

ASARCO EL PASO COPPER SMELTER REMEDIAL INVESTIGATION REPORT EL PASO, TEXAS

Prepared For:

ASARCO

2301 West Paisano Drive
El Paso, Texas 79922

Prepared By:



Hydrometrics, Inc.[®]
consulting scientists, engineers and contractors



**VOLUME
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October 1998



Cast# 202

**El Paso Plant
Amarillo Copper Refinery**

October 9, 1998

Thomas E. Martin
Environmental Manager

HAND DELIVERED

Executive Director
C/O John L. Sadlier
Enforcement Division
Texas Natural Resource Conservation Commission
Austin, TX 78753

**Re: Remedial Investigation Report Submittal
ASARCO Incorporated
El Paso Plant
Docket No. 96-0212-MLM-E; SWR No. 31235; Permit No. WQ 02321
Agreed Order**

Dear Mr. Sadlier:

As required by Ordering Provision No. 6 of the above referenced Agreed Order, enclosed are two copies of the Remedial Investigation Report for the El Paso Plant of ASARCO Incorporated (Asarco). This report was prepared by Hydrometrics, Incorporated, Asarco's contractor on this project.

Do not hesitate to contact me at the number below if you have any questions regarding this report.

Sincerely,

Thomas E. Martin

Cc: Frank Espino, TNRCC Region 6, El Paso
Donald Robbins, Asarco, Salt Lake City
R. Keith Hopson, Brown McCarroll & Oaks Hartline, Austin
Kent Lang, Hydrometrics, Tucson
Lairy Johnson, Hydrometrics, El Paso

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REMEDIAL INVESTIGATION REPORT
EL PASO, TEXAS**

Prepared for:

ASARCO Incorporated
2301 West Paisano Drive
El Paso, Texas 79922

Prepared by:

Hydrometrics, Inc.

3275 W. Ina Road
Suite 205
Tucson, AZ 85741

2301 W. Paisano Dr.
El Paso, TX 79922

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**ASARCO EL PASO COPPER SMELTER
REMEDIAL INVESTIGATION REPORT
EL PASO, TEXAS**

1.0 INTRODUCTION

The Texas Natural Resource Conservation Commission (TNRCC) conducted a compliance inspection at the ASARCO Incorporated (Asarco) El Paso Copper Smelter in the City of El Paso, El Paso County, Texas from May 31 through June 13, 1994 (Figure 1-1). TNRCC subsequently sampled soil, surface water and groundwater on January 12 and 13, 1995 as a follow-up to the inspection. During these events, the TNRCC documented unauthorized discharges of industrial solid waste, wastewater, and stormwater. Based on the results of the 1994 and 1995 multimedia inspection and sampling events, the TNRCC issued Asarco an Agreed Order (Docket No. 96-0212-MLM-E) effective August 29, 1996, which requires a remedial investigation of the facility (TNRCC, 1996).

The Agreed Order required that the remedial investigation (RI) be performed to characterize the environment (soil, surface water and groundwater) in and around the Asarco El Paso Copper Smelter (herein referred to as the Plant), and to determine the nature and extent of potential releases of constituents of concern (COCs) to the environment. In November 1996, Asarco prepared and submitted to the TNRCC a Remedial Investigation Work Plan (Hydrometrics, 1996). The Remedial Investigation Work Plan provides a detailed plan for completing the RI, and to provide the necessary data for compliance with TNRCC requirements presented in the Texas Administrative Code, Title 30, Chapter 335, Subchapter S, Risk Reduction Standards. The general RI technical approach taken to meet TNRCC Risk Reduction Standards includes the following elements:

- Identification of contaminant sources
- Identification of potential contaminant pathways and receptors
- Evaluation of risk-based critical values (risk reduction standards)
- Assessment of the exposure of human and environmental receptors to contaminants
- Recommendations for corrective action to achieve risk reduction standards

In the absence of specific TNRCC guidance regarding RI work plan preparation, the Work Plan was prepared in general accordance with the United States Environmental Protection Agency (EPA) guidance for RI work plans contained in the Resource Conservation and Recovery Act (RCRA) Corrective Action Plan (EPA, 1994a). Other supporting guidance documents included Guidance for the Data Quality Objectives Process (EPA, 1994b), and EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations (EPA, 1994c).

The remedial investigation summarized in this report was conducted from February 1997 through June 1998 and includes four quarterly monitoring events for surface water and groundwater. This report contains the results of the RI and presents a General Proposal for Corrective Action.

1.1 REMEDIAL INVESTIGATION REPORT ORGANIZATION

The results of the remedial investigation are presented in the following sections:

- **Section 1.0:** Presents the history of the plant, environmental setting, summary of previous investigations, remedial investigation objectives, and organization of the report.
- **Section 2.0:** Presents the results of the remedial investigation in terms of the distribution, fate, and transport of constituents of concern (COCs) in soil, surface water, and groundwater in and around the study area.

- **Section 3.0:** Discusses the relationship between smelter operations and potential contaminant source areas and contaminant source materials. Source materials are characterized according to concentrations of COCs and volume of impacted material, visual characteristics, observed or potential impacts to surface water and groundwater, and potential concern for exposure scenarios.
- **Section 4.0:** Presents a general proposal for corrective action and includes the results of the risk based assessment, an overview of corrective action processes and alternatives, selected corrective action alternatives and associated costs estimates, and a schedule to assure appropriate remediation in compliance with Texas Administrative Code, Title 30, Chapter 335, Subchapter S, Risk Reduction Standards.
- **Section 5.0:** Presents conclusions based upon the information gathered during the investigation.
- **Section 6.0:** Lists the references cited in the report.

1.2 FACILITY DESCRIPTION AND BACKGROUND INFORMATION

1.2.1 Plant Location and Property Boundaries

The Asarco El Paso Copper Smelter is located within the city limits of El Paso, Texas (Figure 1-1). As previously noted, throughout this document, the Asarco El Paso Copper Smelter is also referred to as the Plant. The Plant occupies 64 acres bounded by U.S. Interstate Highway 10 to the east and U.S. Highway 85 (Paisano Drive) to the west.

1.2.2 Plant History

The Plant began operations in 1887 as a lead smelter with an initial daily capacity of 150 tons of ore. The smelter was originally owned by the Consolidated Kansas City Smelting and Refining Company. Asarco was formed in 1899 and this Plant was one of the original plants brought into the new company along with several other smelting and refining facilities. The original process for smelting involved roasting the ore in heaps, then in hand-reverberatory roasters. Ore used for smelting originated primarily from mines in Northern Mexico, Arizona and New Mexico.

After a fire nearly destroyed the facility, it was rebuilt in 1902 with the capacity for smelting lead. Copper production began in 1910 with the smelting of concentrates. The matte produced by this process was transported to a smelter for converting. Due to internal problems in Mexico during this period, the amount of lead ore received declined significantly, and copper became the predominant product of the smelter.

In 1914, the El Paso Smelter was expanded to process 278 tons/day of lead ore. In 1928, lead production was approximately 400 tons/day, and copper production was 150 tons/day. In the 1930s, the plant added a Godfrey roaster for cadmium oxide production.

In 1948, a blast furnace slag fuming plant for zinc recovery was constructed. In the late 1970s, an antimony plant was completed, as well as a sinter plant with unloading and bedding systems.

The zinc-fuming furnace was closed by 1982. In 1985, the lead plant was closed and has been remodeled as a Mobile Equipment Shop and Storage/Pilot Plant. The cadmium plant was shut down in 1992. The antimony plant was operated until 1986, and has not been operated since. These closed facilities are in various states of demolition and/or remodeling.

Currently, the Plant is a primary copper smelter that produces about 140,000 tons/year of copper. The copper is processed from approximately 415,000 tons/year of copper concentrate (concentrate) and 18,000 tons/year of copper scrap. Raw materials include copper concentrate, silica sand, rock, limerock, copper scrap, pig iron, blister copper and speiss (a byproduct). Other materials used include lubricating oils and greases, and cooling tower and boiler treatment chemicals. A concentrate auger, two CONTOP flash-smelting reactors and a holding furnace replaced a reverberatory furnace and two wedge roasters in 1993.

A new wastewater treatment system (part of CONTOP project) was built and started in 1992. The system includes a 150 gallons-per-minute (gpm) lime precipitation plant for metals, a

vapor compressor and a spray dryer. The effluent is used as boiler and cooling tower makeup. The sludge from the lime settle Waste Treatment Plant is recycled in the process for its metals. The solids from the stormwater are disposed of off-site as hazardous waste (Dames and Moore, 1996). A new stormwater control system has been designed and is scheduled for construction beginning in late 1998 (Dames & Moore, 1998). No process water is discharged from the site.

Table 1-1 presents a summary of the Plant history.

1.2.3 Current Operations

Asarco's El Paso Plant processes copper concentrates and other copper and precious metal bearing materials into 99.0 percent pure copper, sulfuric acid, and various by-products. The Plant receives over 35 thousand tons each month of concentrates, by-products, scrap copper and flux for processing by rail car and truck. The copper concentrates come primarily from Asarco's mines in Arizona and Montana. This section of the report provides a summary description of the Plant's current operations. Operations are divided into six sub-operations as follows:

- Unloading and Bedding
- Copper Smelting
- Copper Converting
- Anode Casting
- Sulfuric Acid Plants
- Water Treatment.

A Plant operations process diagram is in Figure 1-2.

1.2.3.1 Unloading and Bedding

Before unloading concentrates, workers take samples from each rail car using a large metal auger to recover material from throughout the depth of the load. The samples are bagged, labeled and analyzed for moisture and metal content. After weighing each car the material is unloaded in a covered building by bridge cranes, or through use of bottom dump cars. The unloading building was placed in service in 1979 and consists of two bays, each 40 feet wide and 225 feet long. Material is loaded into six, 30-ton hoppers that are ventilated by a 28,500 CFM dust collection system. The hoppers feed a series of belts that transport the concentrates, along with silica fluxes and recycled material, to the bedding building where these materials are blended into a mix. The bedding building contains 14, forty-foot wide bins, ten of which are 180 feet long and four of which are 160 feet long. It spans an area equal to three football fields in size, with a capacity of 80 thousand tons of material.

