

Identification of Corrective Action Technologies

This section presents corrective action technologies identified to address groundwater contamination for the POL Hill AST-2 Area. Only those technologies that are deemed implementable, based on site-specific conditions and COCs, are identified and described. Section 4.1 presents the technologies applicable for impacted soil and Section 4.2 presents the technologies applicable for impacted groundwater.

4.1 Soil Technologies

No remedial technologies were identified for soil. Screening of soil-sample analytical results indicates that contamination by TPH (measured as diesel) in the AST-2 Area exists primarily at levels below the RCG (200 mg/kg). The only sample that contained TPH (measured as diesel) at levels above the RCG was taken from within fractures in the bedrock beneath the former AST-2. Given the overall low levels and limited extent of the diesel contamination in the soil and the impracticability of excavating the bedrock, no further soil remediation will be conducted.

4.2 Groundwater Technologies

Site-specific conditions indicate that the impacted groundwater is isolated within fractured bedrock that has low hydraulic conductivities. As a result, technologies that use pump and treat methods were categorically excluded from consideration. Technologies that are considered applicable for remediation of the POL Hill AST-2 Area groundwater are institutional controls, in situ biodegradation, and MNA. These baseline technologies were selected as implementable because they are appropriate given site-specific conditions, use standard equipment, are available locally, and are frequently used in the remediation of hydrocarbon contamination. Descriptions of each technology with regard to site-specific information are presented in the following subsections.

4.2.1 Institutional Controls

Institutional controls considered applicable to groundwater contamination include:

- Physical barriers (e.g., fence installation) and deed restrictions (e.g., covenants restricting future use) can be used to aid in deterring unauthorized site access or usage.
- Groundwater monitoring is performed in conjunction with institutional controls to verify that contaminants are not migrating at unacceptable levels from the source and that the institutional controls are protective of human health and the environment.

- In this case, institutional controls can be used to limit the risk to receptors by limiting access to the contaminated site and the contaminant monitoring is used to ensure that migration is not occurring beyond the controlled area.

4.2.2 In Situ Biodegradation

In situ biological treatment utilizes native microorganisms (e.g., bacteria, actinomycetes, and fungi) to break down organic contaminants into benign compounds (e.g., biomass, water, and carbon dioxide). Treatment generally consists of optimizing conditions of pH, temperature, oxygen content, and nutrient concentration to stimulate the growth of microorganisms that will feed on the contaminants. Optimization usually is performed by adding liquid nutrient solutions to the groundwater. These solutions contain the required minerals and chemical agents to bring the pH, oxygen, and nutrient levels into the required ranges for microorganisms to feed on the contaminant.

The optimum pH for bacterial growth is near 7. This pH is generally maintained by adding lime to the soil to promote microbial activity. Some fungi have a competitive advantage under slightly acidic conditions, whereas actinomycetes flourish at slightly alkaline pH (Alexander, 1977).

However, near-neutral pH is most favorable to microbial functioning in general (Chambers et al., 1991). Groundwater samples from the POL Hill AST-2 Area show groundwater pH between 7.0 and 7.5, which is nearly optimum for microbial functioning.

Temperature is one of the most important factors controlling microbiological activity and the rate of decomposition of organic matter. Bachmann et al. (1988) reported that temperatures in the 20° to 30°C range were the most favorable. Microbial activity has been shown to decrease greatly at 10°C and essentially cease at 5°C for most organic materials. Groundwater samples from the POL Hill AST-2 Area show groundwater temperature between 16° and 20°C, which is in the favorable to most-favorable range for microbial growth.

During the decomposition of organic contaminants, inorganic nitrogen is rapidly consumed by the microorganisms, eventually resulting in slowdown of the degradation rate. Additional nitrogen must be supplied to attain optimum waste-decomposition rates. Other nutrients such as phosphorous, potassium, sulfur, and trace elements are usually present in adequate quantities in most organic wastes or groundwater to satisfy the needs of the majority of soil microorganisms. Additional nitrogen is typically supplied to attain optimum waste-decomposition rates.

Biological treatment can also be performed by increasing the oxygen levels in the soil through air injection (also known as bio-sparging). However, this method is generally less effective as the nutrient and pH levels may not be optimum for microorganisms to destroy the contaminant. Therefore, for this plan, biological treatment is assumed to consist of liquid addition to the contaminated groundwater to optimize oxygen, pH, and nutrient levels.

