

## 5.0 Contaminant Fate and Transport

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### 5.1 Introduction

Two major factors affecting the fate and transport of a chemical when released to the environment are its mobility and its persistence. Mobility is a measure of the tendency for a chemical to migrate through the environment and is affected by the physical/chemical characteristics of the chemical.

The major processes at work in the natural environment include: aqueous solubility, volatilization, sorption, hydrolysis, photolysis, and oxidation rates. Persistence, a measure of the time a chemical remains in the environment, is influenced by many of the same factors affecting chemical mobility (e.g., photolysis, hydrolysis, and oxidation rates). Persistence is also a function of chemical-biological interactions in the environment such as biodegradation and/or bioaccumulation.

Potential routes of transport and transport mechanisms that may be applicable to the contaminants at Parcel 94(7) are presented and evaluated in Section 5.2. The persistence of chemicals detected at the site and factors affecting the environmental fate and transport process are presented in Section 5.3. Table 5-1 lists the physical and chemical properties of the organic chemicals detected above ESVs or SSSLs at the site. Table 5-2 provides data on the distribution coefficient for metals.

Section 5.4 evaluates the direction and rate of contaminant migration at Parcel 94(7) and includes Table 5-3, which summarizes the rate and distance of migration estimated for VOCs cited in Table 5-1. Also included in Section 5.4 are geologic cross sections of the site that show the vertical and horizontal distribution of total VOCs.

For the purposes of this RI report, only a qualitative evaluation of potential routes of migration, contaminants of persistence, and contaminant migration is presented. Fate and transport modeling were not included in the scope of work.

### 5.2 Potential Routes of Migration

Contaminants can be transported from their source(s) to other areas as a result of several potential transport mechanisms and migration pathways. The migration of contaminants at a site is dependent on factors that include 1) site characteristics such as soil and bedrock conditions, groundwater and surface water conditions, climatic conditions; and 2) contaminant characteristics. As part of the evaluation process for Parcel 94(7), potential migration pathways considered are:

- Fugitive dust emissions and volatilization from soil
- Erosion and surface water runoff

Table 5-1

**Physical and Chemical Parameters Affecting Environmental Fate of Organic Chemicals  
Former Chemical Laundry and Motor Pool Area 1500, Parcel 94(7)  
Fort McClellan, Calhoun County, Alabama**

Compound	Molecular Weight (g/mole)	Water Solubility (mg/L@20C)	Vapor Pressure (mm Hg @20C)	Octanol-Water Partition Coefficient (Log K <sub>ow</sub> )	Adsorption Coefficient (Log K <sub>oc</sub> )	K <sub>oc</sub> -Calc (mL/g)	Mobility	K <sub>oc</sub> -Meas (mL/g)	Henry's Law Constant (atm-m <sup>3</sup> /mol)	Specific Gravity g/cm <sup>3</sup>
<b>Volatiles Organic Compounds</b>										
Benzene	78.11 <sup>b</sup>	1.75 E+03 <sup>e</sup>	9.52 E+01(25C) <sup>b</sup>	2.13 <sup>e</sup>	1.77 <sup>e</sup>	5.89 E <sup>e</sup>	high <sup>c</sup>	6.17E+01 <sup>e</sup>	5.55 E-03 <sup>e</sup>	0.8765 <sup>d</sup>
Chlorobenzene	112.56 <sup>a</sup>	4.72 E+02 <sup>e</sup>	1.19 E+01(25C) <sup>b</sup>	2.86 <sup>e</sup>	2.34 <sup>e</sup>	2.19 E+02 <sup>e</sup>		2.24 E+02 <sup>e</sup>	3.70 E-03 <sup>e</sup>	1.1058 <sup>d</sup>
Cis-1,2-Dichloroethene	96.94 <sup>b</sup>	3.50 E+03 <sup>e</sup>	2.00E+02(35C) <sup>b</sup>	1.86 <sup>e</sup>	1.55 <sup>e</sup>	3.55E+01		NA	4.08 E-03 <sup>e</sup>	1.2837 <sup>d</sup>
Trichloroethene	131.4 <sup>b</sup>	1.10 E+03(25C) <sup>b</sup>	6.9E+01 <sup>b</sup>	2.71 <sup>e</sup>	2.22 <sup>e</sup>	1.66 E+02 <sup>e</sup>	medium <sup>e</sup>	9.43 E+01 <sup>e</sup>	1.03 E-02 <sup>b</sup>	1.4642 <sup>d</sup>
Vinyl Chloride	62.5 <sup>b</sup>	2.76 E+03(25C) <sup>e</sup>	2.66 E+03(25C) <sup>b</sup>	1.50 <sup>e</sup>	1.27 <sup>e</sup>	1.86 E+01 <sup>e</sup>		NA	2.70 E-02 <sup>e</sup>	0.9106 <sup>d</sup>
<b>Semivolatiles Organic Compounds</b>										
Naphthalene	128.16 <sup>a</sup>	3.1 E+01 <sup>g</sup>	8.70 E-02 <sup>g</sup>	3.29 <sup>g</sup>	2.97 <sup>g</sup>	2.00E+03 <sup>e</sup>		1.19 E+03 <sup>g</sup>	4.60 E-04 <sup>g</sup>	1.162 <sup>d</sup>
Anthracene	178.2 <sup>f</sup>	7.60 E-02 <sup>f</sup>	1.70 E-05 (25C) <sup>f</sup>	4.45 <sup>f</sup>	4.15 <sup>f</sup>	2.95E+04 <sup>e</sup>		2.35 E+04 <sup>e</sup>	1.77E-05 <sup>f</sup>	1.283 <sup>d</sup>
Phenanthrene	178.2 <sup>f</sup>	1.2 <sup>f</sup>	6.80 E-04 (25C) <sup>f</sup>	4.45 <sup>f</sup>	4.15 <sup>f</sup>	NA		NA	2.56 E-05 <sup>f</sup>	0.980 <sup>d</sup>
Fluoranthene	202.3 <sup>f</sup>	2.0 - 2.6 E-01 <sup>f</sup>	5.00 E-06 (25C) <sup>f</sup>	4.90 <sup>f</sup>	4.58 <sup>f</sup>	1.07E+05 <sup>e</sup>		4.91 E+04 <sup>e</sup>	6.50 E-06 <sup>f</sup>	1.252 <sup>d</sup>
Pyrene	202.3 <sup>f</sup>	7.70 E-02 <sup>f</sup>	2.50 E-06 (25C) <sup>f</sup>	4.88 <sup>f</sup>	4.58 <sup>f</sup>	1.05E+05 <sup>e</sup>		6.80 E+04 <sup>e</sup>	1.14 E-05 <sup>f</sup>	1.271 <sup>d</sup>
Dibenz(a,h)anthracene	278.4 <sup>f</sup>	5.00 E-04 <sup>f</sup>	1.00 E-10 <sup>f</sup>	6.84 <sup>f</sup>	6.53 <sup>f</sup>	3.80 E+06 <sup>e</sup>		1.78 E+06 <sup>e</sup>	7.30 E-08 <sup>f</sup>	1.282 <sup>d</sup>
Benzo(a)anthracene	228.3 <sup>f</sup>	1.00 E-02 <sup>f</sup>	2.20 E-08 <sup>f</sup>	5.61 <sup>f</sup>	5.30 <sup>f</sup>	3.98 E+06 <sup>e</sup>		3.58 E+05 <sup>e</sup>	1.00 E-06 <sup>f</sup>	1.274 <sup>d</sup>
Benzo(a)pyrene	252.3 <sup>f</sup>	2.30 E-03 <sup>f</sup>	5.60 E-09 <sup>f</sup>	6.06 <sup>f</sup>	6.74 <sup>f</sup>	1.02 E+06 <sup>e</sup>		9.69 E+05 <sup>e</sup>	4.90 E-07 <sup>f</sup>	1.351 <sup>d</sup>
Benzo(b)fluoranthene	252.3 <sup>f</sup>	1.20 E-03 <sup>f</sup>	5.00 E-07 <sup>f</sup>	6.04 <sup>f</sup>	5.74 <sup>f</sup>	1.23 E+06 <sup>e</sup>		NA	1.22 E-05 <sup>f</sup>	NA
Chrysene	228.3 <sup>f</sup>	2.80 E-03 <sup>f</sup>	6.3 E-07 (25C) <sup>f</sup>	5.16 <sup>f</sup>	5.30 <sup>f</sup>	3.98 E+05 <sup>e</sup>		NA	1.05 E-06 <sup>f</sup>	1.274 <sup>d</sup>
Indeno(1,2,3,-cd)pyrene	276.3 <sup>f</sup>	6.20 E-02 <sup>f</sup>	1.00 E-06 to -11 <sup>f</sup>	6.58 <sup>f</sup>	6.20 <sup>f</sup>	3.47 E+06 <sup>e</sup>		NA	6.95 E-08 <sup>f</sup>	NA

**References:**<sup>a</sup>Howard, P.H. (1989)<sup>b</sup>Howard, P. H., (1990)<sup>c</sup>U.S. Environmental Protection Agency, (1986)<sup>d</sup>U.S. Environmental Protection Agency, (1992)<sup>e</sup>U.S. Environmental Protection Agency, (1996)<sup>f</sup>ATDSR, (1995b)<sup>g</sup>ATDSR, (1995a)atm-m<sup>3</sup>/mol - Cubic meter per mole per atmosphere.

g/mole - Grams per mole.

g/cm<sup>3</sup> - Grams per cubic centimeter.K<sub>ow</sub> - Octanol-water coefficient.K<sub>oc</sub> - Organic partitioning coefficient.

mL/g - Milliliters per gram.

mm Hg - Millimeters of mercury.

NA - Not available.

**Table 5-2**

**Distribution Coefficient,  $K_d$   
Former Chemical Laundry and Motor Pool Area 1500, Parcel 94(7)  
Fort McClellan, Calhoun County, Alabama**

<b>Metal</b>	<b><math>K_d</math> Geometric Mean</b>	<b><math>K_d</math> Range</b>	<b>No. Values</b>	<b>Potential Groundwater Mobility</b>
Antimony	45			Medium
Arsenic	200			Low
Arsenic (+3)	3.3	1.0-8.3	19	
Barium	60			Medium-Low
Beryllium	650			Low
Cadmium	6.4	1.26-26.8	28	Medium
Chromium	850			Low
Chromium (+3)	--			
Chromium (+6)	37	1.2-1800	18	Medium
Cobalt	47			Medium
Copper	35			Medium
Lead	900			Low
Manganese	65			Medium-Low
Mercury	10			Medium
Nickel	150			Low
Selenium	300			Low
Silver	46	10-1,000	16	Medium
Thallium	1,500			Low
Vanadium	1,000			Low
Zinc	38	0.1-8,000	146	Medium

Units in milliliters per gram.

