Supplemental Remedial Investigation and Feasibility Study
Pederson's Fryer Farms
Pierce County, Washington

May 10, 2012

Prepared for

Washington State Department of Ecology

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TABLE OF CONTENTS

Page

FIGURES

TABLES

APPENDICES

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LIST OF ABBREVIATIONS AND ACRONYMS

ARAR	Applicable or Relevant Appropriate Requirements
BGS	Below ground surface
BTEX	Benzene, Toluene, Ethyl benzene and Xylenes
CAP	Cleanup Action Plan
COC	Constituent of concern
CSIA	Compound Specific Isotopic Analysis
CSM	Conceptual Site Model
CUL	Cleanup level
DCA	Disproportionate Cost Analysis
DO	Dissolved Oxygen
DRO	Diesel-range organics
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FS	Feasibility Study
ft	Feet
gpm	Gallons per minute
GRO	Gasoline-range organics
ISCO	*in situ* chemical oxidation
LNAPL	Light nonaqueous phase liquid
mg/kg	Milligrams per kilograms
mg/L	Milligrams per liter
MNA	Monitored Natural Attenuation
MTCA	Model Toxics Control Act
ORC	Oxygen release compound
ORO	Oil-range organics
psi	Pounds per square inch
RAO	Remedial Action Objectives
RI	Remedial Investigation
SL	Screening level
SVE	Soil Vapor Extraction
TPH	Total Petroleum Hydrocarbons
UST	Underground storage tank
VI	Vapor Intrusion
WAC	Washington Administrative Code
yd^3	Cubic yards
μ/L	Micrograms per liter
μg/m^3	Micrograms per cubic meter

1.0 INTRODUCTION

This document presents the results of a supplemental remedial investigation (supplemental RI) and feasibility study (FS) for the former Pederson's Fryer Farms property located at 2901 72nd Street East in Tacoma, Washington (the site). Responsibility for conducting remedial actions has been delegated to the Washington State Department of Ecology (Ecology). Landau Associates is assisting Ecology with implementing remedial actions at the site. A RI report (Landau Associates 2011c) was previously submitted to Ecology on October 21, 2011. The location of the site is shown on the vicinity map on Figure 1-1.

Leaking underground storage tanks (USTs) at the site resulted in releases of total petroleum hydrocarbons (TPH) and related constituents to soil and groundwater. Previous remedial actions (i.e., activities conducted prior to the current RI) included UST decommissioning and TPH-impacted soil removal; however, some contaminated soil was left in place. Landau Associates performed a RI between November 2010 and August 2011. RI activities characterized the nature and extent of contamination and the results of decommissioning a remaining onsite UST. Initial RI results are documented in the RI report (Landau Associates 2011b). The report also documents specific data gaps associated with site characterization. Data gaps were addressed through supplemental RI activities. The scope of these activities are documented in a work plan addendum (Landau Associates 2011b) submitted to Ecology in August 2011 and a second work plan addendum (Landau Associates 2011d) submitted to Ecology in November 2011. Supplemental RI activities were completed between September 2011 and January 2012.

1.1 AREAS OF CONCERN

Site documentation has identified 11 historical USTs at seven locations on the Pederson's Fryer Farms property. For convenience, each of these seven locations has been designated as Areas A through G. The 11 USTs contained gasoline, diesel, waste oil, or heating oil. A description of each UST area is presented in Table 1-1 along with the current status of each UST. The location of each UST area is shown on Figure 1-2. Additional site description details are presented Sections 1 and 2 of the RI Report.

1.2 OBJECTIVES OF THE SUPPLEMENTAL REMEDIAL INVESTIGATION AND FEASIBILITY STUDY

The objective of the supplemental RI/FS is to collect and further evaluate information regarding the site to enable the evaluation and selection of cleanup action alternatives. Specifically, the supplemental RI/FS:

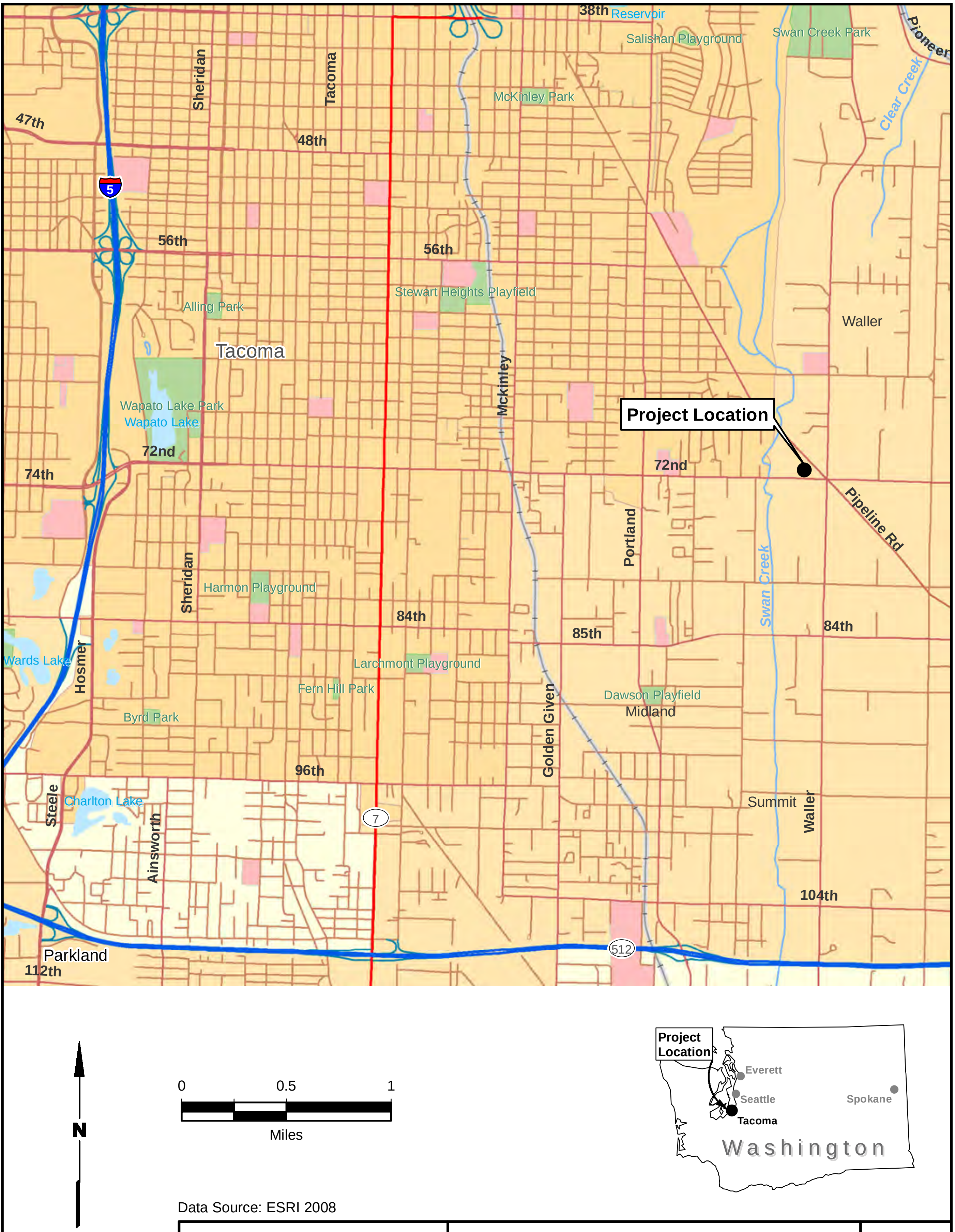
- Incorporates results of the supplemental RI to refine the nature and extent of contamination for affected media (i.e., soil, groundwater, and indoor air) previously discussed in the RI report
- Presents an updated conceptual model of hydrogeology and contaminant fate and transport
- Identifies cleanup standards for affected media
- Develops and evaluates cleanup action alternatives that protect human health and the environment
- Presents a preferred cleanup action alternative.

This document presents the information collected and the evaluations performed to achieve this purpose.

1.3 REPORT ORGANIZATION

This supplemental RI/FS report is organized as follows:

- Section 2.0 presents supplemental RI results, including a discussion of geology, hydrogeology, nature and extent of contamination, contaminant fate and transport, and a current conceptual site model (CSM)
- Section 3.0 presents the development of cleanup standards for the site, identifies remedial action objectives (RAOs), and identifies potentially applicable laws
- Section 4.0 presents the results of two FS pilot tests, monitoring site natural attenuation parameters, and the screening of remedial technologies
- Section 5.0 describes the remedial alternatives
- Section 6.0 evaluates the remedial alternatives, including a description of the evaluation criteria, the evaluation of the alternatives against the evaluation criteria, and presentation of the disproportionate cost analysis
- Section 7.0 presents the summary and conclusions, including a description of the preferred alternative.



Data Source: ESRI 2008

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Pederson's Fryer Farms Pierce County, Washington	**Vicinity Map**	Figure 1-1

Legend

▭ Area of Concern

▨ Former Excavation Area

- - - - - - Tax Parcel

Note
1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.
2. PCS = Petroleum Contaminated Soil.

0 60 120

Scale in Feet

Data Source: Pierce County GIS;
Bing Maps Aerial 2010.

Y:\Projects\136006\010\013\Supplemental RI & FS\MapDocs\Fig1-2-AreasofConcern.mxd 3/5/2012 NAD 1983 StatePlane Washington South FIPS 4602 Feet

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Pederson's Fryer Farms Pierce County, Washington	**Areas of Concern**	Figure 1-2

TABLE 1-1
SUMMARY OF AREAS OF CONCERN
PEDERSON'S FRYER FARMS RI/FS

Area of Concern	Tank History	Tank Status
Area A (Northern Tank Farm)	- 12,000 gal diesel tank - 8,000 gal gasoline tank - 6,000 gal diesel tank - 550 gal waste oil tank	All four tanks closed in place in January 1997. All four tanks removed in March 1998.
Area B	- 3,000 gal diesel tank - 6,000 gal unleaded gasoline tank - two gasoline pump islands	Tanks and pump islands removed in 1994
Area C	300 gal waste oil tank	Tank removed in 1994
Area D	500 gal heating oil tank	Closed in place in January 1997. Still exists on site.
Area E	8,000 gal diesel/heating oil tank	Closed in place January 1997. Decommissioned June/July 2011.
Area F	2,000 gal gasoline UST	Closed in place January 1997. Removed August 2000.
Area G	500 gal gasoline UST	Closed in place January 1997. Removed August 2000.

2.0 SUPPLEMENTAL REMEDIAL INVESTIGATION

The supplemental RI field work included recurring work defined in the original work plan (Landau Associates 2011a) as well as work defined in the two separate work plan addendums (Landau Associates 2011b,d). The original work plan scope included monthly water level collection events and two groundwater sampling events. The two work plan addenda proposed the installation of additional deep monitoring wells, initial indoor air exposure pathway screening, and a vapor intrusion (VI) assessment. The new monitoring wells were proposed to further characterize the nature and extent of contamination in soil and groundwater (shallow and deep water-bearing zones) at select areas of the site. VI samples were collected to characterize potential VI pathways into buildings adjacent to Area A, Area B, Area F, and Area G. The locations of all new wells and VI samples are shown on Figure 2-1.

2.1 FIELD INVESTIGATIONS

The scope of the first work plan addendum (Landau Associates 2011b) was implemented in September 2011. Eight deep wells were proposed, but only seven were installed due to site access issues with Tacoma Public Utilities. Wells MW-23D and MW-24D were preliminarily identified on Tacoma Public Utility's Pipeline Road parcel. MW-23D was marked on the western side of the parcel and MW-24D was marked on the eastern side. Site access was not granted for the Tacoma Public Utility property; therefore, MW-24D was moved to Smith's Landing property east of Pipeline Road[1] and installation of MW-23D was postponed (future installation date undefined). The other six wells (MW-36D through MW-41D) were located on the site and installed without issue. Soil quality sampling was conducted at select wells. Geologic data and soil quality data associated with the new wells are presented in Sections 2.2 and 2.4.1, respectively. Investigative derived waste from September 2011 drilling as well as accumulated purged groundwater from September 2011 and December 2011 groundwater sampling was disposed of in March 2012; the disposal documents are provided in Appendix A.

RI field activities conducted in May 2011 indicated the presence of shallow gasoline-impacted soil at concentrations of concern beneath or adjacent to buildings in Area A, Area B, Area F, and Area G. Based on an initial screening of data, Area F and Area G were selected for further assessment. In September 2011, two indoor air samples were collected at Area F and Area G for volatile organic compounds associated with gasoline contamination: benzene, toluene, ethylbenzene, and xylenes (BTEX). Sample results detected all four BTEX constituents, but only benzene and xylenes were detected at concentrations above Model Toxics Control Act (MTCA) Method B indoor air clean up

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[1] Ecology acquired site access from Roger Smith, owner of Smith's Landing LLC, in April 2011. See Appendix C of the RI Report.

levels[2] (CULs) for unrestricted land use (Landau Associates 2011c). Based on the indoor air sampling results, Ecology and Landau Associates determined that additional VI assessment activity was warranted to evaluate whether a VI exposure pathway could present an unacceptable level of risk at the site and, if so, to incorporate consideration of the VI pathway into remediation goals for the site during the FS.

The VI assessment was composed of two field activities: (1) an indoor air source survey related to BTEX constituents and (2) subsequent sampling to evaluate the VI pathway. On October 25, 2011, Landau Associates performed an indoor air source survey of chemicals stored and used at the site to support current site activities (e.g. building maintenance). All site buildings were visited. Several materials containing BTEX and other volatile organic compounds were noted during the survey, as well as building duct systems associated with indoor air circulation. It was noted that the main facility building had no functioning duct system but the air space appeared to be shared throughout the building with only a few isolated rooms. Following the site visit, Landau Associates reviewed material safety data sheets for volatile chemical products used at the site to determine which contained BTEX constituents. The indoor air source survey confirmed the presence of BTEX-containing materials were stored or used in Areas A, B, F, and G.

Additional VI evaluation tasks are documented in the second work plan addendum (Landau Associates 2011d) including additional VI sampling. The two principal objectives of the VI assessment were:

- To evaluate whether chemical concentrations in subsurface soil gas (specifically sub-slab soil gas) are high enough to present a potential concern for VI to indoor air
- To evaluate whether the concentrations detected in indoor air at Areas F and G are representative of impacts from VI or from other indoor process-related sources.

The VI sampling scope from the second work plan addendum was conducted on November 8, 2011. Sub-slab soil gas and indoor air samples were collected at Areas A, B, F and G for BTEX analysis. The samples were submitted to TestAmerica, Inc. of Tacoma, Washington for analysis by U.S. Environmental Protection Agency (EPA) Method TO-15 (for sub-slab soil gas) and TO-15 SIM (for indoor air). At the time of sampling, Christmas trees were being sprayed with fire-retardant paint (conducted outside, adjacent to Area B) and were set to dry (conducted in a drying room adjacent to Area B as well as in the main facility building) at the site. The fire-retardant paint chemical material safety data sheet indicates that xylenes are a major component. As a result, the drying Christmas trees in the main facility severely impacted the air quality at Area G, and strong vapors were also noted at Area A, Area B, and Area F. Vapors from the fire-retardant spray were notably strong enough that the workers

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[2] Indoor air CULs for the purpose of vapor intrusion assessment are provided by Ecology in their *Draft Guidance for Evaluating Soil Vapor Intrusion in Washington State – Investigation and Remedial Action* (Ecology website 2009).

who were spraying the Christmas trees and Landau Associates field staff wore half-face respirators. Due to the high concentrations of some BTEX constituents (xylenes in particular) associated with the fire-retardant application, the lab was unable to analyze the indoor air samples by SIM; therefore, the lab was only able to report concentrations to the standard TO-15 reporting limits.

In addition to BTEX analysis, samples were collected from site process-related sources, sub-slab soil gas, additional indoor air, and process-related source samples for isotope analysis at each of the four study areas. Isotope analysis consisted of identifying the carbon isotopic signature of benzene[3] by compound specific isotopic analysis (CSIA). CSIA was performed by the University of Oklahoma with instructions to hold the samples. To determine which samples would be analyzed by CSIA, the TO-15 sub-slab soil gas samples were analyzed on a 2-day turnaround to determine if benzene was present in sub-slab soil gas at the four areas of concern. Results indicated that benzene was only detected in sub-slab soil gas at Area F; therefore, CSIA samples for Area F (including sub-slab soil gas, indoor air, and process-related source) were analyzed. The other area samples were not analyzed for CSIA. The results of the VI assessment are presented in Section 2.4.4.

2.2 GEOLOGY

Seven deep soil borings [bottom of the boring deeper than 45 feet (ft) below ground surface (BGS)] were drilled in September 2011 using rotosonic drilling technology. Borings were located at the northern (MW-24D) and western (MW-36D, MW-37D, MW-39D) margins of the site, as well as north of Area E (MW-38D), in Area F (MW-40D), and west of Area G (MW-41D). Monitoring wells were installed in each boring. Wells were surveyed by KPG, Inc. on October 5, 2011. Soil explorations encountered geologic conditions similar to those described in the 2011 RI (Landau Associates 2011c). Geologic unit designations follow definitions presented in the RI (Landau Associates 2011c). New monitoring wells locations are presented on Figure 2-1. Survey results are presented in Table 2-1 and monitoring well details are provided in Table 2-2. Geologic conditions at each soil boring are presented in boring logs in Appendix B. A map of cross section locations is presented on Figure 2-2. Updated cross sections A-A' though E-E' are presented on Figures 2-3 through 2-7.

Glacial lacustrine soil (i.e., Unit 1) is present at the surface in all new borings except MW-38D, where approximately 1 ft of fill was encountered above Unit 1, and MW-40D, where approximately 12 ft of fill was encountered above Unit 2. The thickness of Unit 1 ranged from 7.5 ft to 17 ft, with the thinnest occurrence at paved or filled locations including MW-38D and MW-41D, and the thickest occurrence at MW-36D. Unit 1 soil is gray, gray-brown, brown or light brown in color; reddish-brown mottling was

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[3] The CSIA analysis for benzene was conducted to help identify whether the source of benzene in indoor air contamination was related to VI or other indoor air sources. Benzene is considered the risk driver at the site for VOCs.

observed at approximately 5 ft BGS in MW-36D. Unit 1 soil density ranged from soft to very stiff (for silt) and loose to dense (for sand). Unit 1 soil texture was generally sandy silt with organic matter and gravel contents less than 5 percent by weight (MW-37D, MW-39D, MW-41D), or silty fine to medium sand with organic matter and gravel contents of 5 to 30 percent by weight (MW-24D, MW-36D, MW-38D).

Ablation-till deposits (Unit 2 and Unit 3) were distinguished from Unit 1 by a change in density and soil texture. Relative to Unit 1, the ablation till is generally denser, with higher gravel and lower silt content. Units 2 and 3 are similar in soil texture, color, and density. Unit 2 and Unit 3 soil is generally brown, gray, or grayish-brown in color; reddish-brown mottling was observed at some wells (MW-24D). Unit 2 and Unit 3 soil density ranged from medium dense to very dense. Recovered soil contained cobbles and fragments of dense, matrix-supported gravel. Unit 2 and Unit 3 soil texture was generally sandy gravel to gravelly fine to coarse sand. The relatively less silty, upper portion of ablation till was designated as Unit 2, and the somewhat, more silty, lower portion of ablation till was designated as Unit 3 (Landau Associates 2011c). Occasional interbeds of sandy silt, silty sand, and silty gravel approximately 1- to 5-ft thick were encountered in both units. Unit 2 appeared to generally thin northward, from 28 ft thick at MW-40D to 11-ft thick at MW-24D. Unit 3 generally thickened northward, from 25-ft thick at MW-40D to 41-ft thick at MW-24D.

2.3 HYDROGEOLOGY

Hydrogeologic data at the site was obtained from three primary sources: 1) RI soil explorations, 2) monthly water level measurements at all monitoring wells (May 2011 to January 2012), and 3) semi-continuous water level logging at four monitoring wells (October, 2011 to January 2012)[4]. Evidence of perched, largely discontinuous water-bearing zones was observed at all exploration depths, leading to a revision of the preliminary conceptual hydrogeologic model in regards to the deep water-bearing zone (Landau Associates, 2011c).

2.3.1 SOIL EXPLORATIONS

Seven groundwater monitoring wells were installed in September 2011 to monitor groundwater in the deep water-bearing zone (Landau Associates 2011a). Each well was installed with 15 ft screens, from depths ranging from 45 to 65 ft BGS. The new well locations are presented on Figure 2-1.

Previously existing data suggested the deep water-bearing zone consisted of a continuously saturated regional aquifer. However, at four of the seven new wells (i.e. MW-24D, MW-36D, MW-37D,

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[4] Semi-continuous logging began at three monitoring wells, MW-6, MW-27D, and MW-32D on July 25, 2011. Logging began in an additional well, MW-25D, on October 13, 2011.

and MW-38D) groundwater was not encountered although intervals of moist soil separated by damp soil were observed. In the other three wells (i.e., MW-39D, MW-40D, MW-41D), wet soil intervals were encountered briefly (MW-39D, MW-40D). The only new deep well that initially contained measureable amounts of water in the finished well screen was MW-41D located near Area F. Similar vertical variations in moisture content were observed in previous borings in both shallow and deep zones at the site, including MW-1, MW-8, MW-20, MW-22, MW-30D, MW-31D MW-33S, and MW-35S. The vertical variation in soil moisture content appears to correspond to variations in soil texture and not to hydrogeologic layer. If the deep water-bearing zone was a continuously saturated layer, observed soil moisture content would likely have been more predictable vertically.

2.3.2 MONTHLY WATER LEVEL MEASUREMENTS

Water levels were hand-measured at all wells monthly from May 2011 through January 2012. Measured groundwater levels are presented in Tables 2-3 and 2-4 for shallow and deep water-bearing zones, respectively. Time series plots of monthly water levels in shallow and deep zones are presented on Figures 2-8 and 2-9, respectively.

2.3.2.1 Shallow Water-Bearing Zone

The shallow water-bearing zone is composed of perched groundwater within fill material, lacustrine deposits, and ablation till (Landau Associates 2011c). There are currently 14 shallow zone monitoring wells: 10 of these wells were installed prior to the 2011 RI (MW-1 through MW-6, MW-8, MW10, MW-11, and MW-15) and four of the shallow wells were installed in May 2011. Table 2-2 presents monitoring well details, including well depth and screen information.

Shallow groundwater levels were variable across the site, with the highest levels occurring at or near excavation areas A, C, F and G. Groundwater elevations in the shallow water-bearing zone ranged from 361.8 ft to 402.1 ft (North American Vertical Datum of 1988) across the site. Well MW-34S (Area C) consistently had the highest groundwater elevation,[5] ranging from 398.9 ft to 402.1 ft. The high groundwater levels at this location are interpreted to be due to its location near a building drain sump or dry well. Well MW-35S (Area F) also had relatively high groundwater levels, ranging from 387.6 ft to 391.8 ft elevation. In general, groundwater elevations in shallow zone wells correlated with the screen elevation. This type of relationship is indicative of perched groundwater. A graph of shallow zone

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[5] The high groundwater level observed at MW-34S may be influenced by infiltration from standing water contained in the 5.5-ft deep concrete catch basin, or “dry well” located approximately 7 ft to the south. The dry well has been observed to contain about 2 ft of water (May 27, 2011), presumably surface water from storm runoff or drainage from the building and gravel parking area directly to the south. It is not known whether the basin contains water year round.

groundwater levels versus screen elevation is presented in Figure 2-10. Figure 2-11 presents a map of shallow zone groundwater elevations for September 2011.

Shallow zone groundwater fluctuations appeared to generally follow a seasonal pattern reflecting local precipitation trends.[6] Shallow groundwater levels were generally lowest during September and highest during November and December. Water levels generally declined over the period from June to September, with relatively large decreases in June at wells MW-4 and MW-5 (by 5.2 and 4.3 ft, respectively). Shallow groundwater level hydrographs and precipitation are presented in Figure 2-8.

Shallow water level fluctuations (maximum minus minimum observed water level) over the period of monthly water level measurements were greatest near and within Area A, with smaller fluctuations occurring to the south. Shallow zone fluctuations ranged from 0.2 to 9.3 ft. The largest fluctuations (5.8 to 9.3 ft) in shallow groundwater levels occurred at MW-2, MW-3, MW-4, MW-5, MW-6 and MW-26S, in or near Area A. An exception is well MW-1, which exhibited smaller fluctuations (3.7 ft). The smallest fluctuations were observed in MW-33S (0.2 ft), MW-11 (1.3 ft) and well MW-10 (1.4 ft). The greater shallow-water level fluctuations observed near and at Area A are attributed to the infiltrative nature of the backfill material used to fill the former Area A excavation cavity and the roadway and pipe bedding of Pipeline Road. Groundwater level fluctuations are summarized in Table 2-3.

2.3.2.2 Deep Water-Bearing Zone

The deep water-bearing zone was previously characterized as a continuously saturated zone in the ablation till. However, results of supplemental RI field investigations suggest that the deep water-bearing zone consists of locally saturated areas in the vicinity of Area A and Area F. Outside of these two enhanced recharge areas, the deep water-bearing zone is discontinuously saturated similar to the shallow water-bearing zone.

There are currently 19 deep zone wells. Five of the wells existed prior to the 2011 RI. Seven wells were installed in May 2011 as part of the original RI and seven wells were installed in September 2011 as part of the supplemental RI. Monitoring well details are presented in Table 2-2.

Deep zone groundwater fluctuations ranged from 4.0 ft to 17.5 ft for wells installed over the entire 8-month monitoring period. Fluctuations were greatest at location near Area A and at wells with a longer screen interval. Wells MW-7R, MW-19, MW-20, and MW-22, have screen lengths of 20 ft to 35 ft and undergo maximum water level fluctuations of 11.3 ft to 17.5 ft.[7] In contrast, wells having screen lengths of 10 ft to 15 ft (and which were installed prior to September 2011) undergo smaller water level

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[6] In southwestern Washington, most precipitation is received in winter and spring (November to April) with relatively little precipitation occurring in summer and fall (June to October).

[7] An exception is well MW-9, which has a 35-ft screen and fluctuated only 5.0 ft; water levels at MW-9 are influenced by both shallow and deep zones due to the screened interval (14 to 49 ft).

fluctuations of 4.0 ft to 8.4 ft. The greater degree of fluctuation at wells with longer screen intervals would be expected where transient perched water zones are present, as a longer screen is more likely to intersect a greater number of relatively permeable intervals which may transmit water into and out of the well. Deep zone well groundwater level fluctuations are summarized in Table 2-4.

Similar to the shallow zone groundwater, deep zone groundwater fluctuations appeared to follow a seasonal pattern. Deep groundwater levels were generally lowest during summer and fall (August through October) and highest during winter and spring (December and May). Deep zone groundwater level trends are presented on the hydrograph on Figure 2-9.

Evidence of deep-zone groundwater mounding associated with Areas A and F was observed over the entire 8-month period of monthly measurements. Mounding was least pronounced in early fall (e.g., October) when groundwater levels were lowest. Mounding was more pronounced after the onset of winter rain in November and December. During September and October 2011, a short period of relatively low water levels was observed at MW-19, east of Area A. These water levels produced an anomalously low area in the deep zone groundwater table. This anomalous spatial trend is interpreted to be evidence of a discontinuous deep water-bearing zone that develops in this area in late summer. Spatial deep groundwater level trends for October, November and December 2011 are presented on Figures 2-12, 2-13, and 2-14, and 2-15 respectively.

Variability observed in the spatial and temporal distribution of deep zone groundwater suggests it is not a continuously saturated, hydraulically connected aquifer. The deep water-bearing zone appears to consist of locally saturated areas around Area A and Area F and disconnected intervals of saturation outside of these backfilled excavation areas. The areas of saturation increase in the winter due to higher infiltration rates and mounding. Consequently, some deep wells (MW-37D and MW-38D) that were dry in late summer become saturated during the winter.

2.3.3 SEMI-CONTINUOUS WATER LEVEL MEASUREMENTS

Water levels were logged automatically at hourly intervals in four wells (MW-6, MW-25D, MW-27D, and MW-32D) using Solinst® Levelogger dataloggers Locations for semi-continuous water level monitoring were chosen to evaluate both shallow and deep water levels, and to compare water levels within and outside the estimated Area A boundary. Semi-continuous water level monitoring at wells MW-6, MW-27D, and MW-32D began July 25, 2011. Semi-continuous water level monitoring at well MW-25D began on October 13, 2011. Barometric pressure was also monitored at hourly intervals at well MW-27D using a Solinst Barologger. Barometric pressure readings were subtracted from water level readings to correct for changes in atmospheric pressure. Pressure-corrected water level readings were checked for accuracy by comparing against hand-measured water levels. Daily precipitation measurements collected at Sea-Tac International Airport (17.5 miles north-northeast of site) were compared with water level trends.[8] Figure 2-16 presents semi-continuous water level observations and daily precipitation measurements.

Semi-continuous water level observations indicate that shallow zone water levels respond rapidly to precipitation relative to deep zone water levels. Also, deep zone water levels near Area A are more responsive to precipitation than deep zone water levels farther from Area A. For example, water levels at shallow well MW-6 and deep well MW-25D rise within hours of daily precipitation exceeding about 0.4 inches, but MW-25D responds to a lesser degree than MW-6. In contrast, water levels in nearby deep well MW-27D reflect a muted response to precipitation. At MW-32D, about 450 ft southwest of Area A, no response to individual precipitation events is observed. The limited response to precipitation events at MW-27D and MW-32D indicates that deeper portions of ablation till are hydraulically isolated from the shallow water-bearing zone. The slightly greater seasonal water level response observed at well MW-27D is attributed to the wells proximity to Area A.

2.3.4 SUMMARY

Information obtained during the supplemental RI has helped refine the hydrogeologic understanding of the site. Primary features of the hydrogeologic conceptual model include:

- Perched groundwater in the shallow water-bearing zone responds to seasonal precipitation events
- Deep zone groundwater does not appear to respond to local precipitation events except in the close proximity of large excavation areas that provide a pathway for enhanced recharge.
- Vertical variation in soil moisture content and of the presence of dry deep zone wells suggests that the deep water-bearing zone is not continuously saturated. Instead, the deep water-bearing zone appears to consist of perched, largely disconnected intervals of saturation in the ablation till with the ablation till acting more like an aquitard than an aquifer.

