Focused Feasibility Study
Lilyblad Site
Tacoma, Washington

Prepared for
Washington State
Department of Ecology

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CONTENTS Page

CONTENTS (Continued)

TABLES

FIGURES

CONTENTS (Continued)

APPENDIX A
COST ESTIMATES FOR ALTERNATIVES 1 THROUGH 4

1.0 INTRODUCTION

The Lilyblad site (Site) is located at 2244 Port of Tacoma Road in Tacoma, Washington, and consists of the Lilyblad property and the adjacent properties that have been affected by historical releases from the former Lilyblad and Lilyblad/Sol Pro operations (refer to Figures 1-1 and 1-4). A substantial amount of investigation and remediation work has been completed at the Site. For the purposes of this focused feasibility study (FFS), the Site is defined as the Area of Concern (AOC) for soil and groundwater contamination regardless of property boundaries.

A Supplemental Remedial Investigation report was recently prepared by CH2M Hill (CH2M Hill 2004). This report provides a comprehensive review of the nature and extent of contamination at the Site. It identifies contaminants of concern (COCs), and presents potential cleanup levels (CULs) and points of compliance (POC) for each COC. The COCs include total petroleum hydrocarbons (TPHs), semivolatile organic carbon compounds (SVOCs), and volatile organic carbon compounds (VOCs). The concentration of each COC in soil was compared to its CUL to identify the approximate extent of soil contamination in the unsaturated zone (CH2M Hill, Figure 4-1), the capillary fringe (CH2M Hill, Figure 4-2), the saturated zone (CH2M Hill, Figure 4-3), and in the aquitard (CH2M Hill, Figure 4-4.) The lateral extent of soil contamination was similar in each soil interval.

Concentrations of benzene and vinyl chloride in groundwater were compared to their respective CULs to identify the approximate extent of groundwater contamination in the shallow aquifer (CH2M Hill, Figures 4-5 and 4-6). The vinyl chloride contaminant plume extended further to the southeast (below the PW Eagle building) than the benzene plume. Both the vinyl chloride and benzene groundwater contaminant plumes extended beyond the areas of soil contamination.

The areas of the Site that will require soil and/or groundwater remediation are summarized in Section 1.1. A number of site-specific technical restraints will impact the selection of the appropriate remedial actions at the Site. These restraints are summarized in Section 1.2.

1.1 Description of the Area of Concern for Soil and for Groundwater

The COCs and CULs for soil and groundwater that were used in this FFS (listed in Table 1.1) are based on protection of surface water. This list of CULs differs from the list used by CH2M Hill in its Supplemental RI (RI Tables 4-2 and 4-14), which are based on protection of drinking water. CULs established in the SRI are not applicable to the Site because the shallow aquifer has a low yield and is not a potential drinking water source. Because groundwater at the Site flows into the Blair Waterway, CULs based on surface water protection are appropriate for the Site. Groundwater levels at the Site fluctuate about 1 to 2 feet, which has created a smear zone of hydrocarbons and other contaminants in soil both above and below the water table. This smear zone acts as a secondary source of COCs throughout the Site. The diverse nature of the TPH, SVOC, and VOC COCs at the Site and the presence of the smear zone mutes the impact of the recent change in CULs on area of contaminated soil and groundwater that will require remediation.

Recent interim actions by Terra Vac have removed some contaminants from the Site. Interim actions were conducted in the Light Nonaqueous Phase Liquid (LNAPL), Dissolved Plume, Hot Spot, Multi-Phase Extraction (MPE), and PW Eagle building areas. Terra Vac reported significant reductions in TPH and BTEX concentrations in soil and groundwater in these areas (Terra Vac 2006a). Analytical data related to the effects of treatment on the other VOC and SVOC COCs were not provided.

1.1.1 Area of Concern for Soils

For the purposes of this FFS, the AOC for soil is based on a composite of the areas described by CH2M Hill RI, Figures 4-1 to 4-4. This AOC is depicted on Figure 1-1, and was included as Attachment B in Ecology's scope of work for this FFS (Ecology 2006a), and as Figure 4 in Terra Vac's Site-wide Design Plan (Terra Vac 2005). Figure 1-1 is a conservative representation of the area of the Site where COCs are present in soil at concentrations exceeding CULs.

The surface area of the soil AOC is approximately 115,000 square feet. It contains approximately 43,000 cubic yards of soil from ground surface to 2 feet into the underlying aquitard (assumes an average depth of 10 feet).

The analytical data for the soil sample locations located within the AOC contained in Tables 4-4 to 4-7 of the CH2M Hill RI, and locations that were sampled by Terra Vac prior to May 2004 and reported in their January 2006 Summary of the December 2005 sampling event at the Site (Terra Vac 2006a) were used to compute an estimate of the total mass of contaminants contained in soil within the soil AOC. This estimate was considered to be an estimate of the contaminant load at the Site prior to May 2004 when Terra Vac began more continuous cleanup operations at the Site. The soil sample locations used to develop this estimate are depicted on Figure 1-2. An estimate of the total mass of contaminants within the soil AOC is presented in Table 1.2. The mass loadings calculated in Table 1.2 are gross estimates of the actual loading at the Site prior to May 2004. The calculation assumptions used to develop this estimate are summarized in the "Notes to the Table." Every sample collected within the AOC was given equal weight even though the sample density varied for different areas of the Site. The soil samples were collected by various investigators over an extended period of time. Nonetheless, it was judged that the information in Table 1.2 would provide useful insights into the historical distribution of contaminants in Site soils.

The total mass of contaminants present at the Site prior to May 2004 using this calculation method is approximately 200,000 pounds. Approximately 98 percent of this mass has been reported to be TPH compounds. VOCs comprise about 4,000 pounds of the total mass, while SVOCs comprise about 200 pounds of mass.

Approximately 52 percent of the mass is present in the saturated soil layer, 27 percent in the vadose zone soil layer, 19 percent in the capillary fringe layer, and 2 percent in the aquitard soil layer at the Site.

Approximately 90 percent of the contamination is present on the Lilyblad, Nelson, and Port of Tacoma Road properties, with the remaining contamination (about 10 percent) located on the PW Eagle (PWE) and Saul properties.

Terra Vac conducted interim measures at the Site using dual vapor extraction (DVE)/biodegradation/oxidation technology from May 2004 until March 2006. The remediation system was operated on the Lilyblad property (LNAPL and Hot Spot areas) and on the PWE property (refer to Figure 1-3). Soil and groundwater samples were obtained in December 2005 (Terra Vac 2006a) in these areas to assess the effectiveness of the DVE/bioremediation/ oxidation process that was applied to each area.

The results from the Site soil samples obtained in December 2005 were used to calculate a more current soil contaminant mass loading. Soil sample analytical results in the LNAPL, Hot Spot, MPE, and PWE building areas were substituted for the pre-May 2004 data contained in Table 1.2 to calculate an approximate soil mass loading as of December 2005. This updated calculated mass loading totals about 160,000 pounds and is summarized in Table 1.3. Thus, this rough calculation approach suggests that Terra Vac's efforts removed about 40,000 pounds of contaminants, nearly all of which (on a total mass basis) were TPH compounds. The performance of the Terra Vac technology is discussed further in Section 3.4.1.

The estimate of the soil contaminant load in Table 1.3 assumes that the few soil samples collected in December 2005 in areas where interim remedial actions were completed by CDM (excavation of alley way north of the PWE Manufacturing Building) and Terra Vac are indicative of the actual soil concentrations within the areas treated. The contaminant load summarized in Table 1.3 may not accurately reflect the amount of soil contamination remaining at the Site, since only a small number of soil samples were analyzed in the areas where treatment occurred. These samples may not be representative of the actual soil concentration distribution that is present in each area that was treated.

1.1.2 Area of Concern for Groundwater

For the purposes of this FFS, the AOC for groundwater is based on the areas described by CH2M Hill Figures 4-5 and 4-6. This area of concern is depicted on Figure 1-4, and is a conservative representation of the area of the Site where COCs are present in groundwater at concentrations exceeding risk-based cleanup levels.

Groundwater in the shallow aquifer (above the aquitard) is contaminated with TPH (mostly TPH-D and TPH-G), VOCs (mostly benzene, vinyl chloride, and the degradation products of PCE and TCA), and SVOCs (mostly pentachlorophenol). The surface area of the groundwater AOC is approximately 164,000 square feet. The volume of water expected to be contained in the shallow aquifer below this groundwater AOC is discussed in Section 2.1.

We made a similar calculation as discussed previously for soil using the contaminant concentrations in groundwater that were contained in CH2M Hill RI Table 4-15, and in the Terra Vac (2006a) document. Calculations indicate that approximately 98 percent of the COCs present in the groundwater AOC are TPH compounds. Approximately 80 percent of the contamination was in groundwater within the Lilyblad property line, with about 12 percent in the PWE area, and 7 percent in the MPE area. The total mass of contaminants in the upper aquifer within the groundwater AOC is estimated to be approximately 200 pounds.

1.2 Site-Specific Technical Restraints

The physical and chemical features of the Site influence the implementation of the remedial actions described in Sections 2.1 through 2.4. Three groups of physical factors can influence the implementation of these remedial actions: 1) factors associated with the active use of the facility, 2) factors limiting access to and removal of contaminated soil and groundwater, and 3) site-specific geologic and hydrologic conditions promoting or prohibiting the applicability of certain remedial technologies. In addition to these physical factors, various chemical attributes of the Site can influence the performance of a remedial alternative that may prevent the alternative from attaining the cleanup levels in a reasonable time frame.

1.2.1 An Active Facility

The soil and groundwater AOCs include the Lilyblad facility, portions of the PWE manufacturing facility, a small portion of the northern portion of the Saul property below the railroad tracks traversing the property, and small portions of the Nelson and Port of Tacoma Road properties on the northern end of the Site (refer to Figures 1-1 and 1-4). The Lilyblad facility is currently used to receive, repackage, store, and distribute a variety of petroleum products. These activities require that Lilyblad, PWE, and railroad employees have access to and use of most of the property.

The implementation of Alternatives 1 through 3 would be limited by the presence of heavy equipment, vehicular traffic, employees, rail lines along the eastern edge of the Saul property, traffic on the Port of Tacoma Road, buried utilities, fences, and other electrically conductive ground penetrations. Both the PW Pipe and Lilyblad properties are also active facilities with heavy cargo traffic bringing in materials and shipping bulk products. The Site is part of a major industrial area near the Port of Tacoma with many active buildings in commercial or industrial use.

To allow Lilyblad, PWE, and the railroad to remain operational, a staged or phased approach to remediation within the property boundaries of the Site would be required. Each remedial action must also be conducive to staggered construction/installation if impacts to business interruptions were to be minimized. The presence of Lilyblad and PWE employees, delivery drivers, railcars, and railroad personnel within the Site boundaries require that the selected remedial actions be implemented with the institutional and engineering controls necessary to limit exposure of Site workers and visitors to Site COCs. In addition to access and Site safety issues, the location of facility structures, along with the limited access to those structures, have a significant influence on the selection of the appropriate remedial action for the Site.

1.2.2 Access to Contaminated Soil and Groundwater

Access to areas containing contaminated soil and groundwater is severely restricted at the Site by existing structures, buildings, and 54 above-ground storage tanks (ASTs). These structures cover approximately 40 percent of the Site. The excavation of soils near building foundations will require shoring to retain building stability. Subsurface utilities (storm drains, water and sewer lines) and above-ground structures, fences, road curbs, and the railroad spur servicing the Lilyblad and PWE properties restrict access to soil and limit placement options for *in situ* treatment technologies. The surrounding properties and the proximity of neighboring facilities further limit the available space to store and stage construction equipment.

1.2.3 Topographic, Geologic, and Hydrogeologic Conditions That Affect Selection of Remedial Actions

The Site is relatively flat. Depth to groundwater in the upper aquifer ranges from 3 to 8 feet. As discussed previously, contamination in the area of concern is within unsaturated, smear zone, and saturated soils, as well as the upper 1 to 2 feet of the underlying silt aquitard. The excavation of smear zone and saturated soils will require dewatering and likely water treatment.

There is a groundwater divide running through the center of the Lilyblad Site. Groundwater in the northern portion of the Site flows north, while groundwater in the southern area of the Site flows toward the south-southwest. The groundwater flow rate north of the divide varies from about 9 to 18 feet per year (CH2M Hill RI, Section 3.5.3.2). The groundwater flow rate south of the divide varies from approximately 20 to 25 feet per year. Groundwater flow rates decrease near the silt aquitard.

Water levels in the upper sand aquifer are higher than those present in the deeper second aquifer, which implies that there exists a potential for the downward movement of groundwater through the silt aquitard. The downward flow of groundwater is calculated using input parameters from CH2M Hill (2004, Section 3.5.3.2) and the following relationship:

$$Q = K\ i\ A \qquad (1 - 1)$$

Where:

Q = Quantity of water in gallons per year;
K = Hydraulic Conductivity in feet per year = 0.1035 to 1.035;
i = gradient in ft/ft = 0.25; and
A = area of footprint of plume in ft^2 = 164,000.

The calculated volume of groundwater flow through the aquitard ranges from 32,000 to 320,000 gallons per year.

Lilyblad has received a wastewater discharge authorization through MTCA Agreed Order No. DE95HS-S292. This discharge authorization includes the substantive provisions of an active RCRA NPDES permit allowing discharge to a catch basin that connects to the City of Tacoma's storm drainage system located in front of the Lilyblad facility along Port of Tacoma Road. The city's storm drainage system empties into the Lincoln Avenue Ditch, which flows into the Blair Waterway. Water from the Lincoln Avenue Ditch enters a closed culvert, and remains in the culvert until it is discharged through a tide gate to the Blair Waterway. Groundwater from the PWE facility discharges to a storm drainage system that runs along the PWE facility and along the U. S. Oil property line to the west and connects to the Lincoln Avenue Ditch.

1.2.4 Chemical and Physical Properties and their Impact on Remedial Technologies

Site COCs have a variety of vapor pressures, moderate to low-solubility, and are moderately to strongly adsorbed to subsurface soil. As a result of these characteristics, the COCs can potentially exist in four phases: in a nonaqueous phase liquid (NAPL), dissolved in groundwater, mixed with other gases in soil vapor, and sorbed to soil particles (i.e., solid phase).

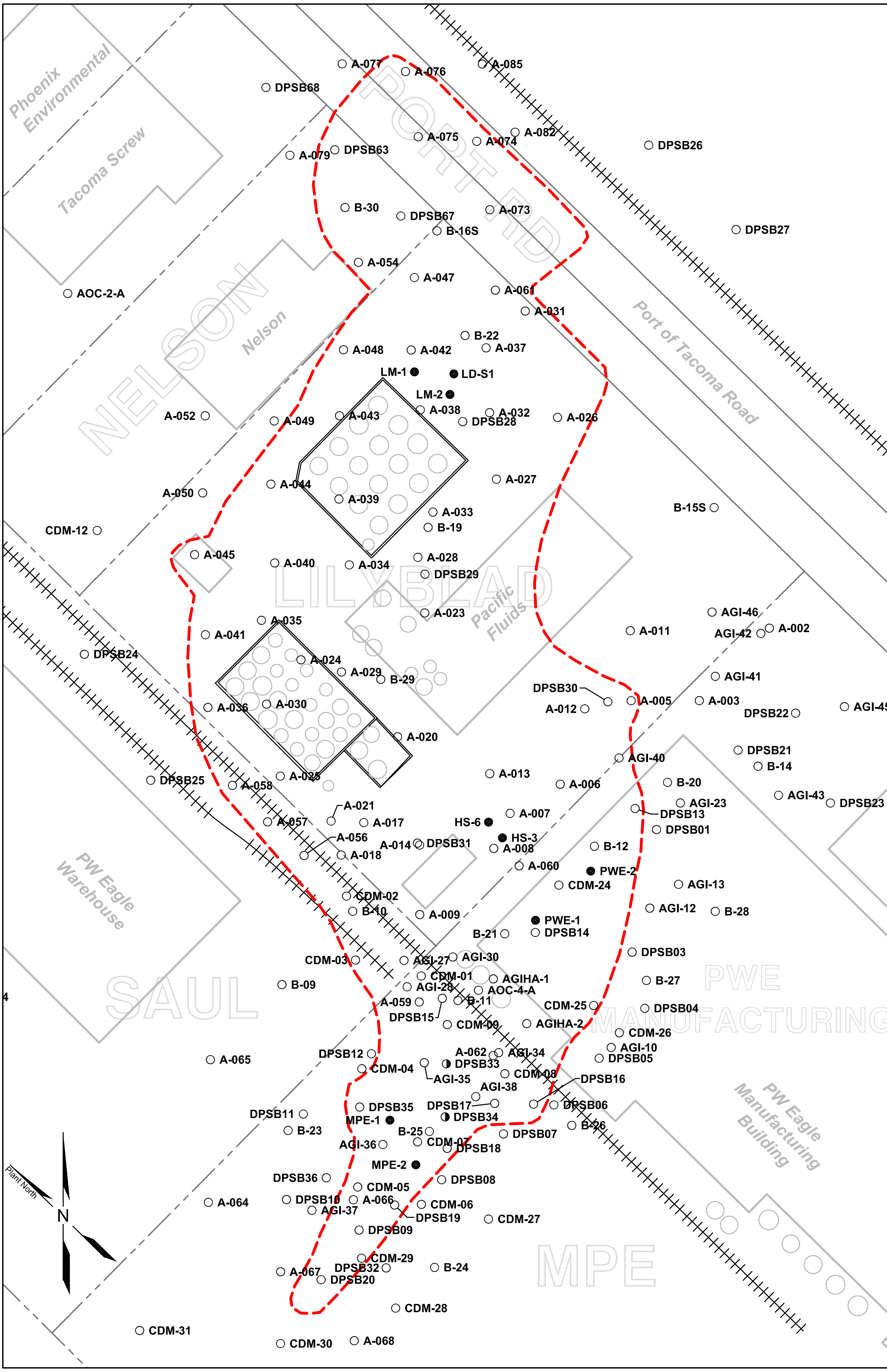
The large amount of VOCs at the Site must be considered as potential remedial actions are considered. The VOCs in the soil and groundwater will volatilize when exposed to the atmosphere during soil excavation or groundwater extraction. Appropriate health and safety measures must be implemented to protect site workers, the public, and the environment.

The chemical and physical properties of the COCs influence how they migrate and which remedial methods are most effective for their removal. Historically differing remedial methods have been use to treat soil and groundwater contaminated by TPH, SVOC, and VOC COCs. The *In Situ* Treatment with and without Natural Attenuation Alternative (Alternative 2) will include several treatment technologies. These technologies will consist of multi-phase extraction (for VOCs), *in situ* biotreatment (for TPHs), and *in situ* chemical oxidation (for SVOCs).

Table 1.1 - MTCA Method B Cleanup Level (CUL) for Soil and Groundwater

Chemical Group	Contaminant of Concern	Soil CUL in mg/kg	Groundwater CUL in ug/L
VOC	1,1,1-trichloroethane	1.1	227
	1,1,2-trichloroethane	0.05	16
	1,1-dichloroethane	164	52,000
	1,1-dichloroethene	0.008	1.93
	1,2,4-trimethylbenzene	10,350	26,000
	1,2-dichloroethane	0.1	37
	1,4-dichlorobenzene	0.065	4.86
	Benzene	0.075	22.7
	bis(2-ethylhexyl)phthaate	4.4	2.2
	cis-1,2-dichlorobenzene	14.9	5,200
	Ethylbenzene	41.1	6,910
	m,p-xylene	58.4	26,000
	Methylene chloride	1.3	590
	Tetrachloroethene	0.025	3
	Toluene	71.3	15,000
	Trichloroethene	0.12	30
	Vinyl chloride	0.008	2
SVOC	Naphthalene	116	4,940
	Pentachlorophenol	0.038	3
	2-methylnaphthalene	--	23
TPH	Diesel-range hydrocarbons	2,000	1,000
	Gasoline-range hydrocarbons	100	1,000
	Motor oil-range hydrocarbons	2,000	1,000

Area of Concern for Soil
Lilyblad Site



Source: CH2M Hill 2004 and Terra Vac 2006a.

Approximate Extent of Soil Contamination

Property Line

Railroad

Soil Sample Location and Number

CDM-30 ○ CH2M Hill

MPE-2 ● Terra Vac

DPSB34 ◑ Terra Vac and CH2M Hill

0 60 120

Scale in Feet

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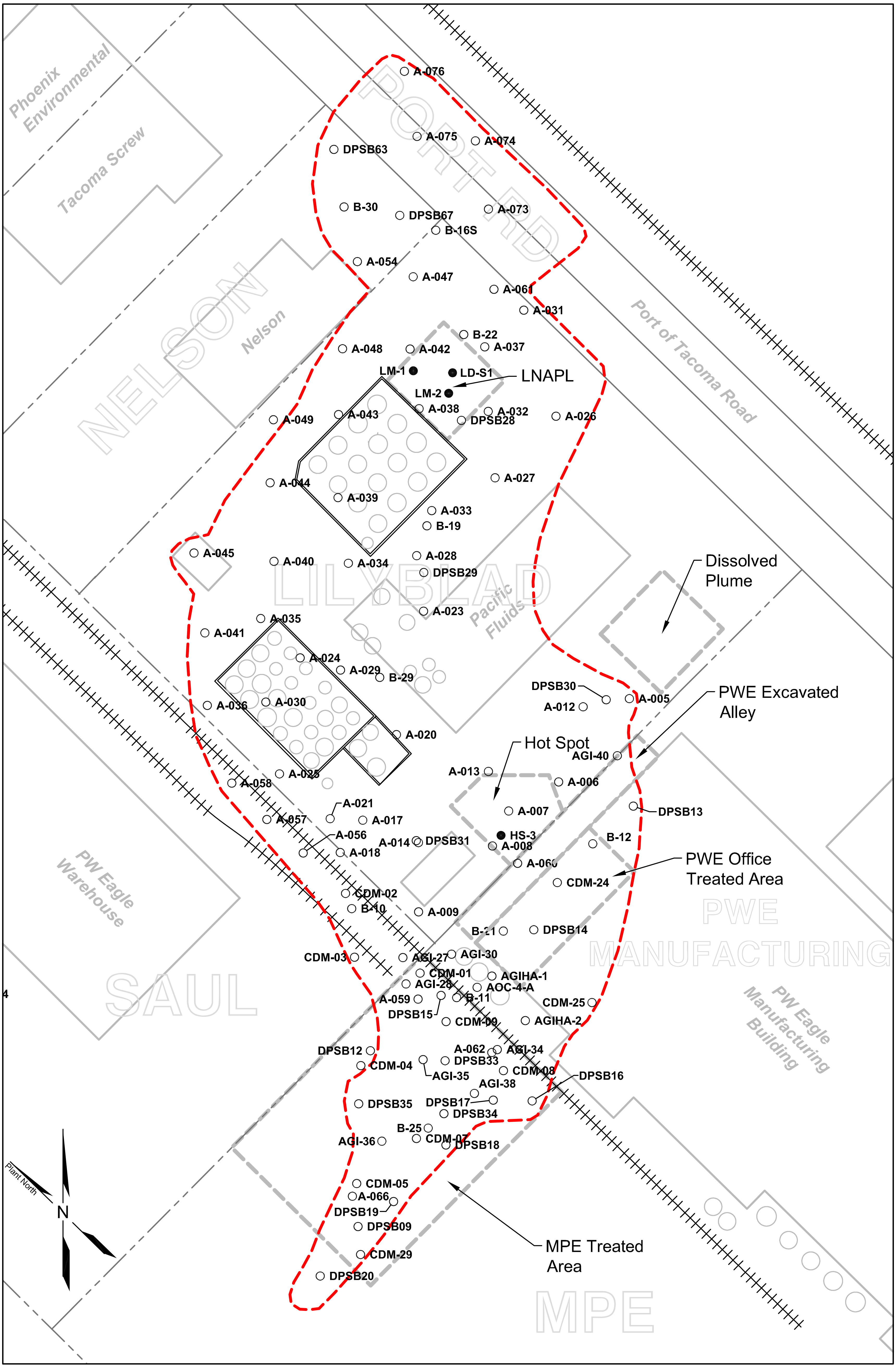
17330-02 1/07

Figure 1-1

Historical Contaminant Distribution at the Lilyblad Site
Lilyblad Site



Source: CH2M Hill 2004 and Terra Vac 2006a.

(red dashed line)	Approximate Extent of Soil Contamination
CDM-30 ○	CH2M Hill Soil Sample Location and Number
HS-6 ●	Terra Vac Soil Sample Location and Number
(railroad symbol)	Railroad
(dash line)	Property Line
(grey dashed line)	Terra Vac Treatment Areas

0 60 120
Scale in Feet

Note: Soil sample data used to prepare Table 1.2.

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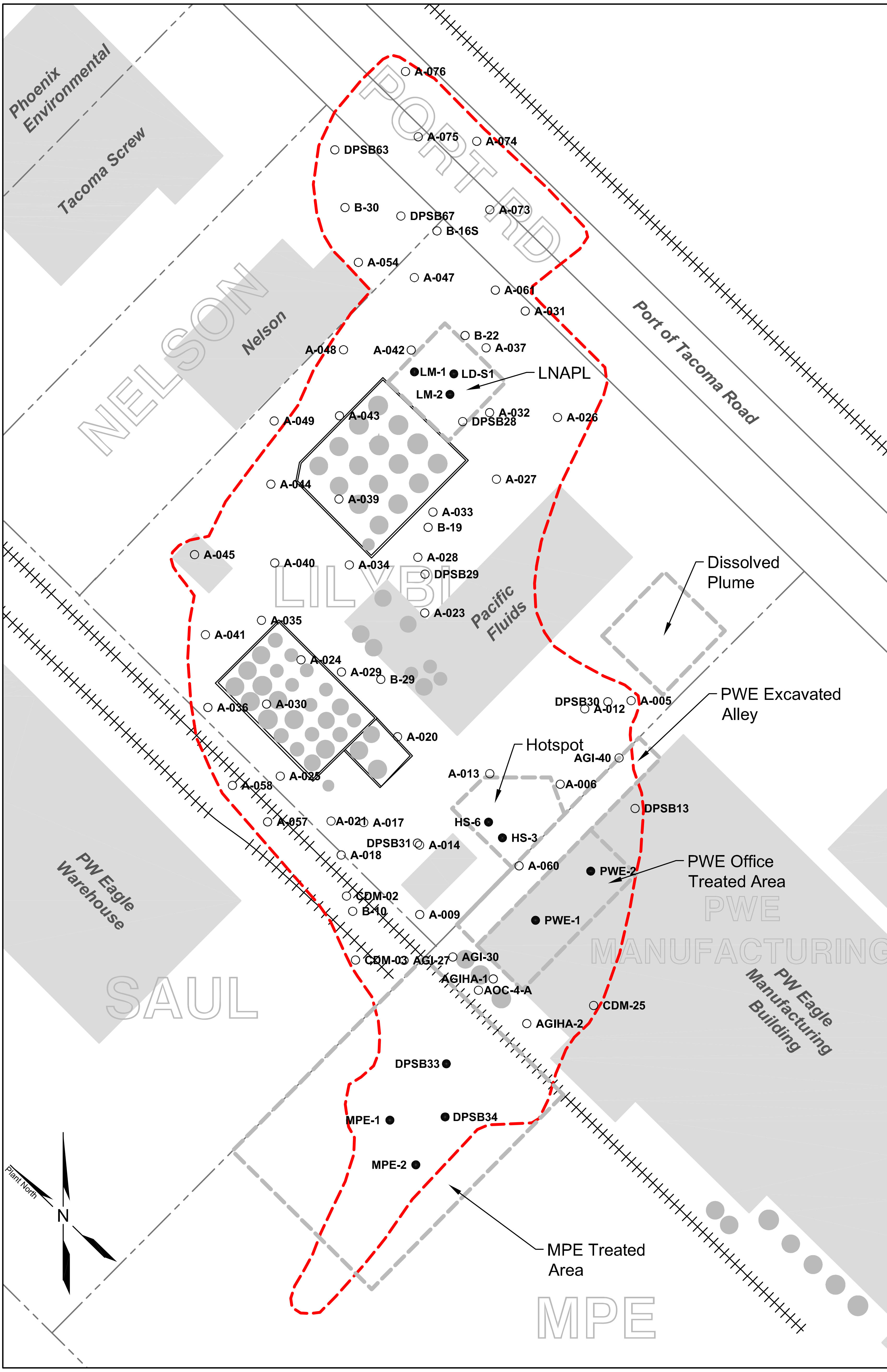
Figure 1-2

Post-Interim Measure Contaminant Distribution at the Lilyblad Site
Lilyblad Site



Source: CH2M Hill 2004 and Terra Vac 2006a.

Approximate Extent of Soil Contamination

Terra Vac Treatment Areas

CDM-30 CH2M Hill Soil Sample Location and Number

Railroad

Property Line

MPE-2 Terra Vac Soil Sample Location and Number

0 60 120
Scale in Feet

Note: Soil sample data used to prepare Table 1.3.

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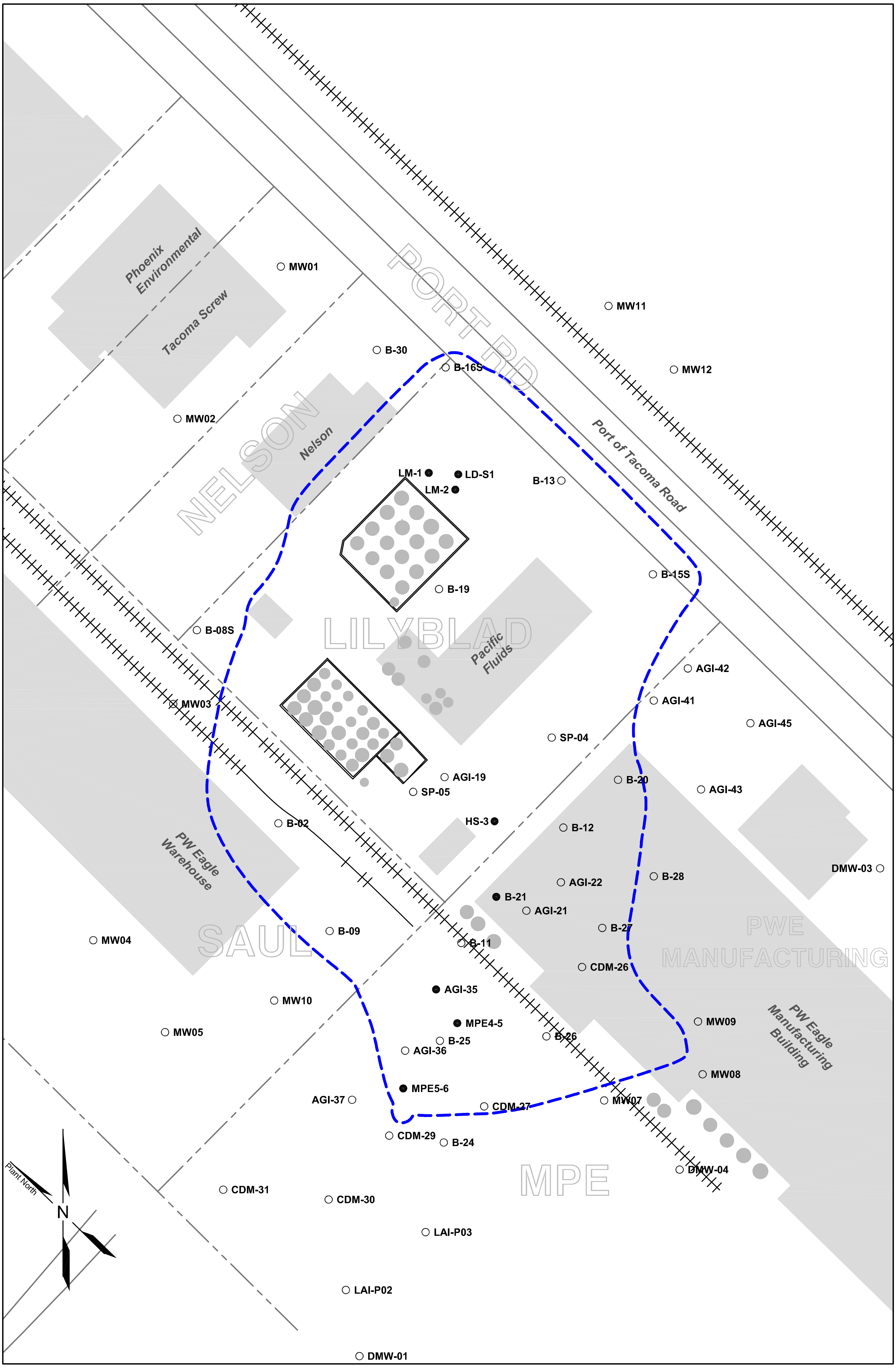
Figure 1-3

Area of Concern for Groundwater
Lilyblad Site



Source: CH2M Hill 2004 and Terra Vac 2006a.

Approximate Extent of Groundwater Contamination

Property Line

Railroad

Groundwater Sample Location and Number

CDM-30 ○ CH2M Hill

MPE-2 ● Terra Vac

0 80 160

Scale in Feet

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Figure 1-4

Table 1.2 - Estimated Historical Contaminant Distribution in Soil at the Lilyblad Site

Site	Area (ft2)	Layer	Thickness in Feet	Concentration in mg/kg VOC	TPH	SVOC	Number of Samples VOC	TPH	SVOC	Mass Loading in Pounds VOC	TPH	SVOC
LILYBLAD Untreated	59500	UNSATURATED	2.00	1.3	4364	10.5	13	17	9	15	51932	125
		CAPILLARY	2.00	85	1461	2	37	33	13	1012	17386	24
		SATURATED	3.00	119	2863	1.5	9	7	4	2124	51105	27
		AQUITARD	2.00	2.6	246	1.9	14	15	8	31	2927	23
LNAPL	4080	UNSATURATED	2.00	0.41	183	0	2	3	0	0	149	0
		CAPILLARY	2.00	161	5580	0.37	4	4	1	131	4553	0
		SATURATED	3.00	1.2	22390	0	1	2	0	1	27405	0
		AQUITARD	2.00	0.03	51	0	2	2	0	0	42	0
HOT SPOT	2500	UNSATURATED	2.00	19	1886	1.1	4	4	1	10	943	1
		CAPILLARY	2.00	561	5853	8.1	4	4	2	281	2927	4
		SATURATED	3.00	29	556	2	2	2	1	22	417	2
		AQUITARD	2.00	0.03	63	2	1	1	1	0	32	1
PWE Untreated	4190	UNSATURATED	3.00	0.25	314	0	2	2	0	0	395	0
		CAPILLARY	2.00	0	0	0	1	0	0	0	0	0
		SATURATED	5.00	12	3090	0	3	1	0	25	6474	0
		AQUITARD	2.00	0	0	0	0	0	0	0	0	0
PWE Excavated	3700	UNSATURATED	3.00	0	0	0	0	0	0	0	0	0
		CAPILLARY	2.00	173	940	3.5	1	1	1	128	696	3
		SATURATED	5.00	0.05	104	3.2	1	1	1	0	192	6
		AQUITARD	2.00	0.04	85	0.2	1	1	1	0	63	0
PWE OFFICE Treated Area	3160	UNSATURATED	3.00	0	21	0	1	1	0	0	20	0
		CAPILLARY	2.00	46	213	1.1	3	3	3	29	135	1
		SATURATED	5.00	1.8	514	4	5	4	3	3	812	6
		AQUITARD	2.00	0	19	0	0	2	0	0	12	0
MPE Untreated	1200	UNSATURATED	2.00	0.02	0	0	1	0	0	0	0	0
		CAPILLARY	2.00	0.78	12090	0	1	1	0	0	2902	0
		SATURATED	3.50	0.13	1233	0	2	2	0	0	518	0
		AQUITARD	2.00	0	0	0	0	0	0	0	0	0
MPE Treated	12500	UNSATURATED	2.00	1.5	78	0.02	11	6	4	4	195	0
		CAPILLARY	2.00	5	809	0.05	16	15	1	13	2023	0
		SATURATED	3.50	20	1125	0.2	9	7	1	88	4922	1
		AQUITARD	2.00	0	26	0	3	3	0	0	65	0
SAUL	6310	UNSATURATED	1.50	0.6	0	0	2	0	2	1	0	0
		CAPILLARY	2.00	5.6	117	0	3	2	0	7	148	0
		SATURATED	2.00	0.04	0	0	1	0	0	0	0	0
		AQUITARD	2.00	0	36	0	0	0	0	0	45	0
NELSON	2377	UNSATURATED	1.50	0	0	0	0	0	0	0	0	0
		CAPILLARY	2.00	12	2000	0	1	1	0	6	951	0
		SATURATED	5.75	46	3843	0.2	3	0	1	63	5253	0
		AQUITARD	2.00	0	0	0	0	0	0	0	0	0
PORT RD	14838	UNSATURATED	1.50	0	0	0	0	0	0	0	0	0
		CAPILLARY	2.00	10.5	2080	0.35	3	2	1	31	6173	1
		SATURATED	5.75	0.2	290	0	1	0	0	2	2474	0
		AQUITARD	2.00	0.05	255	0	2	0	0	0	757	0
									Grand Totals	**4026**	**195039**	**224**
									Total Mass		**199288**	**lbs**

NOTES

1) Soil concentration data obtained from following sources:

CH2M HILL electronic files (based on Tables 4-4 to 4-12 of Draft Supplemental Remedial Investigation Report - Lilyblad Petroleum, Oct. 2004)

CH2M HILL Draft supplemental Remedial Investigation Report - Lilyblad Petroleum, Oct. 2004, tables 4.6 to 4.12 (TPH concentrations only)

Table 6 of Terra Vac Interim Soil and Groundwater Sampling Event - MPE Treatment Area, PW Eagle Property, Lilyblad Test Areas, January 9, 2006 for the 8/1/03 and 4/1/04 rounds of sampling.

2) Concentrations reported are an average of the data compiled from the sources listed above (see Note 1).

3) Soil samples used to determine contaminant concentrations are contained in overall contaminant extent (see Note 4).

4) Overall contaminant extent based on overlapping plumes from Figures 4-1 to 4-4 in CH2M HILL Draft Supplemental Remedial Investigation Report - Lilyblad Petroleum, Oct. 2004.

5) Overall contaminant extent was divided based on property divisions (Lilyblad, PWE, MPE, Saul, Nelson, and Port of Tacoma Road). Further area divisions were made within property limits of Lilyblad, PWE, and MPE based on Terra Vac treatment areas.

6) Area of each division calculated using GIS.

7) Depth for aquitard assumed to be 2 feet (based on extent of contamination).

8) Depth for capillary layer assumed to be 2 feet.

9) Depth of saturated and unsaturated layer determined using well geological cross section figures (Figures 3-3 to 3-6 of CH2M Hill Draft Supplemental Remedial Investigation Report - Lilyblad Petroleum, Oct. 2004)).

Saturated layer is equal to the distance between the top of the aquitard and the water table.

Unsaturated layer is equal to the distance between the aquitard and the top of the structural fill. Took an average of these values for borings in extent area.

10) Fill density = 100 pcf

Table 1.3 - Estimated Post-Interim Measure Contaminant Loading in Soil at Lilyblad Site

Site	Area (ft2)	Layer	Thickness in Feet	Concentrations in mg/kg			Number of Samples			Mass Loading in Pounds		
				VOC	TPH	SVOC	VOC	TPH	SVOC	VOC	TPH	SVOC
LILYBLAD Untreated	59500	UNSATURATED	2.00	1.3	4364	10.5	13	17	9	15	51932	125
		CAPILLARY	2.00	85	1461	2	37	33	13	1012	17386	24
		SATURATED	3.00	119	2863	1.5	9	7	4	2124	51105	27
		AQUITARD	2.00	2.6	246	1.9	14	15	8	31	2927	23
LNAPL	4080	UNSATURATED	2.00	0.41	183	0	2	3	0	0	149	0
		CAPILLARY	2.00	**0.09**	**104**	0.37	**1**	**3**	1	**0**	**85**	0
		SATURATED	3.00	**0.06**	**53**	0	**1**	**1**	0	**0**	**65**	0
		AQUITARD	2.00	0.03	51	0	2	2	0	0	42	0
HOT SPOT	2500	UNSATURATED	2.00	**9.8**	**3970**	1.1	**2**	**2**	1	**5**	**1985**	1
		CAPILLARY	2.00	**0**	**627**	8.1	**1**	**2**	2	**0**	**314**	4
		SATURATED	3.00	**1.2**	**239**	2	**2**	**2**	1	**1**	**179**	2
		AQUITARD	2.00	0.03	63	2	1	1	1	0	32	1
PWE Untreated	4190	UNSATURATED	3.00	0.25	314	0	2	2	0	0	395	0
		CAPILLARY	2.00	0	0	0	1	0	0	0	0	0
		SATURATED	5.00	12	3090	0	3	1	0	25	6474	0
		AQUITARD	2.00	0	0	0	0	0	0	0	0	0
PWE Excavated	3700	UNSATURATED	3.00	0	0	0	0	0	0	0	0	0
		CAPILLARY	2.00	0	0	0	0	0	0	0	0	0
		SATURATED	5.00	0	0	0	0	0	0	0	0	0
		AQUITARD	2.00	0	0	0	0	0	0	0	0	0
PWE OFFICE Treated Area	3160	UNSATURATED	3.00	0	21	0	1	1	0	0	20	0
		CAPILLARY	2.00	**17**	**5254**	1.1	**2**	**2**	3	**11**	**3321**	1
		SATURATED	5.00	**0.24**	**11**	4	**2**	**2**	3	**0**	**17**	6
		AQUITARD	2.00	0	19	0	0	2	0	0	12	0
MPE Untreated	1200	UNSATURATED	2.00	0.02	0	0	1	0	0	0	0	0
		CAPILLARY	2.00	0.78	12090	0	1	1	0	0	2902	0
		SATURATED	3.50	0.13	1233	0	2	2	0	0	518	0
		AQUITARD	2.00	0	0	0	0	0	0	0	0	0
MPE Treated	12500	UNSATURATED	2.00	1.5	78	0.02	11	6	4	4	195	0
		CAPILLARY	2.00	**0.7**	**285**	0.05	**3**	**3**	1	**2**	**713**	0
		SATURATED	3.50	**0.06**	**14**	0.2	**2**	**1**	1	**0**	**61**	1
		AQUITARD	2.00	0	26	0	3	3	0	0	65	0
SAUL	6310	UNSATURATED	1.50	0.6	0	0	2	0	2	1	0	0
		CAPILLARY	2.00	5.6	117	0	3	2	0	7	148	0
		SATURATED	2.00	0.04	0	0	1	0	0	0	0	0
		AQUITARD	2.00	0	36	0	0	0	0	0	45	0
NELSON	2377	UNSATURATED	1.50	0	0	0	0	0	0	0	0	0
		CAPILLARY	2.00	12	2000	0	1	1	0	6	951	0
		SATURATED	5.75	46	3843	0.2	3	0	1	63	5253	0
		AQUITARD	2.00	0	0	0	0	0	0	0	0	0
PORT RD	14838	UNSATURATED	1.50	0	0	0	0	0	0	0	0	0
		CAPILLARY	2.00	10.5	2080	0.35	3	2	1	31	6173	1
		SATURATED	5.75	0.2	290	0	1	0	0	2	2474	0
		AQUITARD	2.00	0.05	255	0	2	0	0	0	757	0
									Grand Totals	**3340**	**156691**	**215**
									Total Mass		**160246**	**lbs**

NOTES
1) Soil concentration data obtain from following sources:
CH2M HILL electronic files (based on Tables 4-4 to 4-12 of Draft Supplemental Remedial Investigation Report - Lilyblad Petroleum, Oct. 2004)
CH2M HILL Draft Supplemental Remedial Investigation Report - Lilyblad Petroleum, Oct. 2004, Tables 4.6 to 4.12 (TPH concentrations only)
Electronic file "Baseline Sampling Dec 2005.xls" based on Dept. of Ecology data and Table 6 of Terra Vac Interim Soil and Groundwater Sampling Event - MPE Treatment Area, PW Eagle Property, Lilyblad Test Areas, January 9, 2006.
Table 6 of Terra Vac Interim Soil and Groundwater Sampling Event - MPE Treatment Area, PW Eagle Property, Lilyblad Test Areas, January 9, 2006 for the 12/05 sampling event.
2) Concentrations reported are an average of the data compiled from the sources listed above (see Note 1).
3) Wells used to determine contaiminant concentrations are contained in overall contaiminant extent (see Note 4).
4) Overall contaiminant extent based on overlapping plumes from Figures 4-1 to 4-4 in CH2M-HILL Draft supplemental Remedial Investigation Report - Lilyblad Petroleum, Oct. 2004.
5) Overall contaiminant extent was divided based on property divisions (Lilyblad, PWE, MPE, Saul, Nelson and Port of Tacoma road). Further area divisions were made within property limits of Lilyblad, PWE and MPE based on Terra Vac treatment areas.
6) Area calculated using GIS.
7) For Terra Vac treatment areas only soil samples from Terra Vac or Dept of Ecology were used.
8) For split soil samples analyzed by Department of Ecology and Terra Vac, the higher concentration of the two samples was used.
9) Depth for aquitard assumed to be 2 feet (based on extent of contamination).
10) Depth for capillary layer assumed to be 2 feet.
11) Depth of saturated and unsaturated layer determined using well geological cross section figures (Figure 3-3 to 3-6 in CH2M HILL data).
Saturated layer is equal to the distance between the top of the aquitard and the water table.
Unsaturated layer is equal to the distance between the aquitard and the top of the structural fill. Took an average of these values for borings in extent area.
12) Fill density = 100 pcf
13) BOLD NUMBERS are concentrations based only on Terra Vac's 12/05 data. In untreated areas, historial data are presented.
14) Contaminant concentrations for PWE Excavated reported as 0 mg/kg due to excavation performed by CDM in 2001. Excavation described in CDM's Lilyblad Petroleum PW Pipe Facility Interim Action Final Work Plan, March 12, 2001.

2.0 DESCRIPTION OF ALTERNATIVES

Ecology has identified the cleanup alternatives that are evaluated in this FFS. These alternatives are described in this section:

- Section 2.1 – Alternative 1—Containment with Groundwater Controls
- Section 2.2 – Alternative 2—*In Situ* Treatment with and without Natural Attenuation
- Section 2.3 - Alternative 3—Excavation and Disposal of Contaminated Soils
- Section 2-4 – Alternative 4—Hydraulic Control with Groundwater Monitoring

2.1 Alternative 1—Containment with Groundwater Controls

This alternative consists of the installation of a barrier wall to prevent flow of groundwater from the Lilyblad property to adjoining properties and ultimately to Commencement Bay. The barrier system will be operational until the concentration of COCs are low enough that natural attenuation will reduce the concentrations to below the CULs for groundwater as it enters Commencement Bay.

Two barrier systems will be considered; 1) a sheet pile or slurry wall around the perimeter of the Lilyblad property, and 2) a sheet pile or slurry wall around parts of the Site judged to be appropriate. The groundwater retained by the wall will be treated to meet Lilyblad's current NPDES requirements. The groundwater treatment system will be based on the existing treatment system installed by CDM, with modifications as needed to meet the NPDES-like discharge requirements.

The initial step in developing this alternative is to identify the volume of groundwater that will be retained by the barrier configurations of interest to Ecology. This evaluation is discussed in Section 2.1.1. The volume of water retained by the barrier (and requiring treatment) will be a function of the locations established for the barriers. The barrier locations judged to be appropriate are discussed in Section 2.1.2. The advantages and disadvantages of installing a slurry wall or a steel sheet pile wall system are discussed in Section 2.1.2 as well. The design of a treatment system required to reduce COC concentrations in groundwater to acceptable levels (established in the NPDES permit) is described in Section 2.1.3.

Alternative 1 as well as Alternatives 2 through 4 will include institutional controls and compliance monitoring. Institutional controls usually include on-site features, such as signs and fences, and legal mechanisms, such as lease restrictions, deed restrictions, land use and zoning designations, and building permit requirements. The compliance monitoring program established by Ecology for this Site (Terra Vac 2006b) is described Section 2.4.

2.1.1 Groundwater Conditions below the AOC

The hydrogeology and groundwater quality conditions at the Site are described in the CH2M Hill RI, Section 3. The surface elevation of the site is 14 to 18 feet (NAVD88). Contaminated water is contained in the shallow aquifer. The shallow aquifer consists of brown to black, fine to medium Sand with some gravel and shell fragments. The unit becomes finer with depth grading into silty, fine Sand. The bottom of the shallow aquifer is elevation 6 to 10 feet (NAVD88).

The depth to water is generally from 3 to 8 feet below ground surface. Seasonal water level fluctuations range from 0.5 to 1.5 feet. Under natural conditions, there is a groundwater divide near the center of the Lilyblad property. North of the divide groundwater flows to the north-northeast, and south of the divide groundwater flows to the south-southwest. Groundwater flow in the shallow aquifer north of the divide eventually discharges to Blair Waterway. The shallow aquifer is separated from the deeper Second Aquifer by a 6- to 16-foot-thick upper silt aquitard.

Groundwater contamination is limited to the shallow aquifer. The area of groundwater contamination is defined by the extent of benzene and vinyl chloride shown in CH2M-Hill RI Figures 4.5 and 4.6, respectively. The total area of the groundwater AOC is approximately 164,000 square feet. The area of the Lilyblad property is approximately 87,000 square feet with about 83,000 square feet of groundwater contamination falling within the groundwater AOC. Assuming an average saturated thickness of 5 feet and a porosity of 0.42, the volume of contaminated groundwater beneath the Lilyblad property is approximately 1,300,000 gallons. The total groundwater volume below the groundwater AOC is expected to total approximately 2,600,000 gallons.

Under natural conditions, groundwater discharges to the Blair Waterway, which is approximately 1,200 feet from the Site. The time for groundwater to reach the Blair Waterway (if short-cutting does not occur) was calculated using input parameters from CH2M-Hill (2004) for the northern component of shallow groundwater and the following equation:

Travel Time in Feet/Year = D * Ki/n^e (2 – 1)

Where:

D = Distance to Waterway in feet = 1,200;
K = Hydraulic conductivity in ft/day = 5.7 feet/day or 2,080 feet/year;
I = hydraulic gradient = 0.005; and
Ne = porosity = 0.42.

The calculated groundwater travel time within the upper aquifer is about 25 feet/year; therefore, it would take at least 50 years for the northern component of shallow groundwater from the Site to each the Blair Waterway. The travel time within the upper aquifer for a specific chemical to reach the waterway via natural groundwater flow will be significantly longer due to effects of retardation. Retardation reduces chemical migration for the COCs typically by a factor of 2 to 5 times. Therefore, the migration of COCs to the Blair Waterway could take 100 years or more, if short-cutting did not occur.

It should be noted that groundwater exiting the Site to the northeast will likely intersect a stormwater line located below the Port of Tacoma Road. At least some portion of this groundwater may follow the stormwater line and reach the Blair Waterway in significantly less time than the 50-year estimate for natural groundwater flow. Groundwater exiting to the south also likely intersects a stormwater line that discharges to the Lincoln Avenue Ditch and ultimately the Blair Waterway.

2.1.2 Description of the Barrier

The Lilyblad property is currently occupied by Pacific Functional Fluids (Pacific Fluids). Pacific Fluids manufactures, stores, and distributes custom petroleum blends and other chemicals. The Pacific Fluids facility includes an office building, a small warehouse, a truck-loading rack, a laboratory/boiler room, three concrete-bermed tank farms, and several equipment storage and work areas. These buildings occupy approximately 40 percent of the 2-acre Lilyblad property. The perimeter of the Lilyblad facility runs to about 1,200 linear feet. This would be the length of the barrier if it were practical to install it completely around the perimeter of the Lilyblad property. The primary underground utility corridors serving the Lilyblad property were described in the CH2M-Hill RI, Section 3.1.2 and Figure 3.1. These corridors run along three of the four legs of the perimeter of the Lilyblad property with perimeter penetrations on all sides of the property. Other buried utilities are also present within the property boundary. The specific locations of these lines are not known. Installation of a barrier wall in the vicinity of underground utilities is problematical and would be expensive. The utilities would have to be moved or penetrations through the barrier wall would have to be installed to accommodate existing utilities.

Slurry Wall Barrier

A slurry wall consists of a vertical trench that is excavated down to the aquitard at the Site, approximately 8 to 12 feet below ground surface. The trench is filled with a low permeability material, such as a mixture of soil, bentonite, and cement. The slurry wall envisioned for the Lilyblad property is a wall that is about 2 feet thick. Dewatering of saturated soils and the subsequent treatment of the water removed from the trench will be necessary if this option is used. Use of suitable Site soils in the bentonite backfill mixture will reduce disposal costs and can lower permeability of the wall, but will require a larger construction foot print at the Site to accommodate mixing. The soils above the aquitard on this Site consist of structural fill, ranging from approximately 1 to 5 feet in thickness, and dredge spoils, ranging from approximately 5 to 8 feet in thickness. It is unlikely that the dredge spoils would provide a suitable backfill material for the slurry wall and would require disposal. Slurry wall excavations will require standoff distance from parallel utility corridors and building foundations to prevent undermining. This will decrease the effective perimeter of the cutoff wall, particularly in the vicinity of the Nelson Building to the north and the gas main along the east perimeter.

With proper engineering controls, the slurry wall can be installed around utility penetrations. These controls will include controlled excavation in the vicinity of utilities (i.e., air knife), support for exposed lines, and installation of flexible sleeves for utilities to limit damage with settlement of the slurry wall. Capping of the slurry wall with Site soils above the seasonal level of groundwater can dissipate overlying loads to the slurry-encased utilities as well as decrease soil disposal costs. Bench-scale testing would be required for this alternative to determine the proper slurry mixture, applicability of Site soil use, deterioration of cutoff wall due to Site contaminants, and compressibility and strength of the wall.

Sheet Pile Barrier

A steel sheet pile wall is constructed by driving vertical sheets of steel down to the aquitard to form a vertical barrier wall. The sheets are assembled before installation and are driven or vibrated into the ground. Installation of sheet piling will require removal of the existing asphalt/concrete cover. The sheet pile wall envisioned for this Site is 0.25-inch-thick steel driven a maximum of 2 feet into the aquitard. The sheet piling will be terminated at the top of the structural fill layer to facilitate an asphalt/concrete cover. Use of interlock sealant will decrease the permeability of the cutoff wall. The presence of known utility corridors and the likely presence of other unknown buried objects and lines complicate the installation of a sheet pile at this Site. Before the sheet pile is driven, a trench could be dug in areas where utilities were thought to be present. This step could entail the dewatering of saturated soil and the treatment of the water removed from the Site.

Pile driving and vibratory pile installation require standoff distance from utilities to prevent damage to the lines. Utility standoff will decrease the effective perimeter of the cutoff wall in the vicinity of the north perimeter water lines and the gas main along the east perimeter. Use of non-vibratory pile installation, such as the direct push method, could decrease utility standoff distances. Utility penetrations around the perimeter of the Site would require disconnecting and capping of the lines prior to pile installation. Rerouting utility lines lying in water-bearing zones through the sheet pile wall will require the engineering of sleeves or seals to prevent loss of groundwater through these penetrations.

The installation of a barrier wall will cause significant business interruptions to Pacific Fluids and other entities operating at the Site. The advantages and disadvantages of slurry wall and sheet pile barriers are summarized in Table 2.1.

Location of the Barrier Wall

Groundwater conditions beneath the Site (Section 2.3.1) were considered along with the practical limitations of both the slurry wall and sheet pile barriers to identify the proposed locations of the barrier walls.

Alternative 1 – Variation A will place a continuous barrier (a slurry wall or steel sheet pile) that encircles the Lilyblad property (about 1,100 linear feet of barrier) as near to its property line as is practical given the location of underground utilities and other obstructions. This barrier location is depicted on Figure 2-1A. The barrier contains approximately 50 percent of the area of the groundwater AOC. The locations of known utility corridors were avoided as much as practicable in identifying the barrier location shown on Figure 2-1A.

Alternative 1 – Variation B will place a barrier (slurry wall or steel sheet pile) around approximately 50 percent of the Lilyblad property line (about 550 feet of barrier) in the general vicinity of the locations where CDM installed temporary plastic barrier walls during 2001. As part of an interim cleanup action, CDM installed vapor and groundwater recovery systems in two "L" shaped trenches at the northeast and southwest corners of the Lilyblad property (refer to Figure 2-1B). Shoring for the trenches included 0.25-inch-thick vinyl sheet piling driven a maximum of 2 feet into the aquitard. Following construction of the extraction trenches, the sheet piling was removed from both trenches with the exception of approximately 195 feet in the alley way between Lilyblad and the PW Eagle properties. The intent was to leave this sheet piling in place to serve as a groundwater barrier on the south perimeter of the site (CDM 2001). The CDM trench locations intercept the natural northeast and southwest components of the groundwater flow that exits the Lilyblad facility (refer to CH2M Hill Figure 3-7 and Figure 2-1B of this report).

Volume of Groundwater that will Require Treatment

Each of the barrier wall configurations identified above will generate groundwater that will require treatment. Groundwater that will require treatment is expected to total:

- Barrier around the perimeter of the Lilyblad site = 1 gpm; and
- Barrier segments installed as shown in Figure 2-1B = 2 gpm.

The amount of groundwater generated by the full barrier is a function of the recharge to the shallow aquifer from precipitation and leakage from utility lines within the footprint of the barrier. Since pavement or buildings cover most the Lilyblad property, the amount of recharge from precipitation is likely to be small. Assuming that 25 percent of rainfall is recharged to the aquifer (about 425,000 gallons per year), and that leakage through pavements totals approximately 80,000 gallons per year, about 1 gpm will generated for treatment by the full barrier configuration. The amount of groundwater generated by the partial barrier is also a function of the recharge to the shallow aquifer from precipitation and leakage from utility lines (about 515,000 gallons per year) as well as the amount of inflow and pumping required to maintain hydraulic control (approximately 500,000 gallons per year). The partial barrier is expected to require additional hydraulic control of up to 2 gpm to maintain containment of contaminated water similar to the level achieved by the full barrier.

For Variation A of Alternative 1, a well extraction pump will be used to extract water directly from five wells located within the barrier perimeter. The extracted groundwater will be sent to the groundwater treatment system. For Variation B, the groundwater that collects in the trenches adjacent to the discontinuous barrier will be pumped directly to the groundwater treatment system.

2.1.3 Groundwater and Soil Vapor Treatment System

The CDM treatment system was originally installed in 2001. Its original design included high-vacuum liquid ring pumps (LRP) for groundwater and soil vapor recovery. The system had a design capacity of 10 gpm. Groundwater passed through a holding tank into an air sparge tank where VOCs were stripped and transported to a 1,000 cfm thermal oxidizer for treatment along with vapors that were extracted directly from recovery trenches and MPE wells. Treated vapor was chilled in a quenching tower and treated for residual chlorides in a packed-bed scrubber tower by a 5 gpm flow of water from a City water supply. The stripped groundwater passed through two 2-micron cartridge filters to remove particulates, and two 2,000-pound liquid-phase carbon adsorption units, in series, to reduce hydrocarbon concentrations to required concentrations. The scrubber water supply was pH balanced with a metered sodium hydroxide solution to neutralize chlorides, cooled by a 20-ton Carrier chiller by passing through two plate and frame heat exchangers, and was subsequently discharged to the surface water sewer. The treated effluent was passed through flow, pH, and temperature sensors before being discharged under the Lilyblad NPDES permit (ERI 2004).

The thermal oxidizer portion of the system was shut down and replaced by two 1,000-pound carbon adsorption vessels in series in September 2003.

Terra Vac modified the CDM system in May 2004. The key components of this modified system include a surge tank, air stripping system, a particulate filter followed by activated carbon treatment for groundwater and vapors (removed from the stripping system), and a cooling system for maintaining discharges below 19°C to comply with existing NPDES-like permit requirements. The simplified treatment system operated by Terra Vac has been demonstrated to produce effluent that can meet Ecology's NPDES-like requirements. The treatment system proposed for this alternative will consist of the groundwater treatment components used by Terra Vac and shown on Figure 2-2. This configuration will require that additional modifications be made to the original CDM treatment system.

2.2 Alternative 2—In Situ Treatment with and without Natural Attenuation

This alternative utilizes a generic *in situ* treatment system, consisting of: 1) soil vapor extraction, 2) biodegradation using nutrients and chemical additions, and 3) chemical oxidation. The groundwater and soil vapor produced by the *in situ* system will be treated by the modified CDM system described in Section 2.1.3.

The technical elements of the generic *in situ* treatment system are described in Section 2.2.1. The system can be operated to achieve a variety of results. The operation of the system to achieve all soil and groundwater CULs is described in Section 2.2.2 (Variation A). The operation of the system to remove TPH to Method B levels, and the use of institutional controls and monitored natural attenuation for other COCs is discussed in Section 2.2.3 (Variation B). Finally, a combination of the most effective containment option identified by Alternative 1 (full or partial barrier around the Lilyblad property) together with *in situ* treatment of impacted soil and groundwater located outside of the Lilyblad property lines to achieve CULs for all COCs is described in Section 2.2.4 (Variation C).

2.2.1 Components of the Generic *In Situ* Treatment System

Soil and groundwater COC concentrations above CULs exist over most of the Lilyblad property and extend onto adjacent properties (refer to Figures 1-1 and 1-4). The soil AOC is approximately 2.6 acres in area. About 88 percent of the contaminant mass currently at the Site is located on the Lilyblad, Nelson, and Port of Tacoma Road properties (refer to Table 1.3). Much of this contamination is located in historical release areas on the Site near the rear and front tank farms, and the Lilyblad/Sol Pro processing areas and along the rail spur to the east of the Lilyblad property (refer to Figures 1-1 and 1-4).

The COCs are intermingled within the soil column. As a result, the soil column will have to be treated to reduce COCs to acceptable concentrations. The COC concentrations in soil will have to be reduced to remove the source of COCs to the groundwater. The affected soil column varies from 8 to 12 feet in depth. Groundwater is encountered at depths from 3 to 8 feet. DVE technology is the presumptive remedy used for removing VOCs from soil and groundwater in such conditions.

In situ biodegradation has been used successfully to reduce the concentration of TPH compounds in soil and groundwater. The interim measures recently conducted by Terra Vac at the Site demonstrated that *in situ* bioremediation could significantly reduce overall TPH concentrations in soil and groundwater at the Site (Terra Vac 2006a).

Soil and groundwater contaminated with SVOCs such as pentachlorophenol and naphthalene can often be treated *in situ* via chemical oxidation (EPA 1998). Terra Vac recently demonstrated that an oxidant could be successfully injected into the subsurface at Lilyblad (Terra Vac 2006a). Unfortunately analytical results demonstrating the effectiveness of the technology in destroying SVOCs were not provided.

The generic treatment system considered by this alternative will consist of DVE, DVE with the addition of agents that increase the rate of biodegradation, and DVE with the addition of oxidants. This alternative assumes that DVE would be used at all accessible locations at the Site, that *in situ* bioremediation would be used in areas where TPH concentrations are elevated, and that *in situ* oxidation would be used in areas where SVOC concentrations were elevated. This generic treatment system is similar to the system employed by Terra Vac to conduct Interim Measures at the Site. The key components of this groundwater and soil vapor treatment system include a surge tank, air stripping system, a particulate filter followed by activated carbon treatment for groundwater and vapors (removed from the stripping system), and a cooling system for maintaining discharges below 19°C to comply with existing NPDES-like permit requirements.

The soil vapor treatment system has been shown by Terra Vac to be able to meet the requirements established by the Puget Sound Clean Air Agency (PSCAA) for the operation of the DVE/bioremediation/oxidation treatment train, in PSCAA Notice of Construction Number 99367.

A process flow diagram of the generic DVE/bioremediation/oxidation treatment system is presented on Figure 2-3.

2.2.2 Variation A – Operate the Generic System to Achieve Method B Levels for all COCs

The treatment system would be mobile and would be installed at numerous locations around the Site. Terra Vac was able to achieve a radius of influence for its DVE wells of approximately 40 feet. Assuming that this spacing would be 'typical' for a generic treatment system, approximately 80 DVE wells will be needed to treat the entire Site (refer to Terra Vac 2005). Several extraction and/or injection systems could be installed at the Site at the same time. This alternative assumes that four treatment systems will be installed at any one time. These systems may be functioning in a DVE, bioremediation, or oxidation mode.

Terra Vac has operated a DVE/bioremediation/oxidation treatment train at pilot-scale or as an Interim Measure at the Site from September 2003 through February 2006. The Terra Vac treatment train was operated in the dissolved plume, LNAPL, and Hot Spot areas on the Lilyblad property, and in the MPE and PW Eagle manufacturing building areas on PWE property (refer to Figure 1-3). It is likely that these areas will require less future remediation to remove residual COCs in soil and groundwater than untreated areas of the Site. The operation of the treatment system for Variation A is expected to follow the outline presented by Terra Vac (Terra Vac 2005). Site-wide remediation for Variation A will begin with the sequential operation of extraction wells in DVE mode on the Lilyblad property, along the adjacent rail spur (Saul Property), and on the PW Eagle property. This will act to dewater the treatment area, remove soil vapor to the maximum extent practical, continue to provide containment of groundwater, and prevent the off-site migration of contaminants.

It is anticipated that it will take approximately 2 months to dewater the Site and remove an appreciable amount of the VOCs from the source areas. Bioremediation will begin in those well locations where TPH concentrations are the most elevated. Bioremediation is expected to take up to 5 years to be completed. Once bioremediation is complete, the oxidation of SVOCs will begin. This process is expected to last up to 1 year. Refer to Section 3.4.2 for a more detailed discussion of expected remediation time frames for Alternative 2. The treatment system will operate in an area of the Site until it is determined that the system has removed the maximum practical amount of contamination in that area. Ecology will make this determination.

A four-unit operating system is expected to generate up to 10 gpm of groundwater and up to 1,000 standard cubic feet per minute (SCFM) of vapor that requires treatment. Terra Vac proposed that two extraction and treatment systems be installed at the Site: one 3-unit system operating from the Nelson building and a second one-unit system operating in the alley way to the north of the PW Eagle manufacturing facility. This approach was depicted on Figure 12 of the Site Wide Remedial Action Design Plan prepared by Terra Vac (Terra Vac 2005). The cost estimate for Variation A of Alternative 2 (refer to Appendix A.2) contains additional information about the anticipated quantities of nutrients, oxidants, and other additives that are expected to be used to implement this variation of Alternative 2. The groundwater and soil vapor treatment systems use activated carbon to adsorb COCs before groundwater or soil vapor is released to the environment. It is expected that the four-unit treatment train will generate about 1,000 pounds of spent carbon per month. This carbon will be shipped off the Site and reactivated.

Alternative 2 – Variation A uses active remediation to destroy and/or remove COCs from the entire soil AOC and from the entire groundwater AOC. Variation A is expected to destroy and/or remove approximately 160,000 pounds of COCs in the soil AOC (refer to Table 1-3), and reduce the concentration of COCs in groundwater to CULs.

2.2.3 Variation B – Operate the Generic System to Achieve Method B CULs for TPH Compounds, Reduce the Concentration of VOC COCs and Rely on Monitored Natural Attenuation and Institutional Controls to Achieve Method B CULs for SVOCs

This alternative operates the four-unit generic system for a shorter period of time than would be required by Variation A since additional on-site treatment time needed to oxidize SVOCs is not required and monitored natural attenuation is expected to reduce the SVOC and VOC concentrations to acceptable concentrations during the more than 50 years it takes groundwater to flow from the Site to the Blair Waterway (refer to Section 2.1.1). This variation assumes that the DVE and *in situ* bioremediation portions of the generic treatment system would be active at the Site for a period of 5 years (refer to Section 3.4.2).

Variation B also assumes that natural attenuation will decrease the concentrations of VOC and SVOC COCs to acceptable concentrations once the TPH source has been reduced by operating the DVE and bioremediation system modules for a period of 5 years. The potential for natural attenuation at this Site is discussed in Section 3.2. The time period needed for VOC and SVOC COCs to naturally attenuate to CULs established by Ecology is expected to be greater than 50 years (refer to Section 3.2).

The cost estimate for Variation B of Alternative 2 (refer to Appendix A.2) contains additional information about the anticipated quantities of nutrients, oxidants, and other additives that are expected to be used to implement this alternative.

The groundwater and soil vapor treatment systems use activated carbon to adsorb COCs before groundwater or soil vapor is released to the environment. It is expected that the four-unit treatment train will generate about 1,000 pounds of spent carbon per month. This carbon will be shipped off the Site and reactivated.

Alternative 2 – Variation B uses active remediation to destroy and/or remove TPH COCs from the entire soil AOC and from the entire groundwater AOC. Variation B is expected to destroy and/or remove approximately 160,000 pounds of TPH from the soil AOC, a significant portion of the 3,500 pounds of VOCs, and a small portion of the 200 pounds of SVOCs (refer to Table 1-3) in the soil AOC. The concentration of VOC and SVOC COCs in groundwater are not expected to be reduced to CULs by Alternative 2 – Variation B.

2.2.4 Variation C – Containment of Groundwater on the Lilyblad Property and *In Situ* Treatment of Contaminants on Adjacent Properties

Alternative 1 evaluated the potential performance of slurry wall and sheet pile barrier walls designed to contain groundwater on the Lilyblad property. Each of these approaches has advantages and disadvantages. Both the continuous barrier and the partial barrier with enhanced groundwater recovery were judged likely to be effective barriers to groundwater flow. Variation C to Alternative 2 assumes that a continuous slurry wall barrier will be installed, as shown on Figure 2-1A. The generic *in situ* treatment system was described in Section 2.2.1. This system would only be operated on the PW Eagle property north and west of the

PW Eagle manufacturing building, on the Nelson property, and along the rail line right of way on the eastern potion of the Saul property (refer to Figure 1-3) as part of Variation C - Alternative 2. Two generic *in situ* treatment systems are expected to be needed for Variation C of Alternative 2. Variation C assumes that the *in situ* system (along with its groundwater and soil vapor treatment system) would operate for a period of 2 - 3 years (refer to Section 3.4.2).

The cost estimate for Variation C of Alternative 2 (refer to Appendix A.2) contains additional information about the anticipated quantities of nutrients, oxidants, and other additives that are expected to be used to implement this alternative.

The groundwater and soil vapor treatment systems use activated carbon to adsorb COCs before groundwater or soil vapor is released to the environment. It is expected that the two-unit treatment train will generate about 200 pounds of spent carbon per month. This carbon will be shipped off the Site and reactivated.

Alternative 2 – Variation C uses active remediation to destroy and/or remove TPH, VOC, and SVOC COCs from the portion of the soil and groundwater AOCs that are outside of the barrier wall located on the Lilyblad property. Variation C is expected to destroy and/or remove approximately 30,000 pounds of TPH, 280 pounds of VOC, and 18 pounds of SVOC COCs from the soil AOC (refer to Table 1.3). The concentrations of VOC and SVOC COCs in groundwater outside the barrier are expected to be reduced to CULs by Alternative 2 – Variation C.

Alternative 2 – Variation C leaves behind approximately 130,000 pounds of TPH, 3,400 pounds of VOCs, and 200 pounds of SVOCs that are present within the barrier wall on the Lilyblad property.

2.3 Alternative 3—Excavation and Disposal of Contaminated Soils

This alternative considers the demolition of existing buildings and infrastructure to allow for the excavation, removal and disposal of contaminated soil. Two variations of this alternative were considered: 1) Variation A - Excavation of soil above cleanup levels on the Lilyblad property, and 2) Variation B - Excavation of soil on the most contaminated parts of the Lilyblad property and natural attenuation of contaminants thereafter.

The intent of this alternative is to remove the source of the TPH, VOC, and SVOC contamination in soil on the Lilyblad property. Contaminants in soil are widely distributed around the Site (refer to Figure 1-1 and 1-4). Several site-specific technical restraints will affect the implementation of this alternative. These restraints are summarized in Section 2.3.1. Variation A of this alternative is described in Section 2.3.2 and Variation B is described in Section 2.3.3.

2.3.1 Technical and Financial Restraints Affecting the Implementation of this Alternative

The site-specific technical restraints that affect Alternative 3 and all other alternatives were summarized in Section 1.2. These restraints include 1) factors associated with the active use of the facility, 2) factors limiting access to and removal of contaminated soil and groundwater, and 3) site-specific geologic and hydrologic conditions promoting or prohibiting the applicability of certain remedial technologies.

The Lilyblad facility is currently used by Pacific Fluids to receive, repackage, store, and distribute a variety of petroleum products. These activities require that employees have access to, and use of most of the property. Soil contamination is present below the Pacific Fluids tank farms and warehouse and throughout the Lilyblad property (refer to Figures 1-1 and 1-3). The demolition of these facilities would likely put Pacific Fluids out of business and cause costly business interruptions to PWE and the railroad operator. Nonetheless, this alternative assumes that all or some of the facilities on the Lilyblad property will be demolished.

The excavation of soil on the Lilyblad property would have to overcome several technical issues including 1) dewatering of saturated soils prior to excavation, 2) excavations near building foundations, 3) excavations in areas where utilities are known to be or may be present, and 4) excavation work that does not cause undue business interruptions to operating facilities at PWE and the railroad, or on the Nelson or Saul properties.

PWE employees also need to have access to and use of their property. Soil contamination is present below the northwest corner of the PWE manufacturing facility, and below the rail lines to the west of Lilyblad on the Saul property. Buildings adjacent to the Lilyblad property would not be demolished by this alternative.

2.3.2 Variation A - Excavation of Soil above Cleanup Levels

As mentioned previously, buildings occupy approximately 40 percent of the 2-acre Lilyblad property. The Lilyblad property is paved with the exception a small landscaped area of small size. The primary underground utility corridors serving the Lilyblad property were described in the CH2M-Hill RI, Section 3.1.2 and

Figure 3.1. These corridors run along three of the four legs of the perimeter of the property. Other buried utilities are also present within the property boundary. The specific locations of these lines are not known.

To access contaminated soils on the Site, several structures must be demolished. These structures include a warehouse/administration building, two AST farms, a stormwater treatment plant and associated ASTs, a laboratory/boiler building and maintenance trailer, a petroleum pump station, a drum filling station, and a water tank for the wastewater treatment plant on the adjacent Nelson property. A more detailed description of the structures to be demolished under this alternative is outlined below.

Warehouse/Administration Building

The 10,000-square-foot warehouse building is located in the center of the Lilyblad property. On the east side of the building, the warehouse is a two-story office structure with a wood and drywall interior. Each floor is divided into five offices. The west side of the building is an open warehouse, with concrete block walls on the north and west sides, and a post and beam construction on the south. An elevated loading dock is situated on the west side of the building. The entire building is underlain by concrete slab and is covered by an aluminum roof.

North Tank Farm

A tank farm containing 16 tanks in four by four rows lies on the north side of the warehouse. The tanks were presumably used to store various chemicals and petroleum-based lubricants and fuels pertinent to the operations at Lilyblad Petroleum Inc. Each tank is approximately 12 feet in diameter and is estimated to be 25,000 gallons in volume. The tanks are surrounded by an approximately 3-foot-tall reinforced concrete berm. An additional tank of approximately 8,000 gallons lies within the berm, at the southwest corner. Each tank sits on a concrete pad, and gunite was used to fill the spaces between pads. The tank farm footprint is approximately 5,000 square feet.

Concrete separating walls were placed between the warehouse and the North Tank Farm to create three mixing rooms. The rooms are covered with a corrugated metal roof. One room is currently vacant, while the remaining two contain mixing tanks. The mixing tanks are heated and contain a total mixing capacity of 55,000 gallons. Overhead piping connects the mixing rooms with the drum filling station.

West Tank Farm

A second tank farm lies to the west of the warehouse. This tank farm contains 23 tanks of varying sizes. Four tanks are approximately 25,000 gallons, eight tanks are approximately 12,000 gallons, and eleven tanks are approximately 10,000 gallons in volume. It is likely that these tanks were also used to store various chemicals and petroleum-based lubricants and fuels. These tanks are also surrounded by a 3-foot-high reinforced concrete berm and sit on concrete pads surrounded by gunite. The footprint of the bermed area is 3,500 square feet.

A gap has been placed in the western wall of the warehouse to accommodate two ASTs that are each approximately 10 feet in diameter. The ASTs are partially covered by a corrugated metal roof that extends from the warehouse to the West Tank Farm. Pipe connections are routed below the roof, connecting the tank farm to the mixing rooms along the north side of the warehouse.

