EXHIBIT A
ENFORCEMENT ORDER NO. 4515

CLEANUP ACTION PLAN
Lilyblad Site
Tacoma, Washington

Prepared by
Washington Department of Ecology
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1 INTRODUCTION

1.1 Purpose

Ecology prepared this Cleanup Action Plan (CAP) for the Lilyblad Site in Tacoma, Washington. The CAP outlines the procedures for an environmental cleanup at Lilyblad under the Model Toxics Control Act regulations (Chapter 173-340-380 WAC). The purpose of the CAP is to:

- Identify the cleanup standards and point of compliance.
- Summarize cleanup alternatives evaluated in the Feasibility Study.
- Determine the proposed cleanup action plan and include the rationale used to make this determination.
- Describe the proposed cleanup action, schedule for implementation, restoration timeframe, compliance monitoring program.
- Describe measures used to prevent migration and contact with substances, if contamination is left onsite.
- Provide public notice and opportunity for comment on the draft cleanup plan.

The CAP presents the site description, history, and the results of the Remedial Investigation, Supplemental Remedial Investigation, and Feasibility Study. The results provide information pertinent to the purpose of the CAP.

1.2 Facility Description

The facility occupies a 1.98-acre property at 2244 Port of Tacoma Road in Tacoma, Washington. The property borders the PW Eagle property to the southeast and the Nelson property to the northwest. The southwest property line borders a railroad spur on the Saul property and the northeast entrance faces Port of Tacoma Road. Most of the property is paved with asphalt and concrete with the exception of small landscaped areas adjacent to Port of Tacoma Road. The Site itself consists of most of the former Lilyblad property, part of the Port of Tacoma Road, and portions of the P.W. Eagle property, the Nelson property and the Saul property as shown in Figure 1.2.

Pacific Functional Fluids (PFF) currently operates the facility to manufacture, store, repackage, and distribute custom petroleum blends and other chemicals. The facility consists of an office building, warehouse, a truck-loading rack, a laboratory/boiler room, three tank farms, and equipment storage and work areas. A storm drain system underlies the facility and is connected to an onsite water treatment system. PFF uses the railroad spur southwest of the facility for scheduled pickup and delivery of products. The length of the spur along the property line has been fitted with a stormwater catchment system and drain, which lead to the stormwater treatment system.

The main entrance to the facility is located at the administrative office. PFF secures all manufacturing and storage areas within a fence. They lock the office and warehouse after business hours and restrict vehicular access to the fenced area by three gated entries.

1.3 Applicability

This CAP is applicable only to the Lilyblad Site in Tacoma, Washington. Ecology developed the cleanup standards and cleanup actions presented in this report as a result of a remediation process conducted by Lilyblad and Ecology consultants under Ecology oversight. The cleanup levels and cleanup actions identified in this report are site specific and should not apply to other sites.

Potentially Liable Persons (PLPs) cleaning up sites independently, without Ecology oversight, must not cite numerical values of cleanup levels specified in this document as justification for cleanup levels in other unrelated sites. PLPs that are cleaning up other sites under Ecology oversight must base cleanup levels and cleanup standards on site-specific regulatory considerations and not on numerical values contained in this report.

Ecology selected the cleanup action for the site based on the information provided and the cleanup action alternatives identified in the Feasibility Study. The cleanup action meets the following threshold criteria identified in Chapter 173-340-360 WAC:

- Protect human health and the environment.
- Comply with cleanup standards.
- Comply with applicable state and federal laws.
- Provide for compliance monitoring.

Ecology is the lead agency for this action and we will hold a public comment period concerning the action. The PLPs are obligated to determine whether additional permits, approvals, or other substantive requirements are required to implement the cleanup action. In the event that Ecology or the PLPs become aware of additional permits, approvals, or substantive requirements that apply to the cleanup action, each party shall promptly notify the other party of this knowledge. Ecology determines if any additional substantive requirements must be applied at the site.

1.4 Declaration

The preferred cleanup action described in this CAP protects human health and the environment and complies with state and federal laws and cleanup standards for the constituents of concern on site. Ecology gives preference to technologies that provide a permanent solution to the maximum extent practicable.

2 SITE BACKGROUND

2.1 Operational History

The first commercial use of the facility was by Garrett Freight Lines, which occupied the site from its development in the 1960s until about 1970. Lilyblad Petroleum Inc. (Lilyblad) began operation at the facility in 1972 as a distributor of gasoline, diesel, solvents, and packaged petroleum products. Throughout the history of the facility, Lilyblad became involved in various separate recycling operations.

In 1978, Lilyblad installed a Washex® vacuum distillation unit and a Dyna I® solvent reprocessing unit to recycle spent parts washer solvent. Lilyblad removed the Dyna I® solvent reprocessing unit after they determined it was an inefficient process. The facility received approximately 50,000 gallons of chlorinated and non-chlorinated solvent per month for processing. Safety Kleen and later Rapid Clean operated the solvent recycling process under contract. Lilyblad routed steam generated in the adjacent boiler into the still coils to provide the necessary heat for volatilization of the solvents. Lilyblad collected, condensed, and cooled distillate vapors in the system and stored the product liquids in tank farms. Following distillation, Lilyblad loaded the product into tanker trucks and returned it to the customer. They dismantled and removed the Washex® unit in August 1991.

In 1983, Lilyblad entered a joint venture with Sol Pro Inc. to form the Sol Pro/Lilyblad Hazardous Waste Management Corporation. They installed the Brighton Reclaiming System to recycle spent solvent and reprocessed approximately 30,000 gallons of spent solvent per month. The Sol Pro/Lilyblad operation also included the blending of high-heat dangerous wastes fuels, which were transported to cement kilns throughout the United States. Lilyblad released its interest in the Sol Pro/Lilyblad Hazardous Waste Management Corporation in March 1988. The corporation became Sol Pro Hazardous Waste Management Corporation Inc. and moved the Brighton System and its operations offsite.

In 2003, Pacific Functional Fluids purchased Lilyblad's assets, which include accounts receivable and inventory, equipment, and the water treatment system. Pacific Functional Fluids currently operates the facility to store, blend, repackage and distribute chemical and petroleum products. Lilyblad Petroleum Inc. is no longer in business. M&G Holdings currently owns the property.

2.2 Regulatory History

Lilyblad formerly operated the facility as an interim status dangerous waste treatment, storage, and disposal (TSD) facility regulated under Subtitle C of Public Law 94-580, the Resource Conservation and Recovery Act (RCRA). Ecology is authorized to enforce RCRA through Chapter 70.105 RCW, the Hazardous Waste Management Act (HWMA) of 1976. Ecology implements the HWMA through the Dangerous Waste Regulations in Chapter 173-303 WAC. Corrective action requirements for releases of dangerous waste and dangerous constituents at facilities seeking or required to have a permit to treat, store, recycle, or dispose of dangerous wastes are described in Chapter 173-303-646 WAC. To fulfill corrective actions requirements, Ecology issued enforcement actions pursuant to the Model Toxics Control Act (Chapters 70.105 RCW and 173-340 WAC). Ecology named Lilyblad and Sol Pro potentially liable persons (PLPs) in accordance with Chapter 173-340-500 WAC.

On October 30, 1995, the PLPs and Ecology entered into the Agreed Order DE 95HS-S292 requiring the PLPs to prepare the remedial investigation/feasibility study (RI/FS) and CAP. Ecology issued an amendment to the Order on October 10, 2000. Under the amendment, Lilyblad developed and implemented an interim action work plan to remediate contaminated groundwater and soil at the site. Ecology amended the Order on August 15, 2006 and took over the preparation of the FS and CAP.

Ecology directed regulatory actions affecting the Site, including the implementation and termination of several interim remedial actions and pilot studies. Camp Dresser and & McKee (CDM) implemented the interim action required by the Agreed Order 95HS-S292. In March 2001, CDM installed the groundwater interception trench system on the north and south corners of the Lilyblad property. They installed and operated multi-phase extraction (MPE) wells on the west side of the PW Eagle manufacturing building. They added a treatment system to treat extracted groundwater and soil vapor from the trenches and MPE wells. CDM's remedial activities were not effective in removing contaminants and were discontinued by September 2003.

