

ATTACHMENT 2E* ATTENUATION

ACTION LEVELS DETERMINATION
(PROVIDED ON THUMB DRIVE)





*** For Attenuation Action Levels Determination, See *Arroyo Groundwater Arsenic Discharge Concentration Predictions and Estimation of Flushing Timeframes* (Appendix 3.9).**

*** Please see the following pages for summary of Protective Concentration Level development.**

ATTACHMENT 2E - PROTECTIVE CONCENTRATION LEVEL DEVELOPMENT

Protective Concentration Levels (PCLs) are risk-based remediation levels derived using algorithms and exposure assumptions (30 TAC §350.74), chemical and physical parameters (30 TAC §350.73), and toxicity factors updated annually with Tier 1 PCL updates. The PCLs have been derived for site-specific exposure media and land use scenarios consistent with current and future land uses. This document presents a summary of information described in the *Groundwater Flux Estimate Summary* (Arcadis 2016a) and the *Conceptual Site Model, Pathway Evaluation, and Protective Concentration Level Report* (Arcadis 2016b).

Surface Water PCLs

Surface water PCLs (^{SW}SW) are derived based on the use classification of the water body published in the TSWQS (30 TAC §307). Segment 2314 of the Rio Grande is classified as being used as a potable water source and a highly valued ecological habitat. As a result, the ^{SW}SW PCLs were derived from a comparison of aquatic life criteria (acute and chronic criteria) and human health-based criteria (consumption of water and aquatic organisms and consumption of organisms only). The aquatic life criteria for arsenic, cadmium, chromium, copper, lead, nickel, and zinc have hardness-dependent toxicity criteria and are based on dissolved concentrations of metals. The hardness and total suspended solids (TSS) data used to calculate aquatic life criteria for these metals were obtained from the *Procedures to Implement the Texas Surface Water Quality Standards* (TCEQ, 2010). A comparison of aquatic life criteria and human health-based criteria is presented in **Table 2E-1**.

Sediment PCLs

Sediment PCLs for metals in the Rio Grande are based on direct contact with human receptors under a recreational scenario and ecological receptors based on benthic organisms. The human health-based Tier 1 PCLs for recreational exposure (^{TotSedComb}) are based on incidental ingestion and dermal absorption routes of exposure. The ecological PCLs for sediment in the Rio Grande (^{EcoSed}) are based on the midpoint concentration between benchmark levels and secondary effect levels published in the TCEQ guidance, *Conducting Ecological Risk Assessments at Hazardous Waste Sites in Texas* (RG-263;TCEQ, 2014). A summary of sediment PCLs for the Rio Grande is presented in **Table 2E-2**.

Groundwater PCLs

Groundwater PCLs have been derived based on exposure pathways including direct potable use (^{GWGW_{Ing}}), groundwater discharge to surface water (^{SWG}GW) in the Rio Grande, and adsorption of COCs from discharging groundwater to sediment (^{SedGW}) in the Rio Grande. Groundwater PCLs are based on Tier 1 ^{GWGW_{Ing}} PCLs, which are based on direct potable use of Class 1/Class 2 groundwater, and fate-and-transport PCLs based on groundwater discharge to surface water (^{SWG}GW). The ^{SWG}GW PCLs are based on dilution factors calculated from site-specific groundwater flux estimates and published minimum flow rates for the Rio Grande above the International Dam (Segment 2314) as published in the TCEQ

Attachment 2E - Protective Concentration Level Development (Continued)

Surface Water Quality Standard Implementation Procedures (RG-194; TCEQ, 2010). The ^{SW}GW is considered an initial PCL used strictly for establishing PCLE Zones. The ^{SW}GW PCLs are based on groundwater gradients for individual AAs.

Three monitoring wells were identified as being upgradient from contamination sources at the Former ASARCO Smelter Site (Site). Groundwater quality sample results from semiannual monitoring events conducted between 2003 and 2013 were used to establish background concentrations of metals with regularly detected concentrations. The upper predicted limit (UPL) was calculated at a 95% confidence limit for a one-tail test. The average and UPL concentrations of metals in groundwater samples are summarized in **Table 2E-3**.

The most significant background concentrations reported are for arsenic and selenium. Both of these COCs have background concentrations in excess of regulatory levels. The UPL for arsenic is 0.02 mg/L, which is higher than its maximum contaminant level (MCL) of 0.01 mg/L. The UPL for selenium is 0.035 mg/L, which is below its MCL of 0.05 but higher than the surface water quality criterion of 0.005 mg/L.

The groundwater PCLs for the Site were derived by taking the higher of the Tier 1 ^{GW}GW_{ing} PCLs and the calculated background concentrations. The ^{GW}GW PCLs for the Site are summarized in **Table 2E-4**. Additional PCLs for groundwater are based on the groundwater-to-surface water pathway (^{SW}GW). The calculation of ^{SW}GW PCLs is based on site-specific information used to calculate groundwater-to-surface water dilution factors. The calculation of the dilution factor for groundwater discharge to surface water at the Site is described below.