Stormwater Treatment Plant

Because the Site is almost entirely covered by pavement and buildings, a stormwater treatment plant has been placed in the south side of the West Tank Farm. The treatment plant occupies an 800-square-foot area and contains an oil/water separator, two 11-foot-diameter ASTs, and a 9-foot-diameter AST. The tanks are presumably associated with stormwater treatment.

Laboratory/Boiler Building

A two-story, wood frame building used to house lab equipment, a 250-horsepower boiler, a lunchroom, showers, offices, and storage occupies 900 square feet at the southwest corner of the property. A maintenance trailer is located near the building. More recently, four to six ASTs, each approximately 25,000 gallons, were installed nearby.

Petroleum Pump Station

A loading rack used to fill trucks with diesel and other petroleum products is located near the northwest corner of the Site. This steel frame structure has overhead piping leading to both tank farms. The structure occupies 600 square feet.

Drum Filling Station

A filling station used to fill drums and other containers is located to the north of the pump station near the northwest corner of the Site. This structure occupies 600 square feet and contains overhead piping leading to the mixing facilities adjacent to the warehouse. The structure is equipped with sprinklers and is explosion proof.

Water Tank

A water holding tank associated with the wastewater treatment plant located on the adjacent Nelson property is located at the northwest corner of the Site. The tank is approximately 11 feet in diameter. If demolished, this tank would have to be reinstalled nearby to allow for treatment of dewatering water during excavation activities.

Because petroleum products and solvents were processed in this facility, many of the structures, particularly the tanks and loading facilities, would need to be cleaned prior to demolition. In addition, a hazardous building material (HBM) survey and abatement must also be completed for each structure prior to the commencement of demolition activities.

Once demolition is complete, excavation would occur within the areas on the Lilyblad property that were within the soil AOC shown on Figure 1-1. On average, excavations would reach depths of 12 feet, which is 6 feet below the groundwater table. As a result, a total of 30,000 cubic yards of contaminated soils would be removed, of which 15,000 cubic yards are expected to be saturated and need dewatering prior to excavation and disposal. Variation A of Alternative 3 assumes that excavation would be phased or that the adjacent properties would be available to offer adequate room to stockpile saturated soils for dewatering. Soils would be stockpiled on an incline slope covered with a HDPE liner that is sloped toward a French drain. The collected water would then be pumped to the water treatment plant located on the Nelson property. It is estimated that excavation will occur in the relatively dry months of July and August and that dewatering will require approximately two days to complete.

Because 6 feet of the excavation extends below the groundwater table, dewatering measures must be in place to keep the excavation dry. It is assumed that sump pumps would be placed within the excavation and that collected water will be pumped to the treatment plant located on the Nelson property. Sloping of the excavation side walls or sheet pile installation will be necessary to excavate to the required depths. A 2H:1V slope would be required as a safety measure for excavation side walls. As such, the excavation would only reach the maximum required depth 24 feet within the edge of the property boundary and would leave approximately 6,000 cubic yards of contaminated soil in place. Therefore, the use of sheet pile or slurry wall is considered for this alternative.

Historical sample analytical results indicate that the main VOC constituents are perchloroethylene (PCE), trichloroethylene (TCE), m,p-xylenes, and toluene. Soil concentrations of PCE and TCE are well below the maximum allowable levels established for Rabanco's Roosevelt Subtitle D landfill facility, while xylenes and toluene are not listed in the soil acceptance criteria. The total average SVOC concentration in the soils to be excavated is lower than any of the individual SVOC acceptance criteria. The average TPH concentration of 852.36 mg/kg in soils being excavated under Alternative A is also below Rabanco's acceptance criteria. Based on these results, excavated soil is expected to be suitable for disposal at the Rabanco Landfill. This alternative assumes that the excavated soils can be disposed of at the Roosevelt landfill. Significant additional costs would be incurred if the excavated soil did not meet Rabanco's acceptance criteria and had to be disposed of in a hazardous waste landfill.

Because there is no transfer station in Tacoma, contaminated soils would be loaded into trucks and hauled to a transfer station in Seattle for disposal at the Rabanco Landfill. The excavation would then be backfilled with clean structural fill, compacted, and regraded to the original grade.

The total volume of soil that could be reasonably excavated was calculated to be 30,000 cubic yards. The footprint of this excavation includes all of the soil down to the aquitard that lies within the soil AOC on the Lilyblad property that is depicted on Figure 1-1. This excavation will leave approximately 35,000 pounds the TPH, VOC, and SVOC contamination in place on adjacent properties (refer to Table 1.3). Thus the source term will not be fully removed. However, based on average post-Interim Measure COC concentrations on the Lilyblad property, approximately 3,400 pounds of VOCs, 200 pounds of SVOCs, and 130,000 pounds of TPH would be removed from the Lilyblad property; or a total of approximately 134,000 pounds of contaminants. Therefore, this cleanup alternative variation should remove nearly all of the soil-based contaminants on the Lilyblad property. Performance monitoring will be necessary to designate soils for disposal. The total mass of contaminants in the soil AOC is estimated at approximately 163,000 pounds. Thus this excavation removes and disposes of 82 percent of the COCs present in the soil AOC.

The remaining off-site contamination would continue to contribute contaminants to groundwater flowing through the Site. However, in addition to soils removal, groundwater within the excavation will also be removed and treated. An estimated 500,000 gallons of water will be treated with the on-site treatment system. Some natural attenuation of the remaining residual contaminants would occur as the groundwater flowed toward the Blair Waterway. Compliance monitoring will be necessary for the duration of natural attenuation to ensure that waters with constituent concentrations above CULs are not entering the waterway. The concentrations of constituents are expected to decline to CULs in the 50-year time period that it would take for groundwater below the Site to travel to the Blair Waterway if short-circuiting did not occur (refer to Section 3.2).

2.3.3 Variation B – Excavation of Soils on the Most Contaminated Parts of the Property and Subsequent Natural Attenuation of COCs

Historical sample analysis indicates that soil contamination is present Site-wide. Interim remedial actions have already taken place north of the PW Pipe building, east of the North Tank Farm (LNAPL area), east of the laboratory/boiler building (Hot Spot area), and southwest of the warehouse building (MPE area). Therefore, the most contaminated areas remaining on the Lilyblad property are surrounding the warehouse, beneath both tank farms, and at the northwest corner of the Site, and near the loading rack area (Figure 2-4). Although it is unlikely that the warehouse would need to be demolished to excavate those soils, shoring would be necessary to protect the building's foundation as well as to retain the excavation side walls at depth. In addition, both tank farms, as well as the adjoining structures that house piping and mixing rooms, would need to be demolished.

As with Variation A, the excavation would extend 12 feet below ground surface into the aquitard, and dewatering of saturated soils and the excavation would be necessary. Approximately 16,700 cubic yards of soils would be removed and replaced with clean structural fill, which would be compacted and regraded. It is anticipated that 8,300 cubic yards of soil will be saturated and will need to be dewatered prior to disposal. The soils in this excavation are expected to be similar to those that could potentially be encountered with Variation A. Therefore, these soils are also assumed to be suitable for disposal at Rabanco's landfill. Compliance sampling and analysis will be necessary to designate these soils for disposal.

This excavation variation would result in the removal of 1,900 pounds of VOCs, 120 pounds of SVOCs, and 73,000 pounds of TPH. The total mass of COCs removed would be approximately 75,000 pounds, or approximately 56 percent of the calculated mass of contamination on the Lilyblad property and 46 percent of the total mass of contamination in the soil AOC. This limited excavation alternative will leave approximately 31,000 pounds of TPH, VOCs, and SVOCs in place on adjacent properties (refer to Table 1-3) as well as approximately 58,000 pounds within the Lilyblad property. Thus the source term on the Lilyblad property will not be fully removed by Variation B of Alternative 3.

The remaining contamination would continue to contribute contaminants to groundwater flowing through the Site. Some natural attenuation of these contaminants would occur as the groundwater flowed toward the Blair Waterway. In addition to soils removal, groundwater within the excavation will also be removed and treated. An estimated 300,000 gallons of water will be treated in the on-site treatment system. The concentration of contaminated groundwater within the groundwater AOC is expected to take more than 50 years to decline to CULs (refer to Section 3.2). Compliance monitoring would be conducted to determine whether groundwater contaminants are at concentrations below CULs prior to exiting the Site boundary.

2.4 Alternative 4—Hydraulic Control with Groundwater Monitoring

This alternative includes the maintenance of hydraulic control of groundwater below the Site and routine monitoring of water levels and COC concentrations in monitoring wells surrounding the Site (Ecology 2006c). Ecology has identified the 11 monitoring wells around the perimeter of the Site that will be used to monitor progress of cleanup actions at the Site. The locations of these wells are shown on Figure 2-5.

Terra Vac has prepared a Monitoring Plan (Terra Vac 2006b) that describes the approach to hydraulic control and groundwater monitoring associated with Alternative 4. Hydraulic control will be maintained by connecting the existing DVE system to the following wells to extract groundwater:

- MPE Downgradient wells: AGI-37, B-23, and BR6-3
- MPE well across from sewer drain trench: BR5-7
- End Points of Trench A: P-1A and P-5A
- Endpoints of Trench B: P-1B and P-6B
- East corner of LPI site: DP-3

Based on hydraulic containment efforts previously implemented on the Lilyblad property, MPE area, and PWE building by Terra Vac, it is estimated that hydraulic control of the Site groundwater contaminant plume can be maintained using a groundwater removal rate of approximately 2 gpm (Terra Vac 2006b). The extracted groundwater and soil vapor will be treated by the renovated CDM groundwater treatment system shown on Figure 2-2, and described in Section 2.1.3. The key components of this system include a surge tank, air stripping system, activated carbon treatment for groundwater and vapors (removed from the stripping system), and a cooling system for maintaining discharges below 19 degrees C to comply with Ecology's NPDES-like discharge criteria.

To confirm that groundwater containment has been achieved, groundwater elevations will be measured weekly for the first month after the hydraulic containment system has been activated and quarterly thereafter. Groundwater discharging the treatment system will be sampled and analyzed monthly to assure compliance with discharge requirements.

As part of this alternative, long-term groundwater quality monitoring will also be performed to evaluate the effectiveness and continued need for hydraulic containment. A long-term groundwater monitoring plan would be developed that specifies monitoring well locations, monitoring frequencies, sampling procedures, and analytical and reporting requirements. Cost estimates provided in Appendix A.4 are based on collecting groundwater samples from 11 monitoring wells located along the perimeter of the Site (see Figure 2-5) on a quarterly basis for Year 1, a semi-annual basis for Years 2 through 5, and on a yearly basis for Years 6 through 30. Compliance monitoring groundwater samples will be analyzed for VOCs (EPA Method 8260B with SIM for vinyl chloride and 1,1-DCE), TPH (NWTPH-G/D extended), and SVOCs (EPA Method 8270C and 8170C SIM for pentachlorophenol).

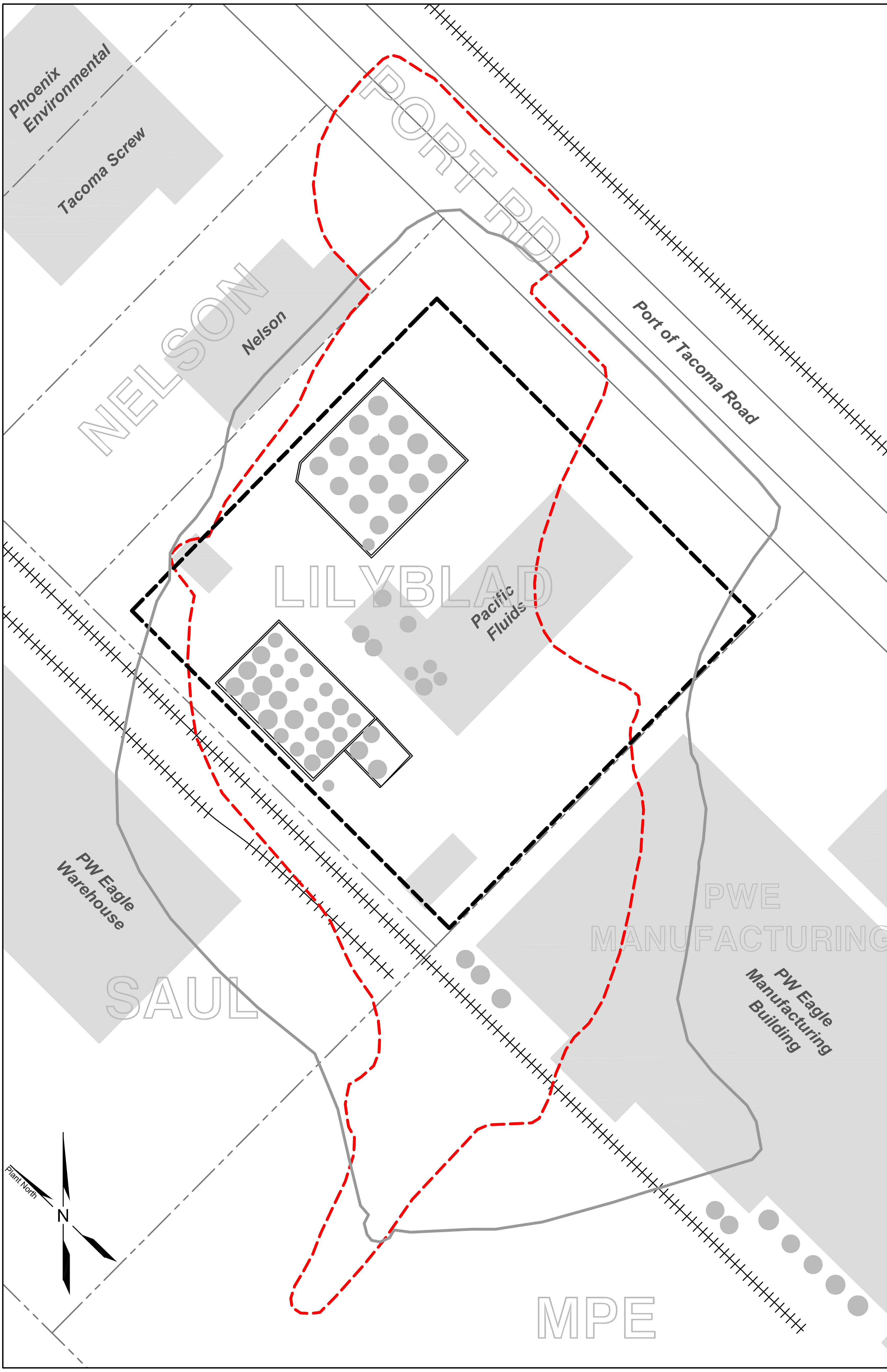
A compliance monitoring plan for groundwater and for soil (if appropriate) will be implemented for Alternatives 1, 2, and 3, as well. The specific elements of the monitoring plans are discussed in Section 3.3, 3.4, and 3.5, respectively.

The groundwater and soil vapor treatment systems utilize activated carbon to adsorb COCs before groundwater or soil vapor is released to the environment. This carbon will be shipped off the Site and reactivated.

Table 2.1 - Advantages/Disadvantages of Using Slurry Wall and Steel Sheet Pile Barriers on the Lilyblad Site

Type of Barrier	Advantages	Disadvantages
Slurry Wall	Work around utility penetrations without disconnect/rerouting.	Requires bench scale testing.
	Closer proximity to utility lines compared to vibratory or driven sheet pile installation.	Requires large excavation with soil disposal.
	Typically lower permeability compared to sheet pile.	Requires excavated soil dewatering and treatment/disposal.
	Potential for partial reuse of excavated soils.	Larger construction footprint for slurry mixing and soil stockpiling.
		Excavation standoff from building foundations and utility lines.
		Longer construction schedule.
		Controlled excavation around utility penetrations.
		Potential for dewatering of trench area prior to and during construction.
		Utility penetration design.
		Higher engineering costs.
Steel Sheet Pile	Shorter construction schedule.	Utility penetration disconnects and rerouting.
	Minimal or no soil disposal.	Utility penetration design.
	Low permeability with interlock sealant.	Utility standoff for vibratory or pile driving installation.
	Minimal or no dewatering.	
	Larger perimeter with non-vibratory pile installation.	
	Lower engineering costs.	

Alternative 1, Variation A - Continuous Barrier Footprint
Lilyblad Site



Source: CH2M Hill 2004.

Approximate Extent of Soil Contamination

Approximate Extent of Groundwater Contamination

Barrier: Variation A

Railroad

Property Line

0 60 120

Scale in Feet

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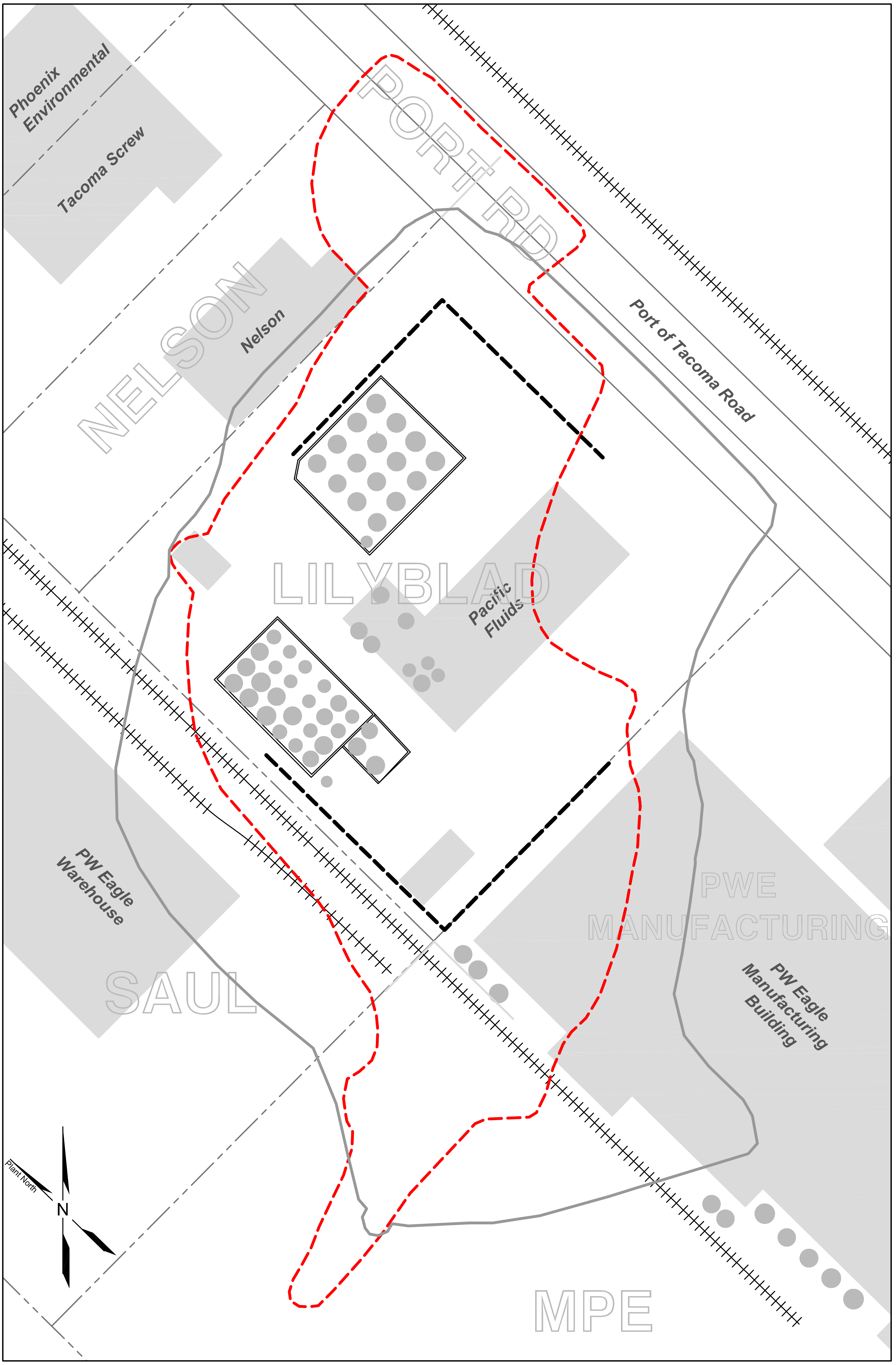
Figure 2-1A

Alternative 1, Variation B - Partial Barrier Footprint
Lilyblad Site



Source: CH2M Hill 2004.

Approximate Extent of Soil Contamination

Approximate Extent of Groundwater Contamination

Barrier: Variation B

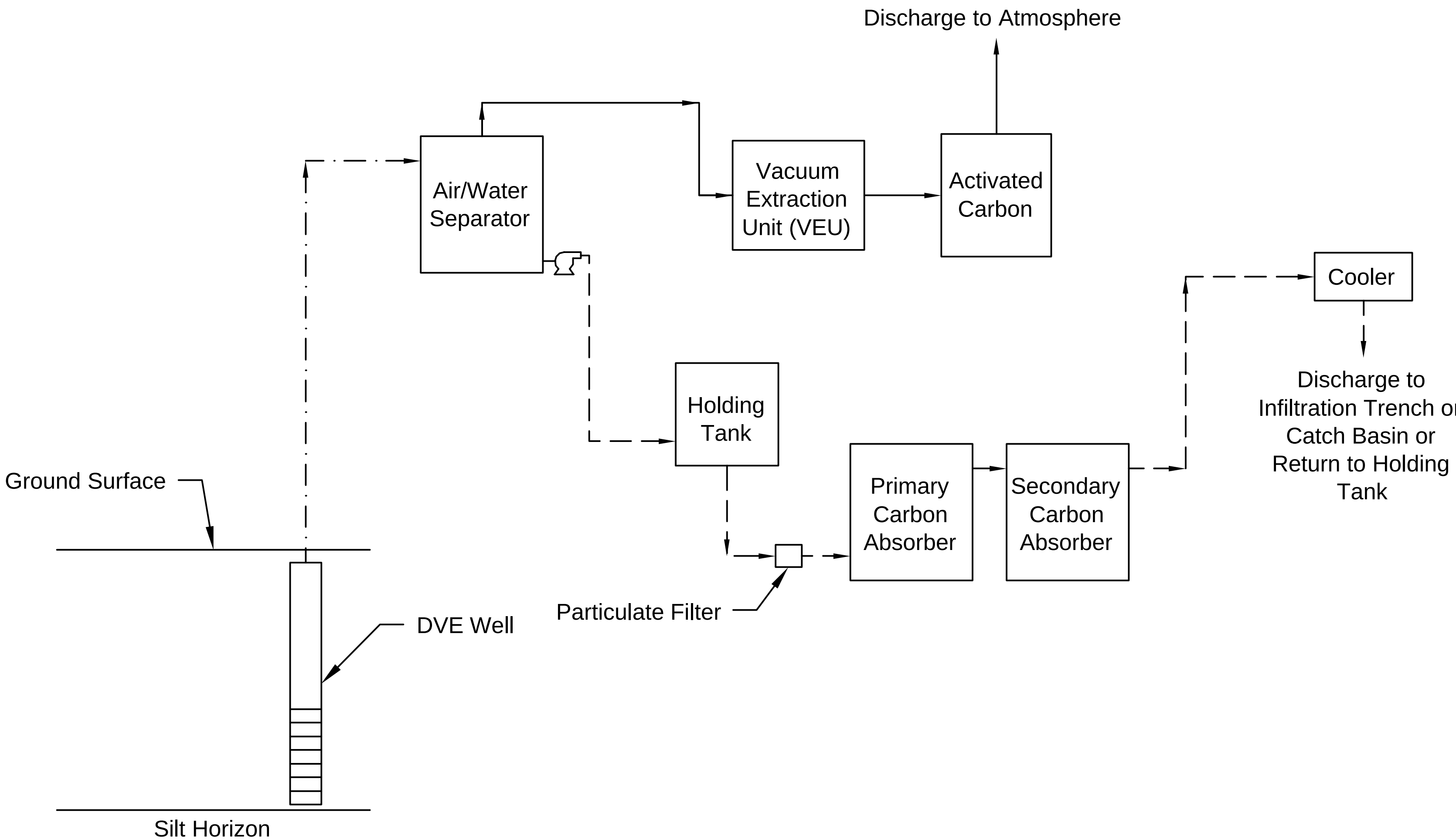
Railroad

Property Line

0 60 120
Scale in Feet

HARTCROWSER
17330-02 1/07
Figure 2-1B

Groundwater and Soil Vapor Treatment System Schematic



Source: Terra Vac 2005.

— — — Water

——— Vapor

— · — · — Water and Vapor

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Figure 2-2

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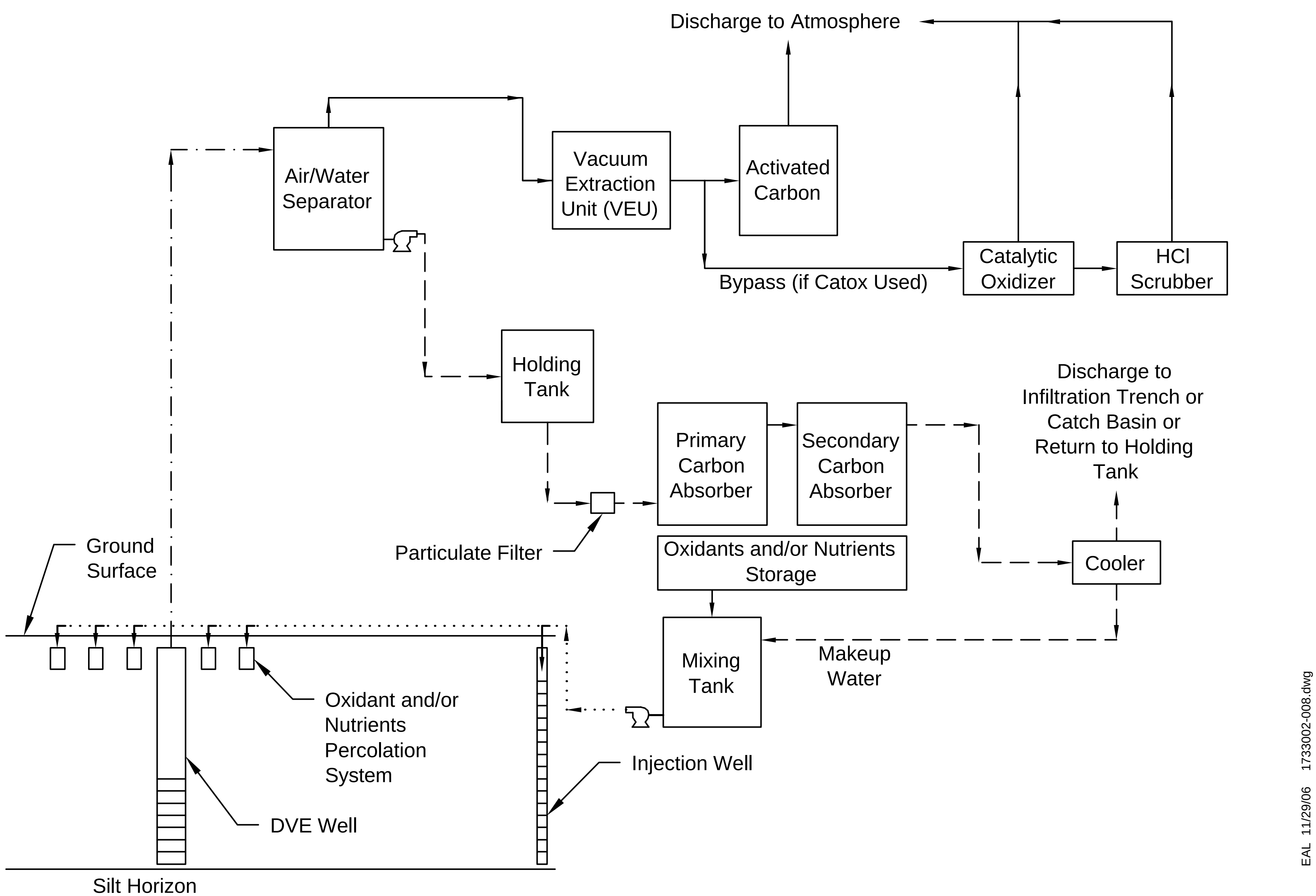
Alternative 2 - Process Flow Diagram Schematic



Source: Terra Vac 2005.

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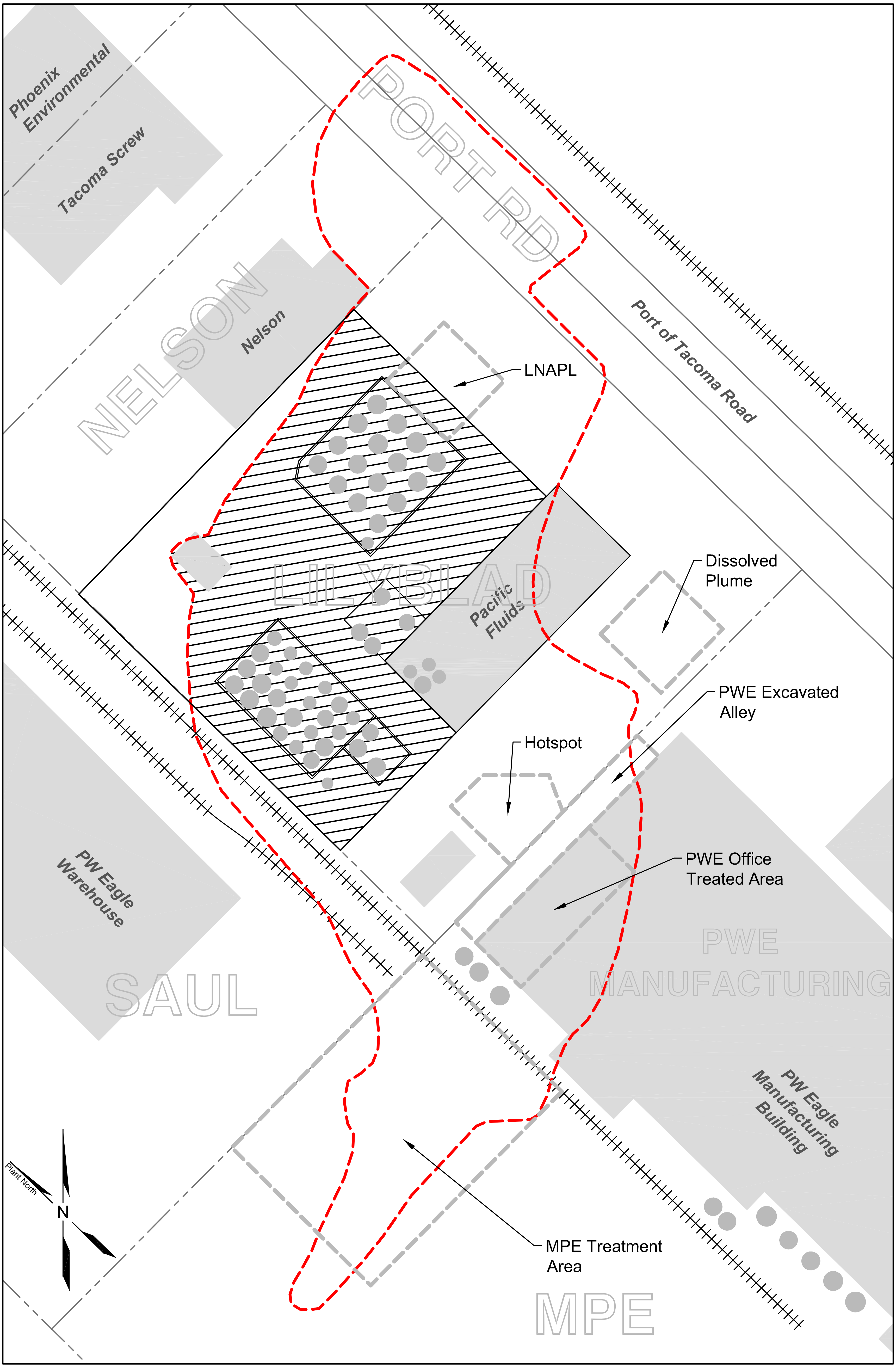
Figure 2-3

17330-02 *11/06*

Alternative 3, Variation B - Proposed Excavation Location Plan

Lilyblad Site



Source: CH2M Hill 2004.

Approximate Extent of Soil Contamination

Terra Vac Treatment Areas

Area of Excavation

Railroad

Property Line

0 60 120

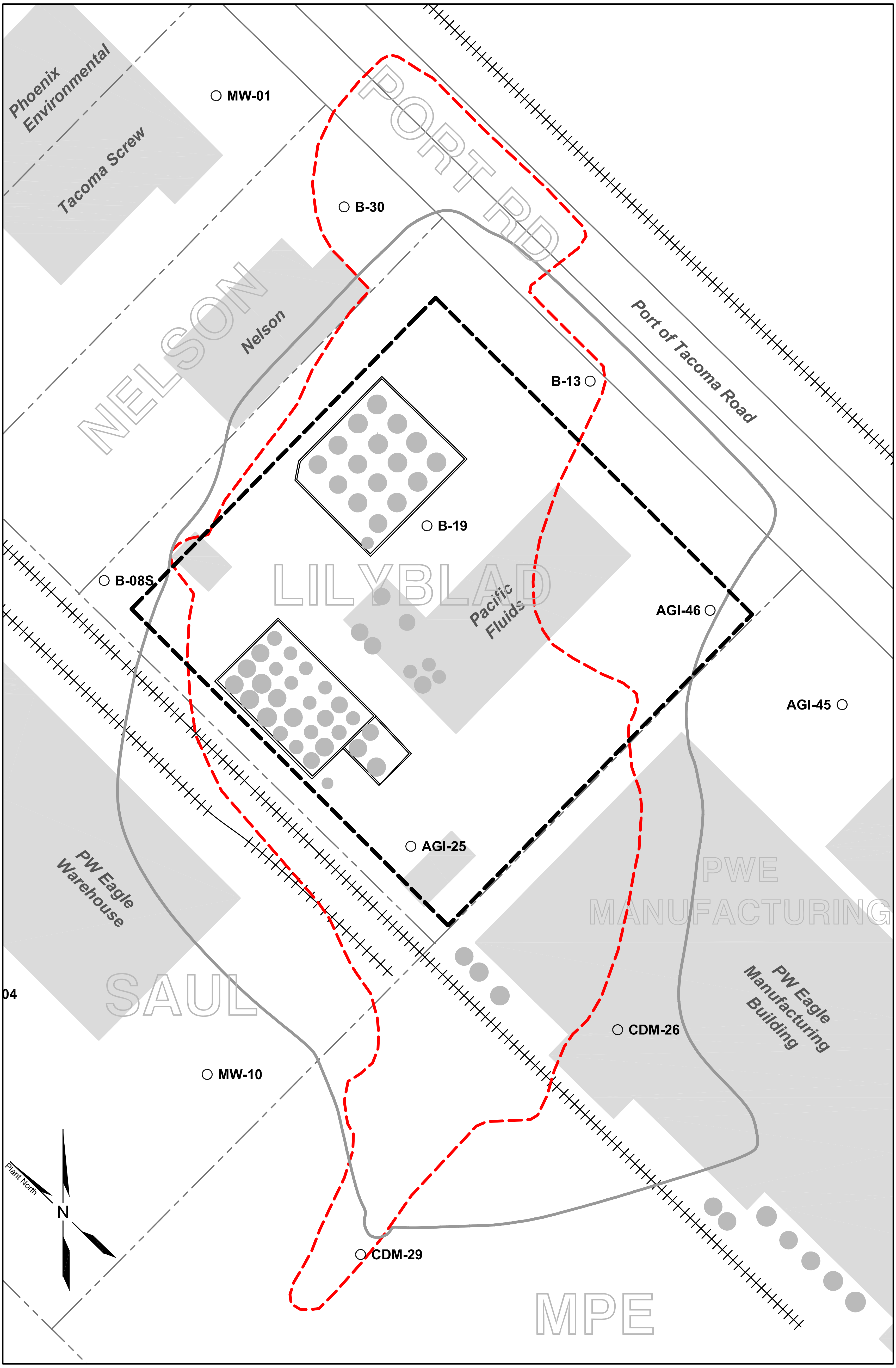
Scale in Feet

HARTCROWSER

17330-02 1/07

Figure 2-4

Monitoring Well Location Plan
Lilyblad Site



Source: CH2M Hill 2004.

Approximate Extent of Soil Contamination

Approximate Extent of Groundwater Contamination

Barrier

Railroad

Property Line

AGI-25 Monitoring Well Location and Number

0 60 120
Scale in Feet

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17330-02 1/07
Figure 2-5

3.0 EVALUATION OF ALTERNATIVES

The four remedial alternatives (with variations) that are being considered by this FFS are evaluated in this section. Descriptions of the evaluation criteria used to evaluate the alternatives are provided in Section 3.1. Several of the alternatives include a provision for natural attenuation of COCs once active remediation has been completed. The potential for natural attenuation at the Site is assessed in Section 3.2. Subsequent sections present evaluations of the four remedial alternatives as follows:

- Alternative 1—Containment with Groundwater Controls (Section 3.3);
- Alternative 2—*In Situ* Treatment with and without Natural Attenuation (Section 3.4);
- Alternative 3—Excavation and Disposal of Contaminated Soils (Section 3.5); and
- Alternative 4—Hydraulic Control with Groundwater Monitoring (Section 3.6).

3.1 Description of Evaluation Criteria

Ecology identified the criteria that should be used to evaluate remediation alternatives within the Model Toxics Control Act (MTCA) regulation (WAC 173-340-360). The purpose of the evaluations is to identify the advantages and disadvantages of each alternative and thereby assist in the decision-making process. The criteria are applied to Alternatives 1 through 4 in Sections 3.3 through 3.6. The specific criteria are all considered important, but they are grouped into three sets of criteria that are weighted differently in the decision-making process. These criteria are:

- Threshold Requirements:
  - Protect Human Health and the Environment;
  - Comply with Cleanup Standards (WAC 173-340-700 through 173-340-760);
  - Comply with Applicable State and Federal Laws (WAC 173-340-710); and
  - Provide for Compliance Monitoring (WAC 173-340-410 and 173-340-720 through 173-340-760).

- Other Requirements:
  - Use Permanent Solutions to the Maximum Practical Extent. If a Disproportional Cost Analysis is used, then evaluate:
    - Protectiveness;
    - Permanence;

- Cost;
- Effectiveness over the Long Term;
- Management of Short-Term Risks;
- Technical and Administrative Implementability; and
- Consideration of Public Concerns.

■ Restoration Time Frame.

Alternatives 1 through 4 will include institutional controls and compliance monitoring. Institutional controls usually include on-site features, such as signs and fences, and legal mechanisms, such as lease restrictions, deed restrictions, land use and zoning designations, and building permit requirements. Ecology will determine the appropriate institutional controls for the Site. The compliance monitoring program established by Ecology for this Site (Terra Vac 2006b) is described in Section 2.4. As a result, compliance monitoring and the nature of the institutional controls judged appropriate for the Site are not included as evaluation criteria in this section. The cost of implementing the compliance monitoring judged appropriate for each alternative was included in the conceptual-level cost estimate prepared for that alternative.

The complex technical requirements of this Site (refer to Section 1.2), together with existing budget constraints, make a disproportionate cost analysis appropriate for this Site. The protectiveness criterion, when conducting a disproportional cost analysis, was judged to be equivalent to the threshold requirement to protect human health and the environment.

An alternative must meet the threshold criteria to be eligible for selection as a remedy. The expected performance of each alternative is assessed to identify its ability to comply with cleanup standards and applicable state and federal laws. If the alternative is judged to comply, the choice use among Alternatives 1 through 4 is then based on evaluation of the remaining eight evaluation factors.

3.1.1 Overall Protection of Human Health and the Environment

This evaluation criterion (WAC 173-340-360(3)(f)(i)) assesses the degree to which existing risks are reduced, the time required to reduce risks at the facility and attain cleanup standards, on- and off-site risks resulting from implementing the alternative, and improvement of overall environmental quality. The expected outcome of each alternative is compared to the CULs (refer to Table 2.1) established by Ecology for the Site.

3.1.2 Comply with Cleanup Standards

Ecology has established cleanup standards in the MTCA regulation. These standards are summarized in WAC 173-340-700 through 173-340-760. Ecology has established CULs for soil and groundwater at the Site that would assure compliance with these cleanup standards. These CULs are listed in Table 2.1.

3.1.3 Comply with Applicable State and Federal Laws

Ecology has established CULs for soil and groundwater at the Site that would assure compliance with applicable state and federal laws. These MTCA Method B CULs are listed in Table 2.1. The point of compliance for soil is throughout the Site for protection of groundwater and ambient air, and from the ground surface to a depth of 15 feet for soil for the protection of human health based on direct contact exposure.

As defined under MTCA 173-340-720(8), the standard point of compliance for Site shallow groundwater is throughout the Site. For Alternative 2A (Operate the Generic System to Achieve Method B Levels for all COCs), this standard point of compliance would be applied. For the remaining alternatives, it would not be practicable to meet CULs throughout the Site within a reasonable timeframe. Therefore, conditional points of compliance would be established. For Alternative 2C (Containment of Groundwater on the Lilyblad Property and *In Situ* Treatment on Adjacent Properties), a conditional point of compliance would be established at the barrier boundary. For all other alternatives, the conditional point of compliance would be established at the current edge of the groundwater plume.

3.1.4 Permanence

Permanence (WAC 173-340-360(3)(f)(ii)) is the degree to which an alternative permanently reduces the toxicity, mobility, or volume of hazardous substances, including adequacy of the alternative in destroying the hazardous substances, reduction or elimination of hazardous substance releases and sources of releases, degree of irreversibility of waste treatment processes, and the characteristics and quantity of treatment residuals generated.

3.1.5 Cost

This criterion (WAC 173-340-360(3)(f)(iii)) includes the cost of construction, net present value of any long-term costs, and agency oversight costs that are cost recoverable. An interest rate of 3 percent was used in the net present value calculation. Long-term costs include operation and maintenance costs, equipment replacement costs, the cost of maintaining institutional controls, and compliance monitoring costs.

3.1.6 Effectiveness over the Long Term

This criterion (WAC 1173-340-360(3)(iv)) assesses the degree of certainty that the alternative will be successful, reliability of the alternative during its operating time on the Site, magnitude of the residual risk with the alternative in place, and the effectiveness of controls required to manage residual wastes.

For this evaluation, an attempt was made to estimate contamination remaining at the Site at 5-, 10-, and 20-year points after an alternative is implemented. An attempt was also made to assess the effectiveness of natural attenuation for Alternative 1; Alternative 2, Variation B; Alternative 3, Variation B; and Alternative 4.

The following types of cleanup actions, in descending order of preference, can be used to assess the relative degree of long-term effectiveness: reuse or recycling; destruction or detoxification; immobilization or solidification; on-site or off-site disposal in an engineered, lined, and monitored facility; on-site isolation or containment with attendant engineering controls; and institutional controls and monitoring.

3.1.7 Management of Short-Term Risks

This criterion described in WAC 173-340-360(3)(f)(v)) assesses the risks to human health and the environment associated with the alternative during construction and implementation, and the effectiveness of measures that will be taken to manage such risks.

3.1.8 Technical and Administrative Implementability

This criterion (WAC 173-340-360(3)(f)(vi)) considers whether the alternative is technically possible including availability of necessary off-site facilities, services, and materials; administrative and regulatory requirements; scheduling; size; complexity; monitoring requirements; access for construction operations and monitoring; and integration with existing facility operations and other current or potential remedial actions.

3.1.9 Consideration of Public Concerns

This criterion (WAC 173-340-360(3)(f)(vii)) addresses the public's concerns, if any, about the preferred alternative identified by Ecology. It will be addressed during the comment period for the Proposed Plan and will not be further addressed in this report.

3.1.10 Restoration Time Frame

The time expected for restoration to be complete is assessed (WAC 173-340-360(4). This time frame must be reasonable when the nine factors summarized in WAC 173-340-360(4)(b) are considered. In some instances where cleanup levels cannot be technically achieved, concentrations that are technically possible to achieve shall be met within a reasonable time frame considering the nine factors specified in WAC 173-340-360(4)(b).

3.2 Potential for Natural Attenuation at the Lilyblad Site

The term "natural attenuation" refers to a variety of physical, chemical, and/or biological processes that under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil and groundwater. Natural attenuation occurs by physical, chemical, and/or biological mechanisms. Physical mechanisms include dispersion, dilution, sorption, and volatilization. Chemical mechanisms include oxidation, reduction, and hydrolysis. Biological transformation or biodegradation occurs by microbial aerobic and anaerobic processes (Ecology 2005).

The natural attenuation of COCs in groundwater is considered as an element of Alternatives 1, 2, and 3. Ecology has published guidance that outlines the process to be used to establish whether natural attenuation is occurring in petroleum-contaminated groundwater at a site, and for estimating the effectiveness of natural attenuation for petroleum-based contaminants (Ecology 2005). While this guidance is not specifically applicable to the natural attenuation of chlorinated solvents, or to mixtures of chlorinated solvents and petroleum products similar to the mixture of COCs present at this Site (refer to Table 2.1), it will be used as a starting point for the evaluation of the potential role that natural attenuation may play at this Site.

Ecology (2005) has defined a five-step process for determining the feasibility of natural attenuation as a cleanup action alternative:

- What is the status of the groundwater plume at the site?
- Is chemical or biological degradation a substantial mechanism of natural attenuation at the site?
- What is the estimated time frame?

- Will the use of natural attenuation be protective of human health and the environment during the estimated remediation time frame?
- Has source control been conducted to the maximum practical extent?

3.2.1 What is the Status of the Groundwater Plume at the Site?

To be considered a feasible cleanup alternative, natural attenuation should be reducing contaminant concentrations over time under current site conditions. The contaminant plume should not be expanding.

The available evidence suggests that concentrations of COCs in the groundwater plume are not increasing. Long-term water quality data have been collected since 1991 from wells B-8S, B-13, SP-4, and SP-5. Plots of benzene and vinyl chloride concentrations detected over time from wells B-13, SP-4, and SP-5 are shown on Figure 3-1, 3-2, and 3-3, respectively. These wells are located on the Site. Well B-8S, which is located at the western corner of the Site cross-gradient of the plume, has not had detectable concentrations of benzene and vinyl chloride. Well B-13 is located adjacent to Port of Tacoma Road near the leading edge of the plume. Concentrations of benzene and vinyl chloride in this well appear to be declining, supporting the conclusion that the concentrations of COCs in the groundwater plume are not increasing. There is insufficient evidence to determine whether the plume is decreasing in size from the available data set. Wells SP-4 and SP-5 are located in the core of the contaminant plume. Concentrations of benzene and vinyl chloride appear to be stable in SP-4 and SP-5 with no apparent trend in concentrations.

Groundwater monitoring data indicate that geochemical conditions within the central area of the plume are anaerobic, methanogenic, and that reductive dechlorination is actively occurring (CDM 2002). Under these conditions, anaerobic biodegradation of chlorinated hydrocarbons is favored rather than the aerobic biodegradation of petroleum hydrocarbons and vinyl chloride. It is likely that favorable conditions for the biodegradation of petroleum hydrocarbons, and vinyl chloride are present at the leading edges of the groundwater plume, which may explain why the COCs in groundwater apparently are not migrating off Site at high concentrations. Natural attenuation is proposed as part of Alternatives 2 and 3. For Alternative 1, natural attenuation is likely to occur as contaminated groundwater that is not contained within the barrier around the Lilyblad property continues to flow toward the Blair Waterway.

For Alternative 2 (Variations B and C), natural attenuation would begin once the hydrocarbons are removed from soil and groundwater at the Site. Petroleum hydrocarbons and related COCs comprise more than 98 percent of the total mass of contaminants at the Site (refer to Section 1.1). The remaining COCs include VOCs and SVOCs. There are no known active primary sources of these COCs at the Site. After the bulk of the COCs are removed by the *in situ* treatment system, the primary secondary source of contaminants to groundwater will likely be residual contamination left in soils (particularly smear zone and aquitard soils). At this time, it is not possible to analytically determine whether the plume would be stable once TPH-related COCs were removed. It is likely that the plume would be decreasing at this point.

For Alternative 3, natural attenuation of COCs in groundwater is considered once the most contaminated soils (refer to Section 2.3) have been removed from the Site via excavation. For this alternative, up to approximately 30,000 cubic yards of soil containing about 134,000 pounds of COCs would be removed from the Lilyblad property if all of the contaminated soil on the property were excavated. Residual contaminated soils would continue to act as a source of COCs to Site groundwater. At this time, it is not possible to analytically determine whether the groundwater plume would be stable once the most contaminated soils have been removed from the Site.

3.2.2 Is Chemical or Biological Degradation a Substantial Mechanism of Natural Attenuation at the Site?

Geochemical indicators associated with the biodegradation process consist of electron acceptors (reactants) or metabolic by-products of the oxidation and/or reduction reactions that occur. Geochemical indicators of petroleum hydrocarbon biodegradation can include O2, NO3-, Mn+2, Fe+2, SO4-2, CH4, redox potential (Eh), and alkalinity. Decreases in O2, NO3-, SO42-, and/or increases in CO2, CH4, Mn+2 are indicators of petroleum hydrocarbon biodegradation. Changes in relative concentrations of these indicators over time provide evidence as to whether natural attenuation is occurring and to what extent. This evaluation requires the collection of groundwater analytical data from different areas within the groundwater AOC and from uncontaminated areas upgradient from the plume over an extended period of time. Unfortunately, the available data set does not contain a sufficient number of samples to provide a defensible assessment of natural attenuation at the Site.

The limited available data sets at individual sample locations make it impossible to critically evaluate trends in the geochemical parameters listed above. The significant reduction in the concentration of TPH-related COCs during the enhanced biodegradation demonstration tests conducted by Terra Vac (refer to Section 3.4) is an indicator that biodegradation of petroleum would be possible in groundwater below the Site as an element of the active *in situ* treatment natural attenuation component of Alternative 2.

Chlorinated hydrocarbon VOCs are known to be present in the groundwater at the Site. PCE and/or TCE products were likely released on the Lilyblad property. The presence of daughter products (DCE and vinyl chloride) of PCE and/or TCE indicates that at least some portions of the groundwater plume are undergoing anaerobic biodegradation.

3.2.3 What is the Estimated Time Frame?

The restoration time frame depends upon four major components: the amount of source mass (and associated dissolution rate), bulk attenuation rates for contaminants, the groundwater cleanup levels needing to be met for the contaminants, and the point of compliance at which the cleanup levels should be achieved.

Alternative 2, Variation B is expected to remove nearly all of the TPH present in soils and groundwater at the Site (refer to Section 3.4). Alternative 2, Variation C combines a barrier on the Lilyblad property with the operation of a DVE/biodegradation/oxidation system on the PWE property and is expected to remove approximately 19 percent of the COCs on the Site.

Alternative 3, Variation B is expected to remove approximately 46 percent of the COCs present at the Site (refer to Section 3.5). The quantity of COCs removed by each of these variations was estimated to develop a range of treatment options that could be evaluated. The volumes of residual contaminated materials remaining after implementation of these alternatives were deemed sufficiently low to potentially allow for natural attenuation of the remaining COCs in groundwater.

The methods for estimating bulk attenuation rates for petroleum contaminants are presented in Appendix F of Ecology's Guidance (Ecology 2005). These methods require 1) a history of COC concentration versus time data for compliance wells during times when natural attenuation is expected to occur, and/or 2) the use of a variety of linear regression, and one- and two-dimensional transport models to estimate the bulk attenuation rate. The data necessary to conduct a regression analysis are not available. The use of one- and two-dimensional models is beyond the scope of this report.

Groundwater at the Site travels northeasterly from a hydraulic mound toward the storm sewer line imbedded in the Port of Tacoma Road, and southwesterly toward a sewer line on the Saul property. Both storm sewer lines empty into the Lincoln Avenue Ditch, which eventually discharges into the Blair Waterway (refer to CH2M Hill SRI, Figure 3-7). In both instances, groundwater exiting the Lilyblad property likely intermixes with groundwater that may have been contaminated by off-site properties and operating practices before it reaches the Blair Waterway. It will be difficult to isolate the contribution of Lilyblad property COC discharges into the Lincoln Avenue Ditch and ultimately the Blair Waterway from other sources.

For the reasons cited above, it is not possible to establish quantitative remediation time frames for the natural attenuation of groundwater at the Site as part of this FFS.

3.2.4 Will the Use of Natural Attenuation be Protective of Human Health and the Environment during the Estimated Remediation Time Frame?

As discussed previously, groundwater at the Site travels toward storm sewer lines that discharge into the Lincoln Avenue Ditch, which eventually empties into the Blair Waterway. It will be difficult to isolate the contribution of Lilyblad property COC concentrations to the concentrations of COCs that are present at the point where the storm drains below the Port of Tacoma Road and the Lincoln Avenue Ditch, and ultimately reaches the Blair Waterway. Thus it will not be possible (based on existing information) to isolate the contribution of the COCs present in the groundwater emanating from the Site to the overall risk to human health and the environment posed by the total COC load that will be present when groundwater from the Site eventually reaches the Blair Waterway.

3.2.5 Has Source Control Been Conducted to the Maximum Practical Extent?

Natural attenuation is proposed as part of Alternatives 1, 2 (Variations B and C), and 3. For Alternative 1, natural attenuation will occur as the impacted Site groundwater located outside of the Lilyblad property barrier continues to flow toward the Blair Waterway. In the context of the alternatives that were evaluated, the quantities of COCs removed by Alternative 2, Variation B and Alternative 3, Variation B were judged to represent source control to the maximum practical extent. Variation A for Alternative 3 also focused on source control but used natural attenuation to a lesser extent to achieve risk reduction. Alternative 2 Variation A achieves risk reduction without using natural attenuation.

3.3. Alternative 1—Containment with Groundwater Controls

This alternative consists of the installation of a barrier wall to prevent the flow of groundwater from the Lilyblad property to adjoining properties and ultimately to the Blair Waterway and Commencement Bay. The barrier system will be operational until the concentration of COCs are low enough that natural attenuation will reduce the concentrations to below the CULs for groundwater as it enters Commencement Bay.

Two barrier systems will be considered: 1) Variation A, a steel sheet pile or slurry wall around the perimeter of the Lilyblad property, and 2) Variation B, a steel sheet pile or slurry wall that reflects the minimal size and length of wall that will prevent contaminated groundwater from the Lilyblad property from migrating onto adjacent properties. Barrier wall locations are depicted on Figures 2-1A and 2-1B. Groundwater pumping from selected wells or interceptor trenches will be used to maintain hydraulic control within the barrier. Groundwater from the hydraulic control system will be treated to meet Lilyblad's current NPDES-like requirements. The groundwater treatment system will be based on the existing treatment system installed by CDM, with modifications as needed to meet the NPDES-like requirements. A schematic of this groundwater treatment system is shown on Figure 2-2 and is expected to treat approximately 1,500 gallons per day for Variation A and 3,000 gallons per day for Variation B.

The groundwater treatment system will continue to discharge to the catch basin that connects with the storm drain located below the Port of Tacoma Road. The approximate location of this stormwater line is shown on CH2M Hill RI, Figure 3.1. Compliance monitoring of the COCs in groundwater exiting the Site will be conducted as outlined in the Monitoring Plan for the Site (Terra Vac 2006b) and as described in Section 3.6. Quarterly samples will be obtained at 11 monitoring wells during Year 1, semi-annual samples will be collected during Years 2 through 5, and annual samples will be obtained during Years 6 through 20. Compliance monitoring for the COCs in soil will be conducted at the completion of the installation of the barrier and during Years 5, 10, 15, and 20. Performance monitoring of the groundwater treatment system will occur each day that the system is operational to assure that it is operating properly. The effluent from the system will be analyzed once per month for the compounds listed in the NPDES-like permit that Ecology has established for the Lilyblad property (Ecology 2000).

Additional passive containment to prevent recharge within the aquifer is provided by the existing surface asphalt or concrete paving and buildings with cement floors that are present on the Site.

3.3.1 Expected Performance of Alternative 1

Alternative 1 does not directly reduce the quantity or volume of COCs in soil within the barrier or on the Site. This alternative prevents the horizontal flow of groundwater in the upper aquifer from exiting the footprint of the barrier but does not address the vertical flow of groundwater from the upper to the lower aquifer. Alternative 1, Variation A provides for a continuous barrier to horizontal groundwater flow in the upper aquifer around the Lilyblad property and provides for the removal and treatment of precipitation that will recharge the groundwater within the barrier. Thus Alternative 1, Variation A will assure that COCs in the groundwater retained within the barrier does not reach receptors in the Blair Waterway. Alternative 1 does not inhibit the flow of groundwater, in the groundwater AOC outside of the barrier, toward the Blair Waterway, or of groundwater downward to the lower aquifer.

Alternative 1, Variation B provides hydraulic contaminant of groundwater from a combination of a partial barrier in conjunction with hydraulic control. Alternative 1, Variation B is also expected to largely prevent COCs in the groundwater on the Lilyblad property from reaching receptors in the Blair Waterway. Since the barrier installed by this variation is discontinuous, the possibility exists for some groundwater to escape the barrier. This possibility is judged to be low, given the locations selected for the barrier wall segments, the presence of groundwater trenches adjacent to the barriers, the collection and treatment of the groundwater collected in the trenches; and the materials of construction selected for the barrier.

Once the continuous barrier is installed, groundwater outside the barrier will be prevented from commingling with groundwater within the barrier. The primary source of water to the shallow aquifer on the Lilyblad property once the barrier is installed will be precipitation. As discussed in Section 2.1.2, approximately 425,000 gallons of precipitation is expected to recharge the aquifer within the barrier footprint each year. The upper aquifer within the barrier is expected to contain approximately 1.1 million gallons of water. Thus is would take about 1 to 2 years to replace the groundwater in the aquifer with precipitation. The combination of dilution from recharge and the treatment of water extracted from the Site to maintain hydraulic control will act to remove COCs from the groundwater retained within the barrier. Reduction of COCs in groundwater from biodegradation and other natural attenuation is likely to occur but at such a slow rate that attaining CULs is expected to take 100 or more years. The COCs removed will be replaced by COCs derived from contaminated soil that will remain on Site after the barrier is installed.

Unfortunately, approximately 130,000 pounds of contaminants are currently present within the AOC on the Lilyblad property (Refer to Table 1.3). A significant portion (approximately 50 percent) of the AOC falls outside the boundary of the barrier wall proposed by Alternative 1. The secondary sources of contaminants at these locations outside the barrier will not be treated by Alternative 1. This large 'source term' is expected to supply contaminants to the groundwater for an extended period of time. This time frame is expected to be longer than 100 years. For practical purposes, this restoration time frame suggests that treatment of groundwater on the Site would need to continue indefinitely.

Approximately 1.3 million gallons of groundwater reside in the Site groundwater AOC outside of the barrier proposed by Alternative 1. It is estimated that approximately 60 percent of the groundwater in the AOC will continue to flow toward the Blair Waterway when the barrier is installed. This groundwater is expected to take more than 50 years to reach the Blair Waterway, although short-circuiting by surface drainages could reduce the time for groundwater COCs to reach the waterway. It is likely that natural attenuation will reduce the concentration of COCs in this groundwater, but it is not possible to determine the amount time it would take to reduce concentrations to CULs.

3.3.2 Evaluation of Alternative 1

Alternative 1 is evaluated using the criteria defined in Section 3.1. A summary of this evaluation is provided in Table 3.1

Overall Protection of Human Health and the Environment

Alternative 1 does not directly reduce the quantity, volume, or toxicity of COCs in soil inside or outside of the barrier. Residual contamination will remain in the upper sand and aquitard units.

Alternative 1 does prevent the horizontal flow of groundwater in the upper sand aquifer from exiting the footprint of the barrier. Elevated concentrations of COCs will remain in groundwater both inside and outside the barrier. Alternative 1 provides increased protection beyond the protection provided by Alternative 4—Hydraulic Control and Monitoring, since a physical barrier is placed around the Lilyblad property to prevent COCs in groundwater from exiting the property.

Alternative 1 does not use active measures to treat the approximately 160,000 pounds of contaminants contained within the soil AOC at the Site. It does directly treat the groundwater that is extracted from the Lilyblad property to maintain hydraulic control. It is likely that natural attenuation of COCs in groundwater within the barrier will occur but at a very slow rate. This attenuation will be counter-balanced by the addition of COCs that will enter the groundwater as a result of the soil contamination that will still be present. The rate of natural attenuation of COCs together with the active treatment of extracted groundwater is not expected to achieve CULs for groundwater within the barrier for a very long period of time.

It is estimated that approximately 60 percent of the groundwater within the AOC will continue to flow toward the Blair Waterway when the barrier is installed. This groundwater is expected to take more than 50 years to reach the Blair Waterway if short-circuiting does not occur. It is likely that natural attenuation will reduce the concentration of COCs in this groundwater, but it is not possible to determine the amount of time it would take to reduce concentrations to CULs.

Alternative 1 provides a lesser degree of long-term effectiveness than Alternative 2, which actively destroys COCs in soil and groundwater, and Alternative 3, which excavates and disposes of COCs in soils in an off-site engineered, lined, and monitored Subtitle D landfill facility.

Comply with Cleanup Standards and Applicable State and Federal Laws

Ecology has developed CULs for soil and groundwater at the Site. Alternative 1 does not actively address the COCs in soil at the Site, so soil COC concentrations will exceed CULs throughout the Site.

Alternative 1 will prevent COCs in groundwater within the barrier footprint from reaching the Blair Waterway. About 60 percent of the groundwater within the groundwater AOC falls outside of the barrier proposed by Alternative 1. This groundwater is expected to take more than 50 years to reach the Blair Waterway, although short-circuiting by surface drainages could reduce the time for groundwater COCs to reach the waterway. It is likely that natural attenuation will reduce the concentration of COCs in this groundwater, but it is not possible to determine the amount of time it would take to reduce the concentrations of COCs to CULs.

Permanence

Alternative 1 does not actively treat soils within the soil AOC at the Site. Alternative 1 treats only a small portion of the contaminants present within the groundwater that is extracted from within the barrier. The contaminants are removed from groundwater by activated carbon. Thus, the COCs are not destroyed on Site. The spent carbon is regenerated off the Site by others. Alternative 1 provides significantly less permanence than Alternative 2, which actively treats the soil and groundwater within the AOC, or Alternative 3, which removes and disposes of soil within the Lilyblad property.

Since Variation A places a barrier around the perimeter of the Lilyblad property it is judged to provide a more permanent solution than the discontinuous barrier provided by Variation B.

Cost

A cost estimate and supporting assumptions for this alternative are presented in Appendix A.1. The conceptual-level (±25 percent.) cost estimate for a continuous barrier (Variation A) around the Lilyblad property is $3.1 million for a slurry wall barrier and $ 3.3 million for a steel sheet pile barrier.

The conceptual-level (±25 percent.) cost estimate for a discontinuous barrier around the Lilyblad property (Variation B) is $3.3 million for a slurry wall barrier and $3.4 million for a steel sheet pile barrier.

It should be noted that these cost estimates assume 20 years of groundwater treatment and compliance monitoring. As discussed below, the restoration timeframe for Alternative 1 is expected to exceed 20 years. Estimated costs for Alternative 1 variations will increase significantly if more than 20 years of groundwater treatment and compliance monitoring is required.

Effectiveness over the Long Term

The technologies employed by Alternative 1 have been successfully demonstrated at this scale at many locations. It is judged to be very likely that the continuous barrier (Variation A) would be effective in containing groundwater within its perimeter. Variation B (discontinuous barrier) is also expected to be effective in containing groundwater on the Lilyblad property.

Alternative 1 does not actively address the COCs in soils within the Lilyblad property or in soils within the AOC that fall outside of the barrier perimeter. These soils will continue to pose potential risks to human health and the environment. Alternative 1 does contain groundwater within the barrier. However, groundwater will continue to flow toward the Blair Waterway. This groundwater will continue to pose potential risks to human health and the environment. The existing institutional controls that are currently protecting site workers (e.g., asphalt pavement, building foundations) are expected to continue to be effective in mitigating the risks posed by the soils and groundwater within the AOC to site workers and visitors to the Site.

Alternative 1 provides a lesser degree of long-term effectiveness than Alternative 2 that actively destroys COCs in soil and groundwater, and Alternative 3, which excavates and disposes (off-site) of COCs in soils in an engineered, lined, and monitored Subtitle D landfill facility

Management of Short-Term Risks

Short-term risks to human health and the environment will occur if Alternative 1 is selected. There are many buried utility lines on the Lilyblad property. The installation of a barrier wall in the vicinity of these buried lines will expose site workers to the risks inherent in this activity. These risks can be mitigated by developing detailed work plans that will identify the location of known utility lines. The work plan can also identify contingency procedures that will be used to incrementally install the barrier in a way that anticipates that some buried utilities may not have been identified on site drawings or detected when underground utility lines were located by geophysical means. A health and safety plan would be developed to address these risks, and the risks associated with working in an area where COCs are known to be present at levels above CULs in soil and groundwater.

Active institutional controls and a personnel monitoring program will provide additional protection to site workers and the public who visit the Site.

Alternative 1 has more potential short-term risks to human health and the environment than does Alternative 4—Hydraulic Control and Monitoring. The installation of a barrier wall is judged to have less potential for short-term risks than the operation of a generic treatment system for a period of several years (Alternative 2), or the demolition of buildings and excavation of soil (Alternative 3) on the Lilyblad property.

Technical and Administrative Implementability

Slurry wall and sheet pile barrier walls are well developed technologies that could be implemented with a high degree of confidence for this alternative. The Lilyblad property is located in an industrial area. Access to services, materials, supplies, and skilled labor would be possible. Access for construction operations and monitoring would also be possible.

Installation of the barrier wall would be staged to limit interruption of the operations of Lilyblad and adjacent facilities to the minimal extent practicable. Some business interruptions are likely to occur.

Approximately 1.3 million gallons of groundwater reside in the portion of the groundwater AOC that will be outside of the barrier proposed by Alternative 1. It is estimated that approximately 60 percent of this groundwater will continue to flow toward the Blair Waterway when the barrier is installed. This groundwater is expected to take more than 50 years to reach the Blair Waterway, although short-circuiting by surface drainages could reduce the time for COCs to reach the waterway. It is likely that natural attenuation will reduce the concentration of COCs in this groundwater, but it is not possible to determine the amount of time it would take to reduce concentrations to CULs.

It will be difficult to isolate the contribution of Lilyblad property COC concentrations to the concentrations of COCs that are present at the point where the storm drains below the Port of Tacoma Road and the Lincoln Avenue Ditch, and ultimately reaches the Blair Waterway. Thus it may not be possible (based upon existing information) to isolate the contribution of the COCs present in the groundwater emanating from the Site to the overall risk to human health and the environment posed by the total COC load that will be present when groundwater from the Site eventually reaches the Blair Waterway.

Restoration Time Frame

Alternative 1 does not directly reduce the toxicity, mobility, or volume of the COCs contained in soil on the Site. This large 'source term' is expected to supply contaminants to the groundwater for an extended period of time. This time frame is expected to be longer than 100 years. The groundwater treatment system will continue to operate during this period. It is likely that the concentration of COCs in the soil AOC or in groundwater below the Lilyblad property will exceed CULs established by Ecology for this Site for more than 20 years after the barrier is installed.

Approximately 1 million gallons of groundwater reside in the groundwater AOC that will be outside of the barrier proposed by Alternative 1 (refer to Section 2.1.1). It is estimated that approximately 60 percent of this groundwater will continue to flow toward the Blair Waterway when the barrier is installed. This groundwater is expected to take more than 50 years to reach the Blair Waterway, although short-circuiting by surface drainages could reduce the time for groundwater COCs to reach the waterway. It is likely that natural attenuation will reduce the concentration of COCs in this groundwater, but it is not possible to determine the amount of time it would take to reduce groundwater concentrations to CULs.

3.4 Alternative 2—In Situ Treatment with and without Natural Attenuation

This alternative consists of installation and operation of a generic soil and groundwater treatment system consisting of soil vapor extraction, biodegradation using nutrients and chemical injections, and chemical oxidation.

This system was described in detail in Section 2.2.1 and depicted on Figure 2-3. Extracted groundwater and soil vapor will be treated by the treatment system described in Section 2.1.3 and depicted on Figure 2-2.

The groundwater treatment system will continue to discharge to the catch basin that connects to the storm drain located below the Port of Tacoma Road. The approximate location of this stormwater line is shown on CH2M Hill RI, Figure 3.1. The COCs in groundwater exiting the Lilyblad Site will be monitored as outlined in the Monitoring Plan for the Site (Terra Vac 2006b) and as described in Section 3.6. The Monitoring Plan will be tailored to the expected outcome of each variation of Alternative 2. For Variations B and C, where COCs will remain in groundwater after treatment, annual samples will be obtained at 11 monitoring wells during each year of treatment, and each year thereafter through Year 20. Compliance monitoring for the COCs remaining at concentrations above CULs in soil will be conducted at the completion treatment, and during Years 5, 10, 15, and 20 after treatment is concluded.

For Variation A, where treatment is expected to reduce the concentration of COCs in soil and groundwater to CULs, annual compliance groundwater samples will be collected during each year that treatment is underway. At the completion of treatment (6 years), one year of quarterly sampling and analysis will be conducted to demonstrate that treatment has continued to reduce the concentration of COCs to CULs. Compliance monitoring for the COCs in soil will be conducted at the completion of treatment and once again one year after the completion of treatment.

Performance monitoring of the groundwater treatment system will occur each day that the system is operational to assure that it is operating properly. The effluent from the system will be analyzed once per month for the compounds listed in the NPDES-like permit that Ecology has established for the Lilyblad property (Ecology 2000). The performance monitoring proposed for the treatment train is outlined in Terra Vac (2005a).

Three variations of this alternative are considered: 1) Variation A, operate the generic system until soil CULs are achieved in the soil AOC to a depth of 15 feet and groundwater CULs are met at the point at which groundwater below the Site reaches the Blair Waterway; 2) Variation B, operate the generic system to reduce the concentration of TPH components (gas, diesel, other) in soil to MTCA Method B CULs, substantially reduce the concentration of VOC COCs and utilize institutional controls and natural attenuation for other COCs thereafter; and 3) Variation C, containment of groundwater on the Lilyblad property and treatment of contaminants by the generic system on adjacent properties.

3.4.1 Performance of the Terra Vac System

Terra Vac has been performing pilot-scale tests and interim remedial measures at the Site using elements of a DVE, biodegradation, and chemical oxidation system singly and in combination since September 2003. The system Terra Vac utilized is described in the Site Wide Remedial Action Design Plan that was issued on August 3, 2005 (Terra Vac 2005a). Terra Vac has operated its treatment system in six areas within the Lilyblad and PW Eagle properties. On the Lilyblad property, Terra Vac operated the treatment system in the Pilot Test, LNAPL, Dissolved Plume, and Hot Spot areas (refer to Figure 1-3). On the PW Eagle property, the MPE area and a portion of the PW Eagle manufacturing building footprint were addressed by Terra Vac.

Mass of Contaminants Removed by Terra Vac

Terra Vac measured the concentration of VOCs, carbon dioxide, and methane in soil vapor as its system was operating. Terra Vac used the VOC readings to calculate the pounds of hydrocarbons removed by volatilization, the carbon dioxide readings to calculate the pounds of hydrocarbons removed by biological activity or oxidation, and methane readings to calculate the pounds of hydrocarbons removed as methane or other light hydrocarbons. The calculation approach used by Terra Vac is summarized in Table 3.2. The basis of the calculation approach is contained in Table 3.2 as well. This calculation approach does not 1) distinguish among individual COCs; 2) identify the actual physical or chemical process that produced the soil vapor; 3) consider the COC loading that exits the process through groundwater; nor 4) is it based upon the analysis of actual soil and groundwater samples. The soil vapor flow rates used to calculate the mass load were one-time readings taken near the conclusion of a run and do not represent an average or mean flow rate value during the run. Nonetheless, Terra Vac feels this approach to be a reasonable indicator (±25 percent) of the overall performance of its system at other sites that are similar to the Lilyblad Site (Malot 2006a).

The results of the calculations outlined in Table 3.2 are summarized in Table 3.3. The total operating time in each area is also presented in Table 3.3. Terra Vac estimates that they have removed approximately 80,000 pounds of hydrocarbons from the Site since work began in September 2003 (Terra Vac 2006c). This compares to the estimate summarized in Tables 1.2 and 1.3 that approximately 40,000 pounds of contaminants were removed (nearly all TPH compounds). Both estimates were based upon a set of imperfect assumptions. Nonetheless, it is clear that a significant quantity of TPH COCs were removed by the Terra Vac process.

Post-Remediation Soil and Groundwater Concentrations in Soil and Groundwater

Samples of soil and groundwater were obtained during December 2005 in areas where Terra Vac had conducted operations. A Work Plan for this sampling and analysis event was prepared by Terra Vac and approved by Ecology (Terra Vac 2005b). The sample analytical results were summarized by Terra Vac in a report dated January 9, 2006 (Terra Vac 2006a). The sampling and analysis program was designed to assess the performance of the Terra Vac process. It was not designed to collect information that could be used to determine whether an area treated by Terra Vac was 'clean.' The program collected samples from two to four locations within the areas where Terra Vac operated its treatment system. This sample location density (one sample per 1,200 to 3,000 square feet of surface area) was sufficient to obtain an indicator of performance but not sufficient to certify performance.

The results summarized in Table 6 of Terra Vac (2006a) indicate that the concentration of TPH and BTEX COCs in soil were significantly reduced in the areas where Terra Vac had operated the DVE/Bioremediation/oxidation treatment train. Similar reductions in the concentrations of TPH and BTEX COCs were reported for groundwater samples collected in the same areas.

Post-remediation concentrations of TPH-D, toluene, ethylbenzene, and xylene in soil were below CULs for the soil samples that were analyzed by Terra Vac (2006a, Table 4). The measured concentrations of TPH-G and dichlorobenzene in soil were also below CULs in the LNAPL and in most of the MPE treatment areas.

Post-remediation groundwater analytical results showed that the concentrations of TPH-G and TPH-D were reduced to below CULs in about half of the areas that were treated. Benzene and/or dichlorobenzene were present at concentrations above CULs in most areas that were treated. Again the areas that appeared to receive the most effective treatment were the LNAPL and most of the MPE treatment areas. These areas received the longest period of treatment by the Terra Vac process.

Terra Vac's Estimate of the Time Needed to Complete Remediation of the Site

Terra Vac used the contaminant removal data summarized in Terra Vac (2006a) to estimate the time that would be needed to complete the remediation of soil and groundwater at the Site. The pre-remediation COC concentration data in the area treated were compared to the post-remediation data collected in the area to calculate the removal efficiency for selected COCs in the area.

The following equation was used to calculate a reaction coefficient that represented the removal efficiency achieved and the treatment system operating time needed to achieve the removal efficiency

$$C = C_o e^{-t/k} \qquad (3 - 1)$$

Where:

C = final concentration in mg/kg or ug/L;
C_o = Initial concentration in mg/kg or ug/L;
t = time in days; and
k = reaction coefficient.

Terra Vac compiled the removal efficiency data (the C and the C_o) contained in Terra Vac (2006a) for each area of the Site that was treated. These data along with the cumulative treatment time in each area were plugged into Equation (3-1) to calculate a reaction coefficient for that area. The results of this calculation are summarized in Table 3.4. Terra Vac estimates that it would take approximately 2 to 3 years of enhanced biodegradation to reduce the concentration of TPH COCs to CULs in most areas of the Site. Once the TPH COCs were reduced to CULs, oxidation (9 to 12 months) would be used to treat VOCs and SVOCs in soil. Once the concentrations of VOCs and SVOCs in soil were reduced to CULs, continued oxidation (3 months) would reduce COC concentrations in the remaining groundwater at the site to CULs.

Equation (1) forces the pre- and post remediation data into its format. Equation (1) does not depend on the stoichiometry of chemical reactions that may be occurring as COCs are oxidized, or biodegraded, nor does it represent the specific physical or chemical processes that may be responsible for the removal of COCs that occurs. Nonetheless, Terra Vac feels the equation is useful in providing an indication of the time that will be needed to reach CULs in a given soil and groundwater media (Malot 2006a).