2.4 NATURE AND EXTENT

The following subsections present data results of the two supplemental RI field programs and the final two groundwater sampling events by media (e.g. soil, shallow and deep groundwater, and vapor intrusion). All soil and groundwater data were evaluated against preliminary CULs presented in the RI report and the VI air data were evaluated against preliminary CULs and screening levels (SLs) presented in Ecology’s draft VI guidance document (Ecology website 2009). All preliminary CULs and SLs are

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[8] Data was downloaded January 6, 2011 from MesoWest, http://mesowest.utah.edu/index.html, University of Utah Department of Atmospheric Sciences.

MTCA Method B levels for unrestricted land use. The site constituents of concern (COCs) are the same as those presented in the RI report.

2.4.1 SOIL

The main objective of the September 2011 supplemental RI drilling program was to further characterize the deep zone water quality. However, some soil quality sampling was conducted in accordance with the first work plan addendum. Soil was sampled at MW-38D, MW-39D, and MW-40D (in the former Area F excavation). Observations and sampling results (where applicable) are described below for each well in the context of areas of concern (specifically Area A, Area E, Area F, and Area G).

2.4.1.1 Area A

Wells MW-24D, MW-36D, and MW-37D were drilled to evaluate the horizontal extent of contamination associated with Area A. MW-24D is located approximately 150-ft north of Area A, adjacent to a vegetated ditch that runs along Pipeline Road. The ground surface elevation at MW-24D is approximately 7-ft lower than at well MW-25D, which is located at the Area A former excavation. MW-24D was drilled to a depth of 60 ft BGS. During drilling, mottling was observed at approximately 16.5 ft BGS and 37 ft BGS, but no groundwater was encountered. No petroleum hydrocarbon odor was noted and no sheen was observed. Therefore, it appears that the groundwater contamination from Area A does not extend to MW-24D.

MW-36D is located approximately 70 ft west of the Area A excavation. The ground surface elevation at MW-36D is approximately the same as at MW-25D. MW-36D was drilled to a depth of 65 ft BGS. During drilling, mottling was observed within the first 5 ft BGS and at approximately 29 ft BGS, but no groundwater was encountered. A slight sour odor was noted within the first 5 ft BGS, but it did not appear similar to a hydrocarbon odor and no sheen was observed. From 38 ft to 40 ft BGS, a slight hydrocarbon odor was noted but no sheen was observed. Between 40 ft and 55 ft BGS, a moderately strong to very strong hydrocarbon odor was noted; the strongest odor was noted between 43 ft and 45 ft BGS. Sheen was noted between 40 ft and 47 ft BGS. These field observations suggest that some level of hydrocarbon contamination from Area A extends out to MW-36D. Winter groundwater monitoring activities through February 2012 indicate that MW-36D is dry. Until groundwater migrates to MW-36D, it is unclear if seasonal groundwater concentrations would be of concern.

MW-37D is located approximately 110 ft southwest of the Area A excavation. The ground surface elevation at MW-37D is approximately the same as MW-25D. MW-37D was drilled to a depth of 65ft BGS. During drilling, mottling was observed within the first 5 ft BGS and at approximately 29.5 ft BGS (similar to MW-36D), but no groundwater was encountered. No hydrocarbon odor was noted and no sheen was observed. Therefore, it appears that the groundwater contamination from Area A does not extend out to MW-37D.

2.4.1.2 Area E

Wells MW-38D and MW-39D were drilled to evaluate the horizontal extent of contamination associated with Area E. MW-38D is located approximately 60 ft north-northeast of the Area E UST at the base of the Area E shipping room loading dock. The loading dock is a low point that receives runoff from a large upgradient paved surface. Consequently, stormwater runoff collects at the bottom of the loading dock and discharges to a series of stormwater structures. From the structures, stormwater is supposed to be pumped upgradient to a stormwater conveyance via a submersible pump; however, ponded stormwater has been observed at the loading dock and the pump was not operating. The ground surface elevation at MW-38D is approximately 4 ft lower than boring E-1, which was drilled on the shop floor adjacent to the Area E UST. MW-38D was drilled to a depth of 65 ft BGS. During drilling, the soil was damp immediately beneath the concrete paving to 18 ft BGS. The damp soil was potentially related to both water discharge to area drains in the shipping room (recent tenant operations in shipping room used water for bear grass rinsing) and stormwater infiltration at the bottom of the loading dock. Soil was also observed to be damp from 40 ft to 48 ft BGS but groundwater was not encountered. The only noted odor was described as "possible slight hydrocarbon odor" and was encountered from 48 ft to 54.5 ft BGS.

Although no significant hydrocarbon odor or sheen was noted in the 65 ft exploration at MW-38D, one soil sample was collected at 5.5 ft BGS. This depth corresponds to the elevation of the bottom of the Area E UST. Since the Area E UST was a diesel/heating oil UST, the sample was analyzed by method Northwest diesel-range total petroleum hydrocarbon extended for diesel-range organics (DRO) and oil-range organics (ORO); the concentrations were below detectable levels.

MW-39D is located approximately 110 ft west of the Area E UST, just beyond the west wall of the main facility building. The ground surface elevation at MW-39D is approximately 2 ft lower than the building shop floor elevation. The bottom elevation of the Area E UST is approximately 8 ft BGS with respect to the ground surface at MW-39D. MW-39D was drilled to a depth of 65 ft BGS. The first 8 ft of soil was removed using an air knife due to the potential presence of an abandoned sewer line[9]. The field hydrogeologist instructed the air knife operator to remove the soil slowly to allow for soil inspection. The first 4 ft of soil was damp and the soil again appeared to be damp from 8 to 17.5 ft BGS. Intermittent

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[9] Historical records indicate that the former sewer discharge line from the Pederson's Fryer Farms wastewater pre-treatment plan was routed south along the western parcel boundary of 2901 72nd Street East where it redirected west along the right-of-way of 72nd Street East until it connected into a City of Tacoma sanitary manhole. It is unclear if this line was properly decommissioned.

damp zones were noted to 48 ft BGS. The driller indicated that groundwater was encountered at 58 ft BGS, although the soil did not appear to be damp.

At MW-39D, the only depths at which a hydrocarbon odor was noted were from 8 ft to 10 ft BGS; there was no sheen. The depths at which hydrocarbon odor was observed correlate with the bottom depth of the Area E UST. One soil sample was collected from 8 to 8.25 ft BGS. Since the Area E UST was a diesel/heating oil UST, the sample was analyzed for DRO and ORO. The concentrations were below detectable levels. The lack of a sheen and lack of detectable TPH in soil indicates that there is not significant hydrocarbon contamination at MW-39D.

The field observations and results from MW-38D and MW-39D help bound the extent of contamination associated with the Area E UST. The results from the MW-39D sample were below detectable levels, the observed hydrocarbon odor from 8 ft to 10 ft BGS indicates that Area E impacts may extend west of the main facility, but at concentrations that are below levels of concern. Soil results are for both MW-38D and MW-39D are provided in Table 2-5.

2.4.1.3 Area F

Well MW-40D was drilled to evaluate the horizontal extent of contamination associated with Area F. MW-40D is located in the westernmost portion of the former Area F excavation. The Area F excavation is shallower in this location but thickens to a maximum depth of about 25 ft BGS to the east. Excavation fill was encountered to 12 ft BGS when drilling MW-40D.

MW-40D was drilled to a depth of 65 ft BGS. The first 4 ft of soil was removed using an air knife due to the presence of a private sewer line[10]. The field hydrogeologist instructed the air knife operator to remove the soil slowly to allow for soil inspection. The first 4 ft of soil appeared to be damp. The soil again appeared to be damp from 14 ft to 16.5 ft BGS. Soil beneath 16.5 ft BGS was moist (no apparent intermittent damp zones) to the final depth of 65 ft BGS. Groundwater was not encountered.

A hydrocarbon odor and slight sheen was observed at 4 ft BGS. The odor became very strong between 10 and 12 ft BGS, and then began to decrease. By 14 ft BGS there was no hydrocarbon odor or sheen down to the final depth of 65 ft BGS.

The depths at which hydrocarbon odor was observed correlate with the approximate bottom depth of the former Area F excavation. One soil sample was collected from 10 to 10.5 ft BGS. The sample was analyzed for gasoline-range organics (GRO), DRO, ORO and BTEX. The concentration for GRO exceeded the preliminary CUL at 600 milligrams per kilogram (mg/kg). Of the BTEX constituents, only xylenes were detected at 3.3 mg/kg, which is below the CUL. DRO and ORO were below CULs at

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[10] The shallow private sanitary sewer line leads from the main facility building to an onsite septic system.

concentrations of 89 mg/kg and 270 mg/kg, respectively. In summary, soil contamination impacts appear to extend only immediately below the bottom depth of the former Area F excavation. There is no evidence of groundwater contamination. Additionally, MW-40D remains dry (Section 2.3). The soil concentration results for MW-40D are presented in Table 2-5.

2.4.1.4 Area G

MW-41D is located approximately 50 ft west of the former Area G excavation. It is located approximately 4 ft from a private stormwater conveyance system and catch basin. MW-41D was drilled to a depth of 63.3 ft BGS. During drilling, a damp zone was observed between 9 ft and 16 ft BGS. Mottling was observed from 10 ft to 28 ft BGS and again from 61.5 to 63.3 ft BGS. The mottling noted between 10 ft and 28 ft BGS was not observed while drilling nearby Area G deep well MW-30D during the RI. It is possible that stormwater conveyed to the nearby catch basin infiltrates to the ground, generating a shallow groundwater zone causing mottling at MW-41D. During drilling, groundwater was encountered at 53.2 ft BGS.

The Area G UST was a 500-gallon gasoline UST. During drilling no gasoline hydrocarbon odors or sheen were observed and photoionization detector screening results were low. However, between 10 ft and 23 ft BGS an unknown odor described as similar to burnt oil was noted. A sample was not collected since the odor appeared unrelated to Area G. In summary, impacts from Area G were not observed at MW-41D.

2.4.2 SHALLOW AND DEEP WATER-BEARING ZONES

Two complete groundwater sampling events were conducted in June 2011 and were presented in the RI report (herein termed RI sampling). The monitoring well network has since expanded with the addition of the seven new deep wells installed in September 2011. The current well network consists of 14 shallow wells and 25 deep wells. In accordance with the RI/FS work plan, a September 2011 quarterly sampling event of RI (and supplemental RI wells[11]) and a December 2011 semiannual sampling event of the entire well network (pre-RI wells, RI wells, and supplemental RI wells) were conducted; since the results of these two sampling events are being incorporated into supplemental RI, they are herein considered to be supplemental RI sampling events). As of December 2011, the seven new supplemental RI deep wells were either dry or did not have a sufficient quantity of water to allow for sample collection and thus, have not yet been sampled.

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[11] RI and supplemental RI wells are those wells that were installed by Landau Associates. The RI/supplemental RI wells begin numerically at MW-24D and go to MW-41D.

As discussed in the RI report, significant groundwater COCs include: DRO, ORO, and GRO. Where GRO is present, BTEX are also COCs. The following sections discuss contaminant occurrence and trends of potential significance by area. Groundwater results were compared against screening criteria presented in the RI:

- DRO = 0.5 milligrams per liter (mg/L)
- ORO = 0.5 mg/L
- GRO = 0 .8 mg/L (assumes benzene present)
- Benzene = 5 micrograms per liter (µg/L)
- Toluene = 1000 µg/L
- Ethylbenzene = 700 µg/L
- Total Xylenes = 1000 µg/L

The maximum and most recent DRO, ORO, and GRO (benzene also displayed since impacts CUL for GRO) groundwater concentration data for the shallow and deep zones are presented on Figures 2-17 through 2-22. All RI and supplemental RI groundwater quality data is tabulated in Table 2-6

2.4.2.1 Area A

Seven Area A shallow wells were sampled during the supplemental RI (MW-1 through MW-6, and MW-26S). Concentrations of the COCs remained below detectable limits at MW-1, MW-2, MW-3, MW-4 and MW-6. Concentrations of the COCs at MW-5 were approximately the same from June 2011 to December 2011, except the DRO concentration increased to 0.73 mg/L, just above the CUL. Concentrations of DRO and ORO declined at well MW-26S; DRO remained above the CUL (at 2.5 mg/L), but ORO declined to below the CUL (at 0.28 mg/L).

All the Area A deep wells, except MW-36D, (i.e., MW-7R, MW-19, MW-20, MW-22, MW-25D, and MW-27D) were sampled[12] during the supplemental RI. Concentrations of the COCs at MW-22 (below CULs) and MW-27D (above CULs) were similar to previous detections observed during the RI; concentrations at the other four wells fluctuated appreciably. At well MW-7R, concentrations of DRO (5.8 mg/L), ORO (0.3 mg/L), and GRO (0.3mg/L) have decreased from the previous sampling events; DRO remains above the CUL, ORO has declined below the CUL, and GRO continues to be below the CUL. At well MW-19, concentrations of DRO (24 mg/L), ORO (0.68 mg/L), and GRO (0.86 mg/L) have increased from the previous sampling events; DRO remains above the CUL and both ORO and GRO now exceed their respective CULs. MW-20 concentrations for DRO (87 mg/L), ORO (3.1 mg/L), and GRO

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[12] MW-36D did not have sufficient water to sample; however, soil observations during drilling indicated the presence of hydrocarbon odor and sheen. Therefore, seasonal groundwater may be impacted when present.

(1.6 mg/L) have increased; all continue to exceed CULs. At well MW-25D, DRO (24 mg/L) and ORO (1.2 mg/L) increased, and GRO concentrations decreased (0.38 mg/L) from the previous sampling events. At well MW-25D, concentrations of DRO continue to exceed the CUL, ORO first exceeded the CUL during the September 2011 and increased in December 2011, and the GRO concentration fell below the CUL for the first time in December 2011.

2.4.2.2 Area B

The two Area B shallow wells (MW-8 and MW-10) were sampled during the supplemental RI. Concentrations of all COCs were below detectable levels except for GRO at MW-10. GRO was detected at 0.057 mg/L (below the CUL) in September 2011. GRO was not detected at MW-10 during the December 2011 sampling event.

The two Area B deep wells (MW-9 and MW-28D) were also sampled during the supplemental RI. At well MW-9, GRO concentrations increased slightly from below detectable levels to 0.14 mg/L. At well MW-28D, DRO concentrations continued to exceed the CUL (2.2 mg/L in September; 1.4 mg/L in December) but low level detections of GRO remained below the CUL. Although MW-28D is termed an Area B deep well based on location, its DRO and GRO impacts are attributed to Area A.

2.4.2.3 Area C

Area C wells include one shallow well (MW-34S) and one deep well (MW-31D) were sampled during the supplemental RI sampling events. DRO and ORO concentrations at MW-34S continue to be below detectable levels, and concentrations of GRO remained relatively constant with a slight increase in September 2011 (0.19 mg/L) and a decrease to the lowest concentration to date in December 2011 (0.061 mg/L). DRO and GRO concentrations at MW-31D remained below CULs with a slight decrease; ORO remained below detectable levels. Although MW-31D is termed an Area C deep well based on location, its GRO and DRO impacts are attributed to the Area A mounding.

2.4.2.4 Area F

Area F shallow wells (MW-11 and MW-35S) were sampled during the supplemental RI. Concentrations of the COCs remained below detectable limits at MW-11 (outside former excavation) but concentrations of DRO, GRO, and BTEX fluctuated at MW-35S (inside former excavation). The DRO concentration at MW-35S was 1.2 mg/L in June 2011, but decreased below the CUL to 0.13 mg/L in December 2011. In contrast, GRO and BTEX concentrations increased by almost 50 percent. For example, GRO increased from 7.4 mg/L to 12 mg/L, and benzene increased from 15 mg/L to 29 mg/L. GRO and benzene were already above CULs in June 2011, but the increase in concentrations of other

BTEX constituents resulted in ethylbenzene (740 mg/L) and total xylenes (1,258 mg/L) being detected above CULs in December 2011.

The two Area F deep wells (MW-29D and MW-40D) were also sampled during the supplemental RI. At well MW-29D, concentrations of DRO, ORO, and BTEX continue to be below detectable levels. GRO was detected (0.068 mg/L) in the sample from this well for the first time in December 2011; however, GRO was not detected in the duplicate sample.

2.4.2.5 Area G

Area G wells include two shallow wells (MW-15 and MW-33S) and two deep wells (MW-30D and MW-41D). However, of the four wells, only MW-15 had a sufficient volume of groundwater to be sampled during the supplemental RI. The concentration of DRO and ORO at MW-15 increased to 1.7 mg/L and 0.77 mg/L, respectively, which are above CULs. This is the first time MW-15 has exceeded for DRO and ORO. Although occasionally just above the CUL, GRO concentrations at MW-15 remained below the CUL; BTEX constituents also remained below the CUL.

2.4.3 VAPOR INTRUSION ASSESSMENT

Supplemental RI activities included preliminary indoor air screening for VI, an indoor air source survey, and a VI assessment as described in Section 2.1. Data results from the preliminary indoor air screening and observations made during the indoor air source survey were presented in the second work plan addendum (Landau Associates 2011c). The four areas of concern evaluated during the VI assessment were Area A, Area B, Area F, and Area G. The sample locations of all VI samples are shown on Figure 2-23 and 2-24. Concentration data for benzene and xylenes, which are the primary chemicals of interest with respect to the VI pathway, are also presented on these figures.

Sub-slab soil gas and indoor air samples from Area A, Area B, Area F, and Area G were analyzed for BTEX. As indicated in the sections below, except for benzene in Area F, all sub-slab soil gas concentrations for BTEX were well below screening levels protective of indoor air. Based on the benzene concentration detected in Area F sub-slab soil gas [38 micrograms per cubic meter ($\mu g/m^3$)], samples from that area were further analyzed by CSIA. The fire-retardant process source was also analyzed by CSIA since it was a potential contributor to indoor air at Area F at time of sampling.

BTEX concentrations and applicable MTCA SLs for indoor air and soil gas are presented in Table 2-7 and Table 2-8, respectively. The CSIA data is presented under Section 2.4.4.3 below. The results of the VI assessment are presented in the following subsections by area.

2.4.3.1 Area A

One of the four former USTs at Area A was an 800-gallon gasoline UST. The only building included in Area A (the Area A building) is located south of the former UST (Figure 2-23). In May 2011, soil boring A-5 was drilled as close to the Area A building as practical. Results from A-5 indicated the presence of shallow GRO-impacted soil at 10 ft BGS (Landau Associates 2011c). The sub-slab soil gas concentration data collected during the VI assessment indicated that all BTEX constituents were present at concentrations well below MTCA Method B soil gas SLs, except for benzene, which was not detected above the laboratory reporting limit.

At the time of sampling, the Area A building was being used as a marine boat repair shop[13]. Potential process-related sources that could be a source of indoor air BTEX contamination included chemicals used in a working solvent bin, common chemicals used for auto and marine boat repair, and fuel in the tanks of boats stored in the building. Strong vapors associated with the application of fire-retardant spray paint to Christmas trees were also noted inside the Area A building.

All BTEX constituents were detected in the Area A indoor air sample. Of the BTEX constituents, only benzene and total xylenes were detected above MTCA indoor air SLs:

- The benzene concentration in indoor air was 17 µg/m3, which exceeded the MTCA Method B indoor air CUL of 0.32 µg/m3. However, benzene was not detected in the Area A sub-slab soil gas sample. Based on the sub-slab soil gas sample results (non-detect), and also on the presence of known process-related sources of benzene, the detected indoor air benzene concentration is not attributed to subsurface contamination.
- The total xylenes concentration in indoor air was 1,030 µg/m3, which exceeded the MTCA Method B indoor air CUL of 46 µg/m3. However, total xylenes in sub-slab soil gas were detected at a concentration (26µg/m3) below the MTCA Method B soil gas SL of 460 µg/m3. Based on the sub-slab soil gas sample results that were below the SL, and also on the presence of known process-related sources of xylenes, the detected indoor air total xylenes concentration is not attributed to subsurface contamination.

Data collected to evaluate the VI pathway indicates that it is not a complete and significant contaminant migration pathway in Area A. Indoor air concentrations in the Area A building appear to be driven by indoor process-related sources. Sub-slab soil gas BTEX concentrations are all less than applicable SLs for the VI pathway. Existing conditions in Area A appear to be protective of human health with respect to the VI pathway; therefore, remediation to address this pathway will not be considered further in the FS.

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[13] The building in which the marine boat repair shop was located has since burned in a fire; the property owner will have the structure demolished during winter 2012.

2.4.3.2 Area B

The Area B source area historically included two fuel pump islands and a 6,000-gallon gasoline UST. The southeast corner of the Area A building is located adjacent to the former fuel pumps and UST in Area B. In May 2011, soil borings were drilled inside (B-1) and outside (B-2) of the southeast corner of the Area A building. Analytical lab data from soil sampling at these borings identified the presence of GRO and BTEX in near-surface soil at depths less than 7 ft BGS (Landau Associates 2011c). The sub-slab soil gas concentration data collected during the VI assessment indicated that all BTEX constituents were present at concentrations well below MTCA Method B soil gas SLs, except for benzene, which was not detected above the laboratory reporting limit.

At the time of sampling, the Area B sampling area consisted of an office and sales counter associated with, but partitioned off from, the marine boat repair shop in the Area A building. There were no apparent indoor air sources in the partitioned sampling area, but the marine boat repair shop was connected to the sampling area by an internal door and also, reportedly, by a common heating, ventilation, and air conditioning system. Based on the building configuration, process-related sources of air quality contaminants from the Area A building are expected to also affect the Area B sampling space.

Consistent with the nearby Area A indoor air results, the indoor air concentration data indicated that all BTEX constituents were present. Of the BTEX constituents, only benzene and total xylenes were detected above MTCA indoor air SLs:

- The benzene concentration in indoor air was 11 $\mu g/m^3$, which exceeded the MTCA Method B indoor air CUL of 0.32 $\mu g/m^3$. However, benzene was not detected in the Area B sub-slab soil gas sample. Based on the sub-slab soil gas sample results (non-detect), and also on the presence of known indoor process-related sources of benzene, the detected indoor air benzene concentration is not attributed to subsurface contamination.
- The total xylenes concentration in indoor air was 2,300 $\mu g/m^3$, which exceeded the MTCA indoor air CUL of 46 $\mu g/m^3$. However, total xylenes in sub-slab soil gas were detected at a concentration (44 $\mu g/m^3$) below the MTCA Method B soil gas SL of 460 $\mu g/m^3$. Based on the sub-slab soil gas sample results that were below the SL, and also on the presence of known indoor process-related sources of xylenes, the detected indoor air total xylenes concentration is not attributed to subsurface contamination.

Data collected to evaluate the VI pathway indicate that it is not a complete and significant contaminant migration pathway in Area B. Indoor air concentrations in the southeast corner of the Area A building (which is the location of Area B sampling) appear to be driven by indoor process-related sources. Existing conditions in Area B appear to be protective of human health with respect to the VI pathway; therefore, remediation to address this pathway will not be considered further in the FS.

2.4.3.3 Area F

The Area F source area historically included a 2,000-gallon gasoline UST. The building in Area F (the main facility building) is located west of and immediately adjacent to the former UST (Figure 2-24). In May 2011, soil borings were drilled inside (F-3) and just outside (MW-35S) of a corner of the main facility building adjacent to Area F. Analytical results from soil sampling at F-3 and MW-35S identified the presence of gasoline and BTEX in near-surface soil at depths as shallow as 1.5 ft BGS (Landau Associates 2011c); the F-3 soil sample collected at 1.5 ft BGS contained the highest gasoline and BTEX concentrations detected at the site.

Based on the site survey, it was decided that the VI assessment of Area F would occur in the same portion of the main facility building where boring F-3 was located. The sub-slab soil gas data collected during the VI assessment indicated that all BTEX constituents were detected; however, only benzene (38 μg/m^3) exceeded its MTCA Method B soil gas SL (3.2 μg/m^3).

At the time of sampling, the exterior portion of Area F served as a used tire storage area and the building space where the VI assessment was conducted was used for miscellaneous storage. This building space is attached to the main facility building where Christmas trees were drying that had been freshly sprayed with fire-retardant paint. In addition to fumes from the drying Christmas trees, potential indoor air sources included gas-operated equipment, chemicals used for auto repair (e.g., a partially-filled portable fuel can), and other miscellaneous chemical products.

Benzene was the only BTEX constituent not detected during indoor air sampling. However, it should be noted that the benzene reporting limit was elevated (4.6 μg/m^3) due to the high concentrations of other volatile chemicals in the sample[14]. The previous indoor air sample, collected in September 2011, contained benzene at a concentration of 5.1 μg/m^3. Only total xylenes were detected at a concentration (1,980 μg/m^3) exceeding its MTCA Method B indoor air SL (0.32 μg/m^3). Similar to Area A and Area B, the high total xylenes concentration is attributed to indoor process-related source, specifically the fire-retardant spraying operation (Section 2.1).

Because benzene was detected in Area F sub-slab soil gas at a concentration exceeding the SL, the sub-slab soil gas, indoor air, and the process source samples (for both Area F and also the fire-retardant paint source) were further analyzed using CSIA. CSIA measures the distribution of carbon isotopes [^{12}C (lighter) and ^{13}C (heavier)] in benzene via isotopic profiling. The ratio of these two stable carbon isotopes defines each sample's benzene isotopic signature in units expressed as $\delta^{13}C^{0}/_{00}$. The

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[14] As discussed in Section 2.1, TO-15 SIM reporting limits could not be achieved due to the high concentrations of BTEX constituents, such as xylenes, that were present due to the fire-retardant spraying operations occurring at the site during sampling.

precision of the Area F sub-slab soil gas and indoor air samples, and the fire-retardant process source were approximately ± $0.1^0/_{00}$.

Sample	Benzene Isotopic Signature ($\delta^{13}C^0/_{00}$)
Sub-slab Soil Gas	-27.0
Indoor Air	-26.8
Area F Process Source	-26.6
Fire-Retardant Process Source	-30.9

The Area F sub-slab soil gas, indoor air, and process source samples have very similar benzene isotopic signatures, whereas the fire-retardant process source has a noticeably different signature. The sub-slab soil gas and Area F process source samples (primarily driven by vapors from a portable fuel can partially filled with gasoline) appear to have the same isotopic signature, which can present a challenge for evaluating the source of concentrations observed in indoor air. Based on these results alone, it would be difficult to determine whether the benzene concentrations in indoor air are related to the sub-slab soil gas, the Area F indoor process-related sources, or a combination of the two. However, when taken in the context of all data collected to evaluate the VI pathways at the site, the concentrations of benzene in indoor air appear to be associated with process-related sources, not vapor intrusion:

- Benzene is known to be present in products used and stored in all buildings at the site. The most noteworthy sources include flame-retardant paint (which is used extensively at the site in the late fall; residual material and empty drums from the paint are also stored in buildings at the site throughout the year) and gasoline (which is stored in buildings at the site in portable fuel cans and also in the fuel tanks of gas-powered equipment).
- Sub-slab soil gas samples verified that benzene was not detected at the laboratory reporting limit of 0.96 $\mu g/m^3$ in Areas A, B, and G. With no subsurface soil gas contaminant source in those areas, co-located indoor air samples, then, are representative of "background" concentrations (i.e., concentrations associated with normal building use not affected by vapor intrusion from subsurface contaminant sources) in indoor air at the site. The site-specific background concentration range is 8.6 to 17 $\mu g/m^3$. The site-specific background concentration range is comparable to published background concentrations for benzene (10 $\mu g/m^3$) in residential indoor air (Dawson and McAlary 2009).
- Area F was the only area in which sub-slab soil concentration for benzene was greater than the applicable screening level. However, the concentration of benzene in indoor air in Area F ranged from non-detect to 5.1 $\mu g/m^3$, which is less than the background concentrations observed in other buildings at the site (8.6 to 17 $\mu g/m^3$). As the indoor air concentrations in Area F are less than background concentrations at buildings throughout the site, those concentrations appear to be associated with process-related sources, not vapor intrusion.

Taken as a whole, the data leads to the conclusion that observed indoor air concentrations are representative of background conditions associated with normal building operations; the vapor intrusion pathway does not appear to be a complete and significant pathway in this area. Remediation to address this pathway will not be considered further in the FS.

2.4.3.4 Area G

The Area G source area historically included one 500-gallon gasoline UST. The building included in Area G (the main facility building) is located north of and immediately adjacent to the former UST. In May 2011, borings G-1 and MW-30D were drilled adjacent to the building; MW-33S was also drilled further to the south. Analytical results from samples at G-1 and MW-30D indicated the presence of gasoline- and BTEX-impacted soil between 10 ft BGS and 15 ft BGS (Landau Associates 2011c); MW-33S soil sampling indicated that shallow soil was clean. The sub-slab soil gas concentration data collected during the VI assessment indicated that all BTEX constituents were present at concentrations well below MTCA Method B soil gas SLs, except for benzene, which was not detected above the laboratory reporting limit.

At the time of sampling, rooms closest to Area G in the main facility building were used for miscellaneous storage of roof tar repair products and fire-retardant chemical drums. One room served as a chemical storage closet with multiple types of building maintenance chemicals. In the central part of the building, the Christmas trees freshly sprayed with fire-retardant were set to dry. The drying trees produced such strong fumes that the sampling team elected to use half-face respirators while working in Area G; the fumes were observed to be stronger in Area G than in Area A and Area B.

The indoor air concentration data indicated that all BTEX constituents were present except for benzene, which was not detected above the laboratory reporting limit. However, it should be noted that the benzene reporting limit was elevated (8.8 $\mu g/m^3$) due to the high concentrations of other volatile chemicals in the sample. The previous indoor air sample, collected in September 2011, contained benzene at a concentration of 8.6 $\mu g/m^3$:

- Benzene was not detected above the laboratory reporting limit in the Area G sub-slab soil gas sample. Based on the sub-slab soil gas sample results (non-detect), and also on the presence of known process-related sources of benzene, the historically detected indoor air benzene concentration is not attributed to subsurface contamination.
- The total xylenes concentration in indoor air was 273,000 $\mu g/m^3$, which exceeded the MTCA indoor air CUL of 46 $\mu g/m^3$. Toluene and ethylbenzene also exceeded indoor air CULs at similar levels. However, total xylenes, toluene, and ethylbenzene in sub-slab soil gas were detected at concentrations below their respective MTCA Method B soil gas SLs. Based on the sub-slab soil gas sample results that were below the SL, and also on the presence of known process-related sources of toluene, ethylbenzene, and xylenes, the detected indoor air concentrations of these chemicals are not attributed to subsurface contamination.

Data collected to evaluate the VI pathway indicates that it is not a complete and significant contaminant migration pathway in Area G. Because sub-slab soil gas BTEX concentrations are all less than applicable SLs for the VI pathway, indoor air concentrations in Area G appear to be driven by indoor process-related sources. Existing conditions in Area G appear to be protective of human health with respect to the VI pathway; therefore, remediation to address this pathway will not be considered further in the FS.