The TCEQ publishes critical low stream channel flow rates for listed segments of waters of the State in the *Procedures to Implement the Texas Surface Water Quality Standards* (TCEQ, 2010). The Rio Grande near the Site is identified as Segment 2314 in the TSWQS (30 TAC §307). The TCEQ Water Quality Division (WQD) calculated the seven-day, two-year low flow (7Q2) and Harmonic Mean Flow (HMF) for Segment 2314 based on IBWC gaging data for the timeframe from 1981 through 2011. The 7Q2 flow estimated by the TCEQ WQD is 2.1 cubic feet per second (cfs) for Segment 2314 of the Rio Grande, while the HMF calculated by the WQD was 6.2 cfs. The groundwater flow from the combined Plant Site arroyos and PBA AAs is estimated to be 0.074 cfs (Arcadis 2016a). TCEQ guidance allows for a Tier 2 PCL calculation of ^{SW}GW PCLs based on site-specific dilution factors (30 TAC §350.75(i)(4)(E)). Site-specific dilution factors can be calculated using the relative surface water critical low-flow rate (7Q2) for ecological-based criteria and the groundwater flow rate using the following equation (RG-366, TRRP-24):

$$Dilution\ Factor = \frac{GWF}{GWF + 7Q2} = 0.03404$$

where:

GWF = Groundwater Flow (cfs)

7Q2 = Critical Low Surface Water Flow Rate (cfs)

The dilution factor for human health endpoints was calculated using the HMF and the following formula:

Attachment 2E - Protective Concentration Level Development (Continued)

$$DF = \frac{GWF}{GWF + HMF} = 0.01179$$

where:

- DF - Dilution Factor
- GWF - Groundwater Flux (cfs)
- HMF - Mean Harmonic Flow (cfs)

The corresponding combined dilution factor for ecological receptors from all of the arroyos at the Site is 0.03404 based on a 7Q2 flow rate in the Rio Grande of 2.1 cfs and a groundwater flow from the Assessment Areas (AAs) of 0.074 cfs. The dilution factor for human health receptors is 0.01179 based on the HMF of 6.2 cfs in the Rio Grande and the combined groundwater flow rate of 0.074 cfs. **Table 2E-5** presents a summary of the ^{SW}GW PCLs using the site-specific dilution factors. The dilution factors are based on site-specific measurements of groundwater flow. The groundwater flow is largely based on groundwater gradient, which will be subject to controls associated with the remedial response at the Site.

Finally, PCLs were calculated for COCs in groundwater discharging to the Rio Grande that can potentially adsorb to sediment. The ^{Sed}GW PCLs for the Site are summarized in **Table 2E-6**. The groundwater-to-sediment PCL was calculated using equations presented in TCEQ guidance (RG-366/TRRP-24) as follows:

$$^{Sed}GW = ^{Sed}PCL \times K_{Sed-w} \times SWMF$$

where:

- ^{Sed}GW = Groundwater-to-sediment PCL
- SWMF = Surface water mixing factor (assumed to be 1)
- K_{Sed-w} = Sediment-groundwater partitioning coefficient
[(mg/L-groundwater)/(mg/kg-sediment)]

$$K_{Sed-w} = \frac{\rho_{Sed}}{\theta + K_d \rho_{Sed}}$$

where:

- ρ_{Sed} = Sediment bulk density (1.67 g/cm³ – TRRP-24)
- θ = Sediment porosity (0.37 cm³- pore space/cm³ – sediment – TRRP-24)
- K_d = Sediment-water sorption coefficient [g-H₂O/g-sediment – [30 TAC 350.73(f)(1)(C) and 30 TAC 350.73(f)]]

Soil PCLs

The Soil PCLs include those based on fate and transport mechanisms of COCs from soil migrating to groundwater (^{GW}Soil_{ing}), transport from soil to groundwater and discharge to surface water (^{SW-GW}Soil), and transport from soil to groundwater and adsorption to sediment of the Rio Grande (^{Sed-GW}Soil). Soil PCLs also include direct contact pathways (^{Tot}Soil_{Comb}) for residential and commercial/industrial (C/I) land uses. Finally, ecological-based PCLs (^{Eco}Soil) were derived for specific COCs in surface soil of the South

Attachment 2E - Protective Concentration Level Development (Continued)

Arroyo in the East Property AA based on results of the Screening Level Ecological Risk Assessment (SLERA) for the Site (Arcadis 2016b).