1.2.3.2 Copper Smelting

Copper smelting removes iron, sulfur and other impurities, thus purifying the copper. Raw copper concentrate mixes are transferred from the storage building beds via conveyor belts to a fluidized bed dryer, then pneumatically conveyed into the two CONTOP cyclone "reactors." These cyclone reactors, each 21 feet high and 7 1/2 feet in diameter, flash smelt the concentrates into a "molten rain" of 60 percent copper matte and slag. "Tuyeres," or tubes placed at tangent angles to the circumference of the reactor side near the top of the CONTOP vessels, create cyclonic action inside the vessel when pure oxygen, natural gas and copper concentrates are blown in, instantly igniting at 2500 degrees Fahrenheit. The cyclonic action provides improved mixing of reaction components, thus enhancing the flash smelting method for producing copper and separating by-products. During the smelting process, the sulfur dioxide (SO₂) is captured and diverted to one of two acid plants that convert the SO₂ to sulfuric acid. The molten rain of matte and slag falls into a holding furnace where it separates into two layers. "Matte," a copper-rich layer, settles to the bottom and is "tapped" from holes located on the sides of the settling furnace. "Slag," containing silica and iron, floats to the top and is skimmed off to a large ladle holding about 45 tons of molten slag. The slag is trucked to the slag dump by a specially designed diesel powered "Kress Slag

Hauler." Once cooled, the slag, is mined by Parker Brothers Company and processed into railroad ballast, sand blasting media, and asphalt aggregate. The slag produced at the smelter is inert, does not leach harmful substances, and poses no threat to human or animal life, or the environment.

1.2.3.3 Copper Converting

The molten copper matte tapped from the holding furnace is transported in 200 cubic foot ladles by 60-ton overhead cranes to Pierce-Smith copper converters. There are three converters, each 13 feet in diameter, two 35 feet in length, and one 30 feet long. They convert the 60 percent copper matte to 99 percent "blister copper." Each converter produces 90-100 tons of blister copper per cycle. The converter aisle is serviced by three, 60-ton capacity, 90-foot-wide overhead bridge cranes.

Converting takes place in two phases. Phase one is the slag blow to remove the iron in the matte. Oxygen enriched air is blown directly into the molten mass and silica is added to form an iron silicate slag. Sulfur is eliminated during this phase as well.

Slag is "skimmed" or poured from the converter leaving a product known as "white metal," a copper sulfide containing about 75 percent copper.

Phase two is the copper blow to remove all the remaining sulfur. As this is an exothermic reaction, scrap copper is added to control the bath temperature as air, again blown directly into the molten mass, oxidizes the sulfur, forming sulfur dioxide gas that reports to the acid plants. The resulting blister copper is transported to one of the plant's two anode furnaces for oxygen removal and casting.

Converter off-gases pass through the primary hood, then through two high velocity flues, the hot gas fan, a spray chamber for conditioning, a plate and wire electrostatic precipitator, then on to the gas cleaning section of the acid plants. Automatic controls maintain the draft and flow on the converter gas handling system. Gas escaping the primary hoods is captured by

the secondary hoods. The entire converter building is enclosed and ventilated. Converter building and secondary hood ventilation passes through a 500,000 CFM Wheelabrator baghouse and up the 828 foot stack.

1.2.3.4 Anode Casting

Anode casting is the final step in the copper smelting process at the Plant. Capacity of each anode furnace is 150 tons of blister copper. The furnaces are 30 feet long and 11 feet in diameter. Reformed natural gas is blown into the molten copper in the furnace to remove dissolved oxygen. This takes two to four hours. The approximately 99 percent pure copper is then cast into anodes. The anode furnaces are tilted to pour the molten copper into molds on a 22 mold casting wheel. Cast anodes solidify and are lifted by a half-ton crane out of the molds and into a "Bosh" half-ton crane out of the molds and into a "Bosh" tank to cool. About 350 tons of anodes are cast per day.

The cooled anodes are inspected, assigned a lot number, and shipped to the Amarillo, Texas, refinery. In the refinery, the copper then goes through an electrowinning process that produces 99.9 percent pure copper – for use as wire tubing and other products. The impurities removed during the electrowinning are recovered as refined gold and silver, along with selenium, tellurium, and nickel products.

1.2.3.5 Sulfuric Acid Plants

Sulfur dioxide generated from the smelting and converting process is converted to sulfuric acid in the acid plants. Acid plant No. 1 was completed in 1972 and utilizes the double absorption process. The plant has a nominal capacity of 550 short tons per day. Acid plant No. 2, also a double absorption plant, was built in 1978. This plant has a capacity of 750 short tons per day of 100 percent equivalent sulfuric acid. Presently over 97 percent of the sulfur input to the plant is captured and converted into sulfuric acid. With the installation of CONTOP technology, almost no sulfur dioxide escapes the system. Since installing CONTOP, the smelter's 828-foot stack no longer emits any process gases, only baghouse

cleaned ventilation air. This is a significant improvement over an older reverberatory furnace operation.

1.2.3.6 Water Treatment

The water treatment plant handles water from the gas-cleaning scrubbers in the acid plant and removes all metals from the water for reuse. This very high quality water is used as boiler make-up water at the powerhouse. The powerhouse uses the steam created by the CONTOP waste heat boilers to produce electricity and 15-psi air for the converters.

1.2.4 Adjacent Land Use

Land use adjacent to the El Paso Smelter consists of commercial, industrial, manufacturing and residential. Figure 1-3 shows land use adjacent to the project area. To the north of the facility is the small residential community of La Calavera. Immediately to the north of the La Calavera community is a Portland Cement distribution facility and associated quarries. Within one of the historic quarries is the El Paso Water Utilities Water Treatment Plant. To the northwest of the smelter and on the west side of the Rio Grande is one U.S. and one Mexican brick manufacturer, and a former site of a petroleum refinery.

Asarco owns vacant land located east of the facility. East of this property are a number of El Paso commercial properties along Mesa Street (Highway 20). East of the Mesa Street commercial area is a residential area, and to the southeast of the Plant is the University of Texas at El Paso (on land donated by Asarco). South and west of the plant is the Rio Grande, which serves as the international border between the United States and Mexico.

A survey of public records at the Texas Water Development Board (TWDB) and TNRCC was conducted to identify water supply and monitor wells in the vicinity of the Plant. Twenty-five Texas wells were identified within a one-half mile radius of the Plant, and State of Texas well reports were obtained if available. Nearby wells included water supply wells at the University of Texas at El Paso, monitor wells operated by the International Boundary Water Commission (IBWC), monitor wells at the Thunderbird Service Station and several

private domestic wells. The closest domestic well (TWDB number 49-12-6A) is located at 420 Clayton Road, which is about one-half mile north of the Plant and upgradient of the Plant. The State of Texas Water Well Report indicates that the 68-foot deep well is used for domestic and irrigation purposes. The well was drilled in 1975. Information gathered during the well survey is presented in Appendix L.

1.2.5 Facility Permits and Solid Waste Management Units

The Asarco El Paso Smelter operates under five facility permits issued by the TNRCC and the EPA. These permits are listed in Table 1-2. Certain materials and wastes are managed within active Solid Waste Management Units (SWMUs) in accordance with TNRCC Notice of Registration Number 31235 and were not included as part of the remedial investigation. The Asarco El Paso Facility SWMUs are listed in Table 1-3.

1.3 ENVIRONMENTAL SETTING

The following sections provide information regarding the climate, geology, hydrogeology, and surface water hydrology of the Asarco El Paso Copper Smelter and the surrounding area. This information in combination with data collected as part of the RI are used to develop a general understanding of contaminant fate and transport discussed in Section 2.0 of this report.

1.3.1 Climate

The City of El Paso is located in far west Texas with a landscape ranging in elevation from 3600 feet above mean sea level (msl) on a floodplain to greater than 7,000 feet msl in mountainous terrain. The area climate is considered arid and consists of very low relative humidity, low precipitation, hot summers and mild winters. The type of vegetation in the area is dependent on the location relative to the Rio Grande. In the floodplain area of the river, the vegetation consists of shrubs and trees due to the greater amount of available groundwater. Vegetation in the higher elevations consists of plants typically found in the Chihuahuan Desert.

Spring is the windiest time of the year, creating frequent sand and dust storms. The seasonal wind directions are characterized as being from the south-southeast during June through October, and from the northwest during November through May. A wind rose plot for the Asarco facility is shown in Figure 1-4. The average growing season is approximately 248 days in the El Paso area, from March 9 to November 12. This period is based on the first and last average dates for freezing temperatures during the year (Jaco, 1971). The annual lake evaporation for the area is estimated to be 72 inches/year. Pan evaporation tests indicate evaporation rates greater than 100 inches/year. Annually, El Paso is reported to receive 83 percent of the total possible sunshine (Jaco, 1971).

Average monthly temperatures and precipitation are shown in Figures 1-5 and 1-6, respectively. Precipitation averages about 8 inches annually, with 75 percent of this precipitation occurring between April and September (Jaco, 1971). Records show a high variation in annual precipitation ranging from a maximum of nearly 18 inches to less than 2.2 inches (Jaco, 1971). The majority of the precipitation comes in the form of intense storms resulting in high precipitation rates over relatively short time intervals. Total rainfall at the Plant between January 1997 and June 1998 was 14.01 inches.

1.3.2 Geology and Physiography

The Plant is located in El Paso County within the Rio Grande Valley floodplain at an elevation approximately 3,600 feet mean sea level (msl) (Figure 1-7 and Figure 1-7a). The major physiographic features in the El Paso area are the following (Figure 1-8):

- The floodplain of the Rio Grande, at an elevation of approximately 3,600 feet mean sea level (msl).
- An old lakebed located in the northeastern portion of the El Paso area, roughly parallel to the floodplain of the Rio Grande.
- The Hueco Bolson, located to the east of the Franklin Mountains.

- The Franklin Mountains, on the west side of El Paso County at elevations in the vicinity of 7,000 feet msl.
- The Hueco Mountains, on the east side of El Paso County at elevations in the vicinity of 5,500 feet msl.