Terra Vac began a six-month pilot study of in-situ treatment technology at the site in September 2003. The in-situ treatment included dual vacuum extraction (DVE) wells and associated soil vapor and water treatment system. Terra Vac added chemicals to oxidize contaminants and nutrients to enhance biodegradation. They conducted the pilot study at the hot spot, dissolved plume, and LNAPL (light non-aqueous phase liquid) areas on the Lilyblad property. Ecology approved Terra Vac's interim action, which included continuing treatment at the pilot study areas and additional treatment at the former MPE area. The interim action was discontinued in March 2006.

On May 26, 2006, Ecology issued Enforcement Order no. #3334 to Lilyblad. Under the enforcement order, Lilyblad submitted a groundwater monitoring plan. The plan included semi-annual groundwater monitoring at the site and a hydraulic containment plan to prevent further spread of contamination through groundwater flow. The hydraulic containment plan has not been implemented.

2.3 Investigative History

Solvent recycling and petroleum handling practice at the facility resulted in the releases of hazardous substances to the soil and groundwater. Releases and potential releases of hazardous substance have been documented at the site since 1984. Site investigations conducted are documented in the following reports:

- *Remedial Investigation Report, Lilyblad Petroleum/Sol Pro, Inc.* (EHM, October 1999)
- *PW Pipe Facility Interim Action Final Work Plan* (CDM, March 2001)

- *Draft Remedial Investigation Addendum No. 1, Lilyblad Petroleum* (CDM, April 2001)

- *Draft Remedial Investigation Addendum No. 2, Additional Evaluation of cPAH and B2EHP, Lilyblad Petroleum* (CDM, December 2001)

- *Draft Feasibility Study, Lilyblad Petroleum Inc.* (Terra Vac, January 2002)

- *Draft Remedial Investigation Addendum No. 3, Supplemental Investigation of PW Eagle* (CDM, March 2002)

- *Annual Groundwater Monitoring Report, Lilyblad Petroleum Inc*. (CH2M HILL, March 2003)

- *Preliminary Draft, Feasibility Study Amendment, Lilyblad Petroleum Inc.* (CH2MHill, September 2004)

- *Supplemental Remedial Investigation Report, Lilyblad Petroleum Inc.* (CH2M Hill, October 2004)

- *Interim Soil and Groundwater Sampling Event: MPE Treatment Area, PW Eagle Property, Lilyblad Pilot Test Areas* (Terra Vac, January 2006)

- *Focused Feasibility Study: Lilyblad Site* (Hart Crowser, 2007)

Site investigations identified the constituents of concern (COCs) as volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and total petroleum hydrocarbons (TPHs) in the gasoline, diesel, and motor oil ranges. A list of the compounds is provided in Table 4.1.

3 SITE CHARACTERIZATION

3.1 Geology and Subsurface

The site (Figure 1.2) is located in the Tacoma Tide Flats industrial area. Prior to development, the area was part of the Puyallup River delta, which consisted of a series of braided channels, marshes, and lowlands. The upper geologic layer is dredge spoil from the construction of Blair Waterway and includes deltaic silts and sands with marine shells. CH2M Hill identified the subsurface features in the site investigation. The subsurface features include the following layers (from the surface downward):

- Structural Fill –The structural fill consists of slightly silty, sandy gravel to sandy, gravelly silt. The layer is 1 to 4 feet thick at most of the site and 6 to 7 feet thick under the PW Eagle building. The structural fill contains the vadose zone. At the base of the vadose zone is the capillary fringe.

- Upper Sand – The upper sand was formed from dredge spoil fill and consists of brown to black, medium-dense to loose, clean to silty, fine to medium sand with some gravel and shell fragments. The layer becomes finer with depth and grades into silty fine sand over much of the site. The layer thickness is 2 to 8 feet. Groundwater occurs in this unit under water table conditions at depths of 3 to 5 feet below ground surface.

- Upper Silt or Aquitard – The aquitard consists of gray to brown soft, clayey silt to silty clay with abundant organic material. The unit has a thickness of 9 to 16 feet and is made up of low-permeability sediments from native tidal flat deposits.

- Second Sand – The second sand layer consists of black, clean to fine silty fine sand. Red and white grain and shells are present on northern parts of the site. The top of the unit is 19 to 21 feet below the ground surface. Groundwater occurs in this unit and is tidally influenced.

3.2 Hydrogeology

Site investigations show a shallow aquifer and a second aquifer present in the site subsurface. The aquitard layer, as identified in Section 3.1, is located between the aquifers. The aquifers are as follow:

- Shallow Aquifer – The shallow aquifer is not tidally-influenced, according to the 16-hour tidal study in 1993. Except during seasonal extremes in recharge areas, depth to water below the site ranges from about 3 to 8 feet below ground surface. Seasonal fluctuation in the water level is on the order of 1 to 2 feet (CH2M Hill, 2004). Historically, groundwater flow at the site is influenced by a groundwater divide near the center of the Lilyblad property. Groundwater north of the divide flows north-northeast toward buried storm drains to sewer lines located along the Port of Tacoma Road. Groundwater south of the divide flows south-southwest and enters a sewer trench beneath PW Eagle. The natural gradient was low, at approximately 0.006 to 0.008 foot/foot (EHM, 1999).

- Second Aquifer – The second aquifer is tidally influenced (EHM, 1999). A 24-hour tidal study indicates a net flow direction from the southeast to the northwest. The apparent gradient calculated during the 24-hour study was 0.001 foot/foot. The gradient ranges from 0.0005 to 0.0013 foot/foot (CH2M Hill, 2004).

There are artesian aquifers on the Tacoma tideflats that are being pumped for beneficial use. The artesian aquifers are substantially deeper than the shallow and second aquifers and are not affected by the contamination at the site.

3.3 Nature and Extent of Contamination

The primary sources of contaminants at the site are uncontrolled releases of petroleum products, chlorinated solvents, and non-chlorinated solvents near the tank farms, the loading racks, and the former fueling and solvent recycling area on the Lilyblad property. Liquid-phase releases spread laterally before infiltrating further into the subsurface. Liquid-phase product exists as a floating layer at the capillary fringe. Because groundwater at the site fluctuates seasonally by about 1 to 2 feet, the floating layer moves vertically with the groundwater level and creates a smear zone of trapped contaminants in soil pores above and below the water table (CH2M Hill, 2004).

Constituents of concern (COCs) at the site consist of volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and total petroleum hydrocarbons (TPHs). A list of COCs is provided in Table 4.1. The extent of the soil and groundwater plume is presented in Figures 3.3.1 and 3.3.2.

3.3.1 Groundwater

Dissolved constituents of concern in groundwater migrate with the groundwater flow at the site. CH2M Hill collected extensive site groundwater data which is documented in the supplemental remedial investigation (CH2M Hill, 2004). Terra Vac collected additional data during an interim sampling event in 2006 (Terra Vac, 2006). The variability in the data resulted from the complex mix of COCs, the groundwater interaction with residual non-aqueous phase liquid, and the remedial activities to date. The consultants used the data to form a post-interim action composite map of the groundwater plume, as shown in Figure 3.3.1. The dimension of the groundwater plume is expected to increase following the shut down of remedial activities and hydraulic containment in March 2006. Figure 3.3.1 does not include groundwater in the second aquifer. The second aquifer is not impacted by the contamination.

3.3.2 Soil

The consultants determined the extent of soil contamination at the site by sampling soil at the four hydrostratigraphic units (from the surface downward): the unsaturated zone, the capillary fringe, the saturated zone, and the aquitard. Hart Crowser used the analytical results to generate a composite map of the soil plume, as shown in Figure 3.3.2. An estimated 52 percent of the total contaminant mass is in the saturated soil, 27 percent in the vadose zone, 19 percent in the capillary fringe, and 2 percent in the aquitard (Hart Crowser, 2007). From a remedial standpoint, it can be assumed that the entire soil column from the surface to aquitard must be remediated.

4 CLEANUP LEVELS

4.1 Method for Establishing Cleanup Levels

Ecology established the cleanup levels for the site according to MTCA requirements, Chapter 173-340 WAC. Table 4.1 identifies the soil and groundwater cleanup levels for all constituents of concern (COCs). Soil and groundwater cleanup levels prepared by Lilyblad were approved by Ecology on March 31, 2005.