Similar to the discussion for groundwater PCL derivation, soil PCLs are derived using algorithms and assumptions published in the TRRP regulations. The soils at the Site are very alkaline in nature. Based on site-specific soil pH data, the soil-to-groundwater ($^{GW}Soil_{ing}$) PCLs were calculated assuming a site-specific soil pH of 8. The $^{GW}Soil_{ing}$ PCLs are summarized in **Table 2E-7**. The soil-to-groundwater equation is published in the TRRP rule (30 TAC 350.75(b)(1)):

$$^{GW}Soil = \frac{Groundwater\ PCL \times LDF}{K_{SW}}$$

where:

$^{GW}Soil$ = Soil-to-groundwater PCL

LDF = Leachate dilution factor [assumed to be 10 based on 30-acre affected property – 30 TAC 350.75(b)(1)]

K_{SW} = Soil-leachate partitioning coefficient
[(mg/L-groundwater)/(mg/kg-soil)]

$$K_{SW} = \frac{\rho_b}{\theta_{ws} + K_d\rho_b + H'\theta_{as}}$$

where:

ρ_b = Soil bulk density [1.67 g/cm³ – 30 TAC 350.75(b)(1)]

θ_{ws} = Water content of vadose zone [0.16 cm³ – water/cm³ – soil – 30 TAC 350.75(b)(1)]

θ_{as} = Air content of vadose zone [0.21 cm³ – water/cm³ – soil – 30 TAC 350.75(b)(1)]

H' = Henry's constant – dimensionless [30 TAC 350.73(f)]

K_d = Soil-water sorption coefficient [g-H₂O/g-soil – (30 TAC 350.73(f))

The $^{GW}Soil$ and $^{SW-GW}Soil$ PCLs for lead were calculated assuming a loam soil type as described for Site soils. Soil-to-groundwater-to-surface water PCLs ($^{SW-GW}Soil$) were calculated using the same equations and assumptions applied to the $^{GW}Soil$, except the use of the surface water PCL (^{SW}SW) was used as the $^{SW-GW}Soil$ calculation. **Table 2E-8** provides a summary of the soil-to-groundwater-to-surface water PCLs. The calculation of the $^{Sed-GW}Soil$ PCLs are based on the ^{Sed}GW pathway. **Table 2E-9** provides a summary of the soil-to-groundwater-to-sediment pathway for the protection of the Rio Grande.

The direct contact PCLs for soil have been calculated based on multiple routes of exposure including incidental ingestion of soil, dermal absorption of soil directly adhered to skin, and inhalation of fugitive dust from surface soil. PCLs were calculated for each of the environmental media impacted by COC concentrations above residential screening levels and for each of the complete exposure pathways. The direct contact PCLs for both residential and C/I land uses are based on Tier 1 $^{Tot}Soil_{Comb}$ PCLs reported by the TCEQ for all COCs except arsenic. The arsenic $^{Tot}Soil_{Comb}$ PCLs for residential (46 mg/kg) and C/I (320 mg/kg) land uses are based on Tier 2 calculations using a 40% relative bioavailability factor reported by the USEPA. **Table 2E-10** provides a summary of the soil PCLs for residential land use, while **Table 2E-11** provides a summary of soil PCLs calculated for C/I land use.

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The SLERA for the Site indicated that unacceptable exposure of ecological receptors exist in the habitat area of the South Arroyo in the East Property AA. Ecological-based PCLs (^{Eco}Soil) for arsenic, cadmium, copper, lead, and zinc were developed specifically for soil in the South Arroyo. The ^{Eco}Soil PCLs were back-calculated from exposure models for mammalian and avian receptors used in the SLERA. **Table 2E-12** provides a summary of the ^{Eco}Soil PCLs for the South Arroyo.

A summary of PCLs for soil, groundwater, and surface water at the Site is presented in **Table 2E-13**.

References

Arcadis. 2016a. Groundwater Flux Estimate Summary, Former ASARCO Smelter Site, El Paso Texas. Prepared for Texas Custodial Trust, July.

Arcadis. 2016b. Conceptual Site Model, Pathway Evaluation, and Protective Concentration Level Report, Former ASARCO Smelter Site, El Paso, Texas. July.

TCEQ. 2010. Procedures to Implement the Texas Surface Water Quality Standards. RG-194 (revised). Water Quality Division. June 2010.

TCEQ. 2014. Conducting Ecological Risk Assessments at Remediation Sites in Texas. RG-263 (revised). Remediation Division. January.

**Table 2E-1
Summary of PCL Development for COCs in Surface Water of the Rio Grande
Former ASARCO Smelter Site**

	MCL / Tier 1 GW GW	Secondary MCL	Freshwater Acute Criteria (Total)	Freshwater Chronic Criteria (Total)	Water and Fish (Total) ²	Fish Only (Total)	^{SW} SW PCL (Total)
Antimony	0.006	NE	NE	0.16	0.006	1.071	0.006
Arsenic	0.01	NE	0.72	0.32	0.021	NE	0.01
Barium	2	NE	NE	16	NE	NE	2
Cadmium	0.005	NE	0.073	0.0016	0.018	NE	0.0016
Chloride ²	NE	250	NE	NE	340	NE	340
Chromium	0.1	NE	5.99	1	NE	NE	0.1
Cobalt	0.24	NE	45	1.5	NE	NE	0.24
Copper	1.3	1	0.11	0.07	NE	NE	0.07
Iron	NE	0.3	NE	1	NE	NE	NE
Lead	0.015	NE	1.04	0.039	0.0073	0.024	0.0073
Mercury	0.002	NE	0.0024	0.0013	0.000012	0.000012	0.000012
Molybdenum	0.122	NE	60	2	NE	NE	0.122
Nickel	0.49	NE	2.87	0.32	0.97	3.33	0.32
Selenium	0.05	NE	0.02	0.005	0.05	NE	0.005
Silver	0.12	NE	0.0074	0.0007	NE	NE	0.0007
Sulfate ²	NE	250	NE	NE	600	NE	600
Thallium	0.002	NE	NE	0.004	0.00012	NE	0.00012
Zinc	7.3	5	1.05	1.06	NE	NE	1.05
Fluoride	4	2	NE	NE	4	NE	4
Nitrate	10	NE	NE	NE	10	NE	10
Nitrite	1	NE	NE	NE	NE	NE	1