Geologically, El Paso County lies within the Basin and Range Province of West Texas. The surficial geology of the region is controlled by three mountain ranges (the Franklin Mountains, the Hueco Mountains and the Sierra Juarez Range) and the Rio Grande Rift. The geologic descriptions are based upon published geologic reports of the area (King et al, 1971 and Lovejoy, 1976).

The Franklin Mountains are a tilted block of approximately 2,000 feet of bedded limestone, which strikes north south and dips to the west at about 30 degrees. The beds range in age from about 135 million to 600 million years and are underlain by a Pre-Cambrian crystalline basement of igneous and metamorphic bedrock.

The Hueco Mountains are approximately 30 miles to the east of the Franklin Mountains and mark the eastern boundary of the Basin and Range Province. They are a fault block mountain range and contain limestone beds that correlate to those observed in the Franklin Mountains.

The path of the Rio Grande in this region corresponds to the north-south trend of the extensional Rio Grande Rift. The rift separates the Franklin Mountains from the Sierra Juarez to the south. The rift valley is composed of river sediments and alluvial debris that has eroded from the western slope of the Franklin Mountains.

The Sierra Juarez Mountains are located to the south of Ciudad Juarez, Chihuahua, Mexico. They are severely thrust faulted and are thought to have been tectonically transported eastward to their present position. There is no stratigraphic correlation between the Franklin Mountains and the Sierra Juarez.

Geology of the Plant area consists of a mix of colluvial and fluvial sediments. The colluvial sediments are generated by 1) the erosion of a laccolith which is locally known as the "Campus Andesite" (Figure 1-7) and 2) the erosion of the Franklin Mountains. The erosional sediments are laid to the west and mixed with the fluvial sediments of the Rio Grande.

1.3.3 Hydrogeology

The two major aquifers of the region are the Hueco Bolson aquifer, east of the Franklin Mountains, and the Mesilla Bolson aquifer, west of the Franklin Mountains. The Mesilla Bolson underlies the Rio Grande Rift and the river valley. Most of the Mesilla Bolson is in the state of New Mexico, with only the western valley of El Paso County drawing water from the aquifer.

The Hueco Bolson is the principal aquifer for the El Paso area. Structurally, it is a basin created by the down-dropped block between the Franklin Mountains and the Hueco Mountains and subsequently filled with lacustrine and fluvial deposits. The basin underlies 70 percent of El Paso County and extends several miles into Mexico. The deepest part of the basin underlies the El Paso International Airport and consists of nearly 10,000 feet of sediments before bedrock is encountered.

The Hueco Bolson provides over two-thirds of the municipal water used in the El Paso region with the balance coming from the Rio Grande. The aquifer extends into Mexico and is also an important source of drinking water for Ciudad Juarez, Mexico.

Groundwater in the Hueco Bolson occurs in both the fluvial deposits and the underlying lacustrine deposits. The primary source of drinking water for the region is extracted from the poorly sorted, irregularly stratified fluvial deposits, which outcrop over most of east El Paso and range from 400 to 1300 feet thick. The deposits consist of unconsolidated sand lenses alternating with gravel, silt, and clay.

1.3.4 Surface Water Hydrology

There are two surface water bodies to the west of the Facility: 1) the Rio Grande, and 2) the American Canal, a canal used by the United States to remove its allotment of water from the Rio Grande. The canal is concrete-lined to reduce the amount of leakage into the subsurface. Local groundwater elevations fluctuate in conjunction with the amount of water in the Rio Grande. Such fluctuations are a result of seasonal releases of water from Elephant Butte Dam, near Truth or Consequences, New Mexico, which is approximately 100 miles north of El Paso. In the spring, water is released for irrigation purposes, and in the fall the amount of water released is restricted to conserve the water over the winter months.

There is minimal recharge into the aquifers from rain events. Many of the ephemeral drainages (locally known as "arroyos") are generally dry except during or immediately following precipitation/snow melt.

1.4 SUMMARY OF PREVIOUS INVESTIGATIONS

Previous environmental investigations have been completed at the Facility related to diesel fuel releases and the Plant ponds. A summary timeline of milestones related to the operation of the facility and important environmental actions and reports is in Table 1-1.

1.4.1 History of Process Pond Investigations

Three water ponds (Ponds 1, 5 and 6) are located at the Plant. To date, the water in Pond 6 has been used primarily for general supply, stormwater collection, anode cooling and fire water supply. Pond 5 (which is now dry) was used for boiler feed backup and some stormwater collection. Stormwater collection is the primary function of Pond 1. This water is not used in any process. Water in the ponds has exhibited elevated metal ion concentrations; therefore, the Texas Water Commission (TWC, formerly the Texas Department of Water Resources and now known as TNRCC) previously expressed concern that water contained in ponds No. 1, No. 5 and No. 6 may infiltrate and impact the underlying groundwater system. On August 21, 1985, a Compliance Agreement between Asarco and the TWC was prepared to investigate the potential for subsurface contamination caused by potential leakage from the ponds.

Reports entitled "Regional and Local Hydrogeology at the El Paso Plant - September 27, 1985" and "Liner Investigation - Asarco, Inc., El Paso Plant - November 15, 1985" were prepared by Hydro-Search, Inc. in partial fulfillment of the Compliance Agreement between Asarco and the TWC. A report entitled "Groundwater Monitoring Plan, Asarco, Inc., El Paso Plant - October 10, 1985" was prepared by Hydro-Search, Inc. in order to fulfill requirements of the Compliance Agreement.

In a letter dated December 20, 1989, the TWC provided comments concerning Asarco's October 10, 1985, monitoring plan. In a letter dated February 8, 1990, Asarco provided responses to the TWC's comments. On March 14, 1990, the TWC provided Asarco with "Notice to Proceed" to begin monitoring activities.

On May 2, 1990, Hydrometrics initiated groundwater monitoring activities, which included the installation of nine monitor wells, EM-1 through EM-8, and EP-12 (Exhibit 1). Monitor well installations were completed in May, 1990, and the monitor wells were developed and sampled immediately following installation. The first official quarterly groundwater monitoring event was conducted during the period of August 4 to August 6, 1990. Groundwater sampling has continued on a quarterly basis.

Results of these investigations identified elevated concentrations of arsenic, cadmium, manganese and selenium in groundwater in several wells. Free-phase hydrocarbons observed in several monitor wells associated with the diesel releases were sampled and analyzed for metals, but none were detected.

Additionally, for soil classification purposes, split-spoon soil samples were collected at five-foot intervals during monitor well installation, and selected samples from wells EM-2 and EM-7 (Exhibit 1) were submitted for laboratory EP Toxicity metals analyses. Results for well EM-2 did not indicate the presence of metal concentrations above the laboratory

detection limits. Results for well EM-7 showed detectable levels of cadmium (0.8 mg/kg) and lead (4.0 mg/kg) only.

In March 1998, Asarco requested that the 1985 Compliance Agreement be terminated because the ponds were included in the August 1996 Agreed Order. TNRCC concurred, and the 1985 Compliance Agreement was terminated in April 1998. In June 1998, Asarco removed all sources of new water to Ponds 1 and 5, and allowed the standing water in the ponds to evaporate.

1.4.2 History of Diesel Spill Investigations

Two separate areas of diesel contamination have been identified at the Plant, as described below. The Diesel No. 1 and No. 2 investigation areas are identified in Figure 1-9.

Diesel Investigation No. 1

On February 7, 1990, International Boundary and Water Commission (IBWC) workers noticed petroleum hydrocarbons seeping into the American Canal just below the El Paso Smelter (Figure 1-8). Petroleum hydrocarbons were seeping through expansion joints and weep holes in the east concrete wall of the American Canal approximately 350 feet west of three large diesel fuel storage tanks located on plant grounds. Hydrocarbon seepage was observed entering the canal at several locations over an approximately 1,000-foot-long section of the canal. On February 7, 1990, Asarco requested that Hydrometrics conduct an investigation (Diesel Investigation No. 1) to determine whether the hydrocarbon seepage was originating from Asarco facilities. Asarco also contracted with Raba-Kistner Consultants and Applied Earth Sciences (AES) to provide assistance with this investigation.

Details of Diesel Investigation No. 1 activities are contained in previous Hydrometrics reports (1990a, 1990b and 1993). Investigation activities included installation and sampling of monitor wells, installation of continuous groundwater and hydrocarbon pumping and treating systems, hydrocarbon removal from the American Canal, surface water sampling in the American Canal and in the Rio Grande, and excavation and removal of contaminated soils. During February,

March, and April 1992 a hydrocarbon recovery system consisting of 21 wells was installed. Approximately 50 percent of the diesel spill volume has been recovered, and recovery operations are ongoing. Currently, the remediation system consists of a total of 36 monitor and/or recovery wells. Affected groundwater is pumped continuously from the spill area and processed by gravity separation in a tank. Diesel fuel separated from groundwater is stored in a tank. Volatile organics are removed from groundwater by an air stripper, and the treated groundwater is pumped into one of the original on-site 500,000 gallon aboveground storage tanks, which has been converted from diesel storage to water storage. The water is added as plant makeup water for process operations.

The remediation system has been in continuous operation since 1992. Approximately 22,000 gallons of the estimated 40,000 gallons of released diesel have been recovered and 7,500,000 gallons of diesel-affected groundwater treated. The system has prevented additional impacts on the surface waters of the American Canal.

The trend for this site has been a steady reduction of product thickness in the project monitor/recovery wells. The most current event (August 1998) indicated product thickness ranging from a sheen to 0.1 feet. Measurable thickness was encountered in only one recovery well (EP-19) during the August 1998 sampling event.

A plan "A" Risk-based Assessment for this site, prepared by Hydrometrics, Inc., was submitted to and accepted by the TNRCC in April 1997 (Hydrometrics, 1997b). According to the risk-based assessment, levels of constituents of concern were below established cleanup goals, and closure for the site could be requested upon attaining measurable thickness of diesel of less than 0.1 feet for the project site.