The reaction coefficients derived from Site data and listed in Table 3.4 were used to calculate the estimated time needed to reduce the concentration of TPH, VOC, and SVOC COCs in soil and groundwater to CULs at the Site. These estimated time frames were combined with the anticipated use of four separate treatment trains at the Site to prepare an estimate of the sequence of treatment that would be required at the Site to reach CULs. This treatment sequence is summarized in Table 3.5. Terra Vac estimates that a four-treatment train approach would need to operate for about 73 months to remediate the Site.

The approach used by Terra Vac to develop its proposed treatment sequence was evaluated. This evaluation addressed three questions: 1) Were the results obtained by Terra Vac during demonstration tests representative of results that could be expected during full-scale operations at the Site?, 2) Was a conservative design approach used to predict full-scale performance?, and 3) Did the design approach accurately predict the performance that was actually observed at the Site?

The demonstration work conducted by Terra Vac used DVE well spacings that varied from about 20 feet to about 40 feet (Malot 2006c). The full-scale design proposed by Terra Vac uses an approximately 40-foot spacing between DVE wells and a design capacity of 15 SCFM per well. Terra Vac was able to exceed this design flow rate with a DVE well spacing of 40 feet during its demonstration testing in the LNAPL and Dissolved Plume areas of the Site. A 40-foot spacing was not attempted in other areas of the Site.

TPH is the predominant COC at the Site. The biodegradation of this COC is more dependent on the quantity of oxygen provided by the injection well system, and by the hydraulics of the nutrient injection system than by the DVE design flow rate (as long as the DVE wells can remove degradation products as they are produced).

The reaction coefficients listed in Table 3-4 were used by Terra Vac to predict the performance of the full-scale system. These coefficients were derived from the results obtained during demonstration tests. The average value and the standard deviation of the reaction coefficient in an area of the Site were determined. Two standard deviations increments were added to the average value to develop the reaction coefficients listed in Table 3-4.

The results of sampling conducted in December 2005 were compared to the results predicted by the reaction coefficients listed in Table 3-4 (Terra Vac 2006a). The measured concentrations of TPH-D were below the concentrations predicted using a reaction coefficient of 193 days (Table 3-4). Similarly, the measured concentrations of 1,4 dichlorobenzene (using a k of 186 days) and tetrachloroethene (using a k of 199 days) were significantly below the concentrations predicted by Equation 3-1.

The approach used by Terra Vac to develop its proposed treatment system was judged to be reasonable since it was derived using site-specific results obtained in a way that is similar to the way in which the full-scale system would be utilized. Moreover, the predictive model (Equation 3-1) developed using these site-specific results yielded conservative estimates of system performance. This approach was used to develop the expected performance of the generic system that is described in Section 3.4.2.

3.4.2 Expected Performance of the Generic System

The performance of the Terra Vac treatment train at the Site indicates that the generic treatment train can significantly reduce the concentration of the TPH, SVOCs and VOCs at the Site. The results reported by Terra Vac indicate that concentrations of TPH-D, toluene, ethylbenzene, and xylenes in soil can be reduced to CULs if the treatment train (DVE and biodegradation) is allowed to operate for a sufficient period of time.

The results reported for TPH-G and for benzene also suggest (though less strongly than for TPH-D) that the concentration of these compounds in soil could also be reduced to CULs if the treatment train (DVE and bioremediation) were allowed to operate for a sufficient period of time. If benzene is a reasonable surrogate for other VOC COCs in soil, the operation of the treatment train (for a sufficient period of time) can be expected to reduce the concentration of VOC COCs to the CULs established by Ecology.

Oxidation will be required to reduce the concentration of SVOC COCs in soil. Oxidation was used for 2 months (December 2004 to January 2005) in the MPE area, for 5 months in the dissolved plume area (December 2003 to April 2004), and for 1 month in the LNAPL and Hot spot areas of the Lilyblad property. The analysis of soil samples collected in December 2005 did not include analyses for pentachlorophenol or other SVOCs. Direct analytical data that support the assertion that SVOCs could be removed from Site soils by oxidation was not available as this FFS was prepared..

Post-remediation groundwater analytical results showed that the concentration of TPH-G and TPH-D was reduced to below CULs about half the time in the areas that were treated. Benzene and/or dichlorobenzene concentrations were present above CULs in most areas that were treated. Again the areas that appeared to receive the most effective treatment were the LNAPL and most of the MPE treatment areas. The treatment train (DVE, bioremediation, limited oxidation) operated in these areas for an extended period of time. Additional oxidation may have further reduced the concentration of VOC COCs that are present in groundwater. A reduction of the concentration of VOC COCs in groundwater to CULs appears likely if oxidation begins after bioremediation had reduced the concentration of soil COCs to CULs.

Variation A – Operate the Generic System until Soil and Groundwater CULs are Met

The best available description of the operation of the generic treatment train to meet soil and groundwater CULs was prepared by Terra Vac and is summarized in Table 3.5. This estimate envisions three treatment trains operating on the Lilyblad property, and one treatment train operating in the MPE and PW Eagle area. DVE would be active for a 1-month period to achieve hydraulic control of the site. Bioremediation would follow for a total of 59 months. Oxidation of soil and groundwater would follow bioremediation, for a total of 13 months. The total duration of Variation A is approximately 73 months or 6 years.

The operation of the generic system for approximately 6 years is expected to reduce the concentration of TPH COCs in soil to CULs based on the post-treatment analytical results obtained in December 2005. While the December 2005 results were less conclusive regarding the effectiveness of treatment for VOCs, the longer operating time envisioned going forward (32 months of bioremediation followed by 9 to 13 months of oxidation in previously untreated areas versus the 9 to 22 month operating period for the MPE, Hot Spot, and LNAPL Interim Measures) should be sufficient to reduce the concentration of VOC COCs to CULs. The 9- to 13-month duration of the oxidation step should be sufficient to reduce the concentration of SVOC COCs to CULs, once the TPH concentrations have been reduced to CULs by bioremediation.

Alternative 2, Variation A uses active remediation to destroy and/or remove COCs from the entire soil AOC and from the entire groundwater AOC. Variation A is expected to destroy and/or remove approximately 160,000 pounds of COCs from the soil AOC (refer to Table 2.3), and reduce the concentration of groundwater COCs to CULs.

Once active remediation has been completed, the expected concentration of COCs in soil and groundwater would be expected to remain at concentrations below CULs into the future.

Variation B – Operate the Generic System until CULs for TPH Compounds are Met, the Concentration of VOC COCs is Substantially Reduced, and Use Institutional Controls and Natural Attenuation for the Other COCs Thereafter

A description of the operation of the generic treatment train to meet soil and groundwater CULs was prepared by Terra Vac and is summarized in Table 3.5. This estimate envisions three treatment trains operating on the Lilyblad property, and one treatment train operating in the MPE and PW Eagle area. DVE would be active for a 1-month period to achieve hydraulic control of the Site. Bioremediation would follow for a total of 59 months. As with Variation A, this period of bioremediation is considered sufficient for the concentration of TPH COCs in soil to be reduced to CULs based on the port-treatment analytical results obtained in December 2005, and to significantly reduce the concentration of VOC COCs.

The absence of the oxidation treatment step in Variation B will likely result in the presence of VOC and SVOC COCs in soil and groundwater at concentrations above CULs. These COCs would be allowed to naturally attenuate. As discussed in Section 3.2, the available data are not sufficient to calculate the expected degree of natural attenuation of groundwater or soil that would be expected to occur 5, 10, or 15 years after the operation of the DVE and bioremediation treatment train concluded.

Alternative 2, Variation B uses active remediation to destroy and/or remove TPH COCs from the entire soil AOC and from the entire groundwater AOC. Variation B is expected to destroy and/or remove approximately 160,000 pounds of TPH COCs from the soil AOC, but leave a small portion of the 3,500 pounds of VOC COCs and 200 pounds of SVOC COCs (refer to Table 2.3) in the soil AOC. The concentration of VOC and SVOC COCs in groundwater are not expected to be reduced to CULs by Alternative 2, Variation B, since the oxidation treatment step is not employed.

Variation C - Containment of Groundwater on the Lilyblad Property and Use of the Generic System on Adjacent Properties

Approximately 80 percent of the COCs in the soil AOC and 50 percent of the contaminated groundwater in the groundwater AOC is located within the Lilyblad property. Variation C calls for the containment of this soil and groundwater as discussed in Sections 2.1 and 3.3, and the use of the generic system in areas outside of the barrier shown on Figure 2-1A. The areas outside the Lilyblad property include the MPE and PW Eagle areas, the Nelson property, and some property under the Port of Tacoma Road (refer to Table 1.3 and Figures 1-2 and 1-4). The generic treatment train will be used to treat soil and groundwater in these areas.

Two treatment trains (DVE, bioremediation and oxidation) would be used for this alternative. One treatment train would operate in the MPE and PW Eagle areas, the other treatment train would operate on the Nelson property and on the property below the Port of Tacoma Road. The DVE extraction wells, injection wells, and other equipment will be placed in the same locations on adjacent properties as is envisioned for Variation A of Alternative 2. The treatment trains are expected to operate in a bioremediation mode for a period of approximately 20 months and in an oxidation mode for a period of 12 months. Alternative 2, Variation C uses active remediation to destroy and/or remove TPH, VOC, and SVOC COCs from the portion of the soil and groundwater AOCs that are outside of the barrier wall located on the Lilyblad property. Variation C is expected to destroy and/or remove approximately 30,000 pounds of TPH COCs, 280 pounds of VOC COCs, and 18 pounds of SVOC COCs (refer to Table 1.3) in the soil AOC. The concentration of VOC and SVOC COCs in groundwater outside the barrier are expected to be reduced to CULs.

Alternative 2, Variation C leaves behind approximately 130,000 pounds of TPH COCs, 3,100 pounds of VOC COCs, and 180 pounds of SVOC COCs that are present within the barrier wall on the Lilyblad property.

3.4.3 Evaluation of Alternative 2

Alternative 2 is evaluated using the criteria defined in Section 3.1. A summary of the evaluation of Alternative 2, Variations A, B, and C is provided in Table 3.6.

Overall Protection of Human Health and the Environment

Alternative 2 directly reduces the quantity, toxicity, and volume of contaminants in soil and groundwater on the Site. Alternative 2 directly treats and/or removes COCs from soil (approximate values):

Variation	TPH COCs	VOC COCs	SVOC COCs
A	160,000 lb	3,500 lb	200 lb
B	160,000 lb	<3500 lb	<<200 lb
C	30,000 lb	300 lb	<20 lb

Alternative 2 also directly treats groundwater within the groundwater AOC. The percent of the groundwater within the groundwater AOC that is directly treated by each variation of Alternative 2 is summarized below:

Variation	Percent of AOC Treated
A	100
B	100
C	60

Variations A and B of Alternative 2 provide increased protection to human health and the environment relative to Alternatives 1, 3, or 4, since substantial destruction of COCs in soil and groundwater occurs as the generic treatment system is used at the Site. This benefit to human health and the environment occurs within a relatively short (compared to Alternatives, 1, 3, or 4) 3- to 6-year time frame.

This evaluation assumes that the implementation of Alternative 2, Variation A will reduce the concentration of COCs in soil and groundwater to below CULs. Alternative 2, Variation B is expected to reduce the concentration of TPH COCs in soil and groundwater to below CULs and to substantially reduce the concentration of VOC COCs. The concentrations of SVOC COCs in soil and groundwater are expected to be only slightly reduced since oxidation is not employed by Variation B.

Alternative 2, Variation C actively treats soils and groundwater outside of the barrier (and within the soil and groundwater AOCs) installed by Alternative 1. The concentration of COCs in soil and groundwater in these areas after treatment is expected to be below CULs. The groundwater within the barrier will be contained. The groundwater extracted to maintain hydraulic control would be treated. The soil inside the barrier will not receive any treatment. Thus Alternative 2, Variation C, will not meet the CULs established for soil within the barrier. Nonetheless, Alternative 2, Variation C, is judged to be protective of human health and the environment.

After treatment, it is likely that natural attenuation of groundwater will occur. The information needed (refer to Section 3.2) to assess the likely degree of natural attenuation that would occur at the Site is not currently available.

Comply with Cleanup Standards and Applicable State and Federal Laws

This evaluation assumes that the implementation of Alternative 2, Variation A will reduce the concentration of COCs in soil and groundwater to below CULs. Alternative 2, Variation B is likely to reduce the concentration of TPH COCs in soil and groundwater to below CULs and to substantially reduce the concentration of VOC COCs. The concentrations of SVOC COCs in soil and groundwater are expected to be only slightly reduced since oxidation is not employed by Variation B. Thus it is likely that Variation B will achieve CULs for TPH and VOC COCs, and is unlikely to achieve CULs for SVOC COCs.

Alternative 2, Variation C actively treats soils and groundwater outside of the barrier (and within the soil and groundwater AOCs) installed by Alternative 1. The concentration of soil and groundwater COCs after treatment in these areas should be below CULs. Groundwater within the barrier will be contained but not treated. The groundwater extracted to maintain hydraulic control would be treated. Soil inside the barrier will not receive any treatment. Thus CULs established for soil will not be met within the barrier by Alternative 2, Variation C.

After treatment (Variations B or C), it is likely that natural attenuation of groundwater will occur. The information needed to assess the likely degree of natural attenuation that would occur at the Site over time is not currently available.

Permanence

Alternative 2 directly reduces the quantity, toxicity, and volume of COCs in the soil and groundwater, substantially reducing toxicity at the Site. Alternative 2 directly treats and/or removes COCs from soil (approximate values):

Variation	TPH COCs	VOC COCs	SVOC COCs
A	160,000 lb	3500 lb	200 lb
B	160,000 lb	<3500 lb	<200 lb
C	30,000 lb	300 lb	<20 lb

Alternative 2 also directly treats groundwater within the groundwater AOC. The percent of the groundwater within the groundwater AOC that is directly treated by each variation of Alternative 2 is summarized below:

Variation	Percent of AOC Treated
A	100
B	100
C	60

Variations A and B of Alternative 2 provide increased protection to human health and the environment and are more permanent than Alternatives 1, 3, or 4, since substantial destruction of COCs in soil and groundwater occurs as the generic treatment system is used at the Site.

During its 6-year operating period, Alternative 1, Variation A will extract groundwater and soil vapor that will require treatment. Extracted groundwater will be filtered and passed through activated carbon filters to remove COCs, and cooled if necessary to meet NPDES-like requirements prior to discharge. COCs vaporized from vadose zone soils, dewatered saturated zone soil, and groundwater will be collected via granular activated carbon adsorption. Spent activated carbon will be regenerated.

Soil vapor and groundwater extracted by Alternative 2, Variation B during its approximately 5-year period of operation, will also be treated by this groundwater and soil vapor treatment system. In addition, the soil vapor and groundwater treatment system will be used during the approximately 2 to 3 years that the generic treatment train would be used by Alternative 2, Variation C. Groundwater removed from inside of the barrier installed by Variation C would be extracted by pumps and treated by the groundwater treatment system.

Cost

The estimated conceptual-level cost (±25 percent) of each variation of Alternative 2 is presented in Appendix A.2 and summarized below:

Variation A	$4.9 million
Variation B	$4.4 million
Variation C	$5.0 million

Effectiveness over the Long Term

Alternative 2 would provide for a long-term reduction of contaminant concentrations by means of active remediation (all Variations) and the process of natural attenuation (Variations B and C). The technologies used are well understood and have been shown to be effective during the pilot-scale tests and Interim Measures that have been conducted at the Site. The DVE technology is the 'presumptive remedy' for VOCs present in soil and groundwater. *In situ* bioremediation has been shown to be effective in destroying TPH COCs at the Site. *In situ* oxidation has been shown to be effective in destroying SVOC COCs at other sites (EPA 1998).

The VOC COCs removed by the generic treatment train and the compounds produced by the bioremediation of TPH COCs and the oxidation of SVOC COCs and ultimately extracted by the generic system, will be treated by methods that have been shown to be effective during the Interim Measures conducted at the Site. The groundwater and soil vapor treatment system has been shown to be able to meet both NPDES-like and PSCAA discharge requirements.

This evaluation assumes that the implementation of Alternative 2, Variation A will reduce the concentration of COCs in soil and groundwater to below CULs at the conclusion of the 6-year period of operation of the generic treatment train. The small quantity of VOCs and SVOCs expected to remain in soil and groundwater after Alternative 2, Variation B is implemented will continue to naturally attenuate. The progress of natural attenuation will be monitored. The information needed to assess the likely degree of natural attenuation that would occur at the Site over time is not currently available (refer to Section 3.2).

Alternative 2, Variation C is expected to reduce the concentration of COCs to below CULs in a 2- to 3-year time frame in the area outside of the barrier. The concentration of COCs in the soil and groundwater within the barrier is expected to exceed CULs for an extended period of time. The risk to human health and the environment posed by these remaining COCs is low given the expected performance of the barrier, the presence of asphalt and concrete surfaces throughout the area within the barrier, and the enforcement of institutional controls on the Lilyblad property. The COCs that will remain in soil and groundwater within the barrier after Alternative 2, Variation C is implemented will continue to naturally attenuate. The progress of natural attenuation will be monitored. The information needed to assess the likely degree of natural attenuation that would occur at the Site over time is not currently available.

Variations A and B of Alternative 2 provide greater long-term effectiveness than Alternatives 1, 3, or 4, since substantial destruction of COCs in soil and groundwater occurs as the generic treatment system is used at the Site. This benefit to human health and the environment occurs within a relatively short (compared to Alternatives, 1, 3, or 4) 3- to 6-year time frame.

Management of Short-Term Risks

Short-term risks to human health and the environment would occur if Alternative 2 were implemented. These short-term risks will be present during installation and operation of the generic treatment train and its ancillary equipment. The installation of a barrier wall for Variation C will expose site workers to additional risks related to the presence of buried utility lines. Detailed work plans would be developed to identify potential implementation issues, and identify procedures that would be used to resolve these issues. Health and Safely plans would be prepared to address risks associated with working in an area where COCs are known to be present at concentrations above CULs in soil and groundwater.

Active institutional controls and a worker monitoring program will provide additional protection to site workers and the public who may visit the Site.

The variations of Alternative 2 are judged to have more potential short-term risks to human health and the environment than Alternative 1 and Alternative 4, due to the extended period of time that Alternative 2 will be in operation (Variations A and B), and/or the implementation of two remediation technologies (Variation C).

Technical and Administrative Implementability

The generic treatment train has been successfully demonstrated during pilot-scale and Interim Measure operations at the Site. These operations have been conducted with full-scale equipment. The system has been shown to be implementable. The installation and operation of the generic treatment system will be done in a way that minimizes disruptions to the operations on the Lilyblad and PW Eagle properties. It is anticipated that the site-wide generic treatment system can be installed within 6 months.

Slurry wall and sheet pile barriers are well developed technologies that could be implemented with a high degree of confidence by Variation C of Alternative 2. Installation of the barrier would be staged to avoid interruptions to the operations of Lilyblad and adjacent facilities to the maximum practicable extent.

Additional site characterization and modeling would be needed to predict the rate of natural attenuation to more accurately predict future concentrations in soil and groundwater of COCs that may be left behind by Alternative 2, Variations B and C.

Groundwater at the Site travels northeasterly from a hydraulic mound toward the storm sewer line imbedded in the Port of Tacoma Road, and southwesterly toward a sewer line on the Saul property, and eventually discharges to the Lincoln Avenue Ditch and ultimately into the Blair Waterway (refer to CH2M Hill SRI, Figure 3-7). In both instances the groundwater exiting the Lilyblad property likely intermixes with groundwater that may have been contaminated by off-site properties and operating practices before it reaches the Blair Waterway. It will be difficult to isolate the contribution of Lilyblad property COC concentrations from other sources in this highly industrial area.

Restoration Time Frame

This evaluation assumes that the implementation of Alternative 2, Variation A will reduce the concentration of COCs in soil and groundwater to below CULs by the conclusion of the approximately 6-year period of operation of the generic treatment system.

Alternative 2, Variation B is expected to reduce the concentration of TPH COCs in soil and groundwater to below CULs and to substantially reduce the concentration of VOV COCs by the conclusion of its approximately 5-year period of operation. Concentrations of SVOC COCs in soil and groundwater are expected to be only slightly reduced since oxidation is not considered by Variation B. Thus it is likely that Variation B will achieve CULs for TPH and VOV

COCs and is unlikely to achieve CULs for SVOC COCs at the conclusion of its period of operation.

The VOCs and SVOCs that are likely to be present in soil and groundwater at the conclusion of Alternative 2, Variation B's period of operation are expected to naturally attenuate. Additional site characterization and modeling would be needed to predict the rate of natural attenuation to more accurately predict future COC concentrations in soil and groundwater that may be left behind by Alternative 2, Variations B and C.

Alternative 2, Variation C, actively treats soils and groundwater outside of the barrier (and within the soil and groundwater AOCs) installed for this variation. Concentrations of soil and groundwater COCs in these areas after treatment are expected to be below CULs at the conclusion of its 2 to 3 years of operation. Groundwater within the barrier will be contained. The groundwater extracted to maintain hydraulic control would be treated. Soil inside the barrier will not receive any treatment. Thus Alternative 2, Variation C, will not meet the CULs established for soil within the barrier.

3.5 Alternative 3—Excavation and Disposal of Contaminated Soils

Alternative 3 consists of the excavation and removal of contaminated soils from the Lilyblad property. The intent of this alternative is to remove the source of TPH, VOC, and SVOC contamination in soils on the Lilyblad property from the surface down to the aquitard approximately 12 feet below ground surface. Section 2.3 described Alternative 3 in greater detail.

Two variations of this alternative were considered: 1) Variation A, Excavation of soil above cleanup levels on the Lilyblad property, and 2) Variation B, Excavation of soil on the most contaminated parts of the Lilyblad property and natural attenuation of contaminants thereafter.

Both variations of this alternative would have to overcome several technical issues including the dewatering of saturated soils prior to excavation, the active industrial nature of the Site, and the presence of numerous structures and buried utilities within the footprint of the excavation.

To access the soil on the Lilyblad property with COCs above CULs, Variation A of Alternative 3 would require demolition of the structures on the property and the likely closure of the businesses operating on the property. Based on the history and use of the Site, structures requiring demolition will require extensive evaluation for hazardous building materials followed by cleaning and/or abatement prior to demolition. Dewatering of the saturated soils will be required during excavation. Following excavation, the Site will be backfilled with clean structural fill and regraded. This fill material may be re-contaminated as untreated groundwater within the AOC continues to flow below the Lilyblad property.

Alternative 3, Variation B provides for excavation and disposal of soil on the most contaminated parts of the Lilyblad property followed by natural attenuation of the residual soil and groundwater contamination. This variation of Alternative 3 would focus on areas that have not been treated by interim remedial actions, namely in the vicinity of the warehouse, near and below both tank farms, and the pump station area in the northwest corner of the Site (refer to Figure 2-4). It is assumed that the warehouse could remain intact but both tank farms and adjoining structures would require demolition. As with Variation A of Alternative 3, structures requiring demolition on this property will require extensive evaluation prior to demolition, followed by cleaning and/or abatement. Following excavation, the property will be backfilled with clean structural fill and regraded.

Groundwater extracted to dewater the soils during excavation will be treated to meet Ecology's NPDES-like discharge requirements. The groundwater treatment system will be based on the existing treatment system installed by CDM, with modifications as needed to meet the discharge requirements. This groundwater treatment system is shown on Figure 2-2 and is expected to treat approximately 500,000 gallons for Variation A and 300,000 gallons for Variation B as the excavation proceeds on the Lilyblad property.

The COCs in groundwater exiting the Site will be monitored as outlined in the Monitoring Plan for the Site (Terra Vac 2006b) and as described in Section 3.6. Quarterly samples will be obtained at 11 monitoring wells during Year 1 following the completion of excavation, semi-annual samples will be collected during Years 2 through 5, and annual samples will be obtained during Years 6 through 20. Compliance monitoring for the COCs in soil will be conducted at the completion of the installation of excavation and during Years 5, 10, 15, and 20.

3.5.1 Expected Performance of Alternative 3

Alternative 3 will directly reduce the quantity or volume of COCs in soil within the boundary of the Lilyblad property. This alternative does not destroy COCs nor does it prevent the subsequent horizontal flow of groundwater in the upper aquifer from exiting the footprint of the Lilyblad property or of the Site.

Variation A – Excavate All Soil within the Soil AOC on the Lilyblad Property

Alternative 3, Variation A provides for excavation and disposal of Lilyblad property soils within the AOC that are present at concentrations above CULs, from the surface down to the aquitard layer. The total volume of soil that could be excavated under Variation A of Alternative 3 is approximately 30,000 cubic yards. Based on estimates of post-interim measure COCs concentrations remaining on the Site (Table 1.3), approximately 134,000 pounds of contaminants would be removed from the Lilyblad property. TPH-related compounds account for the vast majority of the soil contaminants on the Lilyblad property. Variation A of Alternative 3 would remove approximately 130,000 pounds of TPH, 3,400 pounds of VOCs, and 200 pounds of SVOCs. This removal would represent 100 percent of the calculated mass of contamination on the Lilyblad property and 80 percent of the total mass of contamination in the soil AOC. In addition, an estimated 500,000 gallons of groundwater would be treated during remedial construction.

With the addition of clean fill to the Lilyblad property, it is assumed that Alternative 3, Variation A will completely remove the soil contaminant sources from within the excavation foot print. Remaining contamination in the groundwater flowing from the Lilyblad property would be expected to naturally attenuate, but it is not possible to determine the amount of time it would take to reduce COC concentrations to CULs.

Following remedial activities, approximately 35,000 pounds of TPH, VOC and SVOC contamination will remain in place outside the excavation on the Lilyblad property and on adjacent properties (refer to Table 1.3). Thus the source term will not be fully removed and the soils in these areas would continue to degrade Site groundwater. It is expected that natural attenuation of soil and groundwater COCs in these areas would occur. Further investigation and evaluation would need to be conducted to determine the natural attenuation timeframe for these remaining contaminants.

Variation B – Excavate the Most Contaminate Soils in the Soil AOC on the Lilyblad Property

Alternative 3, Variation B excavates approximately 16,700 cubic yards of soils. This variation would result in the removal of approximately 73,000 pounds of TPH, 1,900 pounds of VOCs, and 120 pounds of SVOCs. In addition, an estimated 300,000 gallons of groundwater would be treated during remedial activity. The total mass of contaminants removed would be approximately 75,000 pounds, or approximately 56 percent of the calculated mass of contamination on the Lilyblad property and 46 percent of the total mass of contamination from the AOC. This excavation will leave approximately 58,000 pounds of contamination in place on the Lilyblad property and 31,000 pounds of contamination in place on adjacent properties (refer to Table 1.3) within the soil AOC. Thus the source term will not be fully removed from Lilyblad or the adjoining properties by Alternative C, Variation B.

The remaining soil contamination would continue to contribute contaminants to groundwater flowing through these properties. Natural attenuation of these contaminants would be expected to occur. Further investigation and evaluation would be needed to determine the natural attenuation timeframe for the remaining contamination on Lilyblad property and on neighboring properties.

3.5.2 Evaluation of Alternative 3

Alternative 3 is evaluated using the criteria defined in Section 3.1. A summary of the evaluation of Alternative 3, Variations A and B is provided in Table 3.7.

Overall Protection of Human Health and the Environment

Alternative 3 directly reduces the quantity of contaminants in the soil on the Site as noted below (approximate values):

Variation	TPH COCs	VOC COCs	SVOC COCs
A	130,000 lb	3,400 lb	200 lb
B	73,000 lb	1,900 lb	120 lb

Alternative 3 initially provides increased protection to human health and the environment relative to Alternatives 1 and 4 since it physically removes soil COCs from the Lilyblad property. Furthermore, this alternative will eliminate or significantly reduce the source of soil COCs to the groundwater flowing through the Lilyblad property.

With the exception of soil dewatering and subsequent water treatment during construction, this alternative does not address groundwater contamination on the Lilyblad or adjacent properties. Unlike Alternatives 1, 2, and 4, this alternative does not prevent, treat, or hydraulically restrict the horizontal flow of groundwater in the upper sand aquifer within the Site. Elevated concentrations of COCs will initially remain in the groundwater on Lilyblad and adjacent properties.

Residual soil contamination will continue to contribute COCs to groundwater in areas outside of the excavation footprint. It is likely that natural attenuation of

COCs in the groundwater will occur but at a very slow rate. This attenuation will be counter-balanced by the addition of COCs that will enter the groundwater as a result of residual soil contamination that will still be present. This groundwater is expected to take more than 50 years to reach the Blair Waterway, although short-circuiting by surface drainages could reduce the time for groundwater COCs to reach the waterway. It is likely that natural attenuation will reduce the concentration of COCs in this groundwater, but it is not possible to determine the amount of time it would take to reduce COCs to CULs.

Comply with Cleanup Standards and Applicable State and Federal Laws

Ecology has developed CULs for soil and groundwater at the Site. This alternative will remove between approximately 46 to 80 percent (dependent on which variation is implemented) of the soil contaminant mass from the soil AOC. Alternative 3 will assure that the concentration of COCs in soil on portions of the Lilyblad property that are excavated will be below CULs.

Alternative 3 will not prevent COCs in groundwater on the Lilyblad and adjoining properties from reaching the Blair Waterway. About 60 percent of the groundwater within the groundwater AOC falls outside of the limits of excavation proposed by Alternative 3. Elevated concentrations (above CULs) of COCs are expected to remain in groundwater on Lilyblad and adjacent properties. This groundwater is expected to take more than 50 years to reach the Blair Waterway, although short-circuiting by surface drainages could reduce the time for groundwater COCs to reach the waterway. It is likely that natural attenuation will reduce the concentration of COCs in this groundwater, but it is not possible to determine the amount of time it would take to reduce COCs to CULs.

Permanence

Alternative 3 directly removes between approximately 46 to 80 percent of the mass of COCs from the soil AOC. It is assumed that Alternative 3 will place excavated soils from the Lilyblad property in an engineered, lined, and monitored Subtitle D landfill. Following excavation, clean structural fill will be backfilled into the excavation. Groundwater COCs and sources of soil COCs outside of the excavations will not be addressed by this alternative and will continue to be present at concentrations that exceed CULs. This alternative provides more permanence than Alternatives 1 and 4 since from 75,000 to 135,000 pounds of COCs are removed from the Lilyblad property and disposed of. This alternative provides less permanence with regards to groundwater than Alternative 2, which actively treats groundwater within the AOC.

Cost

A cost estimate and supporting assumptions for this alternative are presented in Appendix A.3. The conceptual-level (±25 percent.) cost estimate for Variation A is $7.7 million; and $4.2 million for Variation B. These cost estimates exclude the cost of business interruptions or termination that would result if Alternative 3 were implemented.

Effectiveness over the Long Term

Removal of soils above CULs or removal of the most contaminated soils on Lilyblad property will reduce the potential for worker exposure and the amount of COCs that may potentially leach into groundwater.

Alternative 3 does not actively address COCs in groundwater within the Lilyblad property, or soil and groundwater COCs located on adjacent properties that fall within the soil AOC. The presence of these COCs at concentrations above CULs will continue to pose potential risks to human health and the environment. The existing institutional controls that are currently protecting site workers on the adjacent properties (e.g., presence of asphalt pavement and concrete building foundations) are expected to continue to be effective in mitigating the risks posed by the soils and groundwater with the AOC to site workers and visitors to the Site.

Compliance monitoring will be necessary to monitor groundwater COC concentrations as groundwater exits the Site.

Alternative 3 provides a greater degree of long-term effectiveness than Alternatives 1 and 4 since it removes from approximately 75,000 to 135,000 pounds of COCs from the Lilyblad property. With regards to groundwater, Alternative 3 provides a lesser degree of long-term effectiveness than Alternative 2, which will actively treat the groundwater COCs within the groundwater AOC.

Management of Short-Term Risks

Similar to Alternative 1, risks to human health and the environment will occur if this alternative is selected. Excavation and capping of the numerous buried utility lines on the Lilyblad property will expose site workers to risks inherent in this activity. For buildings selected for demolition, the inspection, cleaning, and/or abatement of hazardous materials will expose workers to risk. Additionally, large-scale excavation and dewatering of the contaminated soils will provide a risk of exposure to site workers. A health and safety plan would be developed to address these risks, and the risks associated with working in an area where COCs are known to be present at concentrations above CULs in soil and groundwater.

Active institutional controls and implementation of a construction safety monitoring program will provide additional protection to site workers and the public who visit the Site.

Given the amount of disturbance caused by excavation activities, Alternative 3 has more potential short-term risks to human health and the environment than does Alternative 1—Containment with Groundwater Controls and Alternative 4—Hydraulic Control with Groundwater Monitoring.

Technical and Administrative Implementability

Technologies employed by this alternative are common to the construction industry and with controls to prevent worker exposure, can be readily implemented. The Lilyblad property is located in an industrial area. Access to services, materials, supplies, and skilled labor would be possible. Access to construction operations and monitoring should also be readily available.

This alternative is expected to shut down Lilyblad operations. The feasibility of this outcome has not been assessed. This alternative would also likely cause some interruptions to adjacent business during construction activities.

Restoration Time Frame

Alternative 3 directly reduces the volume of the COCs contained in soil on the Lilyblad property. Soil and groundwater COCs outside of the Lilyblad property but within the AOC are not addressed. It is likely that the concentration of COCs in soil outside the limits of excavation will continue to exceed CULs for a very long period of time.

Groundwater is not directly addressed by Alternative 3. Sources of soil contamination outside the excavation (Variation A) or that remain on the Lilyblad property (Variation B) will continue to degrade groundwater within the AOC. This groundwater is expected to take more than 50 years to reach the Blair Waterway, although short-circuiting by surface drainages could reduce the time for groundwater COCs to reach the waterway. It is likely that natural attenuation will reduce concentration of COCs in this groundwater, but it is not possible to determine the amount of time it would take to reduce COC concentrations to CULs.

3.6 Alternative 4—Hydraulic Control with Groundwater Monitoring

Alternative 4 includes the maintenance of hydraulic control of groundwater below the Site and routine monitoring of water levels and COC concentrations in monitoring wells surrounding the Site (Ecology 2006c).

Based on hydraulic containment efforts previously implemented on the Lilyblad property, MPE area, and PWE building by Terra Vac, it is estimated that hydraulic control of the Site groundwater contaminant plume can be maintained using a groundwater removal rate of 2 gpm (Terra Vac 2006b)). The extracted groundwater and soil vapor will be treated by the renovated CDM groundwater treatment system shown on Figure 2-3, and described in Section 2.3.3. The key components of this system include a surge tank, air stripping system, activated carbon treatment for groundwater and vapors (removed from the stripping system), and a cooling system for maintaining discharges below 19° C to comply with NPDES-like requirements.

To confirm that groundwater containment has been achieved, groundwater elevations will be measured weekly for the first month after the hydraulic containment system has been activated and quarterly thereafter. Groundwater discharging the treatment system will be sampled monthly to assure compliance with discharge requirements.

As part of this alternative, long-term groundwater quality monitoring will also be performed to evaluate the effectiveness and continued need for hydraulic containment. A long-term groundwater monitoring plan would be developed that specifies monitoring well locations, monitoring frequencies, sampling procedures, and analytical and reporting requirements. Cost estimates provided in Appendix A.4 are based on collecting groundwater samples from 11 monitoring wells located along the perimeter of the site (see Figure 2-5) on a quarterly basis for Year 1, a semi-annual basis for Years 2 through 5, and on a yearly basis for Years 6 through 30.

3.6.1 Expected Performance of Alternative 4

Alternative 4 does not directly reduce the quantity or volume of COCs in Site soils. This alternative is expected to significantly reduce horizontal flow of groundwater in the upper aquifer that exits the Site. Alternative 4 provides hydraulic control of groundwater flow in the upper aquifer within the Site. Thus Alternative 4 is expected to reduce the likelihood that COCs in groundwater beneath the Site will reach receptors in the Blair Waterway.

Alternative 4 does not directly reduce the quantity or volume of COCs in soil on the Lilyblad property or adjacent properties. Once hydraulic control is initiated, groundwater on the Site will be replenished by groundwater inflow from off-site sources and from precipitation. A significant source of water to the shallow aquifer on the property will be precipitation. As discussed in Section 2.3.2, approximately 425,000 gallons of precipitation are expected to recharge the aquifer within the AOC each year. The upper aquifer within the AOC is expected to contain approximately 1,300,000 gallons of water. The combination of dilution from recharge and the treatment of water extracted to maintain hydraulic control will act to remove COCs from groundwater within the groundwater AOC. Reduction of COCs in groundwater due to biodegradation and other natural attenuation mechanisms is likely to occur but at such a slow rate that attaining CULs for groundwater will take 100 or more years. The COCs removed will be replaced by COCs that originate from the contaminated soil that will remain on the Site after hydraulic control is initiated.

Unfortunately, approximately 130,000 pounds of contaminants are currently present within the AOC on the Lilyblad property (Refer to Table 1.3). An additional 35,000 pounds (approximately) of contaminants are present in soil that is within the soil AOC and outside of the Lilyblad property. The secondary sources of contaminants at locations throughout the soil AOC will not be treated by Alternative 4. This large 'source term' is expected to supply contaminants to the groundwater for an extended period of time. This time frame is expected to be longer than 100 years. For practical purposes, this restoration time frame suggests that hydraulic control of groundwater on the Lilyblad property would need to continue indefinitely.

3.6.2 Evaluation of Alternative 4

Alternative 4 is evaluated using the criteria defined in Section 3.1. A summary of this evaluation is provided in Table 3.8.

Overall Protection of Human Health and the Environment

Alternative 4 does not directly reduce the quantity or volume of COCs in soil inside or outside of the soil AOC. Residual contamination will remain in the upper sand and aquitard units on the Site.

Alternative 4 does reduce the horizontal flow of groundwater in the upper sand aquifer that exits the footprint of the AOC. Since the groundwater plume is apparently stable, it is likely that the quantity of COCs that will exit the property in groundwater and reach the Blair Waterway will be reduced by this alternative. Elevated concentrations of COCs will remain in groundwater both inside and outside of the Lilyblad property. Alternative 4 provides equivalent protection to that provided by Alternative 1—Containment with Hydraulic Controls since Alternative 4 provides hydraulic control of the entire groundwater AOC, while a physical barrier is placed around the Lilyblad property to prevent COCs in groundwater from exiting the property by Alternative 1. A physical barrier is more effective than hydraulic controls alone in preventing the flow of groundwater.

Alternative 4 does not use active measures to treat the approximately 164,000 pounds of contaminants contained within the soil AOC at the Site. It does directly treat groundwater that is extracted from the groundwater AOC to maintain hydraulic control. Thus, Alternative 4 is less protective of human health and the environment than Alternatives 2 and 3, which treat and/or remove COCs in soil and groundwater. It is likely that natural attenuation of COCs in groundwater within the AOC will occur but at a very slow rate. This attenuation will be counter-balanced by the addition of COCs that will enter the groundwater as a result of leaching from residual soil contamination. The rate of natural attenuation of COCs together with the active treatment of extracted groundwater is not expected to achieve CULs for groundwater within the AOC for a very long period of time.

Comply with Cleanup Standards and Applicable State and Federal Laws

Ecology has developed CULs for soil and groundwater at the Site. Alternative 4 does not actively address the COCs in soil at the Site, so soil COC concentrations will exceed the CULs.

Natural attenuation of COCs in groundwater together with the active treatment of extracted groundwater is not expected to achieve CULs for groundwater within the Lilyblad property or on the Site for a very long period of time.

Permanence

Alternative 4 does not actively treat soils within the soil AOC at the Site. Alternative 4 actively treats only a small portion of the contaminants present within the groundwater that is extracted from the AOC to assure hydraulic control. The contaminants are removed from groundwater by activated carbon. Thus the COCs are not destroyed on site. The spent carbon is regenerated off the site. This alternative provides significantly less permanence than Alternative 1, which installs a physical barrier to prevent the flow of groundwater from exiting the Lilyblad property; Alternative 2, which actively treats the soil and groundwater within the AOC; or Alternative 3, which removes and disposes of soil within the Lilyblad property.

Cost

A cost estimate and supporting assumptions for this alternative are presented in Appendix A.4. The conceptual-level (±25 percent.) cost estimate for Alternative 4 is $3.6 million.

It should be noted that this cost estimate assume 30 years of groundwater treatment and compliance monitoring. As discussed below, the restoration timeframe for Alternative 4 is expected to exceed 30 years. The estimated cost for Alternative 4 will increase significantly if additional groundwater treatment and compliance monitoring are required.

Effectiveness over the Long Term

Technologies employed by Alternative 4 have been successfully demonstrated at this scale at many locations. It is likely that the hydraulic control measures would be effective in containing groundwater within the Lilyblad property.

Alternative 4 does not actively address the COCs in soils within the AOC.. These soils will continue to pose potential risks to human health and the environment. The existing institutional controls that are currently protecting site workers (e.g., presence of asphalt pavement and concrete building foundations) are expected to continue to be effective in mitigating the risks posed by the soils and groundwater within the AOC to site workers and visitors to the Site.

Alternative 4 provides a lesser degree of long-term effectiveness than Alternative 1, which installs a physical barrier around the Lilyblad property; Alternative 2, which actively destroys COCs in soil and groundwater; and Alternative 3, which excavates and disposes of COCs in soils in an on-site engineered, lined, and monitored facility.

Management of Short-Term Risks

Minimal risks to human health and the environment will occur if Alternative 4 is selected. A health and safety plan would be developed to address these risks, and the risks associated with working in an area where COCs are known to be present at concentrations above CULs in soil and groundwater.

Active institutional controls and a personnel monitoring program will provide additional protection to site workers and the public who visit the Site.

This alternative has fewer potential short-term risks to human health and the environment than does Alternative 1—Containment with Hydraulic Controls, since a physical barrier is not installed. Alternative 4 poses significantly less potential for short-term risks than the operation of a generic treatment system for a period of several years (Alternative 2), or the demolition of buildings and excavation of soil (Alternative 3) on the Lilyblad property.

Technical and Administrative Implementability

Hydraulic control is a well developed technology that has been used at the Site during the past several years. The Site is located in an industrial area. Access to services, materials, supplies, and skilled labor would be possible. Access for construction operations and monitoring is also likely readily available.

Installation of hydraulic controls would be staged to minimize interruptions to the operations of Lilyblad and adjacent facilities.

As discussed previously, it will be difficult to isolate the contribution of Site COC concentrations to the Blair Waterway from the contributions of other sources. Thus it may not be possible (based upon existing information) to isolate the contribution of COCs present in the groundwater emanating from the Site to the overall risk to human health and the environment posed by the total COC load that will be present when groundwater from the Site eventually reaches the Blair Waterway.

Restoration Time Frame

Alternative 4 does not directly reduce the toxicity, mobility, or volume of the COCs contained in Site soils. This large 'source term' is expected to supply contaminants to the groundwater for an extended period of time. This time frame is expected to be longer than 30 years. The groundwater treatment system will continue to operate during this period. It is unlikely that the concentration of COCs in soil in the soil AOC or in groundwater below the Lilyblad property will be reduced to the CULs established by Ecology for this Site.

Table 3.1 - Evaluation of Alternative 1—Containment with Groundwater Controls

Criteria	Variation A - Perimeter Barrier Slurry Wall or Steel Sheet Pile	Variation B - Discontinuous Barrier Slurry Wall or Steel Sheet Pile
Overall Protection of Human Health and the Environment	Does not actively address the COCs in soil at the Site. Will not assure that the concentration of COCs in soil at the Site will be below CULs. About 60 percent of the groundwater within the groundwater AOC falls outside of the barrier. This groundwater will not be treated. The technologies employed by this alternative have been successfully demonstrated at this scale at many locations. Variation A provides more protection than Variation B since a complete physical barrier is installed arround the perimeter of the property.	Does not actively address the COCs in soil at the Site. Will not assure that the concentration of COCs in soil at the Site will be below CULs. About 60 percent of the groundwater within the groundwater AOC falls outside of the barrier. This groundwater will not be treated. The technologies employed by this alternative have been successfully demonstrated at this scale at many locations. Variation B provides less protection than Variation A since only a partial barrier is installed at the property.
Comply with Cleanup Standards	Will not assure that the concentration of COCs in soil at the Site will be below CULs. About 60 percent of the groundwater within the groundwater AOC falls outside of the barrier. This groundwater will not be treated. Natural attenuation of groundwater outside the barrier will occur.	Does not actively address the COCs in soil at the Site. Will not assure that the concentration of COCs in soil at the Site will be below CULs. About 60 percent of the groundwater within the groundwater AOC falls outside of the barrier. This groundwater will not be treated. Natural attenuation of groundwater outside the barrier will occur.
Permanence	Does not actively treat the soils in the soil AOC at the Site. Treats only a small portion of the contaminants present within the groundwater that is extracted from within the barrier and treated prior to discharge. Provides a significantly lower degree of permanence than is provided by Alternatives 2 and 3. Variation A provides more permanence than Variation B since a complete physical barrier is installed arround the perimeter of the property.	Does not actively treat the soils within the soil AOC at the Site. Treats only a small portion of the contaminants present within the groundwater that is extracted from within the barrier and treated prior to discharge. Provides a significantly lower degree of permanence than is provided by Alternatives 2 and 3. Variation B provides less permanence than Variation A since only a partial barrier is installed at the property.
Effectiveness over the Long Term	The technologies employed by this alternative have been successfully demonstrated at this scale at many locations. Does not actively address the COCs in soils within the Lilyblad property or in soils and groundwater within the AOC that fall outside of the barrier perimeter. The soils and groundwater will continue to pose potential risks to human health and the environment.	The technologies employed by this alternative have been successfully demonstrated at this scale at many locations. Does not actively address the COCs in soils within the Lilyblad property or in soils and groundwater within the AOC that fall outside of the barrier perimeter. The soils and groundwater will continue to pose potential risks to human health and the environment.
Management of Short-Term Risks	Installation of a barrier wall in the vicinity of buried utility lines will expose site workers to the risks inherent in this activity. These risks will be mitigated by developing detailed work plans and health and safety plans.	Installation of a barrier wall in the vicinity of buried utility lines will expose site workers to the risks inherent in this activity. These risks will be mitigated by developing detailed work plans and health and safety plans.
Technical and Administrative Implementability	Slurry wall and sheet pile barrier walls are well developed technologies that could be implemented with a high degree of confidence for this alternative. Measuring compliance with groundwater CULs at the Blair Waterway will be difficult since groundwater from other source areas will mix with groundwater from the Site prior to discharging to the Blair Waterway.	Slurry wall and sheet pile barrier walls are well developed technologies that could be implemented with a high degree of confidence for this alternative. Measuring compliance with groundwater CULs at the Blair Waterway will be difficult since groundwater from other source areas will mix with groundwater from the Site prior to discharging to the Blair Waterway.

Table 3.1 - Evaluation of Alternative 1—Containment with Groundwater Controls

Criteria	Variation A - Perimeter Barrier Slurry Wall or Steel Sheet Pile		Variation B - Discontinuous Barrier Slurry Wall or Steel Sheet Pile	
Restoration Time Frame	Does not directly reduce the toxicity, mobility, or volume of the COCs contained in soil on the Site. It appears unlikely that the concentration of COCs in soil or in groundwater at the Site, will be reduced to the CULs established by Ecology.		Does not directly reduce the toxicity, mobility, or volume of the COCs contained in soil on the Site. It appears unlikely that the concentration of COCs in soil or in groundwater at the Site, will be reduced to the CULs established by Ecology.	
Conceptual-Level Cost (NPV ±25 percent)	Slurry Wall - $ 3.1 million	Steel Sheet Pile - $ 3.3 million	Slurry Wall - $ 3.3 million	Steel Sheet Pile - $ 3.4 million

Table 3-2 - Approach Used by Terra Vac to Calculate Mass of Contaminants Removed by DVE/Bioremediation/Oxidation Process

Mass of Volatile Removed

(1) lb/day = VOC Reading $\left(\frac{mg}{L}\right)$ Soil Vapor Flow Rate $\left(\frac{ft^3}{\min}\right)$ (0.089)

where:

0.089 = $\left(1440\frac{\min}{day}\right)\left(\frac{1\ lb}{454{,}000mg}\right)\left(28.3\frac{l}{ft^3}\right)$

VOC Reading[a] = Gas Chromatograph Value until August 2005
PID Reading after August 2005
One-time reading taken on last operating day at the
Inlet to the vapor carbon system

$(ft^3/min)^a$ = One-time reading taken on last operating day at the
Inlet to the vapor carbon system

Mass of Hydrocarbons Removed by Biological Activity or Oxidation

(2) lb/day = Soil Vapor Flow Rate $\left(\frac{ft^3}{\min}\right)$ (5.12) (0.089) (%CO_2 - 0.03)

where:

$(\%CO_2)^a$ = CO_2 meter value (Gastector Model 3252OX)
One-time reading taken on last operating day at the
Inlet to the vapor carbon system

0.03 = Background CO_2 reading used until August 2004
CO_2 meter calibrated to local background value after August 2004

5.12 = Mass of Carbon in mg/l per percent of CO_2 factor; or

5.12 = $\left(\frac{MW\ C}{MWCO_2}\right)\left(18.95\frac{mg}{l-\%CO_2}\right)$

5.12 = $\left(\frac{12}{44}\right)$ (18.95)

18.95 = average value computed using the ideal gas law at 0°C and 20°C

Mass of Hydrocarbons Removed as Methane or Light VOC

(3) lb/day = Methane Reading $\left(\frac{mg}{l}\right)$ (Soil Vapor Flow Rate) 0.089

where:

Methane Reading[a] = Gas Chromatograph Value until May 2005.
Methane monitoring stopped in May 2005
One-time reading taken on last operating day at the
Inlet to the vapor carbon system

(a) (Malot 2006)

Table 3-3 - Contaminant Mass Removal Calculated by Terra Vac

Area of the Site	Operating Period	Operating Time[b] in 24-hour Days	Contaminant Mass Removed[a] in Pounds
Initial Pilot Test Area	9/03 to 4/04	104 to 120	12,800
LNAPL Area + Hot Spot Area + Dissolved Plume Area	5/04 to 3/06	520 to 647	33,100
MPE Area	5/04 to 3/06	273 to 429	26,200
PW Eagle Building Area	1/05 to 3/06	322	8,300
Total			80,400

(a)Terra Vac 2006c
(b)Malot 2006b

Table 3.4 - Expected Remediation Time Frame for Soil and Groundwater Calculated by Terra Vac

Media	Area of Site	Apparent Rate Limiting COC	Value of C_o in ug/kg or ug/L (2)	Operating Time in Days	Calculated Reaction Coefficient k (3,4)	Expected Time to Reach CULs in Years (5)
Soil	MPE Area	1,1-Dichlorobenzene	1,900	521	211	1.6
	PWE Building	TPH-D	2,200,000	330	193	2.4
	LNAPL Area	TPH-D	16,800,000	480	193	2.7
	Hot Spot Area	TPH-D	14,800,000	500	193	2.6
		PCE	64,000	500	141	0.5
Groundwater	All (6)	Various	Various	90	50	0.3

Notes:
(1) Data taken from Malot 2006c.
(2) Maximum value at location within the area.
(3) Based on post-remediation data collected during December 2005.
(4) Maximum value and post-remediation value obtained at different locations in same general vicinity.
(5) CUL used as post-remediation COC concentration.
(6) A blended k value was used by Terra Vac for groundwater. Oxidation is required to reach CULs.

Table 3.5 - Treatment Sequence Proposed by Terra Vac

Means of Treatment	Area of Site	Duration in Months (approximate)	Comment
DVE	All	1	Achieve hydraulic control of Site
Biodegradation	Total All Areas	59	Four treatment trains - three in Lilyblad area; one in PWE-MPE area
Oxidation	Total All Areas	13	Begin oxidation once biodegradation is complete
Total	All Areas	73	

Notes:
(1) Source: Malot 2006b

Table 3.6 - Evaluation of Alternative 2—*In Situ* Treatment

Criteria	Variation A - Meet CULs in AOCs	Variation B - Meet CULs for TPH in AOCs	Variation C - Containment on Lilyblad Property; Treatment Off Property
Overall Protection of Human Health and the Environment	Variation A is expected to reduce the concentration of COCs in soil and groundwater to below CULs throughout both the soil and groundwater AOCs. It is the only alternative evaluated during this FFS that will do so. Expected to destroy or remove more than 160,000 pounds of COCs in soil. Employs technologies that have been demonstrated to be effective at the Site. Short-term risks are managable. Expected to reduce the concentration of COCs to below CULs in approximately 6 years.	Variation B is expected to reduce the concentration of TPH COCs in soil and groundwater to below CULs throughout both the soil and groundwater AOCs. VOC concentrations are also expected to be substantially reduced. Expected to destroy or remove more than 160,000 pounds of COCs in soil. Not as effective in destroying SVOCs as Variation A. Employs technologies that have been demonstrated to be effective at the Site. Short-term risks are managable. Reduction of the concentration of TPH COCs to below CULs is expected to be achieved in approximately 5 years. After treatment, it is likely that natural attenuation of VOCs and SVOCs in soil and groundwater will occur. The information (refer to Section 3.2) necessary to assess the likely degree of natural attenuation that would occur at the Site is not currently available.	Actively treats soils and groundwater outside of the barrier (and within the soil and groundwater AOCs) installed by Alternative 1. The concentration of COCs in soil and groundwater in these areas after treatment are expected to be below CULs. The groundwater within the barrier will be contained and some will be treated. The soil inside the barrier will not receive any treatment. Thus the CULs established for soil within the barrier by Ecology will not be met by this alternative. Expected to destroy or remove more than 30,000 pounds of COCs in soil. Employs technologies that have been demonstrated to be effective. Short-term risks are managable.
Comply with Cleanup Standards	This evaluation assumes that the implementation of Variation A will reduce the concentration of COCs in soil and groundwater to below CULs.	It is likely that Variation B will achieve CULs for TPH COCs, is likely to achieve CULs for VOC COCs, and is unlikely to achieve CULs for SVOC COCs.	The concentration of COCs in soil and groundwater in areas outside the barrier after treatment are expected to be at concentrations below CULs. The soil inside the barrier will not receive any treatment. Thus the CULs established for soil by Ecology will not be met within the barrier by Variation C.
Permanence	Expected to destroy and/or remove approximately 160,000 pounds of TPH, 3,500 pounds of VOC, and 200 pounds of SVOC COCs. Directly treats all of the groundwater within the groundwater AOC	Expected to destroy and/or remove approximately 160,000 pounds of TPH, and less than 3,500 pounds of VOC COCs. Directly treats all of the groundwater within the groundwater AOC	Expected to destroy and/or remove approximately 30,000 pounds of TPH, 300 pounds of VOC, and 20 pounds of SVOC COCs. Directly treats approximately 60 percent of the groundwater within the groundwater AOC.
Effectiveness over the Long Term	Provides for a long-term reduction of contaminant concentrations by means of active remediation. The technologies used are well understood and have been shown to be effective during the pilot-scale tests and Interim Measures that have been conducted at the Site	Same as for Variation A, except that oxidation of SVOC COCs in soil and groundwater does not occur. Natural attenuation of these COCs would continue. Variation B is likely to be less effective over the long term than Variation A, since SVOCs are not destroyed.	The concentration of COCs in the soil and groundwater within the barrier is expected to exceed CULs for an extended period of time. The COCs that will remain in soil and groundwater within the barrier after Variation C is implemented will continue to naturally attenuate. The progress of natural attenuation will be monitored. Variation C is less effective over the long term than Variations A or B of Alternative 2, or Alternative 3.
Management of Short-Term Risks	Short-term risks to human health and the environment would occur if this alternative were implemented. These short-term risks will be present during installation and operation of the generic treatment train and its ancillary equipment. Detailed work plans and health and safety plans will be implemented to reduce risks to site workers and the public during the 6 years that this variation is operational.	Same type of risks as Variation A. Less overall short-term risk than Variation A due to the shorter period of operation of the generic treatment train (5 years for Variation B)	The installation of a barrier wall will expose site workers to additional risks related to the presence of buried utility lines. The duration of Variation C (3 years) is shorter than the duration of Variations A and B. Variation C adds the short-term risks associated with the installation of the barrier. Overall short-term risk of this variation judged to be equivalent to the short-term risks associated with Alternative 2, Variation B.
Technical and Administrative Implementability	The generic treatment train has been successfully demonstrated during pilot-scale and Interim Measure operations at the Site. These operations have been conducted with full-scale equipment. The system has been shown to be implementable.	The generic treatment train has been successfully demonstrated during pilot-scale and Interim Measure operations at the Site. These operations have been conducted with full-scale equipment. The system has been shown to be implementable.	The generic treatment train has been successfully demonstrated during pilot-scale and Interim Measure operations at the Site. These operations have been conducted with full-scale equipment. The system has been shown to be implementable. Slurry wall and sheet pile barriers are well developed technologies that could be implemented with a high degree of confidence.
Restoration Time Frame	This evaluation assumes that the implementation of Variation A will reduce the concentration of COCs in soil and groundwater to below CULs by the conclusion of the approximately 6-year period of operation of the generic treatment system.	Variation B is likely to reduce the concentration of THP COCs in soil and groundwater to below CULs and to substantially reduce the concentration of VOC COCs by the conclusion of its approximately 5-year period of operation. The concentrations of SVOC COCs in soil and groundwater are expected to be only slightly reduced since oxidation is not considered by Variation B. The VOCs and SVOCs that are likely to be present in soil and groundwater at the conclusion of Variation B's period of operation are expected to naturally attenuate. Additional site characterization and modeling would be needed to predict the rate of natural attenuation to more accurately predict future concentrations in soil and groundwater of COCs that may be left behind by Alternative 2, Variation B.	The concentration of COCs in soil and groundwater in areas outside of the barrier after remediation by the generic treatment train should be below CULs at the conclusion of its 2 to 3 years of operation. The groundwater within the barrier will be contained and treated as groundwater is withdrawn and treated to maintain hydraulic control. The soil inside the barrier will not receive any treatment. Thus the CULs established for soil by Ecology will not be met within the barrier. The COCs that are likely to be present in soil and groundwater within the barrier are expected to naturally attenuate. Additional site characterization and modeling would be needed to predict the rate of natural attenuation to more accurately predict future concentrations in soil and groundwater of COCs that may be left behind by Alternative C.

Table 3.6 - Evaluation of Alternative 2—*In Situ* Treatment

Criteria	Variation A - Meet CULs in AOCs	Variation B - Meet CULs for TPH in AOCs	Variation C - Containment on Lilyblad Property; Treatment Off Property
Conceptual-Level Cost (NPV ± 25 percent)	$4.9 million	$4.4 million	$5.0 million

Table 3.7 - Evaluation of Alternative 3 - Excavation and Disposal of Contaminated Soil

Criteria	Variation A - Excavate All Contaminated Soils on Lilyblad Property	Variation B - Excavated Most Contaminated Soils on Lilyblad Property
Overall Protection of Human Health and the Environment	Variation A will remove approximately 135,000 pounds of COCs from the Lilyblad property. Variation A will not address the approximately 30,000 pounds of COCs in soil outside of the Lilyblad property. COCs in groundwater within the groundwater AOC will not be addressed by Variation A. It is expected that CULs will not be met in soil outside the excavation footprint or in groundwater in the AOC for a very long period of time. Employs technologies that have been demonstrated at similar facilities. Short-term risks are manageable.	Variation B will remove approximately 75,000 pounds of COCs from soils within the excavation footprint. Variation B will not address approximately 58,000 pounds of COCs in soil on Lilyblad property or 30,000 pounds of COCs in soil outside of the Lilyblad property. COCs in groundwater within the groundwater AOC will not be addressed by Variation B. It is expected that CULs will not be met in the unexcavated areas on Lilyblad property, in soil outside the Lilyblad property, or in groundwater in the AOC for a very long period of time. Employs technologies that have been demonstrated at similar facilities. Short-term risks are manageable.
Comply with Cleanup Standards	Variation A directly removes and disposes of contaminated soil from the Lilyblad property so it will assure that the concentrations of COCs in soil within the excavation footprint will be below CULs. Soil CULs will not be met in areas outside the limits of excavation. COCs in groundwater within the groundwater AOC will not be addressed by Variation A. Concentrations of COCs in groundwater will remain above CULs on Lilyblad property and adjacent areas of the AOC. Soil contaminants outside of the excavation footprint will continue to contribute COCs to groundwater.	Variation B directly removes and disposes of contaminated soil within the excavation footprint so it will assure that the concentrations of COCs in soil in these locations will be below CULs. Soil CULs will not be met on areas outside the limits of excavation. COCs in groundwater within the groundwater AOC will not be addressed by Variation B. Concentrations of COCs will remain in groundwater above CULs on Lilyblad property and adjacent areas of the AOC. Soil contaminants outside of the excavation will continue to contribute COCs to the groundwater.

Table 3.7 - Evaluation of Alternative 3 - Excavation and Disposal of Contaminated Soil

Criteria	Variation A - Excavate All Contaminated Soils on Lilyblad Property	Variation B - Excavated Most Contaminated Soils on Lilyblad Property
Permanence	Variation A actively removes and disposes of approximately 135,000 pounds of COCs in soil from the Lilyblad property. During excavation approximately 500,000 gallons of groundwater would be treated prior to discharge. Following remedial construction, approximately 3,000 pounds of soil COCs will remain within the soil AOC. Groundwater COCs will not be addressed by this alternative.	Variation B actively removes and disposes of approximately 75,000 pounds of COCs in soil from selected locations on the Lilyblad property. During excavation approximately 300,000 gallons of groundwater would be treated prior to discharge. Following remedial construction, approximately 58,000 pounds of COCs in soil will remain on Lilyblad property and approximately 30,000 pounds of soil COCs will remain in locations within the soil AOC. Groundwater COCs will not be addressed by Alternative B. Variation B is less permanent than Variation A since it removes 60,000 fewer pounds of COCs from the Site.
Effectiveness over the Long Term	Provides for a long-term reduction cf COC concentrations by means of the active removal and disposal of contaminated soils from the Lilyblad property. Clean soil plac within the excavation may be recontaminated by COCs in groundwater. The technologies utilized are well understood.	Provides for a long-term reduction cf COC concentrations by means of the active removal and disposal of contaminated soils from the Lilyblad property. Clean soil plac within the excavation may be recontaminated by COCs in groundwater. The technologies utilized are well understood.
Management of Short-Term Risks	Excavation and capping of the numerous buried utility lines on the Lilyblad property prior to construction will expose site workers to the risks inherent in this activity. For buildings selected for demolition, the inspection, cleaning, and/or abatement of hazardous materials will expose workers to risk. Large-scale excavation and dewatering of the contaminated soils will have a high risk of exposure for site worker. These risks will be mitigated by developing detailed work plans and health and safety plans.	Variation B will have the same inherent risks as Variation A, but to a lesser degree due to the reduced level of demolition and excavation. These risks will be mitigated by developing detailed work plans and health and safety plans.

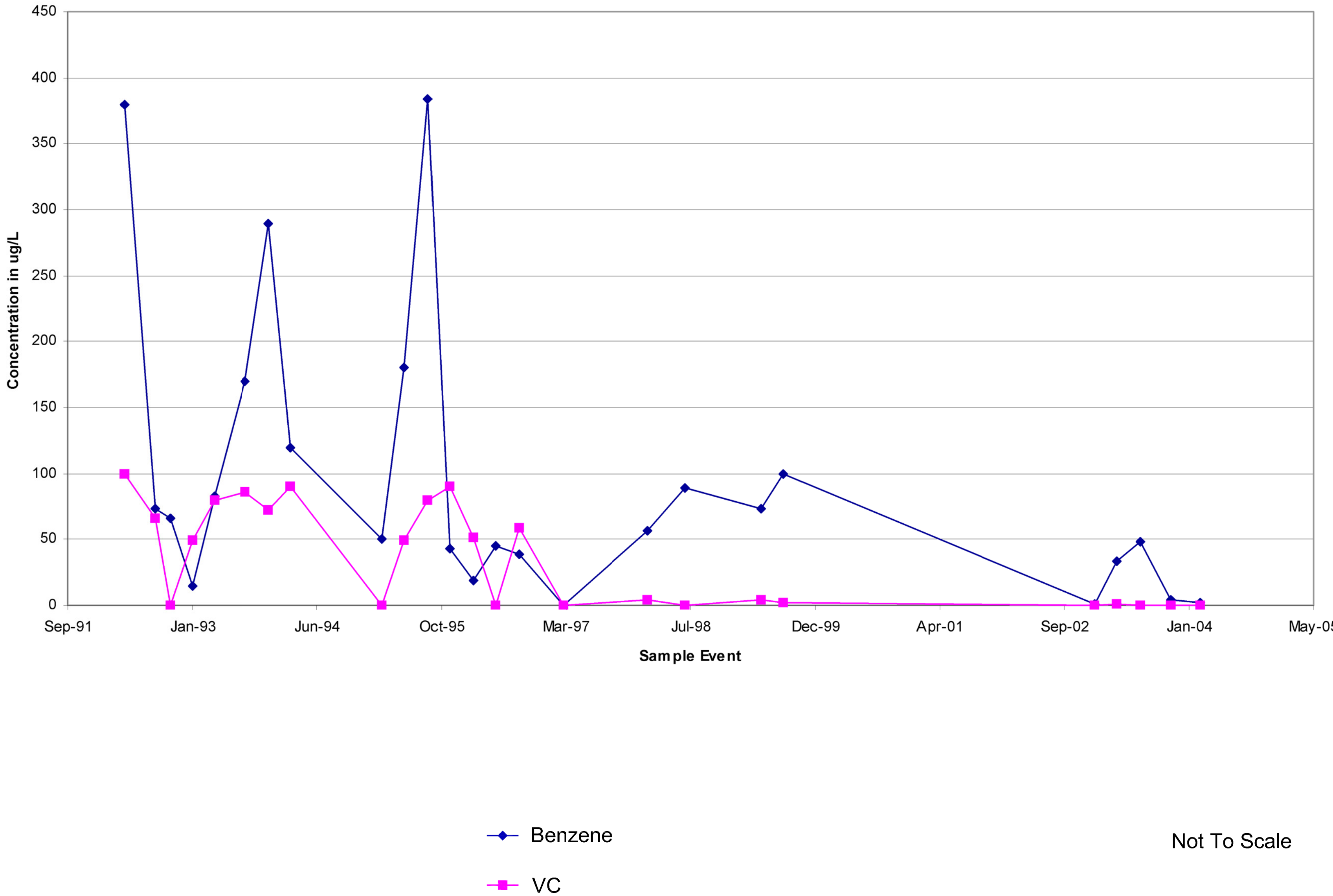
Table 3.7 - Evaluation of Alternative 3 - Excavation and Disposal of Contaminated Soil

Criteria	Variation A - Excavate All Contaminated Soils on Lilyblad Property	Variation B - Excavated Most Contaminated Soils on Lilyblad Property
Technical and Administrative Implementability	The technologies employed by Variation A are common to the construction industry and with controls to prevent worker exposure, can be readily implemented. Variation A will shut down Lilyblad operations. This outcome may not be feasible. Significant space on adjacent properties would be required to stockpile excavated soil. Measuring compliance with groundwater CULs at the Blair Waterway will be difficult since groundwater from other source areas will mix with groundwater from the Site prior to discharging to the Blair Waterway.	The technologies employed by Variation B are common to the construction industry and with controls to prevent worker exposure, can be readily implemented. Variation B will shut down Lilyblad operations. This outcome may not be feasible. Significant space would also be required on adjacent properties to stockpile excavated soil. Measuring compliance with groundwater CULs at the Blair Waterway will be difficult since groundwater from other source areas will mix with groundwater from the Site prior to discharging to the Blair Waterway.
Restoration Time Frame	Will directly remove COCs in soil from within the excavation footprint on the Lilyblad property. CULs for soil within this area will be met once Variation A is implemented. COC concentrations in soil and groundwater outside of the excavation footprint will exceed CULs for a very long period of time.	Will directly remove COCs in soil from within the excavation footprint on the Lilyblad property. CULs for soil within this area will be met once Variation B is implemented. COC concentrations in soil and groundwater outside of the excavation footprint will exceed CULs for a very long period of time.
Conceptual-Level Cost (NPV ±25 percent)	$ 7.7 million	$ 4.2 million

Table 3.8 - Evaluation of Alternative 4 - Hydraulic Controls with Groundwater Monitoring

Criteria	Evaluation of Alternative 4
Overall Protection of Human Health and the Environment	Alternative 4 does not use active measures to treat the approximately 160,000 pounds of contaminants contained within the soil AOC at the Site. Elevated concentrations of COCs (above CULs) will remain in groundwater throughout the AOC. The rate of natural attenuation of COCs together with the active treatment of extracted groundwater is not expected to achieve CULs for groundwater at the Site for a very long period of time.
Comply with Cleanup Standards	Alternative 4 does not actively address the COCs in soil at the Site, so the concentration of COCs in soil will exceed the CULs established by Ecology. The natural attenuation of COCs in groundwater together with the treatment of extracted groundwater will not reduce the concentration of COCs in groundwater to CULs within the groundwater AOC for a very long period of time.
Permanence	Alternative 4 does not actively treat the soils within the soil AOC at the Site. Alternative 4 actively treats only a small portion of the contaminants present within the groundwater that is extracted from the Site to assure hydraulic control, and treated prior to discharge. This alternative provides less permanence than Alternative 1, which installs a physical barrier to prevent the flow of groundwater from exiting the Lilyblad property; and significantly less permanence than Alternative 2, which actively treats the soil and groundwater within the AOC, or Alternative 3, which removes and disposes of soil within the Lilyblad property.
Effectiveness over the Long Term	The technologies employed by this alternative have been successfully demonstrated at this Site. Alternative 4 does not actively address the COCs in soils within the soil AOC. These soils will continue to pose potential risks to human health and the environment. Alternative 4 provides an equivalent degree of long-term effectiveness as Alternative 1, which installs a physical barrier around the Lilyblad property, and a lesser degree of long-term effectiveness than Alternative 2, which actively destroys COCs in soil and groundwater; and Alternative 3, which excavates and disposes of COCs in soils in an off-site engineered, lined, and monitored facility.
Management of Short-Term Risks	Minimal risks to human health and the environment will occur if this alternative is selected. Alternative 4 has fewer potential short-term risks to human health and the environment than does Alternatives 1, 2, or 3.
Technical and Administrative Implementability	Hydraulic control is a well developed technology that has been used at the Site during the past several years. Groundwater from the Site will mix with groundwater from other source areas once it reaches the storm drain below the Port of Tacoma Road. It will be difficult to isolate the contribution of Site COC concentrations in groundwater to the concentrations of COCs that are present at the point where the storm drains below the Port of Tacoma Road and the Lincoln Avenue Ditch, reach the Blair Waterway.
Restoration Time Frame	Alternative 4 does not directly reduce the toxicity, mobility, or volume of the COCs in soil on the Site. This large 'source term' is expected to supply contaminants to the groundwater for longer than 30 years. The groundwater treatment system will continue to operate during this period. The concentration of COCs in soil and in groundwater at the Site will exceed the CULs established by Ecology for this Site for a very long period of time.
Conceptual-Level Cost (NPV ±25 percent)	$ 3.6 million

Benzene and Vinyl Chloride Concentrations in Groundwater at Well B-13
Lilyblad Site



Not To Scale

1733002-011.dwg

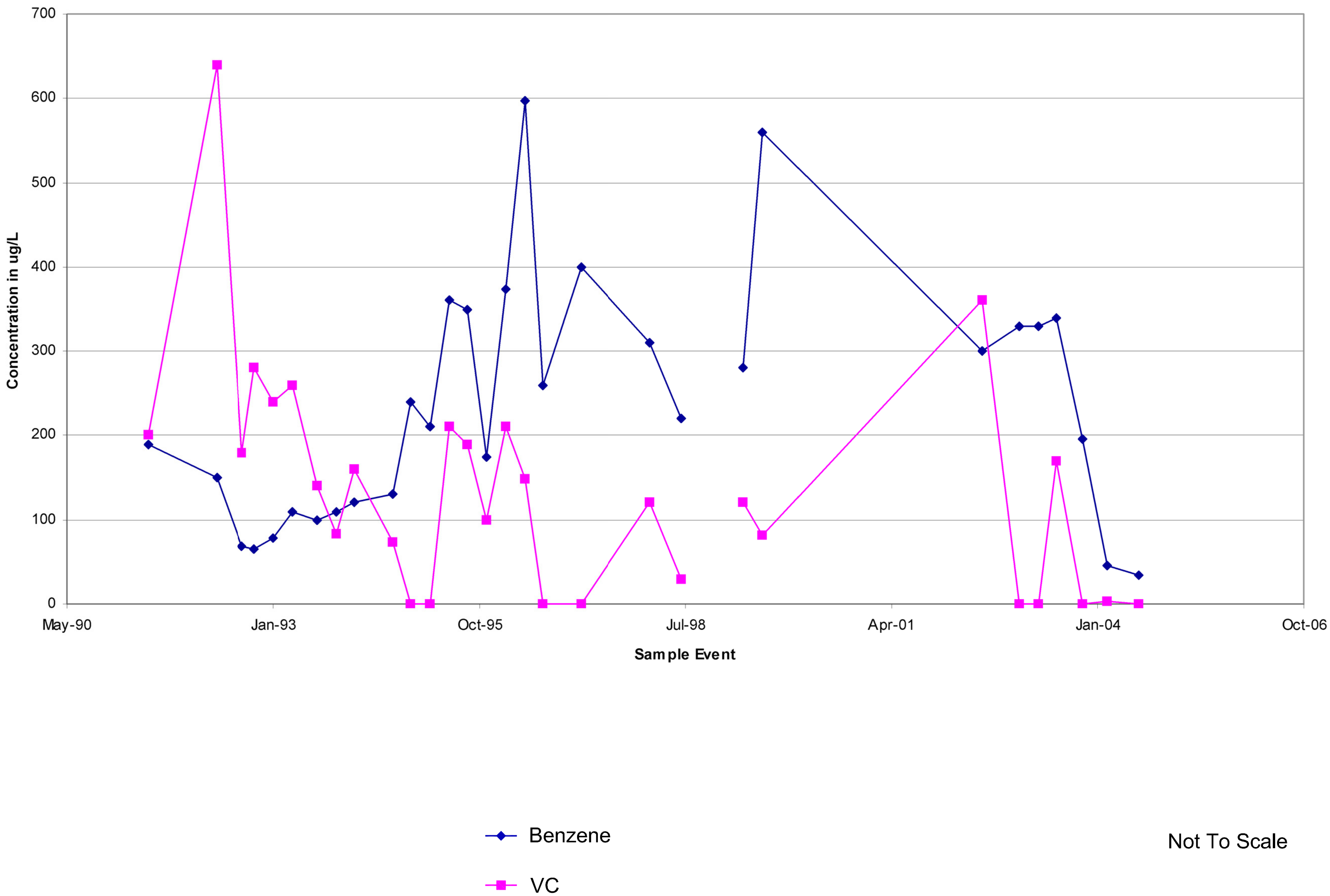
SRN 12/1/06

HARTCROWSER

17330-02 12/06

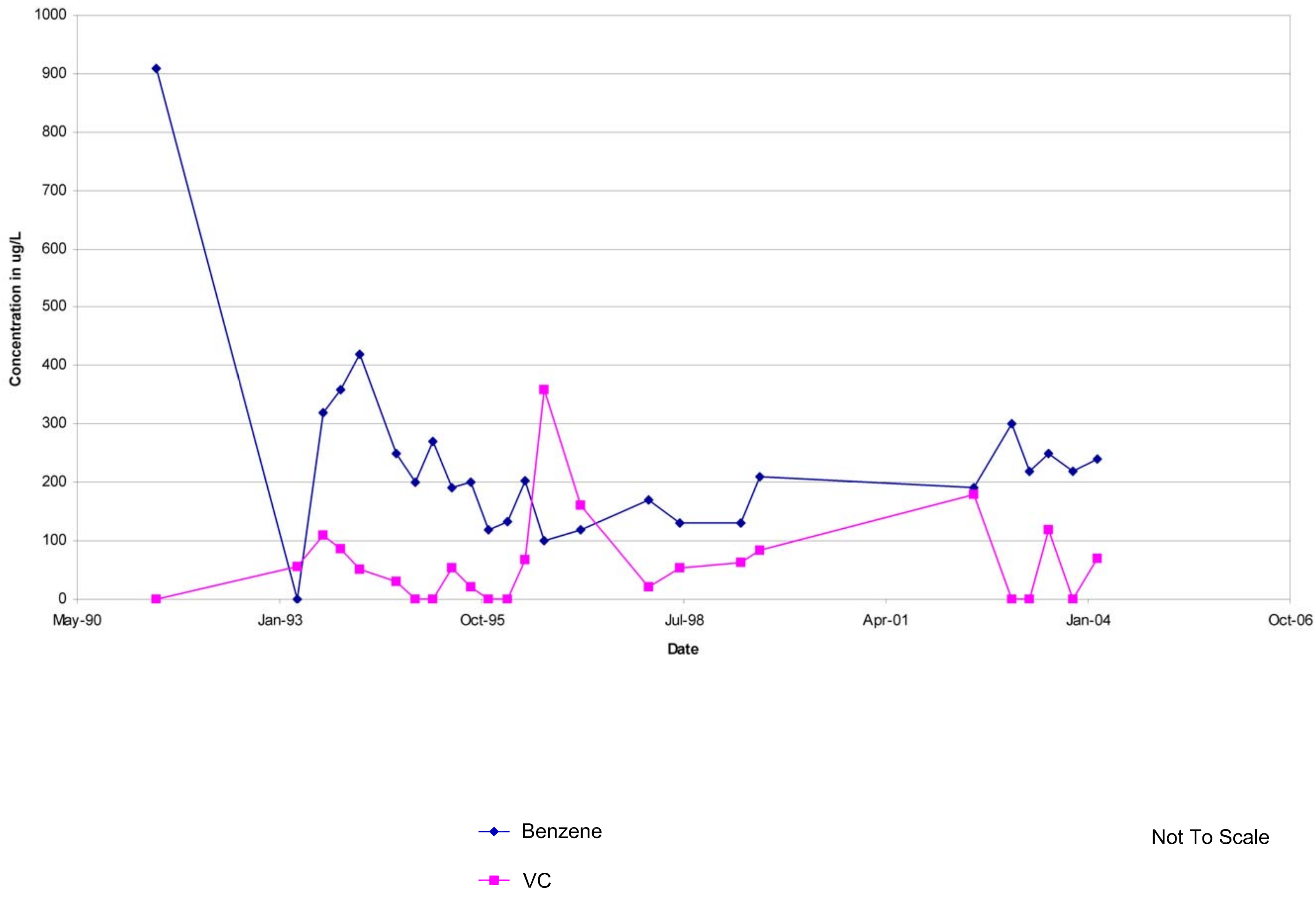
Figure 3-1

Benzene and Vinyl Chloride Concentrations in Groundwater at Well SP-4
Lilyblad Site



Not To Scale

Benzene and Vinyl Chloride Concentrations in Groundwater at Well SP-5
Lilyblad Site



Not To Scale

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Figure 3-3

SRN 12/1/06 1733002-013.dwg

4.0 SUMMARY OF EVALUATION OF ALTERNATIVES

A summary of the analysis of alternatives discussed in Sections 3.3, 3.4, 3.5, and 3.6 is provided in Table 4.1. A comparison of the four alternatives and variations ability to meet evaluation criteria is provided in the following sections.