Ecology determined the groundwater in the shallow aquifer at the site is non-potable, in accordance with Chapter 173-340-720(1)(a) and (2)(a), (b)(i), and (c) WAC. The shallow aquifer has a low yield (less than 0.5 gallons per minute) and is not a potential source of drinking water. Ecology based cleanup levels on groundwater discharges to surface water in the Blair Waterway.

4.2 Groundwater

Because groundwater at the site discharges to marine surface water, Ecology established groundwater cleanup levels for the protection of surface water. We based the cleanup levels for VOCs and SVOCs on the more stringent of two standards: the ambient water quality toxics criteria in 40 CFR 31.136 and the Method B surface water cleanup standards in Chapter 173-340-730 WAC.

Federal and state laws do not have surface water standards or Method B cleanup levels for TPH. Chapter 173-340-730(3)(b)(iii)(C) recommends using Method A groundwater if Method B surface water numbers are not available. Ecology used Method A cleanup levels for TPH gasoline, diesel and motor oil.

4.3 Soil

Ecology evaluated three pathways: direct contact, vapor, and migration of contaminants to the groundwater to determine soil cleanup levels. We derived soil cleanup levels for VOCs and SVOCs using the three-phase partitioning model and groundwater cleanup numbers. Ecology used Method A soil numbers as the cleanup levels for TPH compounds.

5 CLEANUP ALTERNATIVES

5.1 Summary of Alternative Remedies

This subsection of the Cleanup Action Plan summarizes the alternatives evaluated in the focused Feasibility Study (FS) prepared by Hart Crowser in 2007. The FS evaluates the alternatives in accordance with Chapter 173-340-350(8) WAC.

5.1.1 Alternative 1: Barrier Wall

Alternative 1 proposed the installation and operation of a barrier wall to prevent the flow of contaminated groundwater from the Lilyblad property to surrounding properties. This alternative considers a slurry barrier and a steel sheet pile barrier. The slurry barrier would be about 24-inch thick and reach a depth 8 to 12 feet below ground surface. The steel sheet pile barrier would be 0.25-inch thick and driven two feet into the aquitard. Alternative 1 considers the following variations:

- <u>Variation A:</u> A continuous slurry or steel wall on the Lilyblad property. The wall would be as close to the property line as practical to avoid utilities and other obstructions.

- Variation B: A partial slurry or steel wall located in the general vicinity of CDM interception trenches. Two L-shaped wall segments would be constructed in the general location of the north and south corners of the Lilyblad property.

Groundwater retained by the wall would be extracted and treated prior to discharge to the City of Tacoma storm drain. The groundwater treatment system is based on the existing CDM system, with modifications as necessary to meet NPDES permit requirements. The system includes a surge tank, air stripping system, a particulate filter followed by the activated carbon and cooling system units. Based on average annual rainfall and estimated utilities leakage, about 1 gpm of groundwater must be extracted within the continuous barrier wall to prevent wall overflow. The partial barrier wall requires a higher extraction rate of 2 gpm to contain groundwater. Treated groundwater would be sampled and analyzed monthly to assure compliance with NPDES permit requirements.

The barrier wall would remain in operation until the COC concentrations are low enough to allow natural attenuation of soil and groundwater to cleanup levels at a reasonable restoration timeframe.

5.1.2 Alternative 2: In-situ Treatment

Alternative 2 is the application of generic in-situ technology. The in-situ treatment includes the operation of dual vapor extraction (DVE) wells with the injections of nutrients and chemicals into the site subsurface. The added nutrients would enhance the aerobic biodegradation and chemicals would oxidize the contaminants.

In-situ treatment wells would be installed at all accessible areas at the site to treat soil and groundwater. Nutrients injection would be applied in areas with elevated TPH concentrations. Chemical oxidation would be applied in areas with elevated SVOC concentrations. Variation of the alternative includes:

- Variation A: Application of in-situ treatment throughout the site to treat soil and groundwater to cleanup levels for all constituents of concern.

- Variation B: Application of in-situ treatment to remove TPHs and most VOCs from soil and groundwater. SVOCs would to be relatively immobile after the removal of TPH contaminant masses.

- Variation C: Partial application of in-situ technology at the site. A barrier wall, as described in Alternative 1, will be installed and operated on the Lilyblad property. In-situ treatment will be used to actively treat areas of the site outside the barrier wall to meet soil and groundwater cleanup levels.

Extracted groundwater and vapors would be treated through the groundwater and soil vapor treatment system. Groundwater would be treated to NPDES permit limits prior to discharge to the Tacoma storm sewer. Vapor will be treated to meet air permit requirements. Groundwater treatment components are described in alternative 1 Section 5.1.2. The vapor treatment components include a vacuum extraction unit and activated carbon unit. The treatment system schematic is included in Figure 5.1.2.

5.1.3 Alternative 3: Excavation

Alternative 3 includes the full and partial excavation of soil above cleanup levels on the Lilyblad property. A full excavation would apply to all soil above cleanup levels on the Lilyblad property and remove about 30,000 cubic yards of soil. A partial excavation would remove about 16,700 cubic yards of soil on the most contaminated parts of the property. Contaminated soil and groundwater left on site would be allowed to naturally attenuate.

The Lilyblad property is paved with the exception of small landscaped areas. Buildings occupy approximately 40 percent of the 1.98-acre property. Buried utilities include potable water, sanitary sewers, storm sewers, natural gas, and power (CH2M Hill, 2004). Petroleum product pipelines are partially buried in the foundation of buildings. The full excavation requires the demolition of most structures and utilities, including the warehouse/administration building, two tank farms, the stormwater treatment plant, a laboratory/boiler building, a maintenance trailer, a petroleum pump station, a drum filling station, and the wastewater storage tank. The partial excavation requires the demolition of the tank farms and adjoining structures. Buildings not demolished would require shoring. A hazardous building material survey and abatement must also be completed for each structure prior to the commencement of demolition activities.

On average, the excavation would reach a depth of 12 feet, which is 6 feet below the groundwater table. Sloping of the side walls or sheet pile installation would be used to excavate to the required depths. Saturated soil must be dewatered prior to excavation and disposal. Excavation would occur in the relatively dry months of July and August and dewatering would take approximately two days. The work may be phased, unless adjacent properties offer adequate room to stockpile saturated soils. Soil stockpiles would be covered with a HDPE liner and sloped toward a French drain. Water collected in the drain would be pumped to the existing water treatment system on the Nelson property. Groundwater within the excavation would also be pumped to the water treatment plant. Treated water would be discharged to the Tacoma storm sewer. Excavated soil must be disposed in accordance with RCRA requirements and replaced with clean structural fill.

5.1.4 Alternative 4: Monitoring and Hydraulic Control

Alternative 4 includes groundwater monitoring and hydraulic control of the groundwater contaminant plume. A plan for semi-annual water monitoring has been implemented at the site since September 2006. Groundwater elevation is measured during the wet and dry season at 11 wells throughout the site. The data are used to generate a potentiometric map and determine the direction of groundwater flow. Hydraulic control would be added by connecting the existing DVE system to the nine wells throughout the site. The wells would be located at the interception trenches, MPE area, and east corner of the Lilyblad property site. It is estimated that hydraulic control can be maintained with a groundwater extraction rate of 1 gpm (Hart Crowser, 2007).

To confirm groundwater containment has been achieved groundwater elevations would be measured weekly for the first month after the hydraulic containment system has been activated and quarterly thereafter. Long-term groundwater quality monitoring would also be performed to evaluate the effectiveness and continued need for hydraulic containment. A long-term groundwater monitoring plan would be developed, specifying the monitoring well locations, monitoring frequencies, sampling procedures, and analytical and reporting requirements.

The extracted groundwater and soil vapor will be treated by the same groundwater system described in alternative 1, Section 5.1.1. Treated groundwater would be sampled and analyzed monthly to assure compliance with NPDES discharge requirements.

5.2 Selected Cleanup Action

Ecology selected in-situ treatment as described in Section 5.1.2 alternative 2, variation A as the cleanup remedy selected for the site. The remedy consists of dual vacuum extraction technology in combination with bioremediation and chemical oxidation to actively treat soil and groundwater. Bioremediation will be applied to areas with elevated TPH concentrations. Oxidation will treat areas with elevated SVOC concentrations to cleanup levels. The design specifications for the cleanup remedy are in Terra Vac's Site-Wide Remedial Action Plan dated August 2003.