**References:**

- Baes and Sharp (1983)
- Baes et al. (1984)

Table 5-3

**Contaminant Migration Rates  
Former Chemical Laundry and Motor Pool Area 1500, Parcel 94(7)  
Fort McClellan, Calhoun County, Alabama**

Contaminant	$f_{oc}$	$K_{oc}$ (mL/g)	$K_d$	$D_b$ (g/cm <sup>3</sup> )	$n$	$k$ (ft/day)	$l$ (avg)	$V$ (ft/day)	$R_d$	$V_c$ (ft/day)	$V_c$ (ft/year)	Distance Migrated in 50 Years (ft)
<b>Residuum</b>												
Chlorobenzene	0.006	219	1.314	1.6	0.4	4.12	0.0206	0.282907	6.256	0.0452	16.51	825.3
Trichloroethene	0.006	94	0.564	1.6	0.4	4.12	0.0206	0.282907	3.256	0.0869	31.71	1585.7
Cis-1,2-Dichloroethene	0.006	35.5	0.213	1.6	0.4	4.12	0.0206	0.282907	1.852	0.1528	55.76	2787.8
Vinyl Chloride	0.006	18.6	0.1116	1.6	0.4	4.12	0.0206	0.282907	1.4464	0.1956	71.39	3569.6
<b>Bedrock</b>												
Benzene	0.015	58.9	0.8835	2.43	0.2	0.144	0.0278	0.026688	11.7345	0.0023	0.83	41.5
Chlorobenzene	0.015	219	3.285	2.43	0.2	0.144	0.0278	0.026688	40.9128	0.0007	0.24	11.9
Trichloroethene	0.015	94	1.41	2.43	0.2	0.144	0.0278	0.026688	18.1315	0.0015	0.54	26.9
Cis-1,2-Dichloroethene	0.015	35.5	0.5325	2.43	0.2	0.144	0.0278	0.026688	7.4699	0.0036	1.3	65.2
Vinyl Chloride	0.015	18.6	0.279	2.43	0.2	0.144	0.0278	0.026688	4.3899	0.0061	2.22	110.9

$K_d$ , soil adsorption or distribution coefficient =  $(K_{oc})(f_{oc})$ ; relation valid as long as solute present is at concentrations below about 1/2 of its solubility.

% organic carbon assumed at 0.6% ( $f_{oc} = 0.006$ ) EPA default for soils

% organic carbon assumed at 1.5% ( $f_{oc} = 0.015$ ) for sedimentary rocks, Trask and Patnode, (1942)

$V_c$ , average velocity of solute =  $V / R_d$

$V$ , average linear groundwater velocity =  $k(l) / n_e$

$l$  = horizontal hydraulic gradient

$k$  = hydraulic conductivity

$n_e$  = effective porosity =  $n - S$ , where  $S$  is specific retention or storativity

$R_d$ , retardation coefficient =  $1 + (K_d)(D_b/n)$

$D_b$  = bulk density g/cm<sup>3</sup>

$D_b$  assumed for limestone @ 2.43 g/cm<sup>3</sup>

$D_b$  assumed for shales @ 2.3 g/cm<sup>3</sup>

$D_b$  assumed for sandstones @ 2.1 g/cm<sup>3</sup>

$D_b$  assumed for residuum @ 1.6 g/cm<sup>3</sup>

$n$  = total porosity

$n$  assumed @ 40% for silts and clays

$n_e$  estimated @ 30% for residuum, Walton (1988), Domenico and Schwartz (1990)

$n$  assumed @ 20% for bedrock

$n_e$  estimated @ 15% for limestone, Walton (1988), Domenico and Schwartz (1990)

avg - Average.

ft - Feet.

ft/day - Feet per day.

ft/yr - Feet per year.

g/cm<sup>3</sup> - Grams per cubic centimeter.

mL/g - Milliliters per gram.

- Surface water and sediment transport
- Infiltration and leaching from surface soils to subsurface soils to groundwater
- Transport within the groundwater flow system
- Discharge of groundwater to the surface
- Bioaccumulation.

### **5.2.1 Dust Emission and Volatilization**

Site-related contamination could be released through volatilization into the air. This migration path would be limited primarily to volatile compounds in the surficial (0 to 2 feet) soil. Volatile compounds detected at the site were at low concentrations (below SSSLs and ESVs).

Contaminants adsorbed to surface soils could be released to the atmosphere through dust generated during construction activities. All of the source areas of contamination, however, are located beneath asphalt, and no major construction activities have occurred at the site. Significant migration routes through volatilization or dust emissions to the air are not likely.

### **5.2.2 Erosion and Surface Water Runoff**

Surface water runoff has the potential to transfer contaminants either in a dissolved state or adsorbed to soil particulates or organic matter. Transport routes would follow local topography and any site established drainage systems. Because the majority of the site is covered with asphalt, erosion and surface runoff of adsorbed site-specific contaminants is not considered likely.

Contaminant migration in a dissolved state or adsorbed state would be more likely to occur from the surface of the asphalt material covering the site. These contaminants would likely be PAHs.

If erosion and runoff of either dissolved or entrained contaminants occurred, and depending upon their physical and chemical characteristics, evidence of the contaminants would likely be present in surface water and sediments in Ingram Creek or in depositional soil samples on the slopes draining towards the creek from the site. PAHs were detected at concentrations above ESVs in depositional samples collected on the slopes east of the site and in one of the sediment samples from Ingram Creek. The location of the sediment sample (WS-94-SW/SD05) is just downstream from a stormwater discharge line for a largely asphalt-covered area located on the east side of the creek (Figure 4-4). The constituents found, therefore, may not be related to Parcel 94(7).

### **5.2.3 Surface Water and Sediment Transport**

Ingram Creek is a potential receiver of contaminants transported either by overland runoff or by discharge of groundwater to the surface waters of the creek. In addition, overland runoff may be responsible for contaminant occurrence in sediments deposited in Ingram Creek. The presence of

1 volatile organic constituents would be short lived, as their fate in a surface water/air environment  
2 would be dominated by their volatility. Metals and SVOCs would be more prone to be detected.  
3 VOCs and one SVOC (phenol) were detected in surface water samples, but at concentrations below  
4 SSSLs and ESVs. The transport of VOCs and SVOCs by surface water does not appear to be  
5 significant.

6  
7 Sediment present in Ingram Creek is not characterized as being organic rich. The adsorption  
8 capacity of the substrate, therefore, would be low and the potential not likely for creek sediment to  
9 adsorb and then subsequently release contaminants over time. It is more likely that constituents  
10 released to Ingram Creek would remain adsorbed to particulates suspended in surface water and be  
11 transported downstream.

#### 12 13 **5.2.4 Leaching from Surface and Subsurface Soil to Groundwater**

14 Migration of soil contamination via percolation of rainfall and subsequent entry of the leachate  
15 into the groundwater is considered the most probable route of contaminant migration at the site.  
16 Organic constituents presently found in the surface soils at the site are mainly PAHs and  
17 probably result from the degradation of the asphalt cover at the site. They are almost uniquely  
18 restricted to surface soils, although several PAHs were detected in one subsurface soil sample.  
19 The compounds identified as exceeding ESVs are: anthracene, benzo(a)pyrene,  
20 benzo(a)anthracene, chrysene, fluoranthene, phenanthrene, pyrene and naphthalene. In addition,  
21 three other PAHs exceeded SSSLs: dibenz(a,h)anthracene, benzo(b)fluoranthene, and  
22 indeno(1,2,3-cd)pyrene. These compounds have high molecular weight and low water  
23 solubilities; leaching of these compounds to the groundwater is considered unlikely. However,  
24 these chemical characteristics may be overridden by the strongly acidic nature of soils described  
25 for the site, and some leaching may occur.

26  
27 Although VOCs were detected in surface and subsurface soil samples at the site, most were at low  
28 concentrations and none were detected at concentrations exceeding SSSLs or ESVs. This may be  
29 interpreted as an indication of an original limited release and degradation of volatiles, or that  
30 leaching of contaminants from these media to the groundwater system has occurred. Precipitation  
31 percolating through the soil in the unsaturated zone has partitioned contaminants from the soil  
32 matrix into the leachate. The absence of significant concentrations of VOCs in the upper soil  
33 profile and residuum is a qualitative indication of the relative ease with which VOCs may partition.

1 **5.2.5 Groundwater Transport**

2 Contaminants in groundwater can be transported in either a dissolved phase or a soil-adsorbed state.  
3 Soluble chemical constituents will be transported in the direction of groundwater flow. Based on  
4 monitoring well data, the groundwater flow system at Parcel 94(7) consists of flow in the residuum  
5 and flow in the bedrock. The disparate flow directions in the two media are discussed in the site-  
6 specific hydrogeology in Section 3.8.2. The predominant flow direction in the residuum focuses  
7 eastward towards Ingram Creek, whereas the flow in the structurally controlled and fractured  
8 bedrock appears to be semi-radial. Calculations of the vertical hydraulic gradients between  
9 residuum and bedrock are presented in Table 3-2. Head differences between residuum and bedrock  
10 well clusters indicate that both upward and downward weak gradients are present.

11  
12 Soluble chemical constituents entering the groundwater system in either residuum or bedrock  
13 would flow in the direction of groundwater movement. The rate of transport of these chemical  
14 constituents in the residuum is determined, in part, by equilibrium partitioning between the mobile  
15 aqueous phase and the soil particles of the residuum. The degree of partitioning in the residuum is  
16 governed mainly by the organic matter content. In bedrock, the degree of partitioning is  
17 substantially less. At Parcel 94(7), release and transport to the groundwater system is the principal  
18 migration pathway and mechanism of on-site contamination migration and potential off-site  
19 contaminant transport.

20  
21 **5.2.6 Discharge of Groundwater to the Surface**

22 Based on a seep survey conducted in December 2000 (Appendix F), there is no known  
23 groundwater discharge to the surface in the form of seeps, springs, or wetlands at Parcel 94(7).  
24 No standing bodies of water, such as ponds, are present. A seepage flux or other study has not  
25 been conducted to determine if Ingram Creek is primarily a gaining or losing stream. Historical  
26 observations suggest that the creek exhibits perennial flow, although it is frequently observed to  
27 be dry. Hydraulic connectivity between groundwater and surface waters of Ingram Creek is  
28 considered a potential pathway.

