 2.1.2, materials that contain high levels of copper are reclaimed for use in the smelting process. Similar materials from off-site sources are also reintroduced into the process. These materials require additional handling and, in some cases, crushing and screening before they are suitable for use in the smelter. The reverts crushing plant contains several emission sources, such as wet feed bins, dry feed bins, dust bins, crushers, screen and associated conveyors. Storage bins and reverts crushing plant emissions are controlled by baghouses with water spray, and enclosures are used to control fugitive emissions from dumping and conveyors. The 2011 draft Class I/Title V Renewal Permit contains PM mass emission limitation and 20% opacity limits for all reverts crushing plant equipment.

The reverts material can contain levels of arsenic and chromium similar to those found in copper concentrate. Fugitive emissions are generated from the mechanical processing of these materials. Fugitive emissions from this source were not specifically addressed in the previous 1987 Source Apportionment Study or in the ASARCO 1995 Fugitive Particulate Emissions Study. Therefore, their contribution of COPCs to ambient air is unknown. However, results from previous soil sampling in this area have shown high levels of arsenic, copper, lead, cadmium, and chromium, making this area a potential source of COPCs to ambient air both from source fugitive emissions and windblown dust from the contaminated surface soils.

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 is 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.

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 from 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. Particulate matter emissions from this area are likely to result from process operations and vehicle traffic and wind erosion of surface materials.

4.4.16 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 a Copper Basin Railway spur. The Area is bounded by other ASARCO operations to the north and east, and primarily by open desert to the west and south. The smelter slag pile abuts most of the eastern boundary, and is addressed separately as Area #17, Slag Handling.

Exhaust gas from the flash furnace and converter primary ventilation systems is cooled and cleaned before being routed to a double contact sulfuric acid plant designed to remove sulfur dioxide formed in the flash smelting and converting processes. The cleaned gas is vented to the 1,000 foot smelter stack. The draft Class I/Title V Renewal Permit limits the PM mass emissions, opacity and SO_2 from the Acid Plant. Emission controls include good work practice standards to minimize emissions. Metal COPCs have not been identified as a component of the Acid Plant point source emissions.

Fugitive dust emissions from re-entrainment of surface soils and roadways may contain metal COPCs. However, no soils data is available in this area. Further sampling proposed in the Phase II RI is necessary to determine the contribution these sources may have to the COPC concentrations in ambient air.

Key Features within Area #16

Railroad
One railroad spur of the Copper Basin Railway is located within the boundary of 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
Area #16 can be accessed by the public from the south via former roads and hiking trails. This provides the opportunity for the public to be exposed to contaminants associated with Area #16. Particulate matter emissions from this area are likely to result from process operations and vehicle traffic and wind erosion of surface materials.

4.4.17 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.

The primary emissions of metals from the slag handling activities are in the form of fumes from the molten slag dumping and fugitive dust generated in the slag handling and screening steps. With slag containing arsenic at 535 ppm and lead at 1,190 ppm, the slag dumping and reclaim activities are potential sources of elevated levels of arsenic and lead in the ambient air. Cadmium concentration in the slag is at 48 ppm and chromium is at 327 ppm. Emissions from slag handling and crushing are addressed in the 2011 draft Class I/Title V Renewal Permit under the facility fugitive dust sources requirements for storage piles, material handling, and roadways. These requirements include 40% opacity and good management practices to control fugitive dust.

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 higher copper concentration slag deposition area. The crushing activity processes the higher copper concentration slag into a finer size for subsequent recycling into the copper extraction process. The lower 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 Arizona 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 177 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. Particulate matter emissions from this area are likely to result from process operations and vehicle traffic and wind erosion of surface materials.

4.4.18 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. Particulate matter emissions from this area are likely to result from vehicle traffic and wind erosion of surface materials.

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

Area #19, Area Outside of Areas #1 - #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 4-19.

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 High School in Winkelman 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.

Area # 19 includes fugitive PM area sources resulting from historical deposition of COPCs. The nearly continuous operation of copper ore processing at the Hayden Complex and the associated releases of emissions from sources within the Hayden Complex have deposited and continue to deposit metal-containing particulates on lands within and outside the Hayden Complex. This process of continuous deposition of metal-containing particulates on roads, parking lots, roofs, sidewalks, and open lands has created widespread area sources capable of contributing contaminants to the ambient air through wind and mechanical resuspension. These area sources could contribute to ambient air concentrations through the re-entrainment of surface material. Off-Site areas such as these are not addressed in the 2011 draft Hayden Complex Class I/Title V Renewal Permit.

During the Phase I RI, soil samples were collected in non-residential areas, including areas within the towns of Hayden and Winkelman, along with other selected areas within the Hayden Complex and outside the complex. The Hayden Complex operational area samples generally exhibited the highest concentrations of metals in soils. Soils in Hayden, Winkelman, and upland areas contained lower concentrations. This comparison is based on results from samples collected in specific areas within the complex, including the perimeter of the concentrator, former Kennecott smelter areas, the smelter perimeter, and slag dump areas. Although the presence of these depositional area sources was demonstrated during the Phase I RI, the degree to which these sources were contributing to COPCs in ambient was not determined.

The 1987 Source Apportionment Study indicated that differentiating these sources may be possible through an analysis of COPC metals and an evaluation of the differences in metal concentrations comprising the samples both from the source areas and from ambient air monitoring stations. Particle size analysis and particle morphology studies will also aid in differentiating the contributions from these fugitive sources. The Phase II RI is designed to assess the nature and extent these sources contribute to concentrations of COPC is ambient air.

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5.0 PRELIMINARY APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS)

Section 121(d)(2)(A) of CERCLA incorporates into law the CERCLA Compliance Policy, which specifies that Superfund remedial actions must meet any Federal standards, requirements, criteria, or limitations that are determined to be legally applicable or relevant and appropriate requirements (ARARs). Federal statutes that are specifically cited in CERCLA include the Solid Waste Disposal Act (SWDA), the Toxic Substances Control Act (TSCA), the Safe Drinking Water Act (SDWA), the Clean Air Act (CAA), the Clean Water Act (CWA), and the Marine Protection Research and Sanctuaries Act (MPRSA). In addition, state ARARs must be met if they are promulgated, of general applicability, and more stringent than Federal requirements.

A preliminary identification of ARARs is a key step in the project planning task within the RI/FS Work Plan. The preliminary identification of ARARs for this Phase II RI Work Plan, Part I of II (Air) is focused on those that are promulgated to address the requirements of the CAA. A complete list of the preliminary ARARs identified for the Site is included in Table 5-1. This list has been prepared following *CERCLA Compliance with Other Laws Manual*, specifically *Part II- Clean Air Act and Other Environmental Statutes and State Requirements* (EPA, 1989b), and segregates the entries into chemical-specific, location-specific, and action-specific ARARs. Pertinent guidance, policy, or local requirements that do not meet the criteria for listing as ARARs must also be given consideration and, therefore, are listed within the To Be Considered (TBC) category in Table 5-1. The ARARs and TBCs were reviewed for the minimum ambient air criteria level and the results are presented in Table 5-2.

5.1 ARARS Specific to RI Tasks

5.1.1 Federal ARARS

EPA has promulgated air quality regulations pursuant to the CAA within the Code of Federal Regulations (CFR) Title 40. Below is a brief description of the preliminary federal CAA ARARs that have been identified during the development of this Phase II RI/FS Work Plan.

5.1.1.1 National Ambient Air Quality Standards

EPA has promulgated National Ambient Air Quality Standards (NAAQSs), pursuant to the CAA §109, to protect public health and welfare. These standards have been established for six "criteria" pollutants initially identified in the CAA as posing the most significant threats to air quality and, consequently, to public health. These standards, both primary and secondary standards, are established within 40 CFR Part 50. The attainment and maintenance of these primary and secondary standards is the responsibility of the states and is a central component of

the State Implementation Plans (SIPs). EPA has promulgated NAAQSs for the following Site COPCs:

- 40 CFR § 50.6 - Particulate Matter Less Than 10 Microns (PM_{10}): The NAAQS for PM_{10} is 150 ug/m^3 (24-hour average).
- 40 CFR § 50.7 & § 50.8 - Particulate Matter Less Than 2.5 Microns ($PM_{2.5}$): The NAAQS for $PM_{2.5}$ is 35 ug/m^3 (24-hour average) and 15 ug/m^3 (yearly average).
- 40 CFR § 50.12 - Lead (Pb): The NAAQS for lead is 0.15 ug/m^3 as a rolling three-month average.

Ambient Air Quality Monitoring

In conjunction with the promulgation of the NAAQSs, EPA also promulgated specific regulations for the monitoring of ambient air quality by state and/or local agencies for the purpose of determining if an area has achieved these standards, as well as for monitoring by owners or operators of potential sources for permitting purposes. These regulations, as listed below, establish the specific requirements for the collection and evaluation of ambient air quality data and include methodologies, quality assurance, siting criteria for ambient air samplers, minimum air quality monitoring network requirements, and air quality data reporting.

- 40 CFR Part 50 –National Primary and Secondary Ambient Air Quality Standards: Addresses reference methods for the determination of each pollutant in ambient air and how the measured concentrations are to be compared to the standard.
- 40 CFR Part 53- Ambient Air Monitoring Reference and Equivalent Methods: Addresses how ambient air monitors obtain EPA approval for use in the collection of data to be compared to the standards.
- 40 CFR Part 58 –Ambient Air Quality Surveillance: Addresses ambient air network design criteria, monitoring siting criteria, monitoring methodology, and quality assurance requirements.

5.1.1.2 New Source Performance Standards (NSPS)

Under CAA Section 111, EPA establishes air pollutant emission standards for specific categories of new air emission sources. These categories are based on the process or industrial activity performed by the source. The New Source Performance Standards (NSPSs) establish emission limitations and/or work practice requirements with corresponding compliance methodologies. The NSPSs are promulgated within 40 CFR Part 60. The NSPS ARARs specific to the RI Tasks include 40 CFR Part 60 Appendix A - Test Methods. Appendix A includes pollutant-specific methods for testing air emission sources. These methodologies are required to be used for

determining compliance with air emission standards. These same methodologies would be potential ARARs for the source sampling proposed in this RI Work Plan.

5.1.2 Arizona State ARARS

CERCLA requires that for a state requirement to be an ARAR, it must be promulgated and also must be more stringent than federal ARARs. Upon evaluating the Arizona Administrative Code (AAC) and the Arizona Revised Statutes (ARS), no state CAA ARARs were found to be more stringent than the federal ARARs identified at this time for RI Tasks.

5.1.3 Local ARARs

CERCLA Section 121 (d) does not require CERCLA actions to comply with local laws and, therefore, these requirements are not typically identified as ARARs. However, when local requirements such as emission limitations or other control measures are part of the State Implementation Plan (SIP), they may be recognized as potential ARARs. EPA guidance suggests that other local requirements, although not ARARs, should be reviewed as TBCs.

The ADEQ has delegated air quality regulatory authority to three local air agencies within Arizona. These local agencies promulgate regulations either through the adoption by reference of state rules or the development of stand-alone local regulations. The Pinal County Air Quality Control District (PCAQCD) is the local air agency with ADEQ-delegated authority over the area that comprises the ASARCO Hayden Complex. The PCAQCD Code of Regulations is considered to be an "Administrator-approved" element of the Arizona SIP. However, there are no PCAQCD regulations that would qualify as preliminary ARARs for RI tasks.

5.2 TBCs Specific to RI Tasks

Pertinent guidance, policy, or local requirements that do not meet the criteria for listing as ARARs are addressed as federal and state TBCs in the following sub-sections.

5.2.1 Federal TBCs

EPA has developed guidance and/or policy documents to assist in the implementation of federal CAA regulations. These can be in the format of manuals, white papers, technical memoranda, etc. These documents are not promulgated and, therefore, are not considered to be ARARs. However, because the following documents provide technical interpretations of the underlying regulations and more detailed information on compliance methodologies, they are important to the RI process for air and have been identified as federal TBCs.