Dual vacuum extraction (DVE) combines soil vapor and groundwater extraction technologies to simultaneously remove vapor and liquid at the same extraction well. The extraction wells will be installed and operated in accessible areas throughout the soil and groundwater plumes. DVE will create a "new" vadose zone within the cone of depression of the wells and expose previously saturated soil to the vacuum extraction process. Nutrients will be injected into the vadose and saturated soil layer to enhance the aerobic biodegradation of heavy-range hydrocarbon contaminants by indigenous microorganisms. Chemicals will be injected into the subsurface to destroy contaminant compounds by direct oxidation. The remediation system, shown in Figure 5.2, includes:

- DVE wells and piping: The wells will be dewatered to the top of the aquitard and screened from to the top of the water table to the aquitard. Soil between the wells will be dewatered to the maximum extent practical. Piping provides connection for DVE wells, the nutrient/chemical injection systems, and associated equipment and tankage. Pipes may be installed above ground or below ground in areas of heavy traffic.

- Nutrient/chemical injection and delivery system: The nutrients and chemicals will be introduced into the subsurface by injection wells and/or through a surface injection system. The delivery system will include storage tanks, pumps, valves, totalizers, and conveyance piping. The injection system will require an Underground Injection Control (UIC) permit.

- Vapor extraction and treatment system: Vapor at DVE wells will be removed by vapor extraction units (VEUs). Each VEU can operate on a subgroup of approximately 20 wells. Extracted vapors will be treated in the vapor treatment system, which consists of an activated carbon unit, a catalytic oxidizer, and caustic scrubber. The vapor treatment was previously operated as part of the interim action.

- Groundwater treatment system: The groundwater treatment system includes a surge tank, air stripping system and a particulate filter followed by the activated carbon and cooling units. The groundwater treatment system was previously operated as part of the interim action. Treated groundwater will be discharged to the storm sewer or the reinfiltration trench at the site.

Vapors and entrained liquids extracted from DVE wells will be treated by the vapor and groundwater treatment systems. The vapor treatment system was able to meet the Puget Sound Clean Air Agency (PSCAA) requirements for the operation of the DVE, bioremediation, oxidation treatment in PSCAA Notice of Construction Number 99367. The groundwater treatment system was able to meet the requirements in substantive provisions of the NPDES permit in Agreed Order No. DE95HS-S292. Permits for the operation of treatment systems will be issued or modified as required by local and state regulations.

Additional work will be completed before and during the construction period in order to minimize the impacts of installation on human health, environment, and facilities operations. An underground utilities clearance will be completed prior to drilling and excavation. Storm water best management practices will be implemented to prevent storm water run-on and run-off from work areas. Waste management and disposal procedures will apply to installation-derived wastes. Installation-derived wastes include soil cuttings from wells, liquids generated during equipment cleaning, disposable sampling equipment, and personal protective equipment.

Maintenance and monitoring will be performed to track remediation progress and optimize performance of the treatment system. Baseline water sampling will be conducted prior to operation. During the period of operation, monitoring will include vacuum measurements, flow readings, radius of influence readings at well heads, totalizer readings, and total run time readings. Maintenance and monitoring activities include:

- Collecting samples for compliance monitoring.
- Monitoring DVE wells mass removal rate.
- Monitoring effectiveness of vapor and water treatment systems.
- Monitoring nutrients and chemical addition.
- Maintaining remediation equipment.
- Maintaining groundwater extraction rates.
- Maintaining vacuum and flow rate objectives.
- Preparing and submitting reports to Ecology.

The in-situ treatment will be in operation for approximately six years. During this period, DVE technology will continuously remove contaminated groundwater, VOCs, and small quantities of SVOC vapors from soil above the lowered water table. Approximately 59 months of bioremediation will be applied to remove TPHs, followed by 13 months of chemical oxidation to destroy SVOCs. At the conclusion of the six-year operating period, the treatment is expected to substantially reduce VOCs, SVOCs, and TPHs concentrations in the soil and groundwater.

5.3 Justification for Selected Cleanup Action

This section provides the rationale for the selection of in-situ treatment (alternative 2, variation A) as preferred cleanup action. Hart Crowser, under Ecology oversight, compared and evaluated the alternatives in accordance with the requirements in Chapter 173-340-360 WAC. The preferred cleanup action meets the threshold and other requirements as described below.

5.3.1 Protection of Human Health and the Environment

Ecology establishes cleanup levels at the site to protect human health and the environment. We established groundwater cleanup levels based on the protection of surface water and soil cleanup levels based on the protection of groundwater, vapor, and direct contact pathway. Ecology expects the cleanup action to treat COCs to soil and groundwater cleanup levels throughout the site.

5.3.2 Compliance with Cleanup Standards

The cleanup standards are summarized in MTCA regulations Chapter 173-340-700 through 173-340-760 WAC. Ecology established soil and groundwater cleanup levels at the site in accordance with cleanup standards. The preferred cleanup action is expected to achieve cleanup levels as stated in Section 5.3.1.

5.3.3 Compliance with Applicable State and Federal Law

The selected cleanup action will comply with cleanup standards and all applicable laws and regulations. Cleanup activities will meet all laws requiring government approval and permits. Permits are required for the injection systems, the vapor treatment system, and the groundwater treatment and discharge/reinfiltration. Treatment wells are required to meet standards for installation and maintenance.

5.3.4 Permanence

In determining the cleanup action, Ecology considers the degree to which the technology permanently reduces the toxicity, mobility, and volume of hazardous substances under Chapter 173-340-360(3)(f)(ii) WAC. We also consider the irreversibility of treatment, the reduction of COCs, and the nature of residuals generated.

In-situ treatment technology will actively treat the soil and groundwater and reduce the toxicity at the site. Contaminants in the soil and groundwater will be permanently reduced by biodegradation or chemical oxidation. The COCs removed by DVE will be destroyed by the thermal/catalytic oxidizer or adsorbed in the activated carbon unit. Adsorbed COCs will be destroyed with the regeneration of activated carbon. The preferred cleanup action provides a greater degree of permanence than hydraulic control and barrier wall containment.

5.3.5 Cost and Cost Effectiveness

The conceptual-level cost estimate for the cleanup is derived in accordance with Chapter 173-340-360(3)(f)(iii) WAC. The estimate considers the existing remedial infrastructure at the site and includes cost of construction, agency oversight cost, and long-term cost. Long-term cost accounts for operation, maintenance, equipment replacement, and compliance monitoring. Hart Crowser evaluated the net present value of long-term cost using a 3 percent interest rate. The net present value cost estimate for the selected cleanup action is included in Table 5.3.5. The estimate has a 25 percent range uncertainty.

Cost effectiveness is derived from the rough estimation of the cost and pounds of COCs removed or destroyed. Hydraulic containment and barrier wall with pump and treat do not directly remove or destroy COCs. Hart Crowser did not evaluate the cost per pound of removal for these remedies. Excavation would remove all contaminated soil and some groundwater on the Lilyblad property at the cost of about 58 dollars per pound. In-situ treatment would destroy COCs in soil and groundwater at approximately 30 dollars per pound (Hart Crowser, 2007). In-situ treatment becomes the preferred remedy because it is more cost effective and utilizes the technology to the maximum extent practicable.

5.3.6 Long Term Effectiveness

Long term effectiveness considers the degree of success and reliability of the remedy and the impacts of residual risks remaining on site. Cleanup action components are ranked as follows, from most to least effective in the long-term:

- Reuse or recycling
- Destruction or detoxification
- Immobilization or solidification
- Onsite or offsite disposal in an engineered, lined, and monitored facility
- Onsite isolation or containment with attendant engineering controls
- Institutional controls and monitoring

The preferred cleanup remedy ranks high as destruction and detoxification technology. The in-situ technology is well-understood and was shown to be effective during the interim action. Dual vacuum extraction is the presumptive remedy for the treatment of VOCs in soil and groundwater. A presumptive remedy is a preferred technology based on EPA's scientific and engineering evaluation and historical remedy selection. Bioremediation has been demonstrated to be effective in treating TPHs at the site. In-situ chemical oxidation has been effective in destroying SVOCs at other sites. The vapor and groundwater treatment systems are able to meet existing permit requirements.