4.1 Overall Protection of Human Health and the Environment

Alternative 2, Variation A—Operate the Generic System to Achieve CULs for All COCs will treat soil and groundwater throughout the Site. This is the only alternative that is expected to meet cleanup standards throughout the Site. Implementation of the other alternatives will result in only partial compliance with Site cleanup standards. Alternative 2, Variations A and B, directly reduce the quantity, toxicity, and volume of contaminants in soil (160,000 to 164,000 pounds) and groundwater on the Site to a greater extent than the other alternatives that were evaluated. Alternative 3, Variation A (135,000 pounds); Alternative 3 – Variation B (75,000 pounds); and Alternative 2 – Variation C (30,000 pounds) directly reduce the quantity, toxicity, and volume of COCs in soil to a lesser extent than Alternatives 2, Variations A and B. Alternatives 1 and 4 do not directly treat soil at the Site.

Alternative 2, Variation A (100 percent), Variation B (100 percent), and Variation C (50 percent) are the only alternatives evaluated that directly destroy COCs in groundwater at the Site. Alternatives 1, 3, and 4 do not directly destroy COCs in groundwater. Some groundwater will be extracted by Alternatives 1 and 4 to maintain hydraulic control. This groundwater will be treated to remove COCs prior to its discharge from the Lilyblad property.

The four alternatives employ technologies that have been successfully used at the Site or at other similar sites. The technologies have been shown to be implementable. Alternative 3 will require the demolition of all (Variation A) or most (Variation B) of the structures on the Lilyblad property. This outcome may not be economically feasible.

Contaminated soil that would remain at the Site after Alternatives 1, 2 (Variations B and C), 3, or 4 were implemented would exceed CULs for a very long period of time. Contaminated groundwater that exits the Site after Alternative 1, Alternative 2 (Variations B and C), Alternative 3, and Alternative 4 are implemented is expected to take more than 50 years to reach the Blair Waterway, although short-circuiting by surface drainages could reduce the time for groundwater contaminants to reach the waterway. It is likely that natural attenuation will reduce the concentration of COCs in this groundwater, but it is not possible to determine the amount time it would take to reduce COC concentrations to CULs.

Variations A and B of Alternative 2 provide greater long-term effectiveness than Alternatives 1, 3, or 4, since substantial destruction of COCs in soil and groundwater occurs as the generic treatment system is used at the Site. Variation A of Alternative 2 provides more long-term effectiveness than Variation B, since Variation A directly treats SVOC COCs. This benefit to human health and the environment occurs within a relatively short (compared to Alternatives, 1, 3, or 4) 3- to 6-year time frame.

4.2 Comply with Cleanup Standards

Alternative 2, Variation A—Operate the Generic System to Achieve CULs for All COCs will treat soil and groundwater throughout the Site. The evaluation summarized in Section 3.4 assumes that the concentration of COCs in soil and groundwater will be below CULs after this variation of Alternative 2 is implemented. This is the only alternative that is expected to meet cleanup standards for soil and groundwater throughout the Site.

Other alternatives will meet some cleanup standards throughout the Site, but not for all COCs (Alternative 2, Variation B—Operate the Generic System to Achieve CULs for TPH Compounds); will meet CULs for COCs in soil in limited areas of the Site (Alternative 3, Variations A and B, Alternative 2, Variation C); or will prevent some COCs in groundwater from exiting the Site (Alternative 2, Variation C, Alternative 1, and Alternative 4).

4.3 Permanence

Alternative 2, Variations A and B directly reduce the quantity, toxicity, and volume of contaminants in soil and groundwater on the Site to a greater extent than the other alternatives that were evaluated. The quantity of soil that is directly treated by Alternative 2 and removed and disposed of by Alternatives 2 and 3 is listed below (approximate values):

Alternative	Variation	TPH COCs	VOC COCs	SVOC COCs
2	A	160,000 lb	3,500 lb	200 lb
	B	160,000 lb	<3500 lb	<200 lb
	C	30,000 lb	300 lb	<20 lb
3	A	130,000 lb	3,400 lb	200 lb
	B	73,000 lb	1,900 lb	120 lb

Alternative 2 destroys contaminants and thus provides a more effective solution than Alternative 3, which removes and disposes of some of the contaminants.

Alternatives 1 and 4 do not directly reduce the quantity, toxicity, or volume of COCs in soil.

Alternative 2 also directly treats groundwater within the groundwater AOC. The relative percentage of groundwater directly treated by each variation of Alternative 2 is summarized below:

Alternative	Variation	Percent of AOC Treated
2	A	100 percent
	B	100 percent
	C	60 percent

Alternatives 1, 3, and 4 do not directly destroy the COCs in the groundwater within the AOC. Alternative 1 and Alternative 2, Variation C use a barrier to physically contain groundwater on the Lilyblad property (about 50 percent of the groundwater in the groundwater AOC), while Alternative 4 uses hydraulic means to contain groundwater on the Site. Some groundwater will be extracted to maintain hydraulic control by Alternatives 1 and 4. This groundwater will be treated to remove COCs prior to its discharge from the Site.

4.4 Effectiveness over the Long Term

Alternatives 2 and 3 provide for long-term reduction of contaminant mass by treating or excavating impacted soil and groundwater. Technologies utilized by these alternatives have been shown to be effective during the pilot-scale tests and Interim Measures that have been conducted at the Site and/or by their implementation at many other similar sites.

Implementation of Alternatives 1, 2 Variation C, 3, and 4 would leave significant mass of COCs on the Site. Alternatives 1 and 4 would leave approximately 160,000 pounds of contaminants on the Site. Alternative 2, Variation C would leave approximately 134,000 pounds; Alternative 3, Variation A would leave approximately 30,000 pounds; and Alternative 3, Variation B would leave approximately 89,000 pounds of contaminants on the Site.

Alternative 2, Variations A and B provide greater long-term effectiveness than Alternatives 1, 3, or 4, since substantial destruction of COCs in soil and groundwater occurs as the generic treatment system is used at the Site. This benefit to human health and the environment occurs within a relatively short (compared to Alternatives, 1, 3, or 4) 5- to 6-year time frame.

Alternative 3 removes and disposes of from approximately 75,000 to 134,000 pounds of COCs and provides a greater degree of long-term effectiveness than Alternatives 1 and 4.

Alternatives 1 and 4 do not actively treat soils or groundwater at the Site. Alternatives 1 and 4 provide about the same long-term effectiveness since Alternative 1 it uses a physical rather than a hydraulic barrier to confine groundwater to the Lilyblad property, while Alternative 4 maintains hydraulic control over the entire groundwater AOC.

4.5 Management of Short-Term Risks

Short-term risks to human health and the environment would occur if any of the alternatives are implemented. These short-term risks will be present during installation and operation of the generic treatment train and its ancillary equipment (Alternative 2), the demolition of buildings and tank farms and the excavation of soil on Lilyblad property (Alternative 3), the installation of a barrier wall (Alternative 1, Alternative 2, Variation C), or the operation of the hydraulic control system (Alternative 4). Detailed work plans would be developed to identify potential implementation issues, and identify procedures that would be used to resolve these installation and operational issues. Health and Safely Plans would be prepared to address risks associated with working in an area where COCs are known to be present at concentrations above CULs in soil and groundwater.

Active institutional controls and a worker monitoring program will provide additional protection to site workers and the public who may visit the Site.

All variations of Alternative 2 are judged to have more potential short-term risks to human health and the environment than Alternative 1 and Alternative 4, due to the long-term nature of the cleanup activities that will be underway during the 5- to 6-year period of operation (Variations A and B), and/or the implementation of two remediation technologies (Variation C). Alternative 3 is judged to provide about the same degree of short-term risk as Alternative 2, Variations A and B. The short-term risk associated with Alternative 3 would be high during its relatively short (less than 1 year) period of operation.

Alternative 4 would have fewer short-term risks to workers or the environment than any of the other alternatives that were evaluated.

4.6 Technical and Administrative Inplementability

The four alternatives employ technologies that have successfully been used at the Site or at other similar sites. The technologies have been shown to be implementable. Alternative 3 will require the demolition of all (Variation A) or most (Variation B) of the structures on the Lilyblad property. This outcome may not be economically feasible.

Groundwater containing COC concentrations above CULs will exit the Site if Alternative 1, Alternative 2, Variations B and C, and Alternative 3 is implemented. This groundwater is expected to take more than 50 years to reach the Blair Waterway, although short-circuiting by surface drainages could reduce the time for groundwater contaminants to reach the waterway. It is likely that natural attenuation will reduce the concentration of COCs in this groundwater, but it is not possible to determine the amount time it would take to reduce COC concentrations to CULs.

It will be difficult to distinguish the contribution of Site COC concentrations to the Blair Waterway from off-site contaminant sources.

4.7 Restoration Time Frame

Alternative 2, Variation A is expected to meet CULs throughout the Site at the conclusion of its 6-year period of operation. This is the only alternative that is expected to meet cleanup standards for both soil and groundwater in the near term.

Other alternatives will result in achieving only partial compliance with CULs. .Contaminated soil that would remain at the Site after Alternatives 1, 2 (Variations B and C), 3, or 4 were implemented would exceed CULs for a very long period of time. Contaminated groundwater that exits the Site after Alternative 1, Alternative 2 (Variations B and C), and Alternative 3 are implemented is expected to take more than 50 years to reach the Blair Waterway, although short-circuiting by surface drainages could reduce the time for groundwater contaminants to reach the waterway. It is likely that natural attenuation will reduce the concentration of COCs in this groundwater, but it is not possible to determine the amount time it would take to reduce COC concentrations to CULs.

4.8 Conceptual-Level Cost

Conceptual-level (±25 percent) cost estimates and supporting assumptions for the four alternatives are presented in Appendix A.1 to A.4, respectively, and summarized below:

Alternative	Variation	Conceptual Level Cost
1	A	Slurry Wall - $ 3.1 million
		Steel Sheet Pile - $3.3 million
	B	Slurry Wall - $ 3.3 million
		Steel Sheet Pile – 3.4 million
2	A	$4.9 million
	B	$4.4 million
	C	$5.0 million
3	A	$7.7 million
	B	$4.2 million
4		$3.6 million

It should be noted that cost estimates for Alternatives 1 and 4 assume 20- and 30-year durations, respectively, for groundwater treatment system and compliance monitoring. Since restoration timeframes for Alternatives 1 and 4 likely exceed 20 and 30 years, costs for these alternatives would likely increase significantly if groundwater treatment and monitoring are performed until CULs are achieved.

The conceptual level cost estimate for Alternative 3 does not include costs associated with the interruption or termination of businesses operating on the Lilyblad property.

Alternatives 2 and 3 destroy and/or remove and dispose of COCs. The cost per pound destroyed or removed is summarized below:

Alternative	Variation	Cost per Pound
2	A	$30
	B	$27
	C	$165
3	A	$58
	B	$56

4.9 Selection of the Preferred Alternative

Several inferences can be drawn from the information summarized in Table 4.1 and discussed above. For Alternative 1, the conceptual level cost estimate for a continuous barrier is about the same as for the discontinuous barrier, due to the need for additional water to be extracted and treated if a discontinuous barrier is installed. Since a continuous barrier would be more protective, Variation A of Alternative 1 it is the preferred barrier construction option for this Site. Both a slurry wall and a steel sheet pile barrier were judged to be effective. The installation of a continuous slurry wall barrier reduces the risks associated with working near buried utilities, so this approach would reduce short-term risks to human health and the environment during the installation of the barrier.

The conceptual level cost of implementing Alternative 3 varies from about $4.2 to $7.7 million, excluding the cost of business interruption to, or the termination of businesses now operating on the Lilyblad property. Thus implementation of this alternative is likely to cost far in excess of the $4 million available for work at the Site.

The conceptual level cost (±25 percent) of Alternatives 1 ($3.1 million) and 4 ($3.6 million) are within the within the $4 million available for work at the Site. It is likely that these alternatives could be implemented for less than $4 million.

Rigorous planning and budget controls would be needed to implement Alternative 2, Variation B and C for $4 million. Both of these alternative involve the operation of the generic treatment train for an extended period of time.

The conceptual level cost (±25 percent) of Alternative 2, Variation B is $4.4 million. Selection of Variation B has the potential to remove an additional 130,000 pounds of contaminants (mostly TPH) from Site soils than would be removed by Alternative 2, Variation C. The COCs remaining after the implementation of Variation B would be primarily SVOCs, which are not very mobile in the environment.

The generic treatment train would operate for about 5 years to implement Alternative 2, Variation B and for approximately 2 to 3 years to implement Variation C. Variation C would install a slurry wall around the Lilyblad property. The longer period of operation for Variation B would have a greater potential for cost increases due to unforeseen circumstances than the implementation of Variation C.

Of the four alternatives evaluated, Alternative 2, Variation A provides the greatest degree of protection to human health and the environment. The implementation of this variation would take about 6 years. This increased protection comes at an increased cost. The conceptual level cost estimate of $4.9 million for Variation A has a cost range of approximately $3.7 to $6.1 million. Based on cost estimates completed as part of this FFS, it is very likely that the cost of implementing Alternative 2, Variation A would exceed $4 million.

Table 4.1 - Summary of Detailed Analysis of Alternatives

	Alternative 1 -	Alternative 2 - *In Situ* Treamtent			Alternative 3 Excavation and Disposal of Contaminated Soils		Alternative 4 -
Criteria	Containment with Groundwater Controls	Variation A - Meet CULs in AOCs	Variation B - Meet CULs for TPH in AOCs	Variation C - Containment on Lilyblad Property, Treatment off-Property	Variation A - Excavate All Soils on Lilyblad Property	Variation B - Excavate Most Contaminated Soils on Lilybald Property	Hydraulic Control and Monitoring
Overall Protection of Human Health and the Environment	Does not actively address the COCs in soil at the site. About 60 percent of the groundwater within the groundwater AOC falls outside of the barrier. This groundwater will not be treated. The technologies employed by this alternative have been successfully demonstrated at this scale at many locations.	Reduces the concentration of COCs in soil and groundwater to below CULs throughout both the soil and groundwater AOCs. It is the only Alternative evaluated during this FFS that will do so. Expected to destroy or remove more than 160,000 pounds of COCs in soil. Employs technologies that have been demonstratied to be effective at the Site. Short-term risks are managable. Expected to reduce the concentration of COCs to levels below CULs in aporoximately 6 years.	Reduces the concentration of TPH COCs in soil and groundwater to below CULs throughout both the soil and groundwater AOCs. VOC concentrations are also expected to be substantially reduced. Expected to destroy or remove more than 160,000 pounds of COCs in soil. Not as effective in destroying SVOCs as Varaition A. Employs technologies that have been demonstratied to be effective at the Site. Short-term risks are managable. Reduction of the concentration of TPH COCs to levels below CULs is expected to be achieved in aporoximately 5 years.	Actively treats soils and groundwater outside of the barrier installed by Alternative 1. The concentration of COCs in soil and groundwater in these areas after treatment are expected to be at levels below CULs. The groundwater within the barrier will be contained and treated. The soil inside the barrier will not receive any treatment. Thus the CULs established for soil and groundwater within the barrier by Ecology will not be met by this alternative. Expected to destroy or remove more than 30,000 pounds of COCs in soil. Employs technologies that have been demonstratied to be effective. Short-term risks are managable.	Removes and disposes of approximately 135,000 pounds of COCs from the Lilyblad property. Does not address the approximatley 30,000 pounds of COCs in soil outside of the excavation. COCs in groundwater will not be addressed by this Variation. It is expected that CULs will not be met in soil outside the Lilyblad property or in groundwater in the AOC for a very long lperiod of time. Employs technologies that have been demonstrated at similar facilities. Short-term risks are manageable.	Removes approximately 75,000 pounds of COCs from soils within the excavation footprint. Does not address approximately 58,000 pounds of COCs in soil on Lilyblad property or 35,000 lbs of COCs in soil outside of the Lilyblad property. COCs in groundwater within the groundwater AOC will not be addressed. It is expected that CULs will not be met in the unexcavated areas on Lilyblad property, in soil outside the Lilyblad property or in groundwater in the AOC for a very long period of time. Employs technologies that have been demonstrated at similar facilities. Short-term risks are manageable.	Does not use active measures to treat soil and groundwater at the Site. Elevated concentrations of COCs (above CULs) will remain in groundwater and soil within the AOC. The rate of natural attenuation of COCs together with the active treatment of extracted groundwater is not expected to achieve CULs for groundwater on the Site for a very long period of time.
Comply with Cleanup Standards	The concentration of COCs in soil at the site will be avove CULs. About 60 percent of the groundwater within the groundwater AOC falls outside of the barrier. This groundwater will not be treated. Natural attenuation of groundwater outside the barrier is expected to occur.	This evaluation assumes that the implementation of Alternative 2, Variation A will reduce the concentration of COCs in soil and groundwater to below CULs.	It is likely that Variation B will achieve CULs for TPH COCs, is likely to achieve CULs for VOC COCs, and is unlikely to achieve CULs for SVOC COCs for both soil and groundwater.	The concentration of COCs in soil and groundwater in areas outside the barrier after treatment are expected to be below CULs. The soil inside the barrier will not receive any treatment. Thus the CULs established for soil by Ecology will not be met within the barrier by this variation.	Removes and disposes of contaminated soil within the excavation. The concentrations of COCs in soil placed within the excavation will be below CULs. Soil CULs will not be met in areas outside the limits of excavation. COCs in groundwater within the groundwater AOC will not be addressed. Concentrations of COCs in groundwater will remain above CULs on Lilyblad property and adjacent areas of the AOC. Soil contaminants outside of the excavation will continue to contribute COCs to groundwater.	Removes and disposes of contaminated soil on the Lilyblad property in selective locations. The concentrations of COCs in soil in these locations will be below CULs. Soil CULs will not be met in areas outside the limits of excavation. COCs in groundwater within the groundwater AOC will not be addressed by this variation. Concentrations of COCs will remain in groundwater above CULs. Soil contaminants outside of the the selected excavation areas will continue to contribute COCs to the groundwater.	Does not actively address the COCs in soil or groundwater at the Site, so the concentration of COCs in soil and groundwater will exceed the CULs established by Ecology. The natural attenuation of COCs in groundwater together with the active treatment of extracted groundwater will not reduce the concnetration of COCs in groundwater to CULs on the Site for a very long period of time.
Permanence	Does not actively treat the soils at the Site. Treats only a small portion of the contaminants present within the barrier as groundwater is extracted from within the barrier and treated prior to discharge. Provides a significantly lower degree of permanence than is provided by Alternatives 2 and 3. Variation A provides more permanence than Variation B since a complete physical barrier is installed arround the perimeter of the property.	Destroys and/or removes approximately 160,000 pounds of TPH, 3,500 pounds of VOC, and 200 pounds of SVOC COCs. Directly treats all of the groundwater within the groundwater AOC	Destroys and/or removes approximately 160,000 pounds of TPH, and less than 3,500 pounds of VOC COCs. Directly treats all of the groundwater within the groundwater AOC	Destroys and/or removes approximately 30,000 pounds of TPH, 300 pounds of VOC, and 20 pounds of SVOC COCs. Directly treats approximatley 60 percent of the groundwater within the groundwater AOC.	Removes and disposes of approximately 135,000 pounds of COCs in soil within the excavation. During excavation approximately 500,000 gallons of groundwater would be treated prior to discharge. Following remedial construction, 30,000 pounds of soil COCs will remain within the soil AOC. Groundwater COCs will not be addressed by this alternative.	Removes and disposes of approximately 75,000 pounds of COCs in soil from selected locations on the Lilyblad property. During excavation approximately 300,000 gallons of groundwater would be treated prior to discharge. Following remedial construction, approximately 58,000 pounds of COCs in soil will remain on Lilyblad property and approximately 35,000 pounds of soil COCs will remain in neighboring locations within the soil AOC. Groundwater COCs will not be addressed by this Alternative. Variation B is judged to be less permanent than Variation A since it removes 60,000 fewer pounds of COCs from the Site.	Does not actively treat the soils or groundwater at the Site. Treats only a small portion of the contaminants present within the area of hydraulic control as groundwater that is extracted from the Site is treated prior to discharge. Provides less permanence than Alternative 1, which installs a physical barrier to prevent the flow of groundwater from exiting the Lilyblad property; and significantly less permanence than Alternative 2, which actively treats the soil and groundwater within the AOC, or Alternative 3, which removes and disposes of soil within the Lilyblad property.
Effectiveness over the Long Term	The technologies employed by this alternative have been successfully demonstrated at this scale at many locations. Does not actively address the COCs in soils within the soil AOC. These soils will continue to pose potential risks to human health and the environment. Groundwater outside the barrier will not be treated. Significantly less effective over the long term than Alternatives 2 and 3.	Provides for a long-term reduction of contaminant concentrations by means of active remediation. The technologies used are well understood and have been shown to be effective during the pilot-scale tests and Interim Measures that have been conducted at the Site. Provides more long-term effectiveness than any other alternative.	Same as for Variaiton A, except that oxidation of SVOC COCs in soil and groundwater does not occur. Natural attenuation of these COCs would continue. Variation B is likely to be less effective over the long term than Variation A since SVOCs are not destroyed, but be more effective than Alternatives 1, 2 (Variation C), 3, or 4.	The concentration of COCs in the soil and groundwater within the barrier is expected to exceed CULs for an extended period of time. The COCs that will remain in soil and groundwater within the barrier after Alternative 2, Variation C is implemented will continue to naturally attenuate. The progress of natural attenuation will be monitored. Variation C is judged to be less effective over the long-term than Variations A or B of Alternative 2 or Alternative 3.	Provides for a long-term reduction of COC concentrations by means of the active removal and disposal of some contaminated soils on the Lilyblad property. Clean soil placed within the excavation may be recontaminated by COCs in groundwater. The technologies used are well understood. Provides for more long-term effectiveness than Alternatives 1 and 4.	Provides for a long-term reduction of COC concentrations by means of the active removal and disposal of contaminated soils on the Lilyblad property. Clean soil placed within the excavation may be recontaminated by COCs in groundwater.The technologies used are well understood. Provides for more long-term effectiveness than Alternatives 1 and 4.	The technologies employed by this alternative have been successfully demonstrated at this Site. Does not actively address the COCs in soils within the AOC. These soils will continue to pose potential risks to human health and the environment. Provides an equivalent degree of long-term effectiveness as Alternative 1, which installs a physical barrier around the Lilyblad property; and a lesser degree of long-term effectiveness than Alternative 2, which actively destroys COCs in soil and groundwater, and Alternative 3, which excavates and disposes of COCs in soils in an off-site engineered, lined, and monitored facility.
Management of Short Term Risks	Installation of a barrier wall in the vicinity of buried utility lines will expose site workers to the risks inherent in this activity. These risks will be mitigated by developing detailed work plans and health and safety plans.	Short-term risks to human health and the environment would occur if this alternative was implemented. These short-term risks will be present during installation and operation of the generic treatment train and its ancillary equipment. Detailed work plans and health and safety plans will be implemented to reduce risks to site workers and the public during the 6 years that this variation is operational.	Same type of risks as Variation A. Less overall short-term risk than Variation A due to the shorter period of operation of the generic treatment train (5 years for Variation B)	The installation of a barrier wall will expose site workers to additional risks related to the presence of buried utility lines. The duration of Variaiton C (3 years) is shorter than the duration of Variations A and B. Variation C adds the short-term risks associated with the installaion of the barrier. Overall short-term risk of this variation judged to be equivalant to the short-term risks associated with Variation B of Alternative 2.	Excavation and capping of the numerous buried utility lines on the Lilyblad property prior to construction will expose site workers to the risks inherent in this activity. For buildings selected for demolition, the inspection, cleaning, and/or abatement of hazardous materials will expose workers to risk. Large-scale excavation and dewatering of the contaminated site soils will have a high risk of exposure for site worker. These risks will be mitigated by developing detailed work plans and health and safety plans.	Variation B will have the same inherent risks as Variation A, but to a lesser degree due to the reduced amount of demolition and excavation. These risks will be mitigated by developing detailed work plans and health and safety plans.	Minimal risks to human health and the environment will occur if this alternative is selected. Alternative 4 has fewer potential short-term risks to human health and the environment than does Alternatives 1, 2, or 3.
Technical and Administrative Implementability	Slurry wall and sheet pile barrier walls are well developed technologies that could be implemented with a high degree of confidence. Measuring compliance with groundwater CULs at the Blair Waterway will be difficult since groundwater from other source areas will mix with groundwater from the Site prior to discharging to the Blair Waterway.	The generic treatment train has been successfully demonstrated during pilot-scale and Interim Measure operations at the Site. These operations have been conducted with full-scale equipment. The system has been shown to be implementable.	The generic treatment train has been successfully demonstrated during pilot-scale and Interim Measure operations at the Site. These operations have been conducted with full-scale equipment. The system has been shown to be implementable.	The generic treatment train has been successfully demonstrated during pilot-scale and Interim Measure operations at the Site. These operations have been conducted with full-scale equipment. The system has been shown to be implementable. Slurry wall and sheet pile barriers are well developed technologies that could be implemented with a high degree of confidence.	The technologies employed by Variation A are common to the construction industry and with controls to prevent worker exposure, can be readily implemented. Variation A will shut down Pacific Fluids operations. This outcome may not be economically feasible. Significant space on adjacent properties would be required to stockpile excavated soil. Measuring compliance with groundwater CULs at the Blair Waterway will be difficult since groundwater from other source areas will mix with groundwater from the Site prior to discharging to the Blair Waterway.	The technologies employed by Variation B are common to the construction industry and with controls to prevent worker exposure, can be readily implemented. Variation B will shut down Pacific Fluids operations. This outcome may not be economically feasible. Significant space would also be required on adjacent properties to stockpile excavated soil. Measuring compliance with groundwater CULs at the Blair Waterway will be difficult since groundwater from other source areas will mix with groundwater from the Site prior to discharging to the Blair Waterway.	Hydraulic control is a well developed technology that has been used at the Site during the past several years. Groundwater from the Site will mix with groundwater from other source areas once it reaches the storm drain below the Port of Tacoma Road. It will be difficult to isolate the contribution of Site COC concentrations in groundwater to the concentrations of COCs that are present at the point where the storm drains below the Port of Tacoma Road and the Lincoln Avenue Ditch, reach the Blair Waterway.

Table 4.1 - Summary of Detailed Analysis of Alternatives

Criteria	Alternative 1 - Containment with Groundwater Controls	Alternative 2 - *In Situ* Treamtent: Variation A - Meet CULs in AOCs	Alternative 2 - *In Situ* Treamtent: Variation B - Meet CULs for TPH in AOCs	Alternative 2 - *In Situ* Treamtent: Variation C - Containment on Lilyblad Property, Treatment off-Property	Alternative 3 Excavation and Disposal of Contaminated Soils: Variation A - Excavate All Soils on Lilyblad Property	Alternative 3 Excavation and Disposal of Contaminated Soils: Variation B - Excavate Most Contaminated Soils on Lilybald Property	Alternative 4 - Hydraulic Control and Monitoring
Restoration Time Frame	Alternative 1 does not directly reduce the toxicity, mobility, or volume of the COCs contained in soil or groundwater at the Site. The concentration of COCs in soil in the soil AOC or in groundwater below the Sire property, will not be reduced to the CULs established by Ecology by natural attenuation for a very long time..	This evaluation assumes that the implementation of Alternative 2, Variation A will reduce the concentration of COCs in soil and groundwater to below CULs by the conclusion of the approximately 6-year period of operation of the generic treatment system.	Alternative 2, Variation B is likely to reduce the concentration of THP COCs in soil and groundwater to below CULs and to substantially reduce the concentration of VOC COCs by the conclusion of its approximately 5-year period of operation.. The concentrations of SVOC COCs in soil and groundwater are expected to be only slightly reduced since oxidation is not considered by Variation B. The VOCs and SVOCs that are likely to be present in soil and groundwater at the conclusion of Alternative 2, Variation B's period of operation are expected to naturally attenuate. Additional site characterization and modeling would be needed to predict the rate of natural attenuation to more accurately predict future concentrations in soil and groundwater of COCs that may be left behind by Alternative 2, Variation B.	The concentration of COCs in soil and groundwater in areas outside of the barrier after remediation by the generic treatment train should be below CULs at the conclusion of its 2 to 3 years of operation.. The groundwater within the barrier will be contained and treated as groundwater is withdrawn and treated to maintain hydraulic control. The soil inside the barrier will not receive any treatment. Thus the CULs established for soil by Ecology will not be met within the barrier. The COCs that are likely to be present in soil and groundwater within the barrier are expected to naturally attenuate. Additional site characterization and modeling would be needed to predict the rate of natural attenuation to more accurately predict future concentrations in soil and groundwater of COCs that may be left behind by Alternative 2, Variation C.	Will directly remove COCs in soil from within the excavation footprint on the Lilyblad property. CULs for soil within this area will be met once Variation A is implemented. Clean soil placed within the excavation may be recontaminated by COCs in groundwater. COC concentrations in soil and groundwater outside of the excavation footprint will exceed CULs for a very long period of time.	Will directly remove COCs in soil from within the excavation footprint on the Lilyblad property. CULs for most soil within this area will be met once Variation B is implemented. Clean soil placed within the excavation may be recontaminated by COCs in groundwater. COC concentrations in soil and groundwater outside of the excavation footprint will exceed CULs for a very long period of time.	Does not directly reduce the toxicity, mobility, or volume of the COCs contained in soil on the Site. This large 'source term' is expected to supply contaminants to the groundwater for an extended period of time. This time frame is expected to be longer than 30 years. The groundwater treatment system will continue to operate during this period. The concentration of COCs in soil and in groundwater at the Site will exceed the CULs established by Ecology for this Site for a very long period of time.
Conceptual-Level Cost (NPV ±25 percent)	Slurry Wall - $ 3.1 million Steel Sheet Pile - $3.3 million	$4.9 million	$4.4 million	$5.0 million	$ 7.7 million	$ 4.2 million	$3.6 million

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APPENDIX A
COST ESTIMATES FOR ALTERNATIVES 1 THROUGH 4

Table A.1.1 – Alternative 1—Containment with Groundwater Controls

Site: 2244 Port of Tacoma Rd

Location: Tacoma, WA

Phase: Study (-25% to +25%)

Base Year: 2006

Date: November 15, 2005

Description: Four barrier systems will be considered for Alternative 1; A) a slurry wall around the entire perimeter of the Lilyblad property, B) a slury wall around parts of the Lilyblad property judged to contain the most contamination, C) a sheet pile wall around the entire perimeter of the Lilyblad property, and D) a sheet pile wall around parts of the Lilyblad property judged to contain the most contamination. The groundwater retained by the wall will be treated to meet Lilyblad's current NPDES-like requirements. The groundwater treatment system will be based upon the existing treatment system installed by CDM, with modifications as needed to meet the NPDES-like requirements. This alternative will include quarterly groundwater sampling in Year 1, semi-annual groundwater sampling Years 2 through 5, and annual groundwater sampling Years 6 through 20. Soil sampling will occur on a 5-year cycle.

DESCRIPTION	ESTIMATED COST	-25%	+25%	COST TABLE REFERENCE
Slurry wall barrier around entire Lilyblad perimeter	**$ 3,160,027**	$ 2,370,020	$ 3,950,034	A.1.2, A.1.6, A.1.7, A.1.8
Partial slurry wall	**$ 3,335,274**	$ 2,501,456	$ 4,169,093	A.1.3, A.1.6, A.1.7, A.1.8
Sheet pile barrier around entire Lilyblad perimeter	**$ 3,322,787**	$ 2,492,091	$ 4,153,484	A.1.4, A.1.6, A.1.7, A.1.8
Partial sheet pile wall	**$ 3,424,178**	$ 2,568,133	$ 4,280,222	A.1.5, A.1.6, A.1.7, A.1.8

Table A.1.2 - Cost Estimate for Slurry Wall Barrier around Entire Lilyblad Perimeter

Site: 2244 Port of Tacoma Rd

Location: Tacoma, WA

Phase: Study (-25% to +25%)

Base Year: 2006

Description: Alternative 1 Variation A consists of a slurry wall around the entire perimeter of the Lilyblad property. The groundwater retained by the wall will be treated to meet Lilyblad's current NPDES requirements. The groundwater treatment system will be based upon the existing treatment system installed by CDM, with modifications as needed to meet the NPDES-like requirements. This alternative will include quarterly groundwater sampling in Year 1, semi-annual groundwater sampling Years 2 through 5, and annual groundwater sampling Years 6 through 20. Soil sampling will occur on a 5-year cycle.

DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL
Site Prep				
Permits	1	lump sum	$ 5,000.00	$ 5,000
Utility locate	1	lump sum	$ 1,500.00	$ 1,500
Temporary Fencing	1	lump sum	$ 5,000.00	$ 5,000
Concrete Demo & Dispoal	5,900	sq. ft.	$ 3.50	$ 20,650
Site Prep Subtotal				**$ 32,150**
Slurry wall installation				
Contractor mobilization/demobilization	1	lump sum	$ 25,000.00	$ 25,000
Slurry wall barrier	16,500	sq. ft.	$ 16.00	$ 264,000
Soil Testing for Disposal	12	ea.	$ 745.00	$ 8,940
Transport of Contaminated Soil (Non-Hazardous)	366	hours	$ 100.50	$ 36,771
Disposal of Contaminated Soil (Non-Hazardous)	2950	tons	$ 35.00	$ 103,250
Repaving	110	cy	$ 90.00	$ 9,900
Slurry wall installation Subtotal				**$ 447,861**
Total Capital Cost				**$ 480,011**
Other Remediation Costs				
Project management and design	--	--	12%	$ 57,601
Construction oversight	--	--	10%	$ 48,001
Estimated Ecology Oversight Costs	1	LS	$ 30,000.00	$ 30,000
Contingency	--	--	15%	$ 72,002
Other Remediation Cost Subtotal				**$ 207,604**
Total Construction Cost				**$ 687,615**
Groundwater Treatment Costs				
Net Present Value - 20 Years of Operation	1	LS	$ 1,658,054.93	**$ 1,658,055**
Start-up/Upgrade	1	LS	$ 50,000.00	**$ 50,000**
Groundwater Treatment Cost Subtotal				**$ 1,708,055**
Compliance Monitoring Costs (20 Years)				
Year 1 - Quarterly sampling	1	lump sum	$ 97,842.60	$ 97,843
Years 2-5 - Semiannual sampling	1	lump sum	$ 181,845.29	$ 181,845
Years 6-20 - Annual smpling	1	lump sum	$ 259,446.79	$ 259,447
Soil Monitoring on 5 yr Cycle (5 rounds through year 20)	1	lump sum	$ 225,221.87	$ 225,222
Annual Monitoring Cost Subtotal				**$ 764,357**
Total Remediation Cost				**$ 3,160,027**
Minimum (-25%)				**$ 2,370,020**
Maximum (+25%)				**$ 3,950,034**

Notes:
Cost for slurry wall includes excavation 3 foot wide by 15 foot deep around site perimeter (1100 feet), stockpiling of excavated soil, slurry mixing, slurry backfill, and finish to below gravel/pavement grade. Output is assumed to be 100-125 LF/day for slurry wall construction.
Paving costs assumes installation of compact base and concrete.
Assume soil density of 1.4 ton/cy.
Sampling will be for TPH-D extended, TPH-G+BTEX , VOC, PCBs, RCRA 8 metals, and assumes 2 samples for TCLP-metals. Includes sample courier.
From Site to Seattle Transfer Station, approx 70 miles RT. A rate of $100.50/hour for a 3-axle 16 ton dump truck which includes rental, O&M, the operator, and an oiler/spotter for loading.
Disposal of non-hazardous soil based on verbal quote from Rabanco.
Detailed operation costs of groundwater treatment in Table A.1.6.
Compliance Monitoring assumes quarterly monitoring in Year 1, semiannual monitoring Years 2-5, and annual monitoring Years 6-20. Present value callculations in Table A.1.8

Table A.1.3 - Cost Estimate for Partial Slurry Wall Barrier

Site: 2244 Port of Tacoma Rd

Location: Tacoma, WA

Phase: Study (-25% to +25%)

Base Year: 2006

Date: November 15, 2005

Description: Alternative 1 Variation B consists of a partial slurry wall around portions of the Lilyblad property judged to contain the most contamination. The groundwater retained by the wall will be treated to meet Lilyblad's current NPDES requirements. The groundwater treatment system will be based upon the existing treatment system installed by CDM, with modifications as needed to meet the NPDES-like requirements. This alternative will include quarterly groundwater sampling in Year 1, semi-annual groundwater sampling Years 2 through 5, and annual groundwater sampling Years 6 through 20. Soil sampling will occur on a 5-year cycle.

DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL
Site Prep				
Permits	1	lump sum	$ 5,000.00	$ 5,000
Utility locate	1	lump sum	$ 1,500.00	$ 1,500
Temporary Fencing	1	lump sum	$ 5,000.00	$ 5,000
Concrete Demo & Dispoal	3,000	sq. ft.	$ 3.50	$ 10,500
Site Prep Subtotal				**$ 22,000**
Slurry wall installation				
Contractor mobilization/demobilization	1	lump sum	$ 25,000.00	$ 25,000
Slurry wall barrier	8,250	sq. ft.	$ 16.00	$ 132,000
Soil Testing for Disposal	11	ea.	$ 745.00	$ 8,195
Transport of Contaminated Soil (Non-Hazardous)	183	hours	$ 100.50	$ 18,386
Disposal of Contaminated Soil (Non-Hazardous)	1,475	tons	$ 35.00	$ 51,625
Repaving	55	cy	$ 90.00	$ 4,950
Slurry wall installation Subtotal				**$ 240,156**
Total Capital Cost				**$ 262,156**
Other Remediation Costs				
Project management and design	-	-	12%	$ 31,459
Construction oversight	-	-	10%	$ 26,216
Estimated Ecology Oversight Costs	1	LS	15,000	$ 15,000
Contingency	-	-	15%	$ 39,323
Other Remediation Cost Subtotal				**$ 111,998**
Total Construction Cost				**$ 374,153**
Groundwater Treatment Costs				
Net Present Value - 20 Years of Operation	1	lump sum	$ 2,146,764	$ 2,146,764
Start-up/Upgrade	1	lump sum	$ 50,000	$ 50,000
Groundwater Treatment Cost Subtotal				**$ 2,196,764**
Compliance Monitoring Costs				
Year 1 - Quarterly sampling	1	lump sum	$ 97,843	$ 97,843
Years 2-5 - Semiannual sampling	1	lump sum	$ 181,845	$ 181,845
Years 6-20 - Annual smpling	1	lump sum	$ 259,447	$ 259,447
Soil Monitoring on 5 yr Cycle (5 rounds through year 20)	1	lump sum	$ 225,222	$ 225,222
Annual Monitoring Cost Subtotal				**$ 764,357**
Total Remediation Cost				**$ 3,335,274**
Minimum (-25%)				**$ 2,501,456**
Maximum (+25%)				**$ 4,169,093**

Notes:
Cost for slurry wall includes excavation 3 foot wide by 15 foot deep around the northeast and southwest corners of the property (550 feet total lenght for the two sections), stockpiling of excavated soil, slurry mixing, slurry backfill, and finish to below gravel/pavement grade. Output is assumed to be 100-125 LF/day for slurry wall construction.
Paving costs assumes installation of compact base and concrete.
Assume soil density of 1.4 ton/cy.
Sampling will be for TPH-D extended, TPH-G+BTEX , VOC, PCBs, RCRA 8 metals, and assumes 2 samples for TCLP-metals. Includes sample courier.
From Site to Seattle Transfer Station, approx 70 miles RT. A rate of $100.50/hour for a 3-axle 16 ton dump truck which includes rental, O&M, the operator, and an oiler/spotter for loading. Disposal of non-hazardous soil based on verbal quote from Rabanco.
Detailed operation costs of groundwater treatment in Table A.1.6.
Compliance Monitoring assumes quarterly monitoring in Year 1, semiannual monitoring Years 2-5, and annual monitoring Years 6-20. Present value callculations in Table A.1.8.

Table A.1.4 - Cost Estimate for Sheet Pile Barrier around Entire Lilyblad Perimeter

Site: 2244 Port of Tacoma Rd

Location: Tacoma, WA

Phase: Study (-25% to +25%)

Base Year: 2006
Date: November 15, 2005

Description: Alternative 1 Variation C consists of a sheet pile wall around the entire perimeter of the Lilyblad property. The groundwater retained by the wall will be treated to meet Lilyblad's current NPDES requirements. The groundwater treatment system will be based upon the existing treatment system installed by CDM, with modifications as needed to meet the NPDES-like requirements. This alternative will include quarterly groundwater sampling in Year 1, semi-annual groundwater sampling Years 2 through 5, and annual groundwater sampling Years 6 through 20. Soil sampling will occur on a 5-year cycle.

DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL
Site Prep				
Permits	1	lump sum	$ 5,000	$ 5,000
Utility locate	1	lump sum	$ 1,500	$ 1,500
Temporary Fencing	1	lump sum	$ 5,000	$ 5,000
Concrete Demo & Dispoal	4800	sq.ft.	$ 4	$ 16,800
Site Prep Subtotal				**$ 28,300**
Sheet pile installation				
Contractor mobilization/demobilization	1	lump sum	$ 25,000.00	$ 25,000
Sheet pile barrier	1,100	LF	$ 467.00	$ 513,700
Utility Work	1	lump sum	$ 15,000.00	$ 15,000
Repaving	90	cy	$ 90.00	$ 8,100
Soil Testing for Disposal	4	ea.	$ 746.00	$ 2,984
Transport of Contaminated Soil (Non-Hazardous)	15	hours	$ 100.50	$ 1,504
Disposal of Contaminated Soil (Non-Hazardous)	121	tons	$ 35.00	$ 4,226
Sheet pile installation Subtotal				**$ 570,515**
Total Capital Cost				**$ 598,815**
Other Remediation Costs				
Project management and design	-	-	12%	$ 71,858
Construction oversight	-	-	10%	$ 59,881
Estimated Ecology Oversight Costs	1	LS	30,000	$ 30,000
Contingency	-	-	15%	$ 89,822
Other Remediation Cost Subtotal				**$ 251,561**
Total Construction Cost				**$ 850,376**
Groundwater Treatment Costs				
Net Present Value - 20 Years of Operation	1	lump sum	$ 1,658,055	$ 1,658,055
Start-up/Upgrade	1	lump sum	$ 50,000	$ 50,000
Groundwater Treatment Cost Subtotal				**$ 1,708,055**
Compliance Monitoring Costs				
Year 1 - Quarterly sampling	1	lump sum	$ 97,843	$ 97,843
Years 2-5 - Semiannual sampling	1	lump sum	$ 181,845	$ 181,845
Years 6-20 - Annual smpling	1	lump sum	$ 259,447	$ 259,447
Soil Monitoring on 5 yr Cycle (5 rounds through year 20)	1	lump sum	$ 225,222	$ 225,222
Annual Monitoring Cost Subtotal				**$ 764,357**
Total Remediation Cost				**$ 3,322,787**
Minimum (-25%)				**$ 2,492,091**
Maximum (+25%)				**$ 4,153,484**

Notes:
Cost for sheet pile barrier includes asphalt/concrete removal (if applicable), cost of steel sheet piling including seam welding and interlock sealing, and driving piling. Total lenght of sheet pile barrier is 1100 feet.
Utility work includes uncovering, breaking and capping, and reconnecting following sheet pile installation and recovering. Number may be conservative based on actual loaction and number of utilities.
Paving costs assumes installation of compact base and concrete.
From Site to Seattle Transfer Station, approx 70 miles RT. A rate of $100.50/hour for a 3-axle 16 ton dump truck which includes rental, O&M, the operator, and an oiler/spotte for loading. Disposal of non-hazardous soil based on verbal quote from Rabanco.
Assume soil density of 1.4 ton/cy.
Detailed operation costs of groundwater treatment in Table A.1.6.
Compliance Monitoring assumes quarterly monitoring in Year 1, semiannual monitoring Years 2-5, and annual monitoring Years 6-20. Present value callculations in Table A.1.8.

Table A.1.5 - Cost Estimate for Partial Sheet Pile Barrier

Site: 2244 Port of Tacoma Rd

Location: Tacoma, WA

Phase: Study (-25% to +25%)

Base Year: 2006

Date: November 15, 2005

Description: Alternative 1 Variation D consists of a partial sheet pile wall around selected portions of the Lilyblad property judged to contain the most contamination. The groundwater retained by the wall will be treated to meet Lilyblad's current NPDES requirements. The groundwater treatment system will be based upon the existing treatment system installed by CDM, with modifications as needed to meet the NPDES-like requirements. This alternative will include quarterly groundwater sampling in Year 1, semi-annual groundwater sampling Years 2 through 5, and annual groundwater sampling Years 6 through 20. Soil sampling will occur on a 5-year cycle.

DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL
Site Prep				
Permits	1	lump sum	$ 5,000	$ 5,000
Utility locate	1	lump sum	$ 1,500	$ 1,500
Temporary Fencing	1	lump sum	$ 5,000	$ 5,000
Concrete Demo & Dispoal	2450	sq.ft.	$ 4	$ 8,575
Site Prep Subtotal				**$ 20,075**
Sheet pile installation				
Contractor Mobilization/demobilization	1	lump sum	$ 25,000.00	$ 25,000
Sheet pile barrier	550	LF	$ 467.00	$ 256,850
Utility Work	1	lump sum	$ 15,000.00	$ 15,000
Repaving	45	cy	$ 90.00	$ 4,083
Soil Testing for Disposal	4	ea.	$ 746.00	$ 2,984
Transport of Contaminated Soil (Non-Hazardous)	8	hours	$ 100.50	$ 802
Disposal of Contaminated Soil (Non-Hazardous)	64	tons	$ 35.00	$ 2,254
Sheet pile installation Subtotal				**$ 306,974**
Total Capital Cost				**$ 327,049**
Other Remediation Costs				
Project management and design	--	--	12%	$ 39,246
Construction oversight	--	--	10%	$ 32,705
Estimated Ecology Oversight Costs	1	LS	15,000	$ 15,000
Contingency	--	--	15%	$ 49,057
Other Remediation Cost Subtotal				**$ 136,008**
Total Construction Cost				**$ 463,057**
Groundwater Treatment Costs				
Net Present Value - 20 Years of Operation	1	lump sum	$ 2,146,764	$ 2,146,764
Start-up/Upgrade	1	lump sum	$ 50,000	$ 50,000
Groundwater Treatment Cost Subtotal				**$ 2,196,764**
Compliance Monitoring Costs				
Year 1 - Quarterly sampling	1	lump sum	$ 97,842.60	$ 97,842.60
Years 2-5 - Semiannual sampling	1	lump sum	$ 181,845.29	$ 181,845.29
Years 6-20 - Annual smpling	1	lump sum	$ 259,446.79	$ 259,446.79
Soil Monitoring on 5 yr Cycle (5 rounds through year 20)	1	lump sum	$ 225,221.87	$ 225,221.87
Annual Monitoring Cost Subtotal				**$ 764,357**
Total Remediation Cost				**$ 3,424,178**
Minimum (-25%)				**$ 2,568,133**
Maximum (+25%)				**$ 4,280,222**

Notes:
Cost for partial sheet pile barrier includes asphalt/concrete removal (if applicable), cost of steel sheet piling including seam welding and interlock sealing, and driving piling. Total lenght of sheet pile barrier is 550 total linear feet at the northeast and southwest corners of the property .
Utility work includes uncovering, breaking and capping, and reconnecting following sheet pile installation and recovering. Number may be conservative based on actual loaction and number of utilities.
Paving costs assumes installation of compact base and concrete.
From Site to Seattle Transfer Station, approx 70 miles RT. A rate of $100.50/hour for a 3-axle 16 ton dump truck which includes rental, O&M, the operator, and an oiler/spotter for loading. Disposal of non-hazardous soil based on verbal quote from Rabanco.
Assume soil density of 1.4 ton/cy.
Detailed operation costs of groundwater treatment in Table A.1.6.
Compliance Monitoring assumes quarterly monitoring in Year 1, semiannual monitoring Years 2-5, and annual monitoring Years 6-20. Present value callculations in Table A.1.8.

Table A.2.1 - COST ESTIMATE FOR ALTERNATIVE 2 - VARIATION A
***In Situ* Treatment Without Natural Attenuation**

	Variation A - Operate Until CULs are Met			Adjustments Made to Base Case to Prepare This Estimate
	Terra Vac Base Case	This Estimate	Duration	
Installation of the Treatment Train				
Labor				
Project Management	$136,190	$375,000		Add 24 hours/month for reporting to and meeting with Ecology
Other	$215,263	$215,000		during the 6 year duration of the project at $140/hour = about $240,000
Subtotal	$351,453	$590,000		
Subcontractors				
Drilling	$37,375	$37,000		
Trenching	$113,517	$110,000		
Perculation System	$438,840	$440,000		
Other	$45,645	$45,000		
Subtotal	$635,377	$632,000		
Rental and Equipment	$32,760	$35,000		
Supplies				
PVC Pipe and Fittings	$55,200	$55,000		
DVE Process Controls	$23,161	$25,000		
BioVac Process Controls	$51,129	$50,000		
OxyVac Process Controls	$62,928	$65,000		
Other	$81,472	$80,000		
Subtotal	$273,890	$275,000		
Performance Monitoring				
Sampling and Analysis	$14,700	$15,000		
Miscellaneous	$20,790	$20,000		
Installation Subtotal	$1,328,970	$1,567,000		
BioVac Operations per Month				
Monthly Labor	$17,265	$24,000		Increase labor hours from 235 to 320 hours/month at $75/hr
Subcontractors	$0	$0		
Equipment Rentals	$2,630	$2,500		
Supplies	$7,757	$8,000		
Performance Monitoring	$1,715	$2,000		
Other Costs	$480	$500		
Subtotal Per Month	$29,847	$37,000	59	
Subtotal for Period of Operation	$1,760,973	$2,183,000		
OxyVac Operations per Month				
Monthly Labor	$27,445	$31,000		Increase labor hours from 314 to 360/mo at $86/hr
Subcontractors	$0	$0		
Equipment Rentals	$2,630	$2,500		
Supplies	$15,798	$16,000		
Performance Monitoring	$3,020	$3,000		
Other Costs	$340	$500		
Subtotal Per Month	$49,233	$53,000	13	
Subtotal for Period of Operation	$640,029	$689,000		
Sampling and Reporting (1)				
Labor	$48,146			
Subcontractors	$15,525			
Rental Equipment	$0			
Supplies	$0			
Sampling and Analysis	$107,525			
Other Costs	$6,894			
Subtotal Sampling and Reporting	$178,090	$368,000		1) Add five additional rounds of compliance sampling in years 1- 5 at $25,000 per year for a NPV of (i=3, pvf=4.58) = $115,000. Assumes that CULs will be met at end of year 6 and that monitoring thereafter will not be needed 2) Add 10 monthly reports for years 2 - 6 at $ 1500/report = $75,000
Demobilization	$85,000	$85,000		
TOTAL ESTIMATED COST (+/- 25 percent)	$3,993,062	$4,892,000		

Notes
(1) Terra Vac's approach to sampling is summarized in Terra Vac 2005 (Sections 8.2 and 8.3).
Includes quarterly groundwater samples wtihin the AOC for years 1-6. Confirmation samples at end of operations

Table A.2.2 - COST ESTIMATE FOR ALTERNATIVE 2 - VARIATION B
***In Situ* Bioremediation With Natural Attenuation**

	Variation B - Operate Until TPH CULs are Met			Adjustments Made to Base Case to Prepare This Estimate
	Terra Vac Base Case	This Estimate	Duration	
Installation of the Treatment Train				
Labor				
Project Management	$136,190	$335,000		Add 24 hours/month for reporting to and meeting with Ecology
Other	$215,263	$215,000		during the 5 year duration of the project at $140/hour = about $200,000
Subtotal	$351,453	$550,000		
Subcontractors				
Drilling	$37,375	$37,000		
Trenching	$113,517	$110,000		
Perculation System	$438,840	$440,000		
Other	$45,645	$45,000		
Subtotal	$635,377	$632,000		
Rental and Equipment	$32,760	$35,000		
Supplies				
PVC Pipe and Fittings	$55,200	$55,000		
DVE Process Controls	$23,161	$25,000		
BioVac Process Controls	$51,129	$50,000		
OxyVac Process Controls	$62,928	$0		Not needed for this Alternative
Other	$81,472	$80,000		
Subtotal	$273,890	$210,000		
Performance Monitoring				
Sampling and Analysis	$14,700	$15,000		
Miscellaneous	$20,790	$20,000		
Installation Subtotal	$1,328,970	$1,462,000		
BioVac Operations per Month				
Monthly Labor	$17,265	$24,000		Increase labor hours from 235 to 320 hours/month at $75/hr
Subcontractors	$0	$0		
Equipment Rentals	$2,630	$2,500		
Supplies	$7,757	$8,000		
Performance Monitoring	$1,715	$2,000		
Other Costs	$480	$500		
Subtotal Per Month	$29,847	$37,000	59	
Subtotal for Period of Operation	$1,760,973	$2,183,000		
OxyVac Operations per Month				Not needed for Variation B
Monthly Labor	$27,445			
Subcontractors	$0			
Equipment Rentals	$2,630			
Supplies	$15,798			
Performance Monitoring	$3,020			
Other Costs	$340			
Subtotal Per Month	$49,233	$0	0	
Subtotal for Period of Operation		$0		
Sampling and Reporting (1)				
Labor	$48,146			
Subcontractors	$15,525			
Rental Equipment	$0			
Supplies	$0			
Sampling and Analysis	$107,525			
Other Costs	$6,894			
Subtotal Sampling and Reporting	$178,090	$726,000		1) Reduce base estimate by 10 percent to $160,000 2) Add 19 additional rounds of compliance sampling in years 1- 4, 6 - 20 at $25,000 per year for a NPV of (n=19, I=3 %,pvf=14.324) = $358,000. Assumes that CULs for SVOCs will not be met at end of year 5 and that monitoring thereafter will be needed; 3) Add 10 monthly reports for years 2-5 at $1500/report = $60,000. 4) Add soil sampling at years 5,10, 15 and 20 (I=3%, $59,000 per round) = $148,000
Demobilization	$85,000	$75,000		No Oxidation equipment to demobilize
TOTAL ESTIMATED COST (+/- 25 percent)	$3,353,033	$4,446,000		

Notes
(1) Terra Vac's approach to sampling is summarized in Terra Vac 2005 (Sections 8.2 and 8.3).
Includes quarterly groundwater samples within the AOC for years 1-5. Confirmation samples at end of operations

Table A.2.3 - Cost Estimate for Alternative 2 - Variation C
Containment With *In Situ* Treatment and Natural Attenuation

	Variation C - Containment Plus Insutu Treatment			Adjustments to Base Case Made to Prepare This Estimate
	Terra Vac Base Case	This Estimate	Duration	
Installation of the Treatment Train				
Labor				
Project Management	$136,190	$80,000		Variation C has a total duration of about 32 months, rather than the 72 months of Varaition A
Other	$215,263	$130,000		or 59 months of Variation B. Reduce Base Case labor by 40 percent to $210,000.
Subtotal	$351,453	$320,000		Add 24 hours/month for project management and metings with and reporting to Ecology at $140/hour = $107,000
Subcontractors				
Drilling	$37,375	$20,000		Variation C only treats areas outside of the barrier around the Lilyblad property. Two treatment trains will be
Trenching	$113,517	$55,000		used rather than 4 as for Variations A and C. Reduce need for trenching/infiltration by 50 percent
Perculation System	$438,840	$220,000		
Other	$45,645	$25,000		
Subtotal	$635,377	$320,000		
Rental and Equipment	$32,760	$35,000		
Supplies				
PVC Pipe and Fittings	$55,200	$30,000		Variation C only treats areas outside of the barrier around the Lilyblad property. Two treatment trains will be
DVE Process Controls	$23,161	$15,000		used rather than 4 as for Variations A and C. Reduce need for piping and conrols by 50 percent
BioVac Process Controls	$51,129	$25,000		
OxyVac Process Controls	$62,928	$30,000		
Other	$81,472	$40,000		
Subtotal	$273,890	$140,000		
Performance Monitoring				
Sampling and Analysis	$14,700	$15,000		
Miscellaneous	$20,790	$20,000		
Installation Subtotal	$1,328,970	$850,000		
BioVac Operations per Month				
Monthly Labor	$17,265	$18,000		
Subcontractors	$0	$0		
Equipment Rentals	$2,630	$2,500		
Supplies	$7,757	$4,000		Variation C only treats areas outside of the barrier around the Lilyblad property. Two treatment trains will be
Performance Monitoring	$1,715	$2,000		used rather than 4 as for Variations A and C. Reduce need for supplies by 50 percent
Other Costs	$480	$500		
Subtotal Per Month	$29,847	$27,000	20	
Subtotal for Period of Operation	$596,940	$540,000		
OxyVac Operations per Month				
Monthly Labor	$27,445	$27,000		
Subcontractors	$0			
Equipment Rentals	$2,630	$2,500		
Supplies	$15,798	$8,000		Variation C only treats areas outside of the barrier around the Lilyblad property. Two treatment trains will be
Performance Monitoring	$3,020	$3,000		used rather than 4 as for Variations A and C. Reduce need for supplies by 50 percent
Other Costs	$340	$500		
Subtotal Per Month	$49,233	$41,000	12	
Subtotal for Period of Operation	$590,796	$492,000		
Sampling and Reporting (1)				
Labor	$48,146			
Subcontractors	$15,525			
Rental Equipment	$0			
Supplies	$0			
Sampling and Analysis	$107,525			
Other Costs	$6,894			
Subtotal Sampling and Reporting	$178,090	$625,000		1) Reduces Terra Vac cost estimate by 50 percent (to $90,000) since duration is reduced from about 72 months to about 30 months. 2) Add 20 additional rounds of compliance sampling
Demobilization	$85,000	$75,000		in years 1- 20 at $25,000 per year for a NPV of (n=20, I=3%, pvf=14.877) = $372,000. 3) Add 10 monthly reports for year 2 at $1500/report = $15,000. Add soil sampling at years 5, 19, 15 and 20 (I=3%, $59,000/round) = $148,000.
Installation of a Barrier Around the Lilyblad Property	$0	$2,400,000		Assumes barrier around the entire Lilyblad property.
TOTAL ESTIMATED COST (+/- 25 percent)	$2,779,796	$4,982,000		

Notes
(1) Terra Vac's approach to sampling is summarized in Terra Vac 2005 (Sections 8.2 and 8.3).
Includes quarterly groundwater samples on within the AOC for years 1-2. Confirmation samples at end of operations.

Table A.3.1 - Variation A - Demolition of All Lilyblad Structures and Excavation and Disposal of All Contaminated Soils

Site: Lilyblad Petroleum Inc.
Location: Tacoma, Washington
Phase: Feasibility Study (+/-25%)
Base Year: 2007

Description: Demoliton of all structures on Lilyblad property and excavation and disposal of all underlying contaminated soils.

CAPITAL COSTS:

DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL	SOURCE	NOTES
Site Preparation						
Permits	1	LS	5,000	$ 5,000	Previous Project Experience	SEPA Permit
HBM Survey	1	LS	25,000	$ 25,000	Previous Project Experience	
Mobilization	5%	LS	-	$ 233,020	Previous Project Experience	5% of capital costs
Utilities	1	LS	1,500	$ 1,500	Previous Project Experience	utility locate
Security	1	LS	5,000	$ 5,000	Previous Project Experience	Security fencing for equipment compound
SUBTOTAL				$ 269,520		
HBM Abatement						
Asbestos	1	LS	0	$ -	Site Owner	No asbestos on-site. Heated tanks not wrapped in asbestos).
Lead Paint	1	LS	0	$ -	Site Owner	No lead paint on-site (warehouse not painted).
PCBs	1	LS	0	$ -	Site Owner	No PCBs on-site.
Equipment Cleaning						
North Tank Farm	17	tanks	2000	$ 34,000	Certified Cleaning Co.	Price ranges from $500 to $2000 depending on contents
West Tank Farm	23	tanks	1500	$ 34,500	Certified Cleaning Co.	Price ranges from $500 to $2000 depending on contents
Loading Rack	1	LS	15,000	$ 15,000	Certified Cleaning Co.	
Drum Filling Station	1	LS	15,000	$ 15,000	Certified Cleaning Co.	
Lab/Boiler Bldg and Maintenance Trailer	1	LS	20,000	$ 20,000	Certified Cleaning Co.	
Lab/Boiler Bldg ASTs	6	tanks	2000	$ 12,000	Certified Cleaning Co.	Price ranges from $500 to $2000 depending on contents
Demolition						
Warehouse/Administration Building	20,000	SF	3.00	$ 60,000	William B. Dickson Company	Includes disposal of construction debris & demo of utilities.
North Tank Farm	17	tanks	5,000	$ 85,000	William B. Dickson Company	Includes disposal of construction debris & demo of utilities.
West Tank Farm	23	tanks	5,000	$ 115,000	William B. Dickson Company	Includes disposal of construction debris & demo of utilities.
Loading Rack	600	SF	5.00	$ 3,000	William B. Dickson Company	Includes disposal of construction debris & demo of utilities.
Drum Filling Station	600	SF	5.00	$ 3,000	William B. Dickson Company	Includes disposal of construction debris & demo of utilities.
Lab/Boiler Bldg and Maintenance Trailer	900	SF	3.50	$ 3,150	William B. Dickson Company	Includes disposal of construction debris & demo of utilities.
Lab/Boiler Bldg ASTs	6	tanks	6,000	$ 36,000	William B. Dickson Company	Includes disposal of construction debris & demo of utilities.
Water Tank	1	tank	6,000	$ 6,000	William B. Dickson Company	Includes disposal of construction debris & demo of utilities.
Stormwater Treatment Plant & ASTs	1	LS	10,000	$ 10,000	William B. Dickson Company	Includes disposal of construction debris & demo of utilities.
Concrete Demolition	52,272	SF	3.50	$ 182,952	RS Means	Includes disposal of construction debris & demo of utilities.
Excavation						
Sheetpile Installation	1200	lf	485.10	$ 582,123	RS Means	15' depth. Drive, extract & salvage
Unsaturated Soils	28875	CY	2.25	$ 64,969	RS Means	1.5 CY crawler mtd. Backhoe
Saturated Soils	9625	CY	2.70	$ 25,988	RS Means	As above plus 20% surcharge for handling wet soils
Excavation Dewatering	1	LS	10,000	$ 10,000		Sump Pump and Temporary Piping
Soils Dewatering	1	LS	25,000	$ 25,000		HDPE Liner, French Drain, Sump Pump, and Temporary Piping
Water Treatment	679,960	Gal	0.13	$ 91,165.88	Current Treatment Costs	Volume of water initially in excavation plus 2 gpm pumped for 6 weeks for GW containment
Confirmation Sampling	84	Samples	742.32	$ 62,355	ARI Labs, ENA Courier	
Soils Transport	7684	Hr	100.50	$ 772,198	Previous Experience	From Site to Seattle Transfer Station, approx 70 miles RT
Soils Disposal	53900	tons	35.00	$ 1,886,500	Rabanco	1.4 tons/cy, includes transport from transfer station to landfill
Structural Fill - Materials	38,500	CY	10.00	$ 385,000	RS Means	
Structural Fill - Placement	38,500	CY	2.00	$ 77,000	RS Means	75HP Dozer or Loader, Common Earth, 150' haul from stockpile
Structural Fill - Compaction	38,500	CY	1.00	$ 38,500	RS Means	12" lifts, 24" wide vibrating roller, 2 passes
Regrading	10,000	SY	0.50	$ 5,000	RS Means	Course Grading
SUBTOTAL				$ 4,660,399		
Compliance Monitoring Costs (20 Years)					Refer to Appedices A.1.7 and A.1.8	
Groundwater monitoring						
Year 1 - Quarterly sampling	1	LS	$ 97,843	$ 97,843		
Years 2-5 - Semiannual sampling	1	LS	$ 181,845	$ 181,845		
Years 5-20 - Annual sampling	1	LS	$ 259,447	$ 259,447		
Soil monitoring on 5 yr Cycle (5 rounds in 20 yrs)	1	LS	$ 225,222	$ 225,222		
TOTAL MONITORING COSTS				$ 764,357		
Project management and design	12%			$ 591,590		Includes Health and Safety Plan
Construction oversight	10%			$ 492,992		Includes startup labor
Estimated Ecology Oversight Costs	1	LS	50,000	$ 50,000		Subject to revision by Ecology
Contingency	15%			$ 902,175		10% Scope + 5% bid
TOTAL CAPITAL COST				**$ 7,731,000**		
Contingency Capital Cost Range (+/- 25%)			**$ 5,798,250**	**to**	**$9,663,750**	

Notes
Costs are +/-25% FS-level estimates. They do not represent a bid to do the work.
Costs of putting Lilyblad Petroleum Inc. out of business are beyond the scope of this project and are not included in this estimate.
Assumptions
Room for dewatering and treatment system components on adjacent site(s)
Building replacement not within the scope of this project.

Table A.3.2 - Variation B - Demolition of Most Lilyblad Structures and Excavation and Disposal of Most Contaminated Soils

Site: Lilyblad Petroleum Inc.
Location: Tacoma, Washington
Phase: Feasibility Study (+/- 25%)
Base Year: 2007

Description: Demoliton of structures in hot spot areas and excavation and disposal of underlying contaminated soils.

CAPITAL COSTS:

DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL	SOURCE	NOTES
Site Preparation						
Permits	1	LS	5,000	$ 5,000	Previous Project Experience	SEPA Permit
HBM Survey	1	LS	15,000	$ 15,000	Previous Project Experience	
Mobilization	5%	LS	-	$ 115,965	Previous Project Experience	5% of capital costs
Utilities	1	LS	1,500	$ 1,500	Previous Project Experience	utility locate
Security	1	LS	2,000	$ 2,000	Previous Project Experience	Security fencing for equipment compound
SUBTOTAL				$ 139,465		
HBM Abatement						
Asbestos	1	LS	0	$ -	Site Owner	No asbestos on-site. Heated tanks not wrapped in asbestos).
Lead Paint	1	LS	0	$ -	Site Owner	No lead paint on-site (warehouse not painted).
PCBs	1	LS	0	$ -	Site Owner	No PCBs on-site.
Equipment Cleaning						
North Tank Farm	17	tanks	2000	$ 34,000	Certified Cleaning Co.	Price ranges from $500 to $2000 depending on contents
West Tank Farm	23	tanks	1500	$ 34,500	Certified Cleaning Co.	Price ranges from $500 to $2000 depending on contents
Loading Rack	1	LS	15,000	$ 15,000	Certified Cleaning Co.	
Drum Filling Station	1	LS	15,000	$ 15,000	Certified Cleaning Co.	
Demolition						
Mixing Rooms	6,400	SF	3.00	$ 19,200	William B. Dickson Company	Includes disposal of construction debris & demo of utilities.
North Tank Farm	17	tanks	5,000	$ 85,000	William B. Dickson Company	Includes disposal of construction debris & demo of utilities.
West Tank Farm	23	tanks	5,000	$ 115,000	William B. Dickson Company	Includes disposal of construction debris & demo of utilities.
Loading Rack	600	SF	5.00	$ 3,000	William B. Dickson Company	Includes disposal of construction debris & demo of utilities.
Drum Filling Station	600	SF	5.00	$ 3,000	William B. Dickson Company	Includes disposal of construction debris & demo of utilities.
Concrete Demolition	16,500	SF	3.50	$ 57,750	RS Means	Includes disposal of construction debris & demo of utilities.
Excavation						
Sheetpile Installation	860	lf	485.10	$ 417,188	RS Means	15' depth. Drive, extract & salvage
Unsaturated Soils	12525	CY	2.25	$ 28,181	RS Means	1.5 CY crawler mtd. Backhoe
Saturated Soils	4175	CY	2.70	$ 11,273	RS Means	As above plus 20% surcharge for handling wet soils
Excavation Dewatering	1	LS	10,000	$ 10,000		Sump Pump and Temporary Piping
Soils Dewatering	1	LS	25,000	$ 25,000		HDPE Liner, French Drain, Sump Pump, and Temporary Piping
Water Treatment	300000	Gal	0.13	$ 40,222.60	Current Treatment Costs	Volume of water initially in excavation, plus 2 gpm pumped for 3 weeks for GW containment
Confirmation Sampling	45	Samples	745.33	$ 33,540	ARI Labs, ENA Courier	
Soils Transport	3333	Hr	100.50	$ 334,953	Previous Experience	From Site to Seattle Transfer Station, approx 70 miles RT
Soils Disposal	23380	tons	35.00	$ 818,300	Rabanco	1.4 tons/cy, includes transport from transfer station to landfill
Structural Fill - Materials	16,700	CY	10.00	$ 167,000	RS Means	
Structural Fill - Placement	16,700	CY	2.00	$ 33,400	RS Means	75HP Dozer or Loader, Common Earth, 150' haul from stockpile
Structural Fill - Compaction	16,700	CY	1.00	$ 16,700	RS Means	12" lifts, 24" wide vibrating roller, 2 passes
Regrading	4,167	SY	0.50	$ 2,084	RS Means	Course Grading
SUBTOTAL				$ 2,319,291		

ANNUAL OPERATING AND MONITORING COSTS					Refer to Appedices A.1.7 and A.1.8	
Year 1 - Quarterly sampling	1	LS	$ 97,843	$ 97,843		
Years 2-5 - Semiannual sampling	1	LS	$ 181,845	$ 181,845		
Years 5-20 - Annual sampling	1	LS	$ 259,447	$ 259,447		
Soil monitoring on 5 yr Cycle (5 rounds in 20 yrs)	1	LS	$ 225,222	$ 225,222		
TOTAL OPERATING AND MONITORING COST				**$ 764,357**		
Project management and design	12%			$ 295,051		Includes Health and Safety Plan
Construction oversight	10%			$ 245,876		Includes startup labor
Estimated Ecology Oversight Costs	1	LS	30,000	$ 30,000		Subject to revision by Ecology
Contingency	15%			$ 449,952		10% Scope + 5% bid
TOTAL CAPITAL COST				**$ 4,244,000**		
Contingency Capital Cost Range (+/- 25%)			**$ 3,183,000**	**to**	**$5,305,000**	

Notes
Costs are +/-25% FS-level estimates. They do not represent a bid to do the work.
Costs of putting Lilyblad Petroleum Inc. out of business are beyond the scope of this project and are not included in this estimate.
Assumptions
Room for dewatering and treatment system components on adjacent site(s)
Building replacement not within the scope of this project.

Table A.4 Cost Estimate for Alternative 4

Groundwater Treatment	QUANTITY	UNIT	UNIT COST	Cost
Present Cost				
Start-up/Upgrade	1	lump sum	$ 50,000	$ 50,000
Recurring Costs				
Personnel				
Operator	1014	hr	$ 50	$ 50,700
Filter Change-out, labor and equipment	12	ea	$ 1,000	$ 12,000
Activated Carbon Replace/Recharge/disposal	10	ea	$ 1,500	$ 15,000
Operation and Maintenance Costs	12	ea	$ 1,000	$ 12,000
NPDES permitting costs - see BU.5	12	ea	$ 4,270	$ 51,240
Total Recurring Annual Cost				$ 140,940
Present Value Factor				19.60
Recurring Net Present Value (30 years)				$ 2,762,424
Groundwater Treatment Net Present Value (Recurring NPV)				**$ 2,812,424**
Compliance Monitoring Costs - Net Present Value				
Groundwater				
Year 1 - Quarterly sampling	1	lump sum	$ 97,843	$ 97,843
Years 2-5 - Semiannual sampling	1	lump sum	$ 181,845	$ 181,845
Years 6-30 - Annual smpling	1	lump sum	$ 378,439	$ 262,546
Soil monitoring on 5 yr Cycle				
7 rounds through year 30	1	lump sum	$ 277,436	$ 277,436
Compliance Monitoring Total				**$ 819,670**
Total Net Present Value - Groundwater treatment + Compliance Monitoring				**$ 3,632,094**

Notes:
1) Calculations based on groundwater flowrate of 2.0gpm to maintain hydraulic control. Flowrate obtained from Terra Vac's November 3, 2006 Groundwater Monitoring Report.
2) Assume maximum water treatment plant capacity is 10 gpm.
3) Assume operator present for 50% of plant operation time.
4) Assume filter change out once a month at a cost of $1,000/changeout.
5) Assume carbon replacement/recharge/disposal is 5 times/year at a cost of $1,500/changeout.
6) Assume monthly O/M cost of $1,000.
7) NPV method was determine present value costs over 30-year period based on a interest rate of 3%.
8) Compliance monitoring costs based on tables A.1.4 and BU.4.
9) Detail of NPDES permitting costs in table BU.5.

Focused Feasibility Study
Lilyblad Site
Tacoma, Washington

Prepared for
Washington State
Department of Ecology

January 12, 2007
17330-02

HARTCROWSER
Delivering smarter solutions

CONTENTS Page

CONTENTS (Continued)

TABLES

FIGURES

CONTENTS (Continued)

APPENDIX A
COST ESTIMATES FOR ALTERNATIVES 1 THROUGH 4

FOCUSED FEASIBILITY STUDY
LILYBLAD SITE
TACOMA, WASHINGTON

1.0 INTRODUCTION

The Lilyblad site (Site) is located at 2244 Port of Tacoma Road in Tacoma, Washington, and consists of the Lilyblad property and the adjacent properties that have been affected by historical releases from the former Lilyblad and Lilyblad/Sol Pro operations (refer to Figures 1-1 and 1-4). A substantial amount of investigation and remediation work has been completed at the Site. For the purposes of this focused feasibility study (FFS), the Site is defined as the Area of Concern (AOC) for soil and groundwater contamination regardless of property boundaries.