- *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*, EPA/450/G-89/004, 1988.

- *CERCLA Compliance with Other Laws Manual, Part II- Clean Air Act and Other Environmental Statutes and State Requirements*, EPA/540/G-89/009, August 1989.
- *Quality Assurance Handbook for Air Pollution Measurement Systems*, Volume II. EPA-454/B-08-003, December 2008.
- *Meteorological Monitoring Guidance for Regulatory Modeling Applications*, EPA-454/R-99-005, February 2000.
- *Quality Assurance Guidance Document 2.12,* EPA, November 1998; from EPA-454/B-08-003 Part II.
- *Quality Assurance Guidance Document 2.11,* EPA, September 1997; from EPA-454/B-08-003 Part II.
- *Quality Assurance Guidance Document 2.10,* EPA, September 1997; from EPA-454/B-08-003 Part II.
- *AP-42, Fifth Edition Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources*, EPA, January 1995.
- *EPA Technical Note-Lead (Pb) Ambient Air Monitoring Network Design Issues,* February 2009.
- *EPA Technical Note-Pb Monitoring Implementation Strategy Sampler Issues,* February 2009.
- *EPA Technical Note-Pb Monitoring Implementation Strategy Analysis Method Issues,* January 2011.
- *EPA Technical Note-Pb Monitoring Implementation Strategy Quality Assurance Issues,* No Date Provided.
- *EPA- RTI Pb Audit Strip SOP*, May 15, 1998.
- *EPA Technical Note-Lead Data Reporting to AQS,* April 2009.
- *Air/Superfund National Technical Guidance Study Series, Volume IV - Guidance for Ambient Air Monitoring at Superfund Sites (Revised)*, EPA/451/R-93-007, May 1993.
- *Guidance for Siting Ambient Air Monitors Around Stationary Lead Sources,* EPA-454/R-92-009, August 1997.

5.2.2 State TBCs

ADEQ has promulgated regulations within the AAC that were not considered to be ARARs in the above list, as they are not more stringent than the corresponding federal ARARs. However, ADEQ has developed various air program guidance documents that should be considered as candidate TBCs for the RI Tasks.

The following documents have been determined to be a state TBC for the RI Tasks:

- *Arizona Ambient Air Quality Guidelines*, ADEQ, May 1999.
- *Arizona Testing Manual for Air Pollutant Emissions*, Revision F, ADEQ, March 1992.

5.3 ARARS Specific to FS Tasks

5.3.1 Federal ARARS

5.3.1.1 National Emission Standards for Hazardous Air Pollutants (NESHAPs)

CAA Section 112 identified pollutants other than the NAAQS criteria pollutants that also present an unacceptable risk to public health. These pollutants were identified as hazardous air pollutants (HAPs). EPA has established emissions standards for these HAPs as Maximum Achievable Control Technology (MACT) standards through the promulgation of source-specific national emissions standards for hazardous air pollutants (NESHAPs) within 40 CFR Part 63. These NESHAPs are further classified as applicable to either a "major source" of HAPS (i.e., the potential to emit greater than 10 tpy of an individual HAP or 25 tpy of combined HAPs), or an "area source" of HAPs (i.e., having the potential to emit any quantity of HAPs less than the major source thresholds). The NESHAP provisions preliminarily identified as ARARs for the Phase II RI/FS include:

- 40 CFR Part 63 Subpart A – General Provisions: This regulation addresses notification, testing, and reporting requirements that are applicable to any source within a Part 63 source specific standard, such as those listed below.
- 40 CFR Part 63 Subpart QQQ – Primary Copper Smelting at Major Sources: This standard imposes particulate or opacity emission limitations or particulate emission (MACT) control devices for listed sources at a copper smelting facility that is a major source of HAPs emissions.
- 40 CFR Part 63 Subpart EEEEEE – Primary Copper Smelting at Area Sources: This standard imposes particulate and opacity emission limitations or particulate emission MACT for listed sources at a copper smelting facility that is an area source of HAPs emissions.
- 40 CFR Part 61 Subpart O – Inorganic Arsenic Emissions from Primary Copper Smelters: This standard imposes emission limitations on copper converters at any new or existing primary copper smelter.

These standards are addressed within the current draft Class I/Title V Operating Permit for the ASARCO Hayden Complex, as discussed in Section 2.5.3. These requirements would be considered potential ARARs for any operational or source changes at the Site proposed as part of the FS.

5.3.1.2 New Source Performance Standards (NSPS)

Under CAA Section 111, EPA establishes air pollutant emission standards for specific categories of new air emission sources. These categories are based on the process or industrial activity performed by the source. The New Source Performance Standards (NSPSs) establish emission limitations and/or work practice requirements with corresponding compliance methodologies. The NSPSs are promulgated within 40 CFR Part 60. The NSPS ARARs for the Site include:

- 40 CFR Part 60 Subpart A – General Provisions.
- 40 CFR Part 60 Subpart P – Primary Copper Smelters.
- 40 CFR Part 60 Subpart LL – Metallic Mineral Processing Plants.
- 40 CFR Part 60 Appendix A - Test Methods.

5.3.1.3 New Source Review (Pre-Construction Review)

New Source Review (NSR) is a permitting program specific to the permitting of "major" air pollutant emitting activities. What defines an activity as "major" is dependent on whether or not the geographic location of the activity has been designated as meeting the NAAQSs or is in an *attainment area*. The major source definition is triggered at much lower emission thresholds in areas that currently do not meet the NAAQSs (*non-attainment areas*), and the substantive requirements within the NSR permit also would be much more stringent in these areas. The requirements for NSR have been promulgated within 40 CFR Parts 51 and 52, which would be considered as ARARs.

Gila and Pinal Counties both have been designated as moderate *non-attainment* areas for PM_{10}. A major emitting activity in a moderate *non-attainment* area would be any activity that has a potential to emit, exclusive of controls (unless those controls are federally enforceable), 100 tons per year or more of PM_{10}. The substantive requirements of a permit for any major activity emitting PM_{10} would include obtaining emission offsets or meeting the Lowest Achievable Emission Rate (LAER) through the installation of add-on emission controls.

Gila County and eastern Pinal County have been designated as *attainment* areas with respect to the $PM_{2.5}$ and Pb NAAQSs. A major $PM_{2.5}$ or Pb emitting activity listed within 40 CFR 52.21(b)(1) would be any activity with the potential to emit, exclusive of controls (unless those controls are federally enforceable), 100 tons per year or more. Primary copper smelters are a listed activity. The substantive requirements of a permit for any major activity emitting $PM_{2.5}$ or

Pb would include a demonstration through air dispersion modeling that the activity would not adversely impact the area"s attainment status. In addition, the selected emission control technology must be shown to be the Best Available Control Technology (BACT) through a top-down analysis of available technologies.

The applicability of these regulations will be determined during the FS based upon the remedial alternatives being considered and the findings of the Phase II RI.

5.3.2 State ARARS

5.3.2.1 AAC Emissions from Existing and New Nonpoint Sources

AAC Title 18, Chapter 2, Article 6, establishes fugitive PM emission control requirements from nonpoint sources, both existing and new, such as open areas or washes where vehicles, bicycles, or buggies are allowed to travel; roadways; material handling operations; storage piles; and mineral tailings piles. The control requirements may include, for example, application of dust suppressants or water sprays, covers on truck loads, and/or speed limits. The specific sections of the AAC identified as preliminary Site ARARs are:

- R18-2-604 – Open Areas, Washes, Riverbeds.
- R18-2-605 – Roadways and Streets.
- R18-2- 606 – Material Handling.
- R18-2- 607 – Storage Piles.
- R18-2- 608 – Mineral Tailings.
- R18-2-614 – Evaluation of Nonpoint Source Emissions

5.3.2.2 Arizona State Hazardous Air Pollutants Program

AAC Title 18, Chapter 2, Article 17 requires new or modified sources of HAP emissions, both minor and major sources that are not already subject to a federal NESHAP, either to install a specific level of emission control technology or to demonstrate through a Risk Management Analysis that the control technology is not necessary to prevent adverse impacts to human health or the environment. The state HAPS list includes the 187 HAPS on the federal CAA HAPs list.

5.3.3 Local ARARS

Pinal County Code of Regulations 2-8-302, *Performance Standards for Hayden PM_{10} Nonattainment Area,* is a local SIP requirement that imposes opacity limitations on new and existing sources of fugitive dust within the categories of construction; roadway building, use, and maintenance; and bulk material handling, storage and transport.

5.4 To Be Considered –Specific to FS Tasks

It is premature to identify TBCs for clean-up alternatives that will be developed in the FS. These will be identified at the time the array of alternatives is established.

6.0 WORK PLAN RATIONALE AND APPROACH

As described in the Data Quality Objectives (DQOs) section of the QAPP, the following three DQOs have been identified to address the data gaps identified in the previous Site studies through additional data collection in the Phase II RI:

- Characterize emissions sources;
- Characterize air-related Site contaminant distribution; and
- Assess potential risk to human receptors due to inhalation of airborne COPCs.

In addition, this Phase II RI will provide information to apportion Site ambient air contamination to emission sources for use in the Feasibility Study.

The air-related Phase II RI for the Site follows CERCLA guidance such as *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA, 1988) and Superfund Program Representative Sampling Guidance Volume 2: Air (Short-Term Monitoring) Interim Final (EPA, 1995)*. Due to the complex nature of the Site, the RI will be conducted as a dynamic process based on ongoing analysis of current and emerging data. As ambient air data are generated, the data will be analyzed to identify remaining gaps in the data to achieve the RI objectives.

6.1 Overview

Figure 6-1 relates the three DQOs to the scope and approach of the air monitoring and evaluation portion of the Phase II RI/FS being addressed in this Work Plan (Part 1 of 2). A primary endpoint use of the ambient air quality monitoring data to be collected in the Phase II RI is to support the assessment of potential risk to human receptors in the HHRA. As indicated in Figure 6-1, the HHRA for the air exposure pathway will be based on what potential receptors are being exposed to in ambient air, regardless of where the airborne COPCs originate.

The need to relate any areas determined in the HHRA to represent an unacceptable exposure risk to specific emission sources is of primary importance to the evaluation of alternative remedial actions in the FS. Because source controls are likely to be the primary remedy for reducing exposure risk, one will have to know what sources are the primary contributors of COPCs to the areas of excessive exposure so that cost-effective remedies can be selected and implemented. As indicated in Figure 6-1, the source apportionment study (SAS) will be the vehicle used to determine the contribution that potential emission sources make to the ambient airborne particulates and COPCs measured at receptor locations within the Study Area. The SAS will be addressed in Section 6.5 below.

Input to the SAS will include three primary elements, as illustrated in Figure 6-1: (1) the chemical and physical characteristics of particulate matter collected at the ambient air quality monitoring stations (Section 6.2); (2) an understanding of the local meteorological conditions as a determinant of the likelihood that particulates released from a particular source could reach a given receptor location (Section 6.3); and (3) the potential of a particular source to emit particulate matter into the air and the chemical and physical characteristics of the particulates released (Section 6.4). The specific data needs of Part 1 of 2 of the RI (Air) focus on these three inputs to the SAS as the basic building blocks to meet the ultimate study objectives in the HHRA and FS.

Currently there is not a sufficient level of source or ambient air characterization certainty to satisfy the objectives of the Phase II RI. A more complete understanding of the distribution of the COPCs in air is necessary in order to characterize accurately the sources and extent of contamination, and ultimately to assess the risks to human health from COPCs released from the Site. At its highest level, the proposed air quality investigations to fill the data needs will include the following two primary elements consistent with the first two DQOs shown in Figure 6-1:

- Investigation of the particulates suspended in ambient air within the Study Area toward the objective of identifying what COCPs are present and at what concentration to enable the evaluation of exposure risk in the HHRA; and
- Characterization of the potential sources of particulate release into air as both a primary input into the evaluation of alternative remedies in the FS and a key component of the SAS.

