FIGURE 4-5. GROUNDWATER ELEVATION MAP, NOVEMBER OF 2002

4.4 WATER QUALITY RESULTS

To date, a total of twenty-three groundwater/surface water monitoring and sampling events have been conducted. A statistical summary of analytical results for the four primary COC's, arsenic, cadmium, lead and selenium, is presented below:

Parameter	Dissolved			Total		
	Max.	Avg.	95% UCLM	Max.	Avg.	95% UCLM
Groundwater						
• Arsenic	464	6.46	8.06	323	5.34	6.50
• Cadmium	43	0.29	0.43	13	0.11	0.14
• Lead	0.13	0.0032	0.0037	10	0.12	0.16
• Selenium	16	0.42	0.48	15	0.42	0.47
Surface Water						
• Arsenic	0.82	0.0215	0.0344	0.096	0.0086	0.0101
• Cadmium	0.008	0.0025	0.0026	0.0025	0.0025	0.0025
• Lead	0.011	0.0016	0.0017	0.38	0.0092	0.0144
• Selenium	0.2	0.0058	0.0085	0.01	0.003	0.003

Note: All results are in mg/l.
UCLM = upper confidence limit on the mean.

The 4th quarter of 2002 sampling event included 57 groundwater and 11 surface water monitoring stations. The maximum concentrations detected for the four primary COC's are summarized below.

Parameter	Dissolved	Total
	Max.	Max.
Groundwater		
• Arsenic	318	316
• Cadmium	1.9	1.8
• Lead	0.012	6.2
• Selenium	4.0	4.4

Parameter	Dissolved	Total
	Max.	Max.
Surface Water		
• Arsenic	0.022	0.024
• Cadmium	bldl	bldl
• Lead	bldl	bldl
• Selenium	bldl	bldl

Note: All results are in mg/l.
bldl = below laboratory detection limits

A comprehensive record of groundwater and surface water quality results that includes general chemistry and metals analyses is included in Appendix G and Appendix II, respectively. A statistical summary of current site water quality for individual water quality parameters is presented in Table 4-3.

4.4.1 GROUNDWATER RESULTS - SUMMARY

The following discussion of water quality trends focuses on the primary COC's; arsenic, cadmium, lead, and selenium for the entire monitoring record.

Arsenic

The Phase I and Phase III RI Reports found that arsenic was present in groundwater at concentrations above the Maximum Contaminant Level (MCL) of 0.05 mg/l under most of the western half of the plant with higher concentrations (5 to 480 mg/l) of arsenic present in localized plant areas. Data gathered during the Phase IV RI (four sampling events) are also similar to that obtained from previous RI's. The areas identified with high arsenic concentrations include:

- The area downgradient from the Sludge Storage Area (EP-75, EP-53, EP-85, EP-23, and EP-25);
- The area around Ponds 5 and 6 (EP-124, EM-5, EP-77, EP-56, and EP-131);

TABLE 4-3. STATISTICAL SUMMARY OF CURRENT SITE WATER QUALITY FOR INDIVIDUAL WATER QUALITY PARAMETERS (BASED ON THE NOVEMBER OF 2002 MONITORING AND SAMPLING EVENT)

- In the Rio Grande Alluvium, west of the Ponds 5 and 6 Arroyo (EP-116, EP-101, EP-13, EP-118, EP-117, EP-66, EP-132, and EP-133);
- The Rio Grande Alluvium, at the mouth of the Acid Plant and Parker Brothers Arroyos (EP-114, EP-54, EP-49, EP-58, EP-59. EP-122, EP-119, and EP-62);
- In the area downgradient of Pond 1 (EP-14); and
- In an area along the path of the South Terrace Arroyo (EP-20).

Maps showing total arsenic results for the August and November of 2002 sampling events are presented in Figures 4-6 and 4-7, respectively. The maps identify specific areas with concentrations ranging from 1 mg/l to 5.0 mg/l and greater than 5.0 mg/l, respectively.

Cadmium

Cadmium was detected above the MCL of 0.005 mg/l during the most recent sampling event in 20 monitoring wells. Total cadmium concentrations ranging from the MCL to 0.1 mg/l were detected in 10 monitoring wells. Nine wells displayed concentrations between 0.1 mg/l and 1.0 mg/l. Only one monitoring well showed a total cadmium concentration above 1.0 mg/l. Significant total cadmium concentrations have been observed at the following locations:

- Along the path of the Ponds 5 and 6 Arroyo (EP-101, EP-13, EP-26 and EP-116).
- The Rio Grande alluvium at the mouth of the Acid Plant Arroyo (EP-114 and EP-52)

Maps showing total cadmium results for the August and November of 2002 sampling events are presented in Figures 4-8 and 4-9, respectively. The maps identify specific areas with concentrations greater than 1.0 mg/l.