4.2.3 Monitored Natural Attenuation

MNA relies on natural processes to remove contaminants from the groundwater. The only remedial activity conducted is monitoring to evaluate the effectiveness of the natural

remediation process. Natural processes that are capable of reducing hydrocarbon concentrations include (API, 1989):

- **Biodegradation** – Microorganisms convert the hydrocarbons to carbon dioxide and water.
- **Volatilization** – Volatile components vaporize and migrate to the atmosphere.
- **Adsorption** – Hydrocarbons may adhere to the soil particles and become immobile. Only water-soluble components contacted by infiltrating groundwater will become mobile. In general, heavier hydrocarbons have lower water solubilities and tend to be retained in the soil.
- **Dispersion/Dilution** – The rate of flux of the soluble components may be non detectable in the impacted groundwater. Simple dispersion and dilution of the constituents may reduce levels to acceptable standards.

The primary mechanism for contaminant remediation via natural attenuation is biodegradation. Biodegradation is the primary natural process which results in the destruction of the contaminants. Accordingly, successful application of natural attenuation as a treatment process generally requires demonstrating that intrinsic biodegradation is effecting mass reduction at acceptable rates.

As previously discussed in Section 2.7 and specific to the POL Hill AST-2 Area groundwater contamination, no direct correlation can be derived between TRPH data collected during investigations prior to the RI and TPH groundwater sample results collected during the IR and subsequent monitoring events. Therefore, assessments regarding intrinsic biodegradation of petroleum hydrocarbons cannot be directly correlated. However, hydrocarbons that result from water solubilization of petroleum products, namely benzene, toluene, ethylbenzene, and xylene (BTEX), were analyzed for during both previous and recent investigations using EPA Method 8020. Comparison of these data is appropriate and demonstrates that natural attenuation processes are occurring at the site.

Table 4-1 presents a summary of TPH and BTEX analyses for POL Hill AST-2 Area wells between July 1992 and August 2002. This summary is taken from previous work by IT Corp (1999). Validated data supporting the summary from February 1997 onward are provided in Appendix E. Table 4-1 indicates that BTEX concentrations are consistently lower in monitoring well PL-MW-101 throughout the years sampled and suggest that natural attenuation is contributing to groundwater restoration.

An additional three rounds of groundwater sampling have been completed by SOTA as documented in its August 2002 draft report. In addition to testing for extractable and purgeable TPH, geochemical parameters were also recorded during the three sampling rounds to provide additional information on the viability of the MNA remedial alternative. The additional natural attenuation data are included in Table 5 of the SOTA (2002) report, which is included in Appendix I.

The preliminary natural attenuation rate calculations assumed steady-state recharge of dissolved hydrocarbons into the well and that concentrations changes in the same well over time were reliable indicators of natural attenuation. Based on the observed concentration changes over time, the results suggest that natural attenuation is reducing the concentration

of dissolved hydrocarbons in the groundwater within bedrock fractures (IT, 1997c). While the expected rate of natural attenuation is based on a variety of site- and contaminant-specific factors, other case studies with JP-4 fuel contamination have shown approximate biodegradation rate constants (based on total BTEX) to range from 0.012 to 0.003 day⁻¹ (Weidemeier et al., 1999).