Within each of these two study elements is the need to address both the „quantity" and the „characteristics" of the suspended particulates. For purposes of the RI approach, the term „quantity" refers to the mass concentration of particulates in air, with a particular focus on the concentration of PM_{10} and $PM_{2.5}$. The term „characteristics" applies to the chemistry of the suspended particulates and their physical morphology.

The Phase II air study has been designed to address data gaps identified in both the *Draft Remedial Investigation Report for the ASARCO LLC Hayden Plant Site* (CH2M Hill, 2008a) and the scoping work conducted by ITSI in preparing this Work Plan. The sample types, number, and locations were based on data obtained in prior investigations, the potential effects of specific process-related sources of COPCs on ambient air quality, and the potential effects of area sources of fugitive emissions on ambient air quality. To address the data gaps and the HHRA and SAS objectives, various monitoring instruments will be deployed at 15 ambient air monitoring locations selected for use in the Phase II RI. The selected ambient air monitoring locations are shown on Figure 6-2. In addition, both point source emissions and process fugitive emissions will be measured at 19 potential source locations within the ASARCO Hayden

Complex. The source sampling locations are shown on Figure 6-3. Additional information on each of these locations, including the specific rationale and instrumentation for each, is presented in Table 6-1. Samples of surface materials, collected from numerous locations throughout the Site, also will be analyzed and characterized as potential sources of dust emissions. The preliminarily identified general locations for surface samples are presented in Table 6-2 and Figure 6-4.

Both field monitoring and laboratory analyses become important in designing the overall air investigation to address particulate quantity and characterization fully. Table 6-3 depicts the various project elements in relation to the specific monitors and laboratory procedures that will be used in the Phase II air investigation. Additional information on each entry in the table is provided later in this section, with a more detailed description presented in Section 7.0 and the QAPP.

The scope of the Phase II ambient air investigation depicted in Table 6-3 goes beyond normal compliance measurements associated with Federal Reference Methods (FRM) and Federal Equivalent Methods (FEM) for PM_{10}, and $PM_{2.5}$, which are intended only for 24-hour mass concentrations. EPA"s weight of evidence guidance (EPA, 2007) endorses state-of-the-art measurements to reduce source apportionment uncertainties, as does EPA"s PM network design guidance (EPA, 1997a), EPA"s guidance for use of continuous PM monitors (EPA, 1998), and its recommendations for successful receptor model studies (EPA, 1983:1984; 1985; 1994a; 2004b; 2009). The air monitoring strategy proposed herein is based on previous work at the Site, which has already revealed the most likely significant sources of COPCs.

6.2 Ambient Air Quality Investigation

The acquisition of ambient air quality data for this investigation will utilize air quality monitoring instruments located at 15 monitoring stations, six of which are existing monitoring stations to be supplemented with additional instruments, and nine of which are newly proposed as part of the Phase II RI. Each of the monitoring stations is described in detail in a separate attachment to the Network Design Plan, with all stations summarized in Table 6-1 and Figure 6-2. Ambient air monitoring is expected to continue for a minimum of twelve months. The number and locations of ambient air monitors and the frequency of monitoring in this Work Plan are based on:

- Data obtained in prior air related investigations (described in Section 2.4);
- Spatial distribution, variety and potential effect of known and potential process point source emissions, process fugitive emissions, and fugitive dust emissions (described in Section 3.4);
- Local terrain and meteorological conditions (described in Section 2.3);

- A distribution density that will locate areas of highest risk in the residential area.

6.2.1 Ambient Air Monitoring

A Partisol 2025 PM_{10} sampler will be located at each of the 15 existing and planned stations. The sampler will be run for 24 hours every six days to collect PM_{10} samples for subsequent particulate loading and metals analysis. In addition to the PM_{10} sampler, one or more of the following instruments will be located at each monitoring station to enable a more detailed characterization of localized ambient air conditions:

- Partisol $PM_{2.5}$ sampler: $PM_{2.5}$ samplers will be run for 24 hours every three days to collect $PM_{2.5}$ for subsequent particulate loading and metals and other chemical analyses.
- Thermo Scientific MFC-TSP (GS2313) total suspended particulate (TSP) monitor: TSP monitors will be run for 24 hours every twelve days to collect particulate matter for subsequent particulate loading and metals analysis.
- MiniVol portable air sampler: MiniVol samplers will be used to characterize emissions from source areas that are difficult to access. Four MiniVol samplers will be run at each selected location for 24-hours every six days to collect $PM_{2.5}$ and PM_{10} for subsequent analysis of metals, ions, elemental carbon and organic carbon, and particle morphology.
- MetOne Beta Attenuation Monitor (E-BAM): The E-BAM will be run continuously to record hourly PM_{10} mass concentrations even when other samplers are not operating (an E-BAM to measure $PM_{2.5}$ will operated at ST-06). The E-BAM tape will be archived for eventual chemical analysis when an exceptional event is identified (e.g. an exceptionally high PM_{10} or $PM_{2.5}$ concentration during conditions when other samplers are not programmed to operate, in which case the E-BAM tape will be analyzed by XRF).
- DustTrak optical particle counter (OPC): OPCs are easily deployable handheld devices capable of providing real time data on particle mass concentration by size in air. The DustTrak monitor will be run continuously over short periods of time to record short-term (minute-by-minute) variations in particulate matter concentration caused by wind gusts or plume drift, for example.
- Micro-Orifice Uniform Deposit (MOUDI) aerosol sampler: The MOUDI sampler is a cascade impactor that allows air to be drawn through a series of micro-orifice nozzles and collects particles with different aerodynamic diameters on a series of impaction plates. A MOUDI will be located at the High School in Winkelman to collect aerosols in size fractions for chemical analysis (quantitative, ions, and isotopes) and physical morphology. The High School in Winkelman was selected to extend the same type of valuable observations made by the University of Arizona over the past three years, but

which are expected to end in 2012. The MOUDIs will sample continuously for 96 hours (4 days) every 12 days.

Table 6-1 identifies the specific array of instruments that will be deployed at each of the 15 monitoring stations. A second MOUDI will be deployed when available and as necessary to fill any unresolved data gaps as determined by the RPM.

6.2.2 Laboratory Analyses of Particulate Matter Samples

Particulate matter samples collected from ambient air monitoring stations will be analyzed to determine mass concentrations, chemical composition, Pb isotope concentrations, and morphology. The following types of particulate matter sample analyses will be performed, as appropriate.

Gravimetry

Gravimetric analysis (filter pre-exposure and post-exposure weight differential) will be used to determine mass of particulate matter per volume of monitored air (ug/m^3) (PM_{10}, $PM_{2.5}$, TSP, and Mini-Vol filters).

X-Ray Fluorescence

X-ray fluorescence (XRF) analysis will be used to determine the concentration of metals and other elements present in particulate matter samples (PM_{10}, $PM_{2.5}$, MiniVol filters, MOUDI, and E-BAM).

Inductively Coupled Plasma - Mass Spectrometry

Inductively coupled plasma - mass spectrometry (ICP-MS) analysis will be used to determine the concentration of metals, lead isotopes, and other elements present in particulate matter samples (PM_{10}, $PM_{2.5}$, TSP, MiniVol, and MOUDI filters).

Ion Chromatography

Ion chromatography (IC) analysis will be used to measure the concentration of water-soluble anions and cations (MiniVol and MOUDI filters).

Ion Chromatography - Inductively Coupled Plasma - Mass Spectrometry

Ion chromatography - inductively coupled plasma - mass spectrometry (IC-ICP-MS) will be used to determine chromium and arsenic speciation (resuspended soil samples).

Thermal Optical Reflectance

Thermal optical reflectance (TOR) will be used to determine elemental carbon (EC) and organic carbon (OC) concentrations present in particulate matter samples (MiniVol PM_{10} quartz filters).

Scanning Electron Microscopy, Energy-Dispersive X-ray Spectroscopy

Scanning electron microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDX) analyses will be used to determine single particle morphology and elemental composition, respectively (MiniVol and MOUDI filters).

6.3 Meteorological Monitoring

The acquisition of meteorological data for this investigation will utilize meteorological equipment located at all 15 ambient monitoring stations (existing and planned) and a separate meteorological (MET) station described in the Network Design Plan. Each ambient air monitoring location will have an anemometer and wind vane to enable a more detailed characterization of localized wind speed and direction. In addition, instrumentation for the collection of atmospheric pressure, temperature, and humidity will be operated as integral parts of the Partisol Plus 2025 monitors included at each of the ambient air monitoring locations.

The stand-alone MET station (ST-10) will have the following equipment to characterize the local meteorological conditions:

- Anemometer
- Wind vane
- Thermometer
- Barometer
- Hygrometer
- Sonic Detection and Ranging (SODAR) acoustic sounder

A mobile SODAR unit will also be deployed at various locations across the Site (Figure 6-4) to provide additional data for characterization of atmospheric conditions, especially wind flow patterns at higher elevations and mixing height.

6.4 Source Sampling and Characterization

The emission source characterization investigation includes sampling of the following categories of sources:

- Process point source emissions,
- Process fugitive emissions, and
- Area source fugitive dust emissions.

Currently there is significant uncertainty in emission source characterization. Various air pollution controls have been installed or implemented at the Site over the years. Documentation of their effectiveness is not readily available. Because of this uncertainty, an inventory and study

of various potential sources across ASARCO"s Hayden Complex will be carried out as part of this Phase II RI. For source emission characterization and source apportionment, a sampling approach has been designed to obtain chemical, temporal, spatial, and particle morphology "fingerprint" data that can be used, in conjunction with a chemical mass balance (CMB) model, to identify source categories and specific source locations within a category. Sources will be individually assessed, quantified, and grouped by area or process, and potential emissions from each area or process will be determined. The specific sources to be sampled are identified in the following sections, and were described relative to Site operations in Section 2.0 or Section 4.0. Emission source sampling is expected to take place within twelve months on an intermittent schedule to ensure that variations in process and seasonal atmospheric conditions are taken into account.

6.4.1 Source Profile Development

Previous work at the Site (e.g., the 1987 NEA report) identified a finite number of potential particulate matter sources, broadly categorized as process point source emissions, process source fugitive emissions, and area source fugitive dust emissions. The proposed investigation will characterize the chemical and physical nature of these potential sources of particulate matter during short-term (e.g., 24-hour) intensive observation periods conducted four times in one year to coincide with targeted plant operations and seasonal meteorological conditions.

6.4.1.1 Process Point Source Emissions

To satisfy the needs of the SAS, RI sampling will be performed at the following five point emission sources at the Site:

- ST-19 Secondary Hood Baghouse Discharge to Stack
- ST-20 Vent Gas Cottrell Discharge to Stack
- ST-20 Vent Gas Cottrell Discharge to Stack on Smelter Shutdown
- ST-21 Acid Plant Tail Gas Discharge to Inner Stack
- ST-33 Secondary Crusher Source Discharge

These point source sampling locations are shown in Figure 6-3. At each source location, samples will be collected using procedures described in the Field Sampling Plan. Sampling frequency, duration, equipment types, and proposed analyses are summarized in Table 6-1. Stack emissions from other controlled point sources are believed to be small by comparison, and will not be sampled for characterization unless additional information indicates otherwise.

Emissions from the Secondary Hood Baghouse Discharge (ST-19), the Vent Gas Cottrell Discharge (ST-20), and the Acid Plant Tail Gas Discharge to Inner Stack (ST-21) are vented

through the 1,000-foot smelter stack and, due to the stack‟s height and associated meteorology (particularly the mixing height), are expected to be detected only rarely at the ambient air monitoring sites. The smelter stack, which has pollution controls on all contributing sources, has a minor visible plume. ADEQ‟s Draft Title V Permit, indicates that emissions from source ST-33 are controlled by wet scrubbers. Therefore, the outcome of the proposed source sampling program will test the assumption that the sources are not significant contributors to the ambient air particulate matter.