29  
30 **5.2.7 Bioaccumulation**

31 Many organic and inorganic chemicals have the potential to bioconcentrate and bioaccumulate in  
32 plants and/or animals. This may occur through direct bioconcentration from an aqueous  
33 medium, root uptake from soils to plants, ingestion of water, incidental ingestion of soils and  
34 sediments, and ingestion of contaminated plants or animal prey as food sources. Discussion of  
35 these pathways is presented in detail in Chapter 7.0.

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**5.3 Contaminant Persistence**

Factors affecting environmental persistence and mobility processes are defined in this section. These factors deal with the chemical and physical reactions that take place in the environment and their effect on contaminant transport. Physical and chemical parameters affecting the environmental fate of site-related chemicals at Parcel 94(7) are presented in Table 5-1. The environmental fate and transport data for the chemicals detected at the site are discussed. The chemicals are divided into two groups: organic and inorganic. The organic constituents are further divided where possible into groups that share similar characteristics.

**5.3.1 Chemical and Physical Processes Affecting Fate and Transport**

The most important fate and transport process for organic constituents detected at Parcel 94(7) is likely to be aqueous solubility. The greater the solubility of an organic constituent, the greater the potential for migration via groundwater transport. For inorganic constituents, the ability to enter the groundwater transport system is largely determined by the distribution coefficient of the chemical.

A number of measurable chemical parameters are used to determine the rate and extent of a chemical process. The parameters include aqueous solubility, Henry's Law constant, diffusion coefficient, vapor pressure, adsorption/partitioning coefficient, and degradation rate. These parameters can be used to estimate the quantity of contaminants that will go into solution, rates of volatilization, rates of diffusion, quantity of contaminant adsorbed onto or desorbed from soil particles, and rates of degradation.

**5.3.1.1 Aqueous Solubility**

Aqueous solubility is the maximum amount of a chemical that will dissolve in pure water at a specified temperature. The solubility of most organic compounds ranges from approximately 1 to 100,000 mg/L at ambient temperatures. As the solubility of a compound increases, so does the likelihood the compound will go into the water phase. Aqueous solubility is an important determinant of chemical concentration and residence time in water. Highly soluble chemicals readily dissolve in water and remain in solution; chemicals with low solubility tend to adsorb to solids or form nonpolar phases.

### 1 **5.3.1.2 Volatilization**

2 Volatilization is the movement of a chemical from the surface of a liquid or solid matrix to a gas or  
3 vapor phase. Volatilization losses to the air are related to the chemical concentration, molecular  
4 weight, solubility, vapor pressure, and ambient temperature. The tendency for a chemical to  
5 volatilize from water can be estimated from its Henry's Law constant, H (cubic meters per mole per  
6 atmosphere [atm·m<sup>3</sup>/mol]). This measure relates the equilibrium concentrations of a compound in  
7 the dissolved and vapor phases and is a constant at a given temperature. H relates the partial  
8 pressure of a gas above a liquid and a mole fraction of the gas dissolved in the liquid and affects the  
9 rate and extent of volatilization. Lyman et al. (1982) classified compounds based on their H value,  
10 as "readily" (>10<sup>-3</sup>atm·m<sup>3</sup>/mol), "significantly" (10<sup>-3</sup> to 10<sup>-5</sup>atm·m<sup>3</sup>/mol), or "limitedly" (< 10<sup>-5</sup>atm·  
11 m<sup>3</sup>/mol) tending to volatilize from water.  
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### 13 **5.3.1.3 Diffusion**

14 The diffusion coefficient is a measure of the diffusive mobility of a contaminant in solution. As the  
15 diffusion coefficient increases, so does the rate of diffusion. Diffusion coefficients are temperature  
16 dependent and increase with temperature. The diffusion coefficient is important in determining  
17 vapor-phase diffusion. By definition, vapor pressure is the pressure exerted by a chemical vapor in  
18 equilibrium with its solid or liquid form at any given temperature. It is used to calculate the rate of  
19 volatilization of a pure substance or in estimating a Henry's Law constant for chemicals with low  
20 water solubility. The higher the vapor pressure, the more likely a chemical is to exist in a gaseous  
21 state.  
22

### 23 **5.3.1.4 Adsorption/Desorption**

24 Adsorption/desorption is the binding of a chemical to (adsorption) or its release from  
25 (desorption) a solid matrix (e.g., soils, sediments and suspended solids). Partition coefficients  
26 are important measures of sorptive characteristics and help define the relative concentrations of a  
27 given chemical in two phases or matrices. Partition coefficients are expressed as concentration  
28 ratios between two phases and include:  
29

- 30 • Organic partitioning or adsorption coefficient,  $K_{oc}$  – Provides a measure of the  
31 extent of chemical partitioning between organic carbon and water at equilibrium.  
32 The greater the  $K_{oc}$  of a chemical, the more likely that chemical is to adsorb to soil  
33 or sediment rather than remain dissolved in water.  
34
- 35 • Soil adsorption or distribution coefficient,  $K_d$  – Provides a measure of the extent of  
36 chemical partitioning between soil or sediment and water, unadjusted for  
37 dependence on organic carbon. Adsorption coefficients are site specific and

1 specific to soil types.  $K_d$  can be normalized for organic carbon content, by the soil  
2 adsorption coefficient,  $K_{oc}$ , times the soil organic carbon content,  $f_{oc}$ , (mg of  
3 organic carbon/mg soil). If site-specific values cannot be obtained, values can be  
4 estimated from the organic carbon content, carbon content and the octanol-water  
5 coefficient. The higher the  $K_d$  the more likely a chemical is to bind to soil or  
6 sediment rather than remain dissolved in water.

- 7
- 8 • The octanol-water partition coefficient,  $K_{ow}$  – Provides a measure of the extent of  
9 chemical partitioning between water and octanol at equilibrium. The greater the  
10  $K_{ow}$ , the more likely a chemical is to partition to octanol rather than to remain in  
11 water.  $K_{ow}$  can be used to estimate  $K_{oc}$  and to predict bioconcentration in living  
12 organisms. Chemicals with a  $\log K_{ow} < 2.5$  rarely bioaccumulate significantly in  
13 plants or animals and have a high water solubility.
- 14

### 15 **5.3.1.5 Degradation Rate**

16 Degradation rate is a measure of the rate at which a contaminant breaks down into other, simpler  
17 compounds. Types of degradation rates can be broken into four categories: hydrolysis rates,  
18 photolysis rates, oxidation/reduction rates, and biodegradation rates.

- 19
- 20 • Hydrolysis is the reaction of a chemical with hydrogen ions or the hydroxyl  
21 radicals, resulting in the degradation or structural modification of the chemical.  
22 The extent of a chemical's hydrolytic reaction is a function of the molecular  
23 structure of the chemical and the pH of the environment.
  - 24 • Photolysis is a chemical degradation process caused by sunlight. The rate of  
25 degradation from photochemical reactions depends on the chemical's molecular  
26 structure, the proximity and character of the radiant energy (light source), and the  
27 presence of other reactive compounds.
  - 28 • Oxidation/reduction is a chemical reaction in which a chemical either loses an  
29 electron (oxidation) or adds an electron (reduction). Oxidation/reduction rates of  
30 chemicals are significant, in that they influence both the environmental mobility  
31 and fate of a chemical.
  - 32 • Biodegradation of organic compounds can transform them through various  
33 reactions. The chemical processes that remove or transform compounds can  
34 involve oxidation or reduction, depending on whether aerobic or anaerobic  
35 conditions exist. The rate of biodegradation is influenced by numerous  
36 parameters, including but not limited to groundwater temperature, pH, dissolved  
37 oxygen, organic matter content, and phosphate, sulfate, and nitrate concentrations.
- 38  
39  
40  
41

### 1 **5.3.2 Contaminant Fate and Transport**

2 Contaminant fate and transport of VOCs, SVOCs, and inorganic compounds are discussed in the  
3 following sections.

#### 4 5 **5.3.2.1 Volatile Organic Compounds**

6 VOCs were detected in all media sampled at Parcel 94(7), as summarized in Chapter 4.0.  
7 Fourteen VOCs were detected in surface and depositional soils, four VOCs were detected in  
8 surface water, seven VOCs in sediment samples, and thirteen VOCs in subsurface soils. None of  
9 the detections were at concentrations above SSSLs or ESVs. However, VOCs were detected  
10 above residential human health SSSLs in groundwater. Of the eleven VOCs detected in  
11 groundwater samples, five were detected at concentrations exceeding SSSLs. These five  
12 compounds are benzene, cis-1,2-DCE, chlorobenzene, TCE, and vinyl chloride. The chemicals  
13 are subdivided into two groups based on physical and chemical characteristics: aromatic  
14 hydrocarbons and chlorinated aliphatic hydrocarbons. Chemicals from other volatile organic  
15 groups were detected, but individual constituents were at concentrations below SSSLs and are  
16 not discussed.

17  
18 **Aromatic Hydrocarbons.** Benzene was the only aromatic hydrocarbon detected above its  
19 SSSL at the site. It was detected at a low concentration (1.70E-03 mg/L) in only one  
20 groundwater sample; given the former use of the site (i.e., gas stations), it may be site related.  
21 Aromatic VOCs are not likely to be persistent in soils and may be mobilized to groundwater by  
22 infiltration. If released to the soil, they are subject to rapid volatilization near the surface; that  
23 portion of a release not volatilized will be mobile to highly mobile and may leach to the  
24 groundwater. Benzene has a moderate to high solubility in water and is not expected to  
25 significantly adsorb to soils, bioconcentrate, or hydrolyze. Benzene has fairly low  $K_{ow}$  and  $K_{oc}$   
26 coefficients, indicating a low affinity for adsorption to organic matter. Slow biodegradation of  
27 benzene occurs via microbial processes. In some instances, active biological degradation is  
28 indicated by reduced dissolved oxygen and localized reducing conditions. Under anaerobic  
29 conditions, slow degradation has been reported.

30  
31 **Chlorinated Aliphatic Hydrocarbons.** Chlorinated aliphatic hydrocarbons were detected in  
32 groundwater at concentrations exceeding SSSLs. These compounds include TCE, cis-1,2-DCE,  
33 chlorobenzene, and vinyl chloride. The dominant fate process for these compounds in surface  
34 soils or surface water/sediments is volatilization to the atmosphere; however, none of these

1 compounds were detected in these media at concentrations exceeding SSSLs or ESVs. These  
2 constituents are present in groundwater in both residuum and bedrock monitoring wells.