5.3.7 Short Term Risks Management

The cleanup action will consider the risks to human health and the environment associated with construction and implementation, as required in Chapter 173-340-360(3)(f)(v) WAC. Short-term risks will be present during the installation and operation of the treatment system and ancillary equipment. Detailed work plans and health and safety plans will be developed and implemented to reduce impacts on workers and the public. Prior to implementation, work plans and health and safety plans will be submitted to Ecology for approval.

5.3.8 Implementability

Implementability is the evaluation of the technical and administrative feasibility of the cleanup action. Technical feasibility addresses the obstacles of installation, operation, and monitoring. Administrative feasibility considers coordination with local, state, and federal agencies. The evaluation includes the following criteria:

- Availability of necessary off-site facilities, services, and materials
- Administrative and regulatory requirements
- Scheduling
- Scale and complexity
- Monitoring requirements
- Access for construction operations and monitoring
- Integration with existing facility operations and other current or potential remedial actions

The pilot study and interim action have demonstrated that the in-situ treatment is implementable and in compliance with the air permit and NPDES permit requirements. A full-scale in-situ treatment system installation will take about six months. The installation and operation will be conducted in a way that minimizes disruptions to the operations on the Lilyblad and PW Eagle properties.

5.3.9 Consideration of Public Concerns

The CAP will undergo a public comment period to address concerns from individuals, community groups, local governments, tribes, federal and state agencies, or other organizations that may have an interest in the Lilyblad site. Public concerns regarding the remedy will be evaluated after the completion of the public comment period.

5.3.10 Reasonable Restoration Timeframe

Ecology evaluated the restoration timeframe for the cleanup action and determined it is reasonable with respect to the nine factors in Chapter 173-340-360(4)(b). The restoration time frame for the Lilyblad site is estimated using the first-order decay model for removal/destruction of COCs. The model is described as follows:

$$t = -k \ln\left(\frac{C}{C_0}\right) \qquad \text{(Equation 1)}$$

Where
t = restoration timeframe, in days;
C = soil/groundwater cleanup level, in mg/kg or µg/L;
C_o = initial soil/groundwater COC concentration using the same units as C; and
k = reaction coefficient, in days.

The model is an attempt to quantify the COC removal efficiency of the treatment system and does not represent the biological or chemical process at the site. The removal efficiency for any given COC is characterized by its reaction coefficient *k*. Smaller *k* values indicate greater removal efficiency and shorter restoration timeframe. Site-specific data from the remedial investigation and the pilot study support the calculation of *k*. The following equation is used to find *k*:

$$k = \frac{-t_P}{\ln\left(\frac{C_f}{C_i}\right)} \qquad \text{(Equation 2)}$$

Where
k = reaction coefficient, in days;
t_P = operating time of the pilot treatment, in days;
C_i = soil/groundwater COC concentration prior to the pilot test, in mg/kg or µg/L; and
C_f = soil/groundwater COC concentration at the end of the pilot test, using the same units as C_i.

Equation 2 generates a set of k values for soil and water COCs. The mean and standard deviation of *k* were calculated for the rate-limiting COCs, such as tetrachloroethylene and 1,1-dichlorobenzene. To reach a more conservative estimate, two standard deviation increments were added to the mean to obtain the final *k* values. Table 5.3.10 provides a list of final *k* values. Using these *k* values and Equation 1, the restoration timeframe *t* is estimated for the site.

Based on the model, enhanced biodegradation will be implemented for approximately 59 months to remove most of the VOCs and TPHs. Biodegradation will be followed by 13 months of chemical oxidation treat the remaining SVOCs in the soil and groundwater. The restoration timeframe required to achieve soil and groundwater cleanup levels is approximately six years.

6 COMPLIANCE MONITORING

Monitoring is a threshold requirement under Chapter 173-340-360(2)(a)(iv). Compliance monitoring at the site will be implemented in accordance with Chapter 173-340-410. The three components of the compliance monitoring are described as follow:

- <u>Protection monitoring:</u> The purpose of this monitoring is to help reduce impacts on human health the environment during the construction, maintenance, and operation periods. Protection monitoring will be developed as part of the site health and safety plan.

- <u>Performance monitoring:</u> Monitoring is designed to determine if the preferred cleanup action has met performance and permit standards. Baseline sampling and system process monitoring are also included.

- <u>Confirmation monitoring:</u> Monitoring is conducted to determine the long-term effectiveness of the treatment. Soil and groundwater sampling analysis will determine if cleanup levels are achieved at the site.

The proposed monitoring schedule is summarized in Table 5.4. Sampling will be collected in accordance with Ecology's guidance and EPA standard sampling methodology. Offsite sampling analysis will be done at an independent Washington state certified laboratory. Samples will be analyzed for VOCs using EPA Method 8260B, SVOCs using EPA Method 8270C, and TPHs using Washington-approved method NWTPH-d and NWTPH-g. The final compliance monitoring plan and schedule will be developed and submitted to Ecology for review and approval.

7 INSTITUTIONAL CONTROLS

Because of the heterogeneous soil conditions and insufficient SVOCs data (Hart Crowser, 2007), it is possible that SVOCs will remain on site above soil and groundwater cleanup levels in some spots after the six-year treatment. If there are residual contaminants on site after the six-years operation, continuing treatment or institutional controls will be implemented until the site meets cleanup standards. General requirements for institutional controls are in Chapter 173-340-440(9). Site-specific requirements include:

- Protect workers' health and safety.
- Monitor soil vapor for hazardous volatile compounds.
- Implement proper soil disposal practices.
- Test and treat extracted groundwater prior to disposal.

Restrictive covenants containing the general and specific requirements may be issued to properties with residual soil and groundwater contamination. If implemented, institutional controls would remain in place for as long as soil and groundwater remain above cleanup levels. Owners of properties under institutional controls would have to notify Ecology of activities which would disrupt the soil or groundwater at the site.

8 SCHEDULE

Table 6.1 outlines the schedule and tasks. The tasks include the submittal of the Remedial Action Work Plan, Compliance Monitoring Plan, and Health & Safety Plan. Ecology will issue an enforcement order to implement selected remedy. Ecology incorporates the schedule, as shown in Table 6.1, as part of the enforcement order.

9 REFERENCES

CH2M Hill. October 2004. *Draft Supplemental Investigation Report. Lilyblad Petroleum*.

Environmental Health Management (EHM). October 1999. *Remedial Investigation Report. Lilyblad Petroleum/Sol-Pro Inc*.

Hart Crowser. January 2007. *Focused Feasibility Study – Lilyblad Site, Tacoma, Washington*.

Terra Vac. January 2002. *Lilyblad Petroleum Facility Feasibility. Agency Review Draft*.

Terra Vac. August 2005. *Site Wide Remedial Action Design Plan. Lilyblad Petroleum Site*.

Terra Vac. January 2006. *Interim Soil and Groundwater Sampling Event: MPE Treatment Area, PW Eagle Property, and Lilyblad Pilot Test Areas*.