Notes:

1. Results are shown in milligrams per liter (mg/L).
2. Surface water PCL based on basin-specific criteria for Segement 2314 - 30 TAC §307.10(1) - Appendix A.

^{GW}GW = groundwater PCL
MCL= Maximum Contaminant Level
NC = Not calculated
NE = Not established
PCL = Protective Concentration Level
^{SW}SW = surface water PCL

**Table 2E-2
Summary of PCL Development for COCs in Sediment in the Rio Grande
Former ASARCO Smelter Site**

	Freshwater Sediment Benchmark	Freshwater Secondary Effect Levels	Sediment Ecological PCLs - EcoSed	Human Health-based Sediment PCLs - TotSed_{Comb}	Selected Sediment PCL
Antimony	2	25	13.5	83	13.5
Arsenic	9.79	33	21.4	110	21.4
Barium	NE	NE	NE	23,000	23,000
Cadmium	0.99	4.98	3	1,100	3
Chromium	43.4	111	77	36,000	77
Cobalt	50	NE	50	32,000	50
Copper	31.6	149	90	21,000	90
Iron	20,000	40,000	30,000	NE	30,000
Lead	35.8	128	82	500	82
Mercury	0.18	1.06	0.62	34	0.62
Molybdenum	NE	NE	NE	1,800	1,800
Nickel	22.7	48.6	36	1,400	36
Selenium	2	NE	2	3,700	2
Silver	1	2.2	1.4	350	1.4
Thallium	NE	NE	NE	43	43
Zinc	121	459	290	76,000	290

Notes:

1. Results are shown in milligrams per kilogram (mg/kg).

EcoSed = Direct exposure of ecological receptors to COCs in sediment and food chain

NE = Not established

PCL = Protective Concentration Level

TotSed_{Comb} = Direct contact with COCs in sediment by total combined direct contact, assuming incidental ingestion and dermal absorption as potentially complete routes of exposure

Table 2E-3

**Statistical Summary for Background Levels of COCs in Groundwater
based on Water Quality Data from Monitoring Wells EP-86, EP-95, and EP-129 (2003 – 2013)
Former ASARCO Smelter Site**

Groundwater					
	Number of Samples	Average Concentration (mg/L)	Standard Deviation (mg/L)	t_{0.95} value	95% UPL Concentration (mg/L)
Arsenic	44	0.009	0.0065	1.684	0.02
Barium	9	0.025	0.00611	1.833	0.037
Chloride	64	327	58	1.671	425
Chromium	22	0.0045	0.00652	1.717	0.016
Copper	24	0.013	0.02699	1.711	0.06
Fluoride	16	3.44	2.69984	1.746	8.3
Iron	38	0.183	0.30583	1.684	0.704
Molybdenum	9	0.04	0.01515	1.833	0.069
Selenium	45	0.02	0.00928	1.684	0.035
Sulfate	63	748	134	1.671	974
Zinc	35	0.023	0.03579	1.684	0.084

Notes:

1. The upper predicted limit (UPL) was calculated at a 95% confidence limit for a one-tail test. This table summarizes average and UPL concentrations metals in groundwater samples.

mg/L = milligrams per liter

**Table 2E-4
Summary of Groundwater PCL (^{GW}GW) Development
Former ASARCO Smelter Site**

	Maximum Contaminant Level (MCL)	Tier 1 ^{GW}GW_{ing}	Background 95% UPL	Selected ^{GW}GW PCL
Antimony	0.006	0.006	NA	0.006
Arsenic	0.01	0.01	0.02	0.02
Barium	2	2	0.037	2
Cadmium	0.005	0.005	NA	0.005
Chloride	NE	NE	425	425
Chromium	0.1	0.1	0.016	0.1
Cobalt	NE	0.24	NA	0.24
Copper	1.3	1.3	0.06	1.3
Iron	NE	NE	0.704	0.704
Lead	0.015	0.015	NA	0.015
Mercury	0.002	0.002	NA	0.002
Molybdenum	NE	0.122	0.069	0.122
Nickel	NE	0.49	NA	0.49
Selenium	0.05	0.05	0.035	0.05
Silver	NE	0.12	NA	0.12
Sulfate	NE	NE	974	974
Thallium	0.002	0.002	NA	0.002
Zinc	NE	7.3	0.084	7.3
Fluoride	4	4	8.3	8.3
Nitrate	10	10	NA	10
Nitrite	1	1	NA	1

Notes:

- Results are shown in milligrams per liter (mg/L).
- Groundwater Protective Concentration Levels (PCLs) were derived by taking the higher of the Tier 1 ^{GW}GW_{ing} PCLs and the calculated background concentrations.