A Supplemental Remedial Investigation report was recently prepared by CH2M Hill (CH2M Hill 2004). This report provides a comprehensive review of the nature and extent of contamination at the Site. It identifies contaminants of concern (COCs), and presents potential cleanup levels (CULs) and points of compliance (POC) for each COC. The COCs include total petroleum hydrocarbons (TPHs), semivolatile organic carbon compounds (SVOCs), and volatile organic carbon compounds (VOCs). The concentration of each COC in soil was compared to its CUL to identify the approximate extent of soil contamination in the unsaturated zone (CH2M Hill, Figure 4-1), the capillary fringe (CH2M Hill, Figure 4-2), the saturated zone (CH2M Hill, Figure 4-3), and in the aquitard (CH2M Hill, Figure 4-4.) The lateral extent of soil contamination was similar in each soil interval.

Concentrations of benzene and vinyl chloride in groundwater were compared to their respective CULs to identify the approximate extent of groundwater contamination in the shallow aquifer (CH2M Hill, Figures 4-5 and 4-6). The vinyl chloride contaminant plume extended further to the southeast (below the PW Eagle building) than the benzene plume. Both the vinyl chloride and benzene groundwater contaminant plumes extended beyond the areas of soil contamination.

The areas of the Site that will require soil and/or groundwater remediation are summarized in Section 1.1. A number of site-specific technical restraints will impact the selection of the appropriate remedial actions at the Site. These restraints are summarized in Section 1.2.

1.1 Description of the Area of Concern for Soil and for Groundwater

The COCs and CULs for soil and groundwater that were used in this FFS (listed in Table 1.1) are based on protection of surface water. This list of CULs differs from the list used by CH2M Hill in its Supplemental RI (RI Tables 4-2 and 4-14), which are based on protection of drinking water. CULs established in the SRI are not applicable to the Site because the shallow aquifer has a low yield and is not a potential drinking water source. Because groundwater at the Site flows into the Blair Waterway, CULs based on surface water protection are appropriate for the Site. Groundwater levels at the Site fluctuate about 1 to 2 feet, which has created a smear zone of hydrocarbons and other contaminants in soil both above and below the water table. This smear zone acts as a secondary source of COCs throughout the Site. The diverse nature of the TPH, SVOC, and VOC COCs at the Site and the presence of the smear zone mutes the impact of the recent change in CULs on area of contaminated soil and groundwater that will require remediation.

Recent interim actions by Terra Vac have removed some contaminants from the Site. Interim actions were conducted in the Light Nonaqueous Phase Liquid (LNAPL), Dissolved Plume, Hot Spot, Multi-Phase Extraction (MPE), and PW Eagle building areas. Terra Vac reported significant reductions in TPH and BTEX concentrations in soil and groundwater in these areas (Terra Vac 2006a). Analytical data related to the effects of treatment on the other VOC and SVOC COCs were not provided.

1.1.1 Area of Concern for Soils

For the purposes of this FFS, the AOC for soil is based on a composite of the areas described by CH2M Hill RI, Figures 4-1 to 4-4. This AOC is depicted on Figure 1-1, and was included as Attachment B in Ecology's scope of work for this FFS (Ecology 2006a), and as Figure 4 in Terra Vac's Site-wide Design Plan (Terra Vac 2005). Figure 1-1 is a conservative representation of the area of the Site where COCs are present in soil at concentrations exceeding CULs.

The surface area of the soil AOC is approximately 115,000 square feet. It contains approximately 43,000 cubic yards of soil from ground surface to 2 feet into the underlying aquitard (assumes an average depth of 10 feet).

The analytical data for the soil sample locations located within the AOC contained in Tables 4-4 to 4-7 of the CH2M Hill RI, and locations that were sampled by Terra Vac prior to May 2004 and reported in their January 2006 Summary of the December 2005 sampling event at the Site (Terra Vac 2006a) were used to compute an estimate of the total mass of contaminants contained in soil within the soil AOC. This estimate was considered to be an estimate of the contaminant load at the Site prior to May 2004 when Terra Vac began more continuous cleanup operations at the Site. The soil sample locations used to develop this estimate are depicted on Figure 1-2. An estimate of the total mass of contaminants within the soil AOC is presented in Table 1.2. The mass loadings calculated in Table 1.2 are gross estimates of the actual loading at the Site prior to May 2004. The calculation assumptions used to develop this estimate are summarized in the "Notes to the Table." Every sample collected within the AOC was given equal weight even though the sample density varied for different areas of the Site. The soil samples were collected by various investigators over an extended period of time. Nonetheless, it was judged that the information in Table 1.2 would provide useful insights into the historical distribution of contaminants in Site soils.

The total mass of contaminants present at the Site prior to May 2004 using this calculation method is approximately 200,000 pounds. Approximately 98 percent of this mass has been reported to be TPH compounds. VOCs comprise about 4,000 pounds of the total mass, while SVOCs comprise about 200 pounds of mass.

Approximately 52 percent of the mass is present in the saturated soil layer, 27 percent in the vadose zone soil layer, 19 percent in the capillary fringe layer, and 2 percent in the aquitard soil layer at the Site.

Approximately 90 percent of the contamination is present on the Lilyblad, Nelson, and Port of Tacoma Road properties, with the remaining contamination (about 10 percent) located on the PW Eagle (PWE) and Saul properties.

Terra Vac conducted interim measures at the Site using dual vapor extraction (DVE)/biodegradation/oxidation technology from May 2004 until March 2006. The remediation system was operated on the Lilyblad property (LNAPL and Hot Spot areas) and on the PWE property (refer to Figure 1-3). Soil and groundwater samples were obtained in December 2005 (Terra Vac 2006a) in these areas to assess the effectiveness of the DVE/bioremediation/ oxidation process that was applied to each area.

The results from the Site soil samples obtained in December 2005 were used to calculate a more current soil contaminant mass loading. Soil sample analytical results in the LNAPL, Hot Spot, MPE, and PWE building areas were substituted for the pre-May 2004 data contained in Table 1.2 to calculate an approximate soil mass loading as of December 2005. This updated calculated mass loading totals about 160,000 pounds and is summarized in Table 1.3. Thus, this rough calculation approach suggests that Terra Vac's efforts removed about 40,000 pounds of contaminants, nearly all of which (on a total mass basis) were TPH compounds. The performance of the Terra Vac technology is discussed further in Section 3.4.1.

The estimate of the soil contaminant load in Table 1.3 assumes that the few soil samples collected in December 2005 in areas where interim remedial actions were completed by CDM (excavation of alley way north of the PWE Manufacturing Building) and Terra Vac are indicative of the actual soil concentrations within the areas treated. The contaminant load summarized in Table 1.3 may not accurately reflect the amount of soil contamination remaining at the Site, since only a small number of soil samples were analyzed in the areas where treatment occurred. These samples may not be representative of the actual soil concentration distribution that is present in each area that was treated.

1.1.2 Area of Concern for Groundwater

For the purposes of this FFS, the AOC for groundwater is based on the areas described by CH2M Hill Figures 4-5 and 4-6. This area of concern is depicted on Figure 1-4, and is a conservative representation of the area of the Site where COCs are present in groundwater at concentrations exceeding risk-based cleanup levels.

Groundwater in the shallow aquifer (above the aquitard) is contaminated with TPH (mostly TPH-D and TPH-G), VOCs (mostly benzene, vinyl chloride, and the degradation products of PCE and TCA), and SVOCs (mostly pentachlorophenol). The surface area of the groundwater AOC is approximately 164,000 square feet. The volume of water expected to be contained in the shallow aquifer below this groundwater AOC is discussed in Section 2.1.

We made a similar calculation as discussed previously for soil using the contaminant concentrations in groundwater that were contained in CH2M Hill RI Table 4-15, and in the Terra Vac (2006a) document. Calculations indicate that approximately 98 percent of the COCs present in the groundwater AOC are TPH compounds. Approximately 80 percent of the contamination was in groundwater within the Lilyblad property line, with about 12 percent in the PWE area, and 7 percent in the MPE area. The total mass of contaminants in the upper aquifer within the groundwater AOC is estimated to be approximately 200 pounds.

1.2 Site-Specific Technical Restraints

The physical and chemical features of the Site influence the implementation of the remedial actions described in Sections 2.1 through 2.4. Three groups of physical factors can influence the implementation of these remedial actions: 1) factors associated with the active use of the facility, 2) factors limiting access to and removal of contaminated soil and groundwater, and 3) site-specific geologic and hydrologic conditions promoting or prohibiting the applicability of certain remedial technologies. In addition to these physical factors, various chemical attributes of the Site can influence the performance of a remedial alternative that may prevent the alternative from attaining the cleanup levels in a reasonable time frame.

1.2.1 An Active Facility

The soil and groundwater AOCs include the Lilyblad facility, portions of the PWE manufacturing facility, a small portion of the northern portion of the Saul property below the railroad tracks traversing the property, and small portions of the Nelson and Port of Tacoma Road properties on the northern end of the Site (refer to Figures 1-1 and 1-4). The Lilyblad facility is currently used to receive, repackage, store, and distribute a variety of petroleum products. These activities require that Lilyblad, PWE, and railroad employees have access to and use of most of the property.

The implementation of Alternatives 1 through 3 would be limited by the presence of heavy equipment, vehicular traffic, employees, rail lines along the eastern edge of the Saul property, traffic on the Port of Tacoma Road, buried utilities, fences, and other electrically conductive ground penetrations. Both the PW Pipe and Lilyblad properties are also active facilities with heavy cargo traffic bringing in materials and shipping bulk products. The Site is part of a major industrial area near the Port of Tacoma with many active buildings in commercial or industrial use.

To allow Lilyblad, PWE, and the railroad to remain operational, a staged or phased approach to remediation within the property boundaries of the Site would be required. Each remedial action must also be conducive to staggered construction/installation if impacts to business interruptions were to be minimized. The presence of Lilyblad and PWE employees, delivery drivers, railcars, and railroad personnel within the Site boundaries require that the selected remedial actions be implemented with the institutional and engineering controls necessary to limit exposure of Site workers and visitors to Site COCs. In addition to access and Site safety issues, the location of facility structures, along with the limited access to those structures, have a significant influence on the selection of the appropriate remedial action for the Site.

1.2.2 Access to Contaminated Soil and Groundwater

Access to areas containing contaminated soil and groundwater is severely restricted at the Site by existing structures, buildings, and 54 above-ground storage tanks (ASTs). These structures cover approximately 40 percent of the Site. The excavation of soils near building foundations will require shoring to retain building stability. Subsurface utilities (storm drains, water and sewer lines) and above-ground structures, fences, road curbs, and the railroad spur servicing the Lilyblad and PWE properties restrict access to soil and limit placement options for *in situ* treatment technologies. The surrounding properties and the proximity of neighboring facilities further limit the available space to store and stage construction equipment.

1.2.3 Topographic, Geologic, and Hydrogeologic Conditions That Affect Selection of Remedial Actions

The Site is relatively flat. Depth to groundwater in the upper aquifer ranges from 3 to 8 feet. As discussed previously, contamination in the area of concern is within unsaturated, smear zone, and saturated soils, as well as the upper 1 to 2 feet of the underlying silt aquitard. The excavation of smear zone and saturated soils will require dewatering and likely water treatment.

There is a groundwater divide running through the center of the Lilyblad Site. Groundwater in the northern portion of the Site flows north, while groundwater in the southern area of the Site flows toward the south-southwest. The groundwater flow rate north of the divide varies from about 9 to 18 feet per year (CH2M Hill RI, Section 3.5.3.2). The groundwater flow rate south of the divide varies from approximately 20 to 25 feet per year. Groundwater flow rates decrease near the silt aquitard.

Water levels in the upper sand aquifer are higher than those present in the deeper second aquifer, which implies that there exists a potential for the downward movement of groundwater through the silt aquitard. The downward flow of groundwater is calculated using input parameters from CH2M Hill (2004, Section 3.5.3.2) and the following relationship:

$$Q = K\ i\ A \qquad (1-1)$$

Where:

Q = Quantity of water in gallons per year;
K = Hydraulic Conductivity in feet per year = 0.1035 to 1.035;
i = gradient in ft/ft = 0.25; and
A = area of footprint of plume in ft^2 = 164,000.

The calculated volume of groundwater flow through the aquitard ranges from 32,000 to 320,000 gallons per year.

Lilyblad has received a wastewater discharge authorization through MTCA Agreed Order No. DE95HS-S292. This discharge authorization includes the substantive provisions of an active RCRA NPDES permit allowing discharge to a catch basin that connects to the City of Tacoma's storm drainage system located in front of the Lilyblad facility along Port of Tacoma Road. The city's storm drainage system empties into the Lincoln Avenue Ditch, which flows into the Blair Waterway. Water from the Lincoln Avenue Ditch enters a closed culvert, and remains in the culvert until it is discharged through a tide gate to the Blair Waterway. Groundwater from the PWE facility discharges to a storm drainage system that runs along the PWE facility and along the U. S. Oil property line to the west and connects to the Lincoln Avenue Ditch.

1.2.4 Chemical and Physical Properties and their Impact on Remedial Technologies

Site COCs have a variety of vapor pressures, moderate to low-solubility, and are moderately to strongly adsorbed to subsurface soil. As a result of these characteristics, the COCs can potentially exist in four phases: in a nonaqueous phase liquid (NAPL), dissolved in groundwater, mixed with other gases in soil vapor, and sorbed to soil particles (i.e., solid phase).

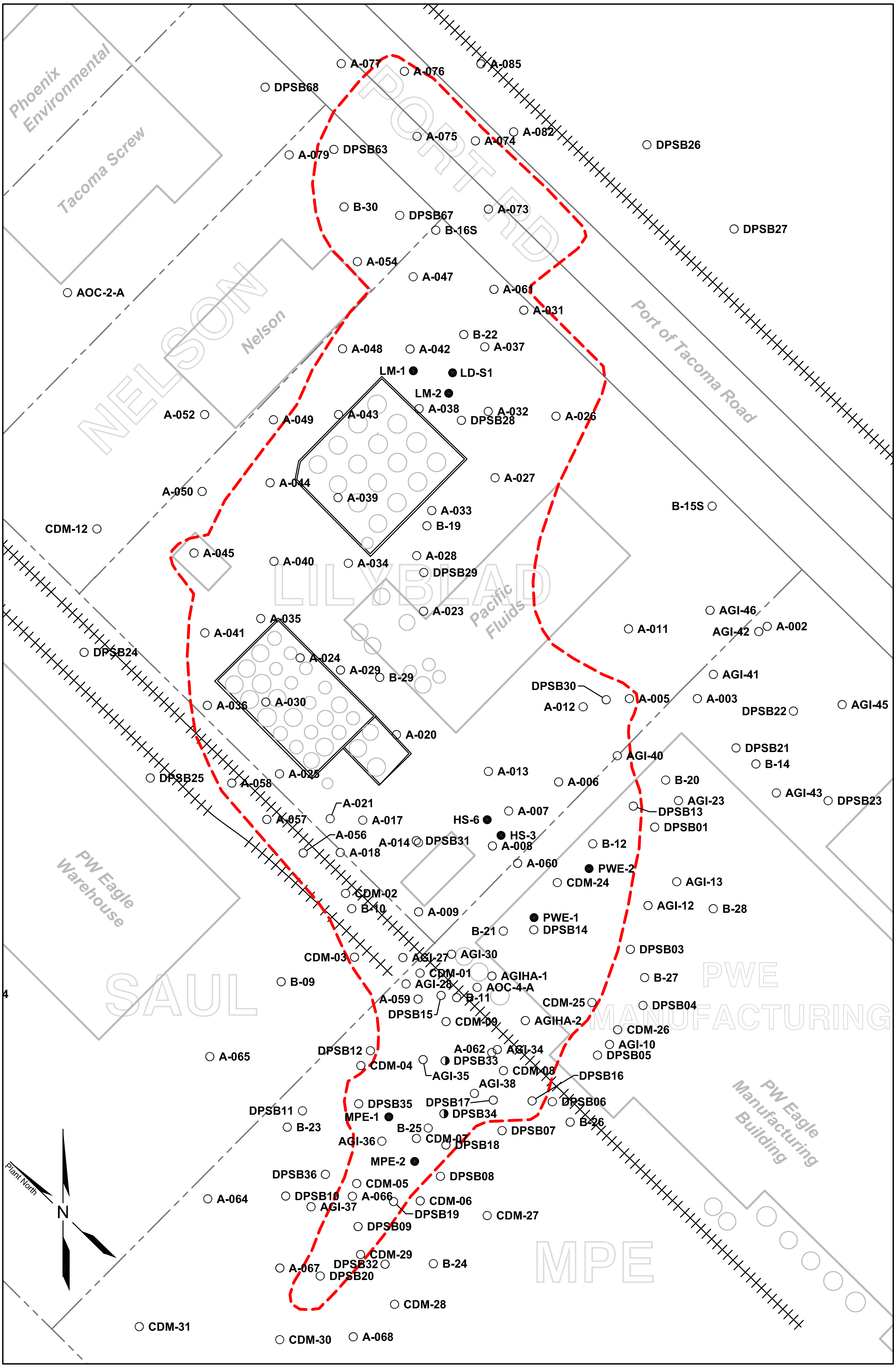
The large amount of VOCs at the Site must be considered as potential remedial actions are considered. The VOCs in the soil and groundwater will volatilize when exposed to the atmosphere during soil excavation or groundwater extraction. Appropriate health and safety measures must be implemented to protect site workers, the public, and the environment.

The chemical and physical properties of the COCs influence how they migrate and which remedial methods are most effective for their removal. Historically differing remedial methods have been use to treat soil and groundwater contaminated by TPH, SVOC, and VOC COCs. The *In Situ* Treatment with and without Natural Attenuation Alternative (Alternative 2) will include several treatment technologies. These technologies will consist of multi-phase extraction (for VOCs), *in situ* biotreatment (for TPHs), and *in situ* chemical oxidation (for SVOCs).

Table 1.1 - MTCA Method B Cleanup Level (CUL) for Soil and Groundwater

Chemical Group	Contaminant of Concern	Soil CUL in mg/kg	Groundwater CUL in ug/L
VOC	1,1,1-trichloroethane	1.1	227
	1,1,2-trichloroethane	0.05	16
	1,1-dichloroethane	164	52,000
	1,1-dichloroethene	0.008	1.93
	1,2,4-trimethylbenzene	10,350	26,000
	1,2-dichloroethane	0.1	37
	1,4-dichlorobenzene	0.065	4.86
	Benzene	0.075	22.7
	bis(2-ethylhexyl)phthaate	4.4	2.2
	cis-1,2-dichlorobenzene	14.9	5,200
	Ethylbenzene	41.1	6,910
	m,p-xylene	58.4	26,000
	Methylene chloride	1.3	590
	Tetrachloroethene	0.025	3
	Toluene	71.3	15,000
	Trichloroethene	0.12	30
	Vinyl chloride	0.008	2
SVOC	Naphthalene	116	4,940
	Pentachlorophenol	0.038	3
	2-methylnaphthalene	--	23
TPH	Diesel-range hydrocarbons	2,000	1,000
	Gasoline-range hydrocarbons	100	1,000
	Motor oil-range hydrocarbons	2,000	1,000

Area of Concern for Soil
Lilyblad Site



Source: CH2M Hill 2004 and Terra Vac 2006a.

▬ ▬ ▬	Approximate Extent of Soil Contamination
— - —	Property Line
┼┼┼┼┼┼	Railroad

Soil Sample Location and Number

CDM-30 ○	CH2M Hill
MPE-2 ●	Terra Vac
DPSB34 ◑	Terra Vac and CH2M Hill

0 60 120
Scale in Feet

1733002-001.dwg
SRN 01/8/07

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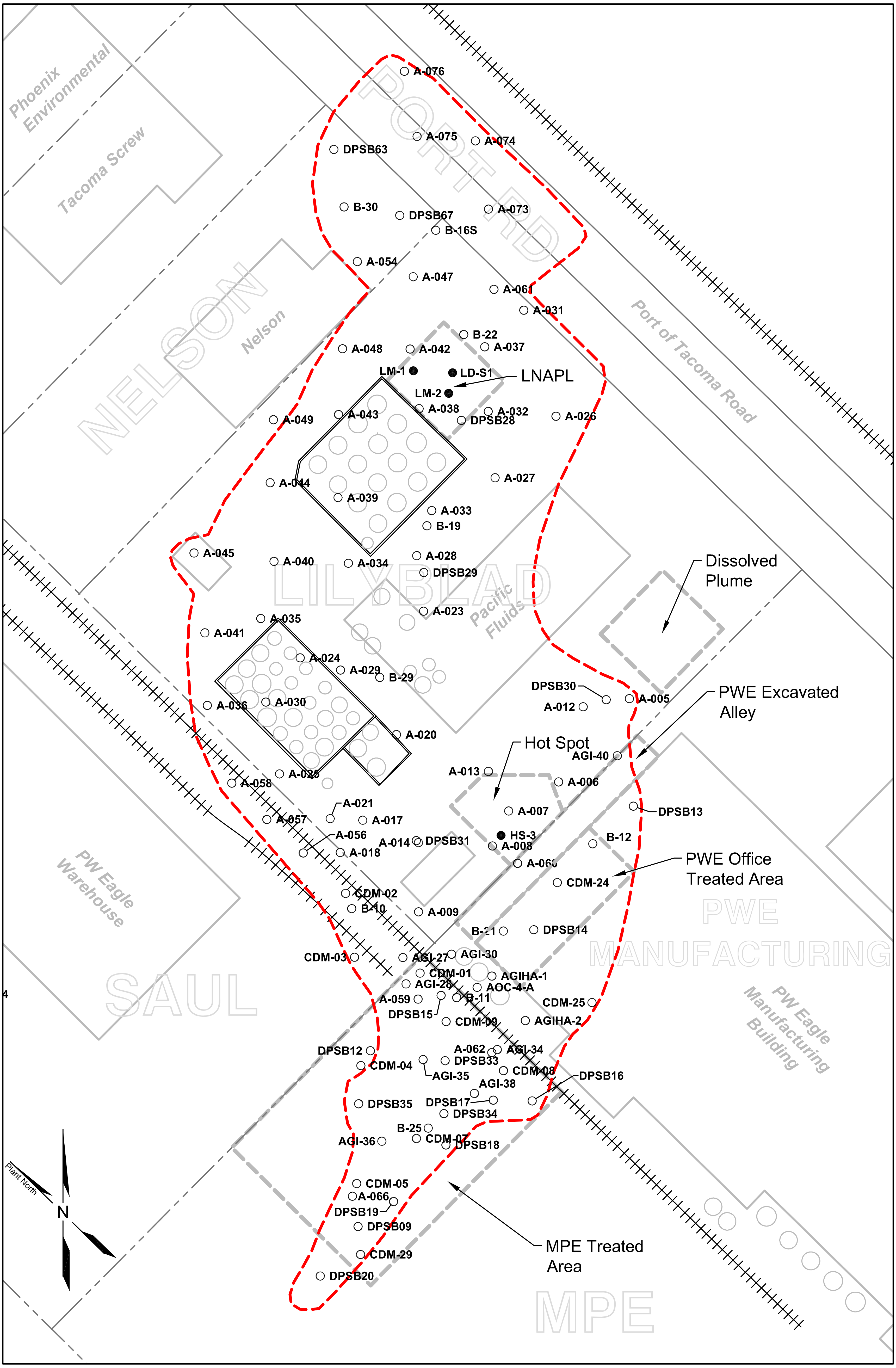
Figure 1-1

Historical Contaminant Distribution at the Lilyblad Site

Lilyblad Site



Source: CH2M Hill 2004 and Terra Vac 2006a.

Approximate Extent of Soil Contamination

CDM-30 ○ CH2M Hill Soil Sample Location and Number

HS-6 ● Terra Vac Soil Sample Location and Number

Railroad

Property Line

Terra Vac Treatment Areas

0 60 120

Scale in Feet

Note: Soil sample data used to prepare Table 1.2.

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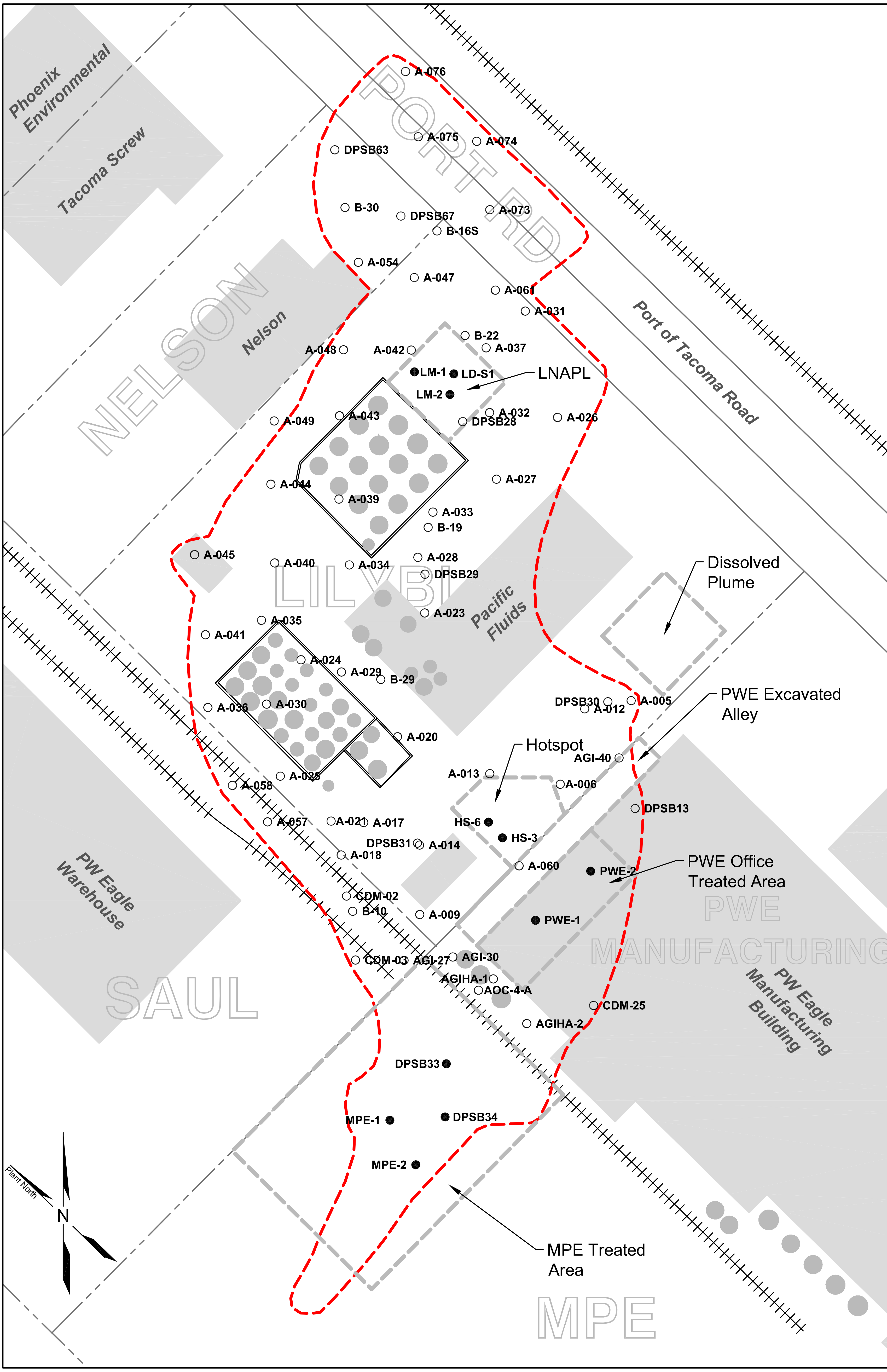
17330-02 1/07

Figure 1-2

Post-Interim Measure Contaminant Distribution at the Lilyblad Site

Lilyblad Site



Source: CH2M Hill 2004 and Terra Vac 2006a.

Approximate Extent of Soil Contamination

Terra Vac Treatment Areas

CDM-30 CH2M Hill Soil Sample Location and Number

Railroad

Property Line

MPE-2 Terra Vac Soil Sample Location and Number

0 60 120

Scale in Feet

Note: Soil sample data used to prepare Table 1.3.

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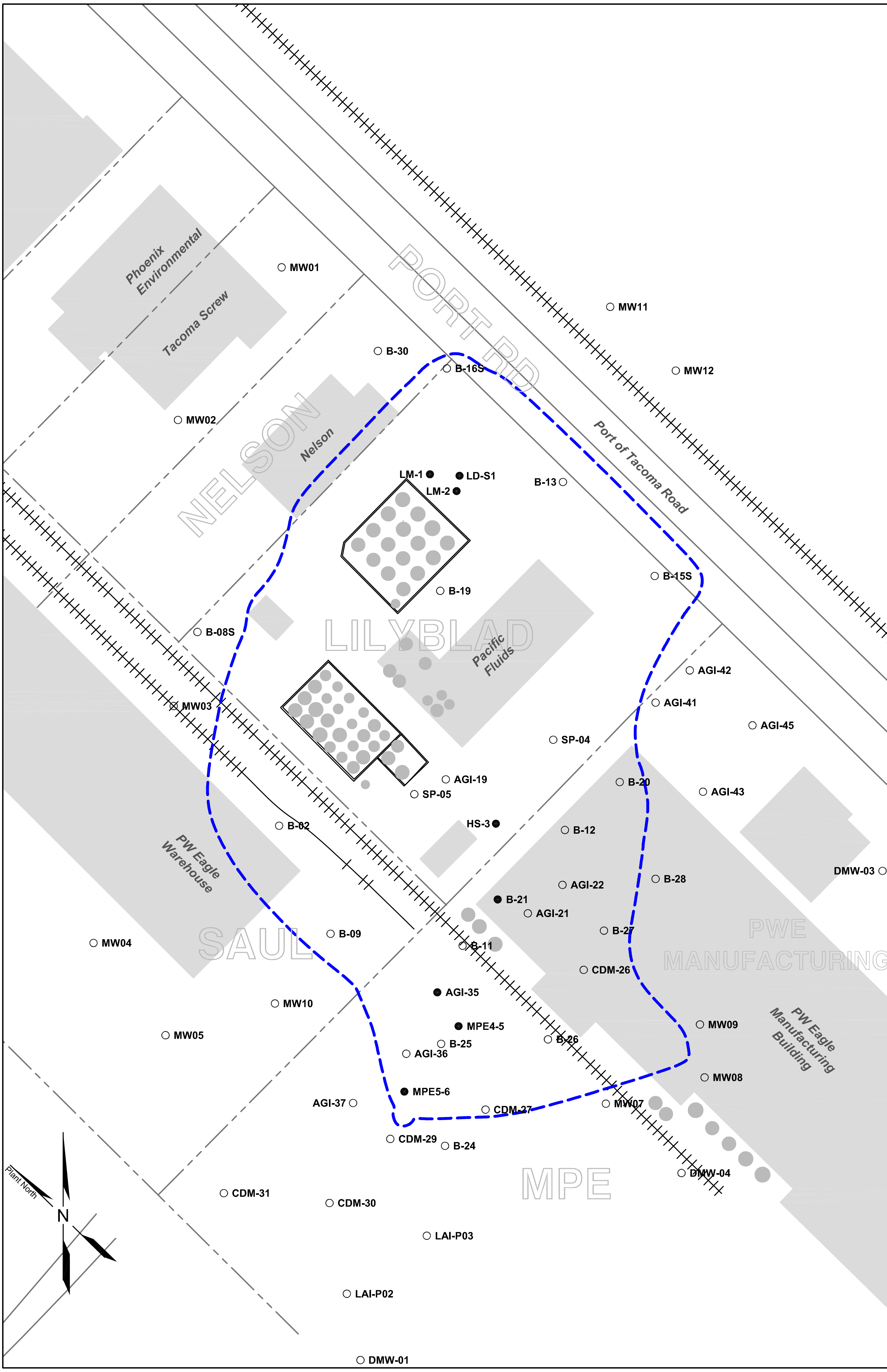
17330-02 1/07

Figure 1-3

Area of Concern for Groundwater
Lilyblad Site



Source: CH2M Hill 2004 and Terra Vac 2006a.

Approximate Extent of Groundwater Contamination

Property Line

Railroad

Groundwater Sample Location and Number

CDM-30 ○ CH2M Hill

MPE-2 ● Terra Vac

0 80 160

Scale in Feet

SRN 01/8/07 1733002-004.dwg

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17330-02 1/07

Figure 1-4

Table 1.2 - Estimated Historical Contaminant Distribution in Soil at the Lilyblad Site

Site	Area (ft2)	Layer	Thickness in Feet	Concentration in mg/kg VOC	TPH	SVOC	Number of Samples VOC	TPH	SVOC	Mass Loading in Pounds VOC	TPH	SVOC
LILYBLAD Untreated	59500	UNSATURATED	2.00	1.3	4364	10.5	13	17	9	15	51932	125
		CAPILLARY	2.00	85	1461	2	37	33	13	1012	17386	24
		SATURATED	3.00	119	2863	1.5	9	7	4	2124	51105	27
		AQUITARD	2.00	2.6	246	1.9	14	15	8	31	2927	23
LNAPL	4080	UNSATURATED	2.00	0.41	183	0	2	3	0	0	149	0
		CAPILLARY	2.00	161	5580	0.37	4	4	1	131	4553	0
		SATURATED	3.00	1.2	22390	0	1	2	0	1	27405	0
		AQUITARD	2.00	0.03	51	0	2	2	0	0	42	0
HOT SPOT	2500	UNSATURATED	2.00	19	1886	1.1	4	4	1	10	943	1
		CAPILLARY	2.00	561	5853	8.1	4	4	2	281	2927	4
		SATURATED	3.00	29	556	2	2	2	1	22	417	2
		AQUITARD	2.00	0.03	63	2	1	1	1	0	32	1
PWE Untreated	4190	UNSATURATED	3.00	0.25	314	0	2	2	0	0	395	0
		CAPILLARY	2.00	0	0	0	1	0	0	0	0	0
		SATURATED	5.00	12	3090	0	3	1	0	25	6474	0
		AQUITARD	2.00	0	0	0	0	0	0	0	0	0
PWE Excavated	3700	UNSATURATED	3.00	0	0	0	0	0	0	0	0	0
		CAPILLARY	2.00	173	940	3.5	1	1	1	128	696	3
		SATURATED	5.00	0.05	104	3.2	1	1	1	0	192	6
		AQUITARD	2.00	0.04	85	0.2	1	1	1	0	63	0
PWE OFFICE Treated Area	3160	UNSATURATED	3.00	0	21	0	1	1	0	0	20	0
		CAPILLARY	2.00	46	213	1.1	3	3	3	29	135	1
		SATURATED	5.00	1.8	514	4	5	4	3	3	812	6
		AQUITARD	2.00	0	19	0	0	2	0	0	12	0
MPE Untreated	1200	UNSATURATED	2.00	0.02	0	0	1	0	0	0	0	0
		CAPILLARY	2.00	0.78	12090	0	1	1	0	0	2902	0
		SATURATED	3.50	0.13	1233	0	2	2	0	0	518	0
		AQUITARD	2.00	0	0	0	0	0	0	0	0	0
MPE Treated	12500	UNSATURATED	2.00	1.5	78	0.02	11	6	4	4	195	0
		CAPILLARY	2.00	5	809	0.05	16	15	1	13	2023	0
		SATURATED	3.50	20	1125	0.2	9	7	1	88	4922	1
		AQUITARD	2.00	0	26	0	3	3	0	0	65	0
SAUL	6310	UNSATURATED	1.50	0.6	0	0	2	0	2	1	0	0
		CAPILLARY	2.00	5.6	117	0	3	2	0	7	148	0
		SATURATED	2.00	0.04	0	0	1	0	0	0	0	0
		AQUITARD	2.00	0	36	0	0	0	0	0	45	0
NELSON	2377	UNSATURATED	1.50	0	0	0	0	0	0	0	0	0
		CAPILLARY	2.00	12	2000	0	1	1	0	6	951	0
		SATURATED	5.75	46	3843	0.2	3	0	1	63	5253	0
		AQUITARD	2.00	0	0	0	0	0	0	0	0	0
PORT RD	14838	UNSATURATED	1.50	0	0	0	0	0	0	0	0	0
		CAPILLARY	2.00	10.5	2080	0.35	3	2	1	31	6173	1
		SATURATED	5.75	0.2	290	0	1	0	0	2	2474	0
		AQUITARD	2.00	0.05	255	0	2	0	0	0	757	0
									Grand Totals	**4026**	**195039**	**224**
									Total Mass		**199288**	**lbs**

NOTES

1) Soil concentration data obtained from following sources:
CH2M HILL electronic files (based on Tables 4-4 to 4-12 of Draft Supplemental Remedial Investigation Report - Lilyblad Petroleum, Oct. 2004)
CH2M HILL Draft supplemental Remedial Investigation Report - Lilyblad Petroleum, Oct. 2004, tables 4.6 to 4.12 (TPH concentrations only)
Table 6 of Terra Vac Interim Soil and Groundwater Sampling Event - MPE Treatment Area, PW Eagle Property, Lilyblad Test Areas, January 9, 2006 for the 8/1/03 and 4/1/04 rounds of sampling.
2) Concentrations reported are an average of the data compiled from the sources listed above (see Note 1).
3) Soil samples used to determine contaminant concentrations are contained in overall contaminant extent (see Note 4).
4) Overall contaminant extent based on overlapping plumes from Figures 4-1 to 4-4 in CH2M HILL Draft Supplemental Remedial Investigation Report - Lilyblad Petroleum, Oct. 2004.
5) Overall contaminant extent was divided based on property divisions (Lilyblad, PWE, MPE, Saul, Nelson, and Port of Tacoma Road). Further area divisions were made within property limits of Lilyblad, PWE, and MPE based on Terra Vac treatment areas.
6) Area of each division calculated using GIS.
7) Depth for aquitard assumed to be 2 feet (based on extent of contamination).
8) Depth for capillary layer assumed to be 2 feet.
9) Depth of saturated and unsaturated layer determined using well geological cross section figures (Figures 3-3 to 3-6 of CH2M Hill Draft Supplemental Remedial Investigation Report - Lilyblad Petroleum, Oct. 2004)).
Saturated layer is equal to the distance between the top of the aquitard and the water table.
Unsaturated layer is equal to the distance between the aquitard and the top of the structural fill. Took an average of these values for borings in extent area.
10) Fill density = 100 pcf

Table 1.3 - Estimated Post-Interim Measure Contaminant Loading in Soil at Lilyblad Site

Site	Area (ft2)	Layer	Thickness	Concentrations in mg/kg			Number of Samples			Mass Loading in Pounds		
			in Feet	VOC	TPH	SVOC	VOC	TPH	SVOC	VOC	TPH	SVOC
LILYBLAD Untreated	59500	UNSATURATED	2.00	1.3	4364	10.5	13	17	9	15	51932	125
		CAPILLARY	2.00	85	1461	2	37	33	13	1012	17386	24
		SATURATED	3.00	119	2863	1.5	9	7	4	2124	51105	27
		AQUITARD	2.00	2.6	246	1.9	14	15	8	31	2927	23
LNAPL	4080	UNSATURATED	2.00	0.41	183	0	2	3	0	0	149	0
		CAPILLARY	2.00	**0.09**	**104**	0.37	**1**	**3**	1	**0**	**85**	0
		SATURATED	3.00	**0.06**	**53**	0	**1**	**1**	0	**0**	**65**	0
		AQUITARD	2.00	0.03	51	0	2	2	0	0	42	0
HOT SPOT	2500	UNSATURATED	2.00	**9.8**	**3970**	1.1	**2**	**2**	1	**5**	**1985**	1
		CAPILLARY	2.00	**0**	**627**	8.1	**1**	**2**	2	**0**	**314**	4
		SATURATED	3.00	**1.2**	**239**	2	**2**	**2**	1	**1**	**179**	2
		AQUITARD	2.00	0.03	63	2	1	1	1	0	32	1
PWE Untreated	4190	UNSATURATED	3.00	0.25	314	0	2	2	0	0	395	0
		CAPILLARY	2.00	0	0	0	1	0	0	0	0	0
		SATURATED	5.00	12	3090	0	3	1	0	25	6474	0
		AQUITARD	2.00	0	0	0	0	0	0	0	0	0
PWE Excavated	3700	UNSATURATED	3.00	0	0	0	0	0	0	0	0	0
		CAPILLARY	2.00	0	0	0	0	0	0	0	0	0
		SATURATED	5.00	0	0	0	0	0	0	0	0	0
		AQUITARD	2.00	0	0	0	0	0	0	0	0	0
PWE OFFICE Treated Area	3160	UNSATURATED	3.00	0	21	0	1	1	0	0	20	0
		CAPILLARY	2.00	**17**	**5254**	1.1	**2**	**2**	3	**11**	**3321**	1
		SATURATED	5.00	**0.24**	**11**	4	**2**	**2**	3	**0**	**17**	6
		AQUITARD	2.00	0	19	0	0	2	0	0	12	0
MPE Untreated	1200	UNSATURATED	2.00	0.02	0	0	1	0	0	0	0	0
		CAPILLARY	2.00	0.78	12090	0	1	1	0	0	2902	0
		SATURATED	3.50	0.13	1233	0	2	2	0	0	518	0
		AQUITARD	2.00	0	0	0	0	0	0	0	0	0
MPE Treated	12500	UNSATURATED	2.00	1.5	78	0.02	11	6	4	4	195	0
		CAPILLARY	2.00	**0.7**	**285**	0.05	**3**	**3**	1	**2**	**713**	0
		SATURATED	3.50	**0.06**	**14**	0.2	**2**	**1**	1	**0**	**61**	1
		AQUITARD	2.00	0	26	0	3	3	0	0	65	0
SAUL	6310	UNSATURATED	1.50	0.6	0	0	2	0	2	1	0	0
		CAPILLARY	2.00	5.6	117	0	3	2	0	7	148	0
		SATURATED	2.00	0.04	0	0	1	0	0	0	0	0
		AQUITARD	2.00	0	36	0	0	0	0	0	45	0
NELSON	2377	UNSATURATED	1.50	0	0	0	0	0	0	0	0	0
		CAPILLARY	2.00	12	2000	0	1	1	0	6	951	0
		SATURATED	5.75	46	3843	0.2	3	0	1	63	5253	0
		AQUITARD	2.00	0	0	0	0	0	0	0	0	0
PORT RD	14838	UNSATURATED	1.50	0	0	0	0	0	0	0	0	0
		CAPILLARY	2.00	10.5	2080	0.35	3	2	1	31	6173	1
		SATURATED	5.75	0.2	290	0	1	0	0	2	2474	0
		AQUITARD	2.00	0.05	255	0	2	0	0	0	757	0
									Grand Totals	**3340**	**156691**	**215**
									Total Mass		**160246**	**lbs**

NOTES

1) Soil concentration data obtain from following sources:

CH2M HILL electronic files (based on Tables 4-4 to 4-12 of Draft Supplemental Remedial Investigation Report - Lilyblad Petroleum, Oct. 2004)

CH2M HILL Draft Supplemental Remedial Investigation Report - Lilyblad Petroleum, Oct. 2004, Tables 4.6 to 4.12 (TPH concentrations only)

Electronic file "Baseline Sampling Dec 2005.xls" based on Dept. of Ecology data and Table 6 of Terra Vac Interim Soil and Groundwater Sampling Event - MPE Treatment Area, PW Eagle Property, Lilyblad Test Areas, January 9, 2006.

Table 6 of Terra Vac Interim Soil and Groundwater Sampling Event - MPE Treatment Area, PW Eagle Property, Lilyblad Test Areas, January 9, 2006 for the 12/05 sampling event.

2) Concentrations reported are an average of the data compiled from the sources listed above (see Note 1).

3) Wells used to determine contaiminant concentrations are contained in overall contaiminant extent (see Note 4).

4) Overall contaiminant extent based on overlapping plumes from Figures 4-1 to 4-4 in CH2M-HILL Draft supplemental Remedial Investigation Report - Lilyblad Petroleum, Oct. 2004.

5) Overall contaiminant extent was divided based on property divisions (Lilyblad, PWE, MPE, Saul, Nelson and Port of Tacoma road). Further area divisions were made within property limits of Lilyblad, PWE and MPE based on Terra Vac treatment areas.

6) Area calculated using GIS.

7) For Terra Vac treatment areas only soil samples from Terra Vac or Dept of Ecology were used.

8) For split soil samples analyzed by Department of Ecology and Terra Vac, the higher concentration of the two samples was used.

9) Depth for aquitard assumed to be 2 feet (based on extent of contamination).

10) Depth for capillary layer assumed to be 2 feet.

11) Depth of saturated and unsaturated layer determined using well geological cross section figures (Figure 3-3 to 3-6 in CH2M HILL data).
Saturated layer is equal to the distance between the top of the aquitard and the water table.
Unsaturated layer is equal to the distance between the aquitard and the top of the structural fill. Took an average of these values for borings in extent area.

12) Fill density = 100 pcf

13) BOLD NUMBERS are concentrations based only on Terra Vac's 12/05 data. In untreated areas, historial data are presented.

14) Contaminant concentrations for PWE Excavated reported as 0 mg/kg due to excavation performed by CDM in 2001. Excavation described in CDM's Lilyblad Petroleum PW Pipe Facility Interim Action Final Work Plan, March 12, 2001.

2.0 DESCRIPTION OF ALTERNATIVES

Ecology has identified the cleanup alternatives that are evaluated in this FFS. These alternatives are described in this section:

- Section 2.1 – Alternative 1—Containment with Groundwater Controls
- Section 2.2 – Alternative 2—*In Situ* Treatment with and without Natural Attenuation
- Section 2.3 - Alternative 3—Excavation and Disposal of Contaminated Soils
- Section 2-4 – Alternative 4—Hydraulic Control with Groundwater Monitoring

2.1 Alternative 1—Containment with Groundwater Controls

This alternative consists of the installation of a barrier wall to prevent flow of groundwater from the Lilyblad property to adjoining properties and ultimately to Commencement Bay. The barrier system will be operational until the concentration of COCs are low enough that natural attenuation will reduce the concentrations to below the CULs for groundwater as it enters Commencement Bay.

Two barrier systems will be considered; 1) a sheet pile or slurry wall around the perimeter of the Lilyblad property, and 2) a sheet pile or slurry wall around parts of the Site judged to be appropriate. The groundwater retained by the wall will be treated to meet Lilyblad's current NPDES requirements. The groundwater treatment system will be based on the existing treatment system installed by CDM, with modifications as needed to meet the NPDES-like discharge requirements.

The initial step in developing this alternative is to identify the volume of groundwater that will be retained by the barrier configurations of interest to Ecology. This evaluation is discussed in Section 2.1.1. The volume of water retained by the barrier (and requiring treatment) will be a function of the locations established for the barriers. The barrier locations judged to be appropriate are discussed in Section 2.1.2. The advantages and disadvantages of installing a slurry wall or a steel sheet pile wall system are discussed in Section 2.1.2 as well. The design of a treatment system required to reduce COC concentrations in groundwater to acceptable levels (established in the NPDES permit) is described in Section 2.1.3.

Alternative 1 as well as Alternatives 2 through 4 will include institutional controls and compliance monitoring. Institutional controls usually include on-site features, such as signs and fences, and legal mechanisms, such as lease restrictions, deed restrictions, land use and zoning designations, and building permit requirements. The compliance monitoring program established by Ecology for this Site (Terra Vac 2006b) is described Section 2.4.

2.1.1 Groundwater Conditions below the AOC

The hydrogeology and groundwater quality conditions at the Site are described in the CH2M Hill RI, Section 3. The surface elevation of the site is 14 to 18 feet (NAVD88). Contaminated water is contained in the shallow aquifer. The shallow aquifer consists of brown to black, fine to medium Sand with some gravel and shell fragments. The unit becomes finer with depth grading into silty, fine Sand. The bottom of the shallow aquifer is elevation 6 to 10 feet (NAVD88).

The depth to water is generally from 3 to 8 feet below ground surface. Seasonal water level fluctuations range from 0.5 to 1.5 feet. Under natural conditions, there is a groundwater divide near the center of the Lilyblad property. North of the divide groundwater flows to the north-northeast, and south of the divide groundwater flows to the south-southwest. Groundwater flow in the shallow aquifer north of the divide eventually discharges to Blair Waterway. The shallow aquifer is separated from the deeper Second Aquifer by a 6- to 16-foot-thick upper silt aquitard.

Groundwater contamination is limited to the shallow aquifer. The area of groundwater contamination is defined by the extent of benzene and vinyl chloride shown in CH2M-Hill RI Figures 4.5 and 4.6, respectively. The total area of the groundwater AOC is approximately 164,000 square feet. The area of the Lilyblad property is approximately 87,000 square feet with about 83,000 square feet of groundwater contamination falling within the groundwater AOC. Assuming an average saturated thickness of 5 feet and a porosity of 0.42, the volume of contaminated groundwater beneath the Lilyblad property is approximately 1,300,000 gallons. The total groundwater volume below the groundwater AOC is expected to total approximately 2,600,000 gallons.

Under natural conditions, groundwater discharges to the Blair Waterway, which is approximately 1,200 feet from the Site. The time for groundwater to reach the Blair Waterway (if short-cutting does not occur) was calculated using input parameters from CH2M-Hill (2004) for the northern component of shallow groundwater and the following equation:

Travel Time in Feet/Year = D * Ki/n^{e} (2 – 1)

Where:

D = Distance to Waterway in feet = 1,200;
K = Hydraulic conductivity in ft/day = 5.7 feet/day or 2,080 feet/year;
I = hydraulic gradient = 0.005; and
Ne = porosity = 0.42.

The calculated groundwater travel time within the upper aquifer is about 25 feet/year; therefore, it would take at least 50 years for the northern component of shallow groundwater from the Site to each the Blair Waterway. The travel time within the upper aquifer for a specific chemical to reach the waterway via natural groundwater flow will be significantly longer due to effects of retardation. Retardation reduces chemical migration for the COCs typically by a factor of 2 to 5 times. Therefore, the migration of COCs to the Blair Waterway could take 100 years or more, if short-cutting did not occur.

It should be noted that groundwater exiting the Site to the northeast will likely intersect a stormwater line located below the Port of Tacoma Road. At least some portion of this groundwater may follow the stormwater line and reach the Blair Waterway in significantly less time than the 50-year estimate for natural groundwater flow. Groundwater exiting to the south also likely intersects a stormwater line that discharges to the Lincoln Avenue Ditch and ultimately the Blair Waterway.

2.1.2 Description of the Barrier

The Lilyblad property is currently occupied by Pacific Functional Fluids (Pacific Fluids). Pacific Fluids manufactures, stores, and distributes custom petroleum blends and other chemicals. The Pacific Fluids facility includes an office building, a small warehouse, a truck-loading rack, a laboratory/boiler room, three concrete-bermed tank farms, and several equipment storage and work areas. These buildings occupy approximately 40 percent of the 2-acre Lilyblad property. The perimeter of the Lilyblad facility runs to about 1,200 linear feet. This would be the length of the barrier if it were practical to install it completely around the perimeter of the Lilyblad property. The primary underground utility corridors serving the Lilyblad property were described in the CH2M-Hill RI, Section 3.1.2 and Figure 3.1. These corridors run along three of the four legs of the perimeter of the Lilyblad property with perimeter penetrations on all sides of the property. Other buried utilities are also present within the property boundary. The specific locations of these lines are not known. Installation of a barrier wall in the vicinity of underground utilities is problematical and would be expensive. The utilities would have to be moved or penetrations through the barrier wall would have to be installed to accommodate existing utilities.

Slurry Wall Barrier

A slurry wall consists of a vertical trench that is excavated down to the aquitard at the Site, approximately 8 to 12 feet below ground surface. The trench is filled with a low permeability material, such as a mixture of soil, bentonite, and cement. The slurry wall envisioned for the Lilyblad property is a wall that is about 2 feet thick. Dewatering of saturated soils and the subsequent treatment of the water removed from the trench will be necessary if this option is used. Use of suitable Site soils in the bentonite backfill mixture will reduce disposal costs and can lower permeability of the wall, but will require a larger construction foot print at the Site to accommodate mixing. The soils above the aquitard on this Site consist of structural fill, ranging from approximately 1 to 5 feet in thickness, and dredge spoils, ranging from approximately 5 to 8 feet in thickness. It is unlikely that the dredge spoils would provide a suitable backfill material for the slurry wall and would require disposal. Slurry wall excavations will require standoff distance from parallel utility corridors and building foundations to prevent undermining. This will decrease the effective perimeter of the cutoff wall, particularly in the vicinity of the Nelson Building to the north and the gas main along the east perimeter.

With proper engineering controls, the slurry wall can be installed around utility penetrations. These controls will include controlled excavation in the vicinity of utilities (i.e., air knife), support for exposed lines, and installation of flexible sleeves for utilities to limit damage with settlement of the slurry wall. Capping of the slurry wall with Site soils above the seasonal level of groundwater can dissipate overlying loads to the slurry-encased utilities as well as decrease soil disposal costs. Bench-scale testing would be required for this alternative to determine the proper slurry mixture, applicability of Site soil use, deterioration of cutoff wall due to Site contaminants, and compressibility and strength of the wall.

Sheet Pile Barrier

A steel sheet pile wall is constructed by driving vertical sheets of steel down to the aquitard to form a vertical barrier wall. The sheets are assembled before installation and are driven or vibrated into the ground. Installation of sheet piling will require removal of the existing asphalt/concrete cover. The sheet pile wall envisioned for this Site is 0.25-inch-thick steel driven a maximum of 2 feet into the aquitard. The sheet piling will be terminated at the top of the structural fill layer to facilitate an asphalt/concrete cover. Use of interlock sealant will decrease the permeability of the cutoff wall. The presence of known utility corridors and the likely presence of other unknown buried objects and lines complicate the installation of a sheet pile at this Site. Before the sheet pile is driven, a trench could be dug in areas where utilities were thought to be present. This step could entail the dewatering of saturated soil and the treatment of the water removed from the Site.

Pile driving and vibratory pile installation require standoff distance from utilities to prevent damage to the lines. Utility standoff will decrease the effective perimeter of the cutoff wall in the vicinity of the north perimeter water lines and the gas main along the east perimeter. Use of non-vibratory pile installation, such as the direct push method, could decrease utility standoff distances. Utility penetrations around the perimeter of the Site would require disconnecting and capping of the lines prior to pile installation. Rerouting utility lines lying in water-bearing zones through the sheet pile wall will require the engineering of sleeves or seals to prevent loss of groundwater through these penetrations.

The installation of a barrier wall will cause significant business interruptions to Pacific Fluids and other entities operating at the Site. The advantages and disadvantages of slurry wall and sheet pile barriers are summarized in Table 2.1.

Location of the Barrier Wall

Groundwater conditions beneath the Site (Section 2.3.1) were considered along with the practical limitations of both the slurry wall and sheet pile barriers to identify the proposed locations of the barrier walls.

Alternative 1 – Variation A will place a continuous barrier (a slurry wall or steel sheet pile) that encircles the Lilyblad property (about 1,100 linear feet of barrier) as near to its property line as is practical given the location of underground utilities and other obstructions. This barrier location is depicted on Figure 2-1A. The barrier contains approximately 50 percent of the area of the groundwater AOC. The locations of known utility corridors were avoided as much as practicable in identifying the barrier location shown on Figure 2-1A.

Alternative 1 – Variation B will place a barrier (slurry wall or steel sheet pile) around approximately 50 percent of the Lilyblad property line (about 550 feet of barrier) in the general vicinity of the locations where CDM installed temporary plastic barrier walls during 2001. As part of an interim cleanup action, CDM installed vapor and groundwater recovery systems in two "L" shaped trenches at the northeast and southwest corners of the Lilyblad property (refer to Figure 2-1B). Shoring for the trenches included 0.25-inch-thick vinyl sheet piling driven a maximum of 2 feet into the aquitard. Following construction of the extraction trenches, the sheet piling was removed from both trenches with the exception of approximately 195 feet in the alley way between Lilyblad and the PW Eagle properties. The intent was to leave this sheet piling in place to serve as a groundwater barrier on the south perimeter of the site (CDM 2001). The CDM trench locations intercept the natural northeast and southwest components of the groundwater flow that exits the Lilyblad facility (refer to CH2M Hill Figure 3-7 and Figure 2-1B of this report).

Volume of Groundwater that will Require Treatment

Each of the barrier wall configurations identified above will generate groundwater that will require treatment. Groundwater that will require treatment is expected to total:

- Barrier around the perimeter of the Lilyblad site = 1 gpm; and
- Barrier segments installed as shown in Figure 2-1B = 2 gpm.

The amount of groundwater generated by the full barrier is a function of the recharge to the shallow aquifer from precipitation and leakage from utility lines within the footprint of the barrier. Since pavement or buildings cover most the Lilyblad property, the amount of recharge from precipitation is likely to be small. Assuming that 25 percent of rainfall is recharged to the aquifer (about 425,000 gallons per year), and that leakage through pavements totals approximately 80,000 gallons per year, about 1 gpm will generated for treatment by the full barrier configuration. The amount of groundwater generated by the partial barrier is also a function of the recharge to the shallow aquifer from precipitation and leakage from utility lines (about 515,000 gallons per year) as well as the amount of inflow and pumping required to maintain hydraulic control (approximately 500,000 gallons per year). The partial barrier is expected to require additional hydraulic control of up to 2 gpm to maintain containment of contaminated water similar to the level achieved by the full barrier.

For Variation A of Alternative 1, a well extraction pump will be used to extract water directly from five wells located within the barrier perimeter. The extracted groundwater will be sent to the groundwater treatment system. For Variation B, the groundwater that collects in the trenches adjacent to the discontinuous barrier will be pumped directly to the groundwater treatment system.

2.1.3 Groundwater and Soil Vapor Treatment System

The CDM treatment system was originally installed in 2001. Its original design included high-vacuum liquid ring pumps (LRP) for groundwater and soil vapor recovery. The system had a design capacity of 10 gpm. Groundwater passed through a holding tank into an air sparge tank where VOCs were stripped and transported to a 1,000 cfm thermal oxidizer for treatment along with vapors that were extracted directly from recovery trenches and MPE wells. Treated vapor was chilled in a quenching tower and treated for residual chlorides in a packed-bed scrubber tower by a 5 gpm flow of water from a City water supply. The stripped groundwater passed through two 2-micron cartridge filters to remove particulates, and two 2,000-pound liquid-phase carbon adsorption units, in series, to reduce hydrocarbon concentrations to required concentrations. The scrubber water supply was pH balanced with a metered sodium hydroxide solution to neutralize chlorides, cooled by a 20-ton Carrier chiller by passing through two plate and frame heat exchangers, and was subsequently discharged to the surface water sewer. The treated effluent was passed through flow, pH, and temperature sensors before being discharged under the Lilyblad NPDES permit (ERI 2004).

The thermal oxidizer portion of the system was shut down and replaced by two 1,000-pound carbon adsorption vessels in series in September 2003.

Terra Vac modified the CDM system in May 2004. The key components of this modified system include a surge tank, air stripping system, a particulate filter followed by activated carbon treatment for groundwater and vapors (removed from the stripping system), and a cooling system for maintaining discharges below 19°C to comply with existing NPDES-like permit requirements. The simplified treatment system operated by Terra Vac has been demonstrated to produce effluent that can meet Ecology's NPDES-like requirements. The treatment system proposed for this alternative will consist of the groundwater treatment components used by Terra Vac and shown on Figure 2-2. This configuration will require that additional modifications be made to the original CDM treatment system.

2.2 Alternative 2—In Situ Treatment with and without Natural Attenuation

This alternative utilizes a generic *in situ* treatment system, consisting of: 1) soil vapor extraction, 2) biodegradation using nutrients and chemical additions, and 3) chemical oxidation. The groundwater and soil vapor produced by the *in situ* system will be treated by the modified CDM system described in Section 2.1.3.

The technical elements of the generic *in situ* treatment system are described in Section 2.2.1. The system can be operated to achieve a variety of results. The operation of the system to achieve all soil and groundwater CULs is described in Section 2.2.2 (Variation A). The operation of the system to remove TPH to Method B levels, and the use of institutional controls and monitored natural attenuation for other COCs is discussed in Section 2.2.3 (Variation B). Finally, a combination of the most effective containment option identified by Alternative 1 (full or partial barrier around the Lilyblad property) together with *in situ* treatment of impacted soil and groundwater located outside of the Lilyblad property lines to achieve CULs for all COCs is described in Section 2.2.4 (Variation C).

2.2.1 Components of the Generic *In Situ* Treatment System

Soil and groundwater COC concentrations above CULs exist over most of the Lilyblad property and extend onto adjacent properties (refer to Figures 1-1 and 1-4). The soil AOC is approximately 2.6 acres in area. About 88 percent of the contaminant mass currently at the Site is located on the Lilyblad, Nelson, and Port of Tacoma Road properties (refer to Table 1.3). Much of this contamination is located in historical release areas on the Site near the rear and front tank farms, and the Lilyblad/Sol Pro processing areas and along the rail spur to the east of the Lilyblad property (refer to Figures 1-1 and 1-4).

The COCs are intermingled within the soil column. As a result, the soil column will have to be treated to reduce COCs to acceptable concentrations. The COC concentrations in soil will have to be reduced to remove the source of COCs to the groundwater. The affected soil column varies from 8 to 12 feet in depth. Groundwater is encountered at depths from 3 to 8 feet. DVE technology is the presumptive remedy used for removing VOCs from soil and groundwater in such conditions.

In situ biodegradation has been used successfully to reduce the concentration of TPH compounds in soil and groundwater. The interim measures recently conducted by Terra Vac at the Site demonstrated that *in situ* bioremediation could significantly reduce overall TPH concentrations in soil and groundwater at the Site (Terra Vac 2006a).

Soil and groundwater contaminated with SVOCs such as pentachlorophenol and naphthalene can often be treated *in situ* via chemical oxidation (EPA 1998). Terra Vac recently demonstrated that an oxidant could be successfully injected into the subsurface at Lilyblad (Terra Vac 2006a). Unfortunately analytical results demonstrating the effectiveness of the technology in destroying SVOCs were not provided.

The generic treatment system considered by this alternative will consist of DVE, DVE with the addition of agents that increase the rate of biodegradation, and DVE with the addition of oxidants. This alternative assumes that DVE would be used at all accessible locations at the Site, that *in situ* bioremediation would be used in areas where TPH concentrations are elevated, and that *in situ* oxidation would be used in areas where SVOC concentrations were elevated. This generic treatment system is similar to the system employed by Terra Vac to conduct Interim Measures at the Site. The key components of this groundwater and soil vapor treatment system include a surge tank, air stripping system, a particulate filter followed by activated carbon treatment for groundwater and vapors (removed from the stripping system), and a cooling system for maintaining discharges below 19°C to comply with existing NPDES-like permit requirements.

The soil vapor treatment system has been shown by Terra Vac to be able to meet the requirements established by the Puget Sound Clean Air Agency (PSCAA) for the operation of the DVE/bioremediation/oxidation treatment train, in PSCAA Notice of Construction Number 99367.

A process flow diagram of the generic DVE/bioremediation/oxidation treatment system is presented on Figure 2-3.

2.2.2 Variation A – Operate the Generic System to Achieve Method B Levels for all COCs

The treatment system would be mobile and would be installed at numerous locations around the Site. Terra Vac was able to achieve a radius of influence for its DVE wells of approximately 40 feet. Assuming that this spacing would be 'typical' for a generic treatment system, approximately 80 DVE wells will be needed to treat the entire Site (refer to Terra Vac 2005). Several extraction and/or injection systems could be installed at the Site at the same time. This alternative assumes that four treatment systems will be installed at any one time. These systems may be functioning in a DVE, bioremediation, or oxidation mode.

Terra Vac has operated a DVE/bioremediation/oxidation treatment train at pilot-scale or as an Interim Measure at the Site from September 2003 through February 2006. The Terra Vac treatment train was operated in the dissolved plume, LNAPL, and Hot Spot areas on the Lilyblad property, and in the MPE and PW Eagle manufacturing building areas on PWE property (refer to Figure 1-3). It is likely that these areas will require less future remediation to remove residual COCs in soil and groundwater than untreated areas of the Site. The operation of the treatment system for Variation A is expected to follow the outline presented by Terra Vac (Terra Vac 2005). Site-wide remediation for Variation A will begin with the sequential operation of extraction wells in DVE mode on the Lilyblad property, along the adjacent rail spur (Saul Property), and on the PW Eagle property. This will act to dewater the treatment area, remove soil vapor to the maximum extent practical, continue to provide containment of groundwater, and prevent the off-site migration of contaminants.

It is anticipated that it will take approximately 2 months to dewater the Site and remove an appreciable amount of the VOCs from the source areas. Bioremediation will begin in those well locations where TPH concentrations are the most elevated. Bioremediation is expected to take up to 5 years to be completed. Once bioremediation is complete, the oxidation of SVOCs will begin. This process is expected to last up to 1 year. Refer to Section 3.4.2 for a more detailed discussion of expected remediation time frames for Alternative 2. The treatment system will operate in an area of the Site until it is determined that the system has removed the maximum practical amount of contamination in that area. Ecology will make this determination.

A four-unit operating system is expected to generate up to 10 gpm of groundwater and up to 1,000 standard cubic feet per minute (SCFM) of vapor that requires treatment. Terra Vac proposed that two extraction and treatment systems be installed at the Site: one 3-unit system operating from the Nelson building and a second one-unit system operating in the alley way to the north of the PW Eagle manufacturing facility. This approach was depicted on Figure 12 of the Site Wide Remedial Action Design Plan prepared by Terra Vac (Terra Vac 2005). The cost estimate for Variation A of Alternative 2 (refer to Appendix A.2) contains additional information about the anticipated quantities of nutrients, oxidants, and other additives that are expected to be used to implement this variation of Alternative 2. The groundwater and soil vapor treatment systems use activated carbon to adsorb COCs before groundwater or soil vapor is released to the environment. It is expected that the four-unit treatment train will generate about 1,000 pounds of spent carbon per month. This carbon will be shipped off the Site and reactivated.

Alternative 2 – Variation A uses active remediation to destroy and/or remove COCs from the entire soil AOC and from the entire groundwater AOC. Variation A is expected to destroy and/or remove approximately 160,000 pounds of COCs in the soil AOC (refer to Table 1-3), and reduce the concentration of COCs in groundwater to CULs.

2.2.3 Variation B – Operate the Generic System to Achieve Method B CULs for TPH Compounds, Reduce the Concentration of VOC COCs and Rely on Monitored Natural Attenuation and Institutional Controls to Achieve Method B CULs for SVOCs

This alternative operates the four-unit generic system for a shorter period of time than would be required by Variation A since additional on-site treatment time needed to oxidize SVOCs is not required and monitored natural attenuation is expected to reduce the SVOC and VOC concentrations to acceptable concentrations during the more than 50 years it takes groundwater to flow from the Site to the Blair Waterway (refer to Section 2.1.1). This variation assumes that the DVE and *in situ* bioremediation portions of the generic treatment system would be active at the Site for a period of 5 years (refer to Section 3.4.2).

Variation B also assumes that natural attenuation will decrease the concentrations of VOC and SVOC COCs to acceptable concentrations once the TPH source has been reduced by operating the DVE and bioremediation system modules for a period of 5 years. The potential for natural attenuation at this Site is discussed in Section 3.2. The time period needed for VOC and SVOC COCs to naturally attenuate to CULs established by Ecology is expected to be greater than 50 years (refer to Section 3.2).

The cost estimate for Variation B of Alternative 2 (refer to Appendix A.2) contains additional information about the anticipated quantities of nutrients, oxidants, and other additives that are expected to be used to implement this alternative.

The groundwater and soil vapor treatment systems use activated carbon to adsorb COCs before groundwater or soil vapor is released to the environment. It is expected that the four-unit treatment train will generate about 1,000 pounds of spent carbon per month. This carbon will be shipped off the Site and reactivated.

Alternative 2 – Variation B uses active remediation to destroy and/or remove TPH COCs from the entire soil AOC and from the entire groundwater AOC. Variation B is expected to destroy and/or remove approximately 160,000 pounds of TPH from the soil AOC, a significant portion of the 3,500 pounds of VOCs, and a small portion of the 200 pounds of SVOCs (refer to Table 1-3) in the soil AOC. The concentration of VOC and SVOC COCs in groundwater are not expected to be reduced to CULs by Alternative 2 – Variation B.

2.2.4 Variation C – Containment of Groundwater on the Lilyblad Property and *In Situ* Treatment of Contaminants on Adjacent Properties

Alternative 1 evaluated the potential performance of slurry wall and sheet pile barrier walls designed to contain groundwater on the Lilyblad property. Each of these approaches has advantages and disadvantages. Both the continuous barrier and the partial barrier with enhanced groundwater recovery were judged likely to be effective barriers to groundwater flow. Variation C to Alternative 2 assumes that a continuous slurry wall barrier will be installed, as shown on Figure 2-1A. The generic *in situ* treatment system was described in Section 2.2.1. This system would only be operated on the PW Eagle property north and west of the

PW Eagle manufacturing building, on the Nelson property, and along the rail line right of way on the eastern potion of the Saul property (refer to Figure 1-3) as part of Variation C - Alternative 2. Two generic *in situ* treatment systems are expected to be needed for Variation C of Alternative 2. Variation C assumes that the *in situ* system (along with its groundwater and soil vapor treatment system) would operate for a period of 2 - 3 years (refer to Section 3.4.2).

The cost estimate for Variation C of Alternative 2 (refer to Appendix A.2) contains additional information about the anticipated quantities of nutrients, oxidants, and other additives that are expected to be used to implement this alternative.

The groundwater and soil vapor treatment systems use activated carbon to adsorb COCs before groundwater or soil vapor is released to the environment. It is expected that the two-unit treatment train will generate about 200 pounds of spent carbon per month. This carbon will be shipped off the Site and reactivated.

Alternative 2 – Variation C uses active remediation to destroy and/or remove TPH, VOC, and SVOC COCs from the portion of the soil and groundwater AOCs that are outside of the barrier wall located on the Lilyblad property. Variation C is expected to destroy and/or remove approximately 30,000 pounds of TPH, 280 pounds of VOC, and 18 pounds of SVOC COCs from the soil AOC (refer to Table 1.3). The concentrations of VOC and SVOC COCs in groundwater outside the barrier are expected to be reduced to CULs by Alternative 2 – Variation C.

Alternative 2 – Variation C leaves behind approximately 130,000 pounds of TPH, 3,400 pounds of VOCs, and 200 pounds of SVOCs that are present within the barrier wall on the Lilyblad property.

2.3 Alternative 3—Excavation and Disposal of Contaminated Soils

This alternative considers the demolition of existing buildings and infrastructure to allow for the excavation, removal and disposal of contaminated soil. Two variations of this alternative were considered: 1) Variation A - Excavation of soil above cleanup levels on the Lilyblad property, and 2) Variation B - Excavation of soil on the most contaminated parts of the Lilyblad property and natural attenuation of contaminants thereafter.

The intent of this alternative is to remove the source of the TPH, VOC, and SVOC contamination in soil on the Lilyblad property. Contaminants in soil are widely distributed around the Site (refer to Figure 1-1 and 1-4). Several site-specific technical restraints will affect the implementation of this alternative. These restraints are summarized in Section 2.3.1. Variation A of this alternative is described in Section 2.3.2 and Variation B is described in Section 2.3.3.

2.3.1 Technical and Financial Restraints Affecting the Implementation of this Alternative

The site-specific technical restraints that affect Alternative 3 and all other alternatives were summarized in Section 1.2. These restraints include 1) factors associated with the active use of the facility, 2) factors limiting access to and removal of contaminated soil and groundwater, and 3) site-specific geologic and hydrologic conditions promoting or prohibiting the applicability of certain remedial technologies.

The Lilyblad facility is currently used by Pacific Fluids to receive, repackage, store, and distribute a variety of petroleum products. These activities require that employees have access to, and use of most of the property. Soil contamination is present below the Pacific Fluids tank farms and warehouse and throughout the Lilyblad property (refer to Figures 1-1 and 1-3). The demolition of these facilities would likely put Pacific Fluids out of business and cause costly business interruptions to PWE and the railroad operator. Nonetheless, this alternative assumes that all or some of the facilities on the Lilyblad property will be demolished.

The excavation of soil on the Lilyblad property would have to overcome several technical issues including 1) dewatering of saturated soils prior to excavation, 2) excavations near building foundations, 3) excavations in areas where utilities are known to be or may be present, and 4) excavation work that does not cause undue business interruptions to operating facilities at PWE and the railroad, or on the Nelson or Saul properties.

PWE employees also need to have access to and use of their property. Soil contamination is present below the northwest corner of the PWE manufacturing facility, and below the rail lines to the west of Lilyblad on the Saul property. Buildings adjacent to the Lilyblad property would not be demolished by this alternative.

2.3.2 Variation A - Excavation of Soil above Cleanup Levels

As mentioned previously, buildings occupy approximately 40 percent of the 2-acre Lilyblad property. The Lilyblad property is paved with the exception a small landscaped area of small size. The primary underground utility corridors serving the Lilyblad property were described in the CH2M-Hill RI, Section 3.1.2 and

Figure 3.1. These corridors run along three of the four legs of the perimeter of the property. Other buried utilities are also present within the property boundary. The specific locations of these lines are not known.

To access contaminated soils on the Site, several structures must be demolished. These structures include a warehouse/administration building, two AST farms, a stormwater treatment plant and associated ASTs, a laboratory/boiler building and maintenance trailer, a petroleum pump station, a drum filling station, and a water tank for the wastewater treatment plant on the adjacent Nelson property. A more detailed description of the structures to be demolished under this alternative is outlined below.

Warehouse/Administration Building

The 10,000-square-foot warehouse building is located in the center of the Lilyblad property. On the east side of the building, the warehouse is a two-story office structure with a wood and drywall interior. Each floor is divided into five offices. The west side of the building is an open warehouse, with concrete block walls on the north and west sides, and a post and beam construction on the south. An elevated loading dock is situated on the west side of the building. The entire building is underlain by concrete slab and is covered by an aluminum roof.

North Tank Farm

A tank farm containing 16 tanks in four by four rows lies on the north side of the warehouse. The tanks were presumably used to store various chemicals and petroleum-based lubricants and fuels pertinent to the operations at Lilyblad Petroleum Inc. Each tank is approximately 12 feet in diameter and is estimated to be 25,000 gallons in volume. The tanks are surrounded by an approximately 3-foot-tall reinforced concrete berm. An additional tank of approximately 8,000 gallons lies within the berm, at the southwest corner. Each tank sits on a concrete pad, and gunite was used to fill the spaces between pads. The tank farm footprint is approximately 5,000 square feet.

Concrete separating walls were placed between the warehouse and the North Tank Farm to create three mixing rooms. The rooms are covered with a corrugated metal roof. One room is currently vacant, while the remaining two contain mixing tanks. The mixing tanks are heated and contain a total mixing capacity of 55,000 gallons. Overhead piping connects the mixing rooms with the drum filling station.

West Tank Farm

A second tank farm lies to the west of the warehouse. This tank farm contains 23 tanks of varying sizes. Four tanks are approximately 25,000 gallons, eight tanks are approximately 12,000 gallons, and eleven tanks are approximately 10,000 gallons in volume. It is likely that these tanks were also used to store various chemicals and petroleum-based lubricants and fuels. These tanks are also surrounded by a 3-foot-high reinforced concrete berm and sit on concrete pads surrounded by gunite. The footprint of the bermed area is 3,500 square feet.

A gap has been placed in the western wall of the warehouse to accommodate two ASTs that are each approximately 10 feet in diameter. The ASTs are partially covered by a corrugated metal roof that extends from the warehouse to the West Tank Farm. Pipe connections are routed below the roof, connecting the tank farm to the mixing rooms along the north side of the warehouse.

Stormwater Treatment Plant

Because the Site is almost entirely covered by pavement and buildings, a stormwater treatment plant has been placed in the south side of the West Tank Farm. The treatment plant occupies an 800-square-foot area and contains an oil/water separator, two 11-foot-diameter ASTs, and a 9-foot-diameter AST. The tanks are presumably associated with stormwater treatment.

Laboratory/Boiler Building

A two-story, wood frame building used to house lab equipment, a 250-horsepower boiler, a lunchroom, showers, offices, and storage occupies 900 square feet at the southwest corner of the property. A maintenance trailer is located near the building. More recently, four to six ASTs, each approximately 25,000 gallons, were installed nearby.