FIGURE 4-6. TOTAL ARSENIC CONCENTRATIONS IN GROUNDWATER, AUGUST OF 2002 SAMPLING EVENT

FIGURE 4-7. TOTAL ARSENIC CONCENTRATIONS IN GROUNDWATER, NOVEMBER 2002 SAMPLING EVENT

FIGURE 4-8. TOTAL CADMIUM CONCENTRATIONS IN GROUNDWATER, AUGUST OF 2002 SAMPLING EVENT

FIGURE 4-9. TOTAL CADMIUM CONCENTRATIONS IN GROUNDWATER, NOVEMBER 2002 SAMPLING EVENT

Lead

Because of the low solubility of lead, it is typically not mobile in groundwater and the dissolved phase is usually only present in groundwater associated with acid source materials and releases. Detectable total lead concentrations are also observed when there is suspended sediment in a sample. This bias is strongly evident in the Phase III RI sampling results for lead.

Total lead was detected above its action level of 0.015 mg/l during the November 2002 sampling event in 13 monitoring wells. Total lead concentrations ranging from its action level of 0.015 mg/l to 1.0 mg/l were detected in 10 monitoring wells. Only one well exhibited concentrations greater than 1.0 mg/l. Significant total lead concentrations have been observed at the following locations:

- Along the path of the Plant Arroyo (EP-52, EP-55 and EP-115);
- Within and at the lower end of the Ponds 5 and 6 Arroyo (EM-7, EP-116, EP-124, EP-125, and EP-101); and
- Within the Rio Grande alluvium (EP-114, EP-117, and EP-118).

Maps showing total lead results for the August and November of 2002 sampling events are presented in Figures 4-10 and 4-11, respectively.

Selenium

Selenium was detected above the MCL of 0.05 mg/l during the November 2002 sampling event in 66% of the monitoring wells sampled. Total selenium concentrations ranging from the MCL to 0.1 mg/l were detected in 4 monitoring wells. Twenty-seven wells showed total selenium concentrations between 0.1 mg/l and 1.0 mg/l. Four wells indicated total selenium concentrations above 1.0-mg/l. Significant total selenium concentrations have been observed at the following areas.

FIGURE 4-10. TOTAL LEAD CONCENTRATIONS IN GROUNDWATER, NOVEMBER 2002 SAMPLING EVENT

FIGURE 4-11. TOTAL LEAD CONCENTRATIONS IN GROUNDWATER, NOVEMBER 2002 SAMPLING EVENT

- Along the path of the Parker's Brother Arroyo, downgradient of the Sludge Storage Area (EP-126, EP-76, EP-75, EP-73, EP-85, EP-53, EP-99, and EP-81);
- Ephemeral Pond (EP-78) and Northern Arroyo (EP-98) Areas;
- Sediment Storage Area (EP-109 and EP-82);
- Along the path of the Acid Plant Arroyo (EP-125, EP-22, EP-25, EP-52, EP-51, EP-55, and EP-100);
- Along the path of Ponds 5&6 Arroyo (EP-131, EP-130, EP-116, and EP-117);
- Along the path of Pond 1 Arroyo (EP-14, EP-102, EP-13, EP-101, and EP-90);
- South Terrace Arroyo Area (EP-72, EP-70, EP-20, and EP-71); and
- In the Rio Grande Alluvium Area (EP-122, EP-119, EP-59, EP-58, EP-60, EP-61, EP-62, EP-63, EP-64, EP-65, EP-66. EP-132, EP-114, EP-115, EP-118, EP-29, EP-35, EP-133, EP-135, and EP-137.

Maps showing total selenium results for the August and November of 2002 sampling events are presented in Figures 4-12 and 4-13, respectively.

Data Analysis

To evaluate the effects of source removal/control actions and natural attenuation on groundwater concentrations, monitoring data was statistically evaluated to identify significant changes in metal concentration with time at individual monitoring locations. Time-series plots illustrating the COC concentrations versus time were used to identify temporal trends.

Where sample data were distributed normally, simple linear regression analysis was used to identify whether data concentrations increased or decreased over time. The Shapiro-Wilks test (Gibbons, 1994) was used to assess whether or not the data were normally distributed (Appendix I). For normally distributed data, the regression analysis involved the development of a t-statistic to test for trend significance (Helsel and Hirsch, 1992).

The null hypothesis, H_0, of a zero slope against the alternative hypothesis, H_A, of a slope different from zero at a 95% confidence level ($\alpha = 0.05$) was tested to determine whether the concentrations changed over time.