^{GW}GW = groundwater PCL

^{GW}GW_{ing} = Groundwater ingestion

NA = Not applicable

NE = Not established

UPL = upper predicted limit

**Table 2E-5
Summary of Groundwater-to-Surface Water PCL (^{SW}GW) Development
Former ASARCO Smelter Site**

	^{SW} SW PCL ¹	Dilution Factor ²	^{SW} GW PCL ¹	Background 95% UPL ¹	Selected ^{SW} GW PCL ¹
Antimony	0.006	0.01179	0.509	NA	0.509
Arsenic	0.01	0.01179	0.848	0.02	0.848
Barium	2	0.01179	170	0.037	170
Cadmium	0.0016	0.03404	0.047	NA	0.047
Chloride	340	0.01179	28,826	425	28,826
Chromium	0.1	0.01179	8.5	0.016	8.5
Cobalt	0.24	0.03404	7.1	NA	7.05
Copper	0.07	0.03404	2.06	0.06	2.06
Iron	NE	0.03404	NE	0.704	NE
Lead	0.0073	0.01179	0.619	NA	0.619
Mercury	0.000012	0.01179	0.00102	NA	0.00102
Molybdenum	0.122	0.01179	10.3	0.069	10.3
Nickel	0.32	0.03404	9.4	NA	9.4
Selenium	0.005	0.03404	0.147	0.035	0.147
Silver	0.0007	0.03404	0.022	NA	0.022
Sulfate	600	0.01179	50,870	974	50,870
Thallium	0.00012	0.01179	0.010	NA	0.010
Zinc	1.05	0.03404	31	0.084	31
Fluoride	4	0.01179	339	8.3	339
Nitrate	10	0.01179	848	NA	848
Nitrite	1	0.01179	85	NA	85

Notes:

1. Results are shown in milligrams per liter (mg/L).

2. Human health-based SWSW PCLs use Harmonic Mean flow of 6.2 cfs for dilution factor, ecological-based SWSW PCLs use 7Q2 Flow of 2.1 cfs for dilution factor. Human health PCLs are used for antimony, arsenic, barium, chloride, chromium, lead, mercury, molybdenum, sulfate, thallium, fluoride, Nitrate, and Nitrite.

^{GW}GW_{ing} = Groundwater ingestion PCL

NA = Not applicable

NE = Not established

PCL = Protective Concentration Level

^{SW}GW = groundwater-to-surface water PCL

^{SW}SW = surface water PCL

UPL = upper predicted limit

**Table 2E-6
Summary of Groundwater-to-Sediment PCL (^{Sed}GW) Development
Former ASARCO Smelter Site**

	Sed PCL (mg/kg)	Kd [30 TAC 350.73(f)]	K_{sed-w}	Selected ^{Sed}GW PCL (mg/L)
Antimony	13.5	31	0.032	0.43
Arsenic	21.4	31	0.032	0.69
Barium	23,000	44	0.023	520
Cadmium	3.0	280	0.004	0.011
Chromium	77	3,400,000	0.0000003	0.00002
Cobalt	50	1202	0.001	0.04
Copper	90	45	0.022	1.99
Iron	NE	NE	NE	NE
Lead	82	597	0.002	0.14
Mercury	0.62	130	0.008	0.005
Molybdenum	1800	20	0.049	89
Nickel	36	180	0.006	0.20
Selenium	2	3.5	0.269	0.54
Silver	1	110	0.009	0.009
Thallium	NE	NE	NE	NE
Zinc	290	95	0.011	3.0

Notes:

1. Results are shown in milligrams per liter (mg/L).

^{Sed}GW = Groundwater to Sediment PCL

K_d (water-to-sed partitioning coefficient) based on TRRP rule [30 TAC 350.73(f)]
based on pH of 7.3 in groundwater.

NA = Not applicable

NE = Not established

K_d = Partitioning coefficients published in 30 TAC 350.73(f).