In line with the risk-based assessment, Hydrometrics proposes to discontinue recovery activities when diesel thicknesses become less than 0.1 feet. The groundwater pumping equipment will be removed from these locations for assessment, cleaning and repair (if necessary). Recovery well locations that are discontinued will be monitored daily during the workweek for the

occurrence of free product. The schedule is estimated as 4 weeks of daily monitoring, if no reoccurrence of diesel is measured, the schedule will then be weekly.

If the product thickness level at any particular recovery/monitor well location increases to 0.1 feet or greater, a recovery pump will be reinstalled and recovery operation at that location resumed. The recovery system will be operated until the next quarterly sampling event. Additional product thickness information will be reviewed and used to determine the status of recovery operations at that location, using the guidelines previously discussed.

When all recovery/monitor well locations continuously sustain product thickness levels of less than 0.1 feet for a period of six months, closure from the TNRCC will be sought, as outlined in the Diesel No. 1 Risk-based Site Assessment.

Diesel Investigation No. 2

On March 30, 1990, Hydrometrics, Inc. began investigation activities (Diesel Investigation No. 2) of an 18,000-gallon aboveground diesel storage tank, which was suspected of having a release of hydrocarbons, located near the former zinc fuming plant. The release was suspected to occur in the twenty feet of underground piping that connects the aboveground tank to a dispenser pump. A backhoe pit was excavated (March 30, 1990) adjacent to the underground piping to evaluate for potential leaks. Visible diesel staining was observed within the backhoe pit adjacent to the piping. The tank and all associated piping have been dismantled and removed from the facility.

On May 21, 1990, Hydrometrics, Inc. installed monitor well EP-21 (see Exhibit 1) adjacent to the 18,000 gallon diesel storage tank. Several hundredths of a foot of phase-separated hydrocarbons were encountered in this monitor well. During the period of August 6 to August 9, 1990, Hydrometrics installed six additional monitor wells, EP-22 through EP-27 (see Exhibit 1), to help determine the extent of diesel contamination from the 18,000 gallon tank. Only one of these additional wells, EP-25, contained phase-separated hydrocarbons. Several

other monitor wells (EP-49, EP-51, EP-52, EP-54 and EP-55) were installed to assess the plume extent.

During sampling activities in July 1993, phase-separated hydrocarbons were encountered in the downgradient monitor well EP-49.

During January 1994 Hydrometrics, Inc. installed eleven additional monitor wells to further delineate the Diesel No. 2 hydrocarbon plume in reaction to the occurrence of phase-separated hydrocarbons in well EP-49. Three of these monitor wells were installed at the Plant in the vicinity of the acid plant. One monitor well (EP-56) is located adjacent to the abandoned monitor well EP-52; one (EP-55) is near the acid plant stack; and one (EP-54) is at the plant fence, approximately 100 feet north of EP-49. The remaining eight monitor wells were installed in the old Smelertown area just west of the Plant and along the west side of Paisano Drive. These wells were designated EP-57 through EP-64 (Exhibit 1). After wells EP-57 through EP-64 were installed, the plume was observed to have impacted monitor wells EP-57 and EP-58.

During the period of March through June of 1994, Hydrometrics, Inc. designed and installed a product recovery trench, an air sparge and soil vapor extraction (SVE) trench, and associated mechanical equipment to help contain and remove diesel fuel from the area of the former Smelertown. The product recovery trench was placed just ahead of the leading edge of the phase-separated hydrocarbon plume to allow liquid-phase hydrocarbons to migrate into the recovery trench. The air sparge/SVE trench was placed downgradient of the dissolved hydrocarbon plume to provide the final removal of any dissolved hydrocarbons prior to groundwater entering the American Canal. This recovery system is currently operating.

During November and December 1997, in which work was conducted to evaluate the best remediation technology for the site. The study recommended a Dual-Phase Extraction system to recover the remaining product and remediate the affected soils in the Smelertown portion of the product plume. Dual-phase recovery is extremely well suited for recovery of free product

and to address bound fuel in soils that may contribute to the free product and dissolved-phase plume during water elevation fluctuations. Dual-phase recovery creates a pressure gradient that forces groundwater to flow into the recovery well (area of least pressure).

Vacuum recovery wells composed of vertical wells spaced throughout the affected plume footprint will allow the entire plume area for Phase I (Smelertown) to be addressed quickly. Vacuum recovery wells will be located in the field as follows:

1. A main header line will be established perpendicular to and in the approximate center of the product plume.
2. Individual vacuum recovery wells will be established from the central header to the 50-foot centers to the general extents of the product plume. The wells will header on 50-foot center to the general extents of the product plume in a rosette pattern.
3. The wells will terminate once unaffected soils are encountered in the field drilling activities. Wells will be installed to the anticipated water table depth, which will allow for the smear zone remediation during low water table periods.

The upgradient barrier will prevent the recharge of the Smelertown area product plume and prevent continued contamination of this area once it has been remediated. The upgradient barrier well(s) will be installed in the vicinity of monitor wells EP-19 and EP-54. Wells will be constructed with PVC casing and screened over the entire interval in which product may be expected. Downhole pneumatic recovery pumps will be used to remove product and create a hydraulic barrier to prevent further downgradient travel towards Smelertown.

Operation and maintenance of the downhole pneumatic system will be required in order to make adjustments for maximum effectiveness during groundwater elevation fluctuations. System protocol requires the operator to adjust the suction tube height and vacuum pressure to maximize product recovery while recovering as little water as possible.

A transmission waterline will be installed to discharge collected water (after primary treatment on the Smelertown site) from the recovery system to either the Plant water treatment system or the Diesel No. 1 remediation site for use as makeup water. Preliminary water quality data, and criteria established by plant personnel, indicate that recovered water can likely be discharged directly to the Plant's makeup water system without further treatment.

Primary treatment will be performed at Smelertown with a coalescing filter (depending on oil/water quality information to be gathered when the recovery system is operating on a mass scale) and an oil/water separator. These units are designed to process up to 15 gpm of total recovered fluids. It is anticipated that, under typical operating conditions, about five gpm will be discharged to the plant makeup water stream.

The system is anticipated to be unobtrusive. Equipment will be housed in a fenced enclosure adjacent to the existing equipment building constructed during Phase II. The privacy fence will be slatted to obstruct the system and ancillary equipment from public view. Wellheads will be secured and protected with steel casing, and vacuum/water pipelines will be buried.

1.5 INVESTIGATION AREAS

As part of the Agreed Order, specific areas on the facility were designated by the TNRCC as areas of concern based on historical and current operations and on the results of the 1994 and 1995 multimedia inspection and sampling events. These areas of concern are identified in the Remedial Investigation Work Plan as Investigation Areas. Investigation Areas are indicated in Exhibit 1. Table 1-4 provides a general description of the Investigation Areas.

The 1996 TNRCC Agreed Order indicated that evaluations of closed plant areas would be considered separately from the Remedial Investigation. The following plants at the site that have been closed: the lead plant, the cadmium plant, the zinc plant, the antimony plant and former copper plant operations (wedge roaster, reverberatory furnace and brick flues). Most of these plants and the related facilities have already been demolished. Closed Plant Evaluation Plans will be prepared for each area to summarize closure actions and outline

field sampling programs. Though these plans have not been submitted to the TNRCC yet, aspects of the field sampling programs will overlap the proposed Corrective Action Plan presented in this RI report.

The 1996 Agreed also specifically excluded the two ongoing diesel remedial programs (Diesel No. 1 and 2 investigation areas), although information gathered from boreholes and wells installed as part of the diesel remedial programs have been used for this RI report.

1.6 EXISTING OR POTENTIAL WASTE CONSTITUENTS

The elements of concern for soil and water are specified in the Agreed Order and in the Remedial Investigation Work Plan. These elements are referred to as Constituents of Concern (COCs) throughout this report and include the following:

- arsenic (As)
- cadmium (Cd)
- chromium (Cr)
- copper (Cu)
- iron (Fe)
- lead (Pb)
- selenium (Se)
- zinc (Zn)

Additional parameters of concern in groundwater include:

- pH
- specific conductivity (SC)
- total dissolved solids (TDS)

Additional waste constituents in soils and groundwater at the facility include organic chemicals associated with diesel fuel. The characterization of these constituents and corrective actions are being addressed through other environmental programs.

1.7 REMEDIAL INVESTIGATION WORK PLAN TASKS

The tasks outlined in the Remedial Investigation Work Plan were developed to identify contamination source areas, groundwater flow pathways, and the vertical and horizontal extents of constituents of concern. Proposed fieldwork included the following:

- Soil and groundwater sampling at the Converter Building Ventilation Baghouse.
- Soil and groundwater sampling at the Boneyard/Slag Area.
- Surface water sampling of ponded area in Slag Area.
- Soil and groundwater sampling at Acid Plants 1 and 2.
- Soil and groundwater sampling at the Front Slope Area.
- Soil and groundwater sampling in Smelertown.
- Soil and groundwater sampling in areas outside of originally identified contaminant source areas, including potential background areas.
- Surface water sampling in the Rio Grande and American Canal.
- Soil sampling of the Bedding and Unloading Plants.
- Soil sampling of the Plant entrance.

Sampling and analysis procedures were described in the RI Work Plan and are not reproduced for this document. Descriptions of sampling and analysis protocols included the following:

- Sampling equipment and techniques.
- Procedures for taking measurements of water level elevations in the monitor wells.
- Procedures for detecting any phase-separated liquids and their thickness, if present.
- Well evacuation procedures, including purged water or water quality prior to sampling and handling.
- Sampling and analysis protocol for field measurements.
- Procedures for decontaminating sampling equipment between sampling events.
- Disposal of field-generated waste.
- Sample handling and preservation techniques, including chain of custody documentation.
- Sampling quality assurance/quality control (QA/QC) procedures.

Samples were submitted primarily for analysis of the parameters identified in the Agreed Order. Based upon the review of the RI Work Plan, TNRCC requested that additional Investigation Areas be added, specifically the Unloading/Bedding Wastewater Treatment area, process ponds 1, 5, and 6, and the sump located near the Plant entrance (TNRCC, 1997). Asarco addressed the TNRCC comments in their response letter and added the requested items to the remedial investigation activities (Asarco, 1997). Included in the Asarco response letter was a revised list of Investigation Areas (ten areas total) and a revised summary table of samples to be collected in each Investigation Area. The results of sampling and a description of identified contamination sources in each Investigation Area are presented in section 2.0 of this RI report.