As indicated in Table 6-1, the two primary sampling instruments for process source testing will be MiniVol samplers and DustTrak OPCs. The use of other instruments is limited by space restrictions at the monitoring locations.

6.4.1.2 Process Fugitive Emissions

There are a number of processes within the Site that discharge fugitive dust. These processes include ore crushing, conveying, and material transfer operations; grinding and milling operations; concentrating operations; matte tap and slag skimming; slag pouring; and smelter building openings (roof vents, side wall openings). Although EPA publishes accepted emission factors (e.g. AP-42) used to estimate mass quantity of these emissions, operational factors can substantially affect emission rates.

In order to quantify the impacts of these process fugitive emissions on ambient air quality at the ASARCO Site, the fugitive emissions from these process sources will be sampled using a Min-Vol sampler, a DustTrak OPC, and a MOUDI sampler, and then characterized in the laboratory to establish unique identifiers associated with each source. These particulate matter identifiers will then be matched with ambient air quality characteristics at receptor locations to quantify impacts of the sources upon receptor ambient air quality through CMB modeling.

Sampling will be performed at or near the following process fugitive emission sources at the Site:

- ST-09 Primary Reverts Crushing Station (South)
- ST-13 Smelter Hill Base, North Side
- ST-14 Water Treatment Filter Cake Storage Area/Smelter Parking Lot
- ST-17 Warehouse Station
- ST-22 Concentrate Bedding Area
- ST-24 Converter Building Roof
- ST-25 Flash Furnace Roof
- ST-26 Concentrator Station

- ST-27 Tailings Pile
- ST-28 Slag Dump Station
- ST-29 Converter Source Station
- ST-30 Flash Furnace Source Station
- ST-31 Anode Pour Source Station
- ST-32 Reverts Crushing Station (North)

Four rounds of sampling (spaced approximately three months apart) to coincide with various plant operations and meteorological seasons are planned for each location. The number and timing of sampling rounds is designed to identify any variations in emissions that may be operational or seasonal in nature.

The source profile sampling will be similar in approach to the ambient air quality contaminant characterization sampling in order to facilitate CMB modeling studies (Table 6-1). MiniVol portable air samplers will be set up at a given process fugitive emission source and operated to collect $PM_{2.5}$ and PM_{10} samples characteristic of plant operations for subsequent analysis for metals, ions, Pb isotopes, elemental carbon and organic carbon, and particle morphology. A DustTrak OPC will be run continuously to record short term (minute-by-minute) variations in particulate matter concentration caused by wind gusts, operation upsets, plume drift, or similar events. A MOUDI sampler will be operated to provide size differentiated samples for analysis.

6.4.1.3 Area Source Fugitive Dust Emissions

The Site also has numerous area sources that discharge fugitive dust. Potential fugitive dust sources identified at the Site include:

- Source building floor dust
- Exterior locations where dust accumulates
- Parking areas
- Paved and unpaved roads
- Construction sites
- Unenclosed material storage areas
- Tailings piles and impoundments
- Disturbed and undisturbed desert soils.

The potential contribution of fugitive dust emissions on human health risk at receptor locations is dependent on both the degree to which the dust is resuspended into the ambient air and the chemical and physical characteristics of those emissions. The potential for fugitive dust to be

emitted to ambient air will be simulated by subjecting surface samples from representative source areas to resuspension testing in the laboratory. The resuspended fraction will then be characterized chemically and physically for direct comparison with ambient particulate matter characteristics observed at the monitoring stations. Proposed general sampling locations are shown in Figure 6-4, with additional information provided in Table 6-2 and the FSP.

6.4.2 Characterization of Particulate Matter Samples

Particulate matter samples collected from all three types of emission sources will be analyzed to determine mass concentrations, chemical composition, Pb isotope concentrations, and physical morphology. The same types of particulate matter sample analyses as proposed for the ambient air samples (Section 6.2.2) will be performed on the emission source samples. These include:

- Particulate Mass
  - Gravimetric analysis
- Particulate Chemistry
  - X-Ray Fluorescence
  - Inductively Coupled Plasma - Mass Spectrometry
  - Ion Chromatography
  - Ion Chromatography – Inductively Coupled Plasma – Mass Spectrometry
  - Thermal Optical Reflectance
- Particulate Physical Morphology
  - Scanning Electron Microscopy and Energy-Dispersive X-Ray Spectroscopy

6.5 Source Apportionment

The overall objective of the source apportionment investigation is to determine the contribution that each potential source of particulate matter containing COPCs makes to the ambient airborne particulate matter observed at receptor sites located in and around the Hayden Site. The approach will be to:

a) Chemically and physically "fingerprint" suspected sources of airborne COPCs, especially lead and arsenic, by sampling campaigns conducted at each individual source.

b) Characterize ambient aerosols sampled for a period of one year at various receptor locations around the Site, especially where people may be adversely affected by hazardous species.

c) Mathematically relate the suspected sources to the observed ambient aerosols using a CMB receptor model to quantify the contribution of each source to the ambient aerosol. A set of simultaneous equations will be developed from which the contribution of each source at each ambient receptor can be calculated.

Specific objectives of the source apportionment study are to:

- Identify and sample actual emissions from potential source contributors;
- Develop complete source emission profiles and determine those marker species that best distinguish among sources at a receptor; and
- Apply source profile and wind direction analyses to quantify source contributions to ambient particulate matter and its components.

To develop a source apportionment for the Site there needs to be a detailed source inventory of potential contributors of the COPCs detected in ambient air within the Study Area. In addition, detailed characterizations of the COPCs present in each of the source emissions and detected in samples at each of the ambient air at receptor locations are essential to source apportionment. The information compiled on the 19 RI Areas, as summarized in Section 4.4 of this Work Plan, was utilized to develop a conceptual model for the source apportionment study that includes descriptions of the number and types of sources that might affect human receptors. This information was also used to guide and refine the siting of measurement systems, the variables to be measured, and the sampling periods and durations to facilitate the collection of the data needed for source apportionment.

While existing data for some of the sources are available from ASARCO permit submissions and previous investigations and sampling, the sampling and the analytical characterization data derived from the Phase II RI will provide the bulk of the information needed for the source apportionment study. In particular, the Phase II RI has been designed to address certain data gaps identified in the *Draft Remedial Investigation Report for the ASARCO LLC Hayden Plant Site* (CH2M Hill, 2008a). These include:

- Analysis of the collected air monitoring filters for particulate morphology and speciation needed to assist in source attribution;
- Sampling of fine-grained soils needed for determination of these areas as possible sources from entrainment during high wind events; and
- Point source and fugitive air monitoring for stack and near-ground emission sources needed to better characterize the source portion of the mass balance model.

The investigations to address the identified data gaps and the associated project objectives were presented in Sections 6.2, 6.3, and 6.4 above.

Step 1: Data Collection

The field sampling and laboratory analysis program described in previous sections will be implemented to collect the source, ambient air, and meteorological data necessary to complete the source apportionment analysis for the Site. To assure that the source apportionment process has the data needed to produce a reliable assessment, the investigation includes an extensive source and receptor monitoring network. The sampling and analysis planned for the investigation will provide the robust database that will facilitate evaluation and produce an accurate basis for characterization. The samplers used in the RI source apportionment study will be operated and maintained in accordance with the FSP, monitoring-related SOPs referenced in the FSP, and the QAPP.

Step 2: Create Source Profiles
Source profiles will be created and refined for each identified potential source of COPCs at the Site by normalizing each chemical and microscopic abundance measurements to the PM mass.

Step 3: Fugitive Dust Emission Potential Maps
Results of laboratory resuspension analysis tests will be assigned to similar surfaces on land use maps of the Study Area. Shaded maps will be created for different wind speed conditions and particle size ranges with shadings showing dust suspension potential of the different exposed surfaces. These maps will be used in conjunction with the spatial isopleths of source related characteristic concentrations and wind roses to apportion elevated dust contributions at the receptors.

Step 4: Descriptive Data Analysis
Tables of averages, standard deviation ranges, and maxima/minima ranges for each measured parameter will be created for each season. These will be compared across the sampling sites and the relation to sources will be evaluated. Diurnal time series of the continuous data will be plotted together and examined for the identification of special events. Periods of high wind speeds will be identified, and the data for those periods will be examined for potential dust suspension. Pollution roses will be constructed for each pollutant for each season and plotted on a map to determine the extent to which source locations can be triangulated.

Any special event such as process upsets, shakedowns, strong winds, and forest fires will be identified, and the data for those days will be examined as special case studies. Days with the highest concentrations for mass, metals, and source markers at any of the monitors may also be selected for case studies. Case studies will include description of the synoptic weather, maps of the air flow patterns, concentration gradient maps, wind and pollution roses, and PM material balances. The descriptive analysis will result in a conceptual model of which sources are likely to influence each receptor under different emissions and meteorological conditions.

Step 5: Spatial and Temporal Analysis
Correlations among the continuous particle concentration, wind speed, and wind direction measurements will be examined to identify short-duration events. Deposits on the E-BAM tapes will be identified for further elemental analysis to confirm source identification. The peaks associated with a source will be differentiated from other ambient measurements and summed for source contributions that are independent of those determined on the 24-hour filters.

Step 6: Weight of Evidence to Validate Source Contribution Estimates
The source contribution estimates from the different CMB solutions and the time series method will be compared, and causes for differences will be sought. The extent to which source contributions are consistent with the occurrence of special events and unusual meteorological conditions will be examined. Source contribution estimates for the ambient air monitoring locations should be consistent with actual measured values. The seasonal and diurnal variation and particle size distribution corresponding to the filter data should be consistent with the source type apportioned. Seasonal average source contribution estimates will be tabulated and evaluated.

Section 4.3.7 of the USEPA *Protocol for Applying and Validating the CMB Model for PM2.5 and VOC* (EPA-451/R-04-001, December 2004) recommends that air dispersion modeling be used as a validation step to corroborate CMB results. Two choices that may be considered for air dispersion modeling are CALPUFF and AERMOD. Based on the following considerations, CALPUFF has been selected for use at the ASARCO Hayden Plant Site if air dispersion modeling is judged to be necessary.

CALPUFF is a Lagrangian model that follows the fate of many small puffs as they move through space and time to simulate a pollutant plume. It therefore allows for non-steady-state dispersion in curved trajectories, whereas AERMOD (a steady-state Gaussian model) assumes continuous dispersion in a straight line trajectory over the averaging period. Because CALPUFF retains emissions information from the previous hour, it allows plumes to meander.

Another advantage of CALPUFF over AERMOD for this particular application is the ability of CALPUFF to compute concentrations during low wind speed and calm (one mile per hour or less) conditions. CALPUFF has the ability to model calm conditions by simulating stagnant puffs which are not dispersed by the wind, but may still undergo dispersion by turbulence. Furthermore, CALPUFF accounts for other possible air flows, including transport caused by up slope/down slope flow characteristic of the Site. Given that light winds and stable conditions are often the worst case scenario for pollution events, it is possible that the calm hours may result in the overall highest impacts, which CALPUFF (but not AERMOD) can model.

For cases involving complex terrain, such as up slope or down slope flows or flows along a river valley, the straight-line, steady-state assumption may not be valid beyond even a few kilometers, and a puff model may be more appropriate. Another consideration in deciding whether a puff or plume model is more appropriate for a particular application is whether the spatial and temporal distribution of a pollutant is important, such as when using the model results for a risk assessment. By contrast, studies of criteria pollutant concentrations typically only predict the highest concentration, irrespective of time or location.

CALPUFF can use the three-dimensional meteorological fields computed by the associated CALMET model, or the on-site meteorological station data that will be measured at the Site. CALPUFF output consists of gridded fields of time-averaged concentrations, time-averaged dry deposition fluxes, and time-averaged wet deposition fluxes, which can be compared to ambient air observations. The post-processing program CALPOST generates ranked tabulations of averages of selected concentration data from these data files. The resolution provided by CALPUFF"s averaging times of one hour for input data (source release rate and meteorology) and output (ambient concentrations) is sufficient for this study.