2.5 CONTAMINANT FATE AND TRANSPORT

The basic understanding of contaminant fate and transport at the site is presented in the RI report. Investigations during the supplemental RI led to significant refinement of this understanding in regards to the deep water-bearing zone. Observations during drilling and the absence of groundwater in deep zone wells indicate that the deep water-bearing zone is not continuously saturated. Instead, the deep water-bearing zone appears to consist of perched, largely disconnected intervals of saturation in the ablation till with the ablation till acting more like an aquitard than an aquifer. The presence of a regular pattern of saturated conditions and groundwater contamination is only present in the direct vicinity of Area A due to the size and depth of the excavation that facilitates groundwater recharge and contaminant transport. However, even at Area A, the extent of horizontal contaminant migration is limited. Supplemental RI explorations and sampling have bounded the extent of contaminant migration to the west (dry well MW-36D), the southwest (dry well MW-37D), the north (dry well MW-24D), the east (MW-22 concentrations below CULs) and the south (MW-31D concentrations below CULs).

2.6 CONCEPTUAL SITE MODEL

A preliminary CSM was presented in the RI report. The CSM has been updated based on data collected during the supplemental RI. The primary refinements include a change in characterization of the deep water-bearing zone as a contaminant migration and exposure pathway and the elimination of VI as an exposure pathway.

The CSM represents current site conditions, identifying potential sources of hazardous substances, potentially affected media, and potential migration and exposure pathways for human and ecological receptors. It considers current conditions and future land use in assessing potential exposure pathways; only complete pathways result in exposure. A complete pathway includes a source and mechanism of release, an exposure medium, and an exposure route by which contact can occur.

Primary release mechanisms at the site include historical releases from USTs and associated distribution piping at six separate areas. USTs and associated distribution piping have been removed or decommissioned; however, residual soil contamination remains and piping is probably also present associated with Area E. Information about each UST area is presented in the RI report. Secondary release mechanisms include leaching and infiltration from soil into groundwater. The media affected by primary and secondary release mechanisms include soil and groundwater.

An important CSM feature that was further evaluated in the supplemental RI was the shallow groundwater zone, which is described here as spatially variable with temporal distributions generally correlated with seasonal precipitation, causing a largely disconnected hydrogeologic environment. Therefore, although the shallow groundwater zone continues to be monitored, shallow groundwater is not considered an aquifer requiring treatment or a direct media of concern, leaving four media of concern (deep groundwater, soil, soil gas, and indoor air).

The supplemental RI appears to have confirmed that Area A deep groundwater impacts are bounded from the former excavation area in most directions with the potential exception of the north/northwest[15]; other areas of concern do not have impacted deep groundwater. Therefore, Area A remains the only area of concern with deep groundwater zone contamination. Although the deep groundwater zone is similar to the shallow zone in that it consists of perched and discontinuous saturated zones outside of Area A and Area F, these areas exhibit higher degrees of saturation because of enhanced infiltration and recharge associated with large backfilled former excavations. The year-round presence of deep groundwater in the deep zone in these areas makes it a media of concern.

Air quality investigations involving the collection of indoor air and soil gas indicated that the VI pathway is generally not of concern. Area F was the only location with both soil gas and indoor air concentrations of concern for BTEX constituents, but evidence indicated that indoor air concentrations are associated with process-related sources rather than subsurface contamination. Therefore, soil gas at Area F may not be of concern but may require confirmation VI sampling at a later time. A qualitative summary table showing where impacted media is present at the remaining areas of concern is presented below:

MEDIA OF CONCERN	AREA A	AREA B	AREA C	AREA E	AREA F	AREA G
Deep Groundwater	**Yes**	No	No	No	No	No
Soil	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Soil Gas	No	No	NS	NS	**No (a)**	No
Indoor Air	No	No	NS	NS	**No (a)**	No

*Note: NS = not sampled

(a) As described above, confirmation VI sampling may be required

---

[15] With respect to the Area A former excavation, MW-25D is spatially in the center and the only deep well north (specifically northwest) of MW-25D is MW-7R. Concentrations of COCs at MW-7R are relatively high and may not bind the plume. MW-23D was not installed due to access issues with Tacoma Public Utilities; therefore, a north to northwest boundary well may still be needed.

Potential human and ecological receptors were identified for the site based on current and reasonable future site land use. It is anticipated that the site will retain its industrial character and that future land uses will be consistent with the current zoning and land use regulations. It appears that the site meets the MTCA definition for industrial property [Washington Administrative Code (WAC) 173-340-200 and WAC 173-340-745] however, there currently appears to be one full-time resident living in a camping trailer at the property[16]. Therefore, unrestricted site use has been assumed as a future use scenario. Potential human receptors include:

- Industrial Workers – site employees/workers/tenants
- Temporary Construction Workers – Personnel temporarily working at the site during non-routine maintenance or construction activities
- Future Residents – Adults or children who may, in the future, reside on the property that is currently part of the site
- Water Supply Consumers – Adults and children who consume privately-supplied water impacted by COCs from the site. This is only applicable on site in the vicinity of Area A.

There are no likely potential ecological receptors applicable to the site. Although MTCA requires consideration of terrestrial plants and animals that may potentially be exposed to hazardous substances, the site is expected to qualify for exclusion from further terrestrial ecological evaluation under WAC 173-340-7491(1)(b) because virtually all contaminated soil is or will be covered by buildings, paved roads, pavement, or other physical barriers that will prevent exposure (see Section 3.1).

Although there is only a low potential for exposure at the site, the complete exposure pathways identified for qualitative evaluation in the RI include:

- Potential exposure of temporary construction workers via ingestion, dermal contact, and inhalation (particulate and volatile emissions) of COCs in onsite soil
- Potential exposure of temporary construction workers via dermal contact and inhalation of COCs in groundwater
- Potential exposure of industrial workers via inhalation of volatile compounds in indoor and outdoor air from COCs in groundwater and soil
- Potential future exposures of offsite residents to COCs in groundwater used as a drinking water source via ingestion, dermal contact, and inhalation
- Potential future exposures of onsite residents to COCs in soil and groundwater via ingestion, dermal contact, and inhalation
- These exposure pathways will be considered in development of CULs.

---

[16] With permission from the property owners, an individual appears to reside in a camping trailer with wheels, elevating it up to 1.5 ft from the ground. The trailer is typically located near Area A.

2.7 SITE CONSTRAINTS

With regards to evaluating the implementability and relative ease with which remedial alternatives can be employed at the site, physical constraints related to structures, potential site user/tenant constraints, and property ownership were evaluated. Identified site constraints are discussed below by area.

2.7.1.1 Area A

Remedial alternatives at Area A will involve soil and groundwater remediation. Physical constraints include the Area A building to the south, an occupied camping trailer to the east, occasional equipment stored to the north and west, and junkyard equipment placed to the north and northwest. Most of the equipment and the trailer can potentially be relocated. As previously discussed, the Area A building caught on fire in November, was partially burned down, and is scheduled to be demolished. The property owner plans to tear down the building in 2012, but may not remove the building slab. Therefore, Area A remediation work planned in the vicinity of the Area A building may need to account for the presence of the remaining building slab. Also, a number of monitoring wells are installed in and around Area A.

Current site users affiliated with Area A include the individual who resides in the trailer to the east and the workers from the junk yard property (northwest of Area A) who travel through Area A to get to their site. During Area A remediation, the trailer may need to be relocated, and depending on the remedial field activity, the junk yard property owner may need to access their site using a secondary entrance that is north of Area A.

Remedial field activities will likely require conducting work on the City of Tacoma's (City) Pipeline Road parcel to the east. Work on this parcel is anticipated to require not only a well-defined site access agreement but also close communication with the City during field activities. Previous efforts to obtain site access from the City to install a well on Pipeline Road were unsuccessful. Therefore, it is anticipated that negotiating an access agreement for remediation work may require several months and should be started during the preparation of the cleanup action plan (CAP).

2.7.1.2 Area B

Remedial alternatives at Area B will involve soil remediation. The southeast portion of the Area A building is also located in Area B. Therefore, the physical constraint of the Area A building slab must also be accounted for at Area B. Other physical features include a stickup monitoring well with bollards (MW-8) and other nearby buildings.

Potential site users affiliated with Area B (and C and E) are intermittent workers who flock, paint, and dry Christmas trees. The spaces used to conduct this work are immediately adjacent to Area B. The work is seasonal and only occurs during the fall and early winter. When work is occurring, Area B may be difficult to access.

2.7.1.3 Area C

Remedial alternatives at Area C will involve soil remediation. A building borders Area C to the north. However, soil quality results from a boring in the building immediately north of the Area C source area were clean; indicating that soil contamination is not anticipated to extend beneath the building. Shoring around the building may still be necessary if physical removal of the contaminated soil occurs. Other physical features include a steel tower structure and adjacent stormwater structures (vault, catch basin, and dry well) that may need to be protected or removed to accommodate remediation work.

Current site users affiliated with Area C are the same as those from Area B. As with Area B, since the site users are only there from fall to early winter, the Area C remedial work may be constrained during this time.

2.7.1.4 Area E

Remedial alternatives at Area E will involve soil remediation. Area E is beneath the slab of the main facility building. Therefore, there are height restrictions, ventilation restrictions, potential aboveground and belowground utility issues, and the building slab will need to be cut and replaced and the shoring will be necessary if physical removal of contaminated soil occurs. Also, the presence of the decommissioned Area E UST (filled with controlled-density fill) may be a consideration.

Current site users affiliated with Area E are the same as those from Area B. As with Area B, since the site users are only there from fall to early winter, the Area E remedial work may be constrained during this time.

2.7.1.5 Area F

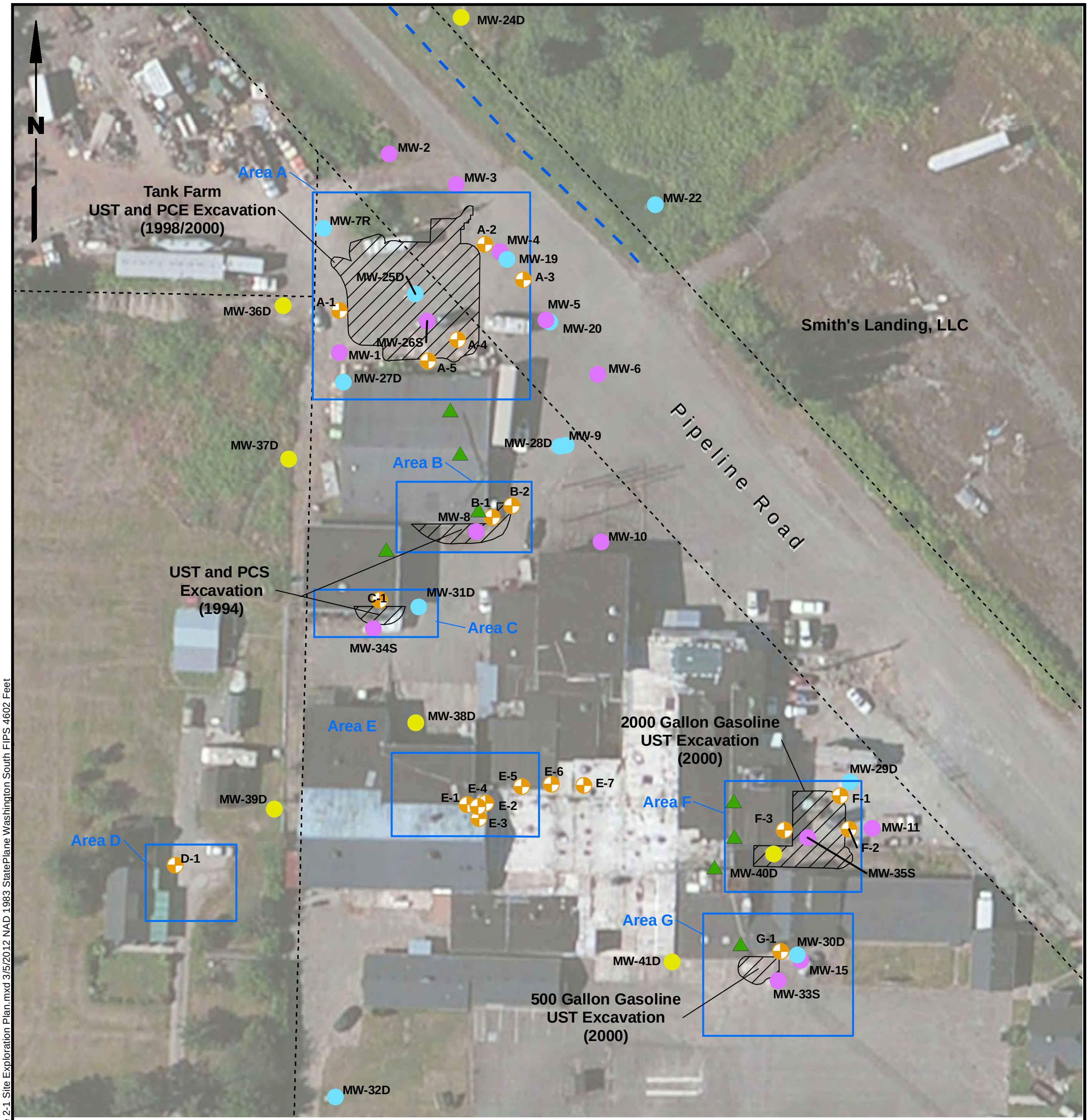
Remedial alternatives at Area F will involve soil remediation. Portions of Area F are surrounded by buildings on up to three sides. Soil contamination is present beneath the building where soil boring F-3 was drilled. Soil beneath the slab of some of the other adjacent buildings was not investigated and may also be contaminated. Therefore, the Area F remediation will have to account for building structures. The property owner may remove some of the surrounding buildings, but the building slabs would likely still be present. Other Area F physical constraints include a barbed-wire fence that bisects the area. Items such as cars and tires are stored within the fenced portion of Area F. In order for remediation work to occur, sections of the barbed-wire fence, the cars, and some tires may need to be removed or relocated. One monitoring well (MW-35S) is also present in Area F and may need to be considered.

The current site user affiliated with Area F is an automotive shop/tire storage facility, which is within the barbed-wire fence area. A portion of the nearby fenced in area may need to be cleared for remediation work (mentioned above), which would displace the storage component of the site user's operation.

2.7.1.6 Area G

Remedial alternatives at Area G will involve soil remediation. Area G is bordered to the north by the main facility building. Soil contamination is anticipated to be present just beneath the slab of a small portion of the building immediately north and northeast of the former Area G excavation. Therefore, the Area G remediation will need to account for preservation of the building structure and foundation. Shoring around the building may be necessary if physical removal of the contaminated soil occurs. Other physical constraints include the onsite private stormwater conveyance system and monitoring wells.

The current site users affiliated with Area G are the site property owners (use of the main facility is mostly for storage) and the after-school program at the building to the east uses the area for parking. Typically the property owner requests that field activities are minimized during the afternoon hours during which the after-school program business operates.



Y:\Projects\136006\010\013\Supplemental RI & FS\MapDocs\Figure 2-1 Site Exploration Plan.mxd 3/5/2012 NAD 1983 StatePlane Washington South FIPS 4602 Feet

Legend

▲	Vapor Intrusion Sample Location	-----	Tax Parcel
⊕	Former Soil Boring	– –	Tacoma Water 54" Pipeline
●	New Monitoring Well - Deep	☐	Area of Concern
●	Existing Monitoring Well - Deep	▨	Former Excavation Area
●	Existing Monitoring Well - Shallow		

Note
1. Area E and Area D USTs are still in place; locations are approximate.
2. MW-23D was not installed.
3. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

0 70 140

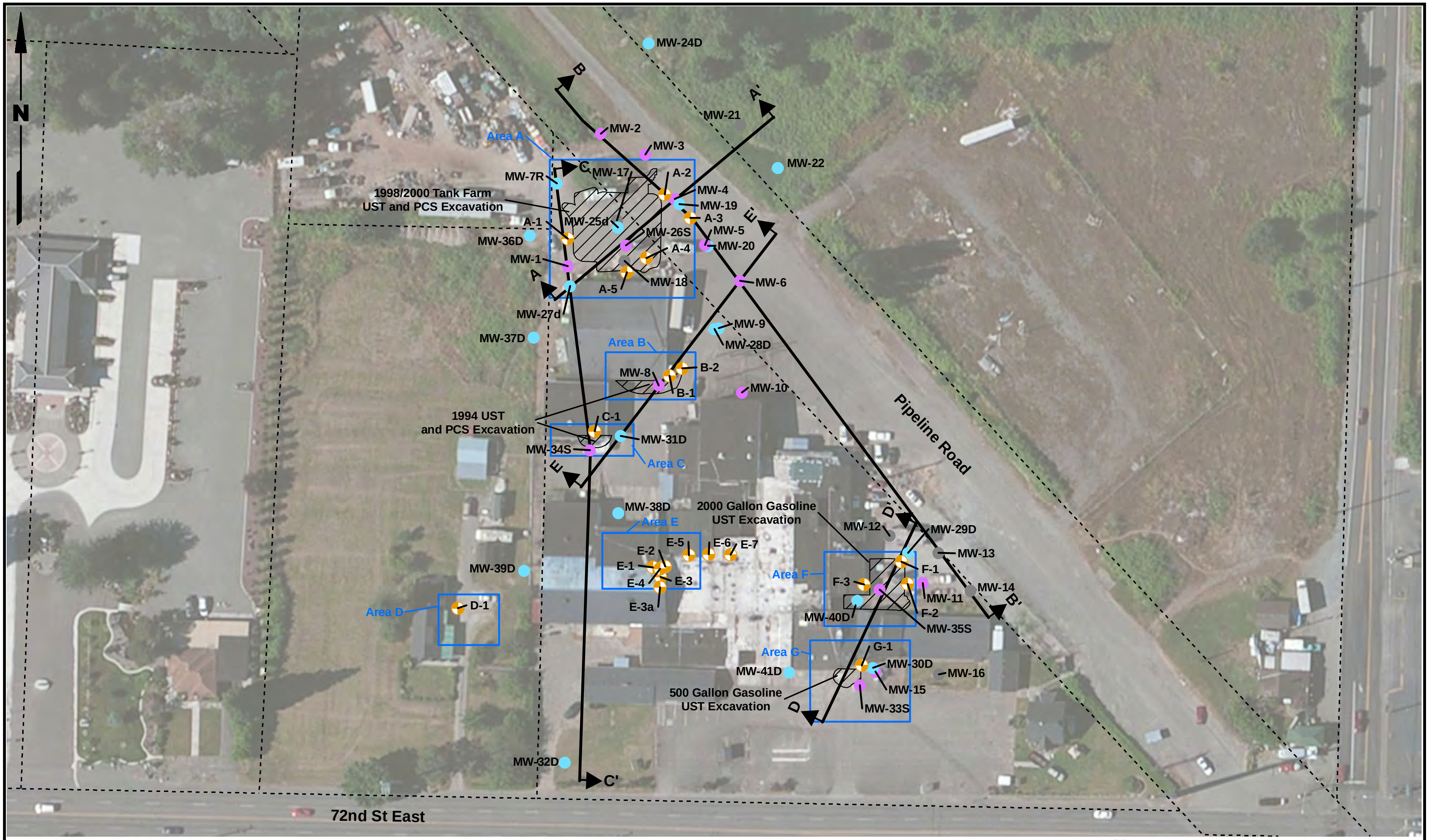
Scale in Feet

Data Source: Pierce County GIS; Bing Maps Aerial

LANDAU ASSOCIATES

Pederson's Fryer Farms Pierce County, Washington	**Site Exploration Plan**	Figure 2-1

Y:\Projects\136006\010\013\Supplemental RI & FS\MapDocs\Figure 2-2 Soil Borings and GW Wells.mxd 3/5/2012 NAD 1983 StatePlane Washington South FIPS 4602 Feet



● Decommissioned Wells
● Monitoring Well - Deep
● Monitoring Well - Shallow
◐ Soil Boring

- - - - Tax Parcel
▨ Former Excavation Area
☐ Area of Concern

A A' Cross Section Location

0 120 240
Scale in Feet

Data Sources: Pierce County GIS; Bing Maps Aerial.

Notes

1. MW-23D was not installed.
2. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

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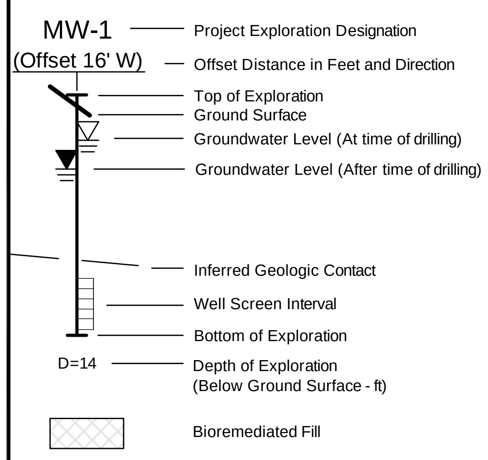
Pederson's Fryer Farms
Pierce County, Washington

Soil Borings and Groundwater Monitoring Wells

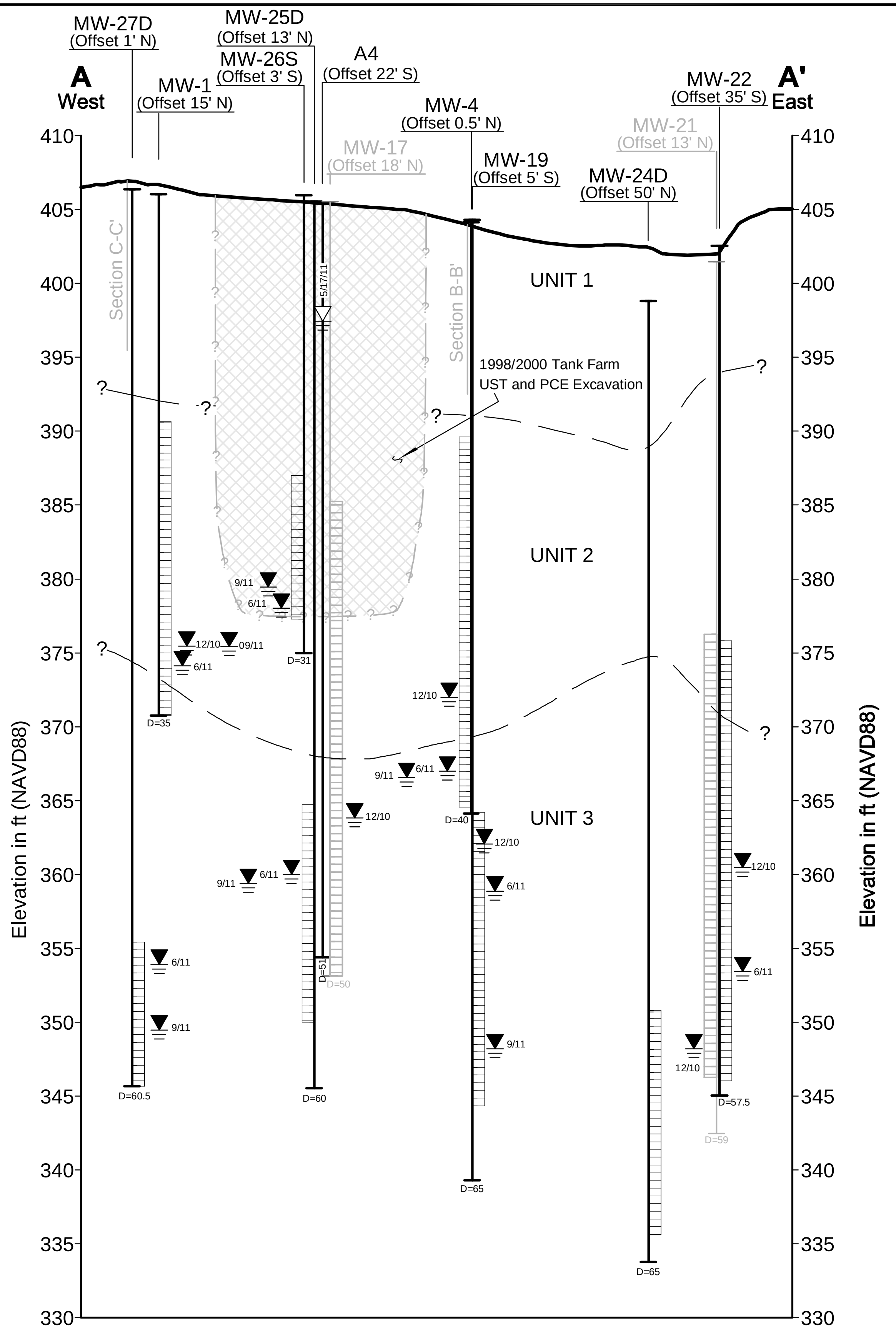
Figure
2-2

Legend



Notes

1. See report text for full descriptions of geologic units. Geologic units are generally defined as follows:
   - Unit 1 - Lacustrine deposit
   - Unit 2 - Ablation Till with decreasing silt content
   - Unit 3 - Ablation Till with gradual silt content increase
2. For cross-section location, see Soil Borings and Groundwater Monitoring Wells figure, Figure 2-2.
3. Wells shown in gray were decommissioned in May 2011
4. Wells with only September 2011 water levels were installed in September 2011.
5. September water levels were collected on 09/20/11.



Ground Surface Profile Source: Puget Sound LiDAR Consortium, 2005

0 50 100

Horizontal Scale: 1" = 50'
Vertical Scale: 1" = 10'

Peterson's Fryer Farms | V:\136\006\010.013\RI Report\Sections-A-E.dwg (A) "Figure 2-3" 1/31/2012

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Pederson's Fryer Farms
Pierce County, Washington

Geologic Cross Section A-A'

Figure
2-3

Legend

MW-1 — Project Exploration Designation

(Offset 16' W) — Offset Distance in Feet and Direction

Top of Exploration

Ground Surface

▽ Groundwater Level (At time of drilling)

▼ Groundwater Level (After time of drilling)

Inferred Geologic Contact

Well Screen Interval

Bottom of Exploration

D=14 — Depth of Exploration (Below Ground Surface - ft)

▨ Bioremediated Fill

Notes

1. See report text for full descriptions of geologic units. Geologic units are generally defined as follows:
   Unit 1 - Lacustrine deposit
   Unit 2 - Ablation Till with decreasing silt content
   Unit 3 - Ablation Till with gradual silt content increase
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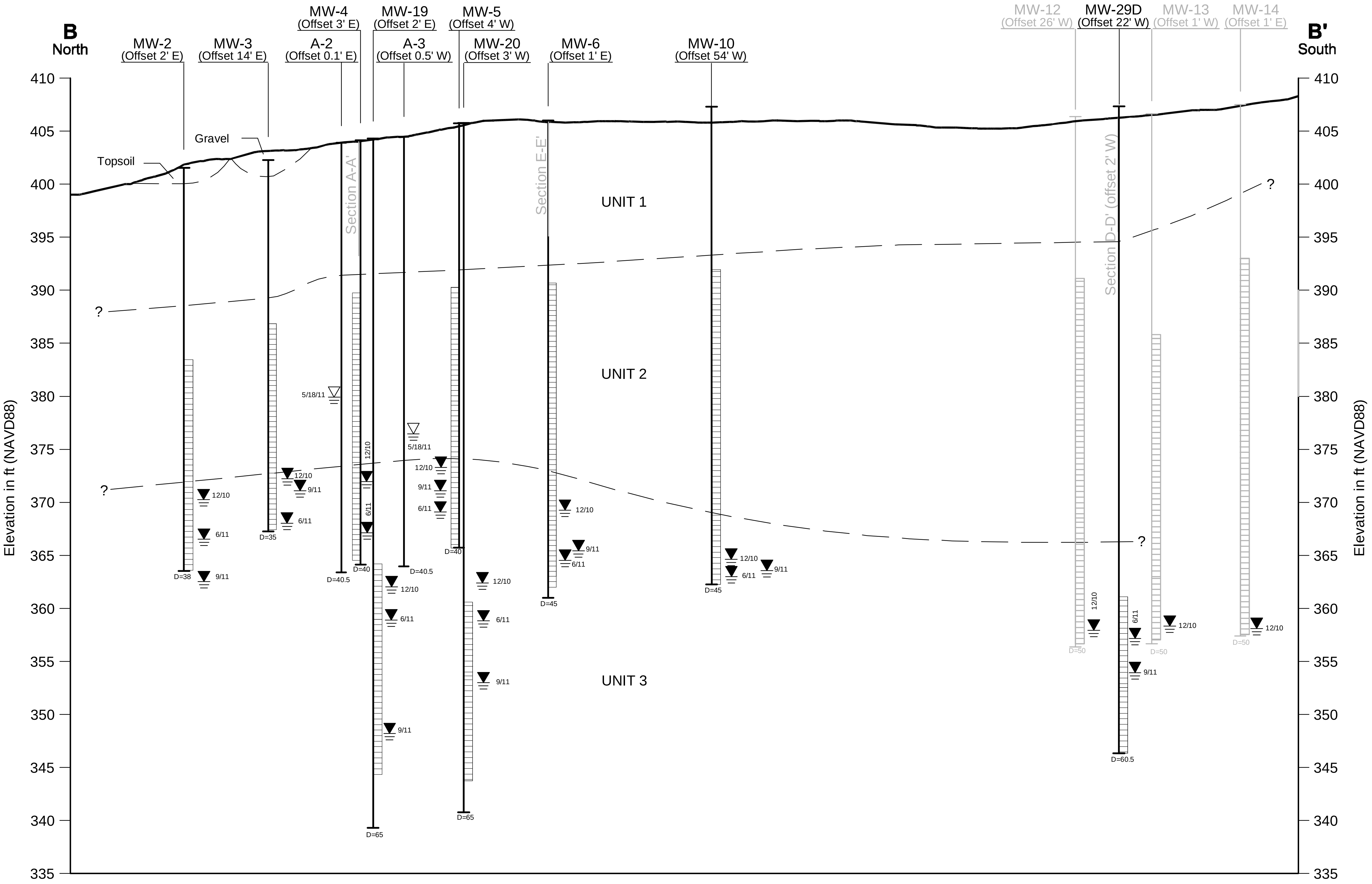

Ground Surface Profile Source: Puget Sound LiDAR Consortium, 2005

0 50 100

Horizontal Scale: 1" = 50'
Vertical Scale: 1" = 10'

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Pederson's Fryer Farms
Pierce County, Washington

Geologic Cross Section B-B'

Figure
2-4

LANDAU ASSOCIATES, INC. | V:\136\006\010.013\RI Report\Sections-A-E.dwg (A) "Figure 2-4" 1/31/2012