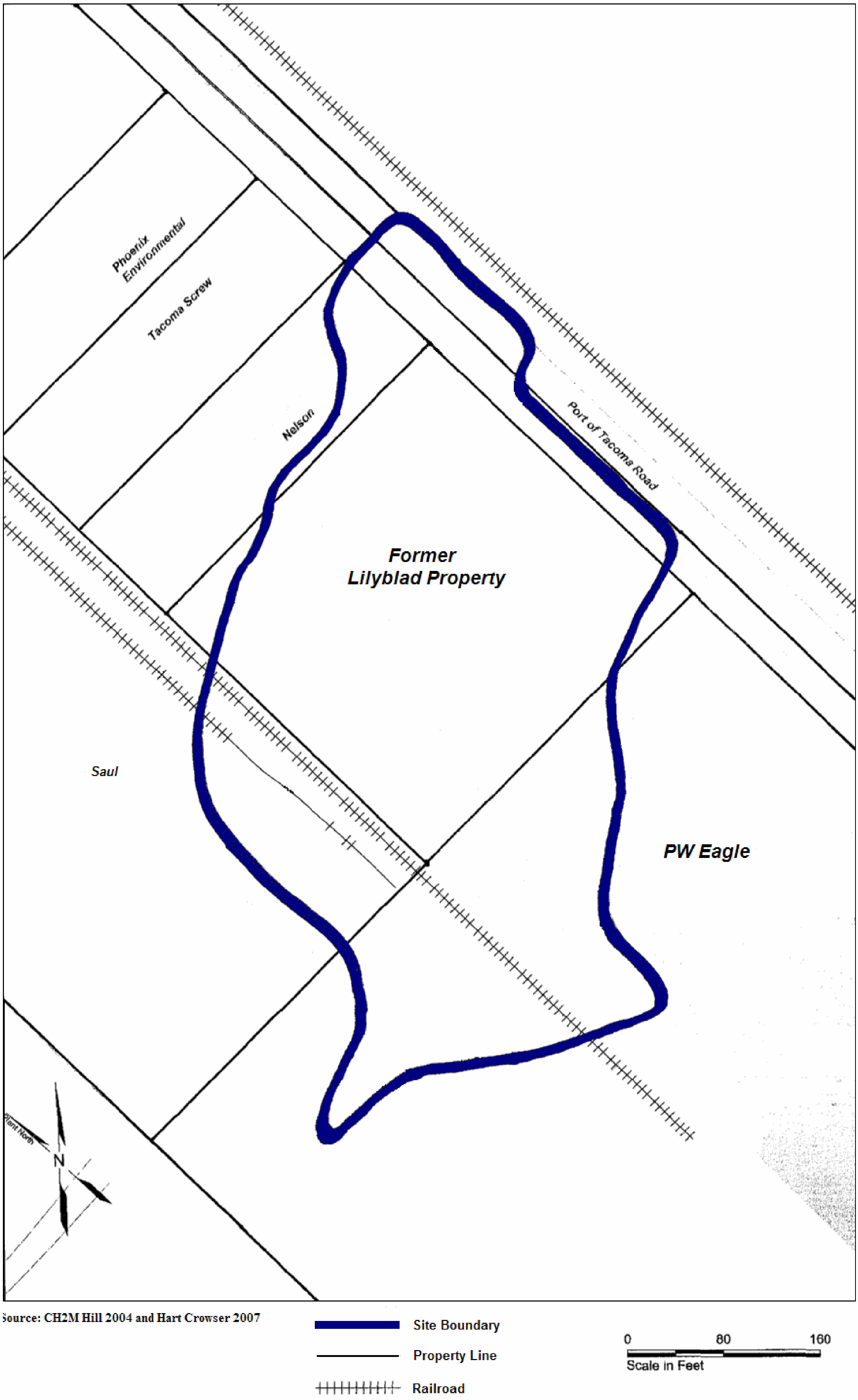
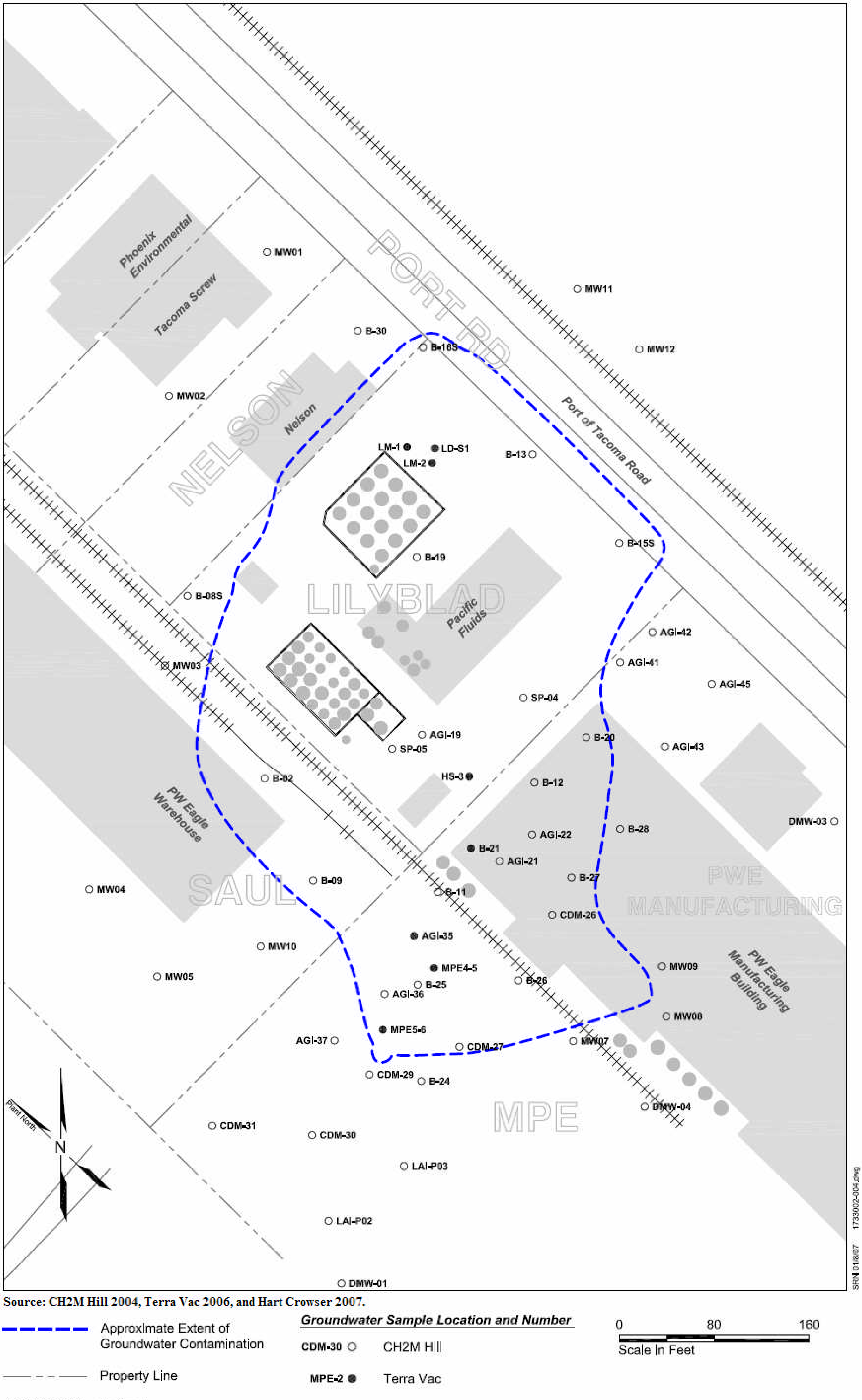
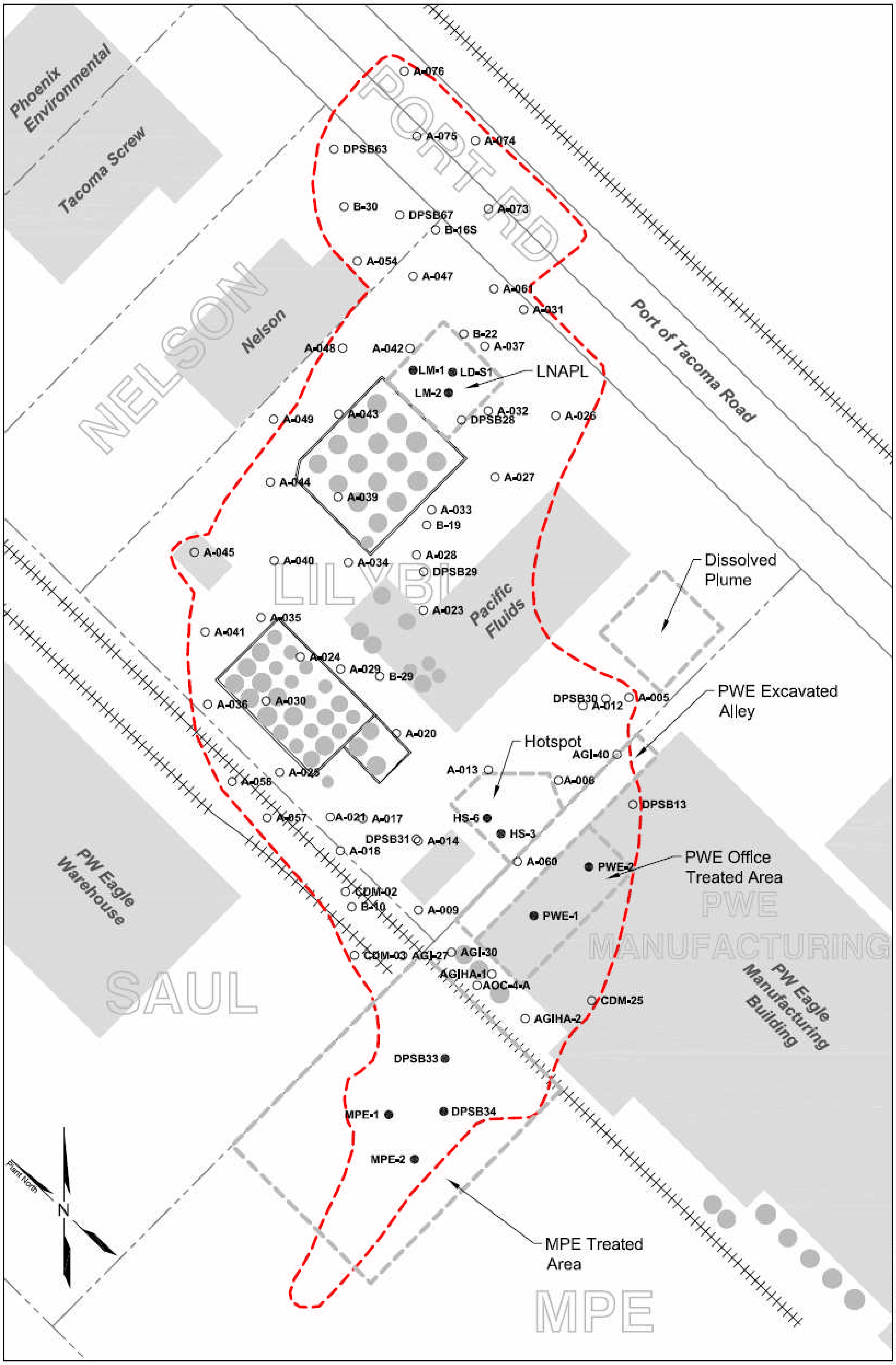