6.6 Risk Assessment

Ambient air contaminant measurements collected during this RI will represent air concentrations at exposure points that will be used in the HHRA. The HHRA will include data evaluation, identification of COPCs, exposure assessment, toxicity assessment, and risk characterization, and will follow the methodology recommended in *Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual (Part F: Supplemental Guidance for Inhalation Risk Assessment)* (EPA, 2009). A separate Risk Assessment Work Plan, Part 1 of 2 (Air) is attached as Appendix A to this Work Plan.

7.0 RI TASKS

The section presents the various tasks that will be performed during the Phase II RI. The primary RI tasks consist of field investigations to collect ambient air quality and characterization data, meteorological data, and source emission characterization data that will be used to evaluate the effects of meteorological conditions on the distribution of COPCs, to complete the source apportionment study and the related CMB receptor model, and to perform the human health risk assessment using ambient air monitoring data. Supporting tasks will also be conducted, as addressed in the following sections.

7.1 Review of New Data and Work Plan Addendum

This Phase II Work Plan, Part 1 of 2 (Air) has been prepared based on a thorough review of previous studies, information, and data available to EPA at the time of preparation. A preliminary site characterization (Section 3.0) and a conceptual site model (Section 4.0) for air were developed based on this review, and were then used as the basis for the proposed network design to fill identified data gaps.

In performing this review, EPA and ITSI recognized that information that may be in ASARCO‟s possession and has not yet been made available to EPA could augment the preliminary site characterization and conceptual site model, which in turn could refine the proposed scope of the Phase II air investigations. In addition, air monitoring sample filters have been archived by EPA for future analysis, and EPA will assess having some of these archived filters analyzed. Once this information is received, EPA will complete a more comprehensive review of any existing and additional information. A technical memorandum will be prepared including recommendations of any appropriate adjustments to the Phase II RI. At the direction of the RPM, an Addendum to the Phase II Work Plan will be prepared to document any resultant scope changes and to present the technical basis for those changes.

7.2 Procurement, Access, Permits, and Authorizations

Before conducting any work at the Site, all preliminary activities will have been completed, and field and project management personnel will have the appropriate access and authorizations to conduct the work. These activities may include the following types, and are discussed further in the sections below:

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

7.2.1 Subcontractor and Consultant Procurement

The assistance of subcontractors and consultants to implement the RI tasks described in this Work Plan is planned. As soon as written authorization has been received from EPA to conduct the RI tasks, work will proceed to procure the following services:

- Subcontractor to support ambient air quality monitoring and equipment maintenance in the field;
- Consultants with particular expertise in smelter operations, ambient air investigation technologies, and local meteorological conditions to support the data evaluation tasks, as a follow-up to consulting services provided at the Work Plan stage; and
- Analytical laboratory(ies) for special purpose testing, including coordination with the U.S. EPA Region 9 Laboratory and Quality Assurance Office.

7.2.2 Access Agreements

As part of the planning stages for the field work, in coordination with the EPA RPM, work will be completed to identify, negotiate, and secure access in order to conduct the various air monitoring tasks as described in this Work Plan.

7.2.3 Regulatory Permits and Authorizations

In accordance with Office of Solid Waste and Emergency Response (OSWER) Directive 9355.7-03 dated February 19, 1992, CERCLA response actions are exempted by law from the requirement to obtain federal, state, or local permits related to any activities conducted completely on the Site. However, compliance with CERCLA requires that the substantive provisions of permitting regulations that are applicable or relevant and appropriate for the installation and operation of permanent air monitoring stations are met. In addition, any required authorizations and any necessary notifications from EPA for the air monitoring work must be secured.

7.3 Field Investigations

The field investigation portion of the air-related RI will consist of investigations of ambient air and source emission contaminant characterization. All monitoring, 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 comprises 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.

- Network Design Plan (NDP), included as Appendix C, which presents the details of the ambient air quality network design developed consistent with CFR Title 40 §58.10 (a), and includes a series of attachments that provide specific information on each of the 15 selected air monitoring stations.
- 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 in the RI is scientifically valid, defensible, and of known and documented quality.
- Site-Specific Health and Safety Plan (SHSP), included as Appendix E, 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.
- Standard Operating Procedure for Sample Tracking and Electronic Data Management, included as Appendix F, 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.

This section provides an overview of the types of site characterization and emissions source data required and the investigative methods that will be used to obtain this data. The following sub-sections describe methods for (1) implementing field activities; (2) defining the sources of contamination; (3) evaluating the nature and extent of COPCs within the Study Area; and (4) understanding meteorological conditions within the Study Area and how they affect COPC transport. Specific information on the field investigation methods described below is provided in Table 6-1, Figure 6-2, and the SAP (Appendix B).

The ongoing assessment of available data, including available facility operational data, during the investigation process (in terms of its contribution to the achievement of RI objectives) will allow for optimization of field investigation activities and identification of remaining data needs. Certain field activities are expected to last approximately two years, but will continue until a robust dataset capable of meeting the RI objectives has been developed.

7.3.1 Ambient Air Quality Investigation

The ambient air quality investigation has two primary elements:

- Investigation of ambient air quality for human health risk assessment;
- Investigation of ambient air contaminant characteristics to provide data for the source apportionment evaluation.

The field monitoring and investigation activities for ambient air will be managed in accordance with the Quality Assurance Project Plan (QAPP) included as the first part of the Sampling and Analysis Plan (SAP) in Appendix B, and the Quality Management Plan (QMP; Appendix D), to assure the quality of all data collected during the investigation. These quality plans meet the requirements of CFR Title 40 Part 58, Appendix A–Quality Assurance Requirements for SLAMS, SPMs and PSD Air Monitoring. All field activities will be conducted in accordance with the approved Site-Specific Health and Safety Plan (SHSP), Appendix E. All field activities are subject to review and approval by the EPA RPM for the Site.

A network of 15 ambient air monitoring locations (comprised of six existing stations with modified equipment and nine additional stations to be installed during the current project) has been developed for this investigation. The design, installation, and operation of this network are described in the following sections, with additional information on each location provided in the Network Design Plan (Appendix C). Procedures for the collection of ambient air quality data are detailed in the Field Sampling Plan (FSP) and the Standard Operating Procedures (SOPs) attached thereto as the second part of the SAP in Appendix B.

7.3.1.1 Ambient Air Monitoring Network Design

The ambient air monitoring network described in the Ambient Air Network Design Plan consists of monitoring sites that have been selected to meet the following needs of the ambient air quality investigation:

- Determine the extent of contamination within the area covered by the network;
- Measure COPC concentrations in non-residential public areas of the Site for use in the public health risk assessment;
- Determine the contribution from significant sources on air quality in support of the source apportionment study; and
- Determine background concentration levels.

The ambient air monitoring network also has been designed to address certain air quality data gaps identified in the *Draft Remedial Investigation Report for the ASARCO LLC Hayden Plant Site* (CH2M Hill, 2008a). These include:

- Lack of total suspended particulate (TSP) monitor data for lead;
- Absence of background air monitors for use in the investigation;
- Lack of collocated monitors at ambient air monitoring sites;
- Lack of ambient air monitoring sites across populated areas and close to suspected source areas;
- Insufficient point source air monitoring for stack and near-ground emission sources;

- Absence of day and night short-term sampling events for emissions comparisons; and
- Insufficient data for short-term sampling events during high wind conditions.

Ambient Air Monitoring Locations

To address these data gaps, the ambient air quality monitoring network design includes fifteen ambient air monitoring locations, plus one meteorological (MET)-only monitoring location. Monitor locations include specific sites in proximity to several potential source areas (such as the raw material crushing operations, materials conveyor, smelting operations, and tailings impoundments) that may impact nearby residents. In addition, general neighborhood locations have been selected to determine impacts to the residential community. The ambient monitoring locations where additional sample collection equipment will be placed and samples will be collected for the risk assessment and source apportionment study are:

- ST-01, Hayden Maintenance Yard
- ST-02, High School in Winkelman
- ST-03, Montgomery Ranch - EPA
- ST-04, Hayden Junction - EPA
- ST-05, Globe Highway - EPA
- ST-06, Hayden Jail - EPA
- ST-08, Hayden West Side Location
- ST-09, South-Southeast of Crushing Facility
- ST-14, Water Treatment Filter Cake Storage Area/Smelter Parking Lot
- ST-16, Terrace Station
- ST-18, North Hayden Station
- ST-23, Hillcrest Avenue
- ST-26, Concentrator Station (Post Office)
- ST-27, Tailings Pile
- ST-34, Background Monitor – Florence, Arizona

The locations of these ambient air monitoring stations are shown on Figure 6-2. Sampling frequency, duration, equipment types, and proposed analyses are summarized in Table 6-1. The exact locations of specific monitors may be changed following completion of the pre-installation activities if access, security, or other siting criteria issues are identified.

Background sampling will be conducted as part of the investigation to distinguish site-related contamination from any naturally occurring or other non-site-related COPCs. Previous site investigations identified the ADEQ Organ Pipe National Monument ambient air station (Organ

Pipe station) as an appropriate representation of background ambient air quality. The RI Report noted, however, that a limited set of 2006 data from the Organ Pipe station comprised the listed average ambient air background concentrations. This was considered a significant data gap within the previous ambient air quality data. To address this data gap, one of the 15 ambient air monitoring locations within the ambient air quality monitoring network is a new background monitoring location. The community of Florence, Arizona, has been selected to represent local ambient air that has not been impacted by the Site. The exact geographic coordinates for the new background monitors will be selected during the pre-installation phase.

Monitor Types

The ambient air monitoring network design has been developed to meet the ARARs found in 40 CFR Part 58, Appendix D, *Network Design Criteria for Ambient Air Quality Monitoring* and 40 CFR Part 58 Subpart B, *Monitoring Network*. The network design plan elements in 40 CFR Part 58 that have been incorporated into the FSP and QAPP include:

- General monitoring requirements;
- Monitoring objectives and spatial scales;
- Design criteria for lead sampled as TSP;
- Design criteria for particulate matter equal to or less than 10 microns in aerodynamic diameter (PM_{10});
- Design criteria for fine particulate matter equal to or less than 2.5 microns in aerodynamic diameter ($PM_{2.5}$).

The EPA *Quality Assurance Handbook for Air Quality Measurement Systems, Volumes 1-5,* and other appropriate EPA or state agency guidance sources, as noted in this text, also have been consulted in developing the ambient air quality field investigation elements of this Work Plan.

All monitoring locations will be equipped with ambient air monitoring instruments that meet current approved Federal Reference Method (FRM) in 40 CFR Part 50 for the specific particulate matter being monitored (i.e. PM_{10}, $PM_{2.5}$, or Pb-TSP). The following types of monitors will be used at all or a portion of the ambient air monitoring locations, as noted in the descriptions.

Partisol 2025 PM_{10} Samplers: A Partisol 2025 PM_{10} monitor will be placed at each of the ambient air monitoring locations listed at the beginning of Section 7.3.1.1. Ambient air particulate matter mass measurements (gravimetric) and chemical speciation analyses will be performed to provide supporting data for source apportionment.

Partisol 2025 $PM_{2.5}$ Samplers: Partisol 2025 $PM_{2.5}$ monitors will be placed at the following four ambient air monitoring locations: ST-14, ST-23, ST-26, and ST-34. Ambient air particulate

matter mass measurements (gravimetric) and chemical speciation analyses will be performed to provide supporting data for source apportionment.

TSP Samplers: Thermo Scientific MFC-TSP (Model GS2313) samplers will be placed to collect TSP samples at ambient air monitoring locations ST-01, ST-02, ST-05, ST-23, ST-26, and ST-34. The TSP samples will be examined for particulate matter mass and Pb concentration.