The non-parametric Mann Kendall test (Gilbert, 1987) for significance was used for data that were not normally distributed (Appendix I). The Mann Kendall test calculates the differences between each observation and all subsequent observations to identify how many times a subsequent observation went up or down. The signs of the differences are then summed and the difference between the totals for negative and positive signs is found. This difference is then used with the sample size and number of ties to develop a test statistic. If the developed statistic exceeds a table value based on a 0.95 confidence level, then the trend is considered significant. The following sections present the results of the statistical analysis for each COC. Only those wells that exhibited statistically significant trends are noted. All other wells either did not have sufficient data to test or the test indicated no significant trend.

Arsenic

In general, arsenic data are similar to the trends identified in previous RI's. Figures 4-6 and 4-7 show total arsenic data for the August and November of 2002 sampling events. Statistical analysis indicates significant declining arsenic concentration trend at monitoring wells at the following locations:

Parker Brothers Arroyo:
- EP-53
- EP-76
- EP-78

Acid Plant Arroyo:
- EP-49
- EP-51
- EP-54
- EP-57
- EP-59

FIGURE 4-12. TOTAL SELENIUM CONCENTRATIONS IN GROUNDWATER, AUGUST OF 2002 SAMPLING EVENT

FIGURE 4-13. TOTAL SELENIUM CONCENTRATIONS IN GROUNDWATER, NOVEMBER OF 2002 SAMPLING EVENT

Sludge Storage Area

EP-23
EP-85

Ponds 5 & 6 Arroyo
EM-5
EP-13

Pond 1 Arroyo
EM-2
EP-12

Statistical analysis indicates significant trends for increasing arsenic concentrations at the following locations:

Parker Brothers Arroyo:

EP-95

Acid Plant Arroyo:
EP-114
EP-22
EP-25
EP-55
EP-62
EP-75

Ponds 5 & 6 Arroyo:
EP-111
EP-116
EP-132
EP-56

Pond 1 Arroyo:
EP-14

South Terrace Arroyo:
EP-20

Other:
EP-106
EP-70

Exhibit 3 shows the graphs of trend for all of the well locations listed above. From the Figure, certain patterns emerge regarding the location of the wells, their exhibited trend, and the proximity to source areas.

In general, there are obvious trends showing decreasing concentrations around identified source areas. These trends are evident in wells downgradient of the sludge storage area (EP-78, EP-76, EP-53, and EP-85), in the vicinity of Ponds 5 & 6 (EM-5), and near Pond 1 (EM-2 and EP-12). These trends seem to indicate that the source area improvements that have been implemented may have had an effect on concentrations in the immediate vicinity of the sources.

Increasing trends in concentration are evident along the centerline of the Acid Plant Arroyo (EP-75, EP-22, EP-25, EP-55 and EP-114) and, to a lesser extent, downgradient of Ponds 5 & 6 (EP-56 and EP-116). These trends suggest that plumes of relatively high arsenic concentration may be migrating downgradient from the sources.

Cadmium

In general, cadmium data are similar to the trends identified in previous RI's. Figures 4-8 and 4-9 show total cadmium data for the August and November of 2002 sampling events. The maps show specific areas with concentrations higher than 1.0 mg/l. Statistical analysis indicates significant declining cadmium concentration trend at monitoring wells located at the these locations:

- EP-49, downgradient of Acid Plant Arroyo
- EP-52, also downgradient of Acid Plant Arroyo
- EP-53, downgradient of Sludge Storage Area

On the other hand, significant increases in cadmium concentrations are exhibited in the following locations:

- EM-5, near Pond 6
- EP-101, west of Pond 1 Arroyo

- EP-101, west of Pond 1 Arroyo
- EP-102, also west of Pond 1 Arroyo
- EP-20, downgradient of South Terrace Arroyo
- EP-55, downgradient of Acid Plant Arroyo

Exhibit 4 presents the graphs of plotted concentrations versus time for all of the wells displaying significant trends in cadmium concentrations. Patterns are not as distinct in the case of cadmium as for arsenic. The well EM-5 in the vicinity of Pond 6 indicates an increasing trend, while the trends in downgradient wells suggest both increasing and decreasing trends. The well EP-55 below the Sludge Storage Area indicates a decreasing trend, and wells downgradient of Pond 6 suggest increasing trends.

Lead

For lead, statistical analysis indicates significant lead concentration trends at EP-55 and EP-116. EP-55 is located downgradient in the Acid Plant Arroyo and EP-116 is downgradient in the Ponds 5 & 6 Arroyo. These wells do not constitute enough of a pattern to allow observations of spatial trends.