K_{sed-w} = Sediment-to-groundwater partitioning coefficient

PCL = Protective Concentration Level

Summary of Tier 2 Soil-to-Groundwater (^{GW}Soil_{Ing})PCLs
Former ASARCO Smelter Site

	K_d^1	H^{i2}	K_{SW}^3	^{GW} GW _{Ing} Res(mg/L)	Tier 2 Res ^{GW} Soil _{Ing} (mg/kg)	^{GW} GW _{Ing} C/I(mg/L)	Tier 2 C/I ^{GW} Soil _{Ing} (mg/kg)
Antimony	22		0.045	0.006	1.33	0.006	1.33
Arsenic	31		0.032	0.02	6.2	0.02	6.2
Barium	52		0.019	2	1,042	2	1,042
Cadmium	4,300		0.00023	0.005	215	0.005	215
Chromium	4,300,000		0.0000002	0.1	1,000,000	0.1	1,000,000
Cobalt	45		0.022	0.24	107	0.73	327
Copper	40		0.025	1.3	519	1.3	519
Iron	NE		NE	0.704	NE	0.704	NE
Lead ^[a]	597		0.0017	0.015	90	0.015	90
Mercury ^[b]	200	0.474	0.0050	0.002	4.0	0.002	4.0
Molybdenum	20		0.050	0.122	24	0.37	74
Nickel	1,900		0.00053	0.49	9,310	1.5	28,501
Selenium	2.2		0.436	0.05	1.15	0.05	1.15
Silver	110		0.009	0.12	132	0.37	407
Thallium	96		0.0104	0.002	1.9	0.002	1.9
Zinc	530		0.0019	7.3	38,697	22	116,621

Notes:

1 - K_d (soil-to-water partitioning coefficient) based on values published in TRRP rule [30 TAC 350.73(f)] based on pH of 8.0.

2 - H^i (unitless Henry's Constant) based on values published in TRRP rule [30 TAC 350.73(f)].

3 - K_{SW} (soil leaching partitioning factor) based on the following equation: $K_{SW} = \rho_b / (\theta_{ws} + K_d\rho_b + H^i\theta_{as})$

where:

ρ_b - Bulk soil porosity; θ_{ws} - Water-filled pore space; and θ_{as} - air-filled pore space.

**Table 2E-8
Summary of PCL Development for transport of COCs from
Soil to Groundwater, Discharging to Surface Water
Former ASARCO Smelter Site**

	K_d^1	H'^2	K_{SW}^3	Selected ^{SW}GW PCL	Tier 2 $^{SW-GW}Soil$	Texas State Background	Selected $^{SW-GW}Soil$ PCL
Antimony*	22		0.045	0.509	112	1	112
Arsenic*	31		0.032	0.848	264	5.9	264
Barium	52		0.019	170	88338	300	88,338
Cadmium*	4,300		0.00023	0.047	2021	NE	2,021
Chromium*	4,300,000		0.0000002	8.48	364,570,278	30	364,570,278
Cobalt*	45		0.022	7.05	3156	7	3,156
Copper*	40		0.025	2.06	821	15	821
Iron	NE		NE	NE	NE	15,000	15,000
Lead*	597		0.0017	0.62	3696	15	3,696
Mercury*	200	0.474	0.0050	0.00102	2.0	0.04	2.0
Molybdenum	20		0.050	10.3	2074	NE	2,074
Nickel*	1,900		0.00053	9.40	178630	10	178,630
Selenium	2.2		0.436	0.15	3	0.3	3
Silver*	110		0.009	0.022	24	NE	24
Thallium	96		0.0104	0.010	10		
Zinc*	530		0.0019	31	163520	30	163,520

Notes:

1 - K_d (soil-to-water partitioning coefficient) based on values published in TRRP rule [30 TAC 350.73(f)] based on pH of 8.0.

2 - H' (unitless Henry's Constant) based on values published in TRRP rule [30 TAC 350.73(f)].

3 - K_{SW} (soil leaching partitioning factor) based on the following equation: $K_{SW} = \rho_b / (\theta_{ws} + K_d\rho_b + H'\theta_{as})$

where:

ρ_b - Bulk soil porosity; θ_{ws} - Water-filled pore space; and θ_{as} - air-filled pore space.

$^{SW-GW}Soil$ = Leaching from soil to groundwater then discharging to surface water

**Table 2E-9
Summary of PCL Development for transport of COCs from
Soil to Groundwater, Discharging to Sediment
Former ASARCO Smelter Site**

	K_d^1	H'^2	K_{SW}^3	Selected Sed GW PCL	Tier 2 Sed-GW Soil	Texas State Background	Selected Sed-GW Soil PCL
Antimony	22		0.045	0.43	96	1	96
Arsenic	31		0.032	0.69	213	5.9	213
Barium	52		0.019	520	270,955	300	270,955
Cadmium	4,300		0.00023	0.011	460	NE	460
Chromium	4,300,000		0.0000002	0.000023	974	30	974
Cobalt	45		0.022	0.042	19	7	19
Copper	40		0.025	1.99	794	15	794
Iron	NE		NE	NE	NE	15,000	15,000
Lead	597		0.0017	0.137	820	15	820
Mercury	200	0.474	0.0050	0.005	9.5	0.04	9.5
Molybdenum	20		0.050	89	17,846	NE	17,846
Nickel	1,900		0.00053	0.20	3,796	10	3,796
Selenium	2.2		0.436	0.537	12	0.3	12
Silver	110		0.009	0.009	10	NE	10
Thallium	96		0.0104	NE	NE	NE	NE
Zinc	530		0.0019	3.046	16,144	30	16,144

Notes:

1 - K_d (soil-to-water partitioning coefficient) based on values published in TRRP rule [30 TAC 350.73(f)] based on pH of 8.0.