Legend

MW-1 — Project Exploration Designation
(Offset 16' W) — Offset Distance in Feet and Direction
Top of Exploration
Ground Surface
Groundwater Level (At time of drilling)
Groundwater Level (After time of drilling)
Inferred Geologic Contact
Well Screen Interval
Bottom of Exploration
D=14 — Depth of Exploration (Below Ground Surface - ft)
▨ Bioremediated Fill

Notes

1. See report text for full descriptions of geologic units. Geologic units are generally defined as follows:
   - Unit 1 - Lacustrine deposit
   - Unit 2 - Ablation Till with decreasing silt content
   - Unit 3 - Ablation Till with gradual silt content increase
2. For cross-section location, see Soil Borings and Groundwater Monitoring Wells figure, Figure 2-2.
3. Wells shown in gray were decommissioned in May 2011
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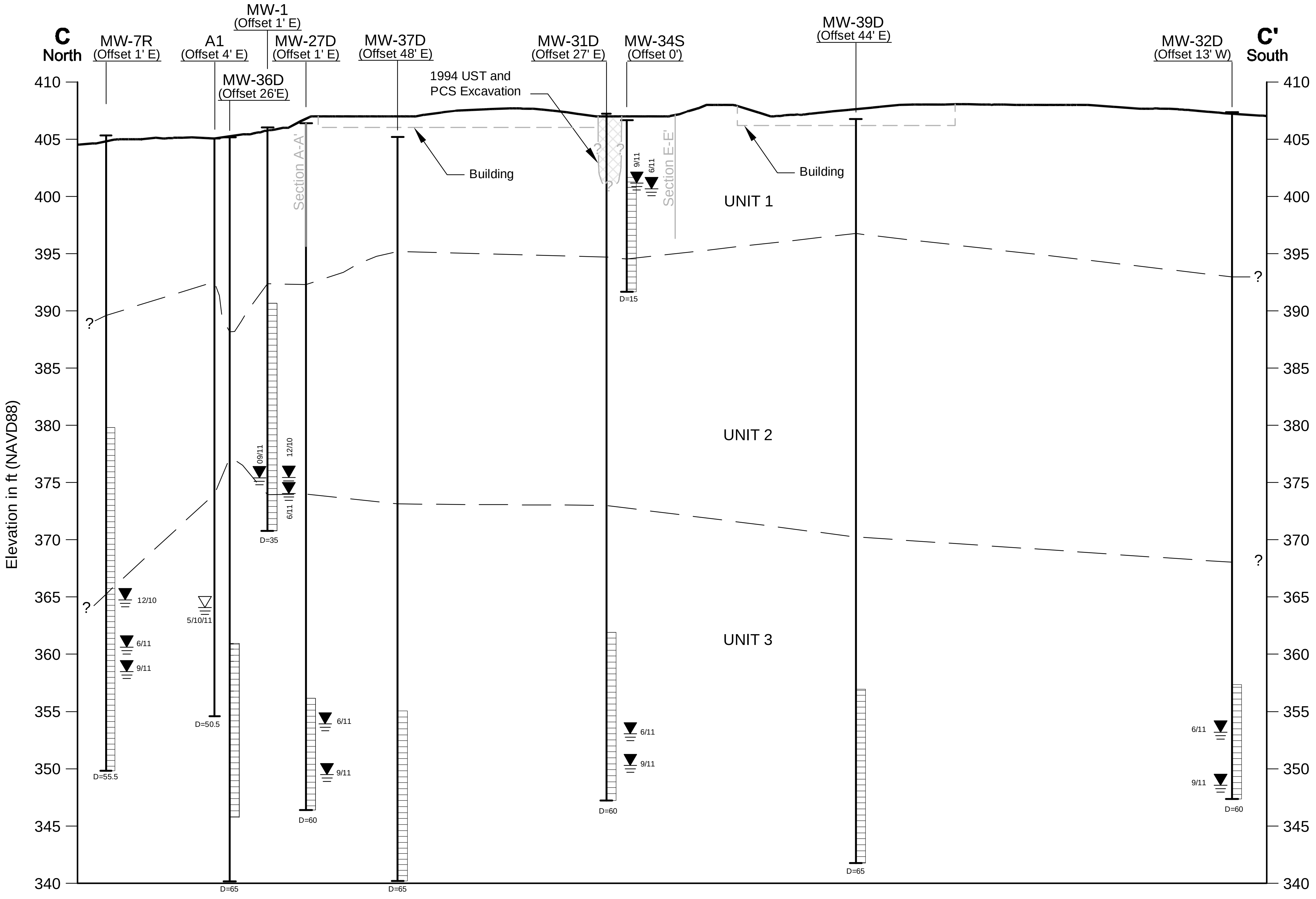

Ground Surface Profile Source: Puget Sound LiDAR Consortium, 2005

0 50 100
Horizontal Scale: 1" = 50'
Vertical Scale: 1" = 10'

Pederson's Fryer Farms
Pierce County, Washington

Geologic Cross Section C-C'

Figure
2-5

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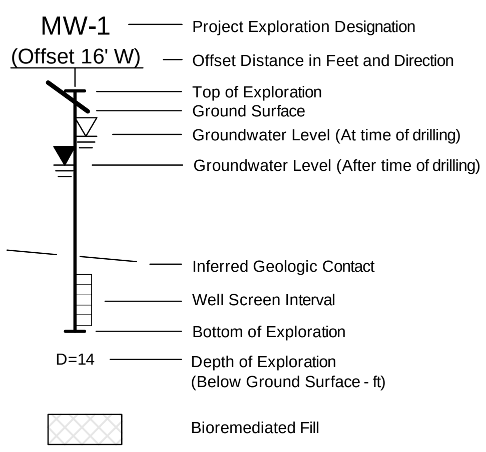
LANDAU ASSOCIATES, INC. | V:\136\006\010.013\RI Report\Sections-A-E.dwg (A) "Figure 2-5" 1/31/2012

Legend



Notes

1. See report text for full descriptions of geologic units. Geologic units are generally defined as follows:
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   - Unit 2 - Ablation Till with decreasing silt content
   - Unit 3 - Ablation Till with gradual silt content increase
2. For cross-section location, see Soil Borings and Groundwater Monitoring Wells figure, Figure 2-2.
3. Wells shown in gray were decommissioned in May 2011
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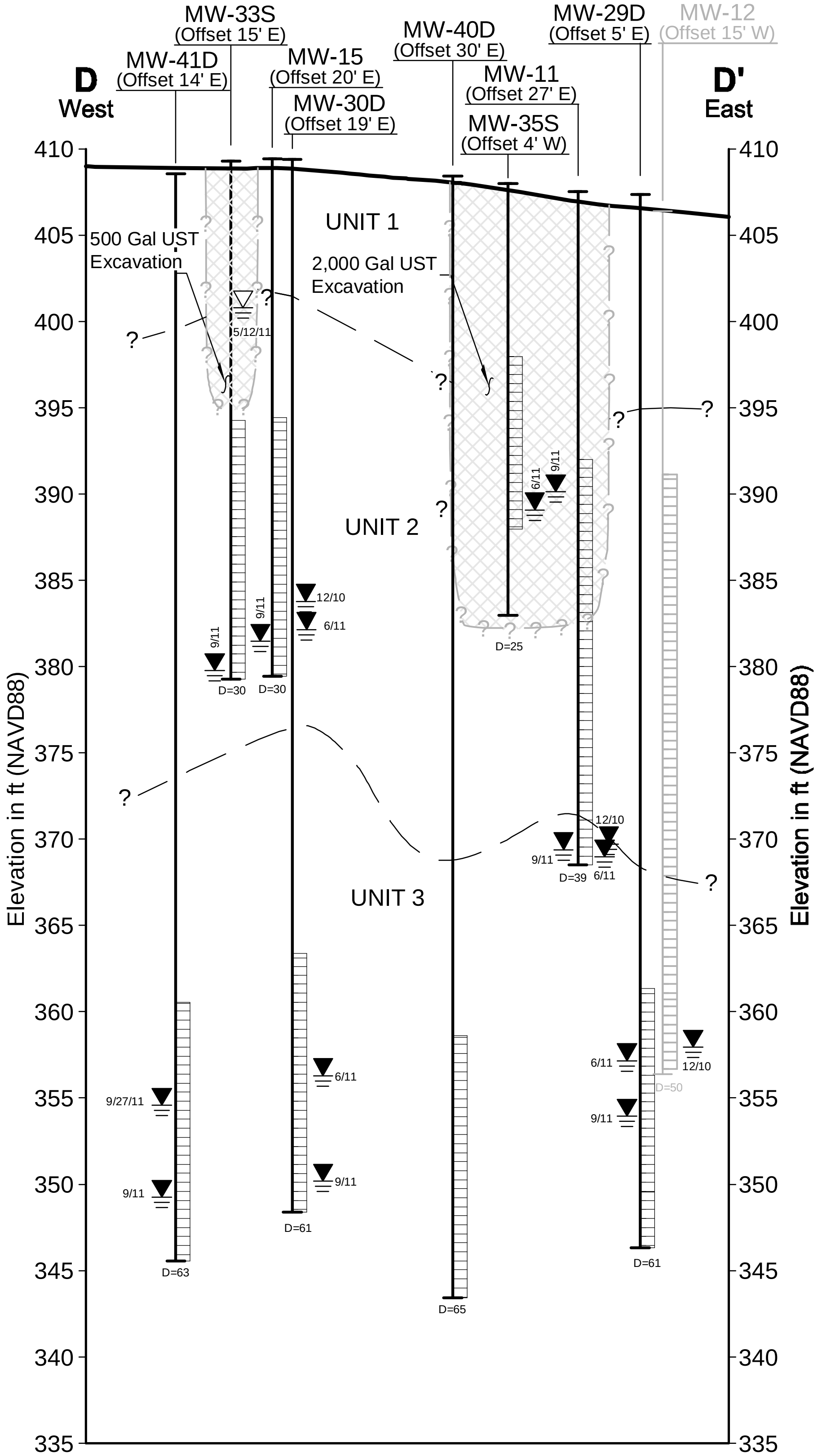
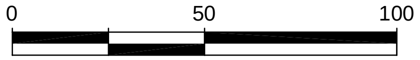


Ground Surface Profile Source: Puget Sound LiDAR Consortium, 2005



Horizontal Scale: 1" = 50'
Vertical Scale: 1" = 10'

Peterson's Fryer Farms | V:\136\006\010.013\RI Report\Sections-A-E.dwg (A) "Figure 2-6" 1/31/2012

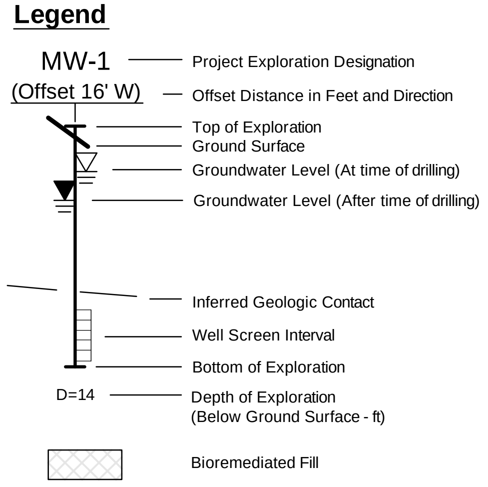
LANDAU ASSOCIATES

Pederson's Fryer Farms
Pierce County, Washington

Geologic Cross Section D-D'

Figure
2-6

Legend



Notes

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   - Unit 1 - Lacustrine deposit
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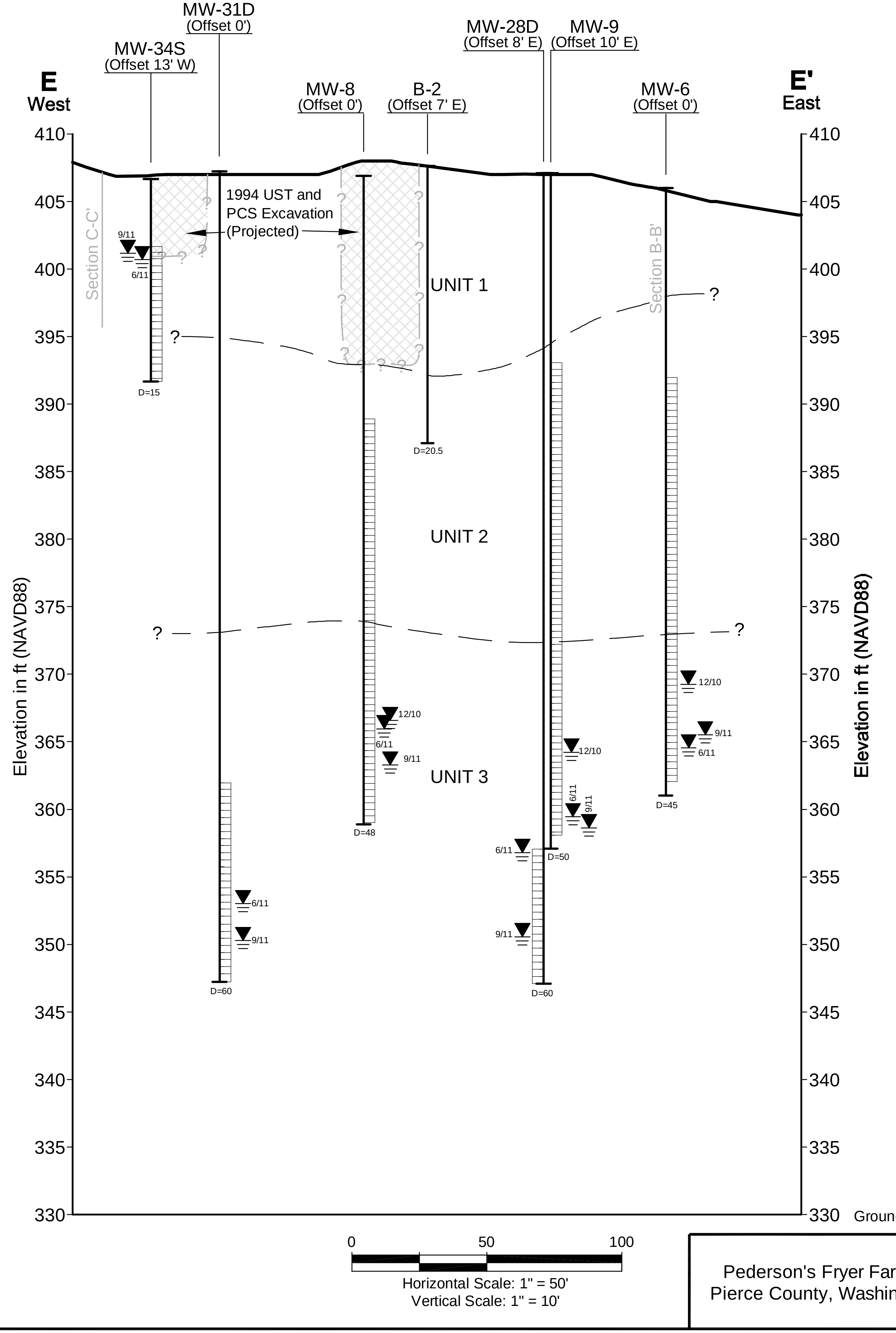

Ground Surface Profile Source: Puget Sound LiDAR Consortium, 2005

Peterson's Fryer Farms | V:\136\006\010.013\RI Report\Sections-A-E.dwg (A) "Figure 2-7" 1/31/2012

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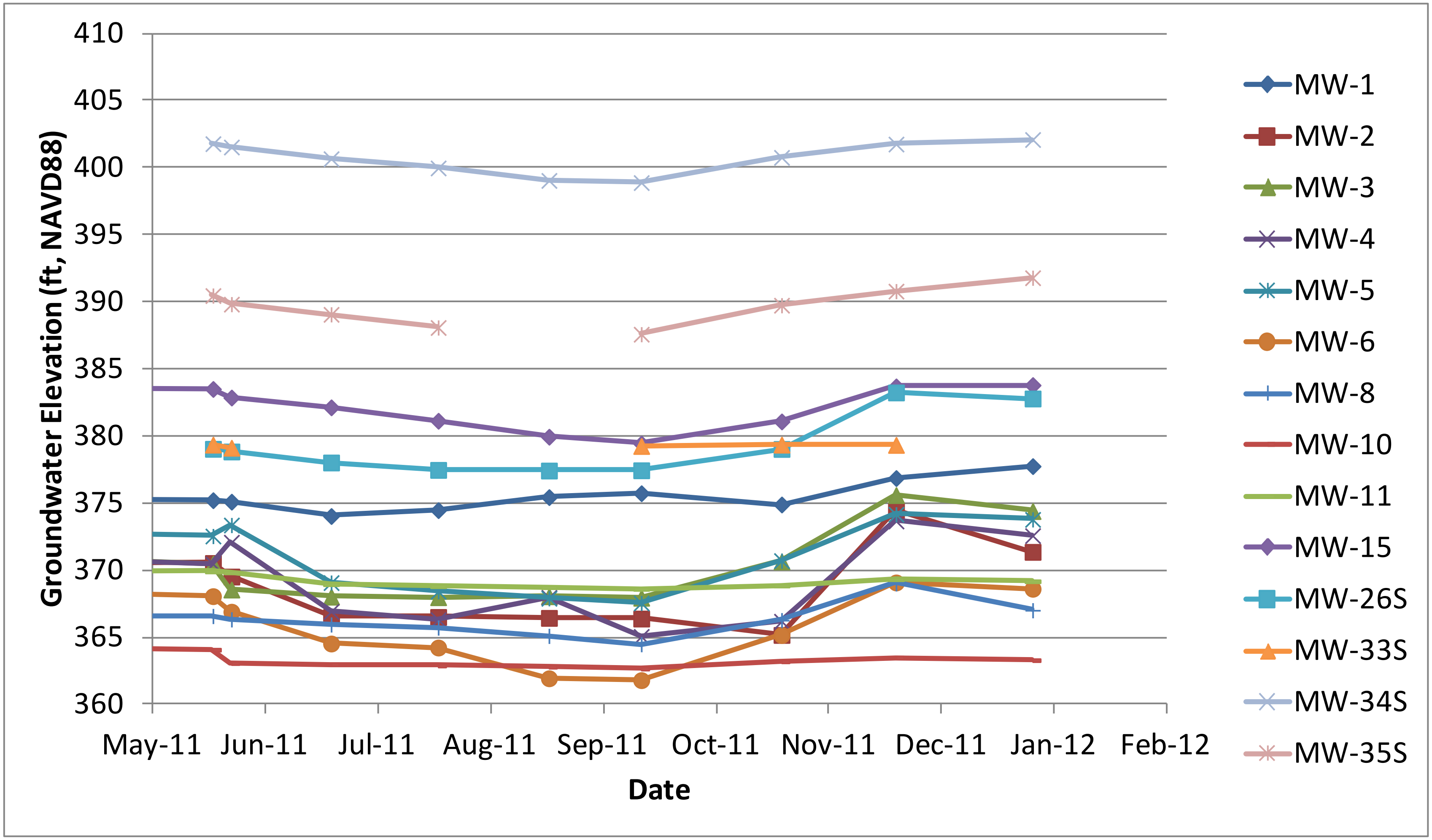
Pederson's Fryer Farms
Pierce County, Washington

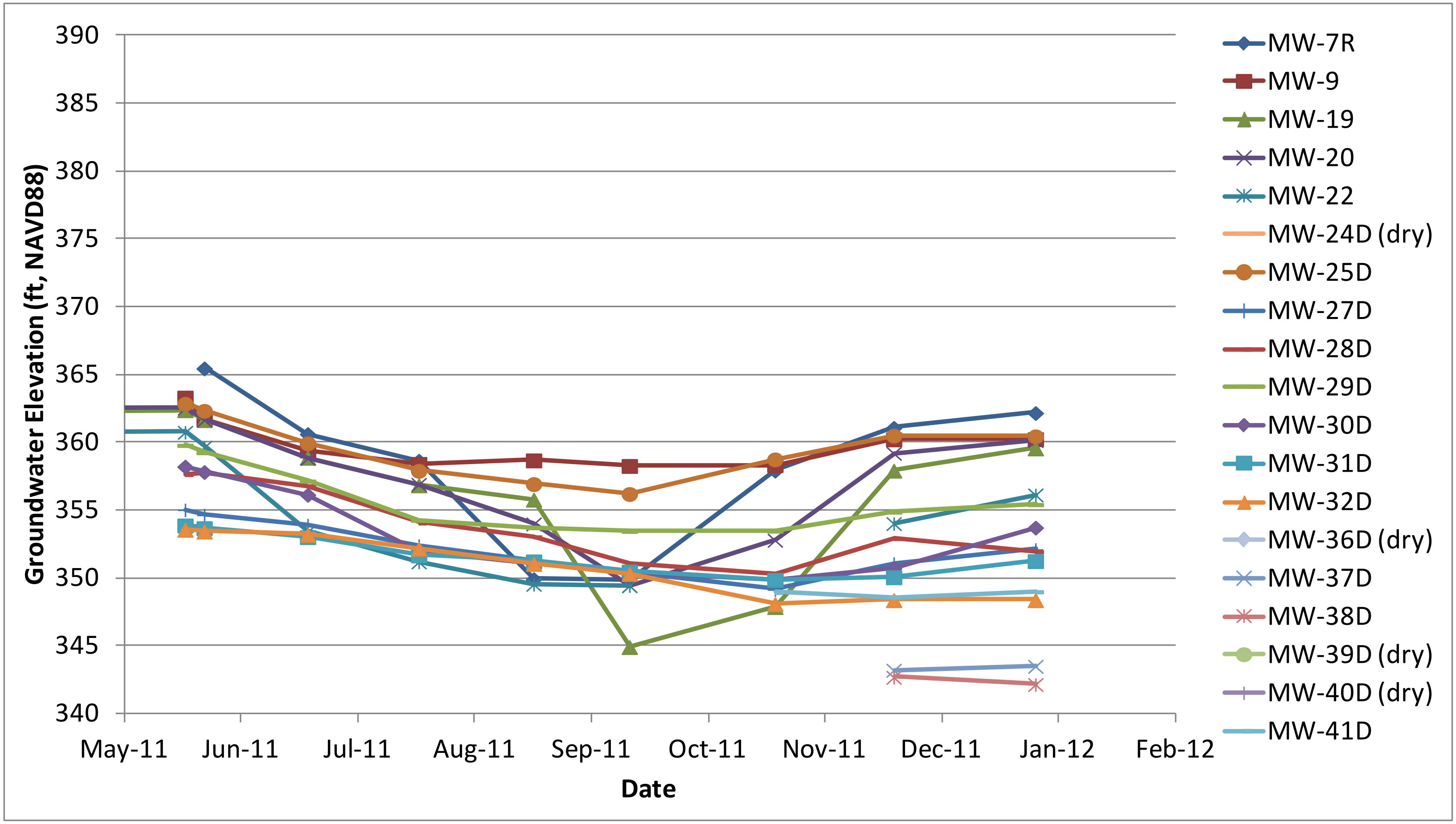
Geologic Cross Section E-E'

Figure
2-7



LANDAU ASSOCIATES

Pederson's Fryer Farms Pierce County, Washington	**Monthly Groundwater Elevations Shallow Water-Bearing Zone**	Figure 2-8

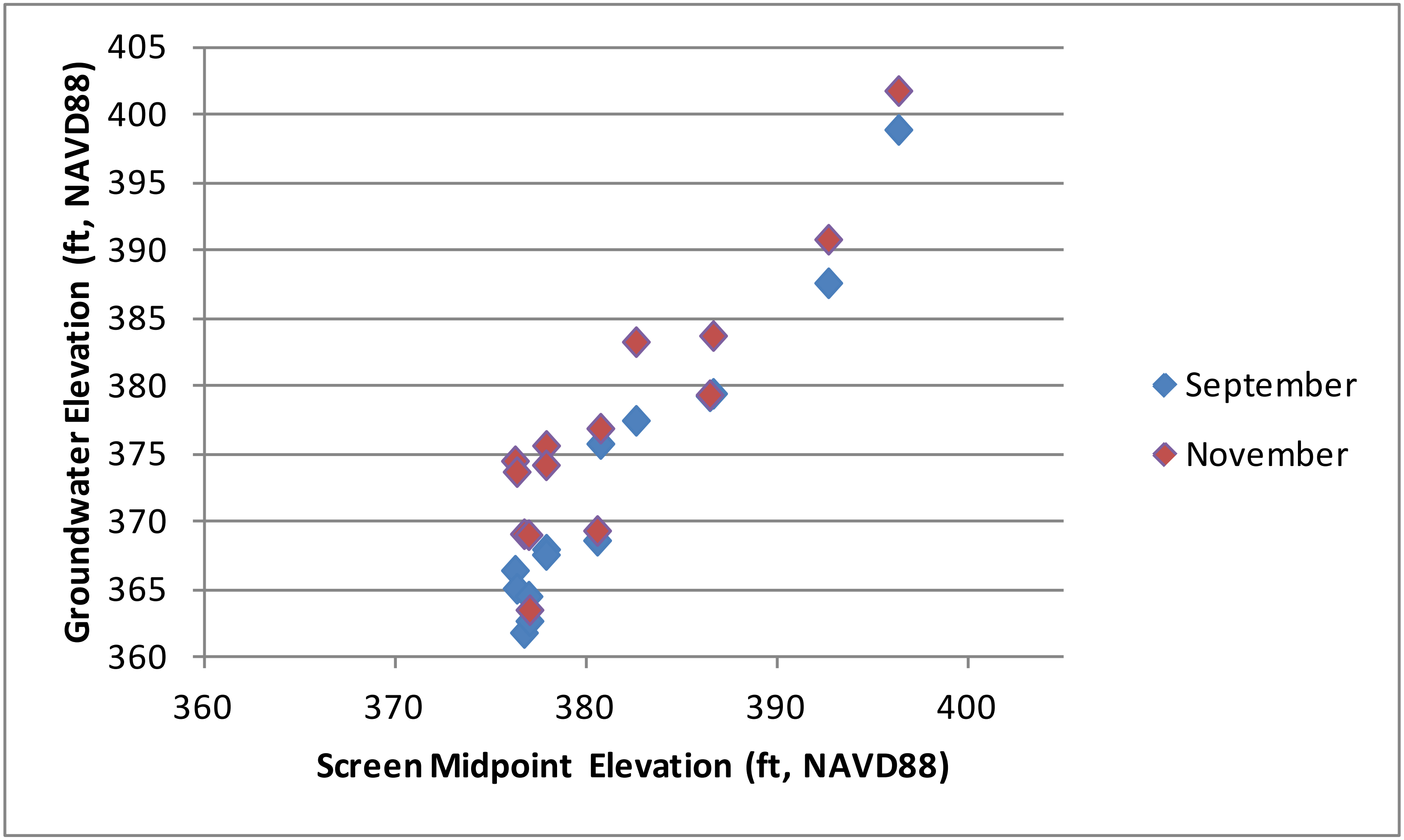


LANDAU ASSOCIATES

Pederson's Fryer Farms
Pierce County, Washington

Monthly Groundwater Elevations
Deep Water-Bearing Zone

Figure
2-9



Pederson's Fryer Farms Pierce County, Washington	**Well Screen Mid-point versus Shallow Zone Groundwater**	Figure 2-10

☐	Area of Concern
▨	Former Excavation Area
●	MW-3 Monitoring Well ID (367.95) Groundwater Elevation (ft, NAVD88)

Note
1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.
2. Water levels were collected September 20, 2011.

0 80 160

Scale in Feet

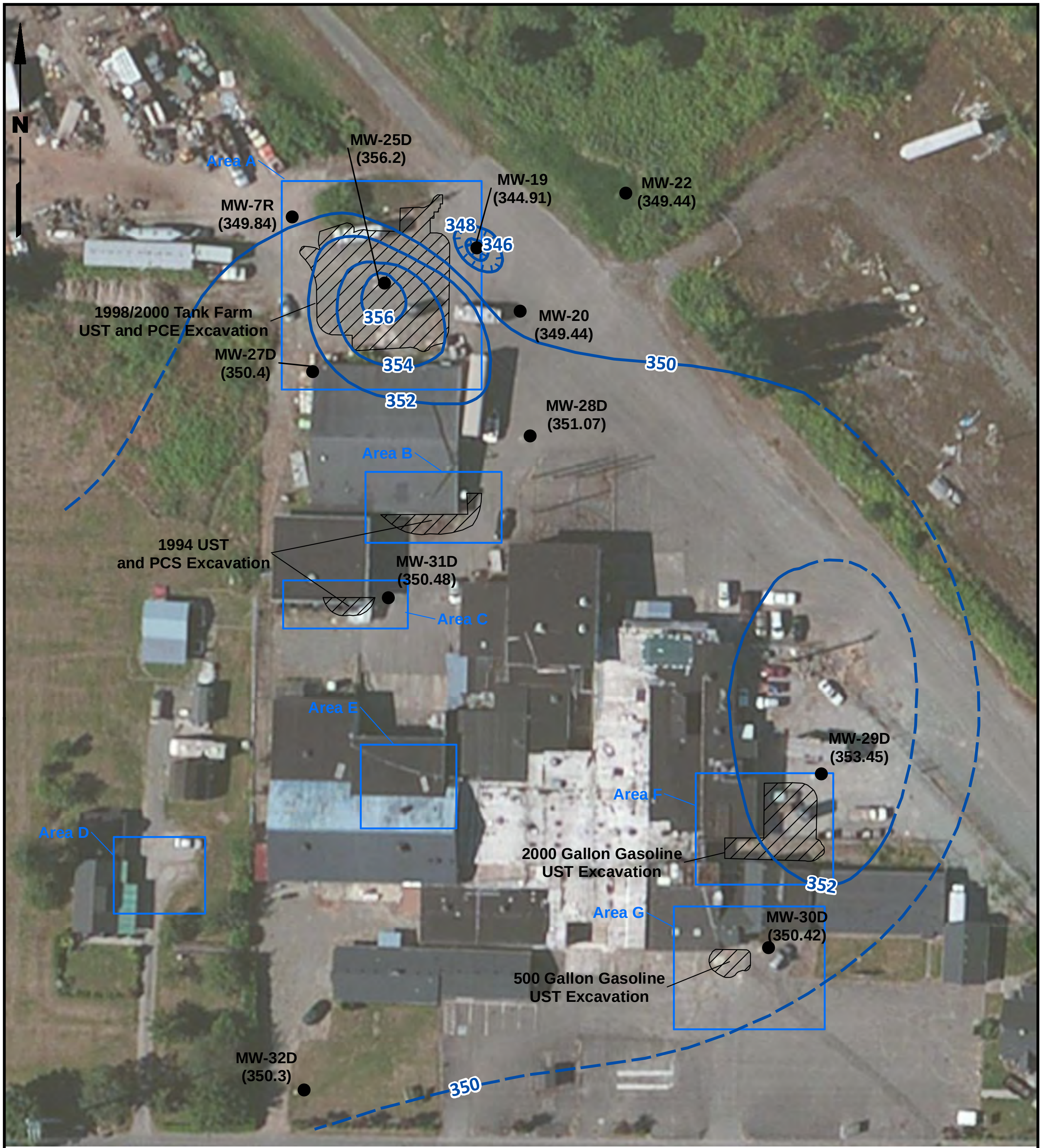
Data Source: Pierce County GIS; Bing Maps Aerial

LANDAU ASSOCIATES

Pederson's Fryer Farms
Pierce County, Washington

Groundwater Elevations - Shallow Wells September 2011

Figure
2-11



- ☐ Area of Concern
- ▨ Former Excavation Area
- ● MW-31D (350.48) Monitoring Well ID Groundwater Elevation (ft, NAVD88)
- ━ Groundwater Contour
- ╌ Inferred Groundwater Contour
- ┴┴┴ Depression

Note
1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.
2. Water levels were collected September 20, 2011.
3. MW-9 not included because it is influenced by shallow & deep groundwater.