MiniVol Filter Samplers: Each ambient air monitoring location listed at the beginning of Section 7.3.1.1 will include four MiniVol samplers, two fitted with a $PM_{2.5}$ size-selective inlet and two with PM_{10} inlets. The four MiniVol samplers will be operated in parallel to accommodate different sampling objectives. (The $PM_{2.5}$ fraction frequently contains higher concentrations of arsenic and lead; and previous investigations suggest that the PM_{10} fraction is dominated by windblown dust.) Figure 7-2 shows a schematic for a combination of four parallel MiniVol samplers as they will be operated at each of the MiniVol sampler locations.

One PM_{10} sampler will be equipped to collect the PM_{10} fraction on a quartz filter to determine elemental carbon and organic carbon, and one will be equipped to collect PM_{10} on a Teflon filter for mass analysis and chemical analyses. One $PM_{2.5}$ sampler will be equipped with a polycarbonate filter (0.1 micrometer pore) that will allow SEM/EDX analysis for particle morphology and elemental composition on select samples, and one $PM_{2.5}$ sampler will be equipped with a Teflon membrane filter for the same analyses as the PM_{10} MiniVol sampler. Separating the fractions will allow for more precise source apportionment. The samplers will be run on a staggered basis for a set time period (24 hours) every sixth day.

Cascade Impactor: Micro-Orifice Uniform Deposit Impactors (MOUDIs), a form of cascade impactor, will be used to segregate the ambient aerosol and particulate matter into 11 different size fractions (from 0.01 to 18 microns in aerodynamic diameter), thereby allowing size-specific chemical and physical analysis for the development of size-specific source and receptor profiles. One MOUDI will be placed at the High School in Winkelman monitoring station (to replace the MOUDI that has been in operation at this location as part of an ongoing University of Arizona Study [Csavina et al.] and is scheduled for relocation to another site), and another will be deployed as needed at other ambient air monitoring locations (when not in use as part of source characterization sampling).

Beta Attenuation Monitor: A MetOne™ Beta Attenuation Monitor (E-BAM) equipped with a PM_{10} inlet will be installed at each of the ambient air monitoring locations (except at ST-06, where an E-BAM with a $PM_{2.5}$ inlet will be installed) to record short-term events that might be missed by the MiniVol samplers (which will be operating on a 24-hour, every sixth day based schedule). Archived samples of tape may be analyzed subsequently, to support source apportionment studies.

Optical Particle Counter: A battery-powered TSI DustTrak DRX Optical Particle Counter (OPC) will be used at each of the ambient air monitoring locations to measure mass concentrations for PM_1, $PM_{2.5}$, PM_4, PM_{10}, and total suspended particulates (TSP) over very short time spans (e.g., a few minutes).

Collocated Monitors: Collocated monitors have been incorporated into the network design in accordance with 40 CFR Part 58 Appendix A. As described in the Network Design Plan (Appendix C), these will include, at a minimum, collocated monitors representing 15% of the total number of monitors within the network for each pollutant.

7.3.1.2 Meteorological Monitoring Network Design

The ambient air quality investigation will include the collection of local meteorological (MET) data. MET data are necessary to support the evaluation of ambient air quality data, provide on-site MET data as inputs to the performance of air dispersion modeling, provide a better understanding of the distribution of COPCs for the assessment of risk, and assist in the screening of alternatives within the subsequent feasibility study.

Each ambient air monitoring location will have an anemometer and wind vane to enable a more detailed characterization of localized wind speed and direction. In addition, instrumentation for the collection of atmospheric pressure, temperature, and humidity will be operated as integral parts of the Partisol Plus 2025 monitors included at each of the ambient air monitoring locations.

The stand-alone MET station (ST-10) will have the following equipment to characterize the local meteorological conditions:

- Anemometer
- Wind vane
- Thermometer
- Barometer
- Hygrometer
- Sonic Detection and Ranging (SODAR) acoustic sounder

To support the evaluation of variations in local MET conditions that could impact the vertical distribution of COPCs at the Site (such as diurnal changes in mixing height, variable conditions resulting from the complex local terrain, and the potential for inversions), additional MET data will be collected using instrumentation designed to monitor and record MET conditions at multiple heights above ground level. As indicated above, a stationary SODAR acoustic sounder will be located at the stand-alone MET station, as shown on Figure 6-2. SODAR can measure wind speeds and directions at various heights from a single ground-level location. In addition, at

a minimum, data for wind speed, wind direction, humidity, dew-point, and temperature will be collected at the 10 meter elevation. Precipitation data will be collected at the five-meter elevation only.

In addition to the stationary SODAR, a trailer-mounted SODAR acoustic sounder will be deployed and moved around the Site as necessary to develop a "climatology" of upper-level winds and mixing heights, thereby leading to a better understanding of how the complex topography of the area affects meteorology. The transportable SODAR will measure wind speed/direction aloft and mixing height, which is currently unknown at the Site. High levels of background "noise" may reduce the maximum reporting height; thus it will be important to identify relatively quiet sites for the SODAR. The SODAR sites will also be located in areas with wide-open wind fetches (i.e., areas with no reflecting objects) to substantially eliminate clutter. See Figure 6-4 for the proposed SODAR sampling locations.

7.3.1.3 System Installation and Startup

Ambient Air Monitors

Each ambient air monitoring station will be constructed in a manner consistent with this Work Plan, the construction plans, and equipment manufacturer‟s specifications. All work will be performed in accordance with the RI/FS Site-Specific Health and Safety Plan (SHSP), Appendix E and any addendums, and with all applicable Occupational Safety and Health Administration (OSHA) standards. All activities related to deployment of ambient air monitors will be subject to review and approval by the EPA RPM for the Site.

At locations where a new power source is required, an electrical contractor will be mobilized following the physical placement of the monitoring equipment. All electrical connections will be established in compliance with state and local electrical codes and consistent with the equipment manufacturer‟s specifications.

Following setup of each ambient air monitor, the monitor will undergo start-up procedures according to the manufacturer‟s specifications. All monitors will be de-bugged and calibrated in accordance with the corresponding SOPs before collection of sampling data begins. Any monitor that fails the start-up process will be identified and a request for technical support or replacement will be submitted to the vendor.

Meteorological Station

Specifications for the meteorological instrumentation and for the installation of the MET station follow the guidelines in the *Quality Assurance Handbook for Air Pollution Measurement Systems Volume IV: Meteorological Measurements* (EPA, 2008f), as applicable. Additional

guidance may be derived from *Ambient Monitoring Guidelines for Prevention of Significant Deterioration* (PSD- Sections 5 and 6; EPA, 1987), *Meteorological Monitoring Guidance for Regulatory Modeling Applications* (EPA, 2000) and *Meteorological Monitoring Guidance for Manual of Procedures, Volume VI, Air Monitoring Procedures* (Bay Area Air Quality Management District [BAAQMD], 2006). All activities are subject to review and approval by the EPA RPM for the Site.

The MET instruments and the SODAR units will be installed in accordance with the manufacturer‟s specifications and guidelines. All work will be performed in accordance with the SHSP and any addendums, and with all applicable OSHA standards.

Following setup, each MET sensor will undergo start-up procedures according to the manufacturer‟s specifications. All sensors will be de-bugged and undergo calibration procedures before investigation data recording begins. Any sensor/meter that fails the start-up process will be identified and a request for technical support or replacement submitted to the vendor.

7.3.1.4 System Operation and Maintenance

Ambient Air Monitors

The operation and maintenance of the monitors within the RI ambient air monitoring network will be conducted in accordance with the FSP, monitoring-related SOPs in the FSP, the QAPP, and the SHSP. Space and access to power are limited at a number of the proposed monitoring locations, and as a result, emphasis has been placed on monitoring systems that do not require extensive environmental control, are low in power consumption or are battery-capable, and have small footprints. Auditing and calibration of each monitor will be performed in accordance with the appropriate SOP(s) and the QAPP. Quality assurance procedures within the QAPP were developed consistent with *Quality Assurance Handbook for Air Pollution Measurement Systems* (EPA, 2008e) and the relevant guidelines in 40 CFR Part 58 Appendix A.

MET Station

In addition to the MET data necessary for the operation of each PM_{10} monitor (i.e., temperature and barometric pressure), additional wind data will be collected at selected PM_{10} monitors using the MET data collection feature of the PM_{10} monitor with add-on anemometer. The operation and maintenance of the MET sensors/meters will follow the procedures outlined within the PM_{10} monitor SOP #4 and the project FSP, QAPP, and SHSP. Quality assurance procedures within the PM_{10} monitor SOP were developed in accordance with the MET sensor manufacturer‟s recommendations and are consistent with EPA guidance in *Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV* (EPA, 2008f).

The stand-alone MET station, including the stationary SODAR unit, will be operated and maintained in accordance with the FSP and the SOPs attached thereto. SOPs for operation, maintenance, and data collection activities, as well as additional quality assurance elements in the QAPP specific to the MET station, were developed in accordance with the MET sensor manufacturer‟s recommendations. All activities related to obtaining meteorological measurements are subject to review and approval by the EPA RPM for the Site.

Auditing and calibration of each MET station sensors will be performed in accordance with the sensor SOP and the QAPP. Quality assurance procedures for MET sensors were developed in accordance with the MET sensor manufacturer‟s recommendations and consistent with EPA guidance in *Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV* (EPA, 2008f).

7.3.1.5 Ambient Air and Meteorological Field Monitoring Program

Ambient Air

The ambient air quality monitoring program will consist of a network of filter-based samplers that meet EPA Federal Reference Method (FRM) standards for regulatory monitoring. All PM samples will be collected for a 24-hour period according to the following schedule:

- PM_{10} Primary — Every sixth day
- PM_{10} Secondary (collocated) — Every twelfth day
- $PM_{2.5}$ Primary — Every third day
- $PM_{2.5}$ Secondary (collocated) — Every sixth day
- Pb-TSP Primary — Every sixth day
- Pb-TSP Secondary (collocated) — Every Twelfth day

The monitoring schedule will follow EPA‟s Ambient Monitoring Technology Information Center Sampling Schedule Calendar (EPA Sampling Calendar), which is published at: http://www.epa.gov/ttn/amtic/calendar.html.

Meteorology

The complex topography of the Hayden site, which is at the confluence of two river valleys and in proximity to numerous smaller drainage washes, gives rise to complicated air-flow patterns that will be documented to support source identification and apportionment. Surface meteorological stations will therefore be deployed at all of the ambient air monitoring locations to record wind speed, wind direction, temperature, barometric pressure, and relative humidity. The observations will be used to reconstruct back-trajectories from receptor to source. The meteorological observations will be recorded at one-minute intervals.

The atmospheric mixing height above the site will also be measured using the SODAR system because it varies markedly as a function of season and time of day.

7.3.2 Emission Source Sampling

As previously noted, chemical source profiles related to fugitive emissions are needed to obtain inter-related information on the chemical, temporal, spatial, and particle size "fingerprints" that can be used, in conjunction with a chemical mass balance model, for source characterization. This section describes the emission source sampling strategy and its rationale. The emission source characterization investigation includes sampling of the following categories of sources:

- Process point source emissions,
- Process fugitive emissions, and
- Area source fugitive dust emissions.

7.3.2.1 Process Point Source Emissions

Sampling will be performed at a limited number of point emission sources at the Site. The point source sampling locations are designated as:

- ST-19 Secondary Hood Baghouse Discharge to Stack
- ST-20 Vent Gas Cottrell Discharge to Stack
- ST-20 Vent Gas Cottrell Discharge to Stack on Smelter Shutdown
- ST-21 Acid Plant Tail Gas Discharge to Inner Stack
- ST-33 Secondary Crusher Source Discharge

The locations of the point source sampling are shown on Figure 6-2; sampling frequency, duration, equipment types, and proposed analysis are summarized in Table 6-1.

Emissions from ST-19, ST-20, and ST-21 are vented through the 1,000-foot smelter stack. Because of the height of the stack and the associated meteorology (particularly the mixing height), these emissions are expected to be detected only rarely at the Site. The smelter stack, which has pollution controls on all contributing sources, has a minor visible plume. As indicated in Section 6, emissions from source ST-33 reportedly are controlled by wet scrubbers. The source sampling will test the assumption that the smelter and crusher stacks are limited contributors to COPCs at the Site. Samples will be collected by using procedures described in the FSP.