2 - H' (unitless Henry's Constant) based on values published in TRRP rule [30 TAC 350.73(f)].

3 - K_{SW} (soil leaching partitioning factor) based on the following equation: $K_{SW} = \rho_b / (\theta_{ws} + K_d\rho_b + H'\theta_{as})$

where:

ρ_b - Bulk soil porosity; θ_{ws} - Water-filled pore space; and θ_{as} - air-filled pore space.

PCL = Protective Concentration Level

^{Sed}GW = Groundwater to Sediment PCL

^{Sed-GW}Soil = Leaching from soil-to-groundwater then adsorbing to sediment

Table 2E-10
Summary of PCL Development for Residential Soils

Former ASARCO Smelter Site

	SAI-Res / Tier 2	Tot ^{Soil} Comb	Air ^{Soil} Inh-VP	Tier 1 ^{GW} Soil _{Ing}	Tier 2 ^{GW} Soil _{Ing}	Texas State Background	Selected ^{GW} Soil _{Ing} PCL	Selected ^{Tot} Soil _{Comb} PCL
Antimony	72	15	NE	2.7	1.33	1	2.7	15
Arsenic	20	46	2,700	2.5	6.22	5.9	6.2	46
Barium	26,000	8,100	NE	220	1,042	300	1,200	8,100
Cadmium	240	52	6,500	0.75	215	NE	215	52
Chromium	59,000	27,000	70,000	1,200	1,000,000	30	1,000,000	27,000
Cobalt	15,000	400	3,000	110	107	7	220	400
Copper	10,000	1,300	NE	520	519	15	520	1,300
Iron	NE	NE	NE	NE	NE	15,000	NE	NE
Lead	500	500	NE	1.5	90	15	90	500
Mercury ^[a]	0.11	8.5	16	1.0	4.0	0.04	4	8.5
Molybdenum	1,100	160	NE	25	24.5	NE	25	160
Nickel	1,900	840	68,000	79	9,310	10	9,300	840
Selenium	1,300	310	NE	1.1	1.15	0.3	1.1	310
Silver	1,370	97	NE	0.24	132	NE	132	97
Zinc	59,000	9,900	NE	1,200	38,697	30	39,000	9,900

Footnotes:

[a] Mercury PCLs for ^{Tot}Soil_{Comb}, ^{Air}Soil_{Inh-VP}, and Tier 2 ^{GW}Soil_{Ing} are based on calculations using site-specific soil pH of 8.0.

Notes:

1. Results are shown in milligrams per kilogram (mg/kg).

SAI-Res = Soil/air ingestion standard for residential use (Texas Risk Reduction Standard 3)

^{Tot}Soil_{Comb} = Direct contact with COCs in surface soil by total combined dermal absorption, incidental soil ingestion, inhalation of vapors or particulate, and ingestion of COCs taken up in home-grown fruits vegetable routes of exposure

^{Air}Soil_{Inh-VP} = Inhalation of COCs adsorbed to fine particulate in wind-blown dust

^{GW}Soil_{Ing} = Leaching of COCs from soil to groundwater

NC = Not calculated

NE = Not established

PCL = Protective Concentration Level

Table 2E-11
Summary of PCL Development for Commercial/Industrial Soils

Former ASARCO Smelter Site

	SAI-Ind / Tier 2	TotSoil _{Comb}	AirSoil _{Inh-VP}	GWSoil _{Ing}	Tier 2 GWSoil _{Ing}	Texas State Background	Selected GWSoil _{Ing} PCL	Selected TotSoil _{Comb} PCL
Antimony	490	310	NE	2.7	0.00	1	2.7	310
Arsenic	200	320	4,500	2.5	er 2 Sed-GWSoil	5.9	6.2	320
Barium	170,000	120,000	NE	220	96	300	1,042	120,000
Cadmium	1,500	760	7,000	0.75	213	NE	215	760
Chromium	350,000	75,000	72,000	1,200	270,955	30	1,000,000	75,000
Cobalt	100,000	2,600	4,200	660	460	7	660	2,600
Copper	74,000	94,000	NE	520	974	15	520	94,000
Iron	NE	NE	NE	NE	18.62	15,000	NE	NE
Lead ^[a]	1,000	1,600	NE	1.5	794	15	90	1,600
Mercury ^[b]	0.15	20	22	1	NE	0.04	4	20
Molybdenum	8,100	4,500	NE	160	820	NE	160	4,500
Nickel	12,000	8,600	110,000	9,900	10	10	28,500	8,600
Selenium	9,300	4,900	NE	1.1	17845.89	0.3	1.15	4,900
Silver	10,200	2,300	NE	0.71	407	NE	407	2,300
Zinc	410,000	250,000	NE	3,500	10	30	116,600	250,000
PCBs	10	7.1	47	5.3	NE	NE	5.3	7.1

Footnotes:

[a] PCL for lead in sand of the East Property is 35 mg/kg, while PCL for lead in loam of Plant Site is 90 mg/kg.