TABLE 4-1
Historical Groundwater Organic Chemical Data Summary

Well	Monitoring Event Date	Monitoring						
		Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Xylenes (µg/L)	Total TPH ^a (µg/L)	TPH-P ^b (µg/L)	TPH-E ^c (µg/L)
PL-MW-101	Jul-92	6	10	110	290	d	d	d
	Aug-92	6	4.3	94	260	d	d	d
	Mar-94	<5	<5	129	405	5350	e	5350
	Feb-97	<10	<10	78	140	11400	4800	6600
	Mar-97	<1	<1	77	120	8500	4600	3900
	Apr-98	<1	<1	46	52	4800	2700	2100
	Jul-98	<1	<1	42	34	3900	2300	1600
	Oct-98	<1	<1	39	47	7600	2900	4700
	Jan-99	NA	NA	NA	NA	9700	4400	5300
	Sep-01	NA	NA	NA	NA	6200	3300	2900
	Feb-02	NA	NA	NA	NA	16000	6200	9800
	Aug-02	NA	NA	NA	NA	5300	2600	2700
PL-MW-103	Jul-92	<1	<1.5	<1.4	<1.4	d	d	d
	Aug-92	<1	<1.5	<1.4	<1.4	d	d	d
	Mar-94	<0.5	<0.5	<0.5	<0.5	417	e	417
	Feb-97	<1	<1	<1	<1	110	<50	110
	Mar-97	<1	<1	<1	<1	<50	<50	<50
	Apr-98	<1	<1	<1	<1	200	e	200
	Jul-98	<1	<1	<1	<1	76	76	<50
	Oct-98	<1	<1	<1	<1	<50	<50	<50
	Jan-99	NA	NA	NA	NA	<50	<50	<50
	Sep-01	NA	NA	NA	NA	320	<50	320
	Feb-02	NA	NA	NA	NA	570	<50	570
	Aug-02	NA	NA	NA	NA	<250	<50	<250
PL-MW-104	Jul-92	<1	<1.5	<1.4	<1.4	d	d	d
	Aug-92	<1	<1.5	<1.4	<1.4	d	d	d
	Mar-94	<0.5	<0.5	<0.5	<0.5	464	e	464
	Feb-97	<1	<1	<1	<1	400	130	270
	Mar-97	<1	<1	<1	<1	410	180	230
	Apr-98	<1	<1	<1	<1	287	67	220
	Jul-98	<1	<1	<1	<1	<50	<50	<50
	Oct-98	<1	<1	<1	<1	263	83	180
	Jan-99	NA	NA	NA	NA	370	200	170
	Sep-01	NA	NA	NA	NA	655	95	560

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	Feb-02	NA	NA	NA	NA	890	110	780
	Aug-02	NA	NA	NA	NA	568	78	490
PL-MW-106	Jul-92	NA	NA	NA	NA	NA	NA	NA
	Aug-92	NA	NA	NA	NA	NA	NA	NA
	Mar-94	NA	NA	NA	NA	NA	NA	NA
	Feb-97	<1	<1	<1	<1	<50	<50	<50
	Mar-97	<1	<1	<1	<1	<50	<50	<50
	Apr-98	<1	<1	<1	<1	<50	<50	<50
	Jul-98	NA	NA	NA	NA	NA	NA	NA
	Sep-98	<1	<1	<1	<1	<50	<50	<50
	Jan-99	NA	NA	NA	NA	NA	NA	NA
	Sep-01	NA	NA	NA	NA	<250	<50	<250
	Feb-02	NA	NA	NA	NA	<250	<50	<250
	Aug-02	NA	NA	NA	NA	<250	<50	<250
PL-MW-107	Jul-92	NA	NA	NA	NA	NA	NA	NA
	Aug-92	NA	NA	NA	NA	NA	NA	NA
	Mar-94	NA	NA	NA	NA	NA	NA	NA
	Feb-97	<1	<1	<1	<1	<50	<50	<50
	Mar-97	<1	<1	<1	<1	<50	<50	<50
	Apr-98	<1	<1	<1	<1	<50	<50	<50
	Jul-98	<1	<1	<1	<1	<50	<50	<50
	Sep-98	<1	<1	<1	<1	<50	<50	<50
	Jan-99	NA	NA	NA	NA	NA	NA	NA
	Sep-01	NA	NA	NA	NA	<250	<50	<250
	Feb-02	NA	NA	NA	NA	<250	<50	<250
	Aug-02	NA	NA	NA	NA	<250	<50	<250
PL-MW-114	Jul-92	<1.1	<1.5	<1.4	<1.4	d	d	d
	Aug-92	<1.1	<1.5	<1.4	<1.4	d	d	d
	Mar-94	<0.5	<0.5	<0.5	<0.5	355	e	355
	Feb-97	<1	<1	<1	<1	<50	<50	<50
	Mar-97	<1	<1	<1	<1	<50	<50	<50
	Apr-98	<1	<1	<1	<1	<50	<50	<50
	Jul-98	<1	<1	<1	<1	<50	<50	<50
	Oct-98	<1	<1	<1	<1	<50	<50	<50
	Jan-99	NA	NA	NA	NA	<50	<50	<50
	Sep-01	NA	NA	NA	NA	<250	<50	<250
	Feb-02	NA	NA	NA	NA	570	<50	570
	Aug-02	NA	NA	NA	NA	<250	<50	<250