Figures 4-10 and 4-11 show total lead data for the August and November of 2002 sampling events.

Selenium

Statistical analysis indicates significant declining selenium concentration trends at the following monitoring wells:

Parker Brothers Arroyo
EP-109

Acid Plant Arroyo
EP-119
EP-52
EP-73

Ponds 5 & 6 Arroyo
EP-101

Pond 1 Arroyo
EP-12
EP-35

Other
EP-51, between Acid Plant and Ponds 5 & 6
EP-59, Rio Grande Alluvium
EP-63, Rio Grande alluvium
EP-90, west of Ponds 5 & 6 Arroyo

Statistically significant increases in selenium concentration are evident at the following locations:

Parker Brothers Arroyo
EP-81

Acid Plant Arroyo
EP-55

Pond 5 & 6 Arroyo
EP-26

Pond 1 Arroyo
EP-14

South Terrace Arroyo
EP-72

Other:
EP-102, west of ponds 5 & 6 Arroyo
EP-65, Rio Grande Alluvium

Exhibit 5 presents the graphs of concentration versus time for all of the wells next to their locations. As with arsenic, some patterns in changes in concentration are evident from the Exhibit. First, wells around Ponds 5 & 6 demonstrate no significant trends. Wells downgradient in the Ponds 5 & 6 Arroyo indicate, for the most part, declining trends, with the exception of EP-55. Wells along the Rio Grande Alluvium also demonstrate declining trends, with the exception of well EP-65. Wells EP-12 and EP-30 in the vicinity of Pond 1 indicate declining trends while well EP-14, located downgradient of Pond 1, indicates an increasing trend.

Figures 4-12 and 4-13 show total selenium data for the August and November of 2002 sampling events. Appendix J contains time series plots for the COC described above.

4.4.2 SURFACE WATER RESULTS

American Canal

Detectable concentrations of arsenic occurred in four surface water samples obtained during August of 1997 and February of 1998 at SEP-1 and SEP-3. Data gathered subsequently from these sampling locations displayed arsenic concentrations below MCL's. Cadmium, lead, and selenium concentrations have always been below their respective MCL's/action levels at these locations.

Rio Grande

Detectable arsenic concentrations ranging from bldl to 0.022 mg/l have been observed in monitoring stations located along the Rio Grande. Cadmium, lead, and selenium concentrations have consistently been below their respective MCL's. The former arsenic MCL of 0.05 mg/l has not been exceeded in any of the surface water stations. However, the new arsenic MCL of 0.01 mg/l, which went into effect March 28, 2002, has been exceeded in all monitoring stations. In the last sampling event, the new MCL was exceeded in monitoring stations SEP-2, SEP-4, SEP-12, and SEP-13. Table 4-4 contains a statistical summary of total and dissolved arsenic concentrations observed in the surface water monitoring stations along the Rio Grande.

Appendices F and G contain cumulative lists of surface water quality results gathered from the American Canal and Rio Grande monitoring stations.

TABLE 4-4. STATISTICAL SUMMARY OF TOTAL AND DISSOLVED ARSENIC CONCENTRATIONS OBSERVED IN SURFACE WATER MONITORING STATIONS ALONG THE RIO GRANDE

5.0 RELATIONSHIP BETWEEN ON-SITE SOURCE AREAS AND GROUNDWATER IMPACTS

5.1 BACKGROUND

This section of the report describes the relationship between identified source areas and impacted groundwater zones within and outside the Asarco facility. Data gathered from previous RI's were evaluated to characterize potential source areas and materials, and to identify release mechanisms and the transport and exposure pathways associated with these materials.

Results from this evaluation indicate that the primary source of metals in the underlying groundwater is from Category I materials identified throughout the facility. Specifically, the sediments and process water historically stored in three unlined ponds are considered to be the primary source of metals in groundwater.

Five arroyos designated as Parker Brothers Arroyo, Pond 1 Arroyo, Ponds 5 and 6 Arroyo, South Terrace Area Arroyo, and Acid Plant Arroyo (Exhibit 6) have been identified within the facility. Groundwater areas with elevated metal concentrations are detected within the buried arroyos, as illustrated in Figures 4-6 though 4-13, which show arsenic, cadmium, lead and selenium concentrations for the August and November of 2002 sampling events. Most groundwater areas showing detectable arsenic concentrations can be linked to the above-mentioned arroyos. Depth to groundwater on the Plant area ranges from 17 to 45 feet bgs. Water levels have declined in the area following closure of the ponds in 1998. Currently, all three ponds are dry. The following subsections describe the relationship between the identified Category I areas and groundwater impacts.