7.3.2.2 Process Fugitive Emission Sources

Sampling will be performed at or near process fugitive emission sources at the Site. These sampling locations are designated as:

- ST-09 Primary Reverts Crushing Station (South)
- ST-13 Smelter Hill Base, North Side
- ST-14 Water Treatment Filter Cake Storage Area/Smelter Parking Lot
- ST-17 Warehouse Station
- ST-22 Concentrate Bedding Area
- ST-24 Converter Building Roof Vents
- ST-25 Flash Furnace Roof Vents
- ST-26 Concentrator Station
- ST-27 Tailings Pile
- ST-28 Slag Dump Station
- ST-29 Converter Source Station
- ST-30 Flash Furnace Source Station
- ST-31 Anode Pour Source Station
- ST-32 Reverts Crushing Station (North)

These monitoring locations are shown on Figure 6-2; sampling frequency, duration, equipment types, and proposed analyses are summarized in Table 6-1.

Four rounds of sampling (spaced approximately three months apart) are planned for each location. The number and timing of sampling rounds is designed to identify any variations in emissions that may be seasonal or operational in nature. During each sampling round, samples will be collected using four MiniVol samplers, a TSI DustTrak DRX sampler, and a MOUDI sampler.

Like the ambient air monitoring sampling, the four MiniVol samplers will include two fitted with a $PM_{2.5}$ size-selective inlet and two others with PM_{10} inlets. The four MiniVol samplers will be operated in parallel. As appropriate, the sampler pump will be run for a set time period (e.g., 24 hours) using a timer, or a meteorological station sensor will be used to trigger wind speed/direction-dependent sampling.

A battery-powered TSI DustTrak OPC will be used at each location to measure mass concentrations (in mg/m^3) for PM_1, $PM_{2.5}$, PM_4, PM_{10}, and TSP. The OPC size distribution data will be evaluated to determine dust suspension properties, transport distances, and potential

health effects of emission events caused by process releases, wind, or mechanical resuspension occurrences.

A MOUDI sampler will be operated to provide size differentiated samples for SEM and ion analysis as described in the FSP and QAPP.

7.3.2.3 Area Fugitive Dust Emission Sources

Potential area fugitive dust sources at the Site include source building floor dust, exterior locations where dust accumulates, parking areas, paved and unpaved roads, construction sites, unenclosed material storage areas, tailings impoundments, historical and accidental waste disposal areas including spills and accumulations, and disturbed and undisturbed desert soils. General area locations for the collection of area fugitive dust emissions have been preliminarily identified and are provided in Table 6-2 and Figure 6-4. The specific sample locations will be based upon field samples collected and field evaluated by XRF in conjunction with the non-air soil sampling portion of the Phase II RI, and as determined in consultation with the EPA RPM. The FSP provides a more detailed discussion of the surface sample collection program and the procedure for selection of sampling locations. The potential for fugitive dust emissions from these potential sources will be simulated by resuspension tests in the laboratory.

7.4 Laboratory Studies: Sample Analysis and Validation

Samples from both the ambient air and emission source sampling programs will undergo a variety of laboratory tests to evaluate the mass, chemical makeup, and physical morphology of the collected particulates. Analyses performed as part of this study will adhere to EPA-approved methods for the chemical analysis of samples. The characterization of inorganic compounds in ambient aerosol samples is described in the EPA *Compendium of Methods for the Determination of Inorganic Compounds in Ambient Air Standard*. Of particular relevance to this work, the compendium includes:

- Method IO-3.1: Selection, Preparation and Extraction of Filter Material.
- Method IO-3.3: Determination of Metals in Ambient Particulate Matter Using X-Ray Fluorescence (XRF) Spectroscopy.
- Method IO-3.4: Determination of Metals in Ambient Particulate Matter Using Inductively Coupled Plasma (ICP) Spectroscopy
- Method IO-3.5: Determination of Metals in Ambient Particulate Matter Using Inductively Coupled Plasma/Mass Spectrometry (ICP/MS).

Water-soluble ions will be determined by EPA-approved Method 9056A, Determination of Inorganic Anions by Ion Chromatography.

7.4.1 Testing Methods

The laboratory program developed for the Phase II RI includes a number of analytical testing methods to meet the varied objectives of the program and the need to accommodate different types of samples and sampling media. A short description of each of the sampling methods is provided below. Section 7.4.2 will link the specific method(s) to be applied to each type of sample.

Gravimetry

Gravimetric analysis (filter pre-exposure and post-exposure weight differential) will be used to determine mass of particulate matter in volume of air (ug/m^3).

X-Ray Fluorescence

X-ray fluorescence (XRF) analysis will be used to determine the concentration of metals and other elements present in particulate matter samples.

Inductively Coupled Plasma - Mass Spectrometry

Inductively coupled plasma - mass spectrometry (ICP-MS) analysis will be used to determine the concentration of metals, lead isotopes, and other elements present in particulate matter samples.

Ion Chromatography

Ion chromatography (IC) analysis will be used to determine water-soluble anions and cations.

Ion Chromatography - Inductively Coupled Plasma - Mass Spectrometry

Ion chromatography - inductively coupled plasma - mass spectrometry (IC-ICP-MS) will be used to determine chromium and arsenic speciation.

Thermal Optical Reflectance

Thermal optical reflectance (TOR) will be used to determine elemental carbon (EC) and organic carbon (OC) concentrations present in particulate matter samples.

Scanning Electron Microscopy, Energy-Dispersive X-ray Spectroscopy

Scanning electron microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDX) analyses will be used to determine single particle morphology and elemental composition, respectively.

7.4.2 Testing Program Flowcharts

Figure 7-1 provides a flowchart of the laboratory program corresponding to each type of monitor being proposed for the study. Each flowchart path provides information on filter selection and preparation, laboratory tests to be performed, and the associate suite of analytical parameters

associated with each test. The section reference provided at the top of each flowchart corresponds to the section of the QAPP where additional details can be found. The following sections provide a summary description of this information.

Field QC samples will be collected as described in Section 8 of the QAPP. Data will be managed in accordance with QAPP Section 7. Data will be validated in accordance with Section 10 of the QAPP.

Thermo Scientific MFC-TSP (GS2313)

Each of the Teflon filters collected from the Thermo Scientific MFC-TSP (GS2313) samplers will have gravimetric and Pb-TSP analyses performed as described in Section B.2 of the QAPP.

Partisol 2025

Each Teflon filter sample collected from either a PM_{10} or $PM_{2.5}$ monitor at ambient air monitoring locations at the Site will have gravimetric, XRF, and ICP-MS analyses performed. The procedures for sample preparation and analysis are described in Section B.3 of the QAPP.

MiniVol

- All Teflon filters from the MiniVol samplers (MiniVols fitted with the $PM_{2.5}$ size-selective inlet and the PM_{10} size-selective inlet, see Figure 7-2) will have gravimetric analysis performed. In addition, XRF and ICP-MS analyses will be performed on these filters. The procedures for sample preparation and analysis are described in Section B.4 of the QAPP.
- Twenty-five percent (25%) of the MiniVol polycarbonate filter samples (see Figure 7-2) collected at Site ambient air monitoring locations (or such smaller subset as is determined by the EPA RPM) will be analyzed for particle morphology and chemistry by SEM/EDX and for ions by ion chromatography. The samples selected for analysis will be for the days having the highest metals concentrations as measured on Teflon filters by XRF analysis. The other 75% of the filters will be archived for future evaluation, if determined appropriate by the EPA RPM.
- Every MiniVol quartz filter sample (see Figure 7-2) collected at the monitoring locations (or such smaller subset as determined by the EPA RPM) at the Site will have a gravimetric analysis, organic carbon and elemental carbon analysis (using the TOR technique), and ion analysis (using IC) performed. The procedures for sample preparation and analyses are described in Section B.4 of the QAPP.

MOUDI

Polycarbonate membrane filters (0.1 micron pore) will be used on each MOUDI stage to collect samples for size-selective chemical speciation, as described by Csavina et al. The filters will be handled and analyzed as described below:

1. Filters corresponding to the 0.18 um cut-off diameter and the 5.6 um cut-off diameter stages will be examined by SEM seeking all spherical particles, which will then be analyzed by EDX for chemical species. All particles containing lead, arsenic, or copper, irrespective of particle morphology, will be quantified by EDX. After these non-destructive analyses are completed, the sample will be analyzed for ions using IC.

2. Filters corresponding to the 0.32 um cut-off diameter and the 10 um cut-off diameter stages will be analyzed by XRF and ICP-MS.

3. Filters corresponding to all other cut-off diameters will be archived for future evaluation, if determined appropriate by the EPA RPM. .

The procedures that will be used for the preparation and analysis of MOUDI filters are described in Section B.5 of the QAPP:

E-BAM

The continuous glass-fiber tapes that have been date-stamped and archived by personnel maintaining the ambient monitoring network will be selectively chosen for subsequent chemical analysis by XRF. The tapes will typically be selected based on events identified by a combination of E-BAM measurements, wind direction and speed data, PM_{10} and $PM2_{.5}$ data, and MOUDI data. The procedures for sample preparation and analyses are described in Section B.6 of the QAPP.

Area Fugitive Dust Samples

Samples of surface soils or other surficial material will be collected to evaluate the potential for area dust emissions to contribute particulate matter to ambient air. Each sample will undergo laboratory resuspension as described in the FSP and QAPP. The resuspended PM_{10} and $PM_{2.5}$ samples will then be analyzed by XRF and ion chromatography to determine the chemical and ion nature of the particulate matter. The procedures for sample preparation and analyses are described in Section B.4 of the QAPP.

Speciation of Chromium and Arsenic

Previous site investigations have not identified the presence of chromium (VI), a known carcinogen, at the Site. For confirmatory purposes, one soil sample will be collected near the reverts storage and crushing facility, the expected source of the highest chromium containing

materials. The sample will be analyzed for chromium (VI) and chromium (III) using a standard method (IC with post-column derivatization [EPA Method 7199]). Similarly, neither As(V) nor As(III) speciation has been reported at the Site. One confirmatory composite floor dust sample collected in the smelter building, the most likely expected source of arsenic, will be analyzed for the individual arsenic oxidation states using IC-ICP-MS (X. Chris Le, et al., Anal. Chem., 2004, 27A).

7.5 Data Analysis and Evaluation

In addition to the data validation and evaluation described in the QAPP, the methods of data evaluation and interpretation anticipated for completion of investigation activities will include, but not be limited to, facility design criteria and operational data reviews; analytical and field measurement data reviews; mapping of COPC concentrations; modeling; and statistical evaluation of data and trends.

Previous investigations of the Site have produced an existing database of emission source and ambient air characterization information. However, as discussed in earlier sections of this Work Plan, there still remain numerous data gaps that will be filled by the Phase II RI investigation. The data acquired during the Phase II investigation will be used for:

- Correlation and comparison of current ASARCO production data with current source and ambient air data to determine any cause and effect relationship between production, source and ambient data;
- Correlation and comparison of ASARCO facility operational data with ambient air data;
- Comparison of source apportionment study data with earlier source apportionment data;
- Comparison of new and expanded ambient air monitoring network data with previously collected ambient air monitoring data;
- Characterization of emission sources within the Hayden Complex and across the Study Area; and
- Identification of previously unrecognized sources and determination of their correlation with fingerprinted sources.

The approach to the evaluation of new and previously collected data will be through a program of data exploration including:

- Examination of data quality (e.g. precision, accuracy, and representativeness);

- Determination of basic statistical parameters (e.g., mean, standard deviation, skewness, and kurtosis) along with minimum, maximum, 2nd Max and 98th percentile values and standard deviation for the 24-hour sample values;
- Examination of data for fit to standard distributions (normal, lognormal, other or nonparametric);
- Evaluation of data sufficiency (numbers of samples for each medium and/or horizon and consistency of analytes); and
- Application of distributional tests (e.g., t-tests) or non-distributional tests (e.g., Wilcoxon rank-sum) to compare datasets for each medium and selected analyte.