Per the Agreed Order the following items are presented in this RI report:

- A detailed site history including previous site owners, previous known site activities, previous known waste management, and current waste management practices.

- A site characterization of the local soil, geology, groundwater, and surface water conditions based upon a literature review.
- Samples of environmental media to define background conditions, hydraulic gradient(s), source(s) of contamination, and the vertical and horizontal extent of contamination.
- Analytical results of samples using appropriate EPA-approved analytical methods. Appropriate quality assurance/quality control (QA/QC) sampling including field duplicates, equipment blanks, and trip blanks.
- Survey of Texas sensitive receptors (i.e., wells) within one-half mile radius of the property owned by Asarco between Interstate Highway 10 and West Paisano Drive in El Paso, Texas.
- Assessment of aquifer parameters (e.g., porosity, transmissivity, hydraulic conductivity and storativity).
- Figures and exhibits presenting facility structures, operations, and storage areas; sampling locations, including locations of soil borings and monitor wells; adjacent properties; all significant topographic features in the vicinity of the site; surface waters in the vicinity; and Investigation Areas.
- Copies of lithologic logs and well construction diagrams.
- Geologic cross-sections.
- Tabulations of all analytical results.
- Copies of the original laboratory data and data validation reports.
- Concentration and depth distribution graphs for constituents of concern identified in the Agreed Order.
- Groundwater contour maps showing hydraulic gradient, static water elevations, groundwater flow paths, and the thickness of any phase-separated liquids determined during the investigation.

- Identification of contaminant source areas.
- A general proposal for corrective action stating the Risk Reduction Standard to be achieved and a detailed schedule for remediation of any contaminated media identified during the assessment necessary to meet the selected Risk Reduction Standard.

2.0 REMEDIAL INVESTIGATION RESULTS

This section presents data gathered regarding soil, surface water and groundwater quality at the Plant and limited adjacent areas. Soil data are discussed first, followed by surface water data and groundwater data. The surface water data are discussed separately as naturally-occurring surface water bodies (i.e., the Rio Grande and American Canal) and as man-made bodies (i.e., the on-site ponds). Data gathered included data generated during field activities conducted in 1997 and 1998 as part of the Remedial Investigation and data obtained from previous studies and public agencies, such as the International Boundary Water Commission. Summary tables are presented in Appendices C (soil data), E (surface water data), F (groundwater level data), and G (groundwater quality data). Laboratory reports and the associated data validation reports are presented in Appendices I and J, respectively.

2.1 SOIL INVESTIGATION RESULTS

Soil samples were collected during the RI at the Investigation Areas related to soil assessments identified in the Remedial Investigation Work Plan (Hydrometrics, 1996). Samples were collected from soil borings, some which were converted to monitor wells. The Investigation Areas are indicated in Table 2-1.

One hundred-forty borings were drilled and sampled as part of the Remedial Investigation (see Exhibit 1 and Appendix B). Shallow soil borings were drilled using a truck-mounted hollow-stem auger drill, with the exception of boring RIBH-1, which was drilled using a reverse circulation, air-rotary technique utilizing a combination down-hole hammer bit and Stradex® casing advancer. Soil samples were collected every five feet for borings RIBH-1 through RIBH-10. Slag was not sampled from RIBH-1 through RIBH-10. For all other borings slag and soil samples were collected at four intervals below ground surface (0-2 inches; 18-30 inches; 36-48 inches; and 48-60 inches). A split-spoon sampling device measuring 2 feet in length and 1.6 inches in diameter was used to collect soil samples. Data collected from other boreholes and wells previously installed at the site, including wells EM-1 through EM-8, were used as appropriate for this report. Wells EM-1 through EM-8 were

constructed in 1985 under a separate order (TNRCC, 1996). Borings AB-1 through AB-5, which were advanced as part of a July 1996 investigation, were used in the investigation of the Front Slope Area (see Section 3.4). In addition, surface grab samples of sediments collected in October 1996 from Ponds 1, 5 and 6 are used in the investigation of the ponds (see Section 3.7).

Monitor wells EP-67 through EP-89 were installed as part of the Remedial Investigation. Wells were installed using a reverse circulation, air-rotary technique utilizing a combination down-hole hammer bit and Stradex[®] casing advancer with the exception of wells EP-80 and EP-81. This technique was selected because of its ability to drill through the slag, large boulders and bedrock present over most of the site. Wells EP-80 and EP-81 were drilled using a truck-mounted hollow-stem auger drill. These two wells are located on the floodplain north of Smelertown. Well depth for each monitor well was determined during the soil boring and sampling activities. Generally, the water table was estimated from drill cuttings, and the boring was then advanced an additional 5 to 15 feet below the water table. Soil samples were collected at five-foot intervals during well construction using a split-spoon sampler. No slag samples were collected during the drilling and installation of the Monitor Wells.

Wells were constructed using 4-inch diameter, flush-threaded, Schedule 40 PVC for the riser and screen. The well screen was 0.020-inch machine-slotted PVC with a threaded bottom cap. Above the screen interval, solid riser was installed with an expanding well plug to seal the well casing. The annulus between the PVC and the outer well bore was filled with 12-20 sieve size sand to a depth of approximately 2 feet above the upper screen interval. Above this interval, bentonite chips were installed and hydrated to a depth of approximately 5 to 10 feet below ground level. The remaining annulus space was filled with concrete to the surface. Wells were completed with an 8-inch diameter, above-ground steel casing with locking cover approximately 2 to 4 feet above ground-level.

Upon completion, all monitor wells were developed by extracting three to ten well volumes of water. Development water was monitored for pH, specific conductivity, temperature and turbidity until parameter measurements stabilized, indicating representative water was being extracted from the aquifer. Development volumes were based on parameter stabilization and a visual observation of reduced turbidity. Well construction details for each well are presented in Table B-2, Appendix B.

One additional well (EP-90) was installed in December 1997 by redrilling well EP-74, which was destroyed during demolition activities at the lead plant and could not be salvaged. A State of Texas Well Report was completed by the well driller (Layne Christensen Company) and submitted to the TNRCC to document the well construction activities. Two wells (EM-1 and EM-8) were plugged and abandoned in August 1998 because groundwater levels had fallen below their monitoring levels. State of Texas Plugging Reports were completed by the well driller and submitted to the TNRCC. Appendix B presents the borehole and well construction details of all borings and wells installed at the facility tabulated on Tables B-1 and B-2, respectively. Appendix B also contains lithologic logs and well construction diagrams.

A total of 634 soil samples were collected, including samples used as Quality Assurance/Quality Control (QA/QC) samples. QA/QC samples were collected at a rate of about five percent, or one QA/QC sample per 20 samples. Selected soil samples were subsequently analyzed by the Asarco Technical Services Center in Salt Lake City. Sampling was conducted in accordance with the SOPs presented in the Work Plan. All samples were analyzed using x-ray fluorescence spectrometry (XRF) methods for analysis of total metals (arsenic, cadmium, chromium, copper, iron, lead, selenium and zinc). Laboratory QA/QC procedures required confirmation analysis of 1 in 20 samples collected using Waste Extraction Test (WET) chemistry methods for total metals analysis using HF extraction. Table C-1, Appendix C, presents a list of the sample locations, sample identifiers and sample depths. Analytical results are presented in Tables C-2 through C-10. Laboratory reports are presented in Appendix I.

Since no boreholes were drilled off-site during this investigation, well EP-86 is considered as the most representative background well, because it is the farthest north and hence is the farthest from site activities (see Figure 2-1). Soil samples were collected from this borehole at five-foot intervals from ground surface to 60 feet (see Table C-1). Each sample, including a duplicate sample collected at 60 feet bgs, was analyzed for arsenic, cadmium, chromium, copper, iron, lead, selenium and zinc (see Table C-10). Soil pH ranged from 8.4 to 10. No detectable concentrations of arsenic, cadmium, or selenium were reported above their respective detection limits of 20 milligrams per kilogram (mg/kg), 10 mg/kg and 10 mg/kg. Chromium was detected in less than half of the samples, at concentrations ranging from the detection limit of 30 mg/kg to 100 mg/kg. Copper was detected in slightly more than half of the samples, at concentrations ranging from just over the detection limit of 20 mg/kg to 76 mg/kg. Iron was detected in all samples at concentrations ranging from 7,000 mg/kg to 22,000 mg/kg. Lead was detected in all but the deepest samples at concentrations ranging from slightly above the detection limit of 10 mg/kg to 87 mg/kg. Zinc was detected in all samples at concentrations ranging from 18 mg/k to 100 mg/kg. Using these results as background concentrations, it appears that arsenic, cadmium and selenium do not naturally occur above detection limits at the site. Chromium, copper, iron, lead, and zinc are all naturally occurring at concentrations up to 100 mg/kg with the exception of iron which is present at high concentrations.

The minimum, maximum and average concentrations of the analyzed parameters for all soil samples collected during the remedial investigation are summarized in Table 2-2. These concentrations are based upon all soil samples analyzed, using one-half the detection limit for a non-detected constituent to calculate the average. Another source of comparable background concentrations in soils is a study published by the US Geological Survey which presents analytical results of soils collected throughout the United States (USGS, 1984). Based upon that study, average concentrations of the eight metals of concern at the site are higher than typical background concentrations, with the exceptions of iron and chromium,

which are only slightly higher. No average concentration was established for soil pH and cadmium.

The pH values detected in soil samples ranged from 5 to 10.2, with an average of 8.5. The minimum metal concentrations were below the respective detection limits, with the exception of iron, which was detected at a minimum concentration of 5,000 mg/kg. The maximum concentrations detected ranged up to 260,000 mg/kg for an iron analysis. The highest metal concentrations detected were iron concentrations, with an average concentration of 30,524 mg/kg for all soil samples collected. The average concentrations of arsenic, cadmium, chromium, copper, lead, selenium and zinc were 616 mg/kg, 124 mg/kg, 86 mg/kg, 4,362 mg/kg, 2,447 mg/kg, 22 mg/kg and 2,695 mg/kg, respectively. All of the average metal concentrations calculated for the site are higher than the background concentrations detected in well EP-86 soil samples and the average background concentrations reported by the USGS. Analytical results for all soil samples are presented in Appendix C, Tables C-2 through C-10, respectively, for Investigation Areas 1, 2, 3, 4, 5, 8, and 10, remedial investigation borings, and monitor wells.