Petroleum Pump Station

A loading rack used to fill trucks with diesel and other petroleum products is located near the northwest corner of the Site. This steel frame structure has overhead piping leading to both tank farms. The structure occupies 600 square feet.

Drum Filling Station

A filling station used to fill drums and other containers is located to the north of the pump station near the northwest corner of the Site. This structure occupies 600 square feet and contains overhead piping leading to the mixing facilities adjacent to the warehouse. The structure is equipped with sprinklers and is explosion proof.

Water Tank

A water holding tank associated with the wastewater treatment plant located on the adjacent Nelson property is located at the northwest corner of the Site. The tank is approximately 11 feet in diameter. If demolished, this tank would have to be reinstalled nearby to allow for treatment of dewatering water during excavation activities.

Because petroleum products and solvents were processed in this facility, many of the structures, particularly the tanks and loading facilities, would need to be cleaned prior to demolition. In addition, a hazardous building material (HBM) survey and abatement must also be completed for each structure prior to the commencement of demolition activities.

Once demolition is complete, excavation would occur within the areas on the Lilyblad property that were within the soil AOC shown on Figure 1-1. On average, excavations would reach depths of 12 feet, which is 6 feet below the groundwater table. As a result, a total of 30,000 cubic yards of contaminated soils would be removed, of which 15,000 cubic yards are expected to be saturated and need dewatering prior to excavation and disposal. Variation A of Alternative 3 assumes that excavation would be phased or that the adjacent properties would be available to offer adequate room to stockpile saturated soils for dewatering. Soils would be stockpiled on an incline slope covered with a HDPE liner that is sloped toward a French drain. The collected water would then be pumped to the water treatment plant located on the Nelson property. It is estimated that excavation will occur in the relatively dry months of July and August and that dewatering will require approximately two days to complete.

Because 6 feet of the excavation extends below the groundwater table, dewatering measures must be in place to keep the excavation dry. It is assumed that sump pumps would be placed within the excavation and that collected water will be pumped to the treatment plant located on the Nelson property. Sloping of the excavation side walls or sheet pile installation will be necessary to excavate to the required depths. A 2H:1V slope would be required as a safety measure for excavation side walls. As such, the excavation would only reach the maximum required depth 24 feet within the edge of the property boundary and would leave approximately 6,000 cubic yards of contaminated soil in place. Therefore, the use of sheet pile or slurry wall is considered for this alternative.

Historical sample analytical results indicate that the main VOC constituents are perchloroethylene (PCE), trichloroethylene (TCE), m,p-xylenes, and toluene. Soil concentrations of PCE and TCE are well below the maximum allowable levels established for Rabanco's Roosevelt Subtitle D landfill facility, while xylenes and toluene are not listed in the soil acceptance criteria. The total average SVOC concentration in the soils to be excavated is lower than any of the individual SVOC acceptance criteria. The average TPH concentration of 852.36 mg/kg in soils being excavated under Alternative A is also below Rabanco's acceptance criteria. Based on these results, excavated soil is expected to be suitable for disposal at the Rabanco Landfill. This alternative assumes that the excavated soils can be disposed of at the Roosevelt landfill. Significant additional costs would be incurred if the excavated soil did not meet Rabanco's acceptance criteria and had to be disposed of in a hazardous waste landfill.

Because there is no transfer station in Tacoma, contaminated soils would be loaded into trucks and hauled to a transfer station in Seattle for disposal at the Rabanco Landfill. The excavation would then be backfilled with clean structural fill, compacted, and regraded to the original grade.

The total volume of soil that could be reasonably excavated was calculated to be 30,000 cubic yards. The footprint of this excavation includes all of the soil down to the aquitard that lies within the soil AOC on the Lilyblad property that is depicted on Figure 1-1. This excavation will leave approximately 35,000 pounds the TPH, VOC, and SVOC contamination in place on adjacent properties (refer to Table 1.3). Thus the source term will not be fully removed. However, based on average post-Interim Measure COC concentrations on the Lilyblad property, approximately 3,400 pounds of VOCs, 200 pounds of SVOCs, and 130,000 pounds of TPH would be removed from the Lilyblad property; or a total of approximately 134,000 pounds of contaminants. Therefore, this cleanup alternative variation should remove nearly all of the soil-based contaminants on the Lilyblad property. Performance monitoring will be necessary to designate soils for disposal. The total mass of contaminants in the soil AOC is estimated at approximately 163,000 pounds. Thus this excavation removes and disposes of 82 percent of the COCs present in the soil AOC.

The remaining off-site contamination would continue to contribute contaminants to groundwater flowing through the Site. However, in addition to soils removal, groundwater within the excavation will also be removed and treated. An estimated 500,000 gallons of water will be treated with the on-site treatment system. Some natural attenuation of the remaining residual contaminants would occur as the groundwater flowed toward the Blair Waterway. Compliance monitoring will be necessary for the duration of natural attenuation to ensure that waters with constituent concentrations above CULs are not entering the waterway. The concentrations of constituents are expected to decline to CULs in the 50-year time period that it would take for groundwater below the Site to travel to the Blair Waterway if short-circuiting did not occur (refer to Section 3.2).

2.3.3 Variation B – Excavation of Soils on the Most Contaminated Parts of the Property and Subsequent Natural Attenuation of COCs

Historical sample analysis indicates that soil contamination is present Site-wide. Interim remedial actions have already taken place north of the PW Pipe building, east of the North Tank Farm (LNAPL area), east of the laboratory/boiler building (Hot Spot area), and southwest of the warehouse building (MPE area). Therefore, the most contaminated areas remaining on the Lilyblad property are surrounding the warehouse, beneath both tank farms, and at the northwest corner of the Site, and near the loading rack area (Figure 2-4). Although it is unlikely that the warehouse would need to be demolished to excavate those soils, shoring would be necessary to protect the building's foundation as well as to retain the excavation side walls at depth. In addition, both tank farms, as well as the adjoining structures that house piping and mixing rooms, would need to be demolished.

As with Variation A, the excavation would extend 12 feet below ground surface into the aquitard, and dewatering of saturated soils and the excavation would be necessary. Approximately 16,700 cubic yards of soils would be removed and replaced with clean structural fill, which would be compacted and regraded. It is anticipated that 8,300 cubic yards of soil will be saturated and will need to be dewatered prior to disposal. The soils in this excavation are expected to be similar to those that could potentially be encountered with Variation A. Therefore, these soils are also assumed to be suitable for disposal at Rabanco's landfill. Compliance sampling and analysis will be necessary to designate these soils for disposal.

This excavation variation would result in the removal of 1,900 pounds of VOCs, 120 pounds of SVOCs, and 73,000 pounds of TPH. The total mass of COCs removed would be approximately 75,000 pounds, or approximately 56 percent of the calculated mass of contamination on the Lilyblad property and 46 percent of the total mass of contamination in the soil AOC. This limited excavation alternative will leave approximately 31,000 pounds of TPH, VOCs, and SVOCs in place on adjacent properties (refer to Table 1-3) as well as approximately 58,000 pounds within the Lilyblad property. Thus the source term on the Lilyblad property will not be fully removed by Variation B of Alternative 3.

The remaining contamination would continue to contribute contaminants to groundwater flowing through the Site. Some natural attenuation of these contaminants would occur as the groundwater flowed toward the Blair Waterway. In addition to soils removal, groundwater within the excavation will also be removed and treated. An estimated 300,000 gallons of water will be treated in the on-site treatment system. The concentration of contaminated groundwater within the groundwater AOC is expected to take more than 50 years to decline to CULs (refer to Section 3.2). Compliance monitoring would be conducted to determine whether groundwater contaminants are at concentrations below CULs prior to exiting the Site boundary.

2.4 Alternative 4—Hydraulic Control with Groundwater Monitoring

This alternative includes the maintenance of hydraulic control of groundwater below the Site and routine monitoring of water levels and COC concentrations in monitoring wells surrounding the Site (Ecology 2006c). Ecology has identified the 11 monitoring wells around the perimeter of the Site that will be used to monitor progress of cleanup actions at the Site. The locations of these wells are shown on Figure 2-5.

Terra Vac has prepared a Monitoring Plan (Terra Vac 2006b) that describes the approach to hydraulic control and groundwater monitoring associated with Alternative 4. Hydraulic control will be maintained by connecting the existing DVE system to the following wells to extract groundwater:

- MPE Downgradient wells: AGI-37, B-23, and BR6-3
- MPE well across from sewer drain trench: BR5-7
- End Points of Trench A: P-1A and P-5A
- Endpoints of Trench B: P-1B and P-6B
- East corner of LPI site: DP-3

Based on hydraulic containment efforts previously implemented on the Lilyblad property, MPE area, and PWE building by Terra Vac, it is estimated that hydraulic control of the Site groundwater contaminant plume can be maintained using a groundwater removal rate of approximately 2 gpm (Terra Vac 2006b). The extracted groundwater and soil vapor will be treated by the renovated CDM groundwater treatment system shown on Figure 2-2, and described in Section 2.1.3. The key components of this system include a surge tank, air stripping system, activated carbon treatment for groundwater and vapors (removed from the stripping system), and a cooling system for maintaining discharges below 19 degrees C to comply with Ecology's NPDES-like discharge criteria.

To confirm that groundwater containment has been achieved, groundwater elevations will be measured weekly for the first month after the hydraulic containment system has been activated and quarterly thereafter. Groundwater discharging the treatment system will be sampled and analyzed monthly to assure compliance with discharge requirements.

As part of this alternative, long-term groundwater quality monitoring will also be performed to evaluate the effectiveness and continued need for hydraulic containment. A long-term groundwater monitoring plan would be developed that specifies monitoring well locations, monitoring frequencies, sampling procedures, and analytical and reporting requirements. Cost estimates provided in Appendix A.4 are based on collecting groundwater samples from 11 monitoring wells located along the perimeter of the Site (see Figure 2-5) on a quarterly basis for Year 1, a semi-annual basis for Years 2 through 5, and on a yearly basis for Years 6 through 30. Compliance monitoring groundwater samples will be analyzed for VOCs (EPA Method 8260B with SIM for vinyl chloride and 1,1-DCE), TPH (NWTPH-G/D extended), and SVOCs (EPA Method 8270C and 8170C SIM for pentachlorophenol).

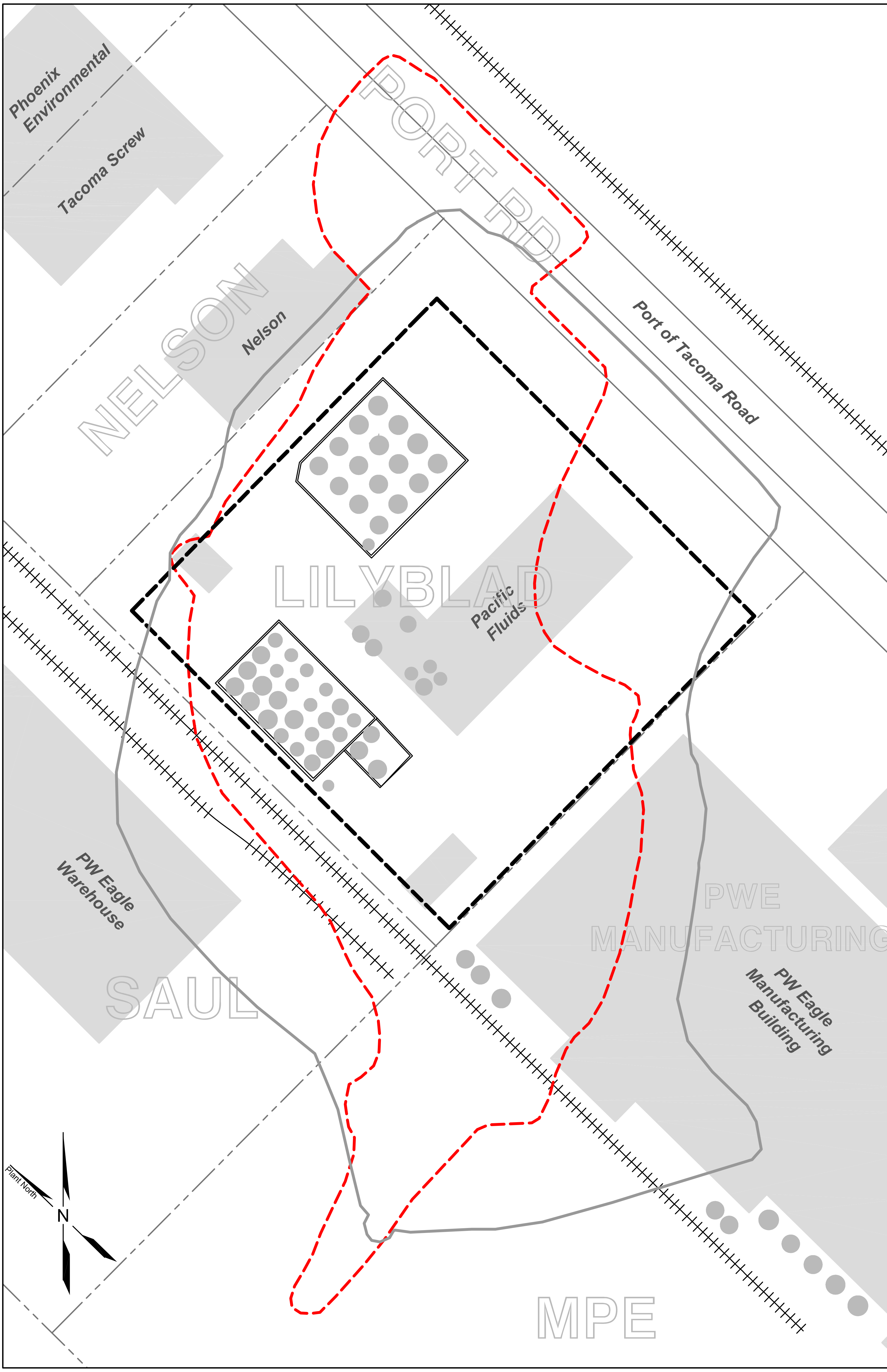
A compliance monitoring plan for groundwater and for soil (if appropriate) will be implemented for Alternatives 1, 2, and 3, as well. The specific elements of the monitoring plans are discussed in Section 3.3, 3.4, and 3.5, respectively.

The groundwater and soil vapor treatment systems utilize activated carbon to adsorb COCs before groundwater or soil vapor is released to the environment. This carbon will be shipped off the Site and reactivated.

Table 2.1 - Advantages/Disadvantages of Using Slurry Wall and Steel Sheet Pile Barriers on the Lilyblad Site

Type of Barrier	Advantages	Disadvantages
Slurry Wall	Work around utility penetrations without disconnect/rerouting.	Requires bench scale testing.
	Closer proximity to utility lines compared to vibratory or driven sheet pile installation.	Requires large excavation with soil disposal.
	Typically lower permeability compared to sheet pile.	Requires excavated soil dewatering and treatment/disposal.
	Potential for partial reuse of excavated soils.	Larger construction footprint for slurry mixing and soil stockpiling.
		Excavation standoff from building foundations and utility lines.
		Longer construction schedule.
		Controlled excavation around utility penetrations.
		Potential for dewatering of trench area prior to and during construction.
		Utility penetration design.
		Higher engineering costs.
Steel Sheet Pile	Shorter construction schedule.	Utility penetration disconnects and rerouting.
	Minimal or no soil disposal.	Utility penetration design.
	Low permeability with interlock sealant.	Utility standoff for vibratory or pile driving installation.
	Minimal or no dewatering.	
	Larger perimeter with non-vibratory pile installation.	
	Lower engineering costs.	

Alternative 1, Variation A - Continuous Barrier Footprint
Lilyblad Site



Source: CH2M Hill 2004.

Approximate Extent of Soil Contamination

Approximate Extent of Groundwater Contamination

Barrier: Variation A

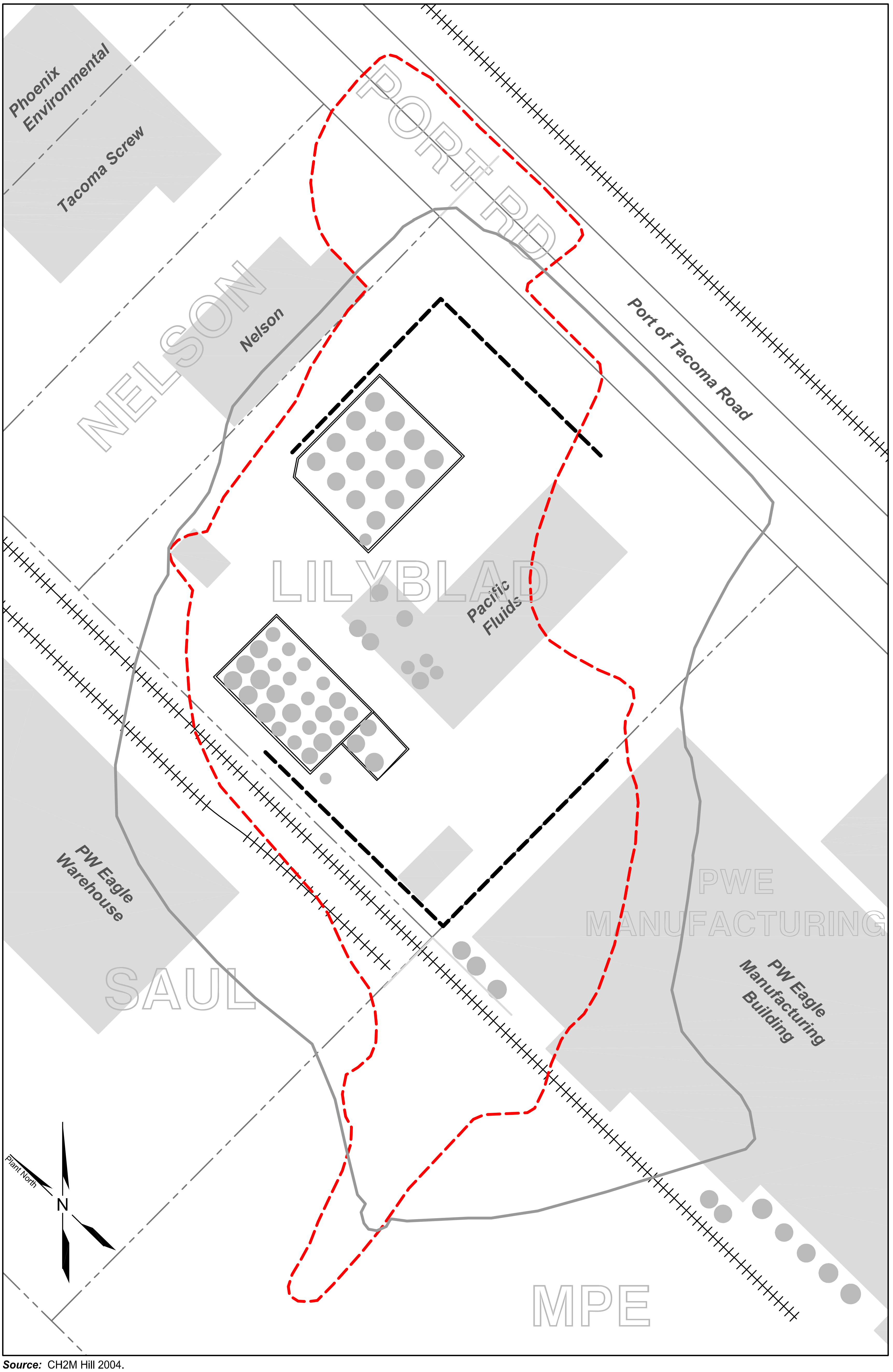
Railroad

Property Line

0 60 120
Scale in Feet

HARTCROWSER
13770-02 1/07
Figure 2-1A

Alternative 1, Variation B - Partial Barrier Footprint
Lilyblad Site



Source: CH2M Hill 2004.

Approximate Extent of Soil Contamination

Approximate Extent of Groundwater Contamination

Barrier: Variation B

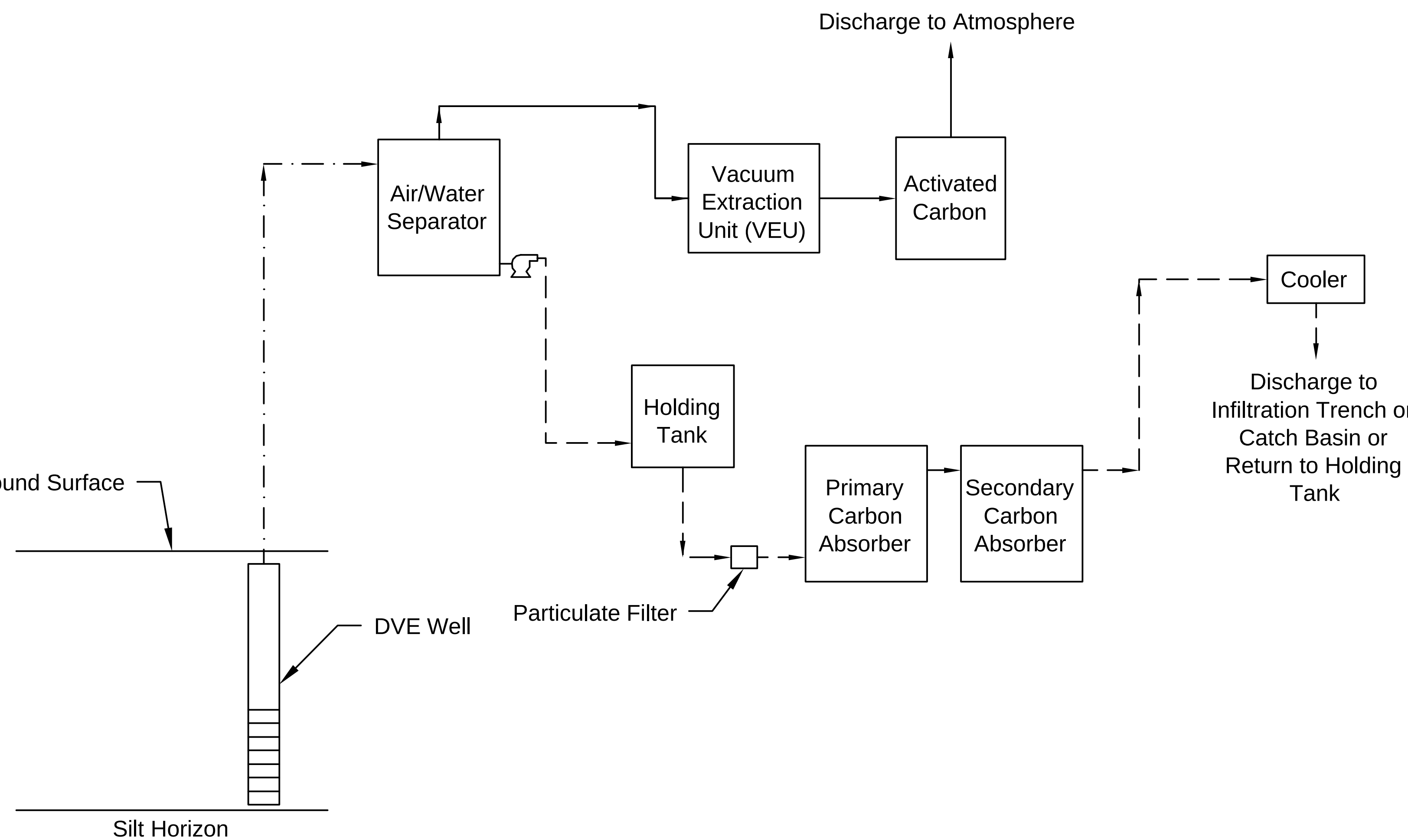
Railroad

Property Line

0 60 120
Scale in Feet

HARTCROWSER
17330-02 1/07
Figure 2-1B

Groundwater and Soil Vapor Treatment System Schematic



Source: Terra Vac 2005.

— — — Water

——— Vapor

— · — · — Water and Vapor

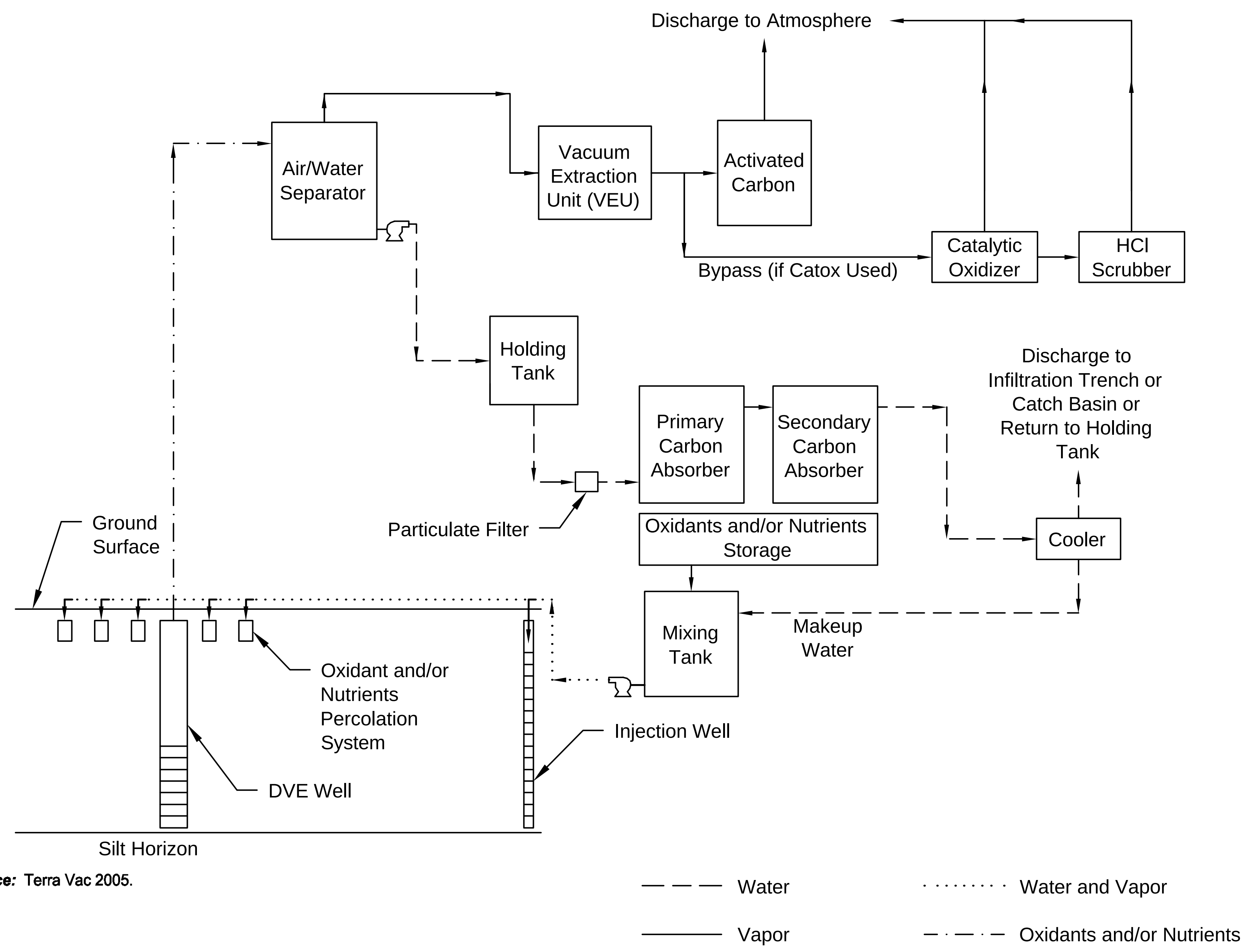
HARTCROWSER

Figure 2-2 *11/06*

17330-02

EAL 11/29/06 1733002-007.dwg

Alternative 2 - Process Flow Diagram Schematic



Source: Terra Vac 2005.

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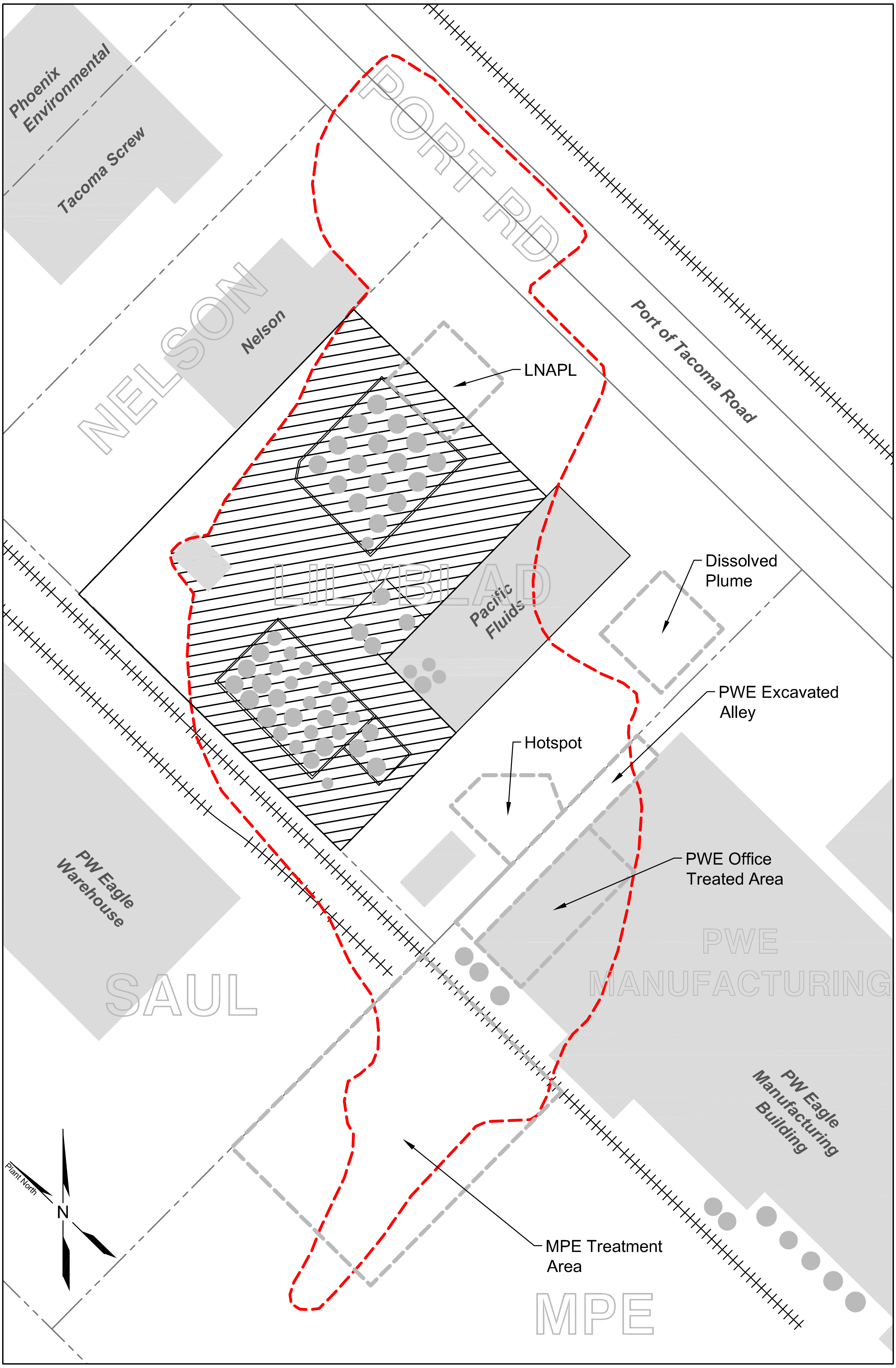
Figure 2-3

17330-02

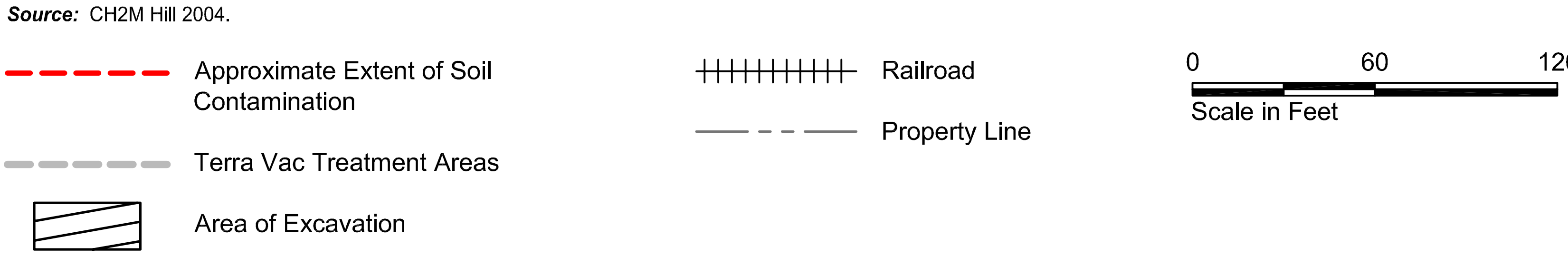
11/06

EAL 11/29/06 1733002-008.dwg

Alternative 3, Variation B - Proposed Excavation Location Plan
Lilyblad Site



Source: CH2M Hill 2004.



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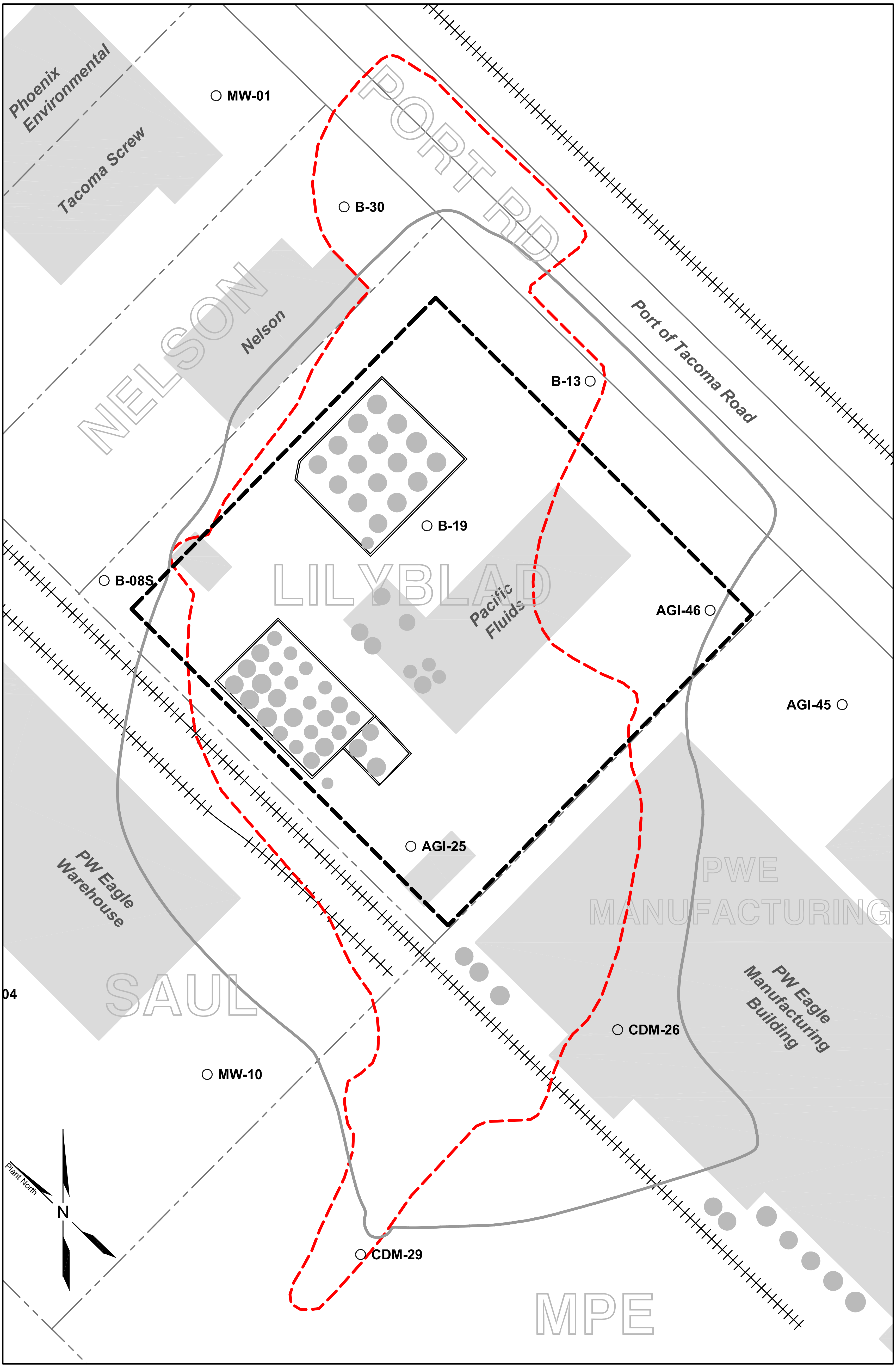
17330-02 1/07
Figure 2-4

Monitoring Well Location Plan
Lilyblad Site



Source: CH2M Hill 2004.

Approximate Extent of Soil Contamination

Approximate Extent of Groundwater Contamination

Barrier

Railroad

Property Line

AGI-25 Monitoring Well Location and Number

0 60 120
Scale in Feet

HARTCROWSER
17330-02 1/07
Figure 2-5

3.0 EVALUATION OF ALTERNATIVES

The four remedial alternatives (with variations) that are being considered by this FFS are evaluated in this section. Descriptions of the evaluation criteria used to evaluate the alternatives are provided in Section 3.1. Several of the alternatives include a provision for natural attenuation of COCs once active remediation has been completed. The potential for natural attenuation at the Site is assessed in Section 3.2. Subsequent sections present evaluations of the four remedial alternatives as follows:

- Alternative 1—Containment with Groundwater Controls (Section 3.3);
- Alternative 2—*In Situ* Treatment with and without Natural Attenuation (Section 3.4);
- Alternative 3—Excavation and Disposal of Contaminated Soils (Section 3.5); and
- Alternative 4—Hydraulic Control with Groundwater Monitoring (Section 3.6).

3.1 Description of Evaluation Criteria

Ecology identified the criteria that should be used to evaluate remediation alternatives within the Model Toxics Control Act (MTCA) regulation (WAC 173-340-360). The purpose of the evaluations is to identify the advantages and disadvantages of each alternative and thereby assist in the decision-making process. The criteria are applied to Alternatives 1 through 4 in Sections 3.3 through 3.6. The specific criteria are all considered important, but they are grouped into three sets of criteria that are weighted differently in the decision-making process. These criteria are:

- Threshold Requirements:
  - Protect Human Health and the Environment;
  - Comply with Cleanup Standards (WAC 173-340-700 through 173-340-760);
  - Comply with Applicable State and Federal Laws (WAC 173-340-710); and
  - Provide for Compliance Monitoring (WAC 173-340-410 and 173-340-720 through 173-340-760).

- Other Requirements:
  - Use Permanent Solutions to the Maximum Practical Extent. If a Disproportional Cost Analysis is used, then evaluate:
    - Protectiveness;
    - Permanence;

- Cost;
- Effectiveness over the Long Term;
- Management of Short-Term Risks;
- Technical and Administrative Implementability; and
- Consideration of Public Concerns.

■ Restoration Time Frame.

Alternatives 1 through 4 will include institutional controls and compliance monitoring. Institutional controls usually include on-site features, such as signs and fences, and legal mechanisms, such as lease restrictions, deed restrictions, land use and zoning designations, and building permit requirements. Ecology will determine the appropriate institutional controls for the Site. The compliance monitoring program established by Ecology for this Site (Terra Vac 2006b) is described in Section 2.4. As a result, compliance monitoring and the nature of the institutional controls judged appropriate for the Site are not included as evaluation criteria in this section. The cost of implementing the compliance monitoring judged appropriate for each alternative was included in the conceptual-level cost estimate prepared for that alternative.

The complex technical requirements of this Site (refer to Section 1.2), together with existing budget constraints, make a disproportionate cost analysis appropriate for this Site. The protectiveness criterion, when conducting a disproportional cost analysis, was judged to be equivalent to the threshold requirement to protect human health and the environment.

An alternative must meet the threshold criteria to be eligible for selection as a remedy. The expected performance of each alternative is assessed to identify its ability to comply with cleanup standards and applicable state and federal laws. If the alternative is judged to comply, the choice use among Alternatives 1 through 4 is then based on evaluation of the remaining eight evaluation factors.

3.1.1 Overall Protection of Human Health and the Environment

This evaluation criterion (WAC 173-340-360(3)(f)(i)) assesses the degree to which existing risks are reduced, the time required to reduce risks at the facility and attain cleanup standards, on- and off-site risks resulting from implementing the alternative, and improvement of overall environmental quality. The expected outcome of each alternative is compared to the CULs (refer to Table 2.1) established by Ecology for the Site.

3.1.2 Comply with Cleanup Standards

Ecology has established cleanup standards in the MTCA regulation. These standards are summarized in WAC 173-340-700 through 173-340-760. Ecology has established CULs for soil and groundwater at the Site that would assure compliance with these cleanup standards. These CULs are listed in Table 2.1.

3.1.3 Comply with Applicable State and Federal Laws

Ecology has established CULs for soil and groundwater at the Site that would assure compliance with applicable state and federal laws. These MTCA Method B CULs are listed in Table 2.1. The point of compliance for soil is throughout the Site for protection of groundwater and ambient air, and from the ground surface to a depth of 15 feet for soil for the protection of human health based on direct contact exposure.

As defined under MTCA 173-340-720(8), the standard point of compliance for Site shallow groundwater is throughout the Site. For Alternative 2A (Operate the Generic System to Achieve Method B Levels for all COCs), this standard point of compliance would be applied. For the remaining alternatives, it would not be practicable to meet CULs throughout the Site within a reasonable timeframe. Therefore, conditional points of compliance would be established. For Alternative 2C (Containment of Groundwater on the Lilyblad Property and *In Situ* Treatment on Adjacent Properties), a conditional point of compliance would be established at the barrier boundary. For all other alternatives, the conditional point of compliance would be established at the current edge of the groundwater plume.

3.1.4 Permanence

Permanence (WAC 173-340-360(3)(f)(ii)) is the degree to which an alternative permanently reduces the toxicity, mobility, or volume of hazardous substances, including adequacy of the alternative in destroying the hazardous substances, reduction or elimination of hazardous substance releases and sources of releases, degree of irreversibility of waste treatment processes, and the characteristics and quantity of treatment residuals generated.

3.1.5 Cost

This criterion (WAC 173-340-360(3)(f)(iii)) includes the cost of construction, net present value of any long-term costs, and agency oversight costs that are cost recoverable. An interest rate of 3 percent was used in the net present value calculation. Long-term costs include operation and maintenance costs, equipment replacement costs, the cost of maintaining institutional controls, and compliance monitoring costs.

3.1.6 Effectiveness over the Long Term

This criterion (WAC 1173-340-360(3)(iv)) assesses the degree of certainty that the alternative will be successful, reliability of the alternative during its operating time on the Site, magnitude of the residual risk with the alternative in place, and the effectiveness of controls required to manage residual wastes.

For this evaluation, an attempt was made to estimate contamination remaining at the Site at 5-, 10-, and 20-year points after an alternative is implemented. An attempt was also made to assess the effectiveness of natural attenuation for Alternative 1; Alternative 2, Variation B; Alternative 3, Variation B; and Alternative 4.

The following types of cleanup actions, in descending order of preference, can be used to assess the relative degree of long-term effectiveness: reuse or recycling; destruction or detoxification; immobilization or solidification; on-site or off-site disposal in an engineered, lined, and monitored facility; on-site isolation or containment with attendant engineering controls; and institutional controls and monitoring.

3.1.7 Management of Short-Term Risks

This criterion described in WAC 173-340-360(3)(f)(v)) assesses the risks to human health and the environment associated with the alternative during construction and implementation, and the effectiveness of measures that will be taken to manage such risks.

3.1.8 Technical and Administrative Implementability

This criterion (WAC 173-340-360(3)(f)(vi)) considers whether the alternative is technically possible including availability of necessary off-site facilities, services, and materials; administrative and regulatory requirements; scheduling; size; complexity; monitoring requirements; access for construction operations and monitoring; and integration with existing facility operations and other current or potential remedial actions.

3.1.9 Consideration of Public Concerns

This criterion (WAC 173-340-360(3)(f)(vii)) addresses the public's concerns, if any, about the preferred alternative identified by Ecology. It will be addressed during the comment period for the Proposed Plan and will not be further addressed in this report.

3.1.10 Restoration Time Frame

The time expected for restoration to be complete is assessed (WAC 173-340-360(4). This time frame must be reasonable when the nine factors summarized in WAC 173-340-360(4)(b) are considered. In some instances where cleanup levels cannot be technically achieved, concentrations that are technically possible to achieve shall be met within a reasonable time frame considering the nine factors specified in WAC 173-340-360(4)(b).

3.2 Potential for Natural Attenuation at the Lilyblad Site

The term "natural attenuation" refers to a variety of physical, chemical, and/or biological processes that under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil and groundwater. Natural attenuation occurs by physical, chemical, and/or biological mechanisms. Physical mechanisms include dispersion, dilution, sorption, and volatilization. Chemical mechanisms include oxidation, reduction, and hydrolysis. Biological transformation or biodegradation occurs by microbial aerobic and anaerobic processes (Ecology 2005).

The natural attenuation of COCs in groundwater is considered as an element of Alternatives 1, 2, and 3. Ecology has published guidance that outlines the process to be used to establish whether natural attenuation is occurring in petroleum-contaminated groundwater at a site, and for estimating the effectiveness of natural attenuation for petroleum-based contaminants (Ecology 2005). While this guidance is not specifically applicable to the natural attenuation of chlorinated solvents, or to mixtures of chlorinated solvents and petroleum products similar to the mixture of COCs present at this Site (refer to Table 2.1), it will be used as a starting point for the evaluation of the potential role that natural attenuation may play at this Site.

Ecology (2005) has defined a five-step process for determining the feasibility of natural attenuation as a cleanup action alternative:

- What is the status of the groundwater plume at the site?
- Is chemical or biological degradation a substantial mechanism of natural attenuation at the site?
- What is the estimated time frame?

- Will the use of natural attenuation be protective of human health and the environment during the estimated remediation time frame?
- Has source control been conducted to the maximum practical extent?

3.2.1 What is the Status of the Groundwater Plume at the Site?

To be considered a feasible cleanup alternative, natural attenuation should be reducing contaminant concentrations over time under current site conditions. The contaminant plume should not be expanding.

The available evidence suggests that concentrations of COCs in the groundwater plume are not increasing. Long-term water quality data have been collected since 1991 from wells B-8S, B-13, SP-4, and SP-5. Plots of benzene and vinyl chloride concentrations detected over time from wells B-13, SP-4, and SP-5 are shown on Figure 3-1, 3-2, and 3-3, respectively. These wells are located on the Site. Well B-8S, which is located at the western corner of the Site cross-gradient of the plume, has not had detectable concentrations of benzene and vinyl chloride. Well B-13 is located adjacent to Port of Tacoma Road near the leading edge of the plume. Concentrations of benzene and vinyl chloride in this well appear to be declining, supporting the conclusion that the concentrations of COCs in the groundwater plume are not increasing. There is insufficient evidence to determine whether the plume is decreasing in size from the available data set. Wells SP-4 and SP-5 are located in the core of the contaminant plume. Concentrations of benzene and vinyl chloride appear to be stable in SP-4 and SP-5 with no apparent trend in concentrations.

Groundwater monitoring data indicate that geochemical conditions within the central area of the plume are anaerobic, methanogenic, and that reductive dechlorination is actively occurring (CDM 2002). Under these conditions, anaerobic biodegradation of chlorinated hydrocarbons is favored rather than the aerobic biodegradation of petroleum hydrocarbons and vinyl chloride. It is likely that favorable conditions for the biodegradation of petroleum hydrocarbons, and vinyl chloride are present at the leading edges of the groundwater plume, which may explain why the COCs in groundwater apparently are not migrating off Site at high concentrations. Natural attenuation is proposed as part of Alternatives 2 and 3. For Alternative 1, natural attenuation is likely to occur as contaminated groundwater that is not contained within the barrier around the Lilyblad property continues to flow toward the Blair Waterway.

For Alternative 2 (Variations B and C), natural attenuation would begin once the hydrocarbons are removed from soil and groundwater at the Site. Petroleum hydrocarbons and related COCs comprise more than 98 percent of the total mass of contaminants at the Site (refer to Section 1.1). The remaining COCs include VOCs and SVOCs. There are no known active primary sources of these COCs at the Site. After the bulk of the COCs are removed by the *in situ* treatment system, the primary secondary source of contaminants to groundwater will likely be residual contamination left in soils (particularly smear zone and aquitard soils). At this time, it is not possible to analytically determine whether the plume would be stable once TPH-related COCs were removed. It is likely that the plume would be decreasing at this point.

For Alternative 3, natural attenuation of COCs in groundwater is considered once the most contaminated soils (refer to Section 2.3) have been removed from the Site via excavation. For this alternative, up to approximately 30,000 cubic yards of soil containing about 134,000 pounds of COCs would be removed from the Lilyblad property if all of the contaminated soil on the property were excavated. Residual contaminated soils would continue to act as a source of COCs to Site groundwater. At this time, it is not possible to analytically determine whether the groundwater plume would be stable once the most contaminated soils have been removed from the Site.

3.2.2 Is Chemical or Biological Degradation a Substantial Mechanism of Natural Attenuation at the Site?

Geochemical indicators associated with the biodegradation process consist of electron acceptors (reactants) or metabolic by-products of the oxidation and/or reduction reactions that occur. Geochemical indicators of petroleum hydrocarbon biodegradation can include O2, NO3-, Mn+2, Fe+2, SO4-2, CH4, redox potential (Eh), and alkalinity. Decreases in O2, NO3-, SO42-, and/or increases in CO2, CH4, Mn+2 are indicators of petroleum hydrocarbon biodegradation. Changes in relative concentrations of these indicators over time provide evidence as to whether natural attenuation is occurring and to what extent. This evaluation requires the collection of groundwater analytical data from different areas within the groundwater AOC and from uncontaminated areas upgradient from the plume over an extended period of time. Unfortunately, the available data set does not contain a sufficient number of samples to provide a defensible assessment of natural attenuation at the Site.

The limited available data sets at individual sample locations make it impossible to critically evaluate trends in the geochemical parameters listed above. The significant reduction in the concentration of TPH-related COCs during the enhanced biodegradation demonstration tests conducted by Terra Vac (refer to Section 3.4) is an indicator that biodegradation of petroleum would be possible in groundwater below the Site as an element of the active *in situ* treatment natural attenuation component of Alternative 2.

Chlorinated hydrocarbon VOCs are known to be present in the groundwater at the Site. PCE and/or TCE products were likely released on the Lilyblad property. The presence of daughter products (DCE and vinyl chloride) of PCE and/or TCE indicates that at least some portions of the groundwater plume are undergoing anaerobic biodegradation.

3.2.3 What is the Estimated Time Frame?

The restoration time frame depends upon four major components: the amount of source mass (and associated dissolution rate), bulk attenuation rates for contaminants, the groundwater cleanup levels needing to be met for the contaminants, and the point of compliance at which the cleanup levels should be achieved.

Alternative 2, Variation B is expected to remove nearly all of the TPH present in soils and groundwater at the Site (refer to Section 3.4). Alternative 2, Variation C combines a barrier on the Lilyblad property with the operation of a DVE/biodegradation/oxidation system on the PWE property and is expected to remove approximately 19 percent of the COCs on the Site.

Alternative 3, Variation B is expected to remove approximately 46 percent of the COCs present at the Site (refer to Section 3.5). The quantity of COCs removed by each of these variations was estimated to develop a range of treatment options that could be evaluated. The volumes of residual contaminated materials remaining after implementation of these alternatives were deemed sufficiently low to potentially allow for natural attenuation of the remaining COCs in groundwater.

The methods for estimating bulk attenuation rates for petroleum contaminants are presented in Appendix F of Ecology's Guidance (Ecology 2005). These methods require 1) a history of COC concentration versus time data for compliance wells during times when natural attenuation is expected to occur, and/or 2) the use of a variety of linear regression, and one- and two-dimensional transport models to estimate the bulk attenuation rate. The data necessary to conduct a regression analysis are not available. The use of one- and two-dimensional models is beyond the scope of this report.

Groundwater at the Site travels northeasterly from a hydraulic mound toward the storm sewer line imbedded in the Port of Tacoma Road, and southwesterly toward a sewer line on the Saul property. Both storm sewer lines empty into the Lincoln Avenue Ditch, which eventually discharges into the Blair Waterway (refer to CH2M Hill SRI, Figure 3-7). In both instances, groundwater exiting the Lilyblad property likely intermixes with groundwater that may have been contaminated by off-site properties and operating practices before it reaches the Blair Waterway. It will be difficult to isolate the contribution of Lilyblad property COC discharges into the Lincoln Avenue Ditch and ultimately the Blair Waterway from other sources.

For the reasons cited above, it is not possible to establish quantitative remediation time frames for the natural attenuation of groundwater at the Site as part of this FFS.

3.2.4 Will the Use of Natural Attenuation be Protective of Human Health and the Environment during the Estimated Remediation Time Frame?

As discussed previously, groundwater at the Site travels toward storm sewer lines that discharge into the Lincoln Avenue Ditch, which eventually empties into the Blair Waterway. It will be difficult to isolate the contribution of Lilyblad property COC concentrations to the concentrations of COCs that are present at the point where the storm drains below the Port of Tacoma Road and the Lincoln Avenue Ditch, and ultimately reaches the Blair Waterway. Thus it will not be possible (based on existing information) to isolate the contribution of the COCs present in the groundwater emanating from the Site to the overall risk to human health and the environment posed by the total COC load that will be present when groundwater from the Site eventually reaches the Blair Waterway.

3.2.5 Has Source Control Been Conducted to the Maximum Practical Extent?

Natural attenuation is proposed as part of Alternatives 1, 2 (Variations B and C), and 3. For Alternative 1, natural attenuation will occur as the impacted Site groundwater located outside of the Lilyblad property barrier continues to flow toward the Blair Waterway. In the context of the alternatives that were evaluated, the quantities of COCs removed by Alternative 2, Variation B and Alternative 3, Variation B were judged to represent source control to the maximum practical extent. Variation A for Alternative 3 also focused on source control but used natural attenuation to a lesser extent to achieve risk reduction. Alternative 2 Variation A achieves risk reduction without using natural attenuation.

3.3. Alternative 1—Containment with Groundwater Controls

This alternative consists of the installation of a barrier wall to prevent the flow of groundwater from the Lilyblad property to adjoining properties and ultimately to the Blair Waterway and Commencement Bay. The barrier system will be operational until the concentration of COCs are low enough that natural attenuation will reduce the concentrations to below the CULs for groundwater as it enters Commencement Bay.

Two barrier systems will be considered: 1) Variation A, a steel sheet pile or slurry wall around the perimeter of the Lilyblad property, and 2) Variation B, a steel sheet pile or slurry wall that reflects the minimal size and length of wall that will prevent contaminated groundwater from the Lilyblad property from migrating onto adjacent properties. Barrier wall locations are depicted on Figures 2-1A and 2-1B. Groundwater pumping from selected wells or interceptor trenches will be used to maintain hydraulic control within the barrier. Groundwater from the hydraulic control system will be treated to meet Lilyblad's current NPDES-like requirements. The groundwater treatment system will be based on the existing treatment system installed by CDM, with modifications as needed to meet the NPDES-like requirements. A schematic of this groundwater treatment system is shown on Figure 2-2 and is expected to treat approximately 1,500 gallons per day for Variation A and 3,000 gallons per day for Variation B.

The groundwater treatment system will continue to discharge to the catch basin that connects with the storm drain located below the Port of Tacoma Road. The approximate location of this stormwater line is shown on CH2M Hill RI, Figure 3.1. Compliance monitoring of the COCs in groundwater exiting the Site will be conducted as outlined in the Monitoring Plan for the Site (Terra Vac 2006b) and as described in Section 3.6. Quarterly samples will be obtained at 11 monitoring wells during Year 1, semi-annual samples will be collected during Years 2 through 5, and annual samples will be obtained during Years 6 through 20. Compliance monitoring for the COCs in soil will be conducted at the completion of the installation of the barrier and during Years 5, 10, 15, and 20. Performance monitoring of the groundwater treatment system will occur each day that the system is operational to assure that it is operating properly. The effluent from the system will be analyzed once per month for the compounds listed in the NPDES-like permit that Ecology has established for the Lilyblad property (Ecology 2000).

Additional passive containment to prevent recharge within the aquifer is provided by the existing surface asphalt or concrete paving and buildings with cement floors that are present on the Site.

3.3.1 Expected Performance of Alternative 1

Alternative 1 does not directly reduce the quantity or volume of COCs in soil within the barrier or on the Site. This alternative prevents the horizontal flow of groundwater in the upper aquifer from exiting the footprint of the barrier but does not address the vertical flow of groundwater from the upper to the lower aquifer. Alternative 1, Variation A provides for a continuous barrier to horizontal groundwater flow in the upper aquifer around the Lilyblad property and provides for the removal and treatment of precipitation that will recharge the groundwater within the barrier. Thus Alternative 1, Variation A will assure that COCs in the groundwater retained within the barrier does not reach receptors in the Blair Waterway. Alternative 1 does not inhibit the flow of groundwater, in the groundwater AOC outside of the barrier, toward the Blair Waterway, or of groundwater downward to the lower aquifer.

Alternative 1, Variation B provides hydraulic contaminant of groundwater from a combination of a partial barrier in conjunction with hydraulic control. Alternative 1, Variation B is also expected to largely prevent COCs in the groundwater on the Lilyblad property from reaching receptors in the Blair Waterway. Since the barrier installed by this variation is discontinuous, the possibility exists for some groundwater to escape the barrier. This possibility is judged to be low, given the locations selected for the barrier wall segments, the presence of groundwater trenches adjacent to the barriers, the collection and treatment of the groundwater collected in the trenches; and the materials of construction selected for the barrier.

Once the continuous barrier is installed, groundwater outside the barrier will be prevented from commingling with groundwater within the barrier. The primary source of water to the shallow aquifer on the Lilyblad property once the barrier is installed will be precipitation. As discussed in Section 2.1.2, approximately 425,000 gallons of precipitation is expected to recharge the aquifer within the barrier footprint each year. The upper aquifer within the barrier is expected to contain approximately 1.1 million gallons of water. Thus is would take about 1 to 2 years to replace the groundwater in the aquifer with precipitation. The combination of dilution from recharge and the treatment of water extracted from the Site to maintain hydraulic control will act to remove COCs from the groundwater retained within the barrier. Reduction of COCs in groundwater from biodegradation and other natural attenuation is likely to occur but at such a slow rate that attaining CULs is expected to take 100 or more years. The COCs removed will be replaced by COCs derived from contaminated soil that will remain on Site after the barrier is installed.

Unfortunately, approximately 130,000 pounds of contaminants are currently present within the AOC on the Lilyblad property (Refer to Table 1.3). A significant portion (approximately 50 percent) of the AOC falls outside the boundary of the barrier wall proposed by Alternative 1. The secondary sources of contaminants at these locations outside the barrier will not be treated by Alternative 1. This large 'source term' is expected to supply contaminants to the groundwater for an extended period of time. This time frame is expected to be longer than 100 years. For practical purposes, this restoration time frame suggests that treatment of groundwater on the Site would need to continue indefinitely.

Approximately 1.3 million gallons of groundwater reside in the Site groundwater AOC outside of the barrier proposed by Alternative 1. It is estimated that approximately 60 percent of the groundwater in the AOC will continue to flow toward the Blair Waterway when the barrier is installed. This groundwater is expected to take more than 50 years to reach the Blair Waterway, although short-circuiting by surface drainages could reduce the time for groundwater COCs to reach the waterway. It is likely that natural attenuation will reduce the concentration of COCs in this groundwater, but it is not possible to determine the amount time it would take to reduce concentrations to CULs.

3.3.2 Evaluation of Alternative 1

Alternative 1 is evaluated using the criteria defined in Section 3.1. A summary of this evaluation is provided in Table 3.1

Overall Protection of Human Health and the Environment

Alternative 1 does not directly reduce the quantity, volume, or toxicity of COCs in soil inside or outside of the barrier. Residual contamination will remain in the upper sand and aquitard units.

Alternative 1 does prevent the horizontal flow of groundwater in the upper sand aquifer from exiting the footprint of the barrier. Elevated concentrations of COCs will remain in groundwater both inside and outside the barrier. Alternative 1 provides increased protection beyond the protection provided by Alternative 4—Hydraulic Control and Monitoring, since a physical barrier is placed around the Lilyblad property to prevent COCs in groundwater from exiting the property.

Alternative 1 does not use active measures to treat the approximately 160,000 pounds of contaminants contained within the soil AOC at the Site. It does directly treat the groundwater that is extracted from the Lilyblad property to maintain hydraulic control. It is likely that natural attenuation of COCs in groundwater within the barrier will occur but at a very slow rate. This attenuation will be counter-balanced by the addition of COCs that will enter the groundwater as a result of the soil contamination that will still be present. The rate of natural attenuation of COCs together with the active treatment of extracted groundwater is not expected to achieve CULs for groundwater within the barrier for a very long period of time.

It is estimated that approximately 60 percent of the groundwater within the AOC will continue to flow toward the Blair Waterway when the barrier is installed. This groundwater is expected to take more than 50 years to reach the Blair Waterway if short-circuiting does not occur. It is likely that natural attenuation will reduce the concentration of COCs in this groundwater, but it is not possible to determine the amount of time it would take to reduce concentrations to CULs.

Alternative 1 provides a lesser degree of long-term effectiveness than Alternative 2, which actively destroys COCs in soil and groundwater, and Alternative 3, which excavates and disposes of COCs in soils in an off-site engineered, lined, and monitored Subtitle D landfill facility.

Comply with Cleanup Standards and Applicable State and Federal Laws

Ecology has developed CULs for soil and groundwater at the Site. Alternative 1 does not actively address the COCs in soil at the Site, so soil COC concentrations will exceed CULs throughout the Site.

Alternative 1 will prevent COCs in groundwater within the barrier footprint from reaching the Blair Waterway. About 60 percent of the groundwater within the groundwater AOC falls outside of the barrier proposed by Alternative 1. This groundwater is expected to take more than 50 years to reach the Blair Waterway, although short-circuiting by surface drainages could reduce the time for groundwater COCs to reach the waterway. It is likely that natural attenuation will reduce the concentration of COCs in this groundwater, but it is not possible to determine the amount of time it would take to reduce the concentrations of COCs to CULs.

Permanence

Alternative 1 does not actively treat soils within the soil AOC at the Site. Alternative 1 treats only a small portion of the contaminants present within the groundwater that is extracted from within the barrier. The contaminants are removed from groundwater by activated carbon. Thus, the COCs are not destroyed on Site. The spent carbon is regenerated off the Site by others. Alternative 1 provides significantly less permanence than Alternative 2, which actively treats the soil and groundwater within the AOC, or Alternative 3, which removes and disposes of soil within the Lilyblad property.

Since Variation A places a barrier around the perimeter of the Lilyblad property it is judged to provide a more permanent solution than the discontinuous barrier provided by Variation B.

Cost

A cost estimate and supporting assumptions for this alternative are presented in Appendix A.1. The conceptual-level (±25 percent.) cost estimate for a continuous barrier (Variation A) around the Lilyblad property is $3.1 million for a slurry wall barrier and $ 3.3 million for a steel sheet pile barrier.

The conceptual-level (±25 percent.) cost estimate for a discontinuous barrier around the Lilyblad property (Variation B) is $3.3 million for a slurry wall barrier and $3.4 million for a steel sheet pile barrier.

It should be noted that these cost estimates assume 20 years of groundwater treatment and compliance monitoring. As discussed below, the restoration timeframe for Alternative 1 is expected to exceed 20 years. Estimated costs for Alternative 1 variations will increase significantly if more than 20 years of groundwater treatment and compliance monitoring is required.

Effectiveness over the Long Term

The technologies employed by Alternative 1 have been successfully demonstrated at this scale at many locations. It is judged to be very likely that the continuous barrier (Variation A) would be effective in containing groundwater within its perimeter. Variation B (discontinuous barrier) is also expected to be effective in containing groundwater on the Lilyblad property.

Alternative 1 does not actively address the COCs in soils within the Lilyblad property or in soils within the AOC that fall outside of the barrier perimeter. These soils will continue to pose potential risks to human health and the environment. Alternative 1 does contain groundwater within the barrier. However, groundwater will continue to flow toward the Blair Waterway. This groundwater will continue to pose potential risks to human health and the environment. The existing institutional controls that are currently protecting site workers (e.g., asphalt pavement, building foundations) are expected to continue to be effective in mitigating the risks posed by the soils and groundwater within the AOC to site workers and visitors to the Site.

Alternative 1 provides a lesser degree of long-term effectiveness than Alternative 2 that actively destroys COCs in soil and groundwater, and Alternative 3, which excavates and disposes (off-site) of COCs in soils in an engineered, lined, and monitored Subtitle D landfill facility

Management of Short-Term Risks

Short-term risks to human health and the environment will occur if Alternative 1 is selected. There are many buried utility lines on the Lilyblad property. The installation of a barrier wall in the vicinity of these buried lines will expose site workers to the risks inherent in this activity. These risks can be mitigated by developing detailed work plans that will identify the location of known utility lines. The work plan can also identify contingency procedures that will be used to incrementally install the barrier in a way that anticipates that some buried utilities may not have been identified on site drawings or detected when underground utility lines were located by geophysical means. A health and safety plan would be developed to address these risks, and the risks associated with working in an area where COCs are known to be present at levels above CULs in soil and groundwater.

Active institutional controls and a personnel monitoring program will provide additional protection to site workers and the public who visit the Site.

Alternative 1 has more potential short-term risks to human health and the environment than does Alternative 4—Hydraulic Control and Monitoring. The installation of a barrier wall is judged to have less potential for short-term risks than the operation of a generic treatment system for a period of several years (Alternative 2), or the demolition of buildings and excavation of soil (Alternative 3) on the Lilyblad property.

Technical and Administrative Implementability

Slurry wall and sheet pile barrier walls are well developed technologies that could be implemented with a high degree of confidence for this alternative. The Lilyblad property is located in an industrial area. Access to services, materials, supplies, and skilled labor would be possible. Access for construction operations and monitoring would also be possible.

Installation of the barrier wall would be staged to limit interruption of the operations of Lilyblad and adjacent facilities to the minimal extent practicable. Some business interruptions are likely to occur.

Approximately 1.3 million gallons of groundwater reside in the portion of the groundwater AOC that will be outside of the barrier proposed by Alternative 1. It is estimated that approximately 60 percent of this groundwater will continue to flow toward the Blair Waterway when the barrier is installed. This groundwater is expected to take more than 50 years to reach the Blair Waterway, although short-circuiting by surface drainages could reduce the time for COCs to reach the waterway. It is likely that natural attenuation will reduce the concentration of COCs in this groundwater, but it is not possible to determine the amount of time it would take to reduce concentrations to CULs.

It will be difficult to isolate the contribution of Lilyblad property COC concentrations to the concentrations of COCs that are present at the point where the storm drains below the Port of Tacoma Road and the Lincoln Avenue Ditch, and ultimately reaches the Blair Waterway. Thus it may not be possible (based upon existing information) to isolate the contribution of the COCs present in the groundwater emanating from the Site to the overall risk to human health and the environment posed by the total COC load that will be present when groundwater from the Site eventually reaches the Blair Waterway.

Restoration Time Frame

Alternative 1 does not directly reduce the toxicity, mobility, or volume of the COCs contained in soil on the Site. This large 'source term' is expected to supply contaminants to the groundwater for an extended period of time. This time frame is expected to be longer than 100 years. The groundwater treatment system will continue to operate during this period. It is likely that the concentration of COCs in the soil AOC or in groundwater below the Lilyblad property will exceed CULs established by Ecology for this Site for more than 20 years after the barrier is installed.

Approximately 1 million gallons of groundwater reside in the groundwater AOC that will be outside of the barrier proposed by Alternative 1 (refer to Section 2.1.1). It is estimated that approximately 60 percent of this groundwater will continue to flow toward the Blair Waterway when the barrier is installed. This groundwater is expected to take more than 50 years to reach the Blair Waterway, although short-circuiting by surface drainages could reduce the time for groundwater COCs to reach the waterway. It is likely that natural attenuation will reduce the concentration of COCs in this groundwater, but it is not possible to determine the amount of time it would take to reduce groundwater concentrations to CULs.

3.4 Alternative 2—In Situ Treatment with and without Natural Attenuation

This alternative consists of installation and operation of a generic soil and groundwater treatment system consisting of soil vapor extraction, biodegradation using nutrients and chemical injections, and chemical oxidation.

This system was described in detail in Section 2.2.1 and depicted on Figure 2-3. Extracted groundwater and soil vapor will be treated by the treatment system described in Section 2.1.3 and depicted on Figure 2-2.

The groundwater treatment system will continue to discharge to the catch basin that connects to the storm drain located below the Port of Tacoma Road. The approximate location of this stormwater line is shown on CH2M Hill RI, Figure 3.1. The COCs in groundwater exiting the Lilyblad Site will be monitored as outlined in the Monitoring Plan for the Site (Terra Vac 2006b) and as described in Section 3.6. The Monitoring Plan will be tailored to the expected outcome of each variation of Alternative 2. For Variations B and C, where COCs will remain in groundwater after treatment, annual samples will be obtained at 11 monitoring wells during each year of treatment, and each year thereafter through Year 20. Compliance monitoring for the COCs remaining at concentrations above CULs in soil will be conducted at the completion treatment, and during Years 5, 10, 15, and 20 after treatment is concluded.

For Variation A, where treatment is expected to reduce the concentration of COCs in soil and groundwater to CULs, annual compliance groundwater samples will be collected during each year that treatment is underway. At the completion of treatment (6 years), one year of quarterly sampling and analysis will be conducted to demonstrate that treatment has continued to reduce the concentration of COCs to CULs. Compliance monitoring for the COCs in soil will be conducted at the completion of treatment and once again one year after the completion of treatment.

Performance monitoring of the groundwater treatment system will occur each day that the system is operational to assure that it is operating properly. The effluent from the system will be analyzed once per month for the compounds listed in the NPDES-like permit that Ecology has established for the Lilyblad property (Ecology 2000). The performance monitoring proposed for the treatment train is outlined in Terra Vac (2005a).

Three variations of this alternative are considered: 1) Variation A, operate the generic system until soil CULs are achieved in the soil AOC to a depth of 15 feet and groundwater CULs are met at the point at which groundwater below the Site reaches the Blair Waterway; 2) Variation B, operate the generic system to reduce the concentration of TPH components (gas, diesel, other) in soil to MTCA Method B CULs, substantially reduce the concentration of VOC COCs and utilize institutional controls and natural attenuation for other COCs thereafter; and 3) Variation C, containment of groundwater on the Lilyblad property and treatment of contaminants by the generic system on adjacent properties.

3.4.1 Performance of the Terra Vac System

Terra Vac has been performing pilot-scale tests and interim remedial measures at the Site using elements of a DVE, biodegradation, and chemical oxidation system singly and in combination since September 2003. The system Terra Vac utilized is described in the Site Wide Remedial Action Design Plan that was issued on August 3, 2005 (Terra Vac 2005a). Terra Vac has operated its treatment system in six areas within the Lilyblad and PW Eagle properties. On the Lilyblad property, Terra Vac operated the treatment system in the Pilot Test, LNAPL, Dissolved Plume, and Hot Spot areas (refer to Figure 1-3). On the PW Eagle property, the MPE area and a portion of the PW Eagle manufacturing building footprint were addressed by Terra Vac.

Mass of Contaminants Removed by Terra Vac

Terra Vac measured the concentration of VOCs, carbon dioxide, and methane in soil vapor as its system was operating. Terra Vac used the VOC readings to calculate the pounds of hydrocarbons removed by volatilization, the carbon dioxide readings to calculate the pounds of hydrocarbons removed by biological activity or oxidation, and methane readings to calculate the pounds of hydrocarbons removed as methane or other light hydrocarbons. The calculation approach used by Terra Vac is summarized in Table 3.2. The basis of the calculation approach is contained in Table 3.2 as well. This calculation approach does not 1) distinguish among individual COCs; 2) identify the actual physical or chemical process that produced the soil vapor; 3) consider the COC loading that exits the process through groundwater; nor 4) is it based upon the analysis of actual soil and groundwater samples. The soil vapor flow rates used to calculate the mass load were one-time readings taken near the conclusion of a run and do not represent an average or mean flow rate value during the run. Nonetheless, Terra Vac feels this approach to be a reasonable indicator (±25 percent) of the overall performance of its system at other sites that are similar to the Lilyblad Site (Malot 2006a).

The results of the calculations outlined in Table 3.2 are summarized in Table 3.3. The total operating time in each area is also presented in Table 3.3. Terra Vac estimates that they have removed approximately 80,000 pounds of hydrocarbons from the Site since work began in September 2003 (Terra Vac 2006c). This compares to the estimate summarized in Tables 1.2 and 1.3 that approximately 40,000 pounds of contaminants were removed (nearly all TPH compounds). Both estimates were based upon a set of imperfect assumptions. Nonetheless, it is clear that a significant quantity of TPH COCs were removed by the Terra Vac process.

Post-Remediation Soil and Groundwater Concentrations in Soil and Groundwater

Samples of soil and groundwater were obtained during December 2005 in areas where Terra Vac had conducted operations. A Work Plan for this sampling and analysis event was prepared by Terra Vac and approved by Ecology (Terra Vac 2005b). The sample analytical results were summarized by Terra Vac in a report dated January 9, 2006 (Terra Vac 2006a). The sampling and analysis program was designed to assess the performance of the Terra Vac process. It was not designed to collect information that could be used to determine whether an area treated by Terra Vac was 'clean.' The program collected samples from two to four locations within the areas where Terra Vac operated its treatment system. This sample location density (one sample per 1,200 to 3,000 square feet of surface area) was sufficient to obtain an indicator of performance but not sufficient to certify performance.

The results summarized in Table 6 of Terra Vac (2006a) indicate that the concentration of TPH and BTEX COCs in soil were significantly reduced in the areas where Terra Vac had operated the DVE/Bioremediation/oxidation treatment train. Similar reductions in the concentrations of TPH and BTEX COCs were reported for groundwater samples collected in the same areas.

Post-remediation concentrations of TPH-D, toluene, ethylbenzene, and xylene in soil were below CULs for the soil samples that were analyzed by Terra Vac (2006a, Table 4). The measured concentrations of TPH-G and dichlorobenzene in soil were also below CULs in the LNAPL and in most of the MPE treatment areas.

Post-remediation groundwater analytical results showed that the concentrations of TPH-G and TPH-D were reduced to below CULs in about half of the areas that were treated. Benzene and/or dichlorobenzene were present at concentrations above CULs in most areas that were treated. Again the areas that appeared to receive the most effective treatment were the LNAPL and most of the MPE treatment areas. These areas received the longest period of treatment by the Terra Vac process.

Terra Vac's Estimate of the Time Needed to Complete Remediation of the Site

Terra Vac used the contaminant removal data summarized in Terra Vac (2006a) to estimate the time that would be needed to complete the remediation of soil and groundwater at the Site. The pre-remediation COC concentration data in the area treated were compared to the post-remediation data collected in the area to calculate the removal efficiency for selected COCs in the area.

The following equation was used to calculate a reaction coefficient that represented the removal efficiency achieved and the treatment system operating time needed to achieve the removal efficiency

$$C = C_o e^{-t/k} \qquad (3 - 1)$$

Where:

C = final concentration in mg/kg or ug/L;
C_o = Initial concentration in mg/kg or ug/L;
t = time in days; and
k = reaction coefficient.

Terra Vac compiled the removal efficiency data (the C and the C_o) contained in Terra Vac (2006a) for each area of the Site that was treated. These data along with the cumulative treatment time in each area were plugged into Equation (3-1) to calculate a reaction coefficient for that area. The results of this calculation are summarized in Table 3.4. Terra Vac estimates that it would take approximately 2 to 3 years of enhanced biodegradation to reduce the concentration of TPH COCs to CULs in most areas of the Site. Once the TPH COCs were reduced to CULs, oxidation (9 to 12 months) would be used to treat VOCs and SVOCs in soil. Once the concentrations of VOCs and SVOCs in soil were reduced to CULs, continued oxidation (3 months) would reduce COC concentrations in the remaining groundwater at the site to CULs.