Historical datasets that will be considered representative of current conditions are those that represent a condition that has not been altered by operational or construction modifications. These datasets would be combined with the new data to provide a more robust statistical basis for the risk assessments and the assessment of the nature and extent of contamination.

7.5.1 Data Analysis and Source Apportionment

This section describes how the measurements obtained during this investigation will be used to determine source contribution estimates and provide a weight of evidence for those attributions.

Relating size-resolved contaminant concentrations and morphology with wind patterns at the Site will be instrumental to source apportionment. This will be achieved by careful and thorough construction of source profiles and receptor profiles. The profiles will be constructed using a robust database including a combination of:

- Meteorological data,
- Gravimetric data,
- Chemical composition data,
- Particle size differentiation data,
- Morphological data, and
- Process operational data.

Along with the source and receptor profiles, data will be tabulated and presented graphically to simplify evaluation. The detailed profiles for sources and receptors, coupled with COPC pollution roses, will provide the basis for assembling the source apportionment. The source apportionment model will be assembled and verified by applying the data from multiple time periods and wind directions to confirm the accuracy of the source apportionment.

Other statistical approaches may also be appropriate pending the outcomes of these initial data evaluations. Evaluation may be performed through statistical software package tests such as those in Excel, Minitab, or ProUCL. The results of statistical evaluations, with conclusions and recommendations, will be presented in the RI Report.

Chemical Mass Balance Receptor Model

Receptor models are mathematical or statistical procedures for identifying and quantifying the sources of air pollutants at a receptor location. Unlike photochemical and dispersion air quality models, receptor models do not use pollutant emissions, meteorological data, and chemical transformation mechanisms to estimate the contribution of sources to receptor concentrations. Instead, receptor models use the chemical and physical characteristics of gases and particles measured at the source and receptor both to identify the presence of source-related COPCs at the receptor location and to quantify the source contributions to receptor concentrations. These models are, therefore, a natural complement to other air quality models and are used as part of State Implementation Plans (SIPs) for identifying sources contributing to air quality problems.

EPA-CMB Version 8.2 model, the most recent EPA-approved CMB model, will be downloaded from EPA‟s Support Center for Regulatory Atmospheric Modeling (SCRAM, at: *http://www.epa.gov/ttn/scram/*) for use in the Phase II RI. CMB 8.2 has been subjected to peer review and is available for regulatory applications. EPA has supported CMB as a regulatory planning tool through its approval of numerous State Implementation Plans (SIPs) that have a source apportionment component. An earlier version of CMB was used successfully in the 1987 source apportionment study (NEA, 1987) described in Section 3 of this Work Plan. EPA‟s CMB 8.2 User‟s Manual (EPA-452/R-04-001 December 2004) will provide the technical approach used to run the model. EPA-

Suspected sources will be related mathematically to the observed ambient aerosols with the CMB 8.2 model, which uses speciated profiles of potentially contributing sources and the corresponding ambient data from analyzed samples to quantify source contributions. The Phase II RI is specifically designed to produce the necessary data sets. Source profiles determined from aerosol samples collected at the suspected sources and analyzed for metals, ions, Pb isotopes, EC/OC, and morphology, as described previously, will be entered into CMB Version 8.2. Similarly, data obtained from samples collected by the ambient samplers also will be entered into the CMB, thus allowing the contribution of each source to each ambient monitor to be calculated by the model using the effective-variance least squares method (EVLS). The least squares method requires that the number of chemical species determined must exceed the number of source profiles characterized. This condition will be easily met in the Phase II RI because approximately 20 chemical species will be quantified for approximately six source profiles.

CMB Model Validation Using Air Dispersion Modeling

The CMB receptor model statistically links the individual contributions of a number of possible source profile emissions to the pattern of species observed at a particular ambient air receptor. The CMB receptor model establishes statistical patterns – it does not account for the actual concentrations observed at the ambient air receptor site under specific source strength and meteorological conditions. This gap in the physical chain of events (source to receptor) can be filled using a dispersion model, such as CALPUFF.

The objective is to run CALPUF to predict the concentration of a pollutant plume (or puffs) emitted from a suspected source(s) at downwind ambient air monitors. CALPUFF, the preferred dispersion model, will be initialized with source strength observations to be made at least four times during the year, and the archived meteorological observations to be made continuously throughout the year, especially the SODAR vertical wind profiles. Pollutant mass concentrations, e.g., PM_{10}, $PM_{2.5}$, lead and arsenic, will be plotted on gridded fields and compared to observations made at the downwind ambient air monitors (MiniVols).

Source strength characteristics are expected to be relatively constant in the absence of process upsets, so a representative average measured source strength will be used to predict pollutant mass concentrations on the days that sources are not being measured. Due to natural variability in wind direction, and the wide spatial distribution of MiniVol sites, not all MiniVols will be downwind from a particular source all the time. Nevertheless, CALPUFF will be run for a sufficient number of cases to predict the effects of sources on pollutant concentrations observed at ambient air sites reliably. CALPUFF will also be run for a sufficient number of seasonal and diurnal meteorological conditions, especially low wind speeds, and low mixing heights in winter, to adequately document the effects of meteorology on pollutant dilution and dispersion within the Study Area.

Finally, CALPUFF will also be used to identify and model the worst case scenarios when a meteorologically confined plume travels directly over a populated area at low speed with minimal dilution.

7.6 Process for Identification and Evaluation of Data Needs, Gaps, and Uncertainties

During the Phase II RI investigations, when data collection activities for a given type of data (e.g., source apportionment) are completed and a complete dataset is received from the laboratory, the data will undergo validation in accordance with procedures detailed in the QAPP. Validated data will be uploaded to the project database in accordance with the data management procedures described in the QAPP. Initial data tables (crosstabs) and data figures will be prepared for initial data assessment purposes. Crosstab tables will be used initially to screen data against regulatory criteria (e.g., RSLs or NAAQSs) and to support an initial assessment as to

whether the current dataset, in combination with existing historical data, appears sufficient to perform the planned evaluations of source apportionment and risk.

On a periodic basis (to be determined by the progress of work performed and the receipt and validation of laboratory analytical data), data will be provided to EPA, ADEQ, and ASARCO. A Technical Memorandum (or other form of communication if pre-approved by EPA) will be prepared and presented to EPA with an evaluation of remaining data gaps and uncertainties. The conclusion may be that all proposed data-collection activities are complete and that the datasets are adequate to proceed with the preparation of an RI report and human health risk assessment. Otherwise, recommendations will be presented to EPA if it is determined that data gaps requiring additional data collection activities still exist, or that modifications to analytical or sampling programs are warranted. All data analysis activities, conclusions, and modifications of work are subject to review and approval by the EPA RPM for the Site.

7.7 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 to ambient air within the Study Area. 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 ambient air.

The scope of the Phase II HHRA for air and the specific approaches, methods, and equations to be utilized are documented in a separate Risk Assessment Work Plan, Part 1 of 2 (Air) attached as Appendix A to this Work Plan.

7.8 RI Report Preparation

After field data collection activities within the study area have been completed, an RI report will be generated to summarize the field work, identify any deviations from this RI/FS Work Plan, present the results of the investigation, and identify areas of unacceptable risk due to COPCs. The RI report will include a narrative on the quality of data obtained during RI activities and whether data collection during the investigation met the project data quality objectives.

The RI report will provide a comprehensive site background and a summary of data existing prior to the initiation of field activities. This discussion will detail operational and investigative activities throughout the site history and identify existing site data. Gaps in data existing prior to

the RI will be presented, and the rationale and methodology followed to obtain the data necessary to fill these gaps will be discussed.

The RI report will detail the nature and extent of COPCs across the Study Area based on both existing data and data generated during the investigation. The RI report also will identify areas where COPCs pose unacceptable risk to human health via the air pathway and quantify those risks.

A primary objective of the RI is to update and refine the 1987 Source Apportionment Study with a more robust data base reflective of current conditions. Therefore, the RI report will summarize the data generated during field activities; describe emissions sources identified during the investigation in detail, including the type of source (point, fugitive, or area) and COPC characteristics; and correlate COPCs within the Study Area with emissions sources. To the extent possible, the RI report will describe the fate and transport of COPCs from identified emissions sources into the Study Area based on the air dispersion model.

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8.0 FEASIBILITY STUDY

This section provides a description of the overall approach for the FS that will be performed in conjunction with the Phase II RI. 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, the findings of the Phase II RI, and risk information determined in the HHRA and Ecological Risk Assessment (ERA). The FS will include an analysis of ARARs.

The FS will follow the pertinent procedures outlined in *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA, 1988). The general FS process to be followed is summarized in the following subsections. It is expected that a Work Plan for the FS will be more fully developed as the RI proceeds.

8.1 Development and Screening of Alternatives

The development and screening of response alternatives consists of six general steps:

- Based on the risk assessments and RI findings, develop remedial action objectives (RAOs) 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.
- Develop general response actions (GRAs) for each environmental medium of interest that might be implemented alone, or in combination, to satisfy RAOs. The GRAs will include, as appropriate, options in which treatment is 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.
- Identify volumes or areas of environmental media to which GRAs might be applied, taking into account the requirements for protectiveness identified in the RAOs and the chemical and physical characterization of the Site.
- Identify and screen the technologies applicable to each GRA to eliminate those that cannot be implemented technically at the Site.
- Identify and evaluate technology process options to select a representative process or processes for each technology type retained for consideration.
- Combine the remaining technologies and process options into media-specific or Site-wide response alternatives. If many distinct, viable options or combinations thereof are

available and developed, a screening of alternatives will be conducted to limit the number of alternatives that undergo detailed analysis by considering only the most promising process options. The alternatives will be screened on a general basis with respect to their effectiveness, implementability, and cost.

Regarding air emissions, insufficient data have been collected at this time to allow a determination as to whether treatability studies are needed. If deemed necessary, treatability studies will focus on reduction of air emissions from active processes and control of airborne emissions from waste storage/disposal areas and other area sources. Studies could include, but may not be limited to, evaluation of improvements to emission controls at the concentrator and smelter facilities, consolidation/stabilization of waste piles in the vicinity of facilities such as the concentrator and Conveyor No. 9, and stabilization or other erosion control methods applied to the tailings impoundments. Evaluation of potential emissions controls on process facilities would require collection of additional air quality monitoring data and possible dispersion modeling.

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 National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (EPA, 1994) 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 provides adequate protection and describes how risks posed through each pathway are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls.
- *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 any revisions to relevant air 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:* Represents the preferred performance goal of the treatment technologies 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 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 strategy involved and identifies the key environmental standards associated with that 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 to and contrasted with one another with respect to each of the evaluation criteria (the comparative analysis).

8.3 Feasibility Study Report

The results of the FS will be presented in an FS Report that describes the remedial alternatives developed and evaluated to address emissions sources and areas of unacceptable risk within the Study Area. Additionally, the FS will include a detailed analysis and comparison of remedial alternatives and the results of any treatability studies.

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 Identification and Screening of General Response Actions, Remedial Technologies, and Process Options
Section 5 Development and Screening of Alternatives
Section 6 Definition of Criteria Used in the Detailed Analysis of Retained Alternatives

Section 7 Detailed Analysis of Retained Alternatives

Section 8 Comparative Analysis of Retained Alternatives

Section 9 References

9.0 COMMUNITY RELATIONS

As required by Section IX of the AOC, A Community Involvement Plan (CIP) 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 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. A summary of the work products that will be submitted also is included in the schedule. Agency review periods were estimated, and other durations not specified in the AOC have been assumed. The schedule is subject to change and may need to be updated periodically depending on field conditions and the actual progress of each scheduled activity.

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