3  
4 Chlorinated hydrocarbons tend to have high solubility in water. The high solubilities are, in part,  
5 due to their relatively low molecular weights and high polarity. The constituents tend to have a  
6 low affinity for soils and are generally highly mobile. The log  $K_{oc}$  values are relatively low and,  
7 therefore, the chemicals have a low affinity for adsorption to organic matter or soil. Transport in  
8 groundwater would thus be expected to be the dominant transport pathway. This does not imply  
9 that there would not be soil-adsorbed volatiles, but rather that, if associated with soils at the site,  
10 they would be miscible and have the potential to be a source for groundwater contamination.

11  
12 Chlorinated hydrocarbons are synthetic solvents used in many industrial activities (e.g.,  
13 degreasers, dry-cleaning processes). They can occur in the environment directly through product  
14 usage or as a breakdown by-product from the degradation of other solvents. The occurrence of  
15 cis-1,2-DCE and vinyl chloride in groundwater indicates that degradation of a precursor solvent  
16 by hydrolysis, biodegradation, or reductive dechlorination under anaerobic conditions has  
17 occurred. The TCE in groundwater may be through product usage or through degradation of  
18 tetrachloroethene. The former is considered more probable, since tetrachloroethene was detected  
19 at a very low concentration in only one groundwater sample at the site and its complete  
20 degradation is not considered likely. Chlorobenzene biodegrades in groundwater, but the rate of  
21 degradation is generally considered slow; 2- and 4-chlorophenol are products of this degradation  
22 (Howard, 1989). However, neither of these compounds were detected in groundwater at the site.

### 23 24 **5.3.2.2 Semivolatile Organic Compounds**

25 Twenty SVOCs, including 17 PAH compounds, were detected in surface and depositional soil  
26 samples at Parcel 94(7). The concentrations of five PAHs (dibenz[a,h]anthracene,  
27 benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, and indeno[1,2,3-cd]pyrene)  
28 exceeded SSSLs; two of these PAHs (benzo[a]anthracene and benzo[a]pyrene) were detected  
29 above ESVs. Six additional PAHs exceeded ESVs: anthracene, chrysene, fluoranthene,  
30 naphthalene, phenanthrene, and pyrene. Five of the eight PAHs that exceeded ESVs in surface  
31 and depositional soils also exceeded ESVs in one sediment sample from Ingram Creek  
32 (anthracene, benzo[a]pyrene, fluoranthene, phenanthrene, and pyrene). Although twelve SVOCs  
33 were detected in subsurface soils, only the PAH benzo(a)pyrene exceeded its SSSL in one  
34 sample (FTA-94-GP01). Two SVOCs were detected in groundwater samples, but their  
35 concentrations were below SSSLs.

1  
2 **Polynuclear Aromatic Hydrocarbons.** PAHs have high organic carbon partition  
3 coefficient ( $K_{oc}$ ) values and, thus, tend to readily adsorb to soils and sediments. High-molecular-  
4 weight PAHs have higher  $K_{oc}$  values, which indicate a stronger tendency to adsorb to organic  
5 carbon. Transport of particle-associated PAHs would be controlled by the slow leaching of  
6 PAHs to percolating water and any gross particle movements such as surface soil runoff. This  
7 may constitute the dominant fate process for these compounds at the site.

8  
9 The solubility of PAHs is variable but in general is low compared to other organic groups;  
10 surface water runoff and groundwater transport would not be considered significant transport  
11 processes. PAHs were not detected in groundwater but were present above ESVs in three  
12 depositional soil samples located topographically downgradient from the site (FTA-94-DEP01,  
13 FTA-94-DEP02, and FTA-94-DEP04) and in one sediment sample (WS-94-SW/SD02). The  
14 sediment sample is located along Ingram Creek (Figure 4-4), upgradient from the site and  
15 immediately downgradient from a stormwater outfall that receives runoff from a nearby but  
16 different asphalted area than Parcel 94(7). PAHs were also detected above ESVs in five surface  
17 soil samples (FTA-94-GP01, FTA-94-GP02, FTA-94-GP11, FTA-94-GP12, and FTA-94-  
18 MW14) and above SSSLs in one subsurface soil sample (FTA-94-GP04), all of which are  
19 located beneath the asphalt cover at the site. Their presence is believed to be directly related to  
20 the asphalt pavement at the site, as no industrial discharges or wastewater treatment plants or  
21 other potential sources exist.

22  
23 The potential for bioaccumulation is important, as PAH compounds with high  $K_{ow}$  values  
24 generally have the tendency to bioaccumulate. The evaluation of types and abundance of aquatic  
25 and terrestrial fauna and flora that may be associated with the site and Ingram Creek is included  
26 in Chapter 7.0.

### 27 28 **5.3.2.3 Inorganic Compounds**

29 Many of the chemical and physical processes governing fate and transport discussed in Section  
30 5.3.1 also influence inorganic compounds. In addition to those processes, complexation,  
31 precipitation/co-precipitation, and cationic exchange are significant factors unique in influencing  
32 the persistence and movement of inorganic chemicals (Alloway, 1990). A brief discussion of  
33 these processes is presented in this section. The distribution coefficient ( $K_d$ ) values for inorganic  
34 constituents are also discussed for metals. For inorganic chemicals, the simple relationship  
35 between soil organic carbon content and sorption observed for organic chemicals does not apply;

1  $K_d$  is essentially independent of  $K_{oc}$  or  $K_{ow}$ .

- 2
- 3 • Complexation is the ability of metals to form numerous organic and inorganic  
4 complexes with inorganic ligands such as carbonate, chloride, hydroxide, and  
5 sulfate in the natural environment. Complexation is influenced by many factors, of  
6 which pH and the availability of complexing compounds are significant.
- 7
- 8 • Precipitation and co-precipitation are important removal mechanisms of dissolved  
9 aqueous species. Precipitation depends upon the ionic concentration/aqueous  
10 solubility, pH, and other physical/chemical considerations of the aqueous media.
- 11
- 12 • Cationic Exchange – Many metals are capable of undergoing substitution with  
13 cations present in the crystal lattice of minerals within soils and sediments. The  
14 type of clay minerals present in the media and factors such as pH and organic  
15 content commonly influences this process.
- 16

17 The potential for inorganic constituents to migrate in groundwater is related to their distribution  
18 coefficient,  $K_d$ . The soil-water distribution coefficient for metals is affected by many  
19 geochemical parameters including, but not restricted to, pH, adsorption to clays,  
20 oxidation/reduction conditions, ion chemistry of the water, and chemical form of the metal.  $K_d$   
21 values for commonly evaluated metals range from less than 1 to over 10,000 milliliters per gram  
22 (mL/g).

23

24 Inorganic solutes in groundwater with  $K_d$  values exceeding 100 mL/g are considered essentially  
25 immobile.  $K_d$  values between 0.1 and 50 mL/g suggest moderate mobility, and  $K_d$  values below  
26 0.1 mL/g suggest high mobility (Dragun, 1988). Trace metals in general tend to be very  
27 immobile. Cations are moderately mobile in groundwater, and anions are the most mobile.  
28 Because of the number of varying geochemical parameters in the field influencing organic  
29 distribution coefficients and differences in experimental methods, a wide range of  $K_d$  values is  
30 obtained.  $K_d$  values are presented in Table 5-2.

31

32 Eleven metals were detected above SSSLs and ESVs in surface soils at Parcel 94(7): aluminum,  
33 beryllium, chromium, cobalt, copper, iron, lead, manganese, mercury, selenium, and zinc. In  
34 subsurface soils, four of the same metals (aluminum, chromium, iron, and manganese) and one  
35 additional metal (arsenic) were detected above SSSLs. In groundwater, six metals were detected  
36 above SSSLs in unfiltered (total) groundwater samples: aluminum, barium, iron, lead, thallium,  
37 and vanadium.

1 Unlike organic compounds discussed in Section 5.3.2.1, metals are not degradable through  
2 biological or chemical actions and are typically considered to be persistent in the environment.  
3 The fate of metals depends primarily on partitioning between soluble and particulate solid  
4 phases. Some metals can be oxidized or reduced through the actions of microorganisms that can  
5 change their chemical and physical properties. Among the mechanisms discussed in the  
6 preceding sections, solubility/aqueous chemical speciation, adsorption/desorption, complexation,  
7 precipitation/co-precipitation, and cationic exchange have the potential to significantly influence  
8 fate and transport of the metals detected.

9  
10 Subsequent to the establishment of background values used in the above screening process, an  
11 integrated statistical and geochemical evaluation was performed for metals detected at elevated  
12 concentrations in soil and groundwater (Appendix L). The elevated concentrations of metals  
13 found in groundwater were concluded to be most likely the result of suspended particulates or the  
14 presence of naturally occurring cations. In soils, most of the elevated concentrations could be  
15 explained by preferential enrichment of samples with clays, iron oxides, or manganese oxides  
16 that naturally concentrate specific elements. Of the soil samples evaluated, only lead in one  
17 subsurface soil sample (FTA-94-GP11) could not be attributed to an association of naturally  
18 occurring manganese oxides. The lead result (40.7 mg/kg), however, was well below its SSSL  
19 (400 mg/kg) and only marginally exceeded its background concentration (38.5 mg/kg).

## 21 **5.4 Contaminant Migration**

22 The chemical and physical processes that are involved in the solute transport of contaminants at  
23 Parcel 94(7) include advection, dispersion, diffusion, and retardation. The response of these  
24 factors to the local hydrogeologic conditions will control the horizontal and vertical migration of  
25 volatile organic compounds. These processes are briefly discussed in Section 5.4.1. In Section  
26 5.4.2, the horizontal, vertical, and downgradient migration of contaminants is discussed.

### 28 **5.4.1 Processes Involved in Solute Transport**

29 The mechanisms that govern contaminant transport in the groundwater flow system include  
30 various physical and chemical processes. These transport processes include advection,  
31 dispersion, diffusion, and retardation.

#### 33 **5.4.1.1 Advection**

34 Advection is the process of contaminant (solute) migration due to the average linear velocity of  
35 groundwater and is typically the most important factor governing solute movement.

1 Contaminants that are moving under advection are travelling at the same rate as the average  
2 linear flow velocity of the groundwater. The advective transport term is computed using  
3 velocities determined from Darcy's law. The governing chemical parameter in advection is  
4 solubility; the effect of advection increases with increasing solubility.

#### 6 **5.4.1.2 Dispersion**

7 Hydrodynamic dispersion is the spread or mixing of contaminants around an average  
8 groundwater flow path. Dispersion can occur both longitudinally and transversely. The mixing  
9 that occurs along or parallel to the flow path in the horizontal plane is called longitudinal  
10 dispersion, and that occurring perpendicular to the pathway of fluid flow is called transverse  
11 dispersion.