Equation (1) forces the pre- and post remediation data into its format. Equation (1) does not depend on the stoichiometry of chemical reactions that may be occurring as COCs are oxidized, or biodegraded, nor does it represent the specific physical or chemical processes that may be responsible for the removal of COCs that occurs. Nonetheless, Terra Vac feels the equation is useful in providing an indication of the time that will be needed to reach CULs in a given soil and groundwater media (Malot 2006a).

The reaction coefficients derived from Site data and listed in Table 3.4 were used to calculate the estimated time needed to reduce the concentration of TPH, VOC, and SVOC COCs in soil and groundwater to CULs at the Site. These estimated time frames were combined with the anticipated use of four separate treatment trains at the Site to prepare an estimate of the sequence of treatment that would be required at the Site to reach CULs. This treatment sequence is summarized in Table 3.5. Terra Vac estimates that a four-treatment train approach would need to operate for about 73 months to remediate the Site.

The approach used by Terra Vac to develop its proposed treatment sequence was evaluated. This evaluation addressed three questions: 1) Were the results obtained by Terra Vac during demonstration tests representative of results that could be expected during full-scale operations at the Site?, 2) Was a conservative design approach used to predict full-scale performance?, and 3) Did the design approach accurately predict the performance that was actually observed at the Site?

The demonstration work conducted by Terra Vac used DVE well spacings that varied from about 20 feet to about 40 feet (Malot 2006c). The full-scale design proposed by Terra Vac uses an approximately 40-foot spacing between DVE wells and a design capacity of 15 SCFM per well. Terra Vac was able to exceed this design flow rate with a DVE well spacing of 40 feet during its demonstration testing in the LNAPL and Dissolved Plume areas of the Site. A 40-foot spacing was not attempted in other areas of the Site.

TPH is the predominant COC at the Site. The biodegradation of this COC is more dependent on the quantity of oxygen provided by the injection well system, and by the hydraulics of the nutrient injection system than by the DVE design flow rate (as long as the DVE wells can remove degradation products as they are produced).

The reaction coefficients listed in Table 3-4 were used by Terra Vac to predict the performance of the full-scale system. These coefficients were derived from the results obtained during demonstration tests. The average value and the standard deviation of the reaction coefficient in an area of the Site were determined. Two standard deviations increments were added to the average value to develop the reaction coefficients listed in Table 3-4.

The results of sampling conducted in December 2005 were compared to the results predicted by the reaction coefficients listed in Table 3-4 (Terra Vac 2006a). The measured concentrations of TPH-D were below the concentrations predicted using a reaction coefficient of 193 days (Table 3-4). Similarly, the measured concentrations of 1,4 dichlorobenzene (using a k of 186 days) and tetrachloroethene (using a k of 199 days) were significantly below the concentrations predicted by Equation 3-1.

The approach used by Terra Vac to develop its proposed treatment system was judged to be reasonable since it was derived using site-specific results obtained in a way that is similar to the way in which the full-scale system would be utilized. Moreover, the predictive model (Equation 3-1) developed using these site-specific results yielded conservative estimates of system performance. This approach was used to develop the expected performance of the generic system that is described in Section 3.4.2.

3.4.2 Expected Performance of the Generic System

The performance of the Terra Vac treatment train at the Site indicates that the generic treatment train can significantly reduce the concentration of the TPH, SVOCs and VOCs at the Site. The results reported by Terra Vac indicate that concentrations of TPH-D, toluene, ethylbenzene, and xylenes in soil can be reduced to CULs if the treatment train (DVE and biodegradation) is allowed to operate for a sufficient period of time.

The results reported for TPH-G and for benzene also suggest (though less strongly than for TPH-D) that the concentration of these compounds in soil could also be reduced to CULs if the treatment train (DVE and bioremediation) were allowed to operate for a sufficient period of time. If benzene is a reasonable surrogate for other VOC COCs in soil, the operation of the treatment train (for a sufficient period of time) can be expected to reduce the concentration of VOC COCs to the CULs established by Ecology.

Oxidation will be required to reduce the concentration of SVOC COCs in soil. Oxidation was used for 2 months (December 2004 to January 2005) in the MPE area, for 5 months in the dissolved plume area (December 2003 to April 2004), and for 1 month in the LNAPL and Hot spot areas of the Lilyblad property. The analysis of soil samples collected in December 2005 did not include analyses for pentachlorophenol or other SVOCs. Direct analytical data that support the assertion that SVOCs could be removed from Site soils by oxidation was not available as this FFS was prepared..

Post-remediation groundwater analytical results showed that the concentration of TPH-G and TPH-D was reduced to below CULs about half the time in the areas that were treated. Benzene and/or dichlorobenzene concentrations were present above CULs in most areas that were treated. Again the areas that appeared to receive the most effective treatment were the LNAPL and most of the MPE treatment areas. The treatment train (DVE, bioremediation, limited oxidation) operated in these areas for an extended period of time. Additional oxidation may have further reduced the concentration of VOC COCs that are present in groundwater. A reduction of the concentration of VOC COCs in groundwater to CULs appears likely if oxidation begins after bioremediation had reduced the concentration of soil COCs to CULs.

Variation A – Operate the Generic System until Soil and Groundwater CULs are Met

The best available description of the operation of the generic treatment train to meet soil and groundwater CULs was prepared by Terra Vac and is summarized in Table 3.5. This estimate envisions three treatment trains operating on the Lilyblad property, and one treatment train operating in the MPE and PW Eagle area. DVE would be active for a 1-month period to achieve hydraulic control of the site. Bioremediation would follow for a total of 59 months. Oxidation of soil and groundwater would follow bioremediation, for a total of 13 months. The total duration of Variation A is approximately 73 months or 6 years.

The operation of the generic system for approximately 6 years is expected to reduce the concentration of TPH COCs in soil to CULs based on the post-treatment analytical results obtained in December 2005. While the December 2005 results were less conclusive regarding the effectiveness of treatment for VOCs, the longer operating time envisioned going forward (32 months of bioremediation followed by 9 to 13 months of oxidation in previously untreated areas versus the 9 to 22 month operating period for the MPE, Hot Spot, and LNAPL Interim Measures) should be sufficient to reduce the concentration of VOC COCs to CULs. The 9- to 13-month duration of the oxidation step should be sufficient to reduce the concentration of SVOC COCs to CULs, once the TPH concentrations have been reduced to CULs by bioremediation.

Alternative 2, Variation A uses active remediation to destroy and/or remove COCs from the entire soil AOC and from the entire groundwater AOC. Variation A is expected to destroy and/or remove approximately 160,000 pounds of COCs from the soil AOC (refer to Table 2.3), and reduce the concentration of groundwater COCs to CULs.

Once active remediation has been completed, the expected concentration of COCs in soil and groundwater would be expected to remain at concentrations below CULs into the future.

Variation B – Operate the Generic System until CULs for TPH Compounds are Met, the Concentration of VOC COCs is Substantially Reduced, and Use Institutional Controls and Natural Attenuation for the Other COCs Thereafter

A description of the operation of the generic treatment train to meet soil and groundwater CULs was prepared by Terra Vac and is summarized in Table 3.5. This estimate envisions three treatment trains operating on the Lilyblad property, and one treatment train operating in the MPE and PW Eagle area. DVE would be active for a 1-month period to achieve hydraulic control of the Site. Bioremediation would follow for a total of 59 months. As with Variation A, this period of bioremediation is considered sufficient for the concentration of TPH COCs in soil to be reduced to CULs based on the port-treatment analytical results obtained in December 2005, and to significantly reduce the concentration of VOC COCs.

The absence of the oxidation treatment step in Variation B will likely result in the presence of VOC and SVOC COCs in soil and groundwater at concentrations above CULs. These COCs would be allowed to naturally attenuate. As discussed in Section 3.2, the available data are not sufficient to calculate the expected degree of natural attenuation of groundwater or soil that would be expected to occur 5, 10, or 15 years after the operation of the DVE and bioremediation treatment train concluded.

Alternative 2, Variation B uses active remediation to destroy and/or remove TPH COCs from the entire soil AOC and from the entire groundwater AOC. Variation B is expected to destroy and/or remove approximately 160,000 pounds of TPH COCs from the soil AOC, but leave a small portion of the 3,500 pounds of VOC COCs and 200 pounds of SVOC COCs (refer to Table 2.3) in the soil AOC. The concentration of VOC and SVOC COCs in groundwater are not expected to be reduced to CULs by Alternative 2, Variation B, since the oxidation treatment step is not employed.

Variation C - Containment of Groundwater on the Lilyblad Property and Use of the Generic System on Adjacent Properties

Approximately 80 percent of the COCs in the soil AOC and 50 percent of the contaminated groundwater in the groundwater AOC is located within the Lilyblad property. Variation C calls for the containment of this soil and groundwater as discussed in Sections 2.1 and 3.3, and the use of the generic system in areas outside of the barrier shown on Figure 2-1A. The areas outside the Lilyblad property include the MPE and PW Eagle areas, the Nelson property, and some property under the Port of Tacoma Road (refer to Table 1.3 and Figures 1-2 and 1-4). The generic treatment train will be used to treat soil and groundwater in these areas.

Two treatment trains (DVE, bioremediation and oxidation) would be used for this alternative. One treatment train would operate in the MPE and PW Eagle areas, the other treatment train would operate on the Nelson property and on the property below the Port of Tacoma Road. The DVE extraction wells, injection wells, and other equipment will be placed in the same locations on adjacent properties as is envisioned for Variation A of Alternative 2. The treatment trains are expected to operate in a bioremediation mode for a period of approximately 20 months and in an oxidation mode for a period of 12 months. Alternative 2, Variation C uses active remediation to destroy and/or remove TPH, VOC, and SVOC COCs from the portion of the soil and groundwater AOCs that are outside of the barrier wall located on the Lilyblad property. Variation C is expected to destroy and/or remove approximately 30,000 pounds of TPH COCs, 280 pounds of VOC COCs, and 18 pounds of SVOC COCs (refer to Table 1.3) in the soil AOC. The concentration of VOC and SVOC COCs in groundwater outside the barrier are expected to be reduced to CULs.

Alternative 2, Variation C leaves behind approximately 130,000 pounds of TPH COCs, 3,100 pounds of VOC COCs, and 180 pounds of SVOC COCs that are present within the barrier wall on the Lilyblad property.

3.4.3 Evaluation of Alternative 2

Alternative 2 is evaluated using the criteria defined in Section 3.1. A summary of the evaluation of Alternative 2, Variations A, B, and C is provided in Table 3.6.

Overall Protection of Human Health and the Environment

Alternative 2 directly reduces the quantity, toxicity, and volume of contaminants in soil and groundwater on the Site. Alternative 2 directly treats and/or removes COCs from soil (approximate values):

Variation	TPH COCs	VOC COCs	SVOC COCs
A	160,000 lb	3,500 lb	200 lb
B	160,000 lb	<3500 lb	<<200 lb
C	30,000 lb	300 lb	<20 lb

Alternative 2 also directly treats groundwater within the groundwater AOC. The percent of the groundwater within the groundwater AOC that is directly treated by each variation of Alternative 2 is summarized below:

Variation	Percent of AOC Treated
A	100
B	100
C	60

Variations A and B of Alternative 2 provide increased protection to human health and the environment relative to Alternatives 1, 3, or 4, since substantial destruction of COCs in soil and groundwater occurs as the generic treatment system is used at the Site. This benefit to human health and the environment occurs within a relatively short (compared to Alternatives, 1, 3, or 4) 3- to 6-year time frame.

This evaluation assumes that the implementation of Alternative 2, Variation A will reduce the concentration of COCs in soil and groundwater to below CULs. Alternative 2, Variation B is expected to reduce the concentration of TPH COCs in soil and groundwater to below CULs and to substantially reduce the concentration of VOC COCs. The concentrations of SVOC COCs in soil and groundwater are expected to be only slightly reduced since oxidation is not employed by Variation B.

Alternative 2, Variation C actively treats soils and groundwater outside of the barrier (and within the soil and groundwater AOCs) installed by Alternative 1. The concentration of COCs in soil and groundwater in these areas after treatment is expected to be below CULs. The groundwater within the barrier will be contained. The groundwater extracted to maintain hydraulic control would be treated. The soil inside the barrier will not receive any treatment. Thus Alternative 2, Variation C, will not meet the CULs established for soil within the barrier. Nonetheless, Alternative 2, Variation C, is judged to be protective of human health and the environment.

After treatment, it is likely that natural attenuation of groundwater will occur. The information needed (refer to Section 3.2) to assess the likely degree of natural attenuation that would occur at the Site is not currently available.

Comply with Cleanup Standards and Applicable State and Federal Laws

This evaluation assumes that the implementation of Alternative 2, Variation A will reduce the concentration of COCs in soil and groundwater to below CULs. Alternative 2, Variation B is likely to reduce the concentration of TPH COCs in soil and groundwater to below CULs and to substantially reduce the concentration of VOC COCs. The concentrations of SVOC COCs in soil and groundwater are expected to be only slightly reduced since oxidation is not employed by Variation B. Thus it is likely that Variation B will achieve CULs for TPH and VOC COCs, and is unlikely to achieve CULs for SVOC COCs.

Alternative 2, Variation C actively treats soils and groundwater outside of the barrier (and within the soil and groundwater AOCs) installed by Alternative 1. The concentration of soil and groundwater COCs after treatment in these areas should be below CULs. Groundwater within the barrier will be contained but not treated. The groundwater extracted to maintain hydraulic control would be treated. Soil inside the barrier will not receive any treatment. Thus CULs established for soil will not be met within the barrier by Alternative 2, Variation C.

After treatment (Variations B or C), it is likely that natural attenuation of groundwater will occur. The information needed to assess the likely degree of natural attenuation that would occur at the Site over time is not currently available.

Permanence

Alternative 2 directly reduces the quantity, toxicity, and volume of COCs in the soil and groundwater, substantially reducing toxicity at the Site. Alternative 2 directly treats and/or removes COCs from soil (approximate values):

Variation	TPH COCs	VOC COCs	SVOC COCs
A	160,000 lb	3500 lb	200 lb
B	160,000 lb	<3500 lb	<200 lb
C	30,000 lb	300 lb	<20 lb

Alternative 2 also directly treats groundwater within the groundwater AOC. The percent of the groundwater within the groundwater AOC that is directly treated by each variation of Alternative 2 is summarized below:

Variation	Percent of AOC Treated
A	100
B	100
C	60

Variations A and B of Alternative 2 provide increased protection to human health and the environment and are more permanent than Alternatives 1, 3, or 4, since substantial destruction of COCs in soil and groundwater occurs as the generic treatment system is used at the Site.

During its 6-year operating period, Alternative 1, Variation A will extract groundwater and soil vapor that will require treatment. Extracted groundwater will be filtered and passed through activated carbon filters to remove COCs, and cooled if necessary to meet NPDES-like requirements prior to discharge. COCs vaporized from vadose zone soils, dewatered saturated zone soil, and groundwater will be collected via granular activated carbon adsorption. Spent activated carbon will be regenerated.

Soil vapor and groundwater extracted by Alternative 2, Variation B during its approximately 5-year period of operation, will also be treated by this groundwater and soil vapor treatment system. In addition, the soil vapor and groundwater treatment system will be used during the approximately 2 to 3 years that the generic treatment train would be used by Alternative 2, Variation C. Groundwater removed from inside of the barrier installed by Variation C would be extracted by pumps and treated by the groundwater treatment system.

Cost

The estimated conceptual-level cost (±25 percent) of each variation of Alternative 2 is presented in Appendix A.2 and summarized below:

Variation A	$4.9 million
Variation B	$4.4 million
Variation C	$5.0 million

Effectiveness over the Long Term

Alternative 2 would provide for a long-term reduction of contaminant concentrations by means of active remediation (all Variations) and the process of natural attenuation (Variations B and C). The technologies used are well understood and have been shown to be effective during the pilot-scale tests and Interim Measures that have been conducted at the Site. The DVE technology is the 'presumptive remedy' for VOCs present in soil and groundwater. *In situ* bioremediation has been shown to be effective in destroying TPH COCs at the Site. *In situ* oxidation has been shown to be effective in destroying SVOC COCs at other sites (EPA 1998).

The VOC COCs removed by the generic treatment train and the compounds produced by the bioremediation of TPH COCs and the oxidation of SVOC COCs and ultimately extracted by the generic system, will be treated by methods that have been shown to be effective during the Interim Measures conducted at the Site. The groundwater and soil vapor treatment system has been shown to be able to meet both NPDES-like and PSCAA discharge requirements.

This evaluation assumes that the implementation of Alternative 2, Variation A will reduce the concentration of COCs in soil and groundwater to below CULs at the conclusion of the 6-year period of operation of the generic treatment train. The small quantity of VOCs and SVOCs expected to remain in soil and groundwater after Alternative 2, Variation B is implemented will continue to naturally attenuate. The progress of natural attenuation will be monitored. The information needed to assess the likely degree of natural attenuation that would occur at the Site over time is not currently available (refer to Section 3.2).

Alternative 2, Variation C is expected to reduce the concentration of COCs to below CULs in a 2- to 3-year time frame in the area outside of the barrier. The concentration of COCs in the soil and groundwater within the barrier is expected to exceed CULs for an extended period of time. The risk to human health and the environment posed by these remaining COCs is low given the expected performance of the barrier, the presence of asphalt and concrete surfaces throughout the area within the barrier, and the enforcement of institutional controls on the Lilyblad property. The COCs that will remain in soil and groundwater within the barrier after Alternative 2, Variation C is implemented will continue to naturally attenuate. The progress of natural attenuation will be monitored. The information needed to assess the likely degree of natural attenuation that would occur at the Site over time is not currently available.

Variations A and B of Alternative 2 provide greater long-term effectiveness than Alternatives 1, 3, or 4, since substantial destruction of COCs in soil and groundwater occurs as the generic treatment system is used at the Site. This benefit to human health and the environment occurs within a relatively short (compared to Alternatives, 1, 3, or 4) 3- to 6-year time frame.

Management of Short-Term Risks

Short-term risks to human health and the environment would occur if Alternative 2 were implemented. These short-term risks will be present during installation and operation of the generic treatment train and its ancillary equipment. The installation of a barrier wall for Variation C will expose site workers to additional risks related to the presence of buried utility lines. Detailed work plans would be developed to identify potential implementation issues, and identify procedures that would be used to resolve these issues. Health and Safely plans would be prepared to address risks associated with working in an area where COCs are known to be present at concentrations above CULs in soil and groundwater.

Active institutional controls and a worker monitoring program will provide additional protection to site workers and the public who may visit the Site.

The variations of Alternative 2 are judged to have more potential short-term risks to human health and the environment than Alternative 1 and Alternative 4, due to the extended period of time that Alternative 2 will be in operation (Variations A and B), and/or the implementation of two remediation technologies (Variation C).

Technical and Administrative Implementability

The generic treatment train has been successfully demonstrated during pilot-scale and Interim Measure operations at the Site. These operations have been conducted with full-scale equipment. The system has been shown to be implementable. The installation and operation of the generic treatment system will be done in a way that minimizes disruptions to the operations on the Lilyblad and PW Eagle properties. It is anticipated that the site-wide generic treatment system can be installed within 6 months.

Slurry wall and sheet pile barriers are well developed technologies that could be implemented with a high degree of confidence by Variation C of Alternative 2. Installation of the barrier would be staged to avoid interruptions to the operations of Lilyblad and adjacent facilities to the maximum practicable extent.

Additional site characterization and modeling would be needed to predict the rate of natural attenuation to more accurately predict future concentrations in soil and groundwater of COCs that may be left behind by Alternative 2, Variations B and C.

Groundwater at the Site travels northeasterly from a hydraulic mound toward the storm sewer line imbedded in the Port of Tacoma Road, and southwesterly toward a sewer line on the Saul property, and eventually discharges to the Lincoln Avenue Ditch and ultimately into the Blair Waterway (refer to CH2M Hill SRI, Figure 3-7). In both instances the groundwater exiting the Lilyblad property likely intermixes with groundwater that may have been contaminated by off-site properties and operating practices before it reaches the Blair Waterway. It will be difficult to isolate the contribution of Lilyblad property COC concentrations from other sources in this highly industrial area.

Restoration Time Frame

This evaluation assumes that the implementation of Alternative 2, Variation A will reduce the concentration of COCs in soil and groundwater to below CULs by the conclusion of the approximately 6-year period of operation of the generic treatment system.

Alternative 2, Variation B is expected to reduce the concentration of TPH COCs in soil and groundwater to below CULs and to substantially reduce the concentration of VOV COCs by the conclusion of its approximately 5-year period of operation. Concentrations of SVOC COCs in soil and groundwater are expected to be only slightly reduced since oxidation is not considered by Variation B. Thus it is likely that Variation B will achieve CULs for TPH and VOV

COCs and is unlikely to achieve CULs for SVOC COCs at the conclusion of its period of operation.

The VOCs and SVOCs that are likely to be present in soil and groundwater at the conclusion of Alternative 2, Variation B's period of operation are expected to naturally attenuate. Additional site characterization and modeling would be needed to predict the rate of natural attenuation to more accurately predict future COC concentrations in soil and groundwater that may be left behind by Alternative 2, Variations B and C.

Alternative 2, Variation C, actively treats soils and groundwater outside of the barrier (and within the soil and groundwater AOCs) installed for this variation. Concentrations of soil and groundwater COCs in these areas after treatment are expected to be below CULs at the conclusion of its 2 to 3 years of operation. Groundwater within the barrier will be contained. The groundwater extracted to maintain hydraulic control would be treated. Soil inside the barrier will not receive any treatment. Thus Alternative 2, Variation C, will not meet the CULs established for soil within the barrier.

3.5 Alternative 3—Excavation and Disposal of Contaminated Soils

Alternative 3 consists of the excavation and removal of contaminated soils from the Lilyblad property. The intent of this alternative is to remove the source of TPH, VOC, and SVOC contamination in soils on the Lilyblad property from the surface down to the aquitard approximately 12 feet below ground surface. Section 2.3 described Alternative 3 in greater detail.

Two variations of this alternative were considered: 1) Variation A, Excavation of soil above cleanup levels on the Lilyblad property, and 2) Variation B, Excavation of soil on the most contaminated parts of the Lilyblad property and natural attenuation of contaminants thereafter.

Both variations of this alternative would have to overcome several technical issues including the dewatering of saturated soils prior to excavation, the active industrial nature of the Site, and the presence of numerous structures and buried utilities within the footprint of the excavation.

To access the soil on the Lilyblad property with COCs above CULs, Variation A of Alternative 3 would require demolition of the structures on the property and the likely closure of the businesses operating on the property. Based on the history and use of the Site, structures requiring demolition will require extensive evaluation for hazardous building materials followed by cleaning and/or abatement prior to demolition. Dewatering of the saturated soils will be required during excavation. Following excavation, the Site will be backfilled with clean structural fill and regraded. This fill material may be re-contaminated as untreated groundwater within the AOC continues to flow below the Lilyblad property.

Alternative 3, Variation B provides for excavation and disposal of soil on the most contaminated parts of the Lilyblad property followed by natural attenuation of the residual soil and groundwater contamination. This variation of Alternative 3 would focus on areas that have not been treated by interim remedial actions, namely in the vicinity of the warehouse, near and below both tank farms, and the pump station area in the northwest corner of the Site (refer to Figure 2-4). It is assumed that the warehouse could remain intact but both tank farms and adjoining structures would require demolition. As with Variation A of Alternative 3, structures requiring demolition on this property will require extensive evaluation prior to demolition, followed by cleaning and/or abatement. Following excavation, the property will be backfilled with clean structural fill and regraded.

Groundwater extracted to dewater the soils during excavation will be treated to meet Ecology's NPDES-like discharge requirements. The groundwater treatment system will be based on the existing treatment system installed by CDM, with modifications as needed to meet the discharge requirements. This groundwater treatment system is shown on Figure 2-2 and is expected to treat approximately 500,000 gallons for Variation A and 300,000 gallons for Variation B as the excavation proceeds on the Lilyblad property.

The COCs in groundwater exiting the Site will be monitored as outlined in the Monitoring Plan for the Site (Terra Vac 2006b) and as described in Section 3.6. Quarterly samples will be obtained at 11 monitoring wells during Year 1 following the completion of excavation, semi-annual samples will be collected during Years 2 through 5, and annual samples will be obtained during Years 6 through 20. Compliance monitoring for the COCs in soil will be conducted at the completion of the installation of excavation and during Years 5, 10, 15, and 20.

3.5.1 Expected Performance of Alternative 3

Alternative 3 will directly reduce the quantity or volume of COCs in soil within the boundary of the Lilyblad property. This alternative does not destroy COCs nor does it prevent the subsequent horizontal flow of groundwater in the upper aquifer from exiting the footprint of the Lilyblad property or of the Site.

Variation A – Excavate All Soil within the Soil AOC on the Lilyblad Property

Alternative 3, Variation A provides for excavation and disposal of Lilyblad property soils within the AOC that are present at concentrations above CULs, from the surface down to the aquitard layer. The total volume of soil that could be excavated under Variation A of Alternative 3 is approximately 30,000 cubic yards. Based on estimates of post-interim measure COCs concentrations remaining on the Site (Table 1.3), approximately 134,000 pounds of contaminants would be removed from the Lilyblad property. TPH-related compounds account for the vast majority of the soil contaminants on the Lilyblad property. Variation A of Alternative 3 would remove approximately 130,000 pounds of TPH, 3,400 pounds of VOCs, and 200 pounds of SVOCs. This removal would represent 100 percent of the calculated mass of contamination on the Lilyblad property and 80 percent of the total mass of contamination in the soil AOC. In addition, an estimated 500,000 gallons of groundwater would be treated during remedial construction.

With the addition of clean fill to the Lilyblad property, it is assumed that Alternative 3, Variation A will completely remove the soil contaminant sources from within the excavation foot print. Remaining contamination in the groundwater flowing from the Lilyblad property would be expected to naturally attenuate, but it is not possible to determine the amount of time it would take to reduce COC concentrations to CULs.

Following remedial activities, approximately 35,000 pounds of TPH, VOC and SVOC contamination will remain in place outside the excavation on the Lilyblad property and on adjacent properties (refer to Table 1.3). Thus the source term will not be fully removed and the soils in these areas would continue to degrade Site groundwater. It is expected that natural attenuation of soil and groundwater COCs in these areas would occur. Further investigation and evaluation would need to be conducted to determine the natural attenuation timeframe for these remaining contaminants.

Variation B – Excavate the Most Contaminate Soils in the Soil AOC on the Lilyblad Property

Alternative 3, Variation B excavates approximately 16,700 cubic yards of soils. This variation would result in the removal of approximately 73,000 pounds of TPH, 1,900 pounds of VOCs, and 120 pounds of SVOCs. In addition, an estimated 300,000 gallons of groundwater would be treated during remedial activity. The total mass of contaminants removed would be approximately 75,000 pounds, or approximately 56 percent of the calculated mass of contamination on the Lilyblad property and 46 percent of the total mass of contamination from the AOC. This excavation will leave approximately 58,000 pounds of contamination in place on the Lilyblad property and 31,000 pounds of contamination in place on adjacent properties (refer to Table 1.3) within the soil AOC. Thus the source term will not be fully removed from Lilyblad or the adjoining properties by Alternative C, Variation B.

The remaining soil contamination would continue to contribute contaminants to groundwater flowing through these properties. Natural attenuation of these contaminants would be expected to occur. Further investigation and evaluation would be needed to determine the natural attenuation timeframe for the remaining contamination on Lilyblad property and on neighboring properties.

3.5.2 Evaluation of Alternative 3

Alternative 3 is evaluated using the criteria defined in Section 3.1. A summary of the evaluation of Alternative 3, Variations A and B is provided in Table 3.7.

Overall Protection of Human Health and the Environment

Alternative 3 directly reduces the quantity of contaminants in the soil on the Site as noted below (approximate values):

Variation	TPH COCs	VOC COCs	SVOC COCs
A	130,000 lb	3,400 lb	200 lb
B	73,000 lb	1,900 lb	120 lb

Alternative 3 initially provides increased protection to human health and the environment relative to Alternatives 1 and 4 since it physically removes soil COCs from the Lilyblad property. Furthermore, this alternative will eliminate or significantly reduce the source of soil COCs to the groundwater flowing through the Lilyblad property.

With the exception of soil dewatering and subsequent water treatment during construction, this alternative does not address groundwater contamination on the Lilyblad or adjacent properties. Unlike Alternatives 1, 2, and 4, this alternative does not prevent, treat, or hydraulically restrict the horizontal flow of groundwater in the upper sand aquifer within the Site. Elevated concentrations of COCs will initially remain in the groundwater on Lilyblad and adjacent properties.

Residual soil contamination will continue to contribute COCs to groundwater in areas outside of the excavation footprint. It is likely that natural attenuation of

COCs in the groundwater will occur but at a very slow rate. This attenuation will be counter-balanced by the addition of COCs that will enter the groundwater as a result of residual soil contamination that will still be present. This groundwater is expected to take more than 50 years to reach the Blair Waterway, although short-circuiting by surface drainages could reduce the time for groundwater COCs to reach the waterway. It is likely that natural attenuation will reduce the concentration of COCs in this groundwater, but it is not possible to determine the amount of time it would take to reduce COCs to CULs.

Comply with Cleanup Standards and Applicable State and Federal Laws

Ecology has developed CULs for soil and groundwater at the Site. This alternative will remove between approximately 46 to 80 percent (dependent on which variation is implemented) of the soil contaminant mass from the soil AOC. Alternative 3 will assure that the concentration of COCs in soil on portions of the Lilyblad property that are excavated will be below CULs.

Alternative 3 will not prevent COCs in groundwater on the Lilyblad and adjoining properties from reaching the Blair Waterway. About 60 percent of the groundwater within the groundwater AOC falls outside of the limits of excavation proposed by Alternative 3. Elevated concentrations (above CULs) of COCs are expected to remain in groundwater on Lilyblad and adjacent properties. This groundwater is expected to take more than 50 years to reach the Blair Waterway, although short-circuiting by surface drainages could reduce the time for groundwater COCs to reach the waterway. It is likely that natural attenuation will reduce the concentration of COCs in this groundwater, but it is not possible to determine the amount of time it would take to reduce COCs to CULs.

Permanence

Alternative 3 directly removes between approximately 46 to 80 percent of the mass of COCs from the soil AOC. It is assumed that Alternative 3 will place excavated soils from the Lilyblad property in an engineered, lined, and monitored Subtitle D landfill. Following excavation, clean structural fill will be backfilled into the excavation. Groundwater COCs and sources of soil COCs outside of the excavations will not be addressed by this alternative and will continue to be present at concentrations that exceed CULs. This alternative provides more permanence than Alternatives 1 and 4 since from 75,000 to 135,000 pounds of COCs are removed from the Lilyblad property and disposed of. This alternative provides less permanence with regards to groundwater than Alternative 2, which actively treats groundwater within the AOC.

Cost

A cost estimate and supporting assumptions for this alternative are presented in Appendix A.3. The conceptual-level (±25 percent.) cost estimate for Variation A is $7.7 million; and $4.2 million for Variation B. These cost estimates exclude the cost of business interruptions or termination that would result if Alternative 3 were implemented.

Effectiveness over the Long Term

Removal of soils above CULs or removal of the most contaminated soils on Lilyblad property will reduce the potential for worker exposure and the amount of COCs that may potentially leach into groundwater.

Alternative 3 does not actively address COCs in groundwater within the Lilyblad property, or soil and groundwater COCs located on adjacent properties that fall within the soil AOC. The presence of these COCs at concentrations above CULs will continue to pose potential risks to human health and the environment. The existing institutional controls that are currently protecting site workers on the adjacent properties (e.g., presence of asphalt pavement and concrete building foundations) are expected to continue to be effective in mitigating the risks posed by the soils and groundwater with the AOC to site workers and visitors to the Site.

Compliance monitoring will be necessary to monitor groundwater COC concentrations as groundwater exits the Site.

Alternative 3 provides a greater degree of long-term effectiveness than Alternatives 1 and 4 since it removes from approximately 75,000 to 135,000 pounds of COCs from the Lilyblad property. With regards to groundwater, Alternative 3 provides a lesser degree of long-term effectiveness than Alternative 2, which will actively treat the groundwater COCs within the groundwater AOC.

Management of Short-Term Risks

Similar to Alternative 1, risks to human health and the environment will occur if this alternative is selected. Excavation and capping of the numerous buried utility lines on the Lilyblad property will expose site workers to risks inherent in this activity. For buildings selected for demolition, the inspection, cleaning, and/or abatement of hazardous materials will expose workers to risk. Additionally, large-scale excavation and dewatering of the contaminated soils will provide a risk of exposure to site workers. A health and safety plan would be developed to address these risks, and the risks associated with working in an area where COCs are known to be present at concentrations above CULs in soil and groundwater.

Active institutional controls and implementation of a construction safety monitoring program will provide additional protection to site workers and the public who visit the Site.

Given the amount of disturbance caused by excavation activities, Alternative 3 has more potential short-term risks to human health and the environment than does Alternative 1—Containment with Groundwater Controls and Alternative 4—Hydraulic Control with Groundwater Monitoring.

Technical and Administrative Implementability

Technologies employed by this alternative are common to the construction industry and with controls to prevent worker exposure, can be readily implemented. The Lilyblad property is located in an industrial area. Access to services, materials, supplies, and skilled labor would be possible. Access to construction operations and monitoring should also be readily available.

This alternative is expected to shut down Lilyblad operations. The feasibility of this outcome has not been assessed. This alternative would also likely cause some interruptions to adjacent business during construction activities.

Restoration Time Frame

Alternative 3 directly reduces the volume of the COCs contained in soil on the Lilyblad property. Soil and groundwater COCs outside of the Lilyblad property but within the AOC are not addressed. It is likely that the concentration of COCs in soil outside the limits of excavation will continue to exceed CULs for a very long period of time.

Groundwater is not directly addressed by Alternative 3. Sources of soil contamination outside the excavation (Variation A) or that remain on the Lilyblad property (Variation B) will continue to degrade groundwater within the AOC. This groundwater is expected to take more than 50 years to reach the Blair Waterway, although short-circuiting by surface drainages could reduce the time for groundwater COCs to reach the waterway. It is likely that natural attenuation will reduce concentration of COCs in this groundwater, but it is not possible to determine the amount of time it would take to reduce COC concentrations to CULs.

3.6 Alternative 4—Hydraulic Control with Groundwater Monitoring

Alternative 4 includes the maintenance of hydraulic control of groundwater below the Site and routine monitoring of water levels and COC concentrations in monitoring wells surrounding the Site (Ecology 2006c).

Based on hydraulic containment efforts previously implemented on the Lilyblad property, MPE area, and PWE building by Terra Vac, it is estimated that hydraulic control of the Site groundwater contaminant plume can be maintained using a groundwater removal rate of 2 gpm (Terra Vac 2006b)). The extracted groundwater and soil vapor will be treated by the renovated CDM groundwater treatment system shown on Figure 2-3, and described in Section 2.3.3. The key components of this system include a surge tank, air stripping system, activated carbon treatment for groundwater and vapors (removed from the stripping system), and a cooling system for maintaining discharges below 19° C to comply with NPDES-like requirements.

To confirm that groundwater containment has been achieved, groundwater elevations will be measured weekly for the first month after the hydraulic containment system has been activated and quarterly thereafter. Groundwater discharging the treatment system will be sampled monthly to assure compliance with discharge requirements.

As part of this alternative, long-term groundwater quality monitoring will also be performed to evaluate the effectiveness and continued need for hydraulic containment. A long-term groundwater monitoring plan would be developed that specifies monitoring well locations, monitoring frequencies, sampling procedures, and analytical and reporting requirements. Cost estimates provided in Appendix A.4 are based on collecting groundwater samples from 11 monitoring wells located along the perimeter of the site (see Figure 2-5) on a quarterly basis for Year 1, a semi-annual basis for Years 2 through 5, and on a yearly basis for Years 6 through 30.

3.6.1 Expected Performance of Alternative 4

Alternative 4 does not directly reduce the quantity or volume of COCs in Site soils. This alternative is expected to significantly reduce horizontal flow of groundwater in the upper aquifer that exits the Site. Alternative 4 provides hydraulic control of groundwater flow in the upper aquifer within the Site. Thus Alternative 4 is expected to reduce the likelihood that COCs in groundwater beneath the Site will reach receptors in the Blair Waterway.

Alternative 4 does not directly reduce the quantity or volume of COCs in soil on the Lilyblad property or adjacent properties. Once hydraulic control is initiated, groundwater on the Site will be replenished by groundwater inflow from off-site sources and from precipitation. A significant source of water to the shallow aquifer on the property will be precipitation. As discussed in Section 2.3.2, approximately 425,000 gallons of precipitation are expected to recharge the aquifer within the AOC each year. The upper aquifer within the AOC is expected to contain approximately 1,300,000 gallons of water. The combination of dilution from recharge and the treatment of water extracted to maintain hydraulic control will act to remove COCs from groundwater within the groundwater AOC. Reduction of COCs in groundwater due to biodegradation and other natural attenuation mechanisms is likely to occur but at such a slow rate that attaining CULs for groundwater will take 100 or more years. The COCs removed will be replaced by COCs that originate from the contaminated soil that will remain on the Site after hydraulic control is initiated.

Unfortunately, approximately 130,000 pounds of contaminants are currently present within the AOC on the Lilyblad property (Refer to Table 1.3). An additional 35,000 pounds (approximately) of contaminants are present in soil that is within the soil AOC and outside of the Lilyblad property. The secondary sources of contaminants at locations throughout the soil AOC will not be treated by Alternative 4. This large 'source term' is expected to supply contaminants to the groundwater for an extended period of time. This time frame is expected to be longer than 100 years. For practical purposes, this restoration time frame suggests that hydraulic control of groundwater on the Lilyblad property would need to continue indefinitely.

3.6.2 Evaluation of Alternative 4

Alternative 4 is evaluated using the criteria defined in Section 3.1. A summary of this evaluation is provided in Table 3.8.

Overall Protection of Human Health and the Environment

Alternative 4 does not directly reduce the quantity or volume of COCs in soil inside or outside of the soil AOC. Residual contamination will remain in the upper sand and aquitard units on the Site.

Alternative 4 does reduce the horizontal flow of groundwater in the upper sand aquifer that exits the footprint of the AOC. Since the groundwater plume is apparently stable, it is likely that the quantity of COCs that will exit the property in groundwater and reach the Blair Waterway will be reduced by this alternative. Elevated concentrations of COCs will remain in groundwater both inside and outside of the Lilyblad property. Alternative 4 provides equivalent protection to that provided by Alternative 1—Containment with Hydraulic Controls since Alternative 4 provides hydraulic control of the entire groundwater AOC, while a physical barrier is placed around the Lilyblad property to prevent COCs in groundwater from exiting the property by Alternative 1. A physical barrier is more effective than hydraulic controls alone in preventing the flow of groundwater.

Alternative 4 does not use active measures to treat the approximately 164,000 pounds of contaminants contained within the soil AOC at the Site. It does directly treat groundwater that is extracted from the groundwater AOC to maintain hydraulic control. Thus, Alternative 4 is less protective of human health and the environment than Alternatives 2 and 3, which treat and/or remove COCs in soil and groundwater. It is likely that natural attenuation of COCs in groundwater within the AOC will occur but at a very slow rate. This attenuation will be counter-balanced by the addition of COCs that will enter the groundwater as a result of leaching from residual soil contamination. The rate of natural attenuation of COCs together with the active treatment of extracted groundwater is not expected to achieve CULs for groundwater within the AOC for a very long period of time.

Comply with Cleanup Standards and Applicable State and Federal Laws

Ecology has developed CULs for soil and groundwater at the Site. Alternative 4 does not actively address the COCs in soil at the Site, so soil COC concentrations will exceed the CULs.

Natural attenuation of COCs in groundwater together with the active treatment of extracted groundwater is not expected to achieve CULs for groundwater within the Lilyblad property or on the Site for a very long period of time.

Permanence

Alternative 4 does not actively treat soils within the soil AOC at the Site. Alternative 4 actively treats only a small portion of the contaminants present within the groundwater that is extracted from the AOC to assure hydraulic control. The contaminants are removed from groundwater by activated carbon. Thus the COCs are not destroyed on site. The spent carbon is regenerated off the site. This alternative provides significantly less permanence than Alternative 1, which installs a physical barrier to prevent the flow of groundwater from exiting the Lilyblad property; Alternative 2, which actively treats the soil and groundwater within the AOC; or Alternative 3, which removes and disposes of soil within the Lilyblad property.

Cost

A cost estimate and supporting assumptions for this alternative are presented in Appendix A.4. The conceptual-level (±25 percent.) cost estimate for Alternative 4 is $3.6 million.

It should be noted that this cost estimate assume 30 years of groundwater treatment and compliance monitoring. As discussed below, the restoration timeframe for Alternative 4 is expected to exceed 30 years. The estimated cost for Alternative 4 will increase significantly if additional groundwater treatment and compliance monitoring are required.

Effectiveness over the Long Term

Technologies employed by Alternative 4 have been successfully demonstrated at this scale at many locations. It is likely that the hydraulic control measures would be effective in containing groundwater within the Lilyblad property.

Alternative 4 does not actively address the COCs in soils within the AOC.. These soils will continue to pose potential risks to human health and the environment. The existing institutional controls that are currently protecting site workers (e.g., presence of asphalt pavement and concrete building foundations) are expected to continue to be effective in mitigating the risks posed by the soils and groundwater within the AOC to site workers and visitors to the Site.

Alternative 4 provides a lesser degree of long-term effectiveness than Alternative 1, which installs a physical barrier around the Lilyblad property; Alternative 2, which actively destroys COCs in soil and groundwater; and Alternative 3, which excavates and disposes of COCs in soils in an on-site engineered, lined, and monitored facility.

Management of Short-Term Risks

Minimal risks to human health and the environment will occur if Alternative 4 is selected. A health and safety plan would be developed to address these risks, and the risks associated with working in an area where COCs are known to be present at concentrations above CULs in soil and groundwater.

Active institutional controls and a personnel monitoring program will provide additional protection to site workers and the public who visit the Site.

This alternative has fewer potential short-term risks to human health and the environment than does Alternative 1—Containment with Hydraulic Controls, since a physical barrier is not installed. Alternative 4 poses significantly less potential for short-term risks than the operation of a generic treatment system for a period of several years (Alternative 2), or the demolition of buildings and excavation of soil (Alternative 3) on the Lilyblad property.

Technical and Administrative Implementability

Hydraulic control is a well developed technology that has been used at the Site during the past several years. The Site is located in an industrial area. Access to services, materials, supplies, and skilled labor would be possible. Access for construction operations and monitoring is also likely readily available.

Installation of hydraulic controls would be staged to minimize interruptions to the operations of Lilyblad and adjacent facilities.

As discussed previously, it will be difficult to isolate the contribution of Site COC concentrations to the Blair Waterway from the contributions of other sources. Thus it may not be possible (based upon existing information) to isolate the contribution of COCs present in the groundwater emanating from the Site to the overall risk to human health and the environment posed by the total COC load that will be present when groundwater from the Site eventually reaches the Blair Waterway.

Restoration Time Frame

Alternative 4 does not directly reduce the toxicity, mobility, or volume of the COCs contained in Site soils. This large 'source term' is expected to supply contaminants to the groundwater for an extended period of time. This time frame is expected to be longer than 30 years. The groundwater treatment system will continue to operate during this period. It is unlikely that the concentration of COCs in soil in the soil AOC or in groundwater below the Lilyblad property will be reduced to the CULs established by Ecology for this Site.

Table 3.1 - Evaluation of Alternative 1—Containment with Groundwater Controls

Criteria	Variation A - Perimeter Barrier Slurry Wall or Steel Sheet Pile	Variation B - Discontinuous Barrier Slurry Wall or Steel Sheet Pile
Overall Protection of Human Health and the Environment	Does not actively address the COCs in soil at the Site. Will not assure that the concentration of COCs in soil at the Site will be below CULs. About 60 percent of the groundwater within the groundwater AOC falls outside of the barrier. This groundwater will not be treated. The technologies employed by this alternative have been successfully demonstrated at this scale at many locations. Variation A provides more protection than Variation B since a complete physical barrier is installed arround the perimeter of the property.	Does not actively address the COCs in soil at the Site. Will not assure that the concentration of COCs in soil at the Site will be below CULs. About 60 percent of the groundwater within the groundwater AOC falls outside of the barrier. This groundwater will not be treated. The technologies employed by this alternative have been successfully demonstrated at this scale at many locations. Variation B provides less protection than Variation A since only a partial barrier is installed at the property.
Comply with Cleanup Standards	Will not assure that the concentration of COCs in soil at the Site will be below CULs. About 60 percent of the groundwater within the groundwater AOC falls outside of the barrier. This groundwater will not be treated. Natural attenuation of groundwater outside the barrier will occur.	Does not actively address the COCs in soil at the Site. Will not assure that the concentration of COCs in soil at the Site will be below CULs. About 60 percent of the groundwater within the groundwater AOC falls outside of the barrier. This groundwater will not be treated. Natural attenuation of groundwater outside the barrier will occur.
Permanence	Does not actively treat the soils in the soil AOC at the Site. Treats only a small portion of the contaminants present within the groundwater that is extracted from within the barrier and treated prior to discharge. Provides a significantly lower degree of permanence than is provided by Alternatives 2 and 3. Variation A provides more permanence than Variation B since a complete physical barrier is installed arround the perimeter of the property.	Does not actively treat the soils within the soil AOC at the Site. Treats only a small portion of the contaminants present within the groundwater that is extracted from within the barrier and treated prior to discharge. Provides a significantly lower degree of permanence than is provided by Alternatives 2 and 3. Variation B provides less permanence than Variation A since only a partial barrier is installed at the property.
Effectiveness over the Long Term	The technologies employed by this alternative have been successfully demonstrated at this scale at many locations. Does not actively address the COCs in soils within the Lilyblad property or in soils and groundwater within the AOC that fall outside of the barrier perimeter. The soils and groundwater will continue to pose potential risks to human health and the environment.	The technologies employed by this alternative have been successfully demonstrated at this scale at many locations. Does not actively address the COCs in soils within the Lilyblad property or in soils and groundwater within the AOC that fall outside of the barrier perimeter. The soils and groundwater will continue to pose potential risks to human health and the environment.
Management of Short-Term Risks	Installation of a barrier wall in the vicinity of buried utility lines will expose site workers to the risks inherent in this activity. These risks will be mitigated by developing detailed work plans and health and safety plans.	Installation of a barrier wall in the vicinity of buried utility lines will expose site workers to the risks inherent in this activity. These risks will be mitigated by developing detailed work plans and health and safety plans.
Technical and Administrative Implementability	Slurry wall and sheet pile barrier walls are well developed technologies that could be implemented with a high degree of confidence for this alternative. Measuring compliance with groundwater CULs at the Blair Waterway will be difficult since groundwater from other source areas will mix with groundwater from the Site prior to discharging to the Blair Waterway.	Slurry wall and sheet pile barrier walls are well developed technologies that could be implemented with a high degree of confidence for this alternative. Measuring compliance with groundwater CULs at the Blair Waterway will be difficult since groundwater from other source areas will mix with groundwater from the Site prior to discharging to the Blair Waterway.

Table 3.1 - Evaluation of Alternative 1—Containment with Groundwater Controls

Criteria	Variation A - Perimeter Barrier Slurry Wall or Steel Sheet Pile		Variation B - Discontinuous Barrier Slurry Wall or Steel Sheet Pile	
Restoration Time Frame	Does not directly reduce the toxicity, mobility, or volume of the COCs contained in soil on the Site. It appears unlikely that the concentration of COCs in soil or in groundwater at the Site, will be reduced to the CULs established by Ecology.		Does not directly reduce the toxicity, mobility, or volume of the COCs contained in soil on the Site. It appears unlikely that the concentration of COCs in soil or in groundwater at the Site, will be reduced to the CULs established by Ecology.	
Conceptual-Level Cost (NPV ±25 percent)	Slurry Wall - $ 3.1 million	Steel Sheet Pile - $ 3.3 million	Slurry Wall - $ 3.3 million	Steel Sheet Pile - $ 3.4 million

Table 3-2 - Approach Used by Terra Vac to Calculate Mass of Contaminants Removed by DVE/Bioremediation/Oxidation Process

Mass of Volatile Removed

(1) lb/day = VOC Reading $\left(\frac{mg}{L}\right)$ Soil Vapor Flow Rate $\left(\frac{ft^3}{\min}\right)$ (0.089)

where:

0.089 = $\left(1440\frac{\min}{day}\right)\left(\frac{1\ lb}{454{,}000mg}\right)\left(28.3\frac{l}{ft^3}\right)$

VOC Reading[a] = Gas Chromatograph Value until August 2005
PID Reading after August 2005
One-time reading taken on last operating day at the Inlet to the vapor carbon system

$(ft^3/min)^a$ = One-time reading taken on last operating day at the Inlet to the vapor carbon system

Mass of Hydrocarbons Removed by Biological Activity or Oxidation

(2) lb/day = Soil Vapor Flow Rate $\left(\frac{ft^3}{\min}\right)$ (5.12) (0.089) (%CO_2 - 0.03)

where:

$(\%CO_2)^a$ = CO_2 meter value (Gastector Model 3252OX)
One-time reading taken on last operating day at the Inlet to the vapor carbon system

0.03 = Background CO_2 reading used until August 2004
CO_2 meter calibrated to local background value after August 2004

5.12 = Mass of Carbon in mg/l per percent of CO_2 factor; or

5.12 = $\left(\frac{MW\ C}{MWCO_2}\right)\left(18.95\frac{mg}{l-\%CO_2}\right)$

5.12 = $\left(\frac{12}{44}\right)$ (18.95)

18.95 = average value computed using the ideal gas law at 0°C and 20°C

Mass of Hydrocarbons Removed as Methane or Light VOC

(3) lb/day = Methane Reading $\left(\frac{mg}{l}\right)$ (Soil Vapor Flow Rate) 0.089

where:

Methane Reading[a] = Gas Chromatograph Value until May 2005.
Methane monitoring stopped in May 2005
One-time reading taken on last operating day at the Inlet to the vapor carbon system

(a) (Malot 2006)

Table 3-3 - Contaminant Mass Removal Calculated by Terra Vac

Area of the Site	Operating Period	Operating Time[b] in 24-hour Days	Contaminant Mass Removed[a] in Pounds
Initial Pilot Test Area	9/03 to 4/04	104 to 120	12,800
LNAPL Area + Hot Spot Area + Dissolved Plume Area	5/04 to 3/06	520 to 647	33,100
MPE Area	5/04 to 3/06	273 to 429	26,200
PW Eagle Building Area	1/05 to 3/06	322	8,300
Total			80,400

(a)Terra Vac 2006c
(b)Malot 2006b

Table 3.4 - Expected Remediation Time Frame for Soil and Groundwater Calculated by Terra Vac

Media	Area of Site	Apparent Rate Limiting COC	Value of C_o in ug/kg or ug/L (2)	Operating Time in Days	Calculated Reaction Coefficient k (3,4)	Expected Time to Reach CULs in Years (5)
Soil	MPE Area	1,1-Dichlorobenzene	1,900	521	211	1.6
	PWE Building	TPH-D	2,200,000	330	193	2.4
	LNAPL Area	TPH-D	16,800,000	480	193	2.7
	Hot Spot Area	TPH-D	14,800,000	500	193	2.6
		PCE	64,000	500	141	0.5
Groundwater	All (6)	Various	Various	90	50	0.3

Notes:
(1) Data taken from Malot 2006c.
(2) Maximum value at location within the area.
(3) Based on post-remediation data collected during December 2005.
(4) Maximum value and post-remediation value obtained at different locations in same general vicinity.
(5) CUL used as post-remediation COC concentration.
(6) A blended k value was used by Terra Vac for groundwater. Oxidation is required to reach CULs.

Table 3.5 - Treatment Sequence Proposed by Terra Vac

Means of Treatment	Area of Site	Duration in Months (approximate)	Comment
DVE	All	1	Achieve hydraulic control of Site
Biodegradation	Total All Areas	59	Four treatment trains - three in Lilyblad area; one in PWE-MPE area
Oxidation	Total All Areas	13	Begin oxidation once biodegradation is complete
Total	All Areas	73	

Notes:
(1) Source: Malot 2006b

Table 3.6 - Evaluation of Alternative 2—*In Situ* Treatment

Criteria	Variation A - Meet CULs in AOCs	Variation B - Meet CULs for TPH in AOCs	Variation C - Containment on Lilyblad Property; Treatment Off Property
Overall Protection of Human Health and the Environment	Variation A is expected to reduce the concentration of COCs in soil and groundwater to below CULs throughout both the soil and groundwater AOCs. It is the only alternative evaluated during this FFS that will do so. Expected to destroy or remove more than 160,000 pounds of COCs in soil. Employs technologies that have been demonstrated to be effective at the Site. Short-term risks are managable. Expected to reduce the concentration of COCs to below CULs in approximately 6 years.	Variation B is expected to reduce the concentration of TPH COCs in soil and groundwater to below CULs throughout both the soil and groundwater AOCs. VOC concentrations are also expected to be substantially reduced. Expected to destroy or remove more than 160,000 pounds of COCs in soil. Not as effective in destroying SVOCs as Variation A. Employs technologies that have been demonstrated to be effective at the Site. Short-term risks are managable. Reduction of the concentration of TPH COCs to below CULs is expected to be achieved in approximately 5 years. After treatment, it is likely that natural attenuation of VOCs and SVOCs in soil and groundwater will occur. The information (refer to Section 3.2) necessary to assess the likely degree of natural attenuation that would occur at the Site is not currently available.	Actively treats soils and groundwater outside of the barrier (and within the soil and groundwater AOCs) installed by Alternative 1. The concentration of COCs in soil and groundwater in these areas after treatment are expected to be below CULs. The groundwater within the barrier will be contained and some will be treated. The soil inside the barrier will not receive any treatment. Thus the CULs established for soil within the barrier by Ecology will not be met by this alternative. Expected to destroy or remove more than 30,000 pounds of COCs in soil. Employs technologies that have been demonstrated to be effective. Short-term risks are managable.
Comply with Cleanup Standards	This evaluation assumes that the implementation of Variation A will reduce the concentration of COCs in soil and groundwater to below CULs.	It is likely that Variation B will achieve CULs for TPH COCs, is likely to achieve CULs for VOC COCs, and is unlikely to achieve CULs for SVOC COCs.	The concentration of COCs in soil and groundwater in areas outside the barrier after treatment are expected to be at concentrations below CULs. The soil inside the barrier will not receive any treatment. Thus the CULs established for soil by Ecology will not be met within the barrier by Variation C.
Permanence	Expected to destroy and/or remove approximately 160,000 pounds of TPH, 3,500 pounds of VOC, and 200 pounds of SVOC COCs. Directly treats all of the groundwater within the groundwater AOC	Expected to destroy and/or remove approximately 160,000 pounds of TPH, and less than 3,500 pounds of VOC COCs. Directly treats all of the groundwater within the groundwater AOC	Expected to destroy and/or remove approximately 30,000 pounds of TPH, 300 pounds of VOC, and 20 pounds of SVOC COCs. Directly treats approximately 60 percent of the groundwater within the groundwater AOC.
Effectiveness over the Long Term	Provides for a long-term reduction of contaminant concentrations by means of active remediation. The technologies used are well understood and have been shown to be effective during the pilot-scale tests and Interim Measures that have been conducted at the Site	Same as for Variation A, except that oxidation of SVOC COCs in soil and groundwater does not occur. Natural attenuation of these COCs would continue. Variation B is likely to be less effective over the long term than Variation A, since SVOCs are not destroyed.	The concentration of COCs in the soil and groundwater within the barrier is expected to exceed CULs for an extended period of time. The COCs that will remain in soil and groundwater within the barrier after Variation C is implemented will continue to naturally attenuate. The progress of natural attenuation will be monitored. Variation C is less effective over the long term than Variations A or B of Alternative 2, or Alternative 3.
Management of Short-Term Risks	Short-term risks to human health and the environment would occur if this alternative were implemented. These short-term risks will be present during installation and operation of the generic treatment train and its ancillary equipment. Detailed work plans and health and safety plans will be implemented to reduce risks to site workers and the public during the 6 years that this variation is operational.	Same type of risks as Variation A. Less overall short-term risk than Variation A due to the shorter period of operation of the generic treatment train (5 years for Variation B)	The installation of a barrier wall will expose site workers to additional risks related to the presence of buried utility lines. The duration of Variation C (3 years) is shorter than the duration of Variations A and B. Variation C adds the short-term risks associated with the installation of the barrier. Overall short-term risk of this variation judged to be equivalent to the short-term risks associated with Alternative 2, Variation B.
Technical and Administrative Implementability	The generic treatment train has been successfully demonstrated during pilot-scale and Interim Measure operations at the Site. These operations have been conducted with full-scale equipment. The system has been shown to be implementable.	The generic treatment train has been successfully demonstrated during pilot-scale and Interim Measure operations at the Site. These operations have been conducted with full-scale equipment. The system has been shown to be implementable.	The generic treatment train has been successfully demonstrated during pilot-scale and Interim Measure operations at the Site. These operations have been conducted with full-scale equipment. The system has been shown to be implementable. Slurry wall and sheet pile barriers are well developed technologies that could be implemented with a high degree of confidence.
Restoration Time Frame	This evaluation assumes that the implementation of Variation A will reduce the concentration of COCs in soil and groundwater to below CULs by the conclusion of the approximately 6-year period of operation of the generic treatment system.	Variation B is likely to reduce the concentration of THP COCs in soil and groundwater to below CULs and to substantially reduce the concentration of VOC COCs by the conclusion of its approximately 5-year period of operation. The concentrations of SVOC COCs in soil and groundwater are expected to be only slightly reduced since oxidation is not considered by Variation B. The VOCs and SVOCs that are likely to be present in soil and groundwater at the conclusion of Variation B's period of operation are expected to naturally attenuate. Additional site characterization and modeling would be needed to predict the rate of natural attenuation to more accurately predict future concentrations in soil and groundwater of COCs that may be left behind by Alternative 2, Variation B.	The concentration of COCs in soil and groundwater in areas outside of the barrier after remediation by the generic treatment train should be below CULs at the conclusion of its 2 to 3 years of operation. The groundwater within the barrier will be contained and treated as groundwater is withdrawn and treated to maintain hydraulic control. The soil inside the barrier will not receive any treatment. Thus the CULs established for soil by Ecology will not be met within the barrier. The COCs that are likely to be present in soil and groundwater within the barrier are expected to naturally attenuate. Additional site characterization and modeling would be needed to predict the rate of natural attenuation to more accurately predict future concentrations in soil and groundwater of COCs that may be left behind by Alternative C.

Table 3.6 - Evaluation of Alternative 2—*In Situ* Treatment

Criteria	Variation A - Meet CULs in AOCs	Variation B - Meet CULs for TPH in AOCs	Variation C - Containment on Lilyblad Property; Treatment Off Property
Conceptual-Level Cost (NPV ± 25 percent)	$4.9 million	$4.4 million	$5.0 million

Table 3.7 - Evaluation of Alternative 3 - Excavation and Disposal of Contaminated Soil

Criteria	Variation A - Excavate All Contaminated Soils on Lilyblad Property	Variation B - Excavated Most Contaminated Soils on Lilyblad Property
Overall Protection of Human Health and the Environment	Variation A will remove approximately 135,000 pounds of COCs from the Lilyblad property. Variation A will not address the approximately 30,000 pounds of COCs in soil outside of the Lilyblad property. COCs in groundwater within the groundwater AOC will not be addressed by Variation A. It is expected that CULs will not be met in soil outside the excavation footprint or in groundwater in the AOC for a very long period of time. Employs technologies that have been demonstrated at similar facilities. Short-term risks are manageable.	Variation B will remove approximately 75,000 pounds of COCs from soils within the excavation footprint. Variation B will not address approximately 58,000 pounds of COCs in soil on Lilyblad property or 30,000 pounds of COCs in soil outside of the Lilyblad property. COCs in groundwater within the groundwater AOC will not be addressed by Variation B. It is expected that CULs will not be met in the unexcavated areas on Lilyblad property, in soil outside the Lilyblad property, or in groundwater in the AOC for a very long period of time. Employs technologies that have been demonstrated at similar facilities. Short-term risks are manageable.
Comply with Cleanup Standards	Variation A directly removes and disposes of contaminated soil from the Lilyblad property so it will assure that the concentrations of COCs in soil within the excavation footprint will be below CULs. Soil CULs will not be met in areas outside the limits of excavation. COCs in groundwater within the groundwater AOC will not be addressed by Variation A. Concentrations of COCs in groundwater will remain above CULs on Lilyblad property and adjacent areas of the AOC. Soil contaminants outside of the excavation footprint will continue to contribute COCs to groundwater.	Variation B directly removes and disposes of contaminated soil within the excavation footprint so it will assure that the concentrations of COCs in soil in these locations will be below CULs. Soil CULs will not be met on areas outside the limits of excavation. COCs in groundwater within the groundwater AOC will not be addressed by Variation B. Concentrations of COCs will remain in groundwater above CULs on Lilyblad property and adjacent areas of the AOC. Soil contaminants outside of the excavation will continue to contribute COCs to the groundwater.

Table 3.7 - Evaluation of Alternative 3 - Excavation and Disposal of Contaminated Soil

Criteria	Variation A - Excavate All Contaminated Soils on Lilyblad Property	Variation B - Excavated Most Contaminated Soils on Lilyblad Property
Permanence	Variation A actively removes and disposes of approximately 135,000 pounds of COCs in soil from the Lilyblad property. During excavation approximately 500,000 gallons of groundwater would be treated prior to discharge. Following remedial construction, approximately 3,000 pounds of soil COCs will remain within the soil AOC. Groundwater COCs will not be addressed by this alternative.	Variation B actively removes and disposes of approximately 75,000 pounds of COCs in soil from selected locations on the Lilyblad property. During excavation approximately 300,000 gallons of groundwater would be treated prior to discharge. Following remedial construction, approximately 58,000 pounds of COCs in soil will remain on Lilyblad property and approximately 30,000 pounds of soil COCs will remain in locations within the soil AOC. Groundwater COCs will not be addressed by Alternative B. Variation B is less permanent than Variation A since it removes 60,000 fewer pounds of COCs from the Site.
Effectiveness over the Long Term	Provides for a long-term reduction cf COC concentrations by means of the active removal and disposal of contaminated soils from the Lilyblad property. Clean soil plac within the excavation may be recontaminated by COCs in groundwater. The technologies utilized are well understood.	Provides for a long-term reduction cf COC concentrations by means of the active removal and disposal of contaminated soils from the Lilyblad property. Clean soil plac within the excavation may be recontaminated by COCs in groundwater. The technologies utilized are well understood.
Management of Short-Term Risks	Excavation and capping of the numerous buried utility lines on the Lilyblad property prior to construction will expose site workers to the risks inherent in this activity. For buildings selected for demolition, the inspection, cleaning, and/or abatement of hazardous materials will expose workers to risk. Large-scale excavation and dewatering of the contaminated soils will have a high risk of exposure for site worker. These risks will be mitigated by developing detailed work plans and health and safety plans.	Variation B will have the same inherent risks as Variation A, but to a lesser degree due to the reduced level of demolition and excavation. These risks will be mitigated by developing detailed work plans and health and safety plans.

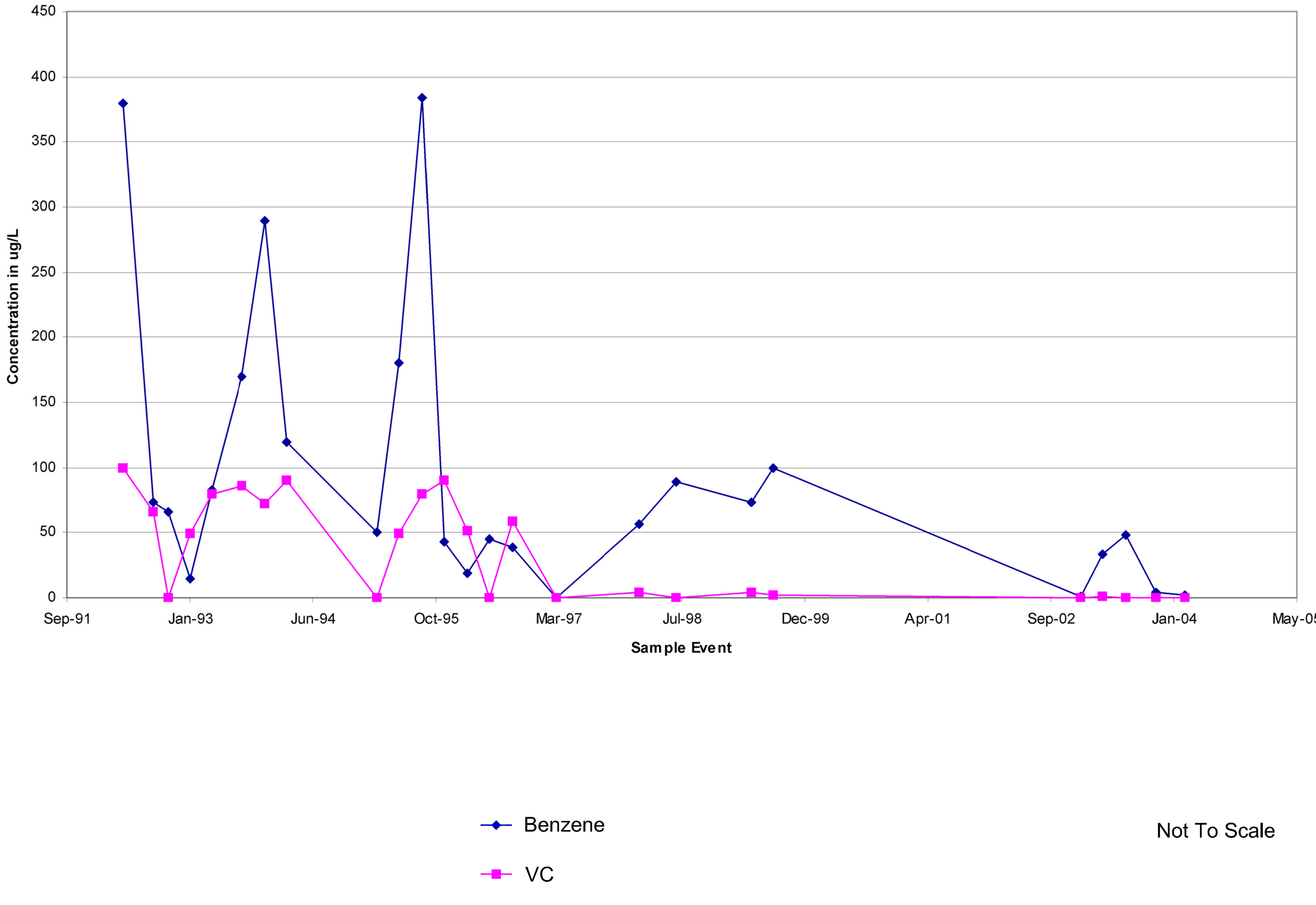
Table 3.7 - Evaluation of Alternative 3 - Excavation and Disposal of Contaminated Soil

Criteria	Variation A - Excavate All Contaminated Soils on Lilyblad Property	Variation B - Excavated Most Contaminated Soils on Lilyblad Property
Technical and Administrative Implementability	The technologies employed by Variation A are common to the construction industry and with controls to prevent worker exposure, can be readily implemented. Variation A will shut down Lilyblad operations. This outcome may not be feasible. Significant space on adjacent properties would be required to stockpile excavated soil. Measuring compliance with groundwater CULs at the Blair Waterway will be difficult since groundwater from other source areas will mix with groundwater from the Site prior to discharging to the Blair Waterway.	The technologies employed by Variation B are common to the construction industry and with controls to prevent worker exposure, can be readily implemented. Variation B will shut down Lilyblad operations. This outcome may not be feasible. Significant space would also be required on adjacent properties to stockpile excavated soil. Measuring compliance with groundwater CULs at the Blair Waterway will be difficult since groundwater from other source areas will mix with groundwater from the Site prior to discharging to the Blair Waterway.
Restoration Time Frame	Will directly remove COCs in soil from within the excavation footprint on the Lilyblad property. CULs for soil within this area will be met once Variation A is implemented. COC concentrations in soil and groundwater outside of the excavation footprint will exceed CULs for a very long period of time.	Will directly remove COCs in soil from within the excavation footprint on the Lilyblad property. CULs for soil within this area will be met once Variation B is implemented. COC concentrations in soil and groundwater outside of the excavation footprint will exceed CULs for a very long period of time.
Conceptual-Level Cost (NPV ±25 percent)	$ 7.7 million	$ 4.2 million

Table 3.8 - Evaluation of Alternative 4 - Hydraulic Controls with Groundwater Monitoring

Criteria	Evaluation of Alternative 4
Overall Protection of Human Health and the Environment	Alternative 4 does not use active measures to treat the approximately 160,000 pounds of contaminants contained within the soil AOC at the Site. Elevated concentrations of COCs (above CULs) will remain in groundwater throughout the AOC. The rate of natural attenuation of COCs together with the active treatment of extracted groundwater is not expected to achieve CULs for groundwater at the Site for a very long period of time.
Comply with Cleanup Standards	Alternative 4 does not actively address the COCs in soil at the Site, so the concentration of COCs in soil will exceed the CULs established by Ecology. The natural attenuation of COCs in groundwater together with the treatment of extracted groundwater will not reduce the concentration of COCs in groundwater to CULs within the groundwater AOC for a very long period of time.
Permanence	Alternative 4 does not actively treat the soils within the soil AOC at the Site. Alternative 4 actively treats only a small portion of the contaminants present within the groundwater that is extracted from the Site to assure hydraulic control, and treated prior to discharge. This alternative provides less permanence than Alternative 1, which installs a physical barrier to prevent the flow of groundwater from exiting the Lilyblad property; and significantly less permanence than Alternative 2, which actively treats the soil and groundwater within the AOC, or Alternative 3, which removes and disposes of soil within the Lilyblad property.
Effectiveness over the Long Term	The technologies employed by this alternative have been successfully demonstrated at this Site. Alternative 4 does not actively address the COCs in soils within the soil AOC. These soils will continue to pose potential risks to human health and the environment. Alternative 4 provides an equivalent degree of long-term effectiveness as Alternative 1, which installs a physical barrier around the Lilyblad property, and a lesser degree of long-term effectiveness than Alternative 2, which actively destroys COCs in soil and groundwater; and Alternative 3, which excavates and disposes of COCs in soils in an off-site engineered, lined, and monitored facility.
Management of Short-Term Risks	Minimal risks to human health and the environment will occur if this alternative is selected. Alternative 4 has fewer potential short-term risks to human health and the environment than does Alternatives 1, 2, or 3.
Technical and Administrative Implementability	Hydraulic control is a well developed technology that has been used at the Site during the past several years. Groundwater from the Site will mix with groundwater from other source areas once it reaches the storm drain below the Port of Tacoma Road. It will be difficult to isolate the contribution of Site COC concentrations in groundwater to the concentrations of COCs that are present at the point where the storm drains below the Port of Tacoma Road and the Lincoln Avenue Ditch, reach the Blair Waterway.
Restoration Time Frame	Alternative 4 does not directly reduce the toxicity, mobility, or volume of the COCs in soil on the Site. This large 'source term' is expected to supply contaminants to the groundwater for longer than 30 years. The groundwater treatment system will continue to operate during this period. The concentration of COCs in soil and in groundwater at the Site will exceed the CULs established by Ecology for this Site for a very long period of time.
Conceptual-Level Cost (NPV ±25 percent)	$ 3.6 million

Benzene and Vinyl Chloride Concentrations in Groundwater at Well B-13
Lilyblad Site



Not To Scale

HARTCROWSER

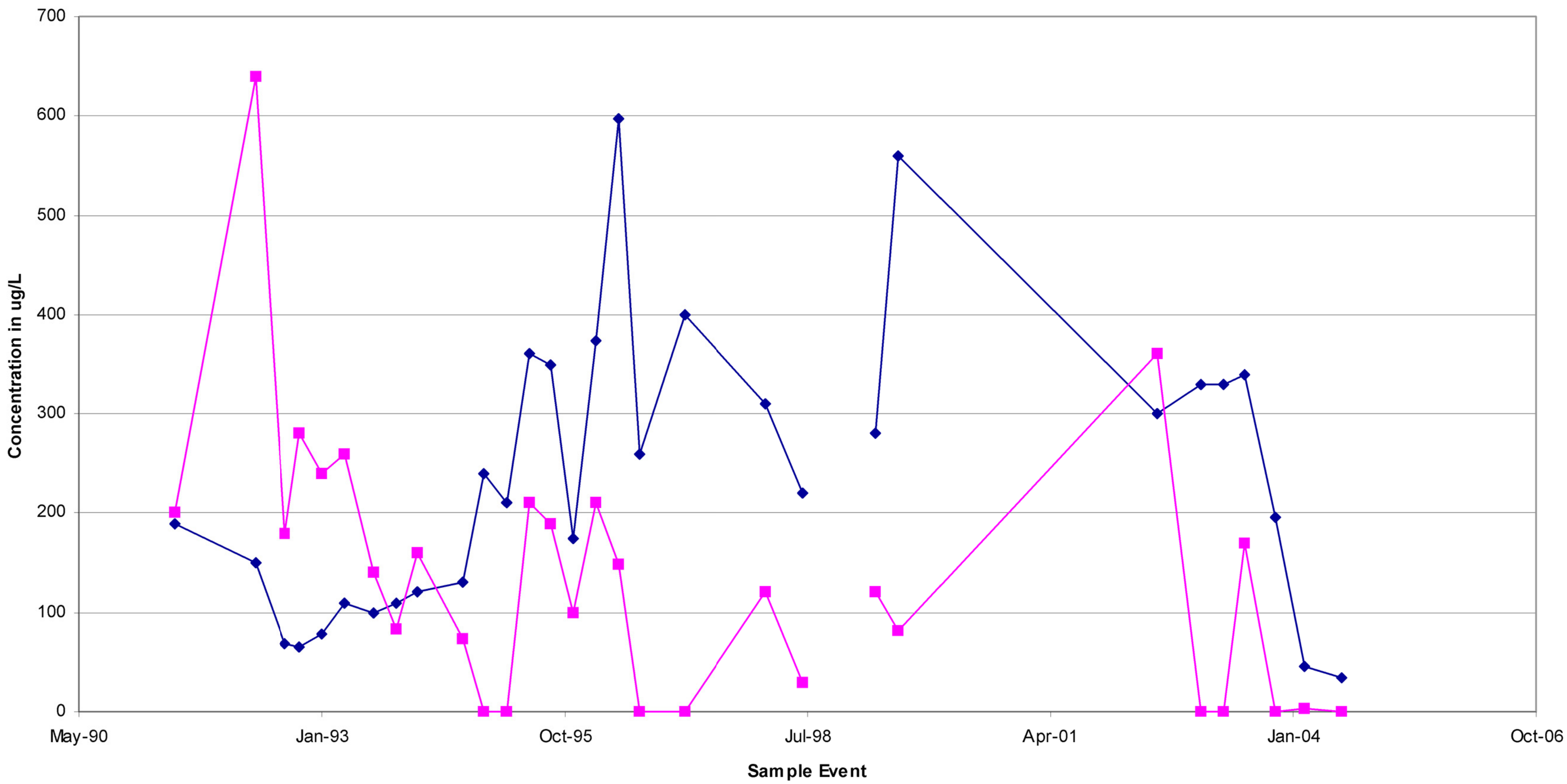
17330-02 12/06

Figure 3-1

1733002-011.dwg

SRN 12/1/06

Benzene and Vinyl Chloride Concentrations in Groundwater at Well SP-4
Lilyblad Site



Not To Scale

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Figure 3-2

Benzene and Vinyl Chloride Concentrations in Groundwater at Well SP-5
Lilyblad Site

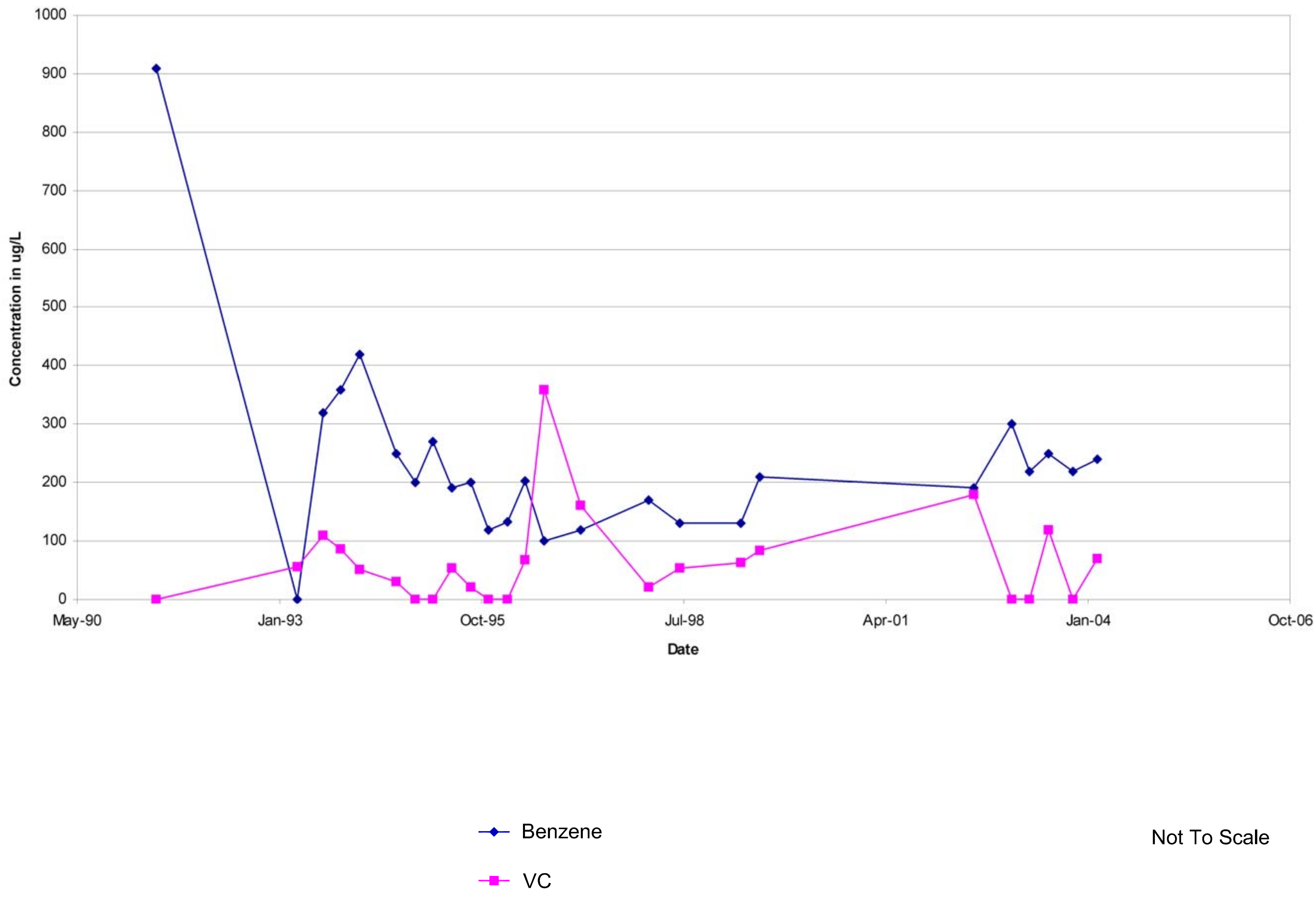

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Figure 3-3

SRN 12/1/06 1733002-013.dwg

4.0 SUMMARY OF EVALUATION OF ALTERNATIVES

A summary of the analysis of alternatives discussed in Sections 3.3, 3.4, 3.5, and 3.6 is provided in Table 4.1. A comparison of the four alternatives and variations ability to meet evaluation criteria is provided in the following sections.