5.2 PONDS 1, 5 AND 6 (IA-9)

Pond 1 was historically used for water storage from the Rio Grande, Pond 5 was used to store fresh make-up water (El Paso City water) for compressor cooling and boiler feed water makeup, and Pond 6 was used for storing fire water, process water, stormwater, cooling tower blowdown and anode cooling water. The three ponds were constructed in naturally occurring arroyos that formerly existed throughout the Plant.

During the Phase I RI, water and sediment samples from these ponds were collected and analyzed. Analytical results indicated elevated metal concentrations in both water and sediments. Therefore, it was concluded that this impacted media had impacted the underlying groundwater system through percolation and leaching. This impacted groundwater then likely migrated downgradient to the Smeltertown/Rio Grande flood plain area via the preferential pathways of the arroyos.

Pond 1

Groundwater within and along the path of Pond 1 Arroyo is represented by monitoring wells EP-13, EP-14, EP-15, EP-29, EP-12, EM-4, EM-2, and EP-43 (Exhibit 6). The primary COCs identified along the path of Pond 1 Arroyo are arsenic and selenium. Cadmium and lead concentrations were below or slightly above their MCL's. The highest total arsenic, cadmium, lead and selenium concentrations detected in the above mentioned wells are 38 mg/l (EP-13), 0.66 mg/l (EP-13), 0.041 mg/l (EP-43) and 5.7 mg/l (EP-13), respectively.

Ponds 5 and 6

Groundwater within and along the path of the Ponds 5 and 6 Arroyo is characterized by monitoring wells EP-124, EP-117, EP-130, EM-7, EM-5, EP-77, EP-56, EP-131and EP-26. The primary COCs identified along the path of the Ponds 5 and 6 Arroyo are arsenic and, to a lesser extent, cadmium, lead and selenium. The highest total arsenic, cadmium, lead and selenium concentrations detected are 12 mg/l (EP-124), 2.7 mg/l (EP-117), 10 mg/l (EP-117), and 1.3 mg/l (EP-117), respectively.

Metal concentrations in monitoring wells associated with the Ponds 5 and 6 Arroyo are generally higher compared to metal concentrations in Pond 1 Arroyo wells. Elevated metal concentrations in these monitoring wells are attributed to the migration of metals from pond sediments and water to the underlying groundwater.

5.2.1 Groundwater Chemical Comparison

Chemical data from water ponds and monitoring wells located along the paths of Ponds 1, Ponds 5 and 6, and Acid Plant Arroyos were evaluated to determine whether geochemical similarities were present.

Pond 1 Arroyo

Chemical data gathered from Pond 1 water and groundwater from monitoring wells EM-2, EM-4, EP-12, EP-13, EP-14, EP-15, EP-29 and EP-43, all located within or near the limits of the arroyo, were plotted on a Piper diagram for comparison (Appendix K). Results from this comparison indicate that water from Pond 1, and groundwater collected from wells associated with Pond 1, were chemically similar.

Ponds 5 & 6 Arroyo

Water samples from Ponds 5 and 6, and from monitoring wells EM-5, EM-6, EP-26, EP-56 and EP-77, were plotted on the same Piper diagram to compare geochemistry (Appendix K). Interpretation of this plot suggests a common water source is likely involved.

Acid Plant Arroyo

The area of the Acid Plant Arroyo extends from the former Zinc Plant operations area to the western property boundary (Exhibit 6). This arroyo has been filled with facility debris and slag. Monitoring wells EP-21, EP-22, EP-23, EP-25, EP-49, EP-53, EP-54, EP-55, EP-73 and EP-76 were used to compare water chemistry to determine if the wells are associated with the same source of groundwater (i.e. flowing through the Acid Plant

Arroyo). Results from this evaluation indicate that the groundwater has a similar source (Appendix K).

5.3 ACID PLANT MIST PRECIPITATOR AREA (IA-1)

This area includes the Medford Sump, which was used to collect stormwater and/or process water from the Acid Plant and the Converter Building Ventilation Baghouse area (Exhibit 1). Soil in the area of the Medford Sump contained the highest concentrations of metals observed within the investigation area, which were attributed to the accumulation and percolation of stormwater and/or process water into this area.

Monitoring wells EP-51 and EP-52, located within the Medford Sump area, have historically shown significant concentrations of metals. The maximum total arsenic, cadmium, lead and selenium concentrations observed in the wells are 1.70 mg/l, 0.51 mg/l, 1.60mg/l, and 0.29 mg/l, respectively. Groundwater flows from east to west across this area, and occurs at a depth of approximately 50 feet bgs. The primary hydrogeologic feature in the area is a slag and soil backfilled arroyo (Acid Plant Arroyo). The arroyo appears to channel and control unsaturated and, to some extent, saturated groundwater flow beneath the facility in this area. Relatively higher concentrations of metals in groundwater appear to be associated with this arroyo.