#### 13 **5.4.1.3 Diffusion**

14 Diffusion is the movement of contaminants as a consequence of a concentration gradient.  
15 Contaminants diffuse from an area of higher concentration to an area of lower concentration, and  
16 diffusion will occur until equilibrium in concentration exists. The rate of diffusion increases  
17 with temperature and decreases as the porosity of the medium increases. The chemical parameter  
18 governing diffusion is the diffusion coefficient; as the diffusion coefficient increases, so does the  
19 extent of contamination movement by diffusion.

#### 21 **5.4.1.4 Retardation**

22 Dissolved contaminants moving through an aquifer may interact with solid constituents  
23 encountered along the flow path. This interaction may include adsorption, partitioning, ion-  
24 exchange reactions, and other chemical and physical processes that remove the dissolved  
25 constituent(s) from groundwater. The greater the fraction of contaminant sorbed, the more its  
26 transport is retarded. Because of these various processes (primarily adsorption), a solute may  
27 move at a slower velocity than the groundwater mass itself. One of several accepted and utilized  
28 equations for estimating the migration rate of a chemical in a soil-groundwater system is the  
29 retardation equation (Fetter, 1988):

$$V_c = V [1 + K_d(D_b/n)]^{-1} = R_d$$

1 where,

2  
3  $V_c$  = Velocity of the chemical at the point where the solute concentration is one-  
4 half the original value

5  $V$  = Average linear velocity of groundwater

6  $K_d$  = Adsorption coefficient

7  $D_b$  = Soil bulk density

8  $n$  = Total porosity

9  $R_d$  = Retardation factor.  
10

11 The adsorption or distribution coefficient is a function of the soil's and solute's chemistry and  
12 therefore can be compound-specific. For volatile organic compounds, the amount of organic  
13 carbon present in the aquifer matrix is an important factor. Generally, the larger the value of  $K_d$ ,  
14 the greater the compound's affinity for the solid matrix (Dragun, 1988). For compounds with  
15 very low  $K_d$ , the contaminant's mass moves at virtually the same rate as the average linear  
16 groundwater velocity. The distribution coefficient is defined by:

17  
18 
$$K_d = C_s / C_w = f_{oc} K_{oc}$$

19  
20 where:

21  
22  $C_s$  = concentration by weight in soil

23  $C_w$  = concentration by volume in water

24  $f_{oc}$  = fraction of organic carbon

25  $K_{oc}$  = organic partitioning coefficient.  
26

#### 27 **5.4.2 Migration of Contaminants**

28 Based on the soil and groundwater data collected at the site, the most significant fate and  
29 transport pathway is the leaching of organic contaminants in subsurface soils and movement  
30 through the residuum into the bedrock groundwater system. The general absence of volatile  
31 organic contaminants in surface and subsurface soils suggests that significant removal and/or  
32 subsequent leaching of organic contaminants to groundwater has proceeded. Although PAHs are  
33 present, they are considered relatively immobile because of their propensity to adsorb to soils.  
34 The site is effectively capped by asphalt. It is considered that additional significant leaching of  
35 near-surface sources to groundwater is not likely.  
36

37 The ability of inorganic constituents to migrate is primarily related to their retardation factor  
38 (Table 5-2). Depending upon how the metals enter site media, some may persist near the source  
39 area longer than others. For example, some metals may enter shallow aquifers in a reduced state.

1 It would be expected that these metals would migrate in the groundwater until pH and Eh  
2 conditions were such that precipitation might occur. If dissolved metals entered the bedrock,  
3 they would likely migrate significant distances through fractures or solution-enhanced pathways.  
4 This migration would be relatively unhindered, due to a chemically more reducing environment  
5 and a lower percentage of naturally present organic matter.  
6

7 Vertical hydraulic gradients for five well clusters at the site are presented in Table 3-2. The  
8 gradients were calculated for hydraulic head differences from groundwater elevations taken in  
9 the summer (August 2001) and fall (November 2001). Gradients derived for the summer month  
10 are generally less than 0.01; for the fall measurement, gradients in general exceed 0.01. The  
11 direction of flow indicated in wells is not necessarily consistent between the two measurement  
12 periods and, with one exception, exhibits either weak upward flow (- values) or downward flow  
13 (+ values). The calculation for the cluster at FTA-94-MW15/MW16 for August shows a  
14 relatively strong upward gradient (0.21). The gradient reflects an anomalously low water level in  
15 the shallower well, attributed to the presence of a large solution cavity penetrated by the well.  
16 The cavity may serve as a localized groundwater sink during periods of limited summer rainfall.  
17

18 The groundwater flow regime at Parcel 94(7) is separated into two separate systems. Flow in the  
19 upper unit, defined by residuum wells and presented on Figures 3-8 and 3-9, is eastward towards  
20 Ingram Creek and essentially corresponds to present topography at the site. The average linear  
21 groundwater flow velocity,  $V$ , is calculated to be 0.28291 feet per day (Table 5-3). A geometric  
22 mean hydraulic conductivity of 4.12, arithmetic mean horizontal hydraulic gradient of 0.0206,  
23 and an assumed porosity of 40 percent were used for the calculation.  
24

25 Groundwater flow in the bedrock system is shown as radial to semi-radial (Figures 3-10 and 3-  
26 11) and, although not directly coincident with the west-southwest plunging anticline mapped on  
27 the Little Oak/Newala Limestone, flow appears to be influenced by the anticline. An average  
28 linear groundwater velocity,  $V$ , in the bedrock is calculated as 0.02669 feet per day (Table 5-3).  
29 A geometric mean hydraulic conductivity of 0.144, arithmetic mean horizontal hydraulic  
30 gradient of 0.0278, and assumed porosity of 20 percent were used in the calculation.  
31

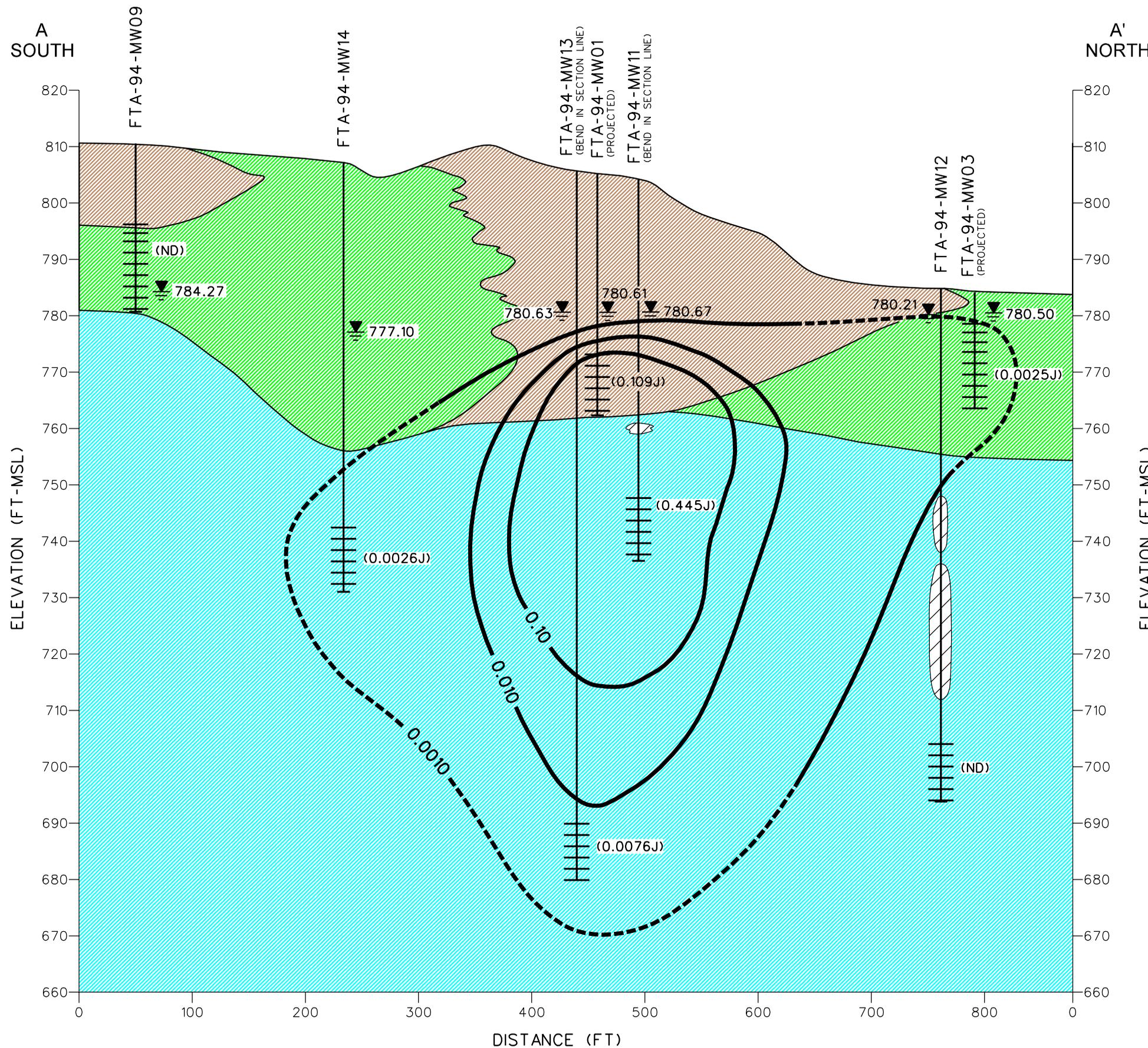
32 Although the source area for the groundwater contamination at Parcel 94(7) has not been  
33 established, contamination in the groundwater is primarily centered on the area around  
34 monitoring well cluster FTA-94-MW01 and FTA-94-MW11. Isopleth maps of total VOCs for  
35 the residuum (Figure 4-10) and bedrock (Figure 4-11) are somewhat misleading, in that relatively

1 low detections of “J”-qualified data for chloroform (FTA-94-MW15), methylene chloride (FTA-  
2 94-MW06) and TCE (FTA-94-MW03) are included in the total and extend the area of apparent  
3 contamination to the north and east. The analytical data presented in Chapter 4.0 show bedrock  
4 well FTA-94-MW11 to have the highest concentrations of the chlorinated solvents vinyl chloride  
5 and TCE in groundwater (Figures 4-8 and 4-9). The only other detection of vinyl chloride,  
6 which coincidentally occurs with an elevated concentration of TCE, is in residuum well FTA-94-  
7 MW01, immediately adjacent to the west (Figure 4-6). The occurrence of vinyl chloride, a  
8 degradation product of TCE, is restricted to these two wells.