2.1.1 Distribution of Constituents of Concern in Soil

Per the Agreed Order issued by the TNRCC, the constituents of concern at the Plant are arsenic, cadmium, chromium, copper, iron, selenium, zinc, lead, pH, specific conductivity and total dissolved solids (TNRCC, 1996). Two of the constituents of concern, specific conductivity and total dissolved solids, apply only to water.

Concentrations are generally highest in the upper soils, typically from ground surface to five or ten feet bgs, as illustrated on graphs presented in Appendix D. For example, arsenic is detected in concentrations greater than 5,000 mg/kg at ground surface along the central-western edge of the facility, near the Acid Plant. Arsenic occurs at concentrations greater than 5,000 mg/kg in only a very limited area at four feet bgs in this area. Some metal distributions, especially iron and chromium, are erratic because they are probably naturally-occurring concentrations. Metals detected in concentrations which are higher than the soil

remediation levels for nonresidential areas are arsenic, cadmium, copper and lead. Though these are not applicable standards, they provide an indication that arsenic, cadmium, copper and lead are the constituents of concern at the site. Depth distributions for all eight metals analyzed are presented in Appendix D for soil samples collected during the monitor well construction, including wells EP-67 through EP-90.

2.2 SURFACE WATER INVESTIGATION RESULTS

2.2.1 Regional Surface Water

As part of the remedial investigation, surface water quality in the vicinity of the Plant was assessed. There are two prominent surface water bodies in the vicinity of the Facility (Figure 2-2): 1) the Rio Grande, which serves as the international boundary between the United States and Mexico; and 2) the American Canal, which is used by the United States to remove its water allotment from the Rio Grande. The canal is concrete-lined, and is approximately nine feet deep (IBWC, 1998). Recharge to the surface water is from upstream dam releases, precipitation, surface runoff, and groundwater.

Surface runoff in the area is primarily controlled by drainages locally known as "arroyos", which are dry except during heavy rain events. The five main arroyos located at the Plant have been designated for the purpose of this report as Parker Brothers Arroyo, Ponds 5 and 6 Arroyo, Pond 1 Arroyo, South Terrace Area Arroyo, and Acid Plant Arroyo (see Figure 2-3). The arroyos have been filled over time with a variety of fill materials, including slag cooled-in-place and redeposited slag, crushed rock, brick, metal, concrete fragments, and native soils. The fill zones are generally dense or firm, but also contain loose zones in many locations (Sergent, Hauskins & Beckwith, 1976).

Surface water flow and quality in the Rio Grande near the vicinity of the Plant are subject to the following influences:

- Effluent discharged from the sewer disposal facility (Northwest Waste Water Treatment Plant) located northwest of Smelertown

- The American Dam, which diverts part of the Rio Grande to the American Canal. The American Canal removes the US allocation of water from the Rio Grande
- Shallow groundwater recharge along the Rio Grande
- The International Dam, located south of the University of Texas at El Paso, which diverts water to the Franklin Canal; it is also the location at which Mexico removes water from the Rio Grande
- The Haskell R. Street Waste Water Treatment Plant, located on Delta Street approximately 1 mile downstream of Asarco
- Seasonal irrigation releases to the Rio Grande from the Elephant Butte Reservoir as regulated by the Elephant Butte Irrigation District.

Historically, surface water also may have been affected by stormwater runoff from the Plant; currently runoff, however, is controlled by berms, pads and sumps. There is a potential for stormwater runoff to leave the Plant near the Plant entrance, however, that potential source will be controlled when the proposed surface drainage improvements (Dames and Moore, 1998) are made.

Surface water at the site, in the American Canal and in the Rio Grande has been sampled by Hydrometrics as part of this investigation and as part of on-going monitoring conducted by the International Boundary Water Commission (IBWC). IBWC data obtained as part of the remedial investigation included water quality data for two locations in the Rio Grande for the years 1995 through May 1998 and flow data in the Rio Grande at three locations for the years 1889 through May 1998 (IBWC, 1998).

Hydrometrics sampled ten surface water locations in the Rio Grande and American Canal quarterly between August 1997 and May 1998. Three sampling locations (SEP-1, SEP-3 and SEP-7) are located in the American Canal. Seven sampling locations (SEP-2, SEP-4, SEP-9, SEP-10, SEP-11, SEP-12 and SEP-13) are located in the Rio Grande. The surface water sample locations are shown on Figure 2-2. Permanent rods located three to five feet from the

American Canal and Rio Grande are surveyed and used as reference points during sampling. The actual sample locations are within the canal and river, hence the locations on Figure 2-3 are the permanent rod locations rather than that of the river.

2.2.2 On-site Process Water Facilities

Three unlined water ponds and a stormwater evaporation pond are located within the Asarco site boundaries. Pond 1 is located on the southwestern portion of the facility with Pond 5 at the approximate center. Pond 6 is located at the northern center and the stormwater evaporation pond ("Rubber Pond") near the facility entrance (Asarco, 1996). Pond 1, historically, has been used for storage of river water. Pond 5 was used as fresh water storage and is currently dry. The water was derived from city water and is used mainly as a source for dust suppression activities. Acid plant cooling tower blowdown, contact and non-contact cooling water, stormwater and city water are stored in Pond 6 for recycling and make-up water. Stormwater from the southern part of the property is retained for evaporation in the Rubber Pond, which is double-lined and has a leak detection collection system. The Rubber Pond was not included in this site investigation. Ponds 1, 5 and 6 will be closed after the stormwater collection and reuse system is completed. Another closed depression (SEP-14) is located at the Plant near the northeastern property boundary, however it was dry during each of the sampling quarters. Water in the closed depression either evaporates or seeps into the ground.

Hydrometrics, Inc. sampled each of the on-site water ponds (Ponds 1, 5 and 6) quarterly between August 1997 and May 1998. The pond locations are shown on Exhibit 1.

2.2.3 Surface Water Quality Results

Results of the surface water quality sampling and flow gauging are discussed below. A reference list of the analytical parameters, units of measurement and abbreviations is presented in Table 2-3 to supplement the data received from IBWC.

2.2.4 IBWC Data

IBWC provided water quality data for the period 1995 through May 1998 for two locations on the Rio Grande: 1) at Courchesne Bridge, which is located upstream of the site, approximately 9.5 miles above the Haskell R. Street Waste Water Treatment Plant and 2) across from Bowie High School football field, which is located downstream from the site and about 1.5 miles above the Haskell R. Street Waste Water Treatment Plant (see Figure 2-2). Though the Bowie High School location is significantly downgradient from the site, the data are discussed in general. The Courchesne Bridge location is the upgradient sampling point on the Rio Grande closest to the Asarco site.

Parameters tested at each location included dissolved oxygen (DO), pH, biochemical oxygen demand (BOD), fecal coliform, chloride, TDS, sulfate, SC, total hardness, ammonia, turbidity and temperature. Samples were collected and analyzed on a weekly basis. The 1997 and 1998 results for the Rio Grande location at Courchesne Bridge are presented in Table 2-4. Based upon the Courchesne Bridge data for the period of January 1997 through May 1998, the average analytical concentrations were 9.0 mg/l DO; 7.9 pH; 3 mg/l BOD; 340 colony-forming units per 100 ml for fecal coliform; 146 mg/l chloride; 761 mg/l TDS; 254 mg/l sulfate; 1,279 microsiemens per centimeter ($\mu\text{S}/\text{cm}$) specific conductivity (SC); 293 mg/l total hardness; 0.1 mg/l ammonia; 115 NTUs turbidity; and 59° F for temperature (Appendix E).

For the same period, the average surface water parameter concentrations at the Rio Grande location across from Bowie High School were 9.0 mg/l DO; 8.1 pH; 4 mg/l BOD; 394 colony-forming units per 100 ml for fecal coliform; 141 mg/l chloride; 767 mg/l TDS; 235 mg/l sulfate; 1,270 $\mu\text{S}/\text{cm}$ SC; 288 mg/l total hardness; 0.3 mg/l ammonia; 86 NTUs turbidity; and 60° F for temperature (Table 2-5 and Appendix E).

The surface water quality results at both locations are similar, which indicates that in the reach of the Rio Grande between the two sampling points, there is little additional influence on the water quality. The parameter exhibiting the largest variance is turbidity, which

averaged 115 Nephelometric Turbidity Units (NTUs) upstream from the facility at Courchesne Bridge and 86 NTUs downstream from the facility at Bowie High School. Graphs illustrating the results of a single sampling event during August of each year at each sampling location are presented in Figures 2-4 through 2-9. The greatest difference in results for these single sampling events is in the fecal coliform results, which ranged from 0 to 1,900 colony-forming units per 100 ml at the location near Bowie High School.

Average concentrations at both locations are summarized in Table 2-6. The averages were calculated using samples collected during the weekly monitoring events between January 1997 and May 1998.

2.2.5 Results of On-Site Pond and Surface Water Sampling by Hydrometrics

Water quality data collected by Hydrometrics at the on-site ponds and at locations within the American Canal (sample locations designated as SEP-7, SEP-1 and SEP-3, upstream to downstream) and within the Rio Grande (sample locations SEP-9, SEP-10, SEP-11, SEP-2, SEP-12, SEP-13, and SEP-4, upstream to downstream) are presented in Appendix E. The surface water sample locations are presented in Figure 2-3. Samples were analyzed in the field for dissolved oxygen, pH, electrical conductivity and water temperature, plus laboratory analyses of pH, electrical conductivity, total dissolved solids, total suspended solids, calcium, magnesium, sodium, potassium, total alkalinity as CaCO₃, bicarbonate, carbonate, sulfate, chloride, fluoride, nitrate and nitrite as N, and dissolved metals (i.e., arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, selenium, silver and zinc) for selected samples. The analytical results are summarized in Tables E-1 through E-3, Appendix E.