5.4 SLUDGE STORAGE AREA (IA-2)

Elevated values of COCs in soil/groundwater may be associated with Acid Plant sludge historically stored in this area and/or from possible leaks from the Bulk Acid Storage area south of the Boneyard area (Exhibit 5). Limerock (54% CaO) was used to neutralize acidity associated with acid plant sludge during storage, which may have resulted in higher mobility of arsenic due to the increased pH. The infiltration of acid from the adjacent storage facility flowing through the slag filled arroyo may also have been a source of metals to the groundwater in this area.

Monitoring wells EP-53, EP-75, and EP-76 located within the Sludge Storage Area have historically shown significantly high metal concentrations. Monitoring wells EP-125 and EP-126, installed to the north and west of the bulk acid storage tanks, showed metal concentrations lower than or slightly above regulatory limits.

The maximum total arsenic, cadmium, lead and selenium concentration observed in wells within the Sludge Storage Area are 55 mg/l (EP-53), 1.8 mg/l (EP-53), 0.18 mg/l (EP-125), and 5.2 mg/l (EP-175), respectively.

Groundwater in this area is encountered at approximately 55 feet bgs, and generally flows east to west. The area overlies the head of a slag-backfilled arroyo, which appears to act as a preferential path for groundwater flow. The arroyo, which drains to the Oglebay Norton Inc. (formerly Parker Brothers Inc.) slag-crushing/recycling operations area and then to the Rio Grande, is referred to as the Parker Brothers Arroyo (Exhibit 5).

5.5 EPHEMERAL POND/POND SEDIMENT STORAGE AREA (IA-12)

This area is the site of a slag-crushing/recycling operation (Oglebay Norton Inc., formerly Parker Brothers). The Ephemeral Pond consists of a catch basin or closed depression in a backfilled arroyo created by the railroad grade in the slag storage area. This depression may be a recharge zone and may accumulate source materials that could contribute metals to the groundwater. In the past, pond sediments were excavated from Pond 6 and stored in the Pond Sediment Storage area (Exhibit 6). Data gathered from pond sediments indicated elevated concentrations of metals.

Groundwater in this area, which appears to be influenced by the Parker Brothers Arroyo was characterized by monitoring wells EP-78, EP-79, EP-81, EP-83, EP-85, EP-108, EP-109, EP-120, EP-121, and EP-123. Arsenic is the primary constituent of concern for this area. The arsenic concentration gradient characterized by monitoring wells suggests that the source of arsenic in groundwater is downgradient from EP-83. The highest total arsenic concentrations detected in monitoring wells within this area are 5.2 mg/l (EP-78), 0.006 mg/l (EP-81), 0.039 mg/l (EP-109), and 0.6 mg/l (EP-78).

5.6 ACID PLANTS 1 AND 2 AREA (IA-3)

The Acid Plants were used to remove and convert sulfur dioxide in off-gases generated during the copper smelting process to concentrated sulfuric acid, which is a by-product. The sulfuric acid was cooled and transported via pipeline to the Bulk Acid Storage Area. Historically, there were periodic releases of liquids from various Acid Plant facilities, including systems associated with the concentrated sulfuric acid, process gas flues and scrubber water. These fluids had a very low pH, which reacted with the underlying soil and slag materials. The resulting leachate may have been high in soluble metals, which then could have migrated to the groundwater.

Generally, the groundwater flow direction in this area is east to west and appears to be influenced by the Acid Plant Arroyo. The depth to groundwater ranges from 50 to 70 feet bgs. Groundwater along the pathway of this arroyo is characterized by monitoring wells EP-25, EP-49, EP-52, EP-54, EP-55 EP-73, and EP-114 located at the mouth of the arroyo.

The primary groundwater COCs in this area are arsenic, cadmium and lead. The highest total arsenic, cadmium, lead, and selenium concentration detected in the above-mentioned wells are 323 mg/l (EP-114), 13 mg/l (EP-49), 6.6 mg/L (EP-114), and 1.1 mg/l (EP-73), respectively. EP-114 is located at the mouth of the arroyo, downslope of the acid plant (Exhibit 6).

5.7 SOILS DOWNSLOPE OF THE ACID PLANTS (SUB IA-4.1)

This area is downslope of Acid Plants 1 and 2 (Exhibit 6). On two occasions in 1995, there were releases of acid plant scrubber water. The scrubber water release percolated downward, surfaced at the base of the slope and ponded at the easement. The majority of elevated metal concentrations in soils occur at depths of zero to five feet bgs.