[b] Mercury PCLs for TotSoil_{Comb}, AirSoil_{Inh-VP}, and Tier 2 GWSoil_{Ing} are based on calculations using site-specific soil pH of 8.0.

Notes:

1. Results are shown in milligrams per kilogram (mg/kg).

SAI-Ind = Soil/air ingestion standard for industrial use (Texas Risk Reduction Standard 2)

SAI-Res = Soil/air ingestion standard for residential use (Texas Risk Reduction Standard 2)

AirSoil_{Inh-VP} = Inhalation of COCs adsorbed to fine particulate in wind-blown dust

GWSoil_{Ing} = Leaching of COCs from soil to groundwater

TotSoil_{Comb} = Direct contact with COCs in surface soil by total combined dermal absorption, incidental soil ingestion, inhalation of vapors or particulate, and ingestion of COCs taken up in home-grown fruits vegetable routes of exposure

NC = Not calculated

NE = Not established

PCL = Protective Concentration Level

Table 2E-12
Ecological Soil PCLs (^{Eco}Soil) for South Arroyo of East Property AA
Former ASARCO Smelter Site

	Surface Soil (0 to 0.5 ft bgs)
Arsenic	78
Cadmium	12
Copper	495
Lead	364
Zinc	469

Notes:

- 1. Results are shown in milligrams per kilogram (mg/kg).
- ^{Eco}Soil = Direct exposure of ecological receptors to COCs in soil and food chain
- ft bgs = feet below ground surface
- PCL = Protective Concentration Level

Summary of Soil, Groundwater, and Surface Water PCLs
Former ASARCO Smelter Site

	C/I Tot ^{Soil} Comb (mg/kg)	Res Tot ^{Soil} Comb (mg/kg)	^{GW} Soil _{Ing} (mg/kg)	^{SW-GW} Soil (mg/kg)	^{Air} Soil _{Inh-VP} (mg/kg)	^{SW} SW PCL (Total)	^{SW} GW (mg/L)	^{Sed} GW (mg/L)	^{GW} GW _{Ing} (mg/L)
Antimony	310	15	2.7	112	NE	0.006	0.509	0.43	0.006
Arsenic	320	46	6.2	264	4,500	0.01	0.848	0.69	0.02
Barium	120,000	8,100	1,042	88,338	NE	2	170	520	2.0
Cadmium	760	52	215	2,021	7,000	0.0016	0.047	0.011	0.005
Chloride	NE	NE	NE	NE	NE	340	28,826	NE	425
Chromium *	75,000	27,000	1,000,000	364,570,278	72,000	0.1	8.48	0.016	0.1
Cobalt	2,600	400	660	3,156	4,200	0.24	7.05	0.04	0.24
Copper	94,000	1,300	520	821	NE	0.07	2.06	1.99	1.3
Iron	NE	NE	NE	15,000	NE	NE	NE	NE	0.704
Lead	1,600	500	90	3,696	NE	0.0073	0.619	0.14	0.015
Mercury	20	9	4	2	22	1.2E-05	0.001	0.005	0.002
Molybdenum	4,500	160	160	2,074	NE	0.122	10.34	89	0.122
Nickel	8,600	840	28,500	178,630	110,000	0.32	9.4	0.20	0.49
Selenium	4,900	310	1	3	NE	0.005	0.147	0.54	0.05
Silver	2,300	97	407	24	NE	0.0007	0.022	0.01	0.12
Sulfate	NE	NE	NE	NE	NE	600	50,870	NE	974
Thallium	NE	NE	NE	NE	NE	0.00012	0.010	NE	0.002
Zinc	250,000	9,900	116,600	163,520	NE	1.05	31	3.0	7.3
PCBs	7.1	NE	5.3	NE	47	NE	NE	NE	NE
Fluoride	NE	NE	NE	NE	NE	4	339	NE	8.3
Nitrate	NE	NE	NE	NE	NE	10	848	NE	10
Nitrite	NE	NE	NE	NE	NE	1	85	NE	1

Notes:

^{GW}GW_{Ing} = groundwater PCL

^{SW}GW = groundwater-to-surface water

^{Sed}GW = groundwater-to-sediment

Tot^{Soil}Comb = Direct contact with COCs in surface soil by total combined dermal absorption, incidental soil ingestion, inhalation of vapors or particulate for both commercial/industrial (C/I) and Residential (Res) scenarios. Res scenario also includes ingestion of COCs taken up in home-grown fruits vegetable routes of exposure

^{GW}Soil_{Ing} = Leaching of COCs from soil to groundwater

^{SW-GW}Soil = Leaching from soil to groundwater then discharging to surface water

^{Air}Soil_{Inh-VP} = Inhalation of COCs adsorbed to fine particulate in wind-blown dust
mg/kg = milligrams per kilogram

mg/L = milligrams per liter

NE = Not established

* ^{Sed}GW for chromium based on Background