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PL-MW-115	Jul-92	<1.1	<1.5	<1.4	<1.4	d	d	d
	Aug-92	<1.1	<1.5	<1.4	<1.4	d	d	d
	Mar-94	<0.5	<0.5	<0.5	<0.5	803	e	803
	Feb-97	<1	<1	<1	<1	140	<50	140
	Mar-97	<1	<1	<1	<1	<50	<50	<50
	Apr-98	<1	<1	<1	<1	100	<50	100
	Jul-98	<1	<1	<1	<1	<50	<50	<50
	Oct-98	<1	<1	<1	<1	<50	<50	<50
	Jan-99	NA	NA	NA	NA	<50	<50	<50
	Sep-01	NA	NA	NA	NA	<250	<50	<250
	Feb-02	NA	NA	NA	NA	250	<50	250
	Aug-02	NA	NA	NA	NA	<250	<50	<250
PL-MW-116	Jul-92	NA	NA	NA	NA	NA	NA	NA
	Aug-92	NA	NA	NA	NA	NA	NA	NA
	Mar-94	NA	NA	NA	NA	NA	NA	NA
	Feb-97	<1	<1	<1	<1	<50	<50	<50
	Mar-97	<1	<1	<1	<1	<50	<50	<50
	Apr-98	<1	<1	<1	<1	<50	<50	<50
	Jul-98	NA	NA	NA	NA	NA	NA	NA
	Sep-98	<1	<1	<1	<1	<50	<50	<50
	Jan-99	NA	NA	NA	NA	<50	<50	<50
	Sep-01	NA	NA	NA	NA	<250	<50	<250
	Feb-02	NA	NA	NA	NA	330^f	<50	330^f
	Aug-02	NA	NA	NA	NA	<250	<50	<250
MW-POLA-120	Jul-92	NS	NS	NS	NS	NS	NS	NS
	Aug-92	NS	NS	NS	NS	NS	NS	NS
	Mar-94	NS	NS	NS	NS	NS	NS	NS
	Feb-97	<1	<1	<1	<1	<50	<50	<50
	Mar-97	<1	<1	<1	<1	<50	<50	<50
	Apr-98	<1	<1	<1	<1	<50	<50	<50
	Jul-98	<1	<1	<1	<1	<50	<50	<50
	Oct-98	<1	<1	<1	<1	<50	<50	<50
	Jan-99	NA	NA	NA	NA	<50	<53	<53
	Sep-01	NS	NS	NS	NS	NS	NS	NS
	Feb-02	NS	NS	NS	NS	NS	NS	NS
	Aug-02	NS	NS	NS	NS	NS	NS	NS

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Well	Monitoring Event Date	Benzene	Toluene	Ethylbenzene	Xylenes	Total TPH ^a	TPH-P ^b	TPH-E ^c
		(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
MW-POLA-121	Jul-92	NS ^g	NS	NS	NS	NS	NS	NS
	Aug-92	NS	NS	NS	NS	NS	NS	NS
	Mar-94	NS	NS	NS	NS	NS	NS	NS
	Feb-97	2.7	<1	7.3	7.7	1060	480	580
	Mar-97	4.6	<1	10	13	1360	630	730
	Apr-98	<1	<1	<1	<1	100	<50	100
	Jul-98	<1	<1	<1	<1	<50	<50	<50
	Oct-98	<1	<1	<1	<1	<50	<50	<50
	Jan-99	NA	NA	NA	NA	54	54	<50
	Sep-01	NA	NA	NA	NA	640	<50	640
	Feb-02	NA	NA	NA	NA	530	<50	530
	Aug-02	NA	NA	NA	NA	360	<50	360

Notes:

Source: SOTA (2002) with historical data are extracted from IT report (IT, 1999).

All detected analytes are shown in bold.

NA Not analyzed.

NS Not sampled.

^a Total petroleum hydrocarbons (extractable and purgeable). The extractable and purgeable hydrocarbons results were added together and followed the IT's method to provide an estimate of the residual hydrocarbon contamination.

^b Total petroleum hydrocarbons measured as purgeable.

^c Total petroleum hydrocarbons measured as extractable.

^d Total petroleum hydrocarbons were quantified using EPA Method 418.1. These results were not considered equivalent to the EPA Method 8015M results obtained from the March 1994 and later monitoring events. The data were not available in IT report.

^e No associated result.

^f Result from duplicate sample.

^g Not sampled, well was not installed until January 1997.

This technology would require monitoring and a decision process to determine site closure has been achieved. A proposed interim monitoring program and strategy for determining site closure is presented in Section 7.