Figure 1.2 Lilyblad Site Boundaries



Source: CH2M Hill 2004, Terra Vac 2006, and Hart Crowser 2007.

Figure 3.3.1 Extent of Groundwater Contamination



Source: CH2M Hill 2004, Terra Vac 2006, and Hart Crowser 2007.

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

Figure 3.3.2 Extent of Soil Contamination

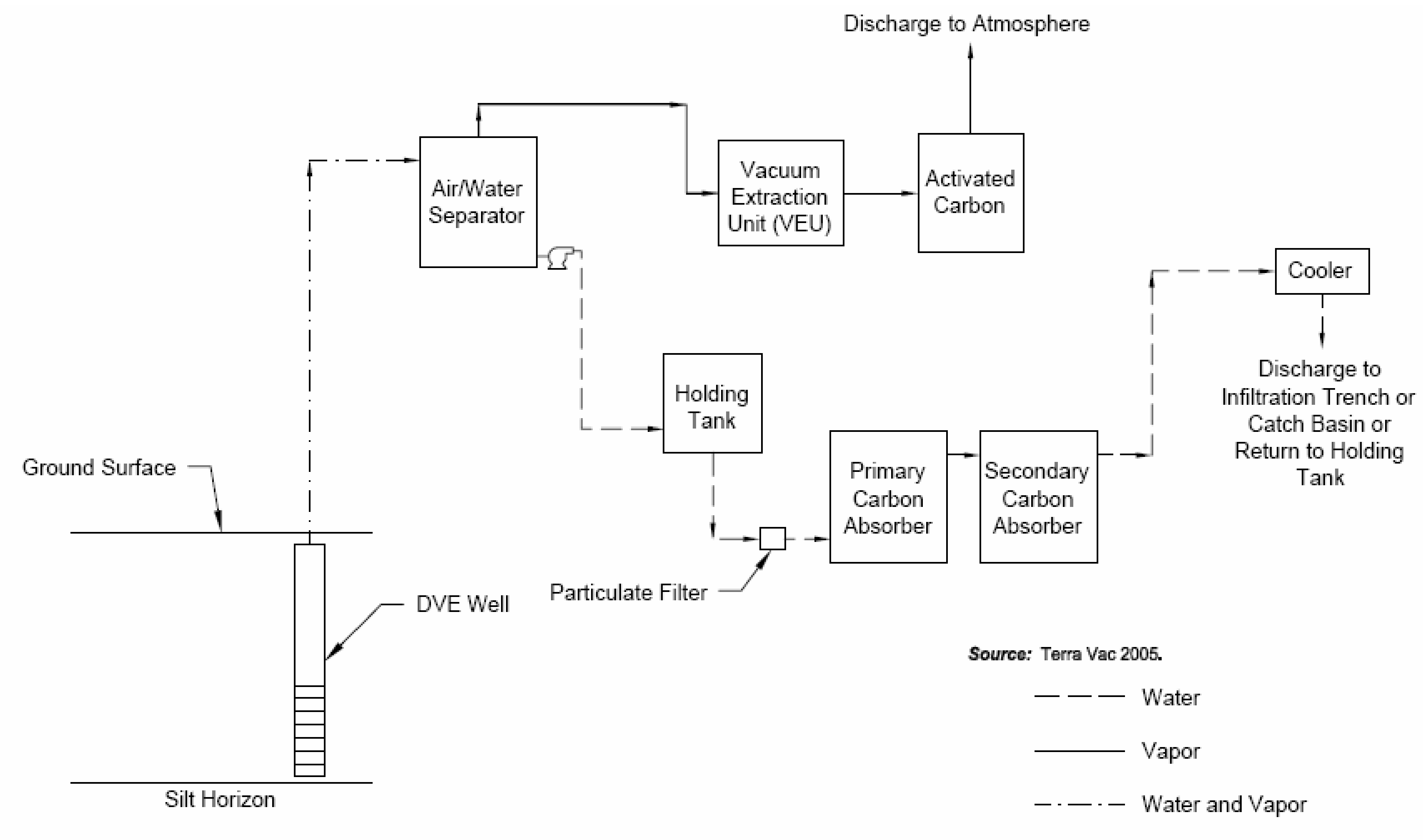


Figure 5.1.2 Flow Diagram of the Vapor and Groundwater System

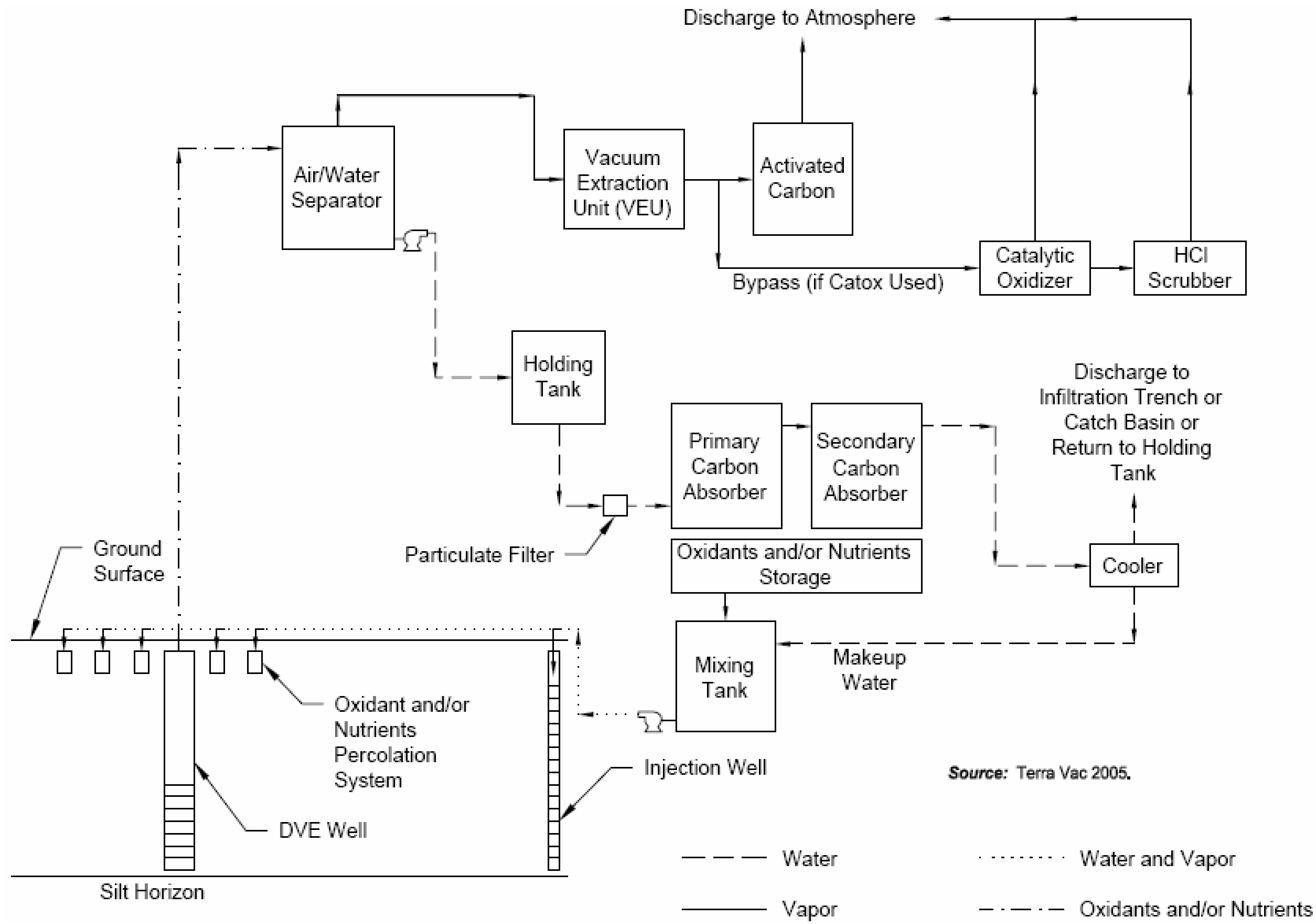


Figure 5.2 Flow Diagram of the In-situ Treatment System

Table 4.1 - Soil and Groundwater Cleanup Levels (CULs)

Chemical Group	Contaminant of concern	Soil CUL (µg/kg)	Groundwater CUL (µg/L)
VOC	1,1,1-trichloroethane	1,144	227
VOC	1,1,2-tricholoroethane	54.1	16
VOC	1,1-dichloroethane	164,000	52,000
VOC	1,1-dichloroethene	7.9	1.93
VOC	1,2,4-trimethylbenzene	10,350,000	26,000
VOC	1,2-dichloroethane	100.6	37
VOC	1,4-dichlorobenzene	64.6	4.86
VOC	Benzene	75	22.7
VOC	bis(2-ethylhexyl)phthalate	4,400	2.2
VOC	cis-1,2-dichlorobenzene	14,880	5200
VOC	Ethylbenzene	41,130	6910
VOC	m,p-xylene	58,400	26,000
VOC	Methylene chloride	1,332	590
VOC	Tetrachloroethene	24.5	3.3
VOC	Toluene	71,340	15,000
VOC	Trichloroethene	121.7	30
VOC	Vinyl chloride	7.91	2.4
SVOC	Naphthalene	115,900	4,940
SVOC	Pentachlorophenol	37.97	3
SVOC	2-methylnaphthalene	-	22.5
TPH	Diesel range hydrocarbons	2,000,000	1000
TPH	Gasoline range hydrocarbons	100,000	1000
MOIL	Motor oil	2,000,000	1000

Table 5.3.5 - Estimated Cost of Preferred Cleanup Action

Installation Cost	
Project management	375,000
Other labor	215,000
Drilling	37,000
Trenching	110,000
Percolation system	440,000
Other subcontractor work	45,000
Rental and Equipment	35,000
PVC pipe and fittings	55,000
DVE process controls	25,000
Bioremediation process controls	50,000
Oxidation process controls	65,000
Other supplies	80,000
Baseline sampling & analysis	15,000
Miscellaneous	20,000
Subtotal	1,567,000
Bioremediation Cost	
Labor, monthly	24,000
Equipments rental, monthly	2,500
Supplies, monthly	8,000
Performance monitoring, monthly	2,000
Other, monthly	500
Subtotal for period of operation	2,183,000
Chemical Oxidation Cost	
Labor, monthly	31,000
Equipments rental, monthly	2,500
Supplies, monthly	16,000
Performance monitoring, monthly	3,000
Other, monthly	500
Subtotal for period of operation	689,000
Sampling and Reporting	
Labor	48,146
Subcontractor	15,525
Sampling & analysis	222,525
Reporting	75,000
Other	6,894
Demobilization	85,000

TOTAL ESTIMATED COST	**$ 4,892,090**

Table 5.3.10 - Reaction Coefficient *k*

Media	Area[1]	Apparent rate limiting COCs	C_o, µg/kg or µg/L[2]	Operating time, day	Reaction coeff., day $^{-1}$[3][4]