Each on-site pond and surface water location was sampled quarterly from August 1997 through May 1998. The minimum, maximum and average concentrations of each parameter are summarized in Table 2-7. The average concentrations were calculated using one-half the detection limit for nondetectable results. If the average concentration is less than the detection limit, the detection limit is indicated.

2.2.6 Rio Grande Surface Water Sampling Results

Rio Grande surface water was sampled at seven locations, designated as SEP-9, SEP-10, SEP-11, SEP-2, SEP-12, SEP-13, and SEP-4 (upstream to downstream), and samples were analyzed for the parameters listed in Table 2-7.

Dissolved oxygen results ranged from 0 to 7.64 mg/l. Results for pH ranged from 7.9 to 8.5. Electrical conductivity ranged from 814 micromhos per centimeter ($\mu\text{mhos/cm}$) to 1,993 $\mu\text{mhos/cm}$. TDS ranged from 526 mg/l to 1,337 mg/l. Total suspended solids (TSS) ranged from 16 mg/l to 432 mg/l. General mineral concentrations of calcium, magnesium, sodium, and potassium ranged from 60 mg/l to 107 mg/l; 14 mg/l to 27 mg/l; 100 mg/l to 286 mg/l; and 7.4 mg/l to 14 mg/l, respectively. Total alkalinity results ranged from 162 mg/l to 235 mg/l. Bicarbonate and carbonate results ranged from 178 mg/l to 299 mg/l and 0.5 mg/l to 17 mg/l, respectively. Sulfate ranged from 131 mg/l to 436 mg/l. Chloride ranged from 67 mg/l to 255 mg/l. Fluoride ranged from 0.57 mg/l to 0.82 mg/l. Nitrate and nitrite (as nitrogen) ranged from 0.21 mg/l to 6.5 mg/l.

Dissolved metal concentrations, including arsenic, cadmium, chromium, copper, iron, lead, selenium and zinc, ranged from below the detection limit of 0.005 mg/l to 0.011 mg/l; are all below the detection limit of 0.005; are all below the detection limit of 0.005 mg/l; are all below the detection limit of 0.025 mg/l; are all below the detection limit of 0.1 mg/l; all were below the detection limit of 0.003 mg/l; all were at or below the detection limit of 0.005 mg/l; and ranged from below the detection limit of 0.02 mg/l to 0.035 mg/l, respectively.

Total recoverable metal concentrations, including arsenic, cadmium, chromium, copper, iron, lead, selenium and zinc, ranged from below the detection limit of 0.003 mg/l to 5.9 mg/l. The arsenic concentrations ranged from below the detection limit of 0.005 mg/l to 0.015 mg/l. Cadmium concentrations ranged from below the detection limit of 0.005 mg/l to 0.008 mg/l. Chromium concentrations were all below the detection limit of 0.01 mg/l. Copper concentrations ranged from below the detection limit of 0.025 mg/l to 0.026 mg/l. Iron was

detected at concentrations ranging from 0.15 mg/l to 5.9 mg/l. Lead concentrations ranged from below the detection limit 0.003mg/l to 0.014 mg/l. Selenium concentrations ranged from below the detection limit of 0.005 mg/l to 0.006 mg/l. Zinc concentrations ranged from below the detection limit of 0.02 mg/l to 0.042 mg/l.

Most of the metal results from the Rio Grande samples are below the detection limit and the MCLs (Appendix E, Table E-3).

2.2.7 American Canal Surface Water Sampling Results

Within the American Canal, surface water samples were collected at SEP-7, SEP-1 and SEP-3, upstream to downstream. Samples were analyzed for common ions, dissolved metals and total recoverable metals. Results are presented in Appendix E.

Dissolved oxygen results ranged from 4.97 mg/l to 12.4 mg/l. Results for pH ranged from 7.6 to 8.5. Electrical conductivity ranged from 896 μ mhos/cm to 5,410 μ mhos/cm. Total dissolved solids ranged from 594 mg/l to 3,979 mg/l. Total suspended solids ranged from 13 mg/l to 275 mg/l. General mineral concentrations of calcium, magnesium, sodium, and potassium ranged from 62 mg/l to 225 mg/l; 15 mg/l to 94 mg/l; 114 mg/l to 965 mg/l; and 6.9 mg/l to 67 mg/l, respectively. Total alkalinity results ranged from 172 mg/l to 388 mg/l. Bicarbonate and carbonate results ranged from 205 mg/l to 381 mg/l and 0.5 mg/l to 11 mg/l, respectively. Sulfate ranged from 156 mg/l to 1,839 mg/l. Chloride ranged from 75 mg/l to 679 mg/l. Fluoride ranged from 0.65 mg/l to 2.3 mg/l. Nitrate and nitrite (as nitrogen) ranged from 0.21 mg/l to 12 mg/l.

Dissolved metal concentrations, including arsenic, cadmium, chromium, copper, iron, lead, selenium and zinc, ranged from below the detection limit of 0.005 mg/l to 0.082 mg/l; ranged from below the detection limit of 0.005 mg/l to 0.13 mg/l; are all below the detection limit of 0.01 mg/l; are all below the detection limit of 0.025 mg/l; are all below the detection limit of 0.1 mg/l; ranged from below the detection limit of 0.003 mg/l to 0.004 mg/l; ranged

from below the detection limit of 0.005 mg/l to 0.2 mg/l; and ranged from below the detection limit of 0.02 mg/l to 0.022 mg/l, respectively.

Total recoverable metal concentrations, including arsenic, cadmium, chromium, copper, iron, lead, selenium and zinc, ranged from below the detection limit of 0.003 mg/l to 4.7 mg/l. Arsenic concentrations ranged from 0.005 mg/l to 1.6 mg/l. Cadmium concentrations ranged from below the detection limit of 0.005 mg/l to 0.019 mg/l. Chromium concentrations were all below the detection limit of 0.01mg/l. Copper concentrations ranged from below the detection limit of 0.025 mg/l to 0.043 mg/l. Iron concentrations ranged from below the detection limit of 0.1 mg/l to 4.7 mg/l. Lead concentrations ranged from below the detection limit 0.003 mg/l to 0.021 mg/l. Selenium concentrations ranged from below the detection limit of 0.005 mg/l to 0.36 mg/l. Zinc concentrations ranged from below the detection limit of 0.02 mg/l to 0.068 mg/l.

2.2.8 On-site Pond Water and Sediment Sampling Results

The three water ponds at the Plant were not designated as part of the initial Remedial Investigation Work Plan (Hydrometrics, 1996); however, they were incorporated into the site assessment based upon the request of TNRCC (1997). Water samples were collected from Ponds 1, 5 and 6 (see Figure 3-8). The closed depression in the northern portion of the Plant (location SEP-14) was dry during all sampling events.

Dissolved oxygen results ranged from 5.29 mg/l to 8.33 mg/l. Results for pH ranged from 7.2 to 9.1. Electrical conductivity ranged from 975 μ mhos/cm to 50,100 μ mhos/cm. Total dissolved solids ranged from 644 mg/l to 53,664 mg/l. Total suspended solids ranged from 1.8 mg/l to 41 mg/l. General mineral concentrations of calcium, magnesium, sodium, and potassium ranged from 35 mg/l to 526 mg/l; 3.2 mg/l to 274 mg/l; 154 mg/l to 16,140 mg/l; and 6.3 mg/l to 715 mg/l, respectively. Total alkalinity results ranged from 73 mg/l to 154 mg/l. Bicarbonate and carbonate results ranged from 61 mg/l to 256 mg/l and 0.5 mg/l to 25 mg/l, respectively. Sulfate ranged from 193 mg/l to 36,326 mg/l. Chloride ranged from 137

mg/l to 2,853 mg/l. Fluoride ranged from 0.91 mg/l to 30 mg/l. Nitrogen ranged from 0.025 mg/l to 34 mg/l.

Dissolved metal concentrations, including arsenic, cadmium, chromium, copper, iron, lead, selenium and zinc, ranged from 0.064 mg/l to 3.7 mg/l; ranged from 0.021 mg/l to 22 mg/l; are all below the detection limit of 0.01 mg/l; ranged from 0.2 mg/l to 1 mg/l; ranged from below the detection limit of 0.1 mg/l to 0.76 mg/l; ranged from 0.004 mg/l to 0.26 mg/l; ranged from below the detection limit of 0.010 mg/l to 1.7 mg/l; and ranged from 0.16 mg/l to 137 mg/l, respectively.

The on-site pond water was not sampled for total recoverable metals because off-site surface water is not directly affected by the ponds. Any impact to off-site surface water can be related to groundwater sources.

Sediments in Ponds 1, 5 and 6 were sampled in 1996 and analyzed for total recoverable metals (Hydrometrics, 1997a). The sediment samples were collected at three locations in each pond from about the upper four inches of sediment. Results indicated elevated metal concentrations in the pond sediments; however, it was believed that the pond water would be the primary source of groundwater contamination and that pond sediments would constitute a minor contributor. The sediment results are presented in Table 2-8.

2.2.9 Comparison of On-site Pond and Surface Water Sampling Results

In all cases, concentrations in the pond water samples were higher than in the Rio Grande and American Canal surface water samples, with Pond 1 having the highest concentrations of the three ponds sampled. The higher concentrations collected from Pond 1 are attributed to initial concentrations in the water stored in the pond and subsequent water evaporation during all sampling events. The relative concentrations of general minerals in each pond are illustrated on Figure 2-10, which presents the general minerals results (i.e., TDS, TSS, temperature, calcium, magnesium, sodium, potassium, bicarbonate, carbonate, sulfate, chloride, fluoride and nitrate-nitrite) for Ponds 1, 5 and 6.

The parameters of pH, SC, TDS, temperature, sulfate and chloride were analyzed for the pond samples, the Rio Grande surface samples collected by Hydrometrics, Inc. and the Rio Grande sample collected by IBWC at Courchesne Bridge during November and December 1997. These results are summarized in Table 2-9.

The results indicate that Pond 1 has the highest concentrations, followed by Pond 6 and sample locations SEP-1 and SEP-3. Locations SEP-1 and SEP-3 are both located in the American Canal. The other samples had lower concentrations and were similar to each other. The analytical data are presented in Figure 2-11.