0 80 160
Scale in Feet

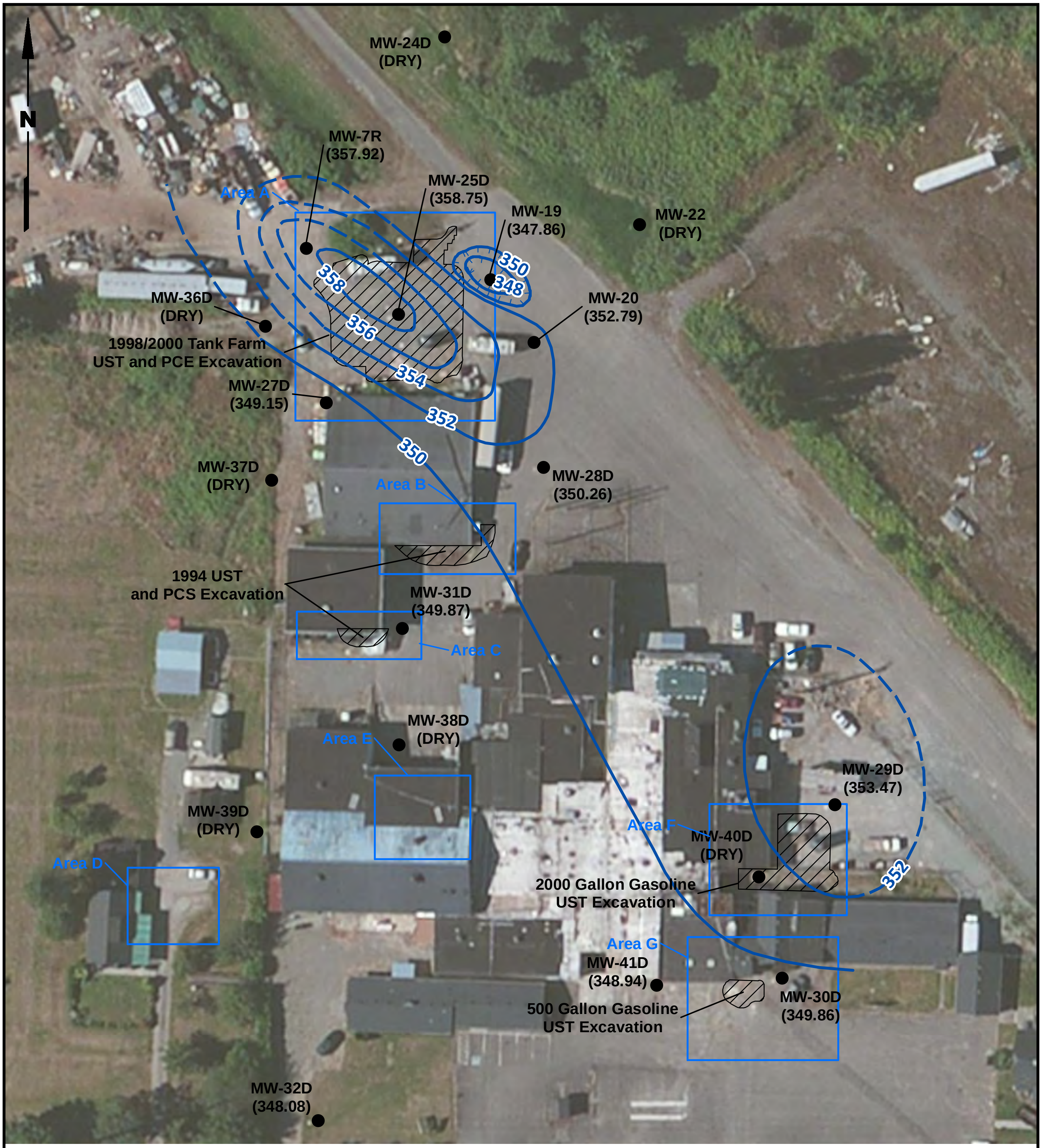
Data Source: Pierce County GIS; Bing Maps Aerial

LANDAU ASSOCIATES

Pederson's Fryer Farms
Pierce County, Washington

Groundwater Elevations - Deep Wells
September 2011

Figure
2-12



☐ Area of Concern

▨ Former Excavation Area

● MW-20 (352.79) Monitoring Well ID Groundwater Elevation (ft, NAVD88)

— Groundwater Contour

- - Inferred Groundwater Contour

┬┬┬ Depression

Note
1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.
2. Water levels were collected October 28, 2011.
3. MW-9 not included because it is influenced by shallow & deep groundwater.

0 80 160

Scale in Feet

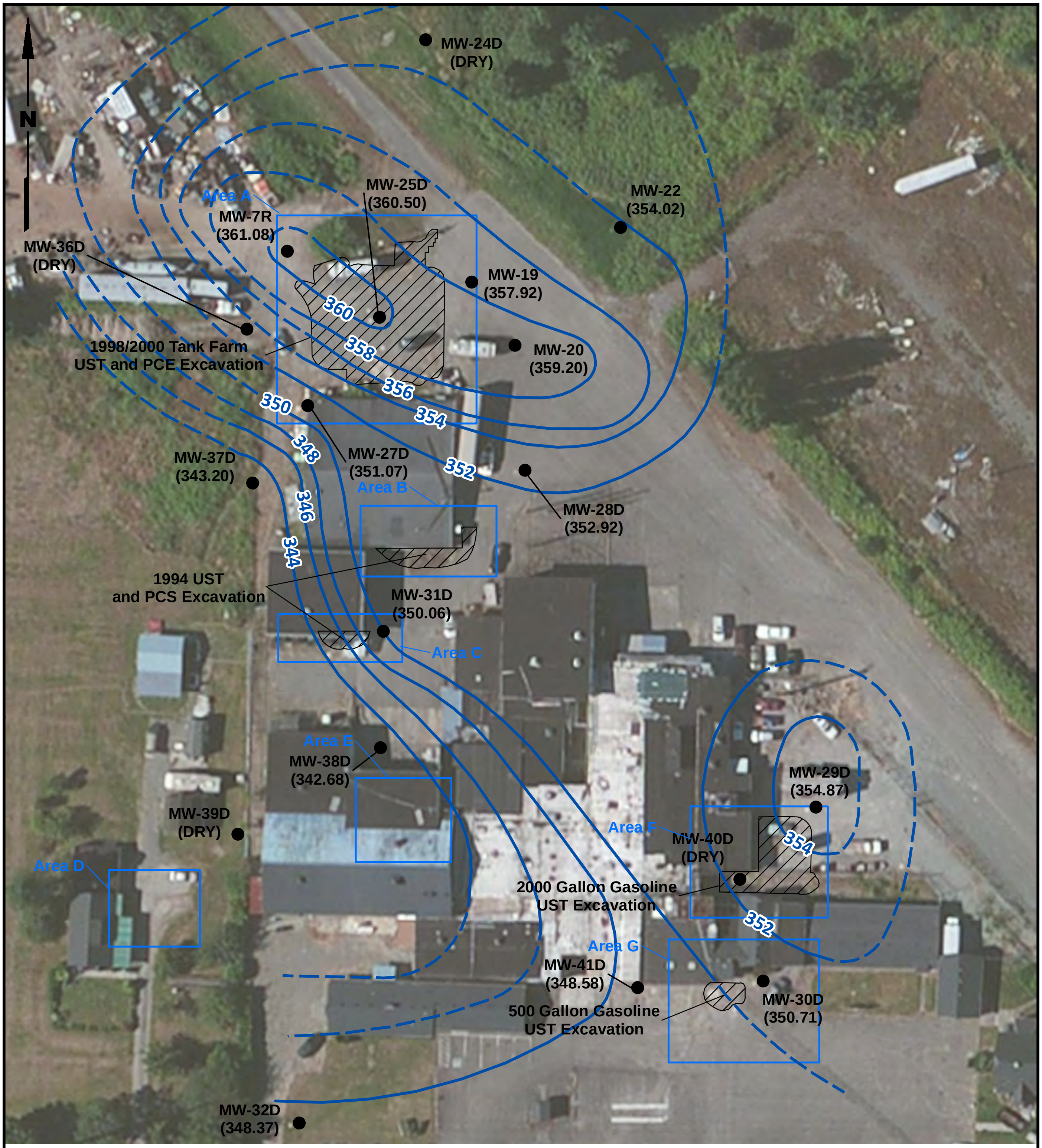
Data Source: Pierce County GIS; Bing Maps Aerial

Landau Associates

Pederson's Fryer Farms
Pierce County, Washington

Groundwater Elevations - Deep Wells
October 2011

Figure
2-13



▭	Area of Concern
▨	Former Excavation Area
● MW-20 (359.20)	Monitoring Well ID Groundwater Elevation (ft, NAVD88)
───	Groundwater Contour
– – –	Inferred Groundwater Contour

Note
1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.
2. Water levels were collected November 28, 2011.
3. MW-9 not included because it is influenced by shallow & deep groundwater.

0 80 160

Scale in Feet

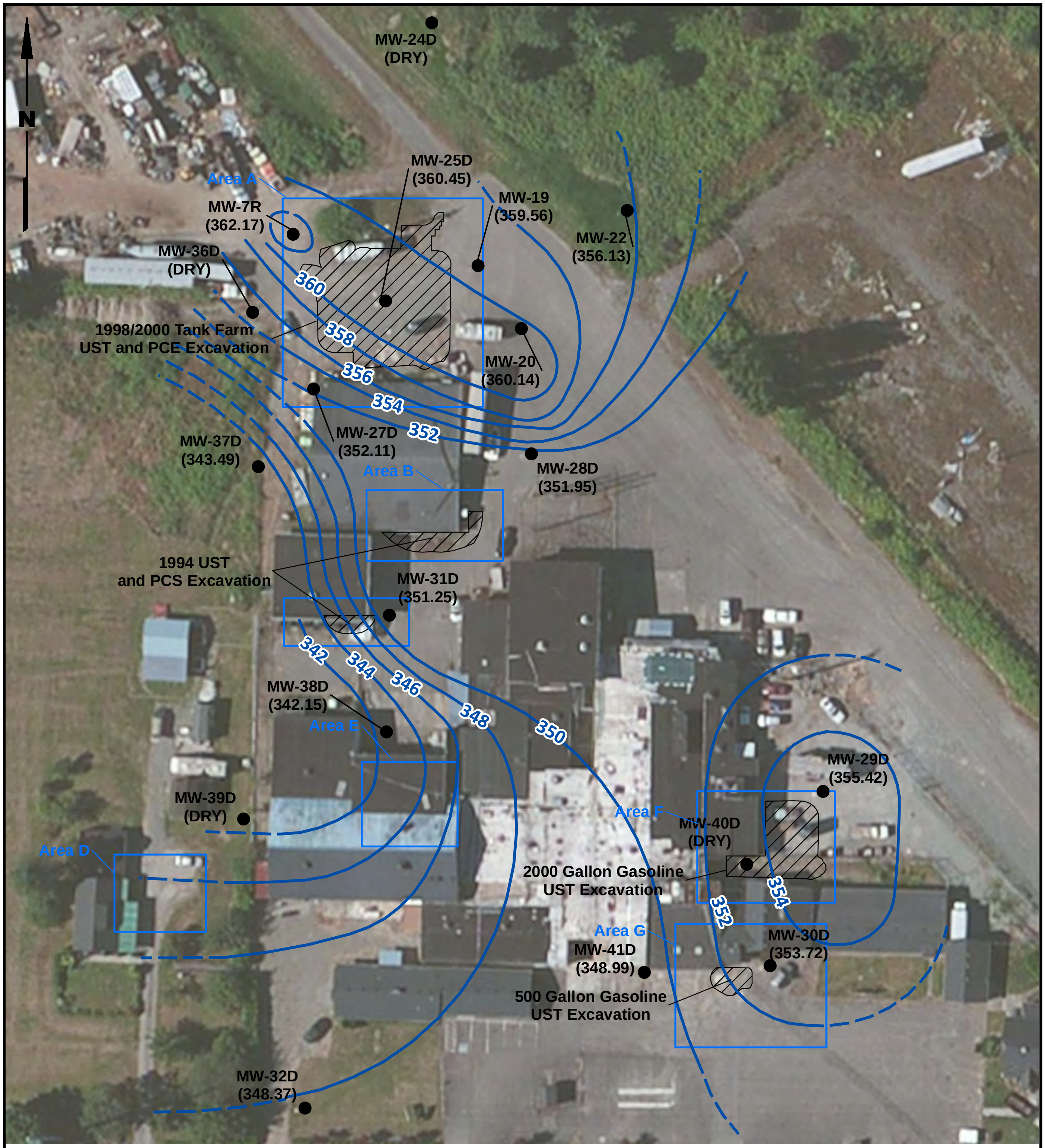
Data Source: Pierce County GIS; Bing Maps Aerial

LANDAU ASSOCIATES

Pederson's Fryer Farms
Pierce County, Washington

Groundwater Elevations - Deep Wells
November 2011

Figure
2-14



▭	Area of Concern
▨	Former Excavation Area
●	MW-28D (351.95) Monitoring Well ID Groundwater Elevation (ft, NAVD88)
―	Groundwater Contours
- -	Inferred Groundwater Contours

Note
1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.
2. Water levels were collected January 4, 2012.
3. MW-9 not included because it is influenced by shallow & deep groundwater.

0 75 150
Scale in Feet

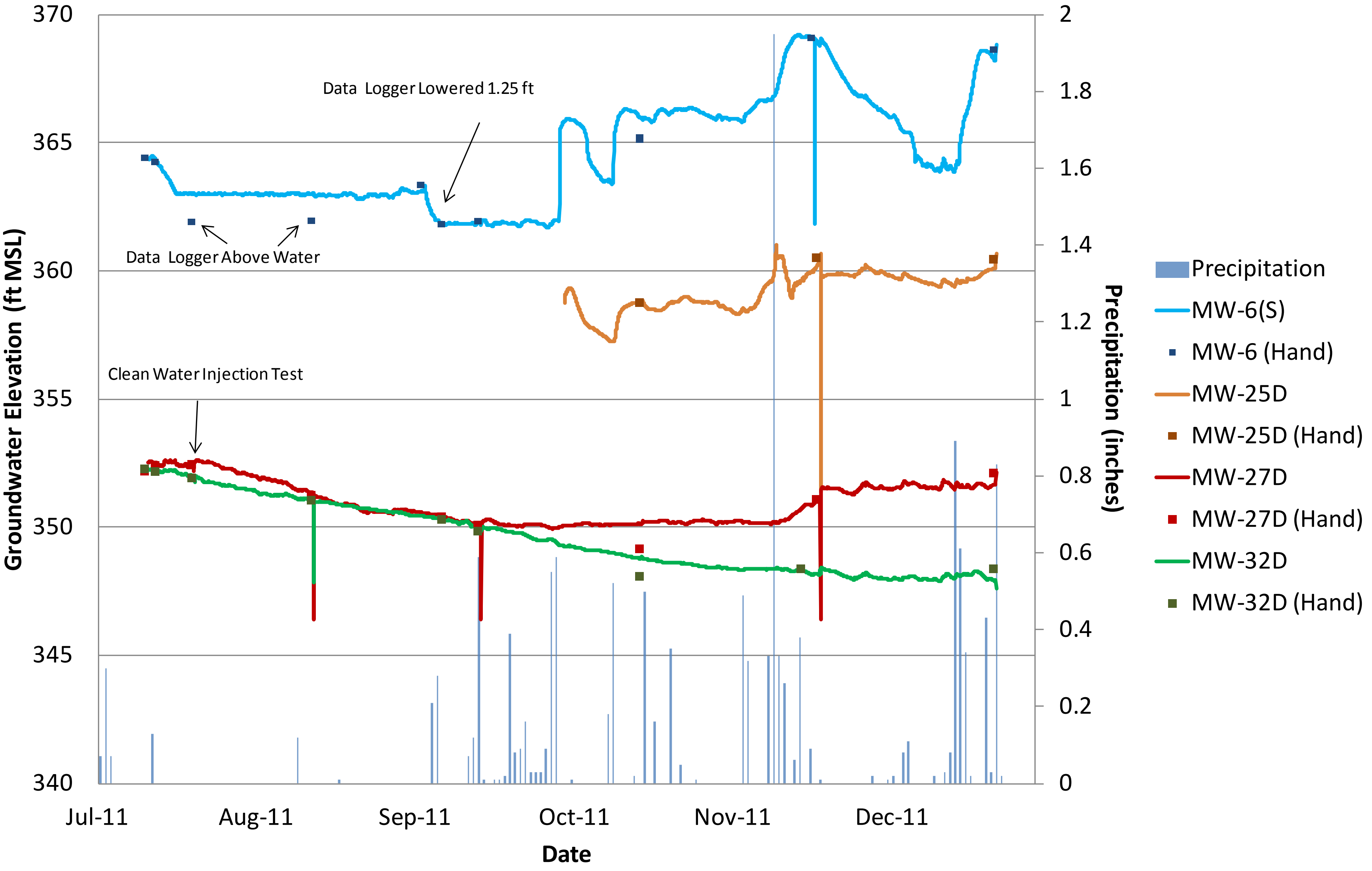
Data Source: Pierce County GIS; Bing Maps Aerial

LANDAU ASSOCIATES

Pederson's Fryer Farms
Pierce County, Washington

Groundwater Elevations - Deep Wells
December 2011

Figure
2-15

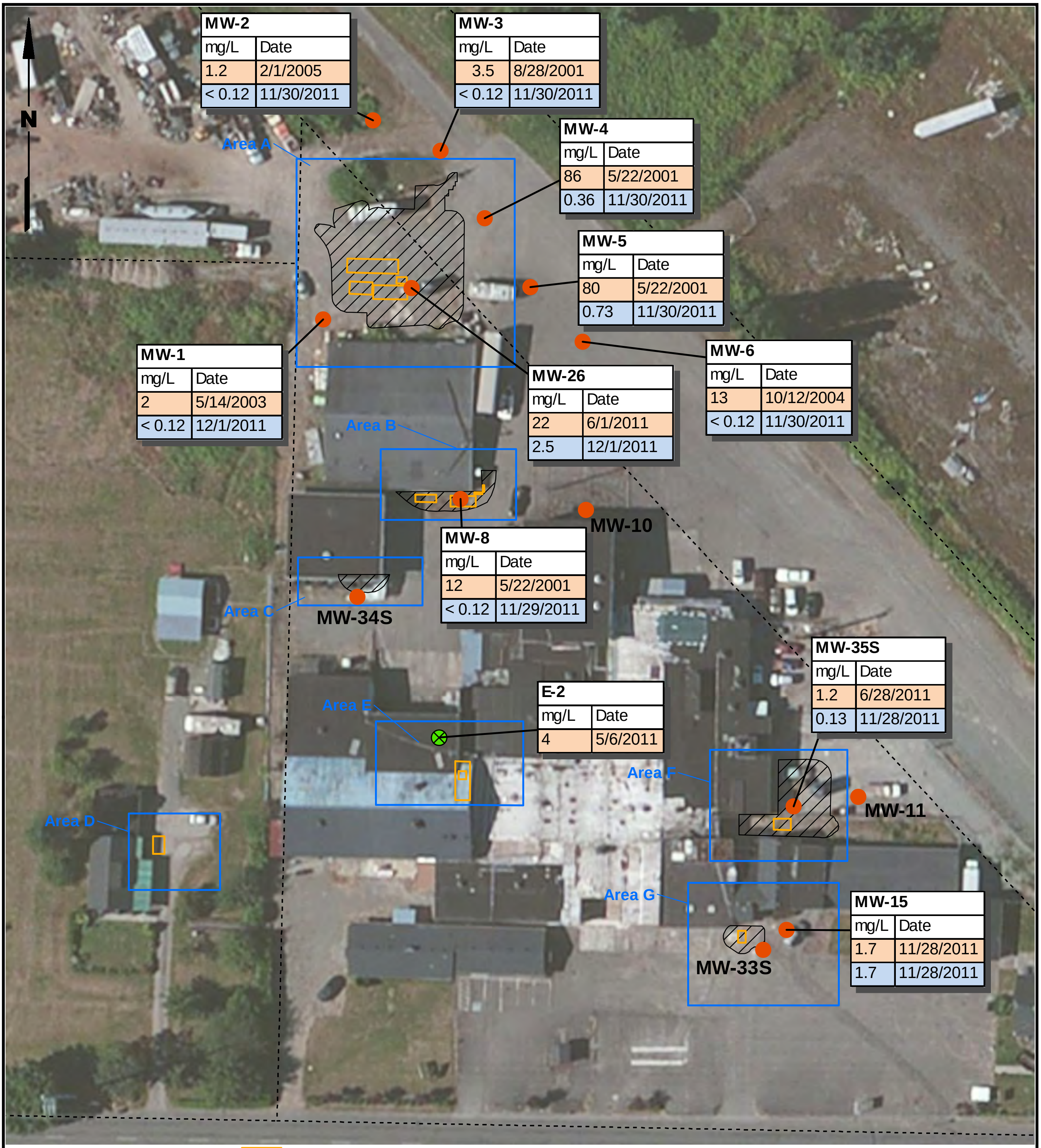


LANDAU ASSOCIATES

Pederson's Fryer Farms
Pierce County, Washington

Semi-Continuous Groundwater Elevations and Precipitation

Figure
2-16



● Shallow Monitoring Well

⊗ Soil Borings

---- Tax Parcel

☐ Area of Concern

▨ Former Excavation Area

🟧 Maximum

🟦 Most Recent

☐ UST Location

0 75 150

Scale in Feet

Data Source: Pierce County GIS; Bing Maps Aerial

Notes

1. Results shown in mg/L.
2. Data is shown only for wells with historical data concentrations that exceed the groundwater CUL of 0.5 mg/L at least once.
3. Dry = wells too dry to sample.
4. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

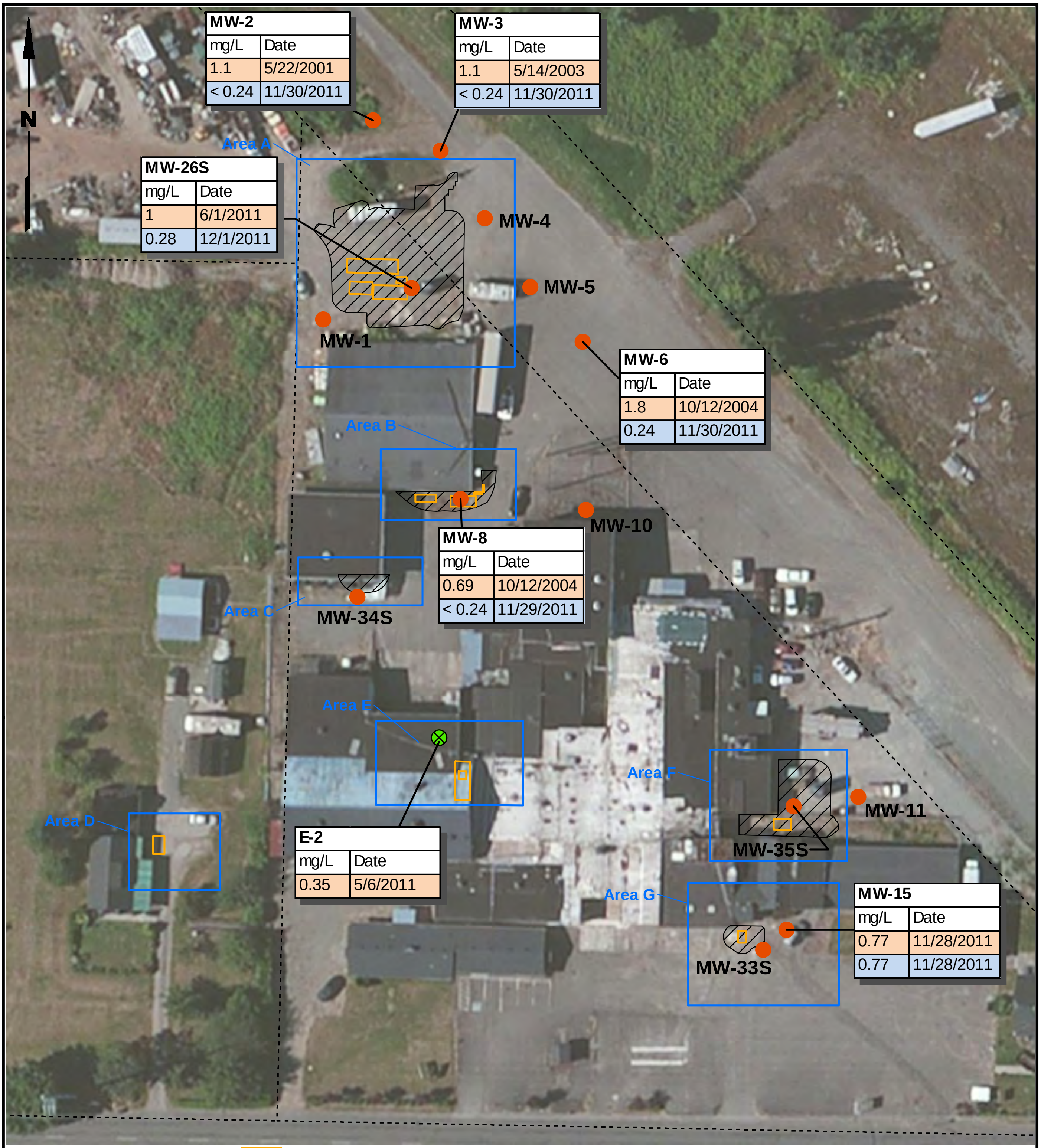
Y:\Projects\136006\010\013\Supplemental RI & FS\MapDocs\Figure 2-17 ShallowWells DRO.mxd 3/5/2012 NAD 1983 StatePlane Washington South FIPS 4602 Feet

LANDAU ASSOCIATES

Pederson's Fryer Farms
Pierce County, Washington

Shallow Groundwater Zone DRO Concentrations Maximum and Most Recent

Figure
2-17



MW-2

mg/L	Date
1.1	5/22/2001
< 0.24	11/30/2011

MW-3

mg/L	Date
1.1	5/14/2003
< 0.24	11/30/2011

MW-26S

mg/L	Date
1	6/1/2011
0.28	12/1/2011

MW-6

mg/L	Date
1.8	10/12/2004
0.24	11/30/2011

MW-8

mg/L	Date
0.69	10/12/2004
< 0.24	11/29/2011

E-2

mg/L	Date
0.35	5/6/2011

MW-15

mg/L	Date
0.77	11/28/2011
0.77	11/28/2011

Y:\Projects\136006\010\013\Supplemental RI & FS\MapDocs\Figure 2-18 ShallowWells ORO.mxd 3/5/2012 NAD 1983 StatePlane Washington South FIPS 4602 Feet

- ● Shallow Monitoring Well
- ☐ UST Location
- ⊗ Soil Borings
- ---- Tax Parcel
- ☐ Area of Concern
- ▨ Former Excavation Area
- 🟧 Maximum
- 🟦 Most Recent

0 75 150

Scale in Feet

Notes

1. Results shown in mg/L.
2. Data is shown only for wells with historical data concentrations that exceed the groundwater CUL of 0.5 mg/L at least once.
3. Dry = wells too dry to sample.
4. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Data Source: Pierce County GIS; Bing Maps Aerial

LANDAU ASSOCIATES

Pederson's Fryer Farms
Pierce County, Washington

Shallow Groundwater Zone ORO Concentrations Maximum and Most Recent

Figure
2-18

MW-26S

GRO	B	Date
1.2	0.60	6/1/2011
<0.05	ND	12/1/2011

MW-35S

GRO	B	Date
12	29	11/28/2011
12	29	11/28/2011

E-2

GRO	B	Date
NA	NA	5/6/2011

MW-15

GRO	B	Date
5.4	ND	1/10/2003
0.63	ND	11/28/2011

● Shallow Monitoring Well
☐ UST Location
⊗ Soil Borings
---- Tax Parcel
☐ Area of Concern
▨ Former Excavation Area
■ Maximum
■ Most Recent

0 75 150
Scale in Feet

Data Source: Pierce County GIS; Bing Maps Aerial

Notes

1. Results shown in mg/L.
2. Data is shown only for wells with historical data concentrations that exceed the groundwater CUL of 0.8 mg/L at least once.
3. GRO = Gasoline Range Organics,
   B = Benzene, ND = Not Detected,
   NA = Not Analyzed, Dry = wells too dry to sample.
4. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