9  
10 Based on the distribution of contaminants and the direction of groundwater flow, the initial  
11 transport in residuum appears to be from an area at or close to the south/southwest of FTA-94-  
12 MW01, towards the east-northeast. Because of the high specific gravity of the primary  
13 constituent (TCE), density stratification within the plume could occur, especially if the  
14 constituents are in a separate phase or at concentrations approaching their solubility limit. The  
15 distribution shown by isopleth and groundwater flow data would suggest that, once the  
16 contaminant plume descends to bedrock, a radial to semi-radial flow to the west and south in the  
17 bedrock will dominate. Figures 5-1 and 5-2 present cross-sectional views of the total VOC  
18 distribution in relation to the subsurface geology. The degree of influence of fracture flow within  
19 the limestone bedrock cannot be assessed from the present data.

20  
21 An estimation of the rate and distance of contaminant migration was calculated for both  
22 residuum and bedrock. The parameters used and the results are shown in Table 5-3. Solute  
23 transport rate in residuum ranged from 16.51 feet/year for chlorobenzene to 71.39 feet/year for  
24 vinyl chloride. In bedrock, contaminant velocity ranged from 0.24 feet/year for chlorobenzene to  
25 2.22 feet/year for vinyl chloride. The minimum and maximum contaminant transport rates  
26 calculated for bedrock suggest that, over a 50-year period, contaminants, if not naturally  
27 attenuated, would have migrated downgradient towards FTA-94-MW14 but would not yet have  
28 reached it. In residuum, the transport rates and migration distances indicate that contaminants  
29 would have reached Ingram Creek, if the contaminants and flow did not descend vertically.

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 PROJ. NO.: 796887  
 INITIATOR: L. O'HARE  
 PROJ. MGR.: J. YACOUB  
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 ENGR. CHECK. BY: S. MORAN  
 DATE LAST REV.:  
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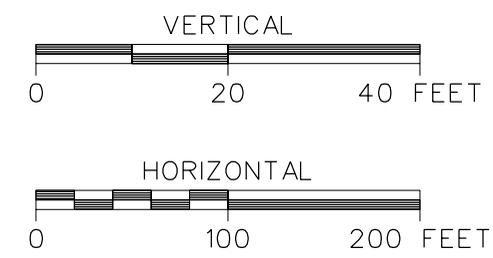


**LEGEND**

- SCREEN INTERVAL
- WATER TABLE (AUGUST 21, 2001)
- 784.27 GROUNDWATER ELEVATION (FT MSL)
- VOID
- 0.10 TOTAL VOC CONCENTRATION (mg/L) (DASHED WHERE INFERRED)
- (ND) NOT DETECTED
- (0.109) CONCENTRATION IN MILLIGRAMS PER LITER (mg/L)
- J ESTIMATED CONCENTRATION
- SILT
- CLAY
- LIMESTONE

**NOTES:**

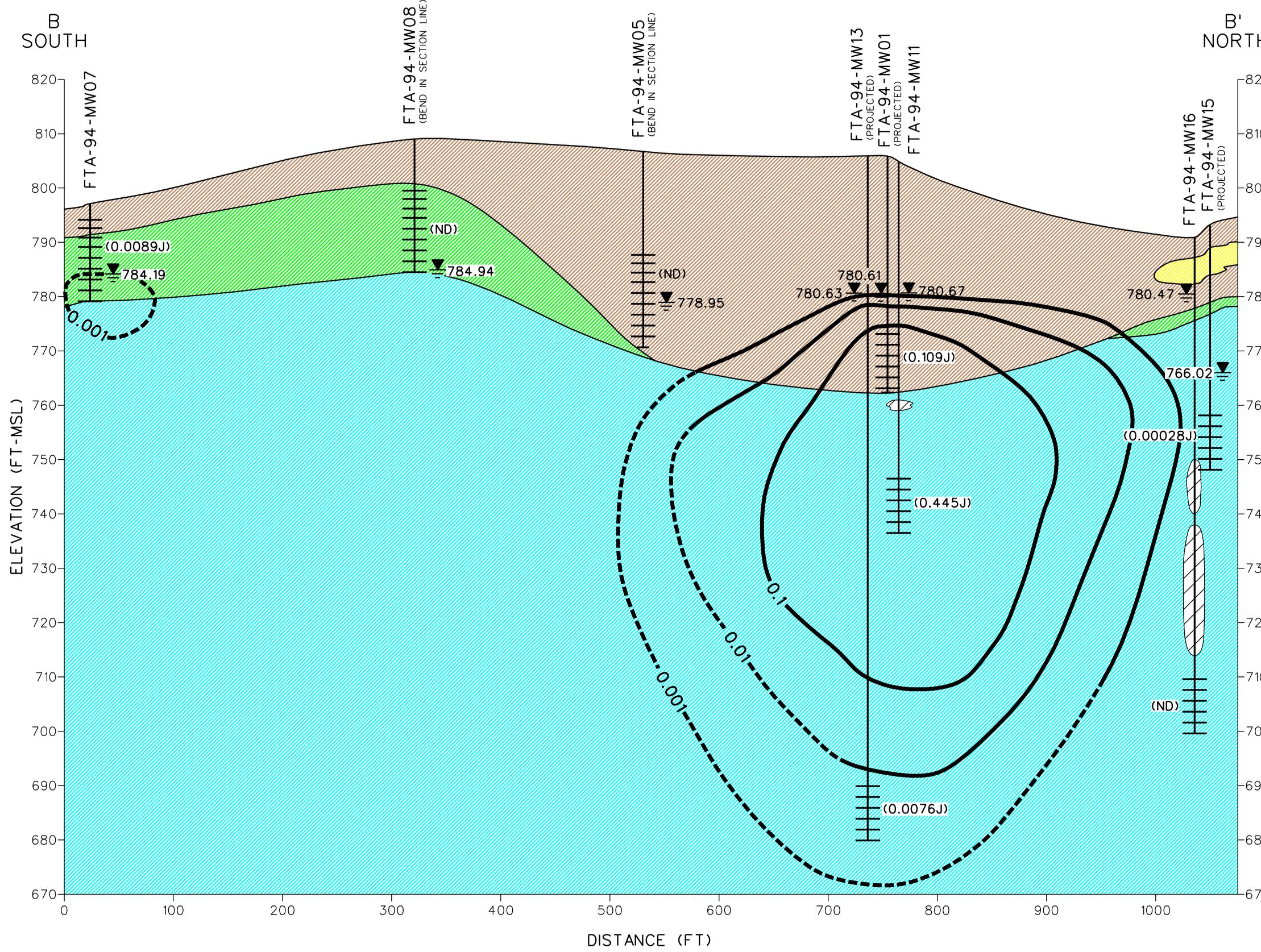
1. ELEVATIONS ARE REFERENCED TO THE NORTH AMERICAN VERTICAL DATUM OF 1988.
2. DASHED WHERE INFERRED.
3. TOTAL VOC CONCENTRATION EXCLUDES COMMON LAB CONTAMINANT ACETONE.



**FIGURE 5-1**  
**TOTAL VOCs CROSS SECTION A-A'**  
**FORMER CHEMICAL LAUNDRY AND**  
**MOTOR POOL AREA 1500**  
**PARCEL 94(7)**

U. S. ARMY CORPS OF ENGINEERS  
 MOBILE DISTRICT  
 FORT McCLELLAN  
 CALHOUN COUNTY, ALABAMA  
 Contract No. DACA21-96-D-0018

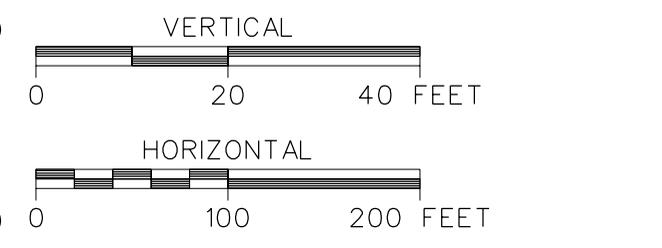
DWG. NO.: \796887es.366  
 PROJ. NO.: 796887  
 INITIATOR: L. O'HARE  
 PROJ. MGR.: J. YACOUB  
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 ENGR. CHK. BY: S. MORAN  
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**LEGEND**

- SCREEN INTERVAL
- WATER TABLE (AUGUST 21, 2001)
- 784.27 GROUNDWATER ELEVATION (FT MSL)
- VOID
- TOTAL VOC CONCENTRATION (mg/L) (DASHED WHERE INFERRED)
- (ND) NOT DETECTED
- (0.445) CONCENTRATION IN MILLIGRAMS PER LITER (mg/L)
- J ESTIMATED CONCENTRATION
- SAND
- SILT
- CLAY
- LIMESTONE

- NOTES:**
- ELEVATIONS ARE REFERENCED TO THE NORTH AMERICAN VERTICAL DATUM OF 1988.
  - DASHED WHERE INFERRED.
  - TOTAL VOC CONCENTRATION EXCLUDES COMMON LAB CONTAMINANT ACETONE.



**FIGURE 5-2**  
 TOTAL VOCs CROSS SECTION B-B'  
 FORMER CHEMICAL LAUNDRY AND  
 MOTOR POOL AREA 1500  
 PARCEL 94(7)  
 U. S. ARMY CORPS OF ENGINEERS  
 MOBILE DISTRICT  
 FORT McCLELLAN  
 CALHOUN COUNTY, ALABAMA  
 Contract No. DACA21-96-D-0018

## 6.0 Streamlined Human Health Risk Assessment

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Due to the large size and complexity of the FTMC installation, a streamlined human health risk assessment (SRA) is developed using SSSLs. The SSSLs are medium-specific and receptor-specific, risk-based screening concentrations that are used to quickly and efficiently screen the site for potential cancer risk and noncancer hazards from residual chemicals in environmental media. The SSSLs address all significant exposure pathways and are sufficiently site-specific with regard to exposure assumptions that they are used to estimate risk with as much precision as a typical baseline risk assessment. The exposure assumptions and SSSL methodology are described in detail in the installation-wide work plan (IT, 2002). The SSSLs were updated with the most current toxicity values and are compiled in the *Human Health and Ecological Screening Values and PAH Background Summary Report* (IT, 2000c); this document also presents toxicity profiles, which are brief descriptions of the physical and toxicological properties of the chemicals that may be identified as contaminants at FTMC sites. In addition, the SSSL for vinyl chloride was revised to capture the August 7, 2000, cancer and noncancer toxicological evaluation updated by the EPA (2002). The chemical-specific variable values used in the SSSL calculations are presented in the *Human Health and Ecological Screening Values and PAH Background Summary Report* (IT, 2000c).