4.1 Overall Protection of Human Health and the Environment

Alternative 2, Variation A—Operate the Generic System to Achieve CULs for All COCs will treat soil and groundwater throughout the Site. This is the only alternative that is expected to meet cleanup standards throughout the Site. Implementation of the other alternatives will result in only partial compliance with Site cleanup standards. Alternative 2, Variations A and B, directly reduce the quantity, toxicity, and volume of contaminants in soil (160,000 to 164,000 pounds) and groundwater on the Site to a greater extent than the other alternatives that were evaluated. Alternative 3, Variation A (135,000 pounds); Alternative 3 – Variation B (75,000 pounds); and Alternative 2 – Variation C (30,000 pounds) directly reduce the quantity, toxicity, and volume of COCs in soil to a lesser extent than Alternatives 2, Variations A and B. Alternatives 1 and 4 do not directly treat soil at the Site.

Alternative 2, Variation A (100 percent), Variation B (100 percent), and Variation C (50 percent) are the only alternatives evaluated that directly destroy COCs in groundwater at the Site. Alternatives 1, 3, and 4 do not directly destroy COCs in groundwater. Some groundwater will be extracted by Alternatives 1 and 4 to maintain hydraulic control. This groundwater will be treated to remove COCs prior to its discharge from the Lilyblad property.

The four alternatives employ technologies that have been successfully used at the Site or at other similar sites. The technologies have been shown to be implementable. Alternative 3 will require the demolition of all (Variation A) or most (Variation B) of the structures on the Lilyblad property. This outcome may not be economically feasible.

Contaminated soil that would remain at the Site after Alternatives 1, 2 (Variations B and C), 3, or 4 were implemented would exceed CULs for a very long period of time. Contaminated groundwater that exits the Site after Alternative 1, Alternative 2 (Variations B and C), Alternative 3, and Alternative 4 are implemented is expected to take more than 50 years to reach the Blair Waterway, although short-circuiting by surface drainages could reduce the time for groundwater contaminants to reach the waterway. It is likely that natural attenuation will reduce the concentration of COCs in this groundwater, but it is not possible to determine the amount time it would take to reduce COC concentrations to CULs.

Variations A and B of Alternative 2 provide greater long-term effectiveness than Alternatives 1, 3, or 4, since substantial destruction of COCs in soil and groundwater occurs as the generic treatment system is used at the Site. Variation A of Alternative 2 provides more long-term effectiveness than Variation B, since Variation A directly treats SVOC COCs. This benefit to human health and the environment occurs within a relatively short (compared to Alternatives, 1, 3, or 4) 3- to 6-year time frame.

4.2 Comply with Cleanup Standards

Alternative 2, Variation A—Operate the Generic System to Achieve CULs for All COCs will treat soil and groundwater throughout the Site. The evaluation summarized in Section 3.4 assumes that the concentration of COCs in soil and groundwater will be below CULs after this variation of Alternative 2 is implemented. This is the only alternative that is expected to meet cleanup standards for soil and groundwater throughout the Site.

Other alternatives will meet some cleanup standards throughout the Site, but not for all COCs (Alternative 2, Variation B—Operate the Generic System to Achieve CULs for TPH Compounds); will meet CULs for COCs in soil in limited areas of the Site (Alternative 3, Variations A and B, Alternative 2, Variation C); or will prevent some COCs in groundwater from exiting the Site (Alternative 2, Variation C, Alternative 1, and Alternative 4).

4.3 Permanence

Alternative 2, Variations A and B directly reduce the quantity, toxicity, and volume of contaminants in soil and groundwater on the Site to a greater extent than the other alternatives that were evaluated. The quantity of soil that is directly treated by Alternative 2 and removed and disposed of by Alternatives 2 and 3 is listed below (approximate values):

Alternative	Variation	TPH COCs	VOC COCs	SVOC COCs
2	A	160,000 lb	3,500 lb	200 lb
	B	160,000 lb	<3500 lb	<200 lb
	C	30,000 lb	300 lb	<20 lb
3	A	130,000 lb	3,400 lb	200 lb
	B	73,000 lb	1,900 lb	120 lb

Alternative 2 destroys contaminants and thus provides a more effective solution than Alternative 3, which removes and disposes of some of the contaminants.

Alternatives 1 and 4 do not directly reduce the quantity, toxicity, or volume of COCs in soil.

Alternative 2 also directly treats groundwater within the groundwater AOC. The relative percentage of groundwater directly treated by each variation of Alternative 2 is summarized below:

Alternative	Variation	Percent of AOC Treated
2	A	100 percent
	B	100 percent
	C	60 percent

Alternatives 1, 3, and 4 do not directly destroy the COCs in the groundwater within the AOC. Alternative 1 and Alternative 2, Variation C use a barrier to physically contain groundwater on the Lilyblad property (about 50 percent of the groundwater in the groundwater AOC), while Alternative 4 uses hydraulic means to contain groundwater on the Site. Some groundwater will be extracted to maintain hydraulic control by Alternatives 1 and 4. This groundwater will be treated to remove COCs prior to its discharge from the Site.

4.4 Effectiveness over the Long Term

Alternatives 2 and 3 provide for long-term reduction of contaminant mass by treating or excavating impacted soil and groundwater. Technologies utilized by these alternatives have been shown to be effective during the pilot-scale tests and Interim Measures that have been conducted at the Site and/or by their implementation at many other similar sites.

Implementation of Alternatives 1, 2 Variation C, 3, and 4 would leave significant mass of COCs on the Site. Alternatives 1 and 4 would leave approximately 160,000 pounds of contaminants on the Site. Alternative 2, Variation C would leave approximately 134,000 pounds; Alternative 3, Variation A would leave approximately 30,000 pounds; and Alternative 3, Variation B would leave approximately 89,000 pounds of contaminants on the Site.

Alternative 2, Variations A and B provide greater long-term effectiveness than Alternatives 1, 3, or 4, since substantial destruction of COCs in soil and groundwater occurs as the generic treatment system is used at the Site. This benefit to human health and the environment occurs within a relatively short (compared to Alternatives, 1, 3, or 4) 5- to 6-year time frame.

Alternative 3 removes and disposes of from approximately 75,000 to 134,000 pounds of COCs and provides a greater degree of long-term effectiveness than Alternatives 1 and 4.

Alternatives 1 and 4 do not actively treat soils or groundwater at the Site. Alternatives 1 and 4 provide about the same long-term effectiveness since Alternative 1 it uses a physical rather than a hydraulic barrier to confine groundwater to the Lilyblad property, while Alternative 4 maintains hydraulic control over the entire groundwater AOC.

4.5 Management of Short-Term Risks

Short-term risks to human health and the environment would occur if any of the alternatives are implemented. These short-term risks will be present during installation and operation of the generic treatment train and its ancillary equipment (Alternative 2), the demolition of buildings and tank farms and the excavation of soil on Lilyblad property (Alternative 3), the installation of a barrier wall (Alternative 1, Alternative 2, Variation C), or the operation of the hydraulic control system (Alternative 4). Detailed work plans would be developed to identify potential implementation issues, and identify procedures that would be used to resolve these installation and operational issues. Health and Safely Plans would be prepared to address risks associated with working in an area where COCs are known to be present at concentrations above CULs in soil and groundwater.

Active institutional controls and a worker monitoring program will provide additional protection to site workers and the public who may visit the Site.

All variations of Alternative 2 are judged to have more potential short-term risks to human health and the environment than Alternative 1 and Alternative 4, due to the long-term nature of the cleanup activities that will be underway during the 5- to 6-year period of operation (Variations A and B), and/or the implementation of two remediation technologies (Variation C). Alternative 3 is judged to provide about the same degree of short-term risk as Alternative 2, Variations A and B. The short-term risk associated with Alternative 3 would be high during its relatively short (less than 1 year) period of operation.

Alternative 4 would have fewer short-term risks to workers or the environment than any of the other alternatives that were evaluated.

4.6 Technical and Administrative Inplementability

The four alternatives employ technologies that have successfully been used at the Site or at other similar sites. The technologies have been shown to be implementable. Alternative 3 will require the demolition of all (Variation A) or most (Variation B) of the structures on the Lilyblad property. This outcome may not be economically feasible.

Groundwater containing COC concentrations above CULs will exit the Site if Alternative 1, Alternative 2, Variations B and C, and Alternative 3 is implemented. This groundwater is expected to take more than 50 years to reach the Blair Waterway, although short-circuiting by surface drainages could reduce the time for groundwater contaminants to reach the waterway. It is likely that natural attenuation will reduce the concentration of COCs in this groundwater, but it is not possible to determine the amount time it would take to reduce COC concentrations to CULs.

It will be difficult to distinguish the contribution of Site COC concentrations to the Blair Waterway from off-site contaminant sources.

4.7 Restoration Time Frame

Alternative 2, Variation A is expected to meet CULs throughout the Site at the conclusion of its 6-year period of operation. This is the only alternative that is expected to meet cleanup standards for both soil and groundwater in the near term.

Other alternatives will result in achieving only partial compliance with CULs. .Contaminated soil that would remain at the Site after Alternatives 1, 2 (Variations B and C), 3, or 4 were implemented would exceed CULs for a very long period of time. Contaminated groundwater that exits the Site after Alternative 1, Alternative 2 (Variations B and C), and Alternative 3 are implemented is expected to take more than 50 years to reach the Blair Waterway, although short-circuiting by surface drainages could reduce the time for groundwater contaminants to reach the waterway. It is likely that natural attenuation will reduce the concentration of COCs in this groundwater, but it is not possible to determine the amount time it would take to reduce COC concentrations to CULs.

4.8 Conceptual-Level Cost

Conceptual-level (±25 percent) cost estimates and supporting assumptions for the four alternatives are presented in Appendix A.1 to A.4, respectively, and summarized below:

Alternative	Variation	Conceptual Level Cost
1	A	Slurry Wall - $ 3.1 million
		Steel Sheet Pile - $3.3 million
	B	Slurry Wall - $ 3.3 million
		Steel Sheet Pile – 3.4 million
2	A	$4.9 million
	B	$4.4 million
	C	$5.0 million
3	A	$7.7 million
	B	$4.2 million
4		$3.6 million

It should be noted that cost estimates for Alternatives 1 and 4 assume 20- and 30-year durations, respectively, for groundwater treatment system and compliance monitoring. Since restoration timeframes for Alternatives 1 and 4 likely exceed 20 and 30 years, costs for these alternatives would likely increase significantly if groundwater treatment and monitoring are performed until CULs are achieved.

The conceptual level cost estimate for Alternative 3 does not include costs associated with the interruption or termination of businesses operating on the Lilyblad property.

Alternatives 2 and 3 destroy and/or remove and dispose of COCs. The cost per pound destroyed or removed is summarized below:

Alternative	Variation	Cost per Pound
2	A	$30
	B	$27
	C	$165
3	A	$58
	B	$56

4.9 Selection of the Preferred Alternative

Several inferences can be drawn from the information summarized in Table 4.1 and discussed above. For Alternative 1, the conceptual level cost estimate for a continuous barrier is about the same as for the discontinuous barrier, due to the need for additional water to be extracted and treated if a discontinuous barrier is installed. Since a continuous barrier would be more protective, Variation A of Alternative 1 it is the preferred barrier construction option for this Site. Both a slurry wall and a steel sheet pile barrier were judged to be effective. The installation of a continuous slurry wall barrier reduces the risks associated with working near buried utilities, so this approach would reduce short-term risks to human health and the environment during the installation of the barrier.

The conceptual level cost of implementing Alternative 3 varies from about $4.2 to $7.7 million, excluding the cost of business interruption to, or the termination of businesses now operating on the Lilyblad property. Thus implementation of this alternative is likely to cost far in excess of the $4 million available for work at the Site.

The conceptual level cost (±25 percent) of Alternatives 1 ($3.1 million) and 4 ($3.6 million) are within the within the $4 million available for work at the Site. It is likely that these alternatives could be implemented for less than $4 million.

Rigorous planning and budget controls would be needed to implement Alternative 2, Variation B and C for $4 million. Both of these alternative involve the operation of the generic treatment train for an extended period of time.

The conceptual level cost (±25 percent) of Alternative 2, Variation B is $4.4 million. Selection of Variation B has the potential to remove an additional 130,000 pounds of contaminants (mostly TPH) from Site soils than would be removed by Alternative 2, Variation C. The COCs remaining after the implementation of Variation B would be primarily SVOCs, which are not very mobile in the environment.

The generic treatment train would operate for about 5 years to implement Alternative 2, Variation B and for approximately 2 to 3 years to implement Variation C. Variation C would install a slurry wall around the Lilyblad property. The longer period of operation for Variation B would have a greater potential for cost increases due to unforeseen circumstances than the implementation of Variation C.

Of the four alternatives evaluated, Alternative 2, Variation A provides the greatest degree of protection to human health and the environment. The implementation of this variation would take about 6 years. This increased protection comes at an increased cost. The conceptual level cost estimate of $4.9 million for Variation A has a cost range of approximately $3.7 to $6.1 million. Based on cost estimates completed as part of this FFS, it is very likely that the cost of implementing Alternative 2, Variation A would exceed $4 million.

Table 4.1 - Summary of Detailed Analysis of Alternatives

	Alternative 1 -	Alternative 2 - *In Situ* Treamtent			Alternative 3 Excavation and Disposal of Contaminated Soils		Alternative 4 -
Criteria	Containment with Groundwater Controls	Variation A - Meet CULs in AOCs	Variation B - Meet CULs for TPH in AOCs	Variation C - Containment on Lilyblad Property, Treatment off-Property	Variation A - Excavate All Soils on Lilyblad Property	Variation B - Excavate Most Contaminated Soils on Lilybald Property	Hydraulic Control and Monitoring
Overall Protection of Human Health and the Environment	Does not actively address the COCs in soil at the site. About 60 percent of the groundwater within the groundwater AOC falls outside of the barrier. This groundwater will not be treated. The technologies employed by this alternative have been successfully demonstrated at this scale at many locations.	Reduces the concentration of COCs in soil and groundwater to below CULs throughout both the soil and groundwater AOCs. It is the only Alternative evaluated during this FFS that will do so. Expected to destroy or remove more than 160,000 pounds of COCs in soil. Employs technologies that have been demonstriated to be effective at the Site. Short-term risks are managable. Expected to reduce the concentration of COCs to levels below CULs in aporoximately 6 years.	Reduces the concentration of TPH COCs in soil and groundwater to below CULs throughout both the soil and groundwater AOCs. VOC concentrations are also expected to be substantially reduced. Expected to destroy or remove more than 160,000 pounds of COCs in soil. Not as effective in destroying SVOCs as Varaition A. Employs technologies that have been demonstratied to be effective at the Site. Short-term risks are managable. Reduction of the concentration of TPH COCs to levels below CULs is expected to be achieved in aporoximately 5 years.	Actively treats soils and groundwater outside of the barrier installed by Alternative 1. The concentration of COCs in soil and groundwater in these areas after treatment are expected to be at levels below CULs. The groundwater within the barrier will be contained and treated. The soil inside the barrier will not receive any treatment. Thus the CULs established for soil and groundwater within the barrier by Ecology will not be met by this alternative. Expected to destroy or remove more than 30,000 pounds of COCs in soil. Employs technologies that have been demonstratied to be effective. Short-term risks are managable.	Removes and disposes of approximately 135,000 pounds of COCs from the Lilyblad property. Does not address the approximatley 30,000 pounds of COCs in soil outside of the excavation. COCs in groundwater will not be addressed by this Variation. It is expected that CULs will not be met in soil outside the Lilyblad property or in groundwater in the AOC for a very long lperiod of time. Employs technologies that have been demonstrated at similar facilities. Short-term risks are manageable.	Removes approximately 75,000 pounds of COCs from soils within the excavation footprint. Does not address approximately 58,000 pounds of COCs in soil on Lilyblad property or 35,000 lbs of COCs in soil outside of the Lilyblad property. COCs in groundwater within the groundwater AOC will not be addressed. It is expected that CULs will not be met in the unexcavated areas on Lilyblad property, in soil outside the Lilyblad property or in groundwater in the AOC for a very long period of time. Employs technologies that have been demonstrated at similar facilities. Short-term risks are manageable.	Does not use active measures to treat soil and groundwater at the Site. Elevated concentrations of COCs (above CULs) will remain in groundwater and soil within the AOC. The rate of natural attenuation of COCs together with the active treatment of extracted groundwater is not expected to achieve CULs for groundwater on the Site for a very long period of time.
Comply with Cleanup Standards	The concentration of COCs in soil at the site will be avove CULs. About 60 percent of the groundwater within the groundwater AOC falls outside of the barrier. This groundwater will not be treated. Natural attenuation of groundwater outside the barrier is expected to occur.	This evaluation assumes that the implementation of Alternative 2, Variation A will reduce the concentration of COCs in soil and groundwater to below CULs.	It is likely that Variation B will achieve CULs for TPH COCs, is likely to achieve CULs for VOC COCs, and is unlikely to achieve CULs for SVOC COCs for both soil and groundwater.	The concentration of COCs in soil and groundwater in areas outside the barrier after treatment are expected to be below CULs. The soil inside the barrier will not receive any treatment. Thus the CULs established for soil by Ecology will not be met within the barrier by this variation.	Removes and disposes of contaminated soil within the excavation. The concentrations of COCs in soil placed within the excavation will be below CULs. Soil CULs will not be met in areas outside the limits of excavation. COCs in groundwater within the groundwater AOC will not be addressed. Concentrations of COCs in groundwater will remain above CULs on Lilyblad property and adjacent areas of the AOC. Soil contaminants outside of the excavation will continue to contribute COCs to groundwater.	Removes and disposes of contaminated soil on the Lilyblad property in selective locations. The concentrations of COCs in soil in these locations will be below CULs. Soil CULs will not be met in areas outside the limits of excavation. COCs in groundwater within the groundwater AOC will not be addressed by this variation. Concentrations of COCs will remain in groundwater above CULs. Soil contaminants outside of the the selected excavation areas will continue to contribute COCs to the groundwater.	Does not actively address the COCs in soil or groundwater at the Site, so the concentration of COCs in soil and groundwater will exceed the CULs established by Ecology. The natural attenuation of COCs in groundwater together with the active treatment of extracted groundwater will not reduce the concnetration of COCs in groundwater to CULs on the Site for a very long period of time.
Permanence	Does not actively treat the soils at the Site. Treats only a small portion of the contaminants present within the barrier as groundwater is extracted from within the barrier and treated prior to discharge. Provides a significantly lower degree of permanence than is provided by Alternatives 2 and 3. Variation A provides more permanence than Variation B since a complete physical barrier is installed arround the perimeter of the property.	Destroys and/or removes approximately 160,000 pounds of TPH, 3,500 pounds of VOC, and 200 pounds of SVOC COCs. Directly treats all of the groundwater within the groundwater AOC	Destroys and/or removes approximately 160,000 pounds of TPH, and less than 3,500 pounds of VOC COCs. Directly treats all of the groundwater within the groundwater AOC	Destroys and/or removes approximately 30,000 pounds of TPH, 300 pounds of VOC, and 20 pounds of SVOC COCs. Directly treats approximatley 60 percent of the groundwater within the groundwater AOC.	Removes and disposes of approximately 135,000 pounds of COCs in soil within the excavation. During excavation approximately 500,000 gallons of groundwater would be treated prior to discharge. Following remedial construction, 30,000 pounds of soil COCs will remain within the soil AOC. Groundwater COCs will not be addressed by this alternative.	Removes and disposes of approximately 75,000 pounds of COCs in soil from selected locations on the Lilyblad property. During excavation approximately 300,000 gallons of groundwater would be treated prior to discharge. Following remedial construction, approximately 58,000 pounds of COCs in soil will remain on Lilyblad property and approximately 35,000 pounds of soil COCs will remain in neighboring locations within the soil AOC. Groundwater COCs will not be addressed by this Alternative. Variation B is judged to be less permanent than Variation A since it removes 60,000 fewer pounds of COCs from the Site.	Does not actively treat the soils or groundwater at the Site. Treats only a small portion of the contaminants present within the area of hydraulic control as groundwater that is extracted from the Site is treated prior to discharge. Provides less permanence than Alternative 1, which installs a physical barrier to prevent the flow of groundwater from exiting the Lilyblad property; and significantly less permanence than Alternative 2, which actively treats the soil and groundwater within the AOC, or Alternative 3, which removes and disposes of soil within the Lilyblad property.
Effectiveness over the Long Term	The technologies employed by this alternative have been successfully demonstrated at this scale at many locations. Does not actively address the COCs in soils within the soil AOC. These soils will continue to pose potential risks to human health and the environment. Groundwater outside the barrier will not be treated. Significantly less effective over the long term than Alternatives 2 and 3.	Provides for a long-term reduction of contaminant concentrations by means of active remediation. The technologies used are well understood and have been shown to be effective during the pilot-scale tests and Interim Measures that have been conducted at the Site. Provides more long-term effectiveness than any other alternative.	Same as for Variaiton A, except that oxidation of SVOC COCs in soil and groundwater does not occur. Natural attenuation of these COCs would continue. Variation B is likely to be less effective over the long term than Variation A since SVOCs are not destroyed, but be more effective than Alternatives 1, 2 (Variation C), 3, or 4.	The concentration of COCs in the soil and groundwater within the barrier is expected to exceed CULs for an extended period of time. The COCs that will remain in soil and groundwater within the barrier after Alternative 2, Variation C is implemented will continue to naturally attenuate. The progress of natural attenuation will be monitored. Variation C is judged to be less effective over the long-term than Variations A or B of Alternative 2 or Alternative 3.	Provides for a long-term reduction of COC concentrations by means of the active removal and disposal of some contaminated soils on the Lilyblad property. Clean soil placed within the excavation may be recontaminated by COCs in groundwater. The technologies used are well understood. Provides for more long-term effectiveness than Alternatives 1 and 4.	Provides for a long-term reduction of COC concentrations by means of the active removal and disposal of contaminated soils on the Lilyblad property. Clean soil placed within the excavation may be recontaminated by COCs in groundwater.The technologies used are well understood. Provides for more long-term effectiveness than Alternatives 1 and 4.	The technologies employed by this alternative have been successfully demonstrated at this Site. Does not actively address the COCs in soils within the AOC. These soils will continue to pose potential risks to human health and the environment. Provides an equivalent degree of long-term effectiveness as Alternative 1, which installs a physical barrier around the Lilyblad property; and a lesser degree of long-term effectiveness than Alternative 2, which actively destroys COCs in soil and groundwater, and Alternative 3, which excavates and disposes of COCs in soils in an off-site engineered, lined, and monitored facility.
Management of Short Term Risks	Installation of a barrier wall in the vicinity of buried utility lines will expose site workers to the risks inherent in this activity. These risks will be mitigated by developing detailed work plans and health and safety plans.	Short-term risks to human health and the environment would occur if this alternative was implemented. These short-term risks will be present during installation and operation of the generic treatment train and its ancillary equipment. Detailed work plans and health and safety plans will be implemented to reduce risks to site workers and the public during the 6 years that this variation is operational.	Same type of risks as Variation A. Less overall short-term risk than Variation A due to the shorter period of operation of the generic treatment train (5 years for Variation B)	The installation of a barrier wall will expose site workers to additional risks related to the presence of buried utility lines. The duration of Variaiton C (3 years) is shorter than the duration of Variations A and B. Variation C adds the short-term risks associated with the installaion of the barrier. Overall short-term risk of this variation judged to be equivalant to the short-term risks associated with Variation B of Alternative 2.	Excavation and capping of the numerous buried utility lines on the Lilyblad property prior to construction will expose site workers to the risks inherent in this activity. For buildings selected for demolition, the inspection, cleaning, and/or abatement of hazardous materials will expose workers to risk. Large-scale excavation and dewatering of the contaminated site soils will have a high risk of exposure for site worker. These risks will be mitigated by developing detailed work plans and health and safety plans.	Variation B will have the same inherent risks as Variation A, but to a lesser degree due to the reduced amount of demolition and excavation. These risks will be mitigated by developing detailed work plans and health and safety plans.	Minimal risks to human health and the environment will occur if this alternative is selected. Alternative 4 has fewer potential short-term risks to human health and the environment than does Alternatives 1, 2, or 3.
Technical and Administrative Implementability	Slurry wall and sheet pile barrier walls are well developed technologies that could be implemented with a high degree of confidence. Measuring compliance with groundwater CULs at the Blair Waterway will be difficult since groundwater from other source areas will mix with groundwater from the Site prior to discharging to the Blair Waterway.	The generic treatment train has been successfully demonstrated during pilot-scale and Interim Measure operations at the Site. These operations have been conducted with full-scale equipment. The system has been shown to be implementable.	The generic treatment train has been successfully demonstrated during pilot-scale and Interim Measure operations at the Site. These operations have been conducted with full-scale equipment. The system has been shown to be implementable.	The generic treatment train has been successfully demonstrated during pilot-scale and Interim Measure operations at the Site. These operations have been conducted with full-scale equipment. The system has been shown to be implementable. Slurry wall and sheet pile barriers are well developed technologies that could be implemented with a high degree of confidence.	The technologies employed by Variation A are common to the construction industry and with controls to prevent worker exposure, can be readily implemented. Variation A will shut down Pacific Fluids operations. This outcome may not be economically feasible. Significant space on adjacent properties would be required to stockpile excavated soil. Measuring compliance with groundwater CULs at the Blair Waterway will be difficult since groundwater from other source areas will mix with groundwater from the Site prior to discharging to the Blair Waterway.	The technologies employed by Variation B are common to the construction industry and with controls to prevent worker exposure, can be readily implemented. Variation B will shut down Pacific Fluids operations. This outcome may not be economically feasible. Significant space would also be required on adjacent properties to stockpile excavated soil. Measuring compliance with groundwater CULs at the Blair Waterway will be difficult since groundwater from other source areas will mix with groundwater from the Site prior to discharging to the Blair Waterway.	Hydraulic control is a well developed technology that has been used at the Site during the past several years. Groundwater from the Site will mix with groundwater from other source areas once it reaches the storm drain below the Port of Tacoma Road. It will be difficult to isolate the contribution of Site COC concentrations in groundwater to the concentrations of COCs that are present at the point where the storm drains below the Port of Tacoma Road and the Lincoln Avenue Ditch, reach the Blair Waterway.

Table 4.1 - Summary of Detailed Analysis of Alternatives

	Alternative 1 -	Alternative 2 - *In Situ* Treamtent			Alternative 3 Excavation and Disposal of Contaminated Soils		Alternative 4 -
Criteria	Containment with Groundwater Controls	Variation A - Meet CULs in AOCs	Variation B - Meet CULs for TPH in AOCs	Variation C - Containment on Lilyblad Property, Treatment off-Property	Variation A - Excavate All Soils on Lilyblad Property	Variation B - Excavate Most Contaminated Soils on Lilybald Property	Hydraulic Control and Monitoring
Restoration Time Frame	Alternative 1 does not directly reduce the toxicity, mobility, or volume of the COCs contained in soil or groundwater at the Site. The concentration of COCs in soil in the soil AOC or in groundwater below the Sire property, will not be reduced to the CULs established by Ecology by natural attenuation for a very long time..	This evaluation assumes that the implementation of Alternative 2, Variation A will reduce the concentration of COCs in soil and groundwater to below CULs by the conclusion of the approximately 6-year period of operation of the generic treatment system.	Alternative 2, Variation B is likely to reduce the concentration of THP COCs in soil and groundwater to below CULs and to substantially reduce the concentration of VOC COCs by the conclusion of its approximately 5-year period of operation.. The concentrations of SVOC COCs in soil and groundwater are expected to be only slightly reduced since oxidation is not considered by Variation B. The VOCs and SVOCs that are likely to be present in soil and groundwater at the conclusion of Alternative 2, Variation B's period of operation are expected to naturally attenuate. Additional site characterization and modeling would be needed to predict the rate of natural attenuation to more accurately predict future concentrations in soil and groundwater of COCs that may be left behind by Alternative 2, Variation B.	The concentration of COCs in soil and groundwater in areas outside of the barrier after remediation by the generic treatment train should be below CULs at the conclusion of its 2 to 3 years of operation.. The groundwater within the barrier will be contained and treated as groundwater is withdrawn and treated to maintain hydraulic control. The soil inside the barrier will not receive any treatment. Thus the CULs established for soil by Ecology will not be met within the barrier. The COCs that are likely to be present in soil and groundwater within the barrier are expected to naturally attenuate. Additional site characterization and modeling would be needed to predict the rate of natural attenuation to more accurately predict future concentrations in soil and groundwater of COCs that may be left behind by Alternative 2, Variation C.	Will directly remove COCs in soil from within the excavation footprint on the Lilyblad property. CULs for soil within this area will be met once Variation A is implemented. Clean soil placed within the excavation may be recontaminated by COCs in groundwater. COC concentrations in soil and groundwater outside of the excavation footprint will exceed CULs for a very long period of time.	Will directly remove COCs in soil from within the excavation footprint on the Lilyblad property. CULs for most soil within this area will be met once Variation B is implemented. Clean soil placed within the excavation may be recontaminated by COCs in groundwater. COC concentrations in soil and groundwater outside of the excavation footprint will exceed CULs for a very long period of time.	Does not directly reduce the toxicity, mobility, or volume of the COCs contained in soil on the Site. This large 'source term' is expected to supply contaminants to the groundwater for an extended period of time. This time frame is expected to be longer than 30 years. The groundwater treatment system will continue to operate during this period. The concentration of COCs in soil and in groundwater at the Site will exceed the CULs established by Ecology for this Site for a very long period of time.
Conceptual-Level Cost (NPV ±25 percent)	Slurry Wall - $ 3.1 million Steel Sheet Pile - $3.3 million	$4.9 million	$4.4 million	$5.0 million	$ 7.7 million	$ 4.2 million	$3.6 million

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APPENDIX A
COST ESTIMATES FOR ALTERNATIVES 1 THROUGH 4

Table A.1.1 – Alternative 1—Containment with Groundwater Controls

Site: 2244 Port of Tacoma Rd

Location: Tacoma, WA

Phase: Study (-25% to +25%)

Base Year: 2006

Date: November 15, 2005

Description: Four barrier systems will be considered for Alternative 1; A) a slurry wall around the entire perimeter of the Lilyblad property, B) a slury wall around parts of the Lilyblad property judged to contain the most contamination, C) a sheet pile wall around the entire perimeter of the Lilyblad property, and D) a sheet pile wall around parts of the Lilyblad property judged to contain the most contamination. The groundwater retained by the wall will be treated to meet Lilyblad's current NPDES-like requirements. The groundwater treatment system will be based upon the existing treatment system installed by CDM, with modifications as needed to meet the NPDES-like requirements. This alternative will include quarterly groundwater sampling in Year 1, semi-annual groundwater sampling Years 2 through 5, and annual groundwater sampling Years 6 through 20. Soil sampling will occur on a 5-year cycle.

DESCRIPTION	ESTIMATED COST	-25%	+25%	COST TABLE REFERENCE
Slurry wall barrier around entire Lilyblad perimeter	**$ 3,160,027**	$ 2,370,020	$ 3,950,034	A.1.2, A.1.6, A.1.7, A.1.8
Partial slurry wall	**$ 3,335,274**	$ 2,501,456	$ 4,169,093	A.1.3, A.1.6, A.1.7, A.1.8
Sheet pile barrier around entire Lilyblad perimeter	**$ 3,322,787**	$ 2,492,091	$ 4,153,484	A.1.4, A.1.6, A.1.7, A.1.8
Partial sheet pile wall	**$ 3,424,178**	$ 2,568,133	$ 4,280,222	A.1.5, A.1.6, A.1.7, A.1.8

Table A.1.2 - Cost Estimate for Slurry Wall Barrier around Entire Lilyblad Perimeter

Site: 2244 Port of Tacoma Rd

Location: Tacoma, WA

Phase: Study (-25% to +25%)

Base Year: 2006

Description: Alternative 1 Variation A consists of a slurry wall around the entire perimeter of the Lilyblad property. The groundwater retained by the wall will be treated to meet Lilyblad's current NPDES requirements. The groundwater treatment system will be based upon the existing treatment system installed by CDM, with modifications as needed to meet the NPDES-like requirements. This alternative will include quarterly groundwater sampling in Year 1, semi-annual groundwater sampling Years 2 through 5, and annual groundwater sampling Years 6 through 20. Soil sampling will occur on a 5-year cycle.

DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL
Site Prep				
Permits	1	lump sum	$ 5,000.00	$ 5,000
Utility locate	1	lump sum	$ 1,500.00	$ 1,500
Temporary Fencing	1	lump sum	$ 5,000.00	$ 5,000
Concrete Demo & Dispoal	5,900	sq. ft.	$ 3.50	$ 20,650
Site Prep Subtotal				**$ 32,150**
Slurry wall installation				
Contractor mobilization/demobilization	1	lump sum	$ 25,000.00	$ 25,000
Slurry wall barrier	16,500	sq. ft.	$ 16.00	$ 264,000
Soil Testing for Disposal	12	ea.	$ 745.00	$ 8,940
Transport of Contaminated Soil (Non-Hazardous)	366	hours	$ 100.50	$ 36,771
Disposal of Contaminated Soil (Non-Hazardous)	2950	tons	$ 35.00	$ 103,250
Repaving	110	cy	$ 90.00	$ 9,900
Slurry wall installation Subtotal				**$ 447,861**
Total Capital Cost				**$ 480,011**
Other Remediation Costs				
Project management and design	--	--	12%	$ 57,601
Construction oversight	--	--	10%	$ 48,001
Estimated Ecology Oversight Costs	1	LS	$ 30,000.00	$ 30,000
Contingency	--	--	15%	$ 72,002
Other Remediation Cost Subtotal				**$ 207,604**
Total Construction Cost				**$ 687,615**
Groundwater Treatment Costs				
Net Present Value - 20 Years of Operation	1	LS	$ 1,658,054.93	**$ 1,658,055**
Start-up/Upgrade	1	LS	$ 50,000.00	**$ 50,000**
Groundwater Treatment Cost Subtotal				**$ 1,708,055**
Compliance Monitoring Costs (20 Years)				
Year 1 - Quarterly sampling	1	lump sum	$ 97,842.60	$ 97,843
Years 2-5 - Semiannual sampling	1	lump sum	$ 181,845.29	$ 181,845
Years 6-20 - Annual smpling	1	lump sum	$ 259,446.79	$ 259,447
Soil Monitoring on 5 yr Cycle (5 rounds through year 20)	1	lump sum	$ 225,221.87	$ 225,222
Annual Monitoring Cost Subtotal				**$ 764,357**
Total Remediation Cost				**$ 3,160,027**
Minimum (-25%)				**$ 2,370,020**
Maximum (+25%)				**$ 3,950,034**

Notes:
Cost for slurry wall includes excavation 3 foot wide by 15 foot deep around site perimeter (1100 feet), stockpiling of excavated soil, slurry mixing, slurry backfill, and finish to below gravel/pavement grade. Output is assumed to be 100-125 LF/day for slurry wall construction.
Paving costs assumes installation of compact base and concrete.
Assume soil density of 1.4 ton/cy.
Sampling will be for TPH-D extended, TPH-G+BTEX , VOC, PCBs, RCRA 8 metals, and assumes 2 samples for TCLP-metals. Includes sample courier.
From Site to Seattle Transfer Station, approx 70 miles RT. A rate of $100.50/hour for a 3-axle 16 ton dump truck which includes rental, O&M, the operator, and an oiler/spotter for loading.
Disposal of non-hazardous soil based on verbal quote from Rabanco.
Detailed operation costs of groundwater treatment in Table A.1.6.
Compliance Monitoring assumes quarterly monitoring in Year 1, semiannual monitoring Years 2-5, and annual monitoring Years 6-20. Present value callculations in Table A.1.8

Table A.1.3 - Cost Estimate for Partial Slurry Wall Barrier

Site: 2244 Port of Tacoma Rd

Location: Tacoma, WA

Phase: Study (-25% to +25%)

Base Year: 2006

Date: November 15, 2005

Description: Alternative 1 Variation B consists of a partial slurry wall around portions of the Lilyblad property judged to contain the most contamination. The groundwater retained by the wall will be treated to meet Lilyblad's current NPDES requirements. The groundwater treatment system will be based upon the existing treatment system installed by CDM, with modifications as needed to meet the NPDES-like requirements. This alternative will include quarterly groundwater sampling in Year 1, semi-annual groundwater sampling Years 2 through 5, and annual groundwater sampling Years 6 through 20. Soil sampling will occur on a 5-year cycle.

DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL
Site Prep				
Permits	1	lump sum	$ 5,000.00	$ 5,000
Utility locate	1	lump sum	$ 1,500.00	$ 1,500
Temporary Fencing	1	lump sum	$ 5,000.00	$ 5,000
Concrete Demo & Dispoal	3,000	sq. ft.	$ 3.50	$ 10,500
Site Prep Subtotal				**$ 22,000**
Slurry wall installation				
Contractor mobilization/demobilization	1	lump sum	$ 25,000.00	$ 25,000
Slurry wall barrier	8,250	sq. ft.	$ 16.00	$ 132,000
Soil Testing for Disposal	11	ea.	$ 745.00	$ 8,195
Transport of Contaminated Soil (Non-Hazardous)	183	hours	$ 100.50	$ 18,386
Disposal of Contaminated Soil (Non-Hazardous)	1,475	tons	$ 35.00	$ 51,625
Repaving	55	cy	$ 90.00	$ 4,950
Slurry wall installation Subtotal				**$ 240,156**
Total Capital Cost				**$ 262,156**
Other Remediation Costs				
Project management and design	-	-	12%	$ 31,459
Construction oversight	-	-	10%	$ 26,216
Estimated Ecology Oversight Costs	1	LS	15,000	$ 15,000
Contingency	-	-	15%	$ 39,323
Other Remediation Cost Subtotal				**$ 111,998**
Total Construction Cost				**$ 374,153**
Groundwater Treatment Costs				
Net Present Value - 20 Years of Operation	1	lump sum	$ 2,146,764	$ 2,146,764
Start-up/Upgrade	1	lump sum	$ 50,000	$ 50,000
Groundwater Treatment Cost Subtotal				**$ 2,196,764**
Compliance Monitoring Costs				
Year 1 - Quarterly sampling	1	lump sum	$ 97,843	$ 97,843
Years 2-5 - Semiannual sampling	1	lump sum	$ 181,845	$ 181,845
Years 6-20 - Annual smpling	1	lump sum	$ 259,447	$ 259,447
Soil Monitoring on 5 yr Cycle (5 rounds through year 20)	1	lump sum	$ 225,222	$ 225,222
Annual Monitoring Cost Subtotal				**$ 764,357**
Total Remediation Cost				**$ 3,335,274**
Minimum (-25%)				**$ 2,501,456**
Maximum (+25%)				**$ 4,169,093**

Notes:
Cost for slurry wall includes excavation 3 foot wide by 15 foot deep around the northeast and southwest corners of the property (550 feet total lenght for the two sections), stockpiling of excavated soil, slurry mixing, slurry backfill, and finish to below gravel/pavement grade. Output is assumed to be 100-125 LF/day for slurry wall construction.
Paving costs assumes installation of compact base and concrete.
Assume soil density of 1.4 ton/cy.
Sampling will be for TPH-D extended, TPH-G+BTEX , VOC, PCBs, RCRA 8 metals, and assumes 2 samples for TCLP-metals. Includes sample courier.
From Site to Seattle Transfer Station, approx 70 miles RT. A rate of $100.50/hour for a 3-axle 16 ton dump truck which includes rental, O&M, the operator, and an oiler/spotter for loading. Disposal of non-hazardous soil based on verbal quote from Rabanco.
Detailed operation costs of groundwater treatment in Table A.1.6.
Compliance Monitoring assumes quarterly monitoring in Year 1, semiannual monitoring Years 2-5, and annual monitoring Years 6-20. Present value callculations in Table A.1.8.

Table A.1.4 - Cost Estimate for Sheet Pile Barrier around Entire Lilyblad Perimeter

Site: 2244 Port of Tacoma Rd

Location: Tacoma, WA

Phase: Study (-25% to +25%)

Base Year: 2006
Date: November 15, 2005

Description: Alternative 1 Variation C consists of a sheet pile wall around the entire perimeter of the Lilyblad property. The groundwater retained by the wall will be treated to meet Lilyblad's current NPDES requirements. The groundwater treatment system will be based upon the existing treatment system installed by CDM, with modifications as needed to meet the NPDES-like requirements. This alternative will include quarterly groundwater sampling in Year 1, semi-annual groundwater sampling Years 2 through 5, and annual groundwater sampling Years 6 through 20. Soil sampling will occur on a 5-year cycle.

DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL
Site Prep				
Permits	1	lump sum	$ 5,000	$ 5,000
Utility locate	1	lump sum	$ 1,500	$ 1,500
Temporary Fencing	1	lump sum	$ 5,000	$ 5,000
Concrete Demo & Dispoal	4800	sq.ft.	$ 4	$ 16,800
Site Prep Subtotal				**$ 28,300**
Sheet pile installation				
Contractor mobilization/demobilization	1	lump sum	$ 25,000.00	$ 25,000
Sheet pile barrier	1,100	LF	$ 467.00	$ 513,700
Utility Work	1	lump sum	$ 15,000.00	$ 15,000
Repaving	90	cy	$ 90.00	$ 8,100
Soil Testing for Disposal	4	ea.	$ 746.00	$ 2,984
Transport of Contaminated Soil (Non-Hazardous)	15	hours	$ 100.50	$ 1,504
Disposal of Contaminated Soil (Non-Hazardous)	121	tons	$ 35.00	$ 4,226
Sheet pile installation Subtotal				**$ 570,515**
Total Capital Cost				**$ 598,815**
Other Remediation Costs				
Project management and design	-	-	12%	$ 71,858
Construction oversight	-	-	10%	$ 59,881
Estimated Ecology Oversight Costs	1	LS	30,000	$ 30,000
Contingency	-	-	15%	$ 89,822
Other Remediation Cost Subtotal				**$ 251,561**
Total Construction Cost				**$ 850,376**
Groundwater Treatment Costs				
Net Present Value - 20 Years of Operation	1	lump sum	$ 1,658,055	$ 1,658,055
Start-up/Upgrade	1	lump sum	$ 50,000	$ 50,000
Groundwater Treatment Cost Subtotal				**$ 1,708,055**
Compliance Monitoring Costs				
Year 1 - Quarterly sampling	1	lump sum	$ 97,843	$ 97,843
Years 2-5 - Semiannual sampling	1	lump sum	$ 181,845	$ 181,845
Years 6-20 - Annual smpling	1	lump sum	$ 259,447	$ 259,447
Soil Monitoring on 5 yr Cycle (5 rounds through year 20)	1	lump sum	$ 225,222	$ 225,222
Annual Monitoring Cost Subtotal				**$ 764,357**
Total Remediation Cost				**$ 3,322,787**
Minimum (-25%)				**$ 2,492,091**
Maximum (+25%)				**$ 4,153,484**

Notes:
Cost for sheet pile barrier includes asphalt/concrete removal (if applicable), cost of steel sheet piling including seam welding and interlock sealing, and driving piling. Total lenght of sheet pile barrier is 1100 feet.
Utility work includes uncovering, breaking and capping, and reconnecting following sheet pile installation and recovering. Number may be conservative based on actual loaction and number of utilities.
Paving costs assumes installation of compact base and concrete.
From Site to Seattle Transfer Station, approx 70 miles RT. A rate of $100.50/hour for a 3-axle 16 ton dump truck which includes rental, O&M, the operator, and an oiler/spotter for loading. Disposal of non-hazardous soil based on verbal quote from Rabanco.
Assume soil density of 1.4 ton/cy.
Detailed operation costs of groundwater treatment in Table A.1.6.
Compliance Monitoring assumes quarterly monitoring in Year 1, semiannual monitoring Years 2-5, and annual monitoring Years 6-20. Present value callculations in Table A.1.8.

Table A.1.5 - Cost Estimate for Partial Sheet Pile Barrier

Site: 2244 Port of Tacoma Rd

Location: Tacoma, WA

Phase: Study (-25% to +25%)

Base Year: 2006

Date: November 15, 2005

Description: Alternative 1 Variation D consists of a partial sheet pile wall around selected portions of the Lilyblad property judged to contain the most contamination. The groundwater retained by the wall will be treated to meet Lilyblad's current NPDES requirements. The groundwater treatment system will be based upon the existing treatment system installed by CDM, with modifications as needed to meet the NPDES-like requirements. This alternative will include quarterly groundwater sampling in Year 1, semi-annual groundwater sampling Years 2 through 5, and annual groundwater sampling Years 6 through 20. Soil sampling will occur on a 5-year cycle.

DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL
Site Prep				
Permits	1	lump sum	$ 5,000	$ 5,000
Utility locate	1	lump sum	$ 1,500	$ 1,500
Temporary Fencing	1	lump sum	$ 5,000	$ 5,000
Concrete Demo & Dispoal	2450	sq.ft.	$ 4	$ 8,575
Site Prep Subtotal				**$ 20,075**
Sheet pile installation				
Contractor Mobilization/demobilization	1	lump sum	$ 25,000.00	$ 25,000
Sheet pile barrier	550	LF	$ 467.00	$ 256,850
Utility Work	1	lump sum	$ 15,000.00	$ 15,000
Repaving	45	cy	$ 90.00	$ 4,083
Soil Testing for Disposal	4	ea.	$ 746.00	$ 2,984
Transport of Contaminated Soil (Non-Hazardous)	8	hours	$ 100.50	$ 802
Disposal of Contaminated Soil (Non-Hazardous)	64	tons	$ 35.00	$ 2,254
Sheet pile installation Subtotal				**$ 306,974**
Total Capital Cost				**$ 327,049**
Other Remediation Costs				
Project management and design	--	--	12%	$ 39,246
Construction oversight	--	--	10%	$ 32,705
Estimated Ecology Oversight Costs	1	LS	15,000	$ 15,000
Contingency	--	--	15%	$ 49,057
Other Remediation Cost Subtotal				**$ 136,008**
Total Construction Cost				**$ 463,057**
Groundwater Treatment Costs				
Net Present Value - 20 Years of Operation	1	lump sum	$ 2,146,764	$ 2,146,764
Start-up/Upgrade	1	lump sum	$ 50,000	$ 50,000
Groundwater Treatment Cost Subtotal				**$ 2,196,764**
Compliance Monitoring Costs				
Year 1 - Quarterly sampling	1	lump sum	$ 97,842.60	$ 97,842.60
Years 2-5 - Semiannual sampling	1	lump sum	$ 181,845.29	$ 181,845.29
Years 6-20 - Annual smpling	1	lump sum	$ 259,446.79	$ 259,446.79
Soil Monitoring on 5 yr Cycle (5 rounds through year 20)	1	lump sum	$ 225,221.87	$ 225,221.87
Annual Monitoring Cost Subtotal				**$ 764,357**
Total Remediation Cost				**$ 3,424,178**
Minimum (-25%)				**$ 2,568,133**
Maximum (+25%)				**$ 4,280,222**

Notes:
Cost for partial sheet pile barrier includes asphalt/concrete removal (if applicable), cost of steel sheet piling including seam welding and interlock sealing, and driving piling. Total lenght of sheet pile barrier is 550 total linear feet at the northeast and southwest corners of the property .
Utility work includes uncovering, breaking and capping, and reconnecting following sheet pile installation and recovering. Number may be conservative based on actual loaction and number of utilities.
Paving costs assumes installation of compact base and concrete.
From Site to Seattle Transfer Station, approx 70 miles RT. A rate of $100.50/hour for a 3-axle 16 ton dump truck which includes rental, O&M, the operator, and an oiler/spotter for loading. Disposal of non-hazardous soil based on verbal quote from Rabanco.
Assume soil density of 1.4 ton/cy.
Detailed operation costs of groundwater treatment in Table A.1.6.
Compliance Monitoring assumes quarterly monitoring in Year 1, semiannual monitoring Years 2-5, and annual monitoring Years 6-20. Present value callculations in Table A.1.8.

Table A.2.1 - COST ESTIMATE FOR ALTERNATIVE 2 - VARIATION A
***In Situ* Treatment Without Natural Attenuation**

	Variation A - Operate Until CULs are Met			Adjustments Made to Base Case to Prepare This Estimate
	Terra Vac Base Case	This Estimate	Duration	
Installation of the Treatment Train				
Labor				
Project Management	$136,190	$375,000		Add 24 hours/month for reporting to and meeting with Ecology
Other	$215,263	$215,000		during the 6 year duration of the project at $140/hour = about $240,000
Subtotal	$351,453	$590,000		
Subcontractors				
Drilling	$37,375	$37,000		
Trenching	$113,517	$110,000		
Perculation System	$438,840	$440,000		
Other	$45,645	$45,000		
Subtotal	$635,377	$632,000		
Rental and Equipment	$32,760	$35,000		
Supplies				
PVC Pipe and Fittings	$55,200	$55,000		
DVE Process Controls	$23,161	$25,000		
BioVac Process Controls	$51,129	$50,000		
OxyVac Process Controls	$62,928	$65,000		
Other	$81,472	$80,000		
Subtotal	$273,890	$275,000		
Performance Monitoring				
Sampling and Analysis	$14,700	$15,000		
Miscellaneous	$20,790	$20,000		
Installation Subtotal	$1,328,970	$1,567,000		
BioVac Operations per Month				
Monthly Labor	$17,265	$24,000		Increase labor hours from 235 to 320 hours/month at $75/hr
Subcontractors	$0	$0		
Equipment Rentals	$2,630	$2,500		
Supplies	$7,757	$8,000		
Performance Monitoring	$1,715	$2,000		
Other Costs	$480	$500		
Subtotal Per Month	$29,847	$37,000	59	
Subtotal for Period of Operation	$1,760,973	$2,183,000		
OxyVac Operations per Month				
Monthly Labor	$27,445	$31,000		Increase labor hours from 314 to 360/mo at $86/hr
Subcontractors	$0	$0		
Equipment Rentals	$2,630	$2,500		
Supplies	$15,798	$16,000		
Performance Monitoring	$3,020	$3,000		
Other Costs	$340	$500		
Subtotal Per Month	$49,233	$53,000	13	
Subtotal for Period of Operation	$640,029	$689,000		
Sampling and Reporting (1)				
Labor	$48,146			
Subcontractors	$15,525			
Rental Equipment	$0			
Supplies	$0			
Sampling and Analysis	$107,525			
Other Costs	$6,894			
Subtotal Sampling and Reporting	$178,090	$368,000		1) Add five additional rounds of compliance sampling in years 1- 5 at $25,000 per year for a NPV of (i=3, pvf=4.58) = $115,000. Assumes that CULs will be met at end of year 6 and that monitoring thereafter will not be needed 2) Add 10 monthly reports for years 2 - 6 at $ 1500/report = $75,000
Demobilization	$85,000	$85,000		
TOTAL ESTIMATED COST (+/- 25 percent)	$3,993,062	$4,892,000		

Notes
(1) Terra Vac's approach to sampling is summarized in Terra Vac 2005 (Sections 8.2 and 8.3).
Includes quarterly groundwater samples wtihin the AOC for years 1-6. Confirmation samples at end of operations

Table A.2.2 - COST ESTIMATE FOR ALTERNATIVE 2 - VARIATION B
***In Situ* Bioremediation With Natural Attenuation**

	Variation B - Operate Until TPH CULs are Met			Adjustments Made to Base Case to Prepare This Estimate
	Terra Vac Base Case	This Estimate	Duration	
Installation of the Treatment Train				
<u>Labor</u>				
Project Management	$136,190	$335,000		Add 24 hours/month for reporting to and meeting with Ecology
Other	$215,263	$215,000		during the 5 year duration of the project at $140/hour = about $200,000
Subtotal	$351,453	$550,000		
<u>Subcontractors</u>				
Drilling	$37,375	$37,000		
Trenching	$113,517	$110,000		
Perculation System	$438,840	$440,000		
Other	$45,645	$45,000		
Subtotal	$635,377	$632,000		
<u>Rental and Equipment</u>	$32,760	$35,000		
<u>Supplies</u>				
PVC Pipe and Fittings	$55,200	$55,000		
DVE Process Controls	$23,161	$25,000		
BioVac Process Controls	$51,129	$50,000		
OxyVac Process Controls	$62,928	$0		Not needed for this Alternative
Other	$81,472	$80,000		
Subtotal	$273,890	$210,000		
<u>Performance Monitoring</u>				
Sampling and Analysis	$14,700	$15,000		
<u>Miscellaneous</u>	$20,790	$20,000		
Installation Subtotal	$1,328,970	$1,462,000		
BioVac Operations per Month				
Monthly Labor	$17,265	$24,000		Increase labor hours from 235 to 320 hours/month at $75/hr
Subcontractors	$0	$0		
Equipment Rentals	$2,630	$2,500		
Supplies	$7,757	$8,000		
Performance Monitoring	$1,715	$2,000		
Other Costs	$480	$500		
Subtotal Per Month	$29,847	$37,000	59	
Subtotal for Period of Operation	$1,760,973	$2,183,000		
OxyVac Operations per Month				Not needed for Variation B
Monthly Labor	$27,445			
Subcontractors	$0			
Equipment Rentals	$2,630			
Supplies	$15,798			
Performance Monitoring	$3,020			
Other Costs	$340			
Subtotal Per Month	$49,233	$0	0	
Subtotal for Period of Operation		$0		
Sampling and Reporting (1)				
Labor	$48,146			
Subcontractors	$15,525			
Rental Equipment	$0			
Supplies	$0			
Sampling and Analysis	$107,525			
Other Costs	$6,894			
Subtotal Sampling and Reporting	$178,090	$726,000		1) Reduce base estimate by 10 percent to $160,000 2) Add 19 additional rounds of compliance sampling in years 1- 4, 6 - 20 at $25,000 per year for a NPV of (n=19, I=3 %,pvf=14.324) = $358,000. Assumes that CULs for SVOCs will not be met at end of year 5 and that monitoring thereafter will be needed; 3) Add 10 monthly reports for years 2-5 at $1500/report = $60,000. 4) Add soil sampling at years 5,10, 15 and 20 (I=3%, $59,000 per round) = $148,000
Demobilization	$85,000	$75,000		No Oxidation equipment to demobilize
<u>TOTAL ESTIMATED COST</u>	$3,353,033	$4,446,000		
(+/- 25 percent)				

Notes
(1) Terra Vac's approach to sampling is summarized in Terra Vac 2005 (Sections 8.2 and 8.3).
Includes quarterly groundwater samples within the AOC for years 1-5. Confirmation samples at end of operations

Table A.2.3 - Cost Estimate for Alternative 2 - Variation C
Containment With *In Situ* Treatment and Natural Attenuation

	Variation C - Containment Plus Insutu Treatment			Adjustments to Base Case Made to Prepare This Estimate
	Terra Vac Base Case	This Estimate	Duration	
Installation of the Treatment Train				
Labor				
Project Management	$136,190	$80,000		Variation C has a total duration of about 32 months, rather than the 72 months of Varaition A
Other	$215,263	$130,000		or 59 months of Variation B. Reduce Base Case labor by 40 percent to $210,000.
Subtotal	$351,453	$320,000		Add 24 hours/month for project management and metings with and reporting to Ecology at $140/hour = $107,000
Subcontractors				
Drilling	$37,375	$20,000		Variation C only treats areas oustside of the barrier around the Lilyblad property. Two treatment trains will be
Trenching	$113,517	$55,000		used rather than 4 as for Variations A and C. Reduce need for trenching/infiltration by 50 percent
Perculation System	$438,840	$220,000		
Other	$45,645	$25,000		
Subtotal	$635,377	$320,000		
Rental and Equipment	$32,760	$35,000		
Supplies				
PVC Pipe and Fittings	$55,200	$30,000		Variation C only treats areas oustside of the barrier around the Lilyblad property. Two treatment trains will be
DVE Process Controls	$23,161	$15,000		used rather than 4 as for Variations A and C. Reduce need for piping and conrols by 50 percent
BioVac Process Controls	$51,129	$25,000		
OxyVac Process Controls	$62,928	$30,000		
Other	$81,472	$40,000		
Subtotal	$273,890	$140,000		
Performance Monitoring				
Sampling and Analysis	$14,700	$15,000		
Miscellaneous	$20,790	$20,000		
Installation Subtotal	$1,328,970	$850,000		
BioVac Operations per Month				
Monthly Labor	$17,265	$18,000		
Subcontractors	$0	$0		
Equipment Rentals	$2,630	$2,500		
Supplies	$7,757	$4,000		Variation C only treats areas oustside of the barrier around the Lilyblad property. Two treatment trains will be
Performance Monitoring	$1,715	$2,000		used rather than 4 as for Variations A and C. Reduce need for supplies by 50 percent
Other Costs	$480	$500		
Subtotal Per Month	$29,847	$27,000	20	
Subtotal for Period of Operation	$596,940	$540,000		
OxyVac Operations per Month				
Monthly Labor	$27,445	$27,000		
Subcontractors	$0			
Equipment Rentals	$2,630	$2,500		
Supplies	$15,798	$8,000		Variation C only treats areas oustside of the barrier around the Lilyblad property. Two treatment trains will be
Performance Monitoring	$3,020	$3,000		used rather than 4 as for Variations A and C. Reduce need for supplies by 50 percent
Other Costs	$340	$500		
Subtotal Per Month	$49,233	$41,000	12	
Subtotal for Period of Operation	$590,796	$492,000		
Sampling and Reporting (1)				
Labor	$48,146			
Subcontractors	$15,525			
Rental Equipment	$0			
Supplies	$0			
Sampling and Analysis	$107,525			
Other Costs	$6,894			
Subtotal Sampling and Reporting	$178,090	$625,000		1) Reduces Terra Vac cost estimate by 50 percent (to $90,000) since duration is reduced from about 72 months to about 30 months. 2) Add 20 additional rounds of compliance sampling
Demobilization	$85,000	$75,000		in years 1- 20 at $25,000 per year for a NPV of (n=20, I=3%, pvf=14.877) = $372,000. 3) Add 10 monthly reports for year 2 at $1500/report = $15,000. Add soil sampling at years 5, 19, 15 and 20 (I=3%, $59,000/round) = $148,000.
Installation of a Barrier Around the Lilyblad Property	$0	$2,400,000		Assumes barrier around the entire Lilyblad property.
TOTAL ESTIMATED COST (+/- 25 percent)	$2,779,796	$4,982,000		

Notes
(1) Terra Vac's approach to sampling is summarized in Terra Vac 2005 (Sections 8.2 and 8.3).
Includes quarterly groundwater samples on within the AOC for years 1-2. Confirmation samples at end of operations.

Table A.3.1 - Variation A - Demolition of All Lilyblad Structures and Excavation and Disposal of All Contaminated Soils

Site: Lilyblad Petroleum Inc.
Location: Tacoma, Washington
Phase: Feasibility Study (+/-25%)
Base Year: 2007

Description: Demoliton of all structures on Lilyblad property and excavation and disposal of all underlying contaminated soils.

CAPITAL COSTS:

DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL	SOURCE	NOTES
Site Preparation						
Permits	1	LS	5,000	$ 5,000	Previous Project Experience	SEPA Permit
HBM Survey	1	LS	25,000	$ 25,000	Previous Project Experience	
Mobilization	5%	LS	-	$ 233,020	Previous Project Experience	5% of capital costs
Utilities	1	LS	1,500	$ 1,500	Previous Project Experience	utility locate
Security	1	LS	5,000	$ 5,000	Previous Project Experience	Security fencing for equipment compound
SUBTOTAL				$ 269,520		
HBM Abatement						
Asbestos	1	LS	0	$ -	Site Owner	No asbestos on-site. Heated tanks not wrapped in asbestos).
Lead Paint	1	LS	0	$ -	Site Owner	No lead paint on-site (warehouse not painted).
PCBs	1	LS	0	$ -	Site Owner	No PCBs on-site.
Equipment Cleaning						
North Tank Farm	17	tanks	2000	$ 34,000	Certified Cleaning Co.	Price ranges from $500 to $2000 depending on contents
West Tank Farm	23	tanks	1500	$ 34,500	Certified Cleaning Co.	Price ranges from $500 to $2000 depending on contents
Loading Rack	1	LS	15,000	$ 15,000	Certified Cleaning Co.	
Drum Filling Station	1	LS	15,000	$ 15,000	Certified Cleaning Co.	
Lab/Boiler Bldg and Maintenance Trailer	1	LS	20,000	$ 20,000	Certified Cleaning Co.	
Lab/Boiler Bldg ASTs	6	tanks	2000	$ 12,000	Certified Cleaning Co.	Price ranges from $500 to $2000 depending on contents
Demolition						
Warehouse/Administration Building	20,000	SF	3.00	$ 60,000	William B. Dickson Company	Includes disposal of construction debris & demo of utilities.
North Tank Farm	17	tanks	5,000	$ 85,000	William B. Dickson Company	Includes disposal of construction debris & demo of utilities.
West Tank Farm	23	tanks	5,000	$ 115,000	William B. Dickson Company	Includes disposal of construction debris & demo of utilities.
Loading Rack	600	SF	5.00	$ 3,000	William B. Dickson Company	Includes disposal of construction debris & demo of utilities.
Drum Filling Station	600	SF	5.00	$ 3,000	William B. Dickson Company	Includes disposal of construction debris & demo of utilities.
Lab/Boiler Bldg and Maintenance Trailer	900	SF	3.50	$ 3,150	William B. Dickson Company	Includes disposal of construction debris & demo of utilities.
Lab/Boiler Bldg ASTs	6	tanks	6,000	$ 36,000	William B. Dickson Company	Includes disposal of construction debris & demo of utilities.
Water Tank	1	tank	6,000	$ 6,000	William B. Dickson Company	Includes disposal of construction debris & demo of utilities.
Stormwater Treatment Plant & ASTs	1	LS	10,000	$ 10,000	William B. Dickson Company	Includes disposal of construction debris & demo of utilities.
Concrete Demolition	52,272	SF	3.50	$ 182,952	RS Means	Includes disposal of construction debris & demo of utilities.
Excavation						
Sheetpile Installation	1200	lf	485.10	$ 582,123	RS Means	15' depth. Drive, extract & salvage
Unsaturated Soils	28875	CY	2.25	$ 64,969	RS Means	1.5 CY crawler mtd. Backhoe
Saturated Soils	9625	CY	2.70	$ 25,988	RS Means	As above plus 20% surcharge for handling wet soils
Excavation Dewatering	1	LS	10,000	$ 10,000		Sump Pump and Temporary Piping
Soils Dewatering	1	LS	25,000	$ 25,000		HDPE Liner, French Drain, Sump Pump, and Temporary Piping
Water Treatment	679,960	Gal	0.13	$ 91,165.88	Current Treatment Costs	Volume of water initially in excavation plus 2 gpm pumped for 6 weeks for GW containment
Confirmation Sampling	84	Samples	742.32	$ 62,355	ARI Labs, ENA Courier	
Soils Transport	7684	Hr	100.50	$ 772,198	Previous Experience	From Site to Seattle Transfer Station, approx 70 miles RT
Soils Disposal	53900	tons	35.00	$ 1,886,500	Rabanco	1.4 tons/cy, includes transport from transfer station to landfill
Structural Fill - Materials	38,500	CY	10.00	$ 385,000	RS Means	
Structural Fill - Placement	38,500	CY	2.00	$ 77,000	RS Means	75HP Dozer or Loader, Common Earth, 150' haul from stockpile
Structural Fill - Compaction	38,500	CY	1.00	$ 38,500	RS Means	12" lifts, 24" wide vibrating roller, 2 passes
Regrading	10,000	SY	0.50	$ 5,000	RS Means	Course Grading
SUBTOTAL				$ 4,660,399		
Compliance Monitoring Costs (20 Years)					Refer to Appedices A.1.7 and A.1.8	
Groundwater monitoring						
Year 1 - Quarterly sampling	1	LS	$ 97,843	$ 97,843		
Years 2-5 - Semiannual sampling	1	LS	$ 181,845	$ 181,845		
Years 5-20 - Annual sampling	1	LS	$ 259,447	$ 259,447		
Soil monitoring on 5 yr Cycle (5 rounds in 20 yrs)	1	LS	$ 225,222	$ 225,222		
TOTAL MONITORING COSTS				$ 764,357		
Project management and design	12%			$ 591,590		Includes Health and Safety Plan
Construction oversight	10%			$ 492,992		Includes startup labor
Estimated Ecology Oversight Costs	1	LS	50,000	$ 50,000		Subject to revision by Ecology
Contingency	15%			$ 902,175		10% Scope + 5% bid
TOTAL CAPITAL COST				**$ 7,731,000**		
Contingency Capital Cost Range (+/- 25%)			**$ 5,798,250**	**to**	**$9,663,750**	

Notes
Costs are +/-25% FS-level estimates. They do not represent a bid to do the work.
Costs of putting Lilyblad Petroleum Inc. out of business are beyond the scope of this project and are not included in this estimate.

Assumptions
Room for dewatering and treatment system components on adjacent site(s)
Building replacement not within the scope of this project.

Table A.3.2 - Variation B - Demolition of Most Lilyblad Structures and Excavation and Disposal of Most Contaminated Soils

Site: Lilyblad Petroleum Inc.
Location: Tacoma, Washington
Phase: Feasibility Study (+/- 25%)
Base Year: 2007

Description: Demoliton of structures in hot spot areas and excavation and disposal of underlying contaminated soils.

CAPITAL COSTS:

DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL	SOURCE	NOTES
Site Preparation						
Permits	1	LS	5,000	$ 5,000	Previous Project Experience	SEPA Permit
HBM Survey	1	LS	15,000	$ 15,000	Previous Project Experience	
Mobilization	5%	LS	-	$ 115,965	Previous Project Experience	5% of capital costs
Utilities	1	LS	1,500	$ 1,500	Previous Project Experience	utility locate
Security	1	LS	2,000	$ 2,000	Previous Project Experience	Security fencing for equipment compound
SUBTOTAL				$ 139,465		
HBM Abatement						
Asbestos	1	LS	0	$ -	Site Owner	No asbestos on-site. Heated tanks not wrapped in asbestos).
Lead Paint	1	LS	0	$ -	Site Owner	No lead paint on-site (warehouse not painted).
PCBs	1	LS	0	$ -	Site Owner	No PCBs on-site.
Equipment Cleaning						
North Tank Farm	17	tanks	2000	$ 34,000	Certified Cleaning Co.	Price ranges from $500 to $2000 depending on contents
West Tank Farm	23	tanks	1500	$ 34,500	Certified Cleaning Co.	Price ranges from $500 to $2000 depending on contents
Loading Rack	1	LS	15,000	$ 15,000	Certified Cleaning Co.	
Drum Filling Station	1	LS	15,000	$ 15,000	Certified Cleaning Co.	
Demolition						
Mixing Rooms	6,400	SF	3.00	$ 19,200	William B. Dickson Company	Includes disposal of construction debris & demo of utilities.
North Tank Farm	17	tanks	5,000	$ 85,000	William B. Dickson Company	Includes disposal of construction debris & demo of utilities.
West Tank Farm	23	tanks	5,000	$ 115,000	William B. Dickson Company	Includes disposal of construction debris & demo of utilities.
Loading Rack	600	SF	5.00	$ 3,000	William B. Dickson Company	Includes disposal of construction debris & demo of utilities.
Drum Filling Station	600	SF	5.00	$ 3,000	William B. Dickson Company	Includes disposal of construction debris & demo of utilities.
Concrete Demolition	16,500	SF	3.50	$ 57,750	RS Means	Includes disposal of construction debris & demo of utilities.
Excavation						
Sheetpile Installation	860	lf	485.10	$ 417,188	RS Means	15' depth. Drive, extract & salvage
Unsaturated Soils	12525	CY	2.25	$ 28,181	RS Means	1.5 CY crawler mtd. Backhoe
Saturated Soils	4175	CY	2.70	$ 11,273	RS Means	As above plus 20% surcharge for handling wet soils
Excavation Dewatering	1	LS	10,000	$ 10,000		Sump Pump and Temporary Piping
Soils Dewatering	1	LS	25,000	$ 25,000		HDPE Liner, French Drain, Sump Pump, and Temporary Piping
Water Treatment	300000	Gal	0.13	$ 40,222.60	Current Treatment Costs	Volume of water initially in excavation, plus 2 gpm pumped for 3 weeks for GW containment
Confirmation Sampling	45	Samples	745.33	$ 33,540	ARI Labs, ENA Courier	
Soils Transport	3333	Hr	100.50	$ 334,953	Previous Experience	From Site to Seattle Transfer Station, approx 70 miles RT
Soils Disposal	23380	tons	35.00	$ 818,300	Rabanco	1.4 tons/cy, includes transport from transfer station to landfill
Structural Fill - Materials	16,700	CY	10.00	$ 167,000	RS Means	
Structural Fill - Placement	16,700	CY	2.00	$ 33,400	RS Means	75HP Dozer or Loader, Common Earth, 150' haul from stockpile
Structural Fill - Compaction	16,700	CY	1.00	$ 16,700	RS Means	12" lifts, 24" wide vibrating roller, 2 passes
Regrading	4,167	SY	0.50	$ 2,084	RS Means	Course Grading
SUBTOTAL				$ 2,319,291		
ANNUAL OPERATING AND MONITORING COSTS					Refer to Appedices A.1.7 and A.1.8	
Year 1 - Quarterly sampling	1	LS	$ 97,843	$ 97,843		
Years 2-5 - Semiannual sampling	1	LS	$ 181,845	$ 181,845		
Years 5-20 - Annual sampling	1	LS	$ 259,447	$ 259,447		
Soil monitoring on 5 yr Cycle (5 rounds in 20 yrs)	1	LS	$ 225,222	$ 225,222		
TOTAL OPERATING AND MONITORING COST				**$ 764,357**		
Project management and design	12%			$ 295,051		Includes Health and Safety Plan
Construction oversight	10%			$ 245,876		Includes startup labor
Estimated Ecology Oversight Costs	1	LS	30,000	$ 30,000		Subject to revision by Ecology
Contingency	15%			$ 449,952		10% Scope + 5% bid
TOTAL CAPITAL COST				**$ 4,244,000**		
Contingency Capital Cost Range (+/- 25%)			**$ 3,183,000**	**to**	**$5,305,000**	

Notes
Costs are +/-25% FS-level estimates. They do not represent a bid to do the work.
Costs of putting Lilyblad Petroleum Inc. out of business are beyond the scope of this project and are not included in this estimate.

Assumptions
Room for dewatering and treatment system components on adjacent site(s)
Building replacement not within the scope of this project.

Table A.4 Cost Estimate for Alternative 4

Groundwater Treatment	**QUANTITY**	**UNIT**	**UNIT COST**	**Cost**
Present Cost				
Start-up/Upgrade	1	lump sum	$ 50,000	$ 50,000
Recurring Costs				
Personnel				
Operator	1014	hr	$ 50	$ 50,700
Filter Change-out, labor and equipment	12	ea	$ 1,000	$ 12,000
Activated Carbon Replace/Recharge/disposal	10	ea	$ 1,500	$ 15,000
Operation and Maintenance Costs	12	ea	$ 1,000	$ 12,000
NPDES permitting costs - see BU.5	12	ea	$ 4,270	$ 51,240
Total Recurring Annual Cost				$ 140,940
Present Value Factor				19.60
Recurring Net Present Value (30 years)				$ 2,762,424
Groundwater Treatment Net Present Value (Recurring NPV)				**$ 2,812,424**
Compliance Monitoring Costs - Net Present Value				
Groundwater				
Year 1 - Quarterly sampling	1	lump sum	$ 97,843	$ 97,843
Years 2-5 - Semiannual sampling	1	lump sum	$ 181,845	$ 181,845
Years 6-30 - Annual smpling	1	lump sum	$ 378,439	$ 262,546
Soil monitoring on 5 yr Cycle				
7 rounds through year 30	1	lump sum	$ 277,436	$ 277,436
Compliance Monitoring Total				**$ 819,670**
Total Net Present Value - Groundwater treatment + Compliance Monitoring				**$ 3,632,094**

Notes:
1) Calculations based on groundwater flowrate of 2.0gpm to maintain hydraulic control. Flowrate obtained from Terra Vac's November 3, 2006 Groundwater Monitoring Report.
2) Assume maximum water treatment plant capacity is 10 gpm.
3) Assume operator present for 50% of plant operation time.
4) Assume filter change out once a month at a cost of $1,000/changeout.
5) Assume carbon replacement/recharge/disposal is 5 times/year at a cost of $1,500/changeout.
6) Assume monthly O/M cost of $1,000.
7) NPV method was determine present value costs over 30-year period based on a interest rate of 3%.
8) Compliance monitoring costs based on tables A.1.4 and BU.4.
9) Detail of NPDES permitting costs in table BU.5.