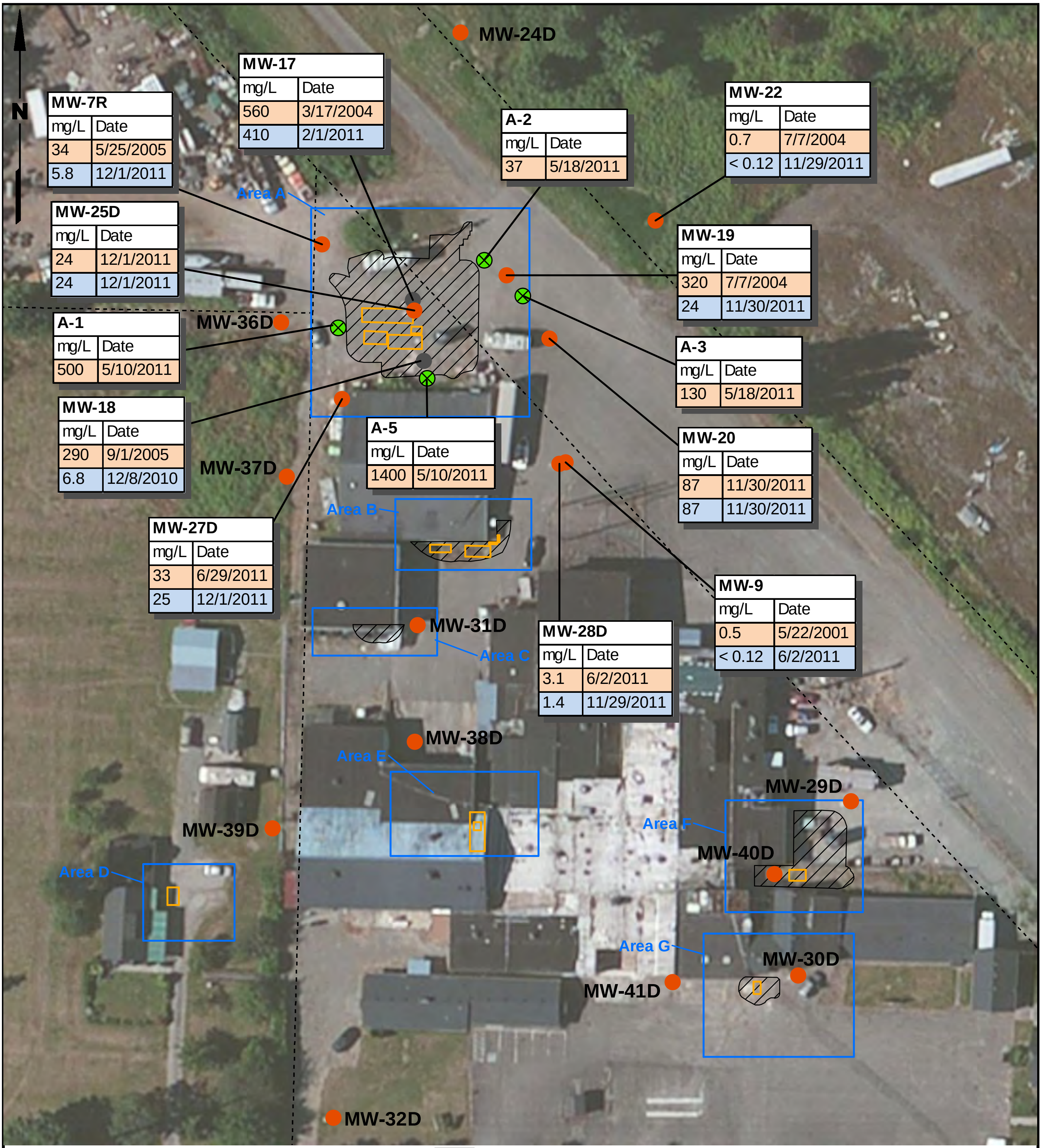
Y:\Projects\136006\010\013\Supplemental RI & FS\MapDocs\Figure 2-19 ShallowWells GRO.mxd 3/5/2012 NAD 1983 StatePlane Washington South FIPS 4602 Feet

LANDAU ASSOCIATES

Pederson's Fryer Farms
Pierce County, Washington

Shallow Groundwater Zone GRO and Benzene Concentrations Maximum and Most Recent

Figure
2-19



MW-7R

mg/L	Date
34	5/25/2005
5.8	12/1/2011

MW-17

mg/L	Date
560	3/17/2004
410	2/1/2011

A-2

mg/L	Date
37	5/18/2011

MW-22

mg/L	Date
0.7	7/7/2004
< 0.12	11/29/2011

MW-25D

mg/L	Date
24	12/1/2011
24	12/1/2011

MW-19

mg/L	Date
320	7/7/2004
24	11/30/2011

A-1

mg/L	Date
500	5/10/2011

A-3

mg/L	Date
130	5/18/2011

MW-18

mg/L	Date
290	9/1/2005
6.8	12/8/2010

A-5

mg/L	Date
1400	5/10/2011

MW-20

mg/L	Date
87	11/30/2011
87	11/30/2011

MW-27D

mg/L	Date
33	6/29/2011
25	12/1/2011

MW-9

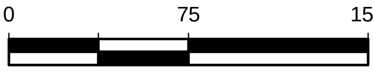
mg/L	Date
0.5	5/22/2001
< 0.12	6/2/2011

MW-28D

mg/L	Date
3.1	6/2/2011
1.4	11/29/2011

● Deep Monitoring Well
● Deep Monitoring Well, Decommissioned May 2011
⊗ Soil Borings
----- Tax Parcel
☐ Area of Concern
▨ Former Excavation Area
☐ UST Locations

🟧 Maximum
🟦 Most Recent



Scale in Feet

Data Source: Pierce County GIS; Bing Maps Aerial

Notes
1. Results shown in mg/L.
2. Data is shown only for wells with historical data concentrations that exceed the groundwater CUL of 0.5 mg/L at least once.
3. Dry = wells too dry to sample.
4. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

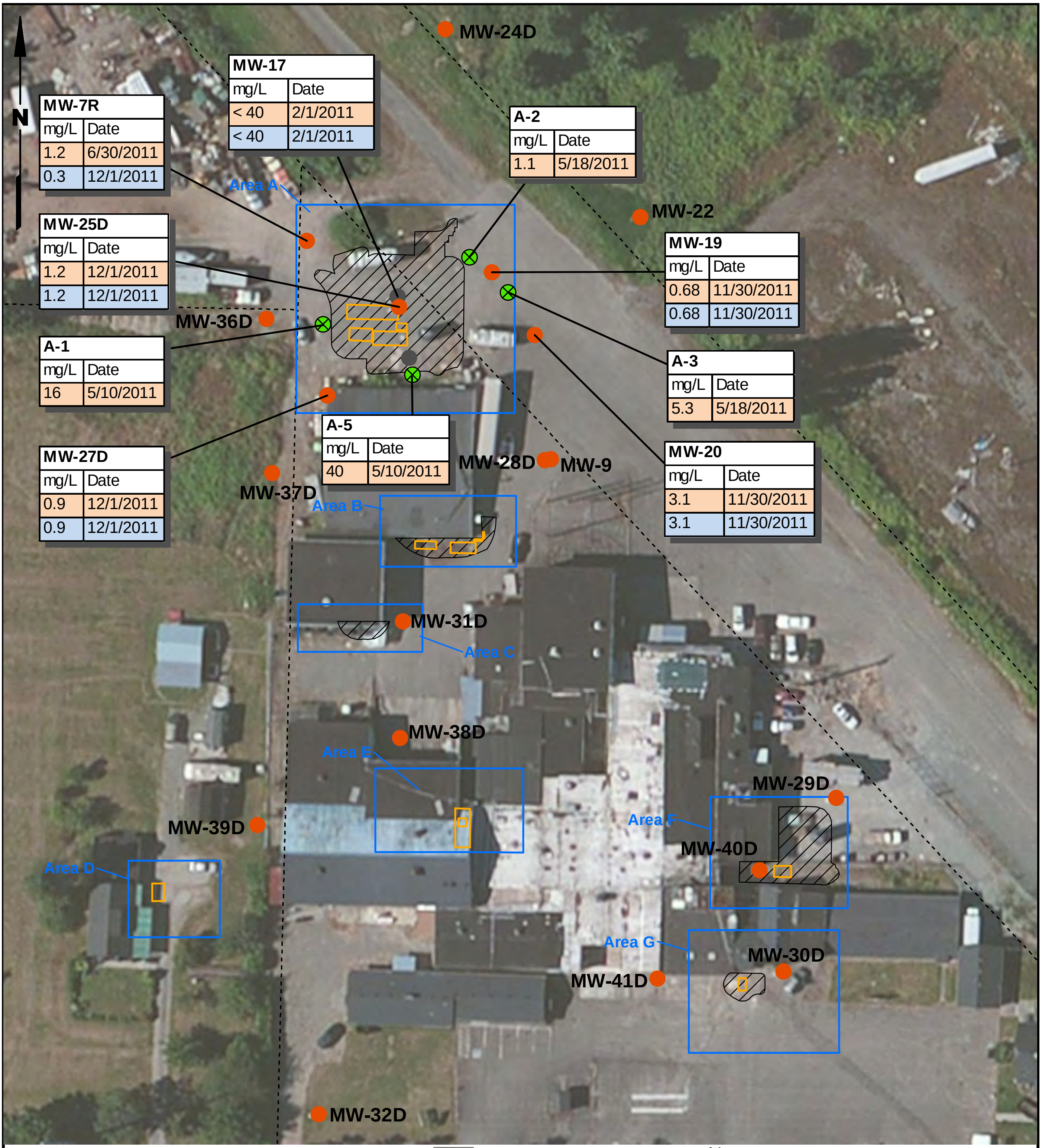
Y:\Projects\136006\010\013\Supplemental RI & FS\MapDocs\Figure 2-20 DeepWellsDRO.mxd 3/5/2012 NAD 1983 StatePlane Washington South FIPS 4602 Feet

LANDAU ASSOCIATES

Pederson's Fryer Farms
Pierce County, Washington

Deep Groundwater Zone DRO Concentrations Maximum and Most Recent

Figure
2-20



● Deep Monitoring Well

● Deep Monitoring Well, Decommissioned May 2011

⊗ Soil Borings

- - - - Tax Parcel

☐ Area of Concern

▨ Former Excavation Area

☐ UST Locations

🟧 Maximum

🟦 Most Recent

0 75 150

Scale in Feet

Data Source: Pierce County GIS; Bing Maps Aerial

Notes

1. Results shown in mg/L.
2. Data is shown only for wells with historical data concentrations that exceed the groundwater CUL of 0.5 mg/L at least once.
3. Dry = wells too dry to sample.
4. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

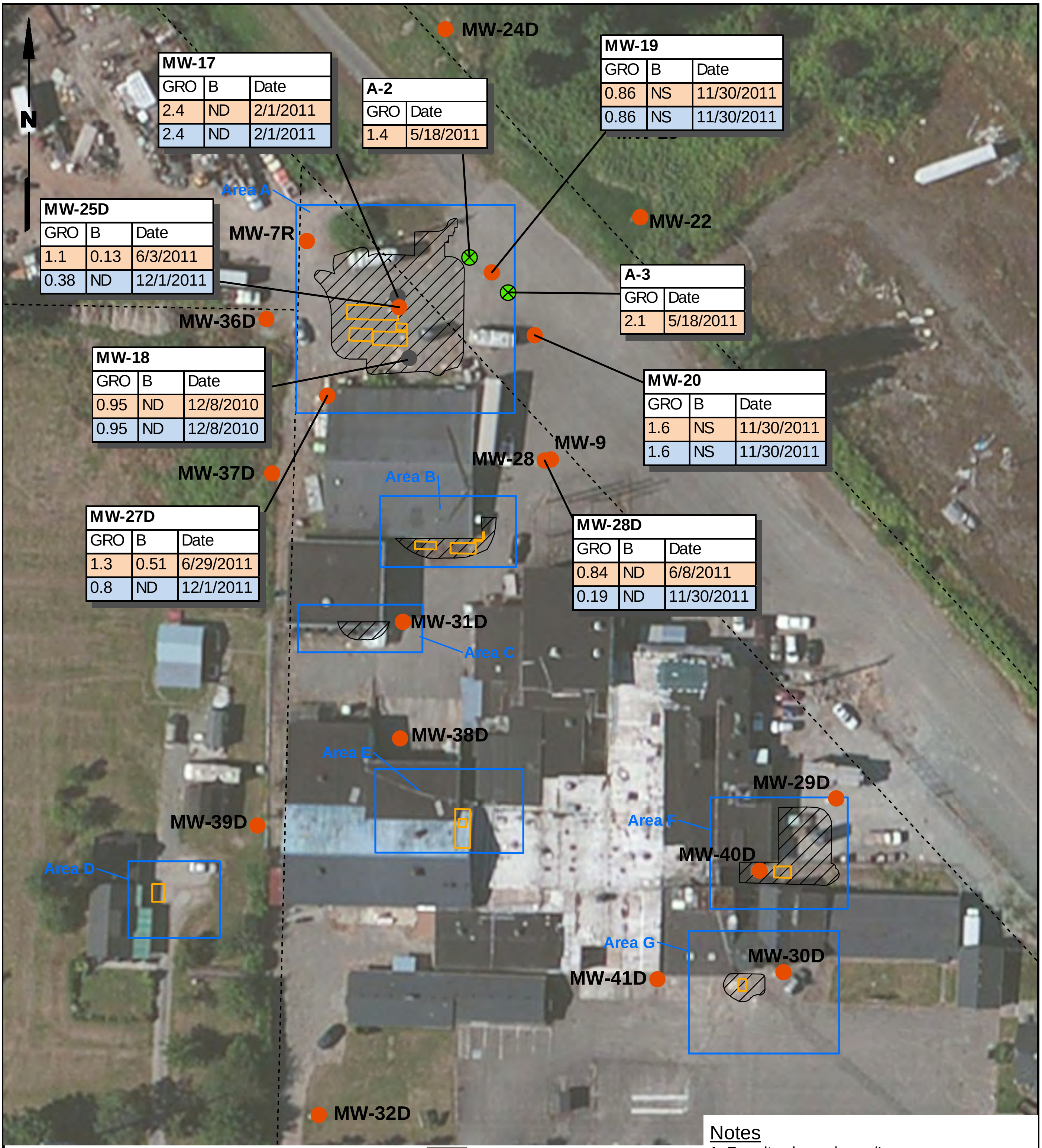
Y:\Projects\136006\010\013\Supplemental RI & FS\MapDocs\Figure 2-21 DeepWells ORO.mxd 3/5/2012 NAD 1983 StatePlane Washington South FIPS 4602 Feet

LANDAU ASSOCIATES

Pederson's Fryer Farms
Pierce County, Washington

Deep Groundwater Zone
ORO Concentrations
Maximum and Most Recent

Figure
2-21



MW-17

GRO	B	Date
2.4	ND	2/1/2011
2.4	ND	2/1/2011

A-2

GRO	Date
1.4	5/18/2011

MW-19

GRO	B	Date
0.86	NS	11/30/2011
0.86	NS	11/30/2011

MW-25D

GRO	B	Date
1.1	0.13	6/3/2011
0.38	ND	12/1/2011

A-3

GRO	Date
2.1	5/18/2011

MW-18

GRO	B	Date
0.95	ND	12/8/2010
0.95	ND	12/8/2010

MW-20

GRO	B	Date
1.6	NS	11/30/2011
1.6	NS	11/30/2011

MW-27D

GRO	B	Date
1.3	0.51	6/29/2011
0.8	ND	12/1/2011

MW-28D

GRO	B	Date
0.84	ND	6/8/2011
0.19	ND	11/30/2011

Y:\Projects\136006\010\013\Supplemental RI & FS\MapDocs\Figure 2-22 DeepWells GRO.mxd 3/5/2012 NAD 1983 StatePlane Washington South FIPS 4602 Feet

●	Deep Monitoring Well
●	Deep Monitoring Well, Decommissioned May 2011
⊗	Soil Borings
-----	Tax Parcel
☐	Area of Concern
▨	Former Excavation Area
☐	UST Location
🟧	Maximum
🟦	Most Recent

0 75 150

Scale in Feet

Data Source: Pierce County GIS; Bing Maps Aerial

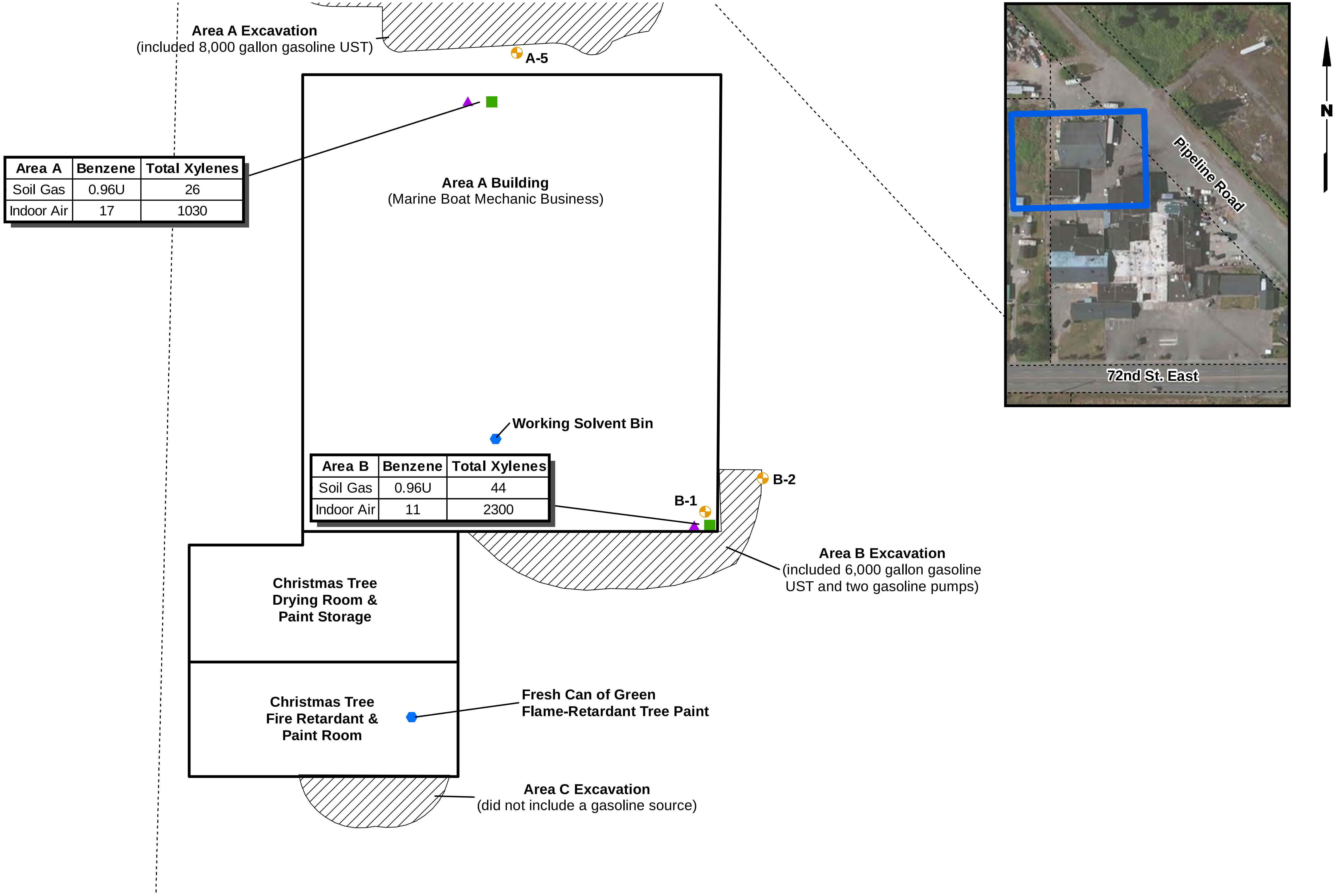
Notes
1. Results shown in mg/L.
2. Data is shown only for wells with historical data concentrations that exceed the groundwater CUL of 0.8 mg/L at least once.
3. DRO = Gasoline Range Organics, B = Benzene, ND = Not Detected, Dry = wells too dry to sample.
4. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

LANDAU ASSOCIATES

Pederson's Fryer Farms
Pierce County, Washington

Deep Groundwater Zone GRO and Benzene Concentrations Maximum and Most Recent

Figure
2-22



Area A	Benzene	Total Xylenes
Soil Gas	0.96U	26
Indoor Air	17	1030

Area B	Benzene	Total Xylenes
Soil Gas	0.96U	44
Indoor Air	11	2300

Legend

- ▲ Indoor Air Sample
- ⬢ Process Source Sample
- 🟩 Sub-Slab Soil Gas Sample
- ⊕ Relevant Former Soil Boring
- ▨ Former Excavation Area
- ------ Tax Parcel

Notes
1. All concentrations are in units micrograms per cubic meter (µg/m³).
2. If analyzed, process source samples were not analyzed to determine concentration data. Therefore, no data is shown is shown for process source samples.
3. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

0 20 40
Scale in Feet

Data Source: Pierce County GIS, Bing Maps Aerial Imagery 2010.

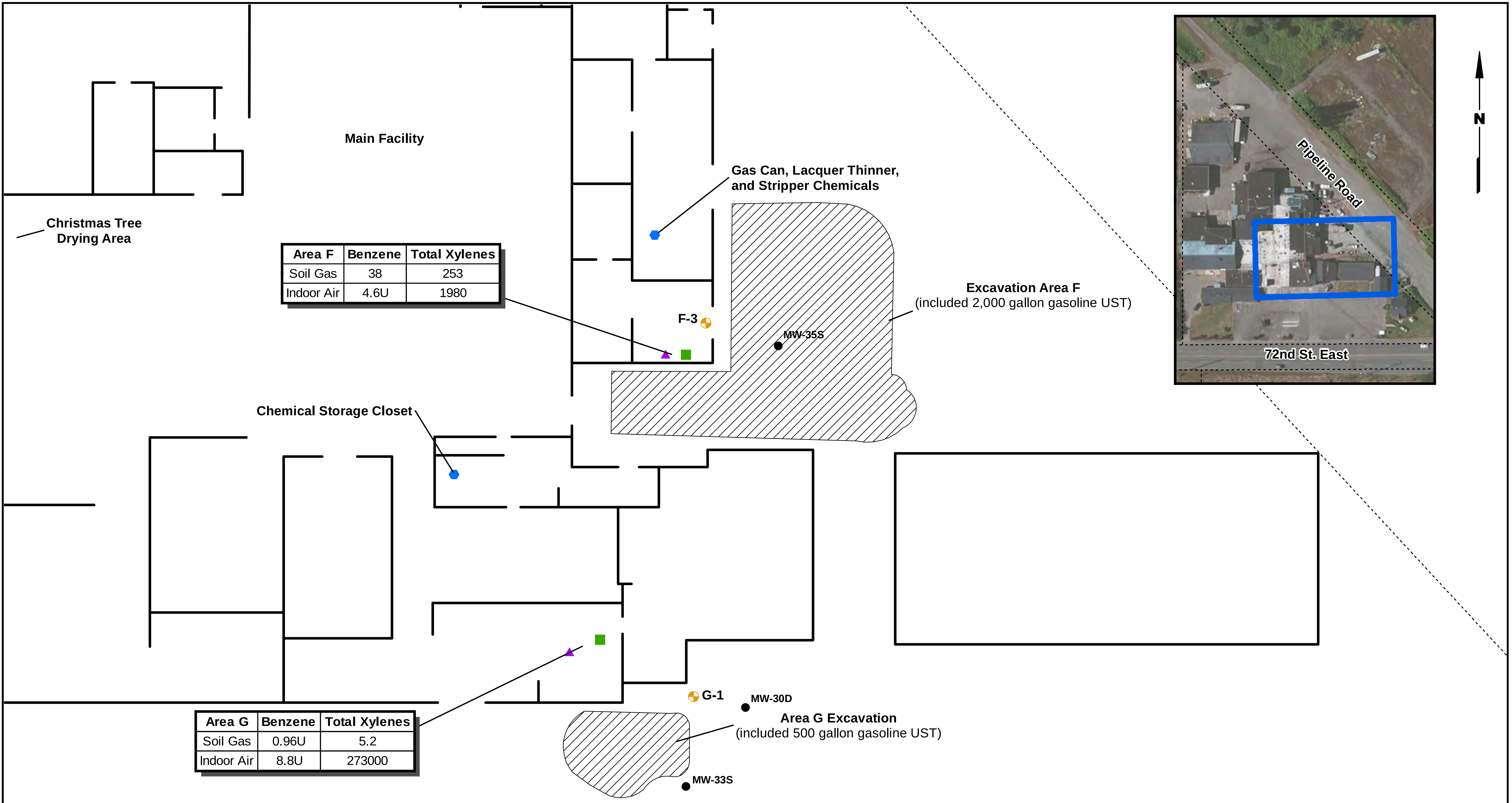
Landau Associates

Pederson's Fryer Farms
Pierce County, Washington

Vapor Intrusion Sampling Locations
Areas A and B

Figure
2-23

Y:\Projects\136006\010\013\Supplemental RI & FS\MapDocs\Figure 2-23-AreaA&B.mxd 5/10/2012 NAD 1983 StatePlane Washington South FIPS 4602 Feet



Area F	Benzene	Total Xylenes
Soil Gas	38	253
Indoor Air	4.6U	1980

Area G	Benzene	Total Xylenes
Soil Gas	0.96U	5.2
Indoor Air	8.8U	273000

Legend

▲ Indoor Air Sample
⬢ Process Source Sample
■ Sub-Slab Soil Gas Sample
⊕ Relevant Former Soil Boring
▨ Former Excavation Area
------ Tax Parcel

Notes
1. All concentrations are in units micrograms per cubic meter (µg/m³).
2. If analyzed, process source samples were not analyzed to determine concentration data. Therefore, no data is shown is shown for process source samples.
3. Portions of building shown here serve as storage for property owners at this time. Building maintenance and Christmas tree flocking chemicals are present in some rooms. Sprayed Christmas trees were drying at time of sampling.
4. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

0 20 40
Scale in Feet

Data Source: Pierce County GIS, Bing Maps Aerial Imagery 2010.

LANDAU ASSOCIATES

Pederson's Fryer Farms
Pierce County, Washington

Vapor Intrusion Sampling Locations
Areas F and G

Figure
2-24

Y:\Projects\136006\010\013\Supplemental RI & FS\MapDocs\Figure 2-24-AreaF&G.mxd 3/5/2012 NAD 1983 StatePlane Washington South FIPS 4602 Feet

TABLE 2-1
MONITORING WELL SURVEY
PEDERSON'S FRYER FARMS RI/FS

Well Name	Northing	Easting	Well Monument Rim Elevation	Top of 2" PVC Elevation	Ground Elevation
MW-1	683836.91	1170109.24	406.03	405.66	--
MW-2	683948.81	1170137.22	404.60	404.19	401.53
MW-3	683931.57	1170175.11	402.27	401.82	--
MW-4	683893.73	1170199.69	404.13	403.78	--
MW-5	683855.05	1170225.46	405.74	405.31	--
MW-6	683824.50	1170254.79	406.00	405.66	--
MW-7R	683906.90	1170100.17	405.13	404.82	--
MW-8	683736.04	1170186.29	410.21	409.90	406.90
MW-9*	683784.55	1170236.91	407.09	406.80	--
MW-10	683730.00	1170256.64	407.31	406.95	--
MW-11	683568.83	1170409.54	407.51	406.99	--
MW-12*	683609.10	1170381.54	406.37	406.11	--
MW-13*	683594.68	1170422.54	406.65	406.36	--
MW-14*	683562.80	1170449.64	Obliterated	407.11	407.50
MW-15	683494.22	1170369.24	409.43	409.06	--
MW-16*	683491.91	1170422.82	409.48	408.99	--
MW-17*	683875.71	1170151.09	405.53	405.22	--
MW-18*	683841.41	1170157.43	406.32	406.11	--
MW-19	683889.41	1170203.71	404.30	403.97	--
MW-20	683854.11	1170227.87	405.78	405.57	--
MW-21*	683956.51	1170255.41	405.38	405.00	401.48
MW-22	683920.24	1170287.10	405.79	405.03	402.53
MW24D	684025.54	1170177.75	401.96	401.93	398.79
MW-25D	683869.77	1170151.91	405.53	404.90	405.53
MW-26S	683854.44	1170158.68	405.97	405.52	405.97
MW-27D	683820.237	1170111.519	406.38	405.85	406.38
MW-28D	683783.99	1170233.359	407.09	406.79	407.09
MW-29D	683594.779	1170396.826	407.35	406.88	407.35
MW-30D	683497.266	1170367.161	409.38	409.05	409.38
MW-31D	683693.504	1170153.992	407.21	406.80	407.21
MW-32D	683417.431	1170106.817	407.35	406.88	407.35
MW-33S	683482.792	1170356.254	409.23	408.88	409.23
MW-34S	683681.206	1170128.32	406.65	406.26	406.65
MW-35S	683563.55	1170373.138	407.97	407.59	407.97
MW36D	683863.19	1170077.42	405.16	404.86	405.16
MW37D	683776.74	1170080.66	408.37	408.20	405.40
MW38D	683628.19	1170152.35	404.70	404.33	404.70
MW39D	683579.52	1170072.45	406.75	406.23	406.75
MW40D	683554.17	1170353.99	408.43	408.09	408.43
MW41D	683493.39	1170296.69	408.56	408.25	408.56

Survey: Coordinate System and Zone: Washington State Plane, South Zone Coordinates.
Horizontal Datum: NAD 83(91), South Zone, US FEET. Vertical Datum: NAVD88, US FEET.
Ground elevation surveyed for above-ground monuments and MW-14. MW-14 was
originally a flush mount but was obliterated so it could not be surveyed.
All units in feet.
-- = No data
* = Decommissioned well

TABLE 2-2
MONITORING WELL DETAILS
PEDERSON'S FRYER FARMS RI/FS

	Aquifer Designation	Soil Exploration Depth (ft) (a)	Measured Well Depth (ft) (a)*	Screen Length (ft)	Screened Interval (ft) (a)
MW-1	S	35	34.9	20	15-35
MW-2	S	35	38.2	20	18-38
MW-3	S	35	34.4	20	14-34
MW-4	S	40	39.5	25	15-40
MW-5	S	40	39.6	25	15-40
MW-6	S	45	44.3	30	14-44
MW-8	S	45	47.9	30	18-48
MW-10	S	45	44.7	30	15-45
MW-11	S	40	38.9	25	14-39
MW-15	S	30	29.9	15	15-30
MW-26S	S	32	28.3	10	18-28
MW-33S	S	30	29.9	15	15-30
MW-34S	S	15	15.2	10	5-15
MW-35S	S	25	20.2	10	10-20
MW-7R	D	55	55.3	30	25-55
MW-9	D	50	49.1	35	14-49
MW-19	D	65	60.2	20	40-60
MW-20	D	65	61.9	20	42-62
MW-22	D	57	56.6	30	27-57
MW-24D	**D**	**65**	**63.0**	**15**	**48-63**
MW-25D	D	61	54.9	15	40-55
MW-27D	D	60	60.2	10	50-60
MW-28D	D	60	60.0	10	50-60
MW-29D	D	60	60.6	15	46-61
MW-30D	D	60	61.2	15	46-61
MW-31D	D	60	59.6	15	45-60
MW-32D	D	60	60.1	10	50-60
MW-36D	**D**	**65**	**59.2**	**15**	**44-59**
MW-37D	**D**	**65**	**65.3**	**15**	**50-65**
MW-38D	**D**	**65**	**62.3**	**15**	**47-62**
MW-39D	**D**	**65**	**65.5**	**15**	**51-66**
MW-40D	**D**	**65**	**65.2**	**15**	**50-65**
MW-41D	**D**	**62**	**63.3**	**15**	**48-63**

S = Shallow water bearing zone
D = Deep water bearing zone
Bold wells were installed September 2011. Well depths were measured September 2011.
(a) All depths given in feet below top of PVC casing. Pre-RI soil exploration depths are those reported on well logs.
* = Pre-RI wells measured December 2010. Well MW-4 re-measured September 2011. RI wells measured May 2011. See text for explanation.