### 6.1 Streamlined Risk Assessment Protocol

An SRA consists of the following steps, which are discussed in the following sections.

- Develop a conceptual site exposure model (CSEM)
- Select site-related chemicals
- Select chemicals of potential concern (COPC)
- Characterize risk
- Identify chemicals of concern (COC)
- Develop remedial goal options (RGO).

#### 6.1.1 Develop a Conceptual Site Exposure Model

The CSEM identifies the potentially contaminated environmental media, contaminant migration pathways, exposure media, plausible receptors, and exposure routes. Four receptor scenarios are evaluated for Parcel 94(7): groundskeeper, construction worker, recreational site user (with hunting), and resident. These receptor scenarios were selected based upon the information provided in the *Fort McClellan Comprehensive Reuse Plan, Implementation Strategy* (EDAW,

1 1997) regarding the proposed future land use for this site. The residential scenario is not likely  
2 for this site but is included to provide additional information to risk managers. Residential  
3 exposure is generally considered to be the most conservative of all exposure scenarios. The  
4 CSEM for Parcel 94(7) is shown on Figure M-1 in Appendix M.

### 6.1.2 **Select Site-Related Chemicals**

7 Generally, chemicals are excluded from the SRA if they are essential nutrients, occur at such a  
8 low detection frequency that they are considered to be artifacts of sampling or laboratory  
9 analysis, or if they are present at concentrations comparable to background. Comparison with  
10 background is limited to metals, because data are not sufficient for quantifying anthropogenic  
11 background levels of organic chemicals. The background data used in this SRA are presented in  
12 the *Final Background Metals Survey Report* (SAIC, 1998).

13  
14 Background screening of metals may include several steps. The first step involves comparing  
15 the maximum detected concentration (MDC) from the site data with the background screening  
16 criterion (BSC), defined as two times the mean of the background data set, consistent with EPA  
17 (1995a) Region IV guidance. If the metal MDC is less than or equal to the BSC, the chemical is  
18 not selected as a site-related chemical. If the MDC exceeds the BSC, the MDC is compared with  
19 the 95 percent upper tolerance limit (UTL) of the background data set as a more refined  
20 statistical approach to comparing site data with background data. The UTL is the upper 95  
21 percent confidence limit of the 95th quantile. The UTLs were calculated from the background  
22 metals data set (SAIC, 1998).

23  
24 Comparison of the MDC with the BSC or the UTL is a simple screen that relates the highest  
25 detection from site data to a reasonable upper bound for background. This comparison, however,  
26 does not relate the entire site data set to the entire background data set, which provides a more  
27 appropriate comparison when exposure is expected to occur randomly and uniformly over the  
28 entire site. Therefore, if the MDC from site data exceeds the UTL, it may be prudent to use the  
29 Mann-Whitney U Test to compare the site data set with the background data set. A geochemical  
30 analysis may also be considered to determine if metals concentrations are anomalous or within  
31 normal background concentrations.

32  
33 A more detailed analysis of background metals in soils and groundwater is presented in  
34 Appendix L. Site-related chemicals are carried to the next step of the SRA.

1 **6.1.3 Select Chemicals of Potential Concern**

2 COPCs are the chemicals that may contribute significantly to risk. They are selected by  
3 comparing the MDCs of site-related chemicals to their respective SSSLs. Since the SSSLs are  
4 receptor-specific, COPCs are also receptor-specific. In other words, a chemical may be selected  
5 as a COPC for residential exposure but not for recreational site use. This occurs because the  
6 SSSL for residential exposure is lower than that for recreational site use, because the resident is  
7 more highly exposed. COPCs may be selected based on potential cancer risk, noncancer effects,  
8 or both. Source-term concentrations (STC) are estimated for the COPCs. An STC is a  
9 conservative estimate of the concentration of the COPC averaged over the entire site. COPCs are  
10 carried to the risk characterization step of the SRA.

11  
12 **6.1.4 Characterize Risk**

13 The appropriate SSSL is applied to the STC to estimate an incremental lifetime cancer risk  
14 (ILCR) or hazard index (HI) for each COPC in each environmental medium, as explained in the  
15 installation-wide work plan (IT, 2002). The ILCRs and HIs are summed across all exposure  
16 routes and chemicals to yield a total ILCR or total HI for a given receptor exposed to a given  
17 medium. The total ILCRs and HIs for each medium are summed to yield a total ILCR and a total  
18 HI for a given receptor exposed to all media. Total ILCR estimates for a receptor below 1E-6 are  
19 considered to be negligible (EPA, 1990). ILCR estimates between 1E-6 and 1E-4 are considered  
20 to fall within a risk management range. ILCR estimates that exceed 1E-4 are considered to be  
21 unacceptable and trigger estimation of remedial goal options (RGO). HI estimates for a receptor  
22 above the threshold level of 1 raise concern for the occurrence of adverse noncancer effects  
23 (EPA, 1989). However, adding HI values for all chemicals may overstate the potential for  
24 adverse effects. EPA (1989) believes that the assumption of additivity is valid only for  
25 chemicals that operate by the same mechanism of toxicity; therefore, the HI values may be  
26 segregated on the basis of mechanism of toxicity. Data on mechanism of toxicity are available  
27 for very few chemicals; therefore, target organ is used as a surrogate, assuming that chemicals  
28 that act on the same target organ may operate by the same mechanism of toxicity.

29  
30 ILCR and HI estimates are presented in the tables in scientific format with two digits to the right  
31 of the decimal to facilitate replication. ILCR and most HI estimates in the text are rounded to  
32 one significant figure to reflect the uncertainty about these values (EPA, 1989; 1995a). HI  
33 estimates greater than 10 are rounded to the nearest whole integer. For example, an ILCR of  
34 1.49E-4 would be rounded to 1E-4 and interpreted as within, but not exceeding, the 1E-6 to 1E-4

1 risk management range. Similarly, an HI of 1.49 would be rounded to 1 and interpreted as not  
2 exceeding the threshold level of 1.

### 3 4 **6.1.5 Identify Chemicals of Concern**

5 COCs are chemicals that contribute significantly to ILCR or HI for a receptor scenario with  
6 unacceptable risk levels, i.e., a total ILCR summed across all COPCs and media greater than 1E-  
7 4 or a total HI greater than 1 (after segregation by target organ).

### 8 9 **6.1.6 Develop Remedial Goal Options**

10 RGOs are risk-specific concentrations developed for chemicals identified as COCs (EPA,  
11 1995a). The cancer-based SSSLs are adopted as RGOs based on an ILCR of 1E-6; RGOs are also  
12 developed for cancer risks of 1E-5 and 1E-4. The noncancer-based SSSLs are adopted as RGOs  
13 based on a noncancer HI of 0.1; RGOs are also developed for HI values of 1 and 3.

## 14 15 **6.2 Results**

16 Receptor tables and the CSEM for Parcel 94(7) are included in Appendix M. Surface soil,  
17 groundwater, total soil (surface soil and subsurface soil combined), surface water, and sediment  
18 are the media evaluated in this SRA. The receptor scenarios determined to be applicable for the  
19 site include the groundskeeper, construction worker, resident, and recreational site user.

### 20 21 **6.2.1 Surface Soil**

22 Four depositional and 16 surface soil samples were evaluated as surface soil in the SRA (Table  
23 M-1). The surface soil samples were collected from a depth interval of 0 to 1 foot. Thirteen of  
24 these samples were analyzed for metals, PCBs, SVOCs, and VOCs. Seven of the twenty samples  
25 were analyzed for VOCs only.

26  
27 Eighteen metals, nineteen SVOCs, and thirteen VOCs were detected in the surface soil samples  
28 (Table M-2). All the metals were determined to be present at levels comparable to background  
29 (Appendix L) or to be essential nutrients; therefore, none of the metals were determined to be  
30 site-related. All organic chemicals detected in surface soil at the site were selected as site-related  
31 chemicals and were carried forward to the COPC selection step.

32  
33 Table M-3 presents the comparison of the surface soil site-related chemicals to the receptor-  
34 specific surface soil SSSLs for COPC selection. The recreational site user, groundskeeper, and  
35 venison consumer were the receptors evaluated for exposure to surface soil. Only four SVOCs

1 (benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, and dibenz[a,h]anthracene) were  
2 selected as COPCs for the groundskeeper. All of the SVOCs selected as surface soil COPCs for  
3 the groundskeeper were selected based only upon their cancer risk. No surface soil COPCs were  
4 selected for the recreational site user or for venison consumption.

5  
6 Table M-4 presents the cancer risk estimates for the groundskeeper exposed to surface soil. The  
7 resulting ILCR of 1E-5 is within the risk management range of 1E-6 to 1E-4.

### 8 9 **6.2.2 Groundwater**

10 Twenty-one groundwater samples collected from 19 wells were evaluated in the SRA (Table  
11 M-5). Four groundwater samples were analyzed for metals, PCBs, SVOCs, and VOCs.

12 Seventeen groundwater samples were analyzed for VOCs only. The resident, groundskeeper,  
13 and construction worker were evaluated for their potential future exposure to groundwater.

14  
15 Seventeen metals, one SVOC, and 13 VOCs were detected in groundwater at the site (Table  
16 M-6). All the metals were determined to be present at levels comparable to background  
17 (Appendix L) or to be essential nutrients; therefore, none of the metals were determined to be  
18 site-related. One SVOC and eight VOCs were detected with sufficient frequency to be selected  
19 as site-related chemicals. Six VOCs (benzene, chloroform, chloromethane, methylene, chloride,  
20 p-cymene, and TCE) were eliminated from consideration as site-related chemicals because they  
21 were detected infrequently (one detection in 20 or 21 samples) at very low concentrations (i.e.,  
22 near or below the reporting limit). This matter is discussed more fully in the uncertainty section.

23  
24 Table M-7 presents the COPC selection for the resident, groundskeeper, and construction worker  
25 exposed to groundwater. Four VOCs were selected as groundwater COPCs for the resident:  
26 chlorobenzene, cis-1,2-DCE, TCE, and vinyl chloride based on noncancer hazard; and TCE and  
27 vinyl chloride based on cancer risk.

28  
29 Groundwater COPCs for the groundskeeper include chlorobenzene and TCE based on noncancer  
30 hazard, and TCE and vinyl chloride based on cancer risk (Table M-7). Groundwater COPCs for  
31 the construction worker are the same as those for the groundskeeper, except that TCE was  
32 selected only because of noncancer hazard.