Soil	MPE	1,1-dichlorobenzene	1,900	521	211
	PWE Building	TPH-diesel	2,200,000	330	193
	LNAPL	TPH-diesel	16,800,000	480	193
	Hot Spot	TPH-diesel	14,800,000	500	193
		Tetrachloroethene	64,000	500	141
Groundwater	All[5]	Various	Various	90	50

Source: Terra Vac 2006
(1) Areas at the Site noted in Figure 3.3.2
(2) Maximum value of soil samples taken within the area
(3) Derived from post-remediation data collected during sampling event December 2005
(4) Maximum value obtained at different locations in same general vicinity
(5) A blended k value used by Terra Vac for groundwater

Table 5.4 - Compliance Monitoring Schedule

Frequency	Media	Number of samples	Parameters	Period[1]	Monitoring Type
–	Groundwater[2]	> 60	VOCs, SVOCs, TPHs	Prior to operation	Baseline
–	Groundwater	10	VOCs, SVOCs, TPHs	After CULs are achieved	Confirmation
–	Air[3]	As needed	VOCs	Installation	Protective
Monthly	Air[4]	20	VOCs, SVOCs, CO_2	Month 1 to 59	Performance
Monthly	Air[4]	50	VOCs, SVOCs, CO_2	Month 60 to 72	Performance
Monthly	Groundwater[2]	20	VOCs, SVOCs, TPHs	Month 1 to 59	Performance
Monthly	Groundwater[2]	40	VOCs, SVOCs, TPHs	Month 60 to 72	Performance
Quarterly	Groundwater	10	VOCs, SVOCs, TPHs	Year 1 to 6	Performance
Quarterly	Groundwater	12	Groundwater elevation	Year 1 to 6	Performance
Annual	Soil	> 20	VOCs, SVOCs, TPHs	Year 1 to 6	Performance, Confirmation
TBD	Water[5]	TBD	TBD	Year 1 to 6	Permit
TBD	Air[6]	TBD	TBD	Year 1 to 6	Permit

Note: A more detailed compliance monitoring schedule will be developed for Ecology’s review and approval
(1) Period of operation, excluding installation
(2) In-house water sampling and analysis
(3) Sampling and analysis will be included in the health and safety plan
(4) In-house air sampling and analysis using gas chromatography
(5) To be determined (TBD) by NPDES permit issued by Ecology
(6) TBD by air permit issued by PSCAA

Table 6.1 - Schedule

Public comment period on Cleanup Action Plan and Enforcement Order	July 3, 2007 to August 17, 2007
Public comment period on State Environmental Policy Act (SEPA) Determination of Non-Significance	July 3, 2007 to July 18, 2007
Issuance of Cleanup Action Plan and Enforcement Order	August 10, 2007
Remedial Action Work Plan and Compliance Monitoring Plan submittals	October 26, 2007
Health & Safety Plan submittal	November 2, 2007
Permit application submittals	November 9, 2007
Start of construction and installation	Within 7 days of obtaining all applicable permits
Filing of Restrictive Covenant	Within 10 days of completion of remediation action