TABLE 2-3
SHALLOW WATER BEARING ZONE GROUNDWATER MEASUREMENTS
PEDERSON'S FRYER FARMS RI/FS

							Groundwater Elevation (ft, NAVD88)							
Well	MW-1	MW-2	MW-3	MW-4	MW-5	MW-6	MW-8	MW-10	MW-11	MW-15	MW-26S	MW-33S	MW-34S	MW-35S
Top of PVC Elevation	405.7	404.2	401.8	403.8	405.3	405.7	409.9	407.0	407.0	409.1	405.5	408.9	406.3	407.6
05/27/11	375.2	370.5	370.5	370.5	372.6	368.1	366.6	364.1	369.9	383.5	379.1	379.4	401.8	390.5
06/01/11	375.1	369.5	368.6	372.1	373.4	366.9	366.3	363.1	369.8	382.9	378.9	379.1	401.5	389.8
06/28/11	374.0	366.5	368.0	366.9	369.1	364.5	366.0	363.0	369.0	382.1	378.0	Dry	400.7	389.1
07/27/11	374.5	366.5	368.0	366.3	368.4	364.2	365.7	362.9	368.8	381.1	377.5	Dry	400.0	388.1
08/26/11	375.5	366.5	368.1	368.0	367.9	362.0	365.1	362.8	368.7	380.0	377.4	Dry	399.1	Dry
09/20/11	375.7	366.4	368.0	365.1	367.6	361.8	364.5	362.7	368.6	379.4	377.5	379.3	398.9	387.6
10/28/11	374.9	365.2	370.7	366.2	370.7	365.2	366.3	363.2	368.9	381.1	379.0	379.4	400.8	389.8
11/28/11	376.9	374.5	375.6	373.7	374.2	369.1	369.0	363.5	369.3	383.7	383.3	379.3	401.8	390.8
01/04/12	377.8	371.4	374.4	372.6	373.8	368.6	367.0	363.3	369.2	383.8	382.8	Dry	402.1	391.8
							Depth to Water (ft)							
05/27/11	30.4	33.7	31.3	33.3	32.8	37.6	43.3	42.9	37.1	25.6	26.5	29.5	4.5	17.1
06/01/11	30.6	34.7	33.3	31.7	31.9	38.8	43.6	43.9	37.2	26.2	26.7	29.8	4.7	17.8
06/28/11	31.6	37.7	33.8	36.9	36.2	41.1	43.9	44.0	38.0	26.9	27.5	Dry	5.6	18.5
07/27/11	31.2	37.7	33.8	37.5	36.9	41.4	44.2	44.1	38.2	27.9	28.0	Dry	6.3	19.5
08/26/11	30.2	37.7	33.8	35.8	37.4	43.7	44.8	44.1	38.3	29.1	28.1	Dry	7.2	Dry
09/20/11	29.9	37.8	33.9	38.7	37.8	43.9	45.4	44.3	38.4	29.6	28.1	29.6	7.4	20.0
10/28/11	30.8	39.0	31.2	37.6	34.6	40.5	43.6	43.7	38.1	28.0	26.5	29.5	5.5	17.8
11/28/11	28.8	29.7	26.2	30.1	31.1	36.6	40.9	43.5	37.7	25.4	22.3	29.5	4.5	16.8
01/04/12	27.9	32.8	27.4	31.2	31.5	37.0	42.9	43.7	37.8	25.3	22.7	Dry	4.2	15.8
							Water Level Fluctuation, 5/27/2011 to 1/4/2012 (ft)							
	3.7	9.3	7.7	8.6	6.6	7.3	4.5	1.4	1.3	4.4	5.8	0.2	3.2	4.2

DCOM = Decommissioned

-- = Well not installed or not measured

TABLE 2-4
DEEP WATER BEARING ZONE GROUNDWATER LEVEL MEASUREMENTS
PEDERSON'S FRYER FARMS RI/FS

Groundwater Level Elevation (ft, NAVD88)

Well	MW-7R	MW-9	MW-19	MW-20	MW-22	MW-24D	MW-25D	MW-27D	MW-28D	MW-29D	MW-30D	MW-31D	MW-32D	MW-36D	MW-37D	MW-38D	MW-39D	MW-40D	MW-41D
Top of PVC Elevation	404.8	406.8	404.0	405.6	405.0	401.9	404.9	405.9	406.8	406.9	409.1	406.8	406.9	405.9	408.4	404.7	406.8	408.4	408.6
05/27/11	--	363.3	362.4	362.5	360.8	--	362.9	355.0	357.6	359.8	358.2	353.9	353.6	--	--	--	--	--	--
06/01/11	365.5	361.7	361.7	361.7	359.7	--	362.3	354.7	357.8	359.3	357.8	353.7	353.4	--	--	--	--	--	--
06/28/11	360.6	359.4	358.9	358.8	353.4	--	359.9	353.9	356.8	357.2	356.1	353.0	353.2	--	--	--	--	--	--
07/27/11	358.7	358.4	356.8	356.9	351.2	--	357.9	352.4	354.1	354.3	352.0	351.7	352.2	--	--	--	--	--	--
08/26/11	349.9	358.7	355.8	354.0	349.5	--	356.9	351.2	353.0	353.7	351.1	351.2	351.0	--	--	--	--	--	--
09/20/11	349.8	358.3	344.9	349.4	349.4	--	356.2	350.4	351.1	353.5	350.4	350.5	350.3	--	--	--	--	--	--
10/28/11	357.9	358.3	347.9	352.8	Dry	Dry	358.8	349.2	350.3	353.5	349.9	349.9	348.1	Dry	Dry	Dry	Dry	Dry	349.3
11/28/11	361.1	360.2	357.9	359.2	354.0	Dry	360.5	351.1	352.9	354.9	350.7	350.1	348.4	Dry	343.4	343.1	Dry	Dry	348.9
01/04/12	362.2	350.2	359.6	360.1	356.1	Dry	360.5	352.1	352.0	355.4	353.7	351.3	348.4	Dry	343.7	342.5	Dry	Dry	349.3
Depth to Water (ft)																			
05/27/11	--	43.5	41.6	43.0	44.3	--	42.1	50.8	49.2	47.1	50.8	52.9	53.3	--	--	--	--	--	--
06/01/11	39.4	45.1	42.3	43.9	45.4	--	42.6	51.2	49.0	47.6	51.2	53.1	53.5	--	--	--	--	--	--
06/28/11	44.2	47.4	45.1	46.7	51.6	--	45.0	51.9	50.0	49.7	52.9	53.8	53.7	--	--	--	--	--	--
07/27/11	46.2	48.4	47.1	48.7	53.8	--	47.0	53.5	52.7	52.6	57.1	55.1	54.7	--	--	--	--	--	--
08/26/11	54.9	48.1	48.2	51.6	55.5	--	48.0	54.6	53.8	53.2	58.0	55.6	55.8	--	--	--	--	--	--
09/20/11	55.0	48.5	59.1	56.1	55.6	--	48.7	55.5	55.7	53.4	58.6	56.3	56.6	--	--	--	--	--	--
10/28/11	46.9	48.5	56.1	52.8	Dry	Dry	46.2	56.7	56.5	53.4	59.2	56.9	58.8	Dry	Dry	Dry	Dry	Dry	59.3
11/28/11	43.7	46.6	46.1	46.4	51.0	Dry	44.4	54.8	53.9	52.0	58.3	56.7	58.5	Dry	65.0	61.7	Dry	Dry	59.7
01/04/12	42.7	56.6	44.4	45.4	48.9	Dry	44.5	53.7	54.8	51.5	55.3	55.6	58.5	Dry	64.7	62.2	Dry	Dry	59.3
Water Level Fluctuation, 5/27/2011 to 1/4/2012 (ft)																			
	15.6	13.1	17.5	13.1	11.3	0.0	6.6	5.9	7.5	6.3	8.4	4.0	5.5	0.0	0.3	0.5	0.0	0.0	0.4

DCOM = Decommissioned

-- = Not measured or not installed.

TABLE 2-5
SUPPLEMENTAL RI MONITORING WELL SOIL ANALYTICAL RESULTS
PEDERSON'S FRYER FARMS RI/FS

	MTCA Method A Soil Cleanup Level for Unrestricted Land Uses (a)	MW-38D (5.5.5) 286881 9/16/2011	MW-39D (8-8.25) 286632 9/14/2011	MW-40D (10-10.25) 286631/286882 9/15/2011
TOTAL PETROLEUM HYDROCARBONS (mg/kg)				
NWTPH-Dx				
Diesel Range Organics	2000	13 U	14 U	**89**
Lube Oil	2000	27 U	28 U	**270**
NWTPH-Gx				
Gasoline Range Organics	30/100 (b)			**600** J
BTEX (mg/kg)				
Method SW8021B				
Benzene	0.03			0.43 U
Toluene	7			1.1 U
Ethylbenzene	6			1.1 U
m, p-Xylene				**3.3**
o-Xylene				2.1 U
Total Xylenes	9 (c)			**3.3**
PAHs (mg/kg)				
Method 8270C				
Naphthalene				
2-Methylnaphthalene				
1-Methylnaphthalene				
Total Naphthalenes	5 (d)			
Acenaphthylene				
Acenaphthene				
Fluorene				
Phenanthrene				
Anthracene				
Fluoranthene				
Pyrene				
Benzo[a]anthracene				
Chrysene				
Benzo[b]fluoranthene				
Benzo[k]fluoranthene				
Benzo[a]pyrene				
Indeno[1,2,3-cd]pyrene				
Dibenz(a,h)anthracene				
Benzo[g,h,i]perylene				
Dibenzofuran				
cPAH TEQ	0.1 (e)			

TABLE 2-5
SUPPLEMENTAL RI MONITORING WELL SOIL ANALYTICAL RESULTS
PEDERSON'S FRYER FARMS RI/FS

	MTCA Method A Soil Cleanup Level for Unrestricted Land Uses (a)	MW-38D (5.5.5) 286881 9/16/2011	MW-39D (8-8.25) 286632 9/14/2011	MW-40D (10-10.25) 286631/286882 9/15/2011
TOTAL METALS (mg/kg)				
Method 6010B				
Lead	250			**28**
PCBs (mg/kg)				
Method 8082				
PCB-1016				
PCB-1221				
PCB-1232				
PCB-1242				
PCB-1248				
PCB-1254				
PCB-1260				
Total PCBs	1			
CONVENTIONAL (%)				
Percent Solids		**91**	**86**	**88**
Percent Moisture		**8.7**	**14**	**12**

U = Indicates the compound was undetected at the reported concentration.
J = Indicates the analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
UJ = The analyte was not detected in the sample; the reported sample reporting limit is an estimate.
Bold = Detected compound.
Box = Exceedance of cleanup level.
-- = A cleanup level is not available for the individual constituent.
(a) All cleanup levels are MTCA Method A
(b) MTCA Method A cleanup level is 30 mg/kg if benzene is present and 100 mg/kg if benzene is not present.
(c) Cleanup level cannot be exceeded by the sum of individual xylene concentrations.
(d) Cleanup level cannot be exceeded by the sum of Naphthalene, 2-Methylnaphthalene, and 1-Methylnaphthalene.
(e) Cleanup level based on toxicity equivalency methodology.

TABLE 2-6
RI AND SUPPLEMENTAL RI SITE WIDE GROUNDWATER ANALYTICAL RESULTS
PEDERSON'S FRYER FARMS RI/FS

	MTCA Method A	MW-01	MW-01	MW-01	MW-01	MW-02	MW-02	MW-02	MW-03
	Cleanup Level for	RZ78C	26582-4	27103-7	30108-2	RZ78Q	26582-1	30090-5	RZ78R
	Groundwater (a)	12/08/2010	6/3/2011	6/29/2011	12/1/2011	12/07/2010	6/3/2011	11/30/2011	12/07/2010
TOTAL PETROLEUM HYDROCARBONS (mg/L)									
NWTPH-Dx									
Diesel Range Organics	0.5	**0.14**	0.12 U	0.12 U	0.12 U	0.10 U	0.12 U	0.12 U	0.10 U
Lube Oil	0.5	0.20 U	0.24 U	0.24 U	0.24 U	0.20 U	0.24 U	0.24 U	0.20 U
NWTPH-Gx									
Gasoline Range Organics	0.8/1.0 (b)	0.10 U	0.050 U	0.050 U	0.050 U	0.10 U	0.050 U	0.050 U	0.10 U
BTEX (µg/L)									
Method SW8021B / SW8260B									
Benzene	5	0.25 U	0.50 U			0.25 U	0.50 U		0.25 U
Methyl tert-butyl ether	20								
Toluene	1000	0.25 U	0.50 U			**1.2**	0.50 U		0.25 U
Ethylbenzene	700	0.25 U	0.50 U			0.25 U	0.50 U		0.25 U
m, p-Xylene	1000 (c)	0.50 U	1.0 U			0.50 U	1.0 U		0.50 U
o-Xylene	1000 (c)	0.25 U	1.0 U			0.25 U	1.0 U		0.25 U
CONVENTIONALS (mg/L)									
Nitrate (300.0)	10		0.90 U				**1.8**		
Sulfate (300.0)	250		**5.2**				**9.3**		
Total Organic Carbon (415.1)	--								
Alkalinity (SM 2320b)	--								
DISSOLVED METALS (µg/L)									
Method 200.8									
Lead	15								
Manganese	--								
DISSOLVED GASES (mg/L)									
Method RSK 175 M									
Methane	--								

TABLE 2-6
RI AND SUPPLEMENTAL RI SITE WIDE GROUNDWATER ANALYTICAL RESULTS
PEDERSON'S FRYER FARMS RI/FS

	MTCA Method A Cleanup Level for Groundwater (a)	MW-01 RZ78C 12/08/2010	MW-01 26582-4 6/3/2011	MW-01 27103-7 6/29/2011	MW-01 30108-2 12/1/2011	MW-02 RZ78Q 12/07/2010	MW-02 26582-1 6/3/2011	MW-02 30090-5 11/30/2011	MW-03 RZ78R 12/07/2010
PAHs (µg/L)									
Method 8270C SIM									
Naphthalene	--								
2-Methylnaphthalene	--								
1-Methylnaphthalene	--								
Total Naphthalenes (d)	160								
Acenaphthylene	--								
Acenaphthene	--								
Fluorene	--								
Phenanthrene	--								
Anthracene	--								
Fluoranthene	--								
Pyrene	--								
Benzo[a]anthracene	--								
Chrysene	--								
Benzo[b]fluoranthene	--								
Benzo[k]fluoranthene	--								
Benzo[a]pyrene	--								
Indeno[1,2,3-cd]pyrene	--								
Dibenz(a,h)anthracene	--								
Benzo[g,h,i]perylene	--								
cPAH TEQ (e)	0.1 (f)								
EDB (µg/L)									
Method 8011									
Ethylene Dibromide	0.01								
VOLATILES (µg/L)									
Method 8260B									
1,2-Dichloroethane	5								
Methyl tert-butyl ether	20								
Naphthalene	--								

TABLE 2-6
RI AND SUPPLEMENTAL RI SITE WIDE GROUNDWATER ANALYTICAL RESULTS
PEDERSON'S FRYER FARMS RI/FS

	MTCA Method A Cleanup Level for Groundwater (a)	MW-03 30090-8 11/30/2011	MW-04 RZ79B 12/07/2010	MW-04 SH05B 2/01/2011	MW-04 26596-4 6/5/2011	MW-04 30090-6 11/30/2011	MW-05 RZ78G 12/08/2010	MW-05 26596-2 6/5/2011	MW-05 30090-3 11/30/2011	MW-06 RZ78H 12/08/2010
TOTAL PETROLEUM HYDROCARBONS (mg/L)										
NWTPH-Dx										
Diesel Range Organics	0.5	0.12 U	**0.31**	**0.66**	**0.17**	**0.36**	0.10 U	**0.12**	**0.73**	0.10 U
Lube Oil	0.5	0.24 U	0.20 U	0.20 U	0.24 U	0.24 U	0.20 U	0.24 U	0.24 U	0.20 U
NWTPH-Gx										
Gasoline Range Organics	0.8/1.0 (b)	0.050 U	**0.11**	0.25 U	**0.070**	**0.074**	0.10 U	**0.070**	0.050 U	0.10 U
BTEX (µg/L)										
Method SW8021B / SW8260B										
Benzene	5		0.25 U	1.0 U			0.25 U			0.25 U
Methyl tert-butyl ether	20									
Toluene	1000		0.25 U	1.0 U			**0.30**			0.25 U
Ethylbenzene	700		0.25 U	1.0 U			0.25 U			0.25 U
m, p-Xylene	1000 (c)		0.50 U	1.0 U			**0.50**			0.50 U
o-Xylene	1000 (c)		0.25 U	1.0 U			**0.30**			0.25 U
CONVENTIONALS (mg/L)										
Nitrate (300.0)	10			**1.2**	**1.0**					
Sulfate (300.0)	250			**6.1**	**4.2**					
Total Organic Carbon (415.1)	--				**17**					
Alkalinity (SM 2320b)	--				**47**					
DISSOLVED METALS (µg/L)										
Method 200.8										
Lead	15									
Manganese	--				**350**					
DISSOLVED GASES (mg/L)										
Method RSK 175 M										
Methane	--				**0.0359**					

TABLE 2-6
RI AND SUPPLEMENTAL RI SITE WIDE GROUNDWATER ANALYTICAL RESULTS
PEDERSON'S FRYER FARMS RI/FS

	MTCA Method A Cleanup Level for Groundwater (a)	MW-03 30090-8 11/30/2011	MW-04 RZ79B 12/07/2010	MW-04 SH05B 2/01/2011	MW-04 26596-4 6/5/2011	MW-04 30090-6 11/30/2011	MW-05 RZ78G 12/08/2010	MW-05 26596-2 6/5/2011	MW-05 30090-3 11/30/2011	MW-06 RZ78H 12/08/2010
PAHs (µg/L)										
Method 8270C SIM										
Naphthalene	--									
2-Methylnaphthalene	--									
1-Methylnaphthalene	--									
Total Naphthalenes (d)	160									
Acenaphthylene	--									
Acenaphthene	--									
Fluorene	--									
Phenanthrene	--									
Anthracene	--									
Fluoranthene	--									
Pyrene	--									
Benzo[a]anthracene	--									
Chrysene	--									
Benzo[b]fluoranthene	--									
Benzo[k]fluoranthene	--									
Benzo[a]pyrene	--									
Indeno[1,2,3-cd]pyrene	--									
Dibenz(a,h)anthracene	--									
Benzo[g,h,i]perylene	--									
cPAH TEQ (e)	0.1 (f)									
EDB (µg/L)										
Method 8011										
Ethylene Dibromide	0.01									
VOLATILES (µg/L)										
Method 8260B										
1,2-Dichloroethane	5									
Methyl tert-butyl ether	20									
Naphthalene	--									

TABLE 2-6
RI AND SUPPLEMENTAL RI SITE WIDE GROUNDWATER ANALYTICAL RESULTS
PEDERSON'S FRYER FARMS RI/FS

	MTCA Method A Cleanup Level for Groundwater (a)	MW-06 26524-7 6/1/2011	MW-06 30090-4 11/30/2011	MW-07R RZ78A 12/08/2010	MW-07R 26596-3 6/5/2011	MW-07R 27133-4 6/30/2011	MW-07R 30108-1 12/1/2011	Dup of MW-07R MW-999 30108-4 12/1/2011	MW-08 RZ78K 12/07/2010
TOTAL PETROLEUM HYDROCARBONS (mg/L)									
NWTPH-Dx									
Diesel Range Organics	0.5	0.12 UJ	0.12 U	**1.8**	**12**	**27**	**5.8** J	**7.3** J	0.10 U
Lube Oil	0.5	0.24 UJ	0.24 U	0.20 U	**0.56**	**1.2**	**0.30**	**0.38**	0.20 U
NWTPH-Gx									
Gasoline Range Organics	0.8/1.0 (b)	0.050 U	0.050 U	0.10 U	**0.061**	**0.41**	**0.30** J	**0.078** J	0.10 U
BTEX (µg/L)									
Method SW8021B / SW8260B									
Benzene	5	0.50 U		0.25 U	0.50 U				0.25 U
Methyl tert-butyl ether	20								
Toluene	1000	0.50 U		0.25 U	0.50 U				0.25 U
Ethylbenzene	700	0.50 U		0.25 U	0.50 U				0.25 U
m, p-Xylene	1000 (c)	1.0 U		0.50 U	1.0 U				0.50 U
o-Xylene	1000 (c)	1.0 U		0.25 U	1.0 U				0.25 U
CONVENTIONALS (mg/L)									
Nitrate (300.0)	10				0.90 U				
Sulfate (300.0)	250				**3.0**				
Total Organic Carbon (415.1)	--								
Alkalinity (SM 2320b)	--								
DISSOLVED METALS (µg/L)									
Method 200.8									
Lead	15								
Manganese	--								
DISSOLVED GASES (mg/L)									
Method RSK 175 M									
Methane	--								

TABLE 2-6
RI AND SUPPLEMENTAL RI SITE WIDE GROUNDWATER ANALYTICAL RESULTS
PEDERSON'S FRYER FARMS RI/FS

	MTCA Method A Cleanup Level for Groundwater (a)	MW-06 26524-7 6/1/2011	MW-06 30090-4 11/30/2011	MW-07R RZ78A 12/08/2010	MW-07R 26596-3 6/5/2011	MW-07R 27133-4 6/30/2011	MW-07R 30108-1 12/1/2011	Dup of MW-07R MW-999 30108-4 12/1/2011	MW-08 RZ78K 12/07/2010
PAHs (µg/L)									
Method 8270C SIM									
Naphthalene	--								
2-Methylnaphthalene	--								
1-Methylnaphthalene	--								
Total Naphthalenes (d)	160								
Acenaphthylene	--								
Acenaphthene	--								
Fluorene	--								
Phenanthrene	--								
Anthracene	--								
Fluoranthene	--								
Pyrene	--								
Benzo[a]anthracene	--								
Chrysene	--								
Benzo[b]fluoranthene	--								
Benzo[k]fluoranthene	--								
Benzo[a]pyrene	--								
Indeno[1,2,3-cd]pyrene	--								
Dibenz(a,h)anthracene	--								
Benzo[g,h,i]perylene	--								
cPAH TEQ (e)	0.1 (f)								
EDB (µg/L)									
Method 8011									
Ethylene Dibromide	0.01								
VOLATILES (µg/L)									
Method 8260B									
1,2-Dichloroethane	5								
Methyl tert-butyl ether	20								
Naphthalene	--								

TABLE 2-6
RI AND SUPPLEMENTAL RI SITE WIDE GROUNDWATER ANALYTICAL RESULTS
PEDERSON'S FRYER FARMS RI/FS

	MTCA Method A Cleanup Level for Groundwater (a)	MW-08 26533-8 6/2/2011	MW-08 27103-5 6/29/2011	MW-08 30059-2 11/29/2011	MW-09 RZ78M 12/07/2010	MW-09 26533-12 6/2/2011	MW-10 RZ78O 12/07/2010	MW-10 30059-1 11/29/2011	MW-11 RZ78J 12/07/2010	MW-11 26524-2 6/1/2011
TOTAL PETROLEUM HYDROCARBONS (mg/L)										
NWTPH-Dx										
Diesel Range Organics	0.5	25 UJ	0.12 U	0.12 U	0.10 U	0.12 UJ	0.10 U	0.12 U	0.10 UJ	0.12 UJ
Lube Oil	0.5	50 UJ	0.24 U	0.24 U	0.20 U	0.24 UJ	0.20 U	0.24 U	0.20 UJ	0.24 UJ
NWTPH-Gx										
Gasoline Range Organics	0.8/1.0 (b)	0.050 U	0.050 U	0.050 U	0.10 U	**0.14**	0.10 U	**0.057**	0.10 U	0.050 U
BTEX (µg/L)										
Method SW8021B / SW8260B										
Benzene	5	0.50 U			0.25 U	0.50 U	0.25 U		0.25 U	0.50 U
Methyl tert-butyl ether	20									
Toluene	1000	0.50 U			0.25 U	0.50 U	0.25 U		0.25 U	0.50 U
Ethylbenzene	700	0.50 U			0.25 U	0.50 U	0.25 U		0.25 U	0.50 U
m, p-Xylene	1000 (c)	1.0 U			0.50 U	1.0 U	0.50 U		0.50 U	1.0 U
o-Xylene	1000 (c)	1.0 U			0.25 U	1.0 U	0.25 U		0.25 U	1.0 U
CONVENTIONALS (mg/L)										
Nitrate (300.0)	10	0.90 U				**4.7**				0.90 U
Sulfate (300.0)	250	**9.3**				**9.7**				**12**
Total Organic Carbon (415.1)	--					**3.5**				
Alkalinity (SM 2320b)	--									
DISSOLVED METALS (µg/L)										
Method 200.8										
Lead	15									
Manganese	--									
DISSOLVED GASES (mg/L)										
Method RSK 175 M										
Methane	--									

TABLE 2-6
RI AND SUPPLEMENTAL RI SITE WIDE GROUNDWATER ANALYTICAL RESULTS
PEDERSON'S FRYER FARMS RI/FS

	MTCA Method A Cleanup Level for Groundwater (a)	MW-08 26533-8 6/2/2011	MW-08 27103-5 6/29/2011	MW-08 30059-2 11/29/2011	MW-09 RZ78M 12/07/2010	MW-09 26533-12 6/2/2011	MW-10 RZ78O 12/07/2010	MW-10 30059-1 11/29/2011	MW-11 RZ78J 12/07/2010	MW-11 26524-2 6/1/2011
PAHs (µg/L)										
Method 8270C SIM										
Naphthalene	--	**0.25**				**0.11**				
2-Methylnaphthalene	--	0.061 U				**0.48**				
1-Methylnaphthalene	--	0.047 U				**0.82**				
Total Naphthalenes (d)	160	**0.25**				**1.41**				
Acenaphthylene	--	0.047 U				0.047 U				
Acenaphthene	--	0.047 U				**0.062**				
Fluorene	--	0.047 U				**0.15**				
Phenanthrene	--	0.047 U				0.047 U				
Anthracene	--	0.047 U				0.047 U				
Fluoranthene	--	0.047 U				0.047 U				
Pyrene	--	0.047 U				0.047 U				
Benzo[a]anthracene	--	0.047 U				0.047 U				
Chrysene	--	0.047 U				0.047 U				
Benzo[b]fluoranthene	--	0.047 U				0.047 U				
Benzo[k]fluoranthene	--	0.047 U				0.047 U				
Benzo[a]pyrene	--	0.094 U				0.094 U				
Indeno[1,2,3-cd]pyrene	--	0.047 U				0.047 U				
Dibenz(a,h)anthracene	--	0.047 U				0.047 U				
Benzo[g,h,i]perylene	--	0.047 U				0.047 U				
cPAH TEQ (e)	0.1 (f)	0.047 U				0.047 U				
EDB (µg/L)										
Method 8011										
Ethylene Dibromide	0.01									
VOLATILES (µg/L)										
Method 8260B										
1,2-Dichloroethane	5									
Methyl tert-butyl ether	20									
Naphthalene	--									

TABLE 2-6
RI AND SUPPLEMENTAL RI SITE WIDE GROUNDWATER ANALYTICAL RESULTS
PEDERSON'S FRYER FARMS RI/FS

	MTCA Method A Cleanup Level for Groundwater (a)	MW-12 RZ78L 12/07/2010	MW-13 RZ78I 12/07/2010	MW-15 RZ78B 12/08/2010	MW-15 26533-5 6/2/2011	MW-15 27092-6 6/28/2011	MW-15-Dup 27092-4 6/28/2011	MW-15 30034-2 11/28/2011	MW-17 RZ78E 12/08/2010	MW-17 SH05C 2/01/2011
TOTAL PETROLEUM HYDROCARBONS (mg/L)										
NWTPH-Dx										
Diesel Range Organics	0.5	0.10 U	0.10 U	0.10 U	**0.26** J	**0.25**		**1.7**	**2.5**	**410**
Lube Oil	0.5	0.20 U	0.20 U	0.20 U	0.24 UJ	0.24 U		**0.77**	0.20 U	40 U
NWTPH-Gx										
Gasoline Range Organics	0.8/1.0 (b)	0.10 U	0.10 U	**2.1**	**0.88**	**0.64**	**0.59**	**0.63**	**0.35**	**2.4** J
BTEX (µg/L)										
Method SW8021B / SW8260B										
Benzene	5	0.25 U	0.25 U	0.25 U	**0.12**	0.50 U	0.50 U	0.5 U	0.25 U	1.0 UJ
Methyl tert-butyl ether	20					1.0 U	1.0 U			
Toluene	1000	0.25 U	0.25 U	**3.1**	**1.4**	**1.8**	**1.7**	**2.1**	0.25 U	1.0 UJ
Ethylbenzene	700	0.25 U	0.25 U	**6.3**	**5.0**	**4.4** J	**3.0** J	**10**	0.25 U	1.0 UJ
m, p-Xylene	1000 (c)	0.50 U	0.50 U	**37**	**12**	1.0 U	1.0 U	**15**	0.50 U	1.0 UJ
o-Xylene	1000 (c)	0.25 U	0.25 U	**0.73**	**0.46**	1.0 U	1.0 U	1.0 U	0.25 U	1.0 UJ
CONVENTIONALS (mg/L)										
Nitrate (300.0)	10				0.90 U					0.1 U
Sulfate (300.0)	250				**2.7**					**6.8**
Total Organic Carbon (415.1)	--				**2.0**					
Alkalinity (SM 2320b)	--				**60**					
DISSOLVED METALS (µg/L)										
Method 200.8										
Lead	15									
Manganese	--				**810**					
DISSOLVED GASES (mg/L)										
Method RSK 175 M										
Methane	--				0.0260 U					