Depth to groundwater in this area is approximately 10 to 13 feet bgs, and it was presumed that the ponded water could have migrated to the water table. Groundwater in this area is being assessed by EP-114. The primary groundwater COCs are arsenic and lead. The maximum total arsenic, cadmium, lead, and selenium concentrations observed in this well are 323 mg/l, 4.0 mg/l, 6.6 mg/l, and 0.18 mg/l, respectively.

5.8 SOIL DOWNSLOPE OF MEDFORD SUMP (SUB IA-4.2)

This area is also located at the mouth of the Acid Plant Arroyo, downslope and southwest of the Acid Plant Mist Precipitator Building and the Medford Sump (Exhibit 6). Arsenic and lead are primary soil COCs in this sub-area as a result of former practices associated with the Medford Sump area, which resulted in ponding of fluids of the area. This source has been eliminated or greatly reduced as part of recent storm water control improvements.

Groundwater in this area is being assessed by EP-115. The maximum total arsenic, cadmium, lead, and selenium concentrations observed in this monitoring well are 0.45 mg/l, 1.1 mg/l, 0.19 mg/l, and 1.7 mg/l, respectively.

5.9 SOIL DOWNSLOPE OF LEAD PLANT (SUB IA-4.3)

This area is downslope of the lead plant baghouse. In 1978, an accidental release of flue dust occurred when a newly installed flue collapsed. The flue fell onto the rail lines and portions of Paisano Drive. Flue dust in the form of mud accumulated in the area. Arsenic and lead appear to be the primary COCs in soil.

Groundwater in this area has been assessed by EP-116 and EP-117 (Exhibit 6). The primary groundwater COCs in this area are arsenic, cadmium and lead. Total maximum arsenic, cadmium, lead, and selenium concentrations observed from the mentioned wells are 11 mg/l (EP-117), 3.5 mg/l (EP-116), 10 mg/l (EP-117) and 1.3 mg/l (EP-117), respectively.

5.10 HISTORIC SMELTERTOWN/RIO GRANDE FLOODPLAIN AREA (IA-5)

This area was historically used generally as private housing for plant employees and their families. In 1972 the town was demolished and the families relocated. Lead in soil appears to be the primary constituent of concern for this area. Overall, this area has probably been impacted by historic operations of the Lead Plant, and possibly by site soil importation and grading for the development of the area for housing.

Groundwater occurs at 9 to 13 feet bgs and generally flows to the west and southwest toward the Rio Grande. The observed variations in concentrations of COCs in groundwater are attributed in part to geology. Aquifer materials in the middle portion of IA-5 (see Exhibit 1) tend to have a clayey composition, which may inhibit the migration or accumulation of metals in groundwater. The hydrogeological conditions in this area suggest that the metals affecting groundwater originated in upgradient source areas, which then migrated downgradient to the Smeltertown/Rio Grande floodplain area via the arroyos.

Groundwater in this area is characterized by monitoring wells EP-57, EP-58, EP-59, EP-60, EP-61, EP-62, EP-63, EP-64, EP-65, EP-66, EP-80, EP-119, EP-122, EP-132, and EP-135 (Exhibit 1). Arsenic and selenium in groundwater appear to be the primary COCs in this area. Concentrations in groundwater are not uniform across the area. Monitoring wells EP-60, EP-61, EP-63, EP-64 and EP-65 have consistantly shown arsenic concentrations below regulatory limits. The highest total arsenic, cadmium, lead and selenium concentrations observed in monitoring wells in the historic Smeltertown area are 11 mg/l (EP-66), 0.012 mg/l (EP-66), 0.046 mg/l (EP-61, and 0.54 mg/l (EP-64), respectively.

5.11 NORTHERN ARROYOS EAST OF I-10 (IA-11)

This area was formerly used for storage of facility construction materials, demolition debris and arsenic processing material. The majority of the area is undisturbed with occasional dirt roads, flood control works including two reservoirs or drainage basins and two dam structures. The predominant topographic features within IA-11 are two open arroyos. These are referred to as the Northern and Southern Arroyos of IA-11. The two arroyos drain into the Ephemeral Pond and Pond Sediment Storage Area.

Groundwater within this area is being investigated by monitoring wells EP-83, EP-84, EP-93, EP-94, EP-95, EP-96, EP-97, EP-98, EP-129 ((Exhibit 6). Depth to groundwater is highly variable ranging from 6 to 60 feet bgs depending on the location of the wells relative to the arroyos. Groundwater in the area generally flows from east to west, with the primary control features being the two arroyos. These arroyos both originate further upgradient than the northern facility boundary.