33  
34 Table M-8 presents the cancer risk and noncancer hazard estimates for the resident exposed to  
35 COPCs in groundwater. The resulting HI for the resident, rounded to one significant figure, is 1,

1 which does not exceed the threshold of 1. The resulting ILCR for the resident exposed to  
2 groundwater is 2E-4, which exceeds the risk management range and falls in the generally  
3 unacceptable category. Therefore, based upon these analytical data, groundwater at Parcel 94(7)  
4 appears to present an unacceptable cancer risk to a future resident.

5  
6 Table M-9 presents the cancer risk and noncancer hazard estimates for the groundskeeper  
7 exposed to COPCs in groundwater. The resulting HI for the groundskeeper is 0.1, which is  
8 below the threshold of 1. The resulting ILCR for the groundskeeper is 2E-5, which is within the  
9 risk management range. Therefore, based upon these analytical data, groundwater at the site  
10 presents neither an unacceptable cancer risk nor a noncancer hazard to a future groundskeeper.

11  
12 Table M-10 presents the cancer risk and noncancer hazard estimates for the construction worker  
13 exposed to COPCs in groundwater. The resulting HI for the construction worker of 0.1 is below  
14 the HI threshold of 1. The resulting ILCR for the groundskeeper of 9E-7 is below the risk  
15 management range. Therefore, based upon these analytical data, groundwater at the site presents  
16 neither an unacceptable cancer risk nor a noncancer hazard to a future construction worker.

17  
18 Table M-11 presents the groundwater RGOs for the resident. All cancer-based COPCs with an  
19 ILCR greater than 1E-6 for the resident were selected as COCs, including TCE and vinyl  
20 chloride. The RGOs are based upon target ILCRs of 1E-6, 1E-5, and 1E-4. The STC of TCE  
21 falls between RGOs based on cancer risks of 1E-6 and 1E-5. The STC of vinyl chloride exceeds  
22 the RGO based on a cancer risk of 1E-4. The STCs for both chemicals exceed their EPA (2000)  
23 maximum contaminant levels (MCL).

### 24 25 **6.2.3 Total Soil**

26 Thirty-four total soil samples were evaluated in the SRA (Table M-12). Total soil is a  
27 combination of the surface soil and subsurface soil data sets, to a total depth of 12 feet. Twenty-  
28 seven soil samples were analyzed for metals, PCBs, SVOCs, and VOCs. Seven soil samples  
29 were analyzed for VOCs only. The resident and the construction worker were evaluated for their  
30 exposure to total soil.

31  
32 Eighteen metals, two PCBs, 19 SVOCs (predominantly PAH compounds), and 17 VOCs were  
33 detected in total soil at the site (Table M-13). After the background (Appendix L) and essential  
34 nutrient screens, one metal (lead), all the SVOCs, and 11 VOCs were determined to be site-  
35 related. Several organics were determined not to be site-related because they had very low

1 detection frequencies at low concentrations near or below their respective reporting limits. The  
2 MDCs of these chemicals were all below their respective SSSLs.

3  
4 Table M-14 presents the COPC selection for the resident and construction worker exposed to  
5 total soil. For the resident, five SVOCs (all PAHs) were selected as COPCs, based on their  
6 cancer risk. Only benzo(a)pyrene was selected as a COPC for the construction worker exposed  
7 to total soil, based upon its cancer risk.

8  
9 Table M-15 presents the cancer risk and noncancer hazard estimates for the resident exposed to  
10 COPCs in total soil. Because no chemicals were selected as COPCs based on noncancer effects,  
11 an HI was not estimated. The resident total soil ILCR of  $3E-5$  is within the cancer risk  
12 management range.

13  
14 Table M-16 presents the cancer risk and noncancer hazard estimates for the construction worker  
15 exposed to COPCs in total soil. Because no chemicals were selected as COPCs based on  
16 noncancer effects, an HI was not estimated. The construction worker total soil ILCR of  $4E-7$  is  
17 below the cancer risk management range. Therefore, no cancer or noncancer based RGOs were  
18 developed for the construction worker exposed to COPCs in total soil.

19  
20 Table M-17 presents the total soil RGOs for the resident. All cancer-based COPCs with an ILCR  
21 greater than  $1E-6$  for the resident were selected as COCs, including benzo(a)anthracene,  
22 benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene. The RGOs are based upon  
23 target ILCRs of  $1E-6$ ,  $1E-5$ , and  $1E-4$ . The STCs of benzo(a)anthracene, benzo(b)fluoranthene,  
24 and dibenz(a,h)anthracene fall between RGOs based on cancer risks of  $1E-6$  and  $1E-5$ ; the STC  
25 of benzo(a)pyrene falls between RGOs based on cancer risks of  $1E-5$  and  $1E-4$ .

#### 26 27 **6.2.4 Future Groundwater Conditions**

28 Soil leaching to groundwater was evaluated for Parcel 94(7). If a residential groundwater COPC  
29 was also detected in total soil, then the total soil MDC was compared to background  
30 concentrations (for metals) and the EPA (1996) soil-screening level. If the total soil MDC was  
31 above background and the soil-screening level, then that chemical was evaluated for its future  
32 potential to leach to groundwater. Table M-18 presents the selection of chemicals for the future  
33 groundwater conditions evaluation. Based upon the screening in Table M-18, none of the current  
34 groundwater COPCs were selected as future groundwater COPCs, based upon each chemical's  
35 potential to leach from soil to groundwater.

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**6.2.5 Surface Water**

Five surface water samples were evaluated in the SRA (Table M-19). Two samples were analyzed for metals, PCBs, SVOCs, and VOCs. Three samples were analyzed for VOCs only. The resident and the recreational site user are the plausible receptor scenarios for exposure to surface water.

Five metals and two VOCs were detected in the five surface water samples (Table M-20). However, after background screening and nutrient elimination, none of the metals were determined to be site-related contaminants. The two VOCs detected in surface water were carried forward to the COPC screening; however, both of the VOCs were detected in only one out of five samples.

As presented in Table M-21, neither site-related VOC was selected as a COPC for the resident or the recreational site user.

**6.2.6 Sediment**

Five sediment samples were evaluated in the SRA (Table M-22). Two samples were analyzed for metals, PCBs, SVOCs, VOCs, and TOC. Three samples were analyzed for VOCs only. The resident and the recreational site user are the plausible receptor scenarios for exposure to sediment.

Fifteen metals, 15 SVOCs (all PAHs), and 7 VOCs were detected in the five sediment samples (Table M-23). However, after background screening and nutrient elimination, none of the metals were determined to be site-related contaminants. All of the organic chemicals were carried forward to the COPC screening; however, some of the VOCs were only detected in one out of five samples.

As presented in Table M-24, none of the site-related chemicals were selected as COPCs for either the resident or the recreational site user.

**6.2.7 Uncertainty Analysis**

Uncertainty is a large part of any risk assessment for a number of reasons, some of which are discussed in the installation-wide work plan (IT, 2002). Generally, uncertainty is handled by making conservative choices when the data are incomplete or compromised by variability. One

1 source of uncertainty in this SRA is the disparity among analyses of samples in the surface soil,  
2 total soil, and groundwater. Very few samples were analyzed for all parameters on a consistent  
3 basis. Therefore, there are large discrepancies among sample sizes for metals, SVOCs, and  
4 VOCs.

5  
6 Probably the most significant site-related uncertainty attends the PAHs identified in surface and  
7 subsurface soil. Five PAHs were identified as COPCs in total soil, including  
8 benzo(a)anthracene, benzo(a)pyrene, benzo(a)fluoranthene, dibenz(a,h)anthracene, and  
9 indeno(1,2,3-cd)pyrene. The MDC of each of the PAHs exceeded the BSC for soil beneath  
10 asphalt as presented in IT (2000), which is why these chemicals were included in the quantitative  
11 evaluation. In every case, however, the site-related arithmetic mean was below the overall mean  
12 of the background data set, and the site-related MDC was below the MDC of the background  
13 data set. It seems likely that the PAHs reflect the large amount of asphalt associated with the site  
14 rather than any specific activity or inadvertent release related to Army activity.

15  
16 Another source of uncertainty arises from a low frequency of detection of several chemicals in  
17 groundwater. Six VOCs (benzene, chloroform, chloromethane, methylene chloride, p-cymene,  
18 and tetrachloroethene) were eliminated from consideration as site-related chemicals in  
19 groundwater because they were detected infrequently (one detection in 20 or 21 samples) at very  
20 low concentrations (i.e., near or below the reporting limit) (Table M-6). None of the reported  
21 concentrations, however, exceeded the respective MCL or SSSL, with one exception. The  
22 reported concentration of benzene (1.70E-3 mg/L) fell below the MCL of 5E-3 mg/L but slightly  
23 exceeded the cancer-based residential SSSL of 1.41E-3 mg/L. An ILCR of 1.21E-6 could be  
24 estimated for residential exposure to benzene in groundwater. This risk level is at the low end of  
25 the risk management range, suggesting that benzene is unlikely to contribute significantly to  
26 unacceptable cancer risk. Furthermore, benzene was not detected in any other wells at the site  
27 (including downgradient wells) or in any of the soil samples collected.

### 28 29 **6.2.8 Conclusions**

30 Cancer risks and noncancer hazards for each medium are summed for each receptor (Table M-  
31 25). Neither ILCR nor HI values were estimated for the recreational site user because no  
32 chemicals were selected as COPCs in surface soil, surface water, or sediment, the only media to  
33 which this receptor is exposed. Total ILCR estimates for the groundskeeper and construction  
34 worker fall within the risk management range, below the 1E-4 level, above which risk is  
35 generally regarded as unacceptable. Total HI estimates for the groundskeeper and construction

1 worker fall below the threshold level of 1. It is concluded that exposure to environmental media  
2 at Parcel 94(7) poses no unacceptable risk of cancer or adverse noncancer effects for the  
3 recreational site user, construction worker, or groundskeeper.

4  
5 The total HI for the resident of 1.23, when rounded to one significant figure, does not exceed the  
6 threshold level of 1. The total ILCR of 2E-4 (Table M-25) exceeds the risk management range  
7 and falls into the generally unacceptable category. Although the ILCR associated with total soil  
8 falls within the risk management range, several PAHs were selected as COCs because their  
9 associated ILCR values exceed 1E-6. However, as explained above, the PAHs probably reflect  
10 the presence of the large amount of asphalt on the site rather than any activity or inadvertent  
11 release attributable to the Army. Clearly, however, vinyl chloride in groundwater is the risk  
12 driver for residential exposure. Vinyl chloride, a known degradation product of the  
13 polychlorinated ethanes/ethenes, was detected in two samples from monitoring well FTA-94-  
14 MW01 and in one sample from monitoring well FTA-94-MW11. Two of the three detected  
15 concentrations exceed the MCL of 2E-3 mg/L.