TABLE 2-6
RI AND SUPPLEMENTAL RI SITE WIDE GROUNDWATER ANALYTICAL RESULTS
PEDERSON'S FRYER FARMS RI/FS

	MTCA Method A Cleanup Level for Groundwater (a)	MW-12 RZ78L 12/07/2010	MW-13 RZ78I 12/07/2010	MW-15 RZ78B 12/08/2010	MW-15 26533-5 6/2/2011	MW-15 27092-6 6/28/2011	MW-15-Dup 27092-4 6/28/2011	MW-15 30034-2 11/28/2011	MW-17 RZ78E 12/08/2010	MW-17 SH05C 2/01/2011
PAHs (µg/L)										
Method 8270C SIM										
Naphthalene	--									
2-Methylnaphthalene	--									
1-Methylnaphthalene	--									
Total Naphthalenes (d)	160									
Acenaphthylene	--									
Acenaphthene	--									
Fluorene	--									
Phenanthrene	--									
Anthracene	--									
Fluoranthene	--									
Pyrene	--									
Benzo[a]anthracene	--									
Chrysene	--									
Benzo[b]fluoranthene	--									
Benzo[k]fluoranthene	--									
Benzo[a]pyrene	--									
Indeno[1,2,3-cd]pyrene	--									
Dibenz(a,h)anthracene	--									
Benzo[g,h,i]perylene	--									
cPAH TEQ (e)	0.1 (f)									
EDB (µg/L)										
Method 8011										
Ethylene Dibromide	0.01				0.010 U					
VOLATILES (µg/L)										
Method 8260B										
1,2-Dichloroethane	5				0.10 U					
Methyl tert-butyl ether	20				0.10 U					
Naphthalene	--				**3.9**					

TABLE 2-6
RI AND SUPPLEMENTAL RI SITE WIDE GROUNDWATER ANALYTICAL RESULTS
PEDERSON'S FRYER FARMS RI/FS

	MTCA Method A Cleanup Level for Groundwater (a)	MW-18 RZ78F 12/08/2010	MW-19 RZ79A 12/07/2010	Dup of MW-19 MW-99 RZ79C 12/07/2010	MW-19 SH05A 2/01/2011	MW-19 26596-5 6/5/2011	MW-19 27103-2 6/29/2011	MW-19 30090-2 11/30/2011	MW-20 RZ78N 12/06/2010
TOTAL PETROLEUM HYDROCARBONS (mg/L)									
NWTPH-Dx									
Diesel Range Organics	0.5	**6.8**	**0.17**	**0.18**	**4.7**	**2.4**	**11**	**24**	**13**
Lube Oil	0.5	1.0 U	0.20 U	0.20 U	0.20 U	0.25 U	**0.50**	**0.68**	2.0 U
NWTPH-Gx									
Gasoline Range Organics	0.8/1.0 (b)	**0.95**	**0.56**	**0.54**	**0.35**	**0.31**	**0.38**	**0.86**	**0.75**
BTEX (µg/L)									
Method SW8021B / SW8260B									
Benzene	5	0.25 U	0.25 U	0.25 U	1.0 U	0.50 U			0.25 U
Methyl tert-butyl ether	20								
Toluene	1000	0.25 U	0.25 U	0.25 U	1.0 U	0.50 U			0.25 U
Ethylbenzene	700	**0.28**	0.25 U	0.25 U	1.0 U	0.50 U			0.25 U
m, p-Xylene	1000 (c)	**1.3**	0.50 U	0.50 U	1.0 U	1.0 U			0.50 U
o-Xylene	1000 (c)	0.25 U	0.25 U	0.25 U	1.0 U	1.0 U			0.25 U
CONVENTIONALS (mg/L)									
Nitrate (300.0)	10				0.1 U	0.90 U			
Sulfate (300.0)	250				**2.8**	**4.1**			
Total Organic Carbon (415.1)	--								
Alkalinity (SM 2320b)	--								
DISSOLVED METALS (µg/L)									
Method 200.8									
Lead	15								
Manganese	--								
DISSOLVED GASES (mg/L)									
Method RSK 175 M									
Methane	--								

TABLE 2-6
RI AND SUPPLEMENTAL RI SITE WIDE GROUNDWATER ANALYTICAL RESULTS
PEDERSON'S FRYER FARMS RI/FS

	MTCA Method A Cleanup Level for Groundwater (a)	MW-18 RZ78F 12/08/2010	MW-19 RZ79A 12/07/2010	Dup of MW-19 MW-99 RZ79C 12/07/2010	MW-19 SH05A 2/01/2011	MW-19 26596-5 6/5/2011	MW-19 27103-2 6/29/2011	MW-19 30090-2 11/30/2011	MW-20 RZ78N 12/06/2010
PAHs (µg/L)									
Method 8270C SIM									
Naphthalene	--								
2-Methylnaphthalene	--								
1-Methylnaphthalene	--								
Total Naphthalenes (d)	160								
Acenaphthylene	--								
Acenaphthene	--								
Fluorene	--								
Phenanthrene	--								
Anthracene	--								
Fluoranthene	--								
Pyrene	--								
Benzo[a]anthracene	--								
Chrysene	--								
Benzo[b]fluoranthene	--								
Benzo[k]fluoranthene	--								
Benzo[a]pyrene	--								
Indeno[1,2,3-cd]pyrene	--								
Dibenz(a,h)anthracene	--								
Benzo[g,h,i]perylene	--								
cPAH TEQ (e)	0.1 (f)								
EDB (µg/L)									
Method 8011									
Ethylene Dibromide	0.01								
VOLATILES (µg/L)									
Method 8260B									
1,2-Dichloroethane	5								
Methyl tert-butyl ether	20								
Naphthalene	--								

TABLE 2-6
RI AND SUPPLEMENTAL RI SITE WIDE GROUNDWATER ANALYTICAL RESULTS
PEDERSON'S FRYER FARMS RI/FS

	MTCA Method A Cleanup Level for Groundwater (a)	MW-20 26596-1 6/5/2011	MW-20 27103-3 6/29/2011	MW-20 30090-1 11/30/2011	MW-21 RZ78D 12/07/2010	MW-22 RZ78P 12/07/2010	MW-22 26582-3 6/3/2011	MW-22 27103-9 6/29/2011	MW-22 30059-6 11/29/2011
TOTAL PETROLEUM HYDROCARBONS (mg/L)									
NWTPH-Dx									
Diesel Range Organics	0.5	**19**	**29**	**87** J	0.10 U	0.10 U	0.12 U	0.12 U	0.12 U
Lube Oil	0.5	**0.73**	**1.1**	**3.1** J	0.20 U	0.20 U	0.24 U	0.24 U	0.24 U
NWTPH-Gx									
Gasoline Range Organics	0.8/1.0 (b)	**0.77**	**1.2**	**1.6**	0.10 U	0.10 U	0.050 U	0.050 U	0.050 U
BTEX (µg/L)									
Method SW8021B / SW8260B									
Benzene	5	0.50 U			0.25 U	0.25 U	0.50 U		
Methyl tert-butyl ether	20								
Toluene	1000	0.50 U			0.25 U	**0.25**	0.50 U		
Ethylbenzene	700	0.50 U			0.25 U	0.25 U	0.50 U		
m, p-Xylene	1000 (c)	1.0 U			0.50 U	0.50 U	1.0 U		
o-Xylene	1000 (c)	1.0 U			0.25 U	**0.34**	1.0 U		
CONVENTIONALS (mg/L)									
Nitrate (300.0)	10	0.90 U					**1.1**		
Sulfate (300.0)	250	1.2 U					**6.1**		
Total Organic Carbon (415.1)	--								
Alkalinity (SM 2320b)	--								
DISSOLVED METALS (µg/L)									
Method 200.8									
Lead	15								
Manganese	--								
DISSOLVED GASES (mg/L)									
Method RSK 175 M									
Methane	--								

TABLE 2-6
RI AND SUPPLEMENTAL RI SITE WIDE GROUNDWATER ANALYTICAL RESULTS
PEDERSON'S FRYER FARMS RI/FS

	MTCA Method A Cleanup Level for Groundwater (a)	MW-20 26596-1 6/5/2011	MW-20 27103-3 6/29/2011	MW-20 30090-1 11/30/2011	MW-21 RZ78D 12/07/2010	MW-22 RZ78P 12/07/2010	MW-22 26582-3 6/3/2011	MW-22 27103-9 6/29/2011	MW-22 30059-6 11/29/2011
PAHs (µg/L)									
Method 8270C SIM									
Naphthalene	--								
2-Methylnaphthalene	--								
1-Methylnaphthalene	--								
Total Naphthalenes (d)	160								
Acenaphthylene	--								
Acenaphthene	--								
Fluorene	--								
Phenanthrene	--								
Anthracene	--								
Fluoranthene	--								
Pyrene	--								
Benzo[a]anthracene	--								
Chrysene	--								
Benzo[b]fluoranthene	--								
Benzo[k]fluoranthene	--								
Benzo[a]pyrene	--								
Indeno[1,2,3-cd]pyrene	--								
Dibenz(a,h)anthracene	--								
Benzo[g,h,i]perylene	--								
cPAH TEQ (e)	0.1 (f)								
EDB (µg/L)									
Method 8011									
Ethylene Dibromide	0.01								
VOLATILES (µg/L)									
Method 8260B									
1,2-Dichloroethane	5								
Methyl tert-butyl ether	20								
Naphthalene	--								

TABLE 2-6
RI AND SUPPLEMENTAL RI SITE WIDE GROUNDWATER ANALYTICAL RESULTS
PEDERSON'S FRYER FARMS RI/FS

	MTCA Method A Cleanup Level for Groundwater (a)	MW-25D 26582-2 6/3/2011/ 6/15/2011	MW-25D 27133-2/ 26831-1 6/30/2011	MW-25D 28888-4 9/27/2011	Dup of MW-25D MW-999 28888-5 9/27/2011	MW-25D 30108-5 12/1/2011	MW-26S 26524-1 6/1/2011	MW-26S 27133-3 6/30/2011	MW-26S 30108-3 12/1/2011
TOTAL PETROLEUM HYDROCARBONS (mg/L)									
NWTPH-Dx									
Diesel Range Organics	0.5	**7.7**	**5.4**	**13**	**13**	**24**	**22** J	**7.3**	**2.5**
Lube Oil	0.5	**0.26**	**0.27**	**0.51**	**0.58**	**1.2**	**1.0** J	**0.51**	**0.28**
NWTPH-Gx									
Gasoline Range Organics	0.8/1.0 (b)	**1.1**	**0.87**	**1.1** J	**0.89** J	**0.38**	**1.2**	**0.54**	0.050 U
BTEX (µg/L)									
Method SW8021B / SW8260B									
Benzene	5	**0.13**	0.50 U	0.50 U	0.50 U	0.50 U	**0.60**	0.50 U	0.50 U
Methyl tert-butyl ether	20		1.0 U					1.0 U	
Toluene	1000	0.10 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U
Ethylbenzene	700	0.10 U	0.50 U	0.50 U	0.50 U	0.50 U	**0.76**	0.50 U	0.50 U
m, p-Xylene	1000 (c)	**1.1**	**1.4**	**1.4**	**1.2**	1.0 U	**3.1**	1.0 U	1.0 U
o-Xylene	1000 (c)	0.10 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
CONVENTIONALS (mg/L)									
Nitrate (300.0)	10	0.90 U	0.90 U	0.90 U	0.90 U	0.90 U	0.90 U	0.90 U	0.90 U
Sulfate (300.0)	250	1.2 U	1.2 U	1.2 U	1.2 U	**9.7**	**4.3**	**3.1**	**5.6**
Total Organic Carbon (415.1)	--	**6.7**							
Alkalinity (SM 2320b)	--	**140**							
DISSOLVED METALS (µg/L)									
Method 200.8									
Lead	15		0.40 U				0.40 U		
Manganese	--		**2900**				**2200**		
DISSOLVED GASES (mg/L)									
Method RSK 175 M									
Methane	--	**6.89**							

TABLE 2-6
RI AND SUPPLEMENTAL RI SITE WIDE GROUNDWATER ANALYTICAL RESULTS
PEDERSON'S FRYER FARMS RI/FS

		MW-25D	MW-25D		Dup of MW-25D				
	MTCA Method A	26582-2	27133-2/	MW-25D	MW-999	MW-25D	MW-26S	MW-26S	MW-26S
	Cleanup Level for	6/3/2011/	26831-1	28888-4	28888-5	30108-5	26524-1	27133-3	30108-3
	Groundwater (a)	6/15/2011	6/30/2011	9/27/2011	9/27/2011	12/1/2011	6/1/2011	6/30/2011	12/1/2011
PAHs (µg/L)									
Method 8270C SIM									
Naphthalene	--	**1.1**							
2-Methylnaphthalene	--	**18**							
1-Methylnaphthalene	--	**67**							
Total Naphthalenes (d)	160	**86.1**							
Acenaphthylene	--	**1.4**							
Acenaphthene	--	**3.5**							
Fluorene	--	**8.2**							
Phenanthrene	--	**15**							
Anthracene	--	**1.1**							
Fluoranthene	--	**0.33**							
Pyrene	--	**1.4**							
Benzo[a]anthracene	--	**0.095**							
Chrysene	--	**0.25**							
Benzo[b]fluoranthene	--	**0.072**							
Benzo[k]fluoranthene	--	0.047 U							
Benzo[a]pyrene	--	0.094 U							
Indeno[1,2,3-cd]pyrene	--	0.047 U							
Dibenz(a,h)anthracene	--	0.047 U							
Benzo[g,h,i]perylene	--	0.047 U							
cPAH TEQ (e)	0.1 (f)	**0.0192**							
EDB (µg/L)									
Method 8011									
Ethylene Dibromide	0.01	0.010 U							
VOLATILES (µg/L)									
Method 8260B									
1,2-Dichloroethane	5	0.10 U							
Methyl tert-butyl ether	20	0.10 U							
Naphthalene	--	**3.0**							

TABLE 2-6
RI AND SUPPLEMENTAL RI SITE WIDE GROUNDWATER ANALYTICAL RESULTS
PEDERSON'S FRYER FARMS RI/FS

	MTCA Method A Cleanup Level for Groundwater (a)	MW-27D 26582-5 6/3/2011	MW-27D 27103-4 6/29/2011	MW-27D 30108-6 12/1/2011	MW-28D 26533-11 6/2/2011	Dup of MW-28D MW-999 26533-10 6/2/2011	MW-28D 27092-7 6/28/2011	MW-28D-Dup 27092-9 6/28/2011	MW-28D 28888-3 9/27/2011
TOTAL PETROLEUM HYDROCARBONS (mg/L)									
NWTPH-Dx									
Diesel Range Organics	0.5	**9.9**	**33**	**25**	**3.1** J	**4.5** J	**1.6**	**1.8**	**2.2**
Lube Oil	0.5	**0.28**	**0.86**	**0.90**	0.24 UJ	0.24 UJ	0.24 U	0.24 U	0.25 U
NWTPH-Gx									
Gasoline Range Organics	0.8/1.0 (b)	**1.3**	**1.3**	**0.8**	**0.84**	**0.73**	**0.61**		**0.25**
BTEX (µg/L)									
Method SW8021B / SW8260B									
Benzene	5	**0.71**	**0.51**		0.10 U	0.50 U	0.50 U		0.50 U
Methyl tert-butyl ether	20						1.0 U		
Toluene	1000	0.50 U	0.50 U		0.10 U	0.50 U	0.50 U		0.50 U
Ethylbenzene	700	0.50 U	0.50 U		0.10 U	0.50 U	0.50 U		0.50 U
m, p-Xylene	1000 (c)	1.0 U	1.0 U		0.20 U	1.0 U	1.0 U		1.0 U
o-Xylene	1000 (c)	1.0 U	1.0 U		0.10 U	1.0 U	1.0 U		1.0 U
CONVENTIONALS (mg/L)									
Nitrate (300.0)	10	0.90 U			0.90 U	0.90 U	0.90 U		0.90 U
Sulfate (300.0)	250	**3.0**			1.2 U	1.2 U	1.2 U		**1.2** J
Total Organic Carbon (415.1)	--	**3.4**							
Alkalinity (SM 2320b)	--	**140**							
DISSOLVED METALS (µg/L)									
Method 200.8									
Lead	15								
Manganese	--	**3000**							
DISSOLVED GASES (mg/L)									
Method RSK 175 M									
Methane	--	**4.91**							

TABLE 2-6
RI AND SUPPLEMENTAL RI SITE WIDE GROUNDWATER ANALYTICAL RESULTS
PEDERSON'S FRYER FARMS RI/FS

						Dup of MW-28D			
	MTCA Method A Cleanup Level for Groundwater (a)	MW-27D	MW-27D	MW-27D	MW-28D	MW-999	MW-28D	MW-28D-Dup	MW-28D
		26582-5	27103-4	30108-6	26533-11	26533-10	27092-7	27092-9	28888-3
		6/3/2011	6/29/2011	12/1/2011	6/2/2011	6/2/2011	6/28/2011	6/28/2011	9/27/2011
PAHs (µg/L)									
Method 8270C SIM									
Naphthalene	--								
2-Methylnaphthalene	--								
1-Methylnaphthalene	--								
Total Naphthalenes (d)	160								
Acenaphthylene	--								
Acenaphthene	--								
Fluorene	--								
Phenanthrene	--								
Anthracene	--								
Fluoranthene	--								
Pyrene	--								
Benzo[a]anthracene	--								
Chrysene	--								
Benzo[b]fluoranthene	--								
Benzo[k]fluoranthene	--								
Benzo[a]pyrene	--								
Indeno[1,2,3-cd]pyrene	--								
Dibenz(a,h)anthracene	--								
Benzo[g,h,i]perylene	--								
cPAH TEQ (e)	0.1 (f)								
EDB (µg/L)									
Method 8011									
Ethylene Dibromide	0.01				0.010 U				
VOLATILES (µg/L)									
Method 8260B									
1,2-Dichloroethane	5				0.10 U				
Methyl tert-butyl ether	20				0.10 U				
Naphthalene	--				**0.62**				

TABLE 2-6
RI AND SUPPLEMENTAL RI SITE WIDE GROUNDWATER ANALYTICAL RESULTS
PEDERSON'S FRYER FARMS RI/FS

	MTCA Method A Cleanup Level for Groundwater (a)	MW-28D 30059-3 11/29/2011	MW-29D 26533-3 6/2/2011	Dup of MW-29D MW-997 26533-9 6/2/2011	MW-29D 27092-5 6/28/2011	MW-29D 28866-2 9/26/2011	MW-29D 30059-4 11/29/2011	MW-29D-Dup 30059-5 11/29/2011	MW-30D 26533-7 6/2/2011
TOTAL PETROLEUM HYDROCARBONS (mg/L)									
NWTPH-Dx									
Diesel Range Organics	0.5	**1.4**	0.12 UJ		0.12 U	0.12 U	0.12 U	0.12 U	0.12 UJ
Lube Oil	0.5	**0.24**	0.24 UJ		0.25 U	0.24 U	0.24 U	0.24 U	0.24 UJ
NWTPH-Gx									
Gasoline Range Organics	0.8/1.0 (b)	**0.19**	0.050 U		0.050 U	0.050 U	**0.068**	0.050 U	0.050 U
BTEX (µg/L)									
Method SW8021B / SW8260B									
Benzene	5	0.50 U	0.10 U	0.10 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U
Methyl tert-butyl ether	20				1.0 U				
Toluene	1000	0.50 U	0.10 U	0.10 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U
Ethylbenzene	700	0.50 U	0.10 U	0.10 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U
m, p-Xylene	1000 (c)	1.0 U	0.20 U	0.20 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
o-Xylene	1000 (c)	1.0 U	0.10 U	0.10 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
CONVENTIONALS (mg/L)									
Nitrate (300.0)	10	0.90 U	**1.3**		**0.99**	**1.3**	**1.4**	**1.4**	**1.1**
Sulfate (300.0)	250	1.2 U	**11**		**13**	**12**	**11**	**11**	**10**
Total Organic Carbon (415.1)	--								
Alkalinity (SM 2320b)	--								
DISSOLVED METALS (µg/L)									
Method 200.8									
Lead	15								
Manganese	--								
DISSOLVED GASES (mg/L)									
Method RSK 175 M									
Methane	--								

TABLE 2-6
RI AND SUPPLEMENTAL RI SITE WIDE GROUNDWATER ANALYTICAL RESULTS
PEDERSON'S FRYER FARMS RI/FS

	MTCA Method A Cleanup Level for Groundwater (a)			Dup of MW-29D					
		MW-28D	MW-29D	MW-997	MW-29D	MW-29D	MW-29D	MW-29D-Dup	MW-30D
		30059-3	26533-3	26533-9	27092-5	28866-2	30059-4	30059-5	26533-7
		11/29/2011	6/2/2011	6/2/2011	6/28/2011	9/26/2011	11/29/2011	11/29/2011	6/2/2011
PAHs (µg/L)									
Method 8270C SIM									
Naphthalene	--								
2-Methylnaphthalene	--								
1-Methylnaphthalene	--								
Total Naphthalenes (d)	160								
Acenaphthylene	--								
Acenaphthene	--								
Fluorene	--								
Phenanthrene	--								
Anthracene	--								
Fluoranthene	--								
Pyrene	--								
Benzo[a]anthracene	--								
Chrysene	--								
Benzo[b]fluoranthene	--								
Benzo[k]fluoranthene	--								
Benzo[a]pyrene	--								
Indeno[1,2,3-cd]pyrene	--								
Dibenz(a,h)anthracene	--								
Benzo[g,h,i]perylene	--								
cPAH TEQ (e)	0.1 (f)								
EDB (µg/L)									
Method 8011									
Ethylene Dibromide	0.01		0.010 U	0.010 U					
VOLATILES (µg/L)									
Method 8260B									
1,2-Dichloroethane	5		0.10 U	0.10 U					
Methyl tert-butyl ether	20		0.10 U	0.10 U					
Naphthalene	--		0.40 U	0.40 U					

TABLE 2-6
RI AND SUPPLEMENTAL RI SITE WIDE GROUNDWATER ANALYTICAL RESULTS
PEDERSON'S FRYER FARMS RI/FS

	MTCA Method A Cleanup Level for Groundwater (a)	MW-30D 27092-2 6/28/2011	MW-30D-Dup 27092-8 6/28/2011	MW-31D 26533-2 6/2/2011	Dup of MW-31D MW-998 26533-1 6/2/2011	MW-31D 27103-8 6/29/2011	MW-31D 28888-2 9/27/2011	MW-31D 30090-7 11/30/2011	MW-32D 26533-4 6/2/2011
TOTAL PETROLEUM HYDROCARBONS (mg/L)									
NWTPH-Dx									
Diesel Range Organics	0.5	0.12 U		**0.44** J	**0.40** J	**0.42**	**0.39**	**0.32**	0.12 UJ
Lube Oil	0.5	0.24 U		0.24 UJ	0.24 UJ	0.24 U	0.24 U	0.24 U	0.24 UJ
NWTPH-Gx									
Gasoline Range Organics	0.8/1.0 (b)	0.050 U		**0.56**	**0.51**	**0.46**	**0.24**	**0.081**	0.050 U
BTEX (µg/L)									
Method SW8021B / SW8260B									
Benzene	5	0.50 U							
Methyl tert-butyl ether	20	1.0 U							
Toluene	1000	0.50 U							
Ethylbenzene	700	0.50 U							
m, p-Xylene	1000 (c)	1.0 U							
o-Xylene	1000 (c)	1.0 U							
CONVENTIONALS (mg/L)									
Nitrate (300.0)	10	**0.97**	**0.97**	0.90 U	0.90 U				**2.4**
Sulfate (300.0)	250	**10**	**10**	1.2 U	1.2 U				**16**
Total Organic Carbon (415.1)	--								
Alkalinity (SM 2320b)	--								
DISSOLVED METALS (µg/L)									
Method 200.8									
Lead	15								
Manganese	--								
DISSOLVED GASES (mg/L)									
Method RSK 175 M									
Methane	--								

TABLE 2-6
RI AND SUPPLEMENTAL RI SITE WIDE GROUNDWATER ANALYTICAL RESULTS
PEDERSON'S FRYER FARMS RI/FS

	MTCA Method A Cleanup Level for Groundwater (a)	MW-30D 27092-2 6/28/2011	MW-30D-Dup 27092-8 6/28/2011	MW-31D 26533-2 6/2/2011	Dup of MW-31D MW-998 26533-1 6/2/2011	MW-31D 27103-8 6/29/2011	MW-31D 28888-2 9/27/2011	MW-31D 30090-7 11/30/2011	MW-32D 26533-4 6/2/2011
PAHs (µg/L)									
Method 8270C SIM									
Naphthalene	--			**2.0**	**1.7**				
2-Methylnaphthalene	--			**7.2**	**6.5**				
1-Methylnaphthalene	--			**23**	**21**				
Total Naphthalenes (d)	160			**32.2**	**29.2**				
Acenaphthylene	--			**0.32**	**0.28**				
Acenaphthene	--			**1.4**	**1.2**				
Fluorene	--			**2.6**	**2.2**				
Phenanthrene	--			**0.92**	**0.75**				
Anthracene	--			**0.057**	**0.047**				
Fluoranthene	--			0.047 U	0.047 U				
Pyrene	--			0.047 U	0.047 U				
Benzo[a]anthracene	--			0.047 U	0.047 U				
Chrysene	--			0.047 U	0.047 U				
Benzo[b]fluoranthene	--			0.047 U	0.047 U				
Benzo[k]fluoranthene	--			0.047 U	0.047 U				
Benzo[a]pyrene	--			0.094 U	0.094 U				
Indeno[1,2,3-cd]pyrene	--			0.047 U	0.047 U				
Dibenz(a,h)anthracene	--			0.047 U	0.047 U				
Benzo[g,h,i]perylene	--			0.047 U	0.047 U				
cPAH TEQ (e)	0.1 (f)			0.047 U	0.047 U				
EDB (µg/L)									
Method 8011									
Ethylene Dibromide	0.01								
VOLATILES (µg/L)									
Method 8260B									
1,2-Dichloroethane	5								
Methyl tert-butyl ether	20								
Naphthalene	--								

TABLE 2-6
RI AND SUPPLEMENTAL RI SITE WIDE GROUNDWATER ANALYTICAL RESULTS
PEDERSON'S FRYER FARMS RI/FS

	MTCA Method A Cleanup Level for Groundwater (a)	MW-34S 26524-6 6/1/2011	MW-34S 27103-6 6/29/2011	MW-34S 28866-3 9/26/2011	MW-34S 30059-7 11/29/2011	MW-35S 26524-4 6/1/2011	MW-35S 27092-3 6/28/2011	MW-35S 30034-1 11/28/2011
TOTAL PETROLEUM HYDROCARBONS (mg/L)								
NWTPH-Dx								
Diesel Range Organics	0.5	0.12 UJ	0.12 U	0.12 U	0.12 U	**0.78** J	**1.2**	**0.13**
Lube Oil	0.5	0.24 UJ	0.24 U	0.24 U	0.24 U	**0.29** J	0.24 U	0.24 U
NWTPH-Gx								
Gasoline Range Organics	0.8/1.0 (b)	**0.091**	**0.15**	**0.19**	**0.061**	**9.8** J	**7.4** J	**12**
BTEX (µg/L)								
Method SW8021B / SW8260B								
Benzene	5					**22**	**15**	**29**
Methyl tert-butyl ether	20						1.0 U	
Toluene	1000					**19**	**12**	**25**
Ethylbenzene	700					**560**	**340**	**740**
m, p-Xylene	1000 (c)					**1300**	**720**	**1200**
o-Xylene	1000 (c)					**82**	**58**	**58**
CONVENTIONALS (mg/L)								
Nitrate (300.0)	10	0.90 U				0.90 U	0.90 U	0.90 U
Sulfate (300.0)	250	**6.6**				1.2 U	1.2 U	1.2 U
Total Organic Carbon (415.1)	--							
Alkalinity (SM 2320b)	--							
DISSOLVED METALS (µg/L)								
Method 200.8								
Lead	15							
Manganese	--							
DISSOLVED GASES (mg/L)								
Method RSK 175 M								
Methane	--							

TABLE 2-6
RI AND SUPPLEMENTAL RI SITE WIDE GROUNDWATER ANALYTICAL RESULTS
PEDERSON'S FRYER FARMS RI/FS

	MTCA Method A Cleanup Level for Groundwater (a)	MW-34S 26524-6 6/1/2011	MW-34S 27103-6 6/29/2011	MW-34S 28866-3 9/26/2011	MW-34S 30059-7 11/29/2011	MW-35S 26524-4 6/1/2011	MW-35S 27092-3 6/28/2011	MW-35S 30034-1 11/28/2011
PAHs (µg/L)								
Method 8270C SIM								
Naphthalene	--	**0.058**						
2-Methylnaphthalene	--	0.061 U						
1-Methylnaphthalene	--	0.047 U						
Total Naphthalenes (d)	160	**0.058**						
Acenaphthylene	--	0.047 U						
Acenaphthene	--	0.047 U						
Fluorene	--	0.047 U						
Phenanthrene	--	0.047 U						
Anthracene	--	0.047 U						
Fluoranthene	--	0.047 U						
Pyrene	--	0.047 U						
Benzo[a]anthracene	--	0.047 U						
Chrysene	--	0.047 U						
Benzo[b]fluoranthene	--	0.047 U						
Benzo[k]fluoranthene	--	0.047 U						
Benzo[a]pyrene	--	0.094 U						
Indeno[1,2,3-cd]pyrene	--	0.047 U						
Dibenz(a,h)anthracene	--	0.047 U						
Benzo[g,h,i]perylene	--	0.047 U						
cPAH TEQ (e)	0.1 (f)	0.047 U						
EDB (µg/L)								
Method 8011								
Ethylene Dibromide	0.01							
VOLATILES (µg/L)								
Method 8260B								
1,2-Dichloroethane	5							
Methyl tert-butyl ether	20							
Naphthalene	--							

U = Indicates the compound was undetected at the reported concentration.
J = Indicates the analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
UJ = The analyte was not detected in the sample; the reported sample reporting limit is an estimate.
The presence or absence of the analyte cannot be verified.
Bold = Detected compound.
Box = Exceedance of cleanup level.
-- = A cleanup level is not available for the individual constituent.
(a) All cleanup levels are MTCA Method A except for conventionals nitrate and sulfate, which are preliminary Method B cleanup levels derived from ARARs and WA State Board of Health MCLs.
(b) MTCA Method A cleanup level is 0.8 ug/L if benzene is present and 1.0 ug/L if benzene is not present.
Benzene was not detected in any sample during this event, but has been detected at MW-15 during previous sampling events.
(c) Cleanup level cannot be exceeded by the sum of individual xylene concentrations.
(d) MTCA Method A cleanup level for naphthalenes is a total value for naphthalene, 1-methyl naphthalene, and 2-methyl naphthalene.
(e) TEQ = toxicity