The highest total arsenic, cadmium, lead, and selenium concentrations observed in the above mentioned monitoring wells are 0.23 mg/l (EP-97), 0.023 mg/l (EP-97), 0.69 mg/l (EP-97), and 0.58 mg/l (EP-98), respectively.

Appendices F and G show cumulative lists of groundwater analytical results for all RI monitoring wells.

6.0 GROUNDWATER ALTERNATIVE ANALYSIS

This Phase IV report has presented and discussed the results of additional monitoring of groundwater quality as proposed in the previously submitted Phase III Remedial Investigation Report. The results of this report support observations made in the past regarding the occurrence of contaminants of concern in the groundwater beneath the El Paso smelter. To summarize, there appear to be potential conduits for contaminants along the paths of the historical arroyos on site that have been backfilled with slag and smelter-related material. With the removal of source areas (i.e. the drying of Ponds 1, 5 and 6), and implementation of on-plant water controls, there is an indication that the concentration of contaminants is decreasing in the vicinity of the sources, and there is some increase in concentrations downgradient. The downgradient increases could be a result of contaminant plumes migrating down the arroyo pathways or historical spills that have not yet run their course.

Future efforts in groundwater investigation at the El Paso smelter will be focused on the analysis of potential for mitigation of waters with elevated groundwater contamination. In order to properly conduct a remedial feasibility analysis, additional information needs to be collected to more completely describe the system. The following sections discuss the information needs more specifically, and present a scope of work for the anticipated remedial alternatives analysis.

The additional investigation activities and alternative evaluations will be closely coordinated with the International Boundary and Water Commission (IBWC) canal restoration project. The IBWC has prepared a conceptual design for the project but construction dewatering parameters have not been defined. Asarco and the IBWC could have an opportunity to develop aquifer data that would be beneficial for the IBWC's design engineers and Asarco's groundwater team, and the construction project offers additional opportunity for potentially innovative mitigative approaches.

6.1 ADDITIONAL INVESTIGATIONS

Additional information is needed to describe the physical and chemical system of groundwater and contaminant occurrence at the El Paso smelter, and to allow an analysis of the most effective and efficient means of mitigating groundwater contaminants. In some cases the information needed will necessitate alteration in the methods of collecting data and in other cases will involve the collection of new information. Information needs are explained further below.

Site water balance. Information regarding water inputs, usage and outputs is needed for the site. This will allow the identification of potential water losses that could be sources that may exacerbate the occurrence and/or migration of contaminants in groundwater. Understanding of such sources could be critical in addressing the mitigation of groundwater contamination at the facility.

Water quality data. In addition to the routine quarterly monitoring of groundwater, additional water quality data will need to be collected from selected wells. These will include sufficient samples to allow speciation of contaminants, and collection of samples from discrete locations (i.e. depths) at selected wells. The data collected will allow further characterization of the plume and will enable better assessment of treatability options.

Aquifer characteristics. Additional information is needed to more completely describe the hydrologic properties of the aquifer. This information will allow for a better understanding of the flow regimes and potential interactions of the arroyos, alluvial aquifer and the river. In addition to enhancement in understanding of the nature of groundwater flow and contaminant transport in the underlying aquifer, this information is also necessary to assess the potential treatability and efficiency for various treatment alternatives.

Bench tests. Treatment technologies will need to be assessed for effectiveness on the groundwater contaminant concentrations at the site. This testing may be in-situ (i.e. in the well) or in the laboratory using samples taken from the wells. Ideally, wells will be targeted for testing based on the presence of contaminants at relatively high concentrations or at concentrations that optimize the various treatment options.

Following the collection of information described above, the data gathered will be evaluated during preparation and completion of an alternative analysis. The details of the conduct of the proposed alternative analysis are presented below.

6.2 ANALYSIS OF ALTERNATIVES

With the collection of the additional data, it will be possible to complete the analysis of treatment alternatives. As mentioned above, treatment feasibility depends on the physical nature of the contamination, the characteristics of the aquifer that will lead to effective containment or collection of contaminant plumes, and the species of contaminant that will be treated. With the above information in hand, it will be possible to proceed with the analysis and ultimate selection of a treatment alternative.

Bench testing will help to identify whether selected alternatives will be effective in treating or mitigating the groundwater contamination at the site. Once the feasibility is established, the remainder of the analysis will identify the capital costs for construction of the alternative, operation and maintenance costs during the operation, and costs related to the dismantling of any treatment apparatus. The life cycle costs for the alternatives would be evaluated against the relative treatment efficacy.

A preliminary list of potential alternatives and approaches is provided below. These alternatives will likely be evaluated during the analysis, and some other alternatives not presently contemplated may be included as well. The final list of alternatives may or may not include all of the approaches discussed below.