Water and surface water data for general mineral samples collected from Ponds 1, 5 and 6, Rio Grande locations SEP-2, SEP-4, SEP-7, SEP-9, SEP-10, SEP-11, SEP-12 and SEP-13, and American Canal locations SEP-1, SEP-3 and SEP-7 were plotted on Piper diagrams (Figures 2-17 through 2-25). Piper diagrams are used to visually present cation and anion compositions of multiple samples on a single graph, thus allowing trends in data to be visually determined. Based upon the Piper diagram for Ponds 5 and 6, both waters are of similar composition to each other and to the Pond 1 sample (Figures 2-18 and 2-19, respectively). Piper diagrams for other surface water samples are discussed in more detail in a later section of this report.

Rio Grande samples collected in August 1997 and February 1998 are plotted on two separate diagrams (Figures 2-22 and 2-23). Rio Grande samples are similar to each other for each individual sample time; however, the geochemistries vary between summer and winter sampling events. The summer samples (August 1997, Figure 2-22) have higher carbonate-bicarbonate concentrations and lower chloride concentrations compared to the winter samples (February 1998, Figure 2-23). Rio Grande water geochemistry is probably influenced by increased flow during the summer and reduced flow during the winter due to dam releases, snow melt, and higher precipitation during the summer.

American Canal samples have similar geochemistries during the summer (increased flow) and slightly dissimilar geochemistries during the winter (low flow) (Figures 2-24 and 2-25, respectively). During the winter, the sample collected at location SEP-7, which is the farthest upstream in the American Canal, had higher carbonate-bicarbonate and chloride concentrations than samples collected at downstream locations SEP-1 and SEP-3.

2.2.10 Rio Grande Flow Data

IBWC maintains a database with mean daily flow measurements at three points in the Rio Grande. Flow data, measured in mean daily discharge in cubic meters per second, is available for the following locations and time periods:

- At the Courchesne Bridge for the period 1889 through May 1998
- At the Pump House below the American Dam for the period 1938 through May 1998
- At the American Dam diversion to the American Canal for the period 1938 through May 1998.

Only the data from 1995 through 1998 were considered for this report. The data are presented in Table 2-10 and shown graphically on Figure 2-12.

The upgradient location at Courchesne Bridge had the highest mean daily flow rates, and the downstream location at the Pump House had the lowest mean daily flow rates. Daily flow rates are highest at Courchesne Bridge because it is located upstream from the American Dam diversion. At the American Dam, water is diverted from the Rio Grande to the American Canal for use by the U.S. The highest flow volumes were noted in July and August, 1995. During this time, the mean daily discharge volumes ranged up to 110 cubic meters per second at Courchesne Bridge. Other sources of flow to the Rio Grande include the Northwest Waste Water Treatment Plant, located about one mile northwest and upstream of the Plant. Water from the Rio Grande is diverted via the American Canal to the Haskell R. Street Waste Water Plant, located about nine miles southeast and downstream of the Plant.

The depth-to-water data for wells located adjacent to the Rio Grande (i.e., wells EP-4 through EP-7) and in wells located in the historic Smelertown area (i.e., wells EP-60 through EP-66) were compared to the Rio Grande flow data to determine whether a correlation existed. Table 2-11 presents the depth-to-water data for 1995 through 1998. Figures 2-13 and 2-14 graphically illustrate the water level measurements in wells EP-4 through EP-7 and EP-60 through EP-66, respectively.

Depths to water in wells EP-4 through EP-7, located adjacent to the Rio Grande from about the Pump House to the eastern edge of the site boundary, fluctuated in a similar manner. Water levels were highest annually in August and lowest during January and February. Depths to water ranged from highs of about 4.5 feet to lows of slightly more than 9 feet (Figure 2-13).

Depths to water in wells EP-60 through EP-66, located in the historic Smelertown area and adjacent to the American Canal, exhibited similar fluctuations with the exception of EP-62. Well EP-62 exhibited a sharp decrease in water level in September 1995 (Figure 2-14), which may be a result of seasonal controls of the Rio Grande. Overall, however, water levels were highest annually in August and lowest in January.

Since the Rio Grande flow volumes are generally highest in summer and lowest in winter, the groundwater in the immediate area tends to recharge more during summer and less in winter. This correlation is evidenced by the higher water levels in the adjacent wells during August, following the higher discharge volumes in the Rio Grande and lower water levels in January and February, following a period of decreased discharge volumes in the Rio Grande.

2.2.11 Trends of Water Quality Parameters and Flow Data in the Rio Grande

Analytical data from water quality samples collected at sampling locations in the Rio Grande at Bowie High Football Stadium and at Courchesne Bridge were reviewed to determine whether analytical results were related to flow volumes. The general trend of flow rates is

presented in Table 2-12. Flow increases in the summer months and decreases during the winter. Figures 2-15 and 2-16 present the general data during 1997 for samples collected at the Bowie High Football Stadium and Courchesne Bridge locations, respectively. Analytical data include dissolved oxygen, pH, biochemical oxygen demand, fecal coliform, chloride, TDS, sulfate, electrical conductivity, total hardness, ammonia, turbidity and temperature.

Overall, the analytical trends between the two sampling locations appear to be similar. One notable exception is a sharp increase in the turbidity in September 1997 at both locations, but particularly at the Bowie High School location (see Figures 2-15 and 2-16). Concentrations of most parameters appear to increase during January and February, which corresponds to periods of lowest flow volumes. Concentrations are decreased during the summer months, which corresponds to a period of highest flow volumes.

The relationship of decreased concentrations during high flow periods and increased concentrations during low flow periods also occurs in the Franklin (American) Canal. Sampling points SEP-7, SEP-3 and SEP-1 are located upgradient to downgradient in the American Canal adjacent to the Plant. Concentrations of trace arsenic are related to the flow rates measured in the American Canal, as shown in Table 2-13. Arsenic concentrations decreased during times of high flow rates and increased during times of low flow rates. This is likely related to dilution resulting from high flow events.

2.2.12 Distribution of Constituents of Concern in Process Pond Water and Surface Water Bodies

Constituents of concern designated by the TNRCC for this facility are arsenic, cadmium, chromium, copper, iron, lead, selenium and zinc, with parameters of concern being pH, specific conductivity and total dissolved solids. The federal drinking water standards (maximum contaminant levels) for each of these parameters are tabulated in Table 2-14 for discussion purposes. Only primary drinking water standards are enforceable. The secondary standards and action levels are included for discussion purposes, but are not enforceable standards.

On-site pond water and surface water was sampled and analyzed for the eleven parameters noted above. The analytical results are tabulated in Appendix E. Arsenic was detected above its MCL of 0.05 mg/l in samples collected from Pond 1, Pond 5, Pond 6, SEP-1 and SEP-3. SEP-1 and SEP-3 are located downgradient in the American Canal, and only had elevated levels of arsenic during the December and February sampling events, indicating that concentrations increased during periods of low flow in the Rio Grande. Flow in the American Canal during the winter is restricted, which indicates that the water samples collected in December and February are not representative of water in the American Canal. It is probable that the water sample results are elevated because the metals have been concentrated due to evaporation or are related to sediments in the canal bottom. Only the samples collected during high flow events can be considered as representative of the American Canal waters.

Cadmium was detected above the MCL of 0.005 mg/l in samples collected from Pond 1, Pond 5, Pond 6, SEP-1 (one sample only collected during February 1998) and SEP-3 (one sample only collected during November 1997).

Chromium was not detected above the detection limit of 0.01 mg/l in the surface water samples. The MCL for chromium is 0.1 mg/l. Copper was not detected above the Texas action level of 1 mg/l. Iron was detected above the secondary MCL of 0.3 mg/l in one sample collected from Pond 6 in December 1997. Lead was detected above the action level of 0.015 mg/l in samples collected from Ponds 1, 5 and 6. Only one Rio Grande sample (SEP-7) had a detectable occurrence of lead. The May 1998 sample for SEP-7 exhibited a lead concentration of 0.004 mg/l, which is at the detection limit.

Selenium was detected above the MCL of 0.05 mg/l in samples collected from Pond 1, Pond 5, Pond 6, SEP-1 and SEP-3. The samples from SEP-1 and SEP-3 exhibited elevated selenium concentrations during the November and February sampling events. The secondary MCL of 5 mg/l for zinc was exceeded only in samples collected from Pond 1.

The State of Texas secondary MCL of greater than 7.0 pH was met in all surface water samples. The federal upper limit of 8.5 pH was exceeded only in single samples collected from Ponds 5 and 6. Total Dissolved Solids were detected above the federal secondary MCL of 500 mg/l in all surface water samples. The Texas secondary MCL of 1,000 mg/l for TDS was exceeded in all November 1997 samples, some February 1998 samples, and in all of the samples collected from Ponds 1 and 6.

Overall, the surface water samples exhibited higher concentrations during the winter months, probably due to evaporation in the ponds and decreased flow (hence less dilution) in the Rio Grande. Six constituents of concern were detected at concentrations above federal and/or state regulatory standards: arsenic, cadmium, iron, lead, selenium and zinc. Chromium and copper were not detected above established regulatory standards. It is probable that the initial elevated concentrations of metals in off-site surface water resulted from historical stormwater and airborne transport of contaminated materials.

2.3 GROUNDWATER INVESTIGATION RESULTS

2.3.1 Local Geology

As part of the Remedial Investigation, the geology of the facility was assessed. The investigation utilized reference materials from Asarco's engineering department, subsurface information gathered during the remedial investigation field work, and data collected during previous investigations and remedial activities. The drilling logs were utilized to generate cross-sections across the Plant, as located in Figure 2-26. Seven cross-sections were developed (Figures 2-27 through 2-33). Each cross-section illustrates the subsurface geology and identifies subsurface features that may be conducive to groundwater migration and transport of constituents. Below is a general description of the geologic/hydrogeologic units of the plant area as developed from a literature review based on previous work (Hydro-Search, 1985) and this study. The geologic units at the facility in order of youngest to oldest (generally shallow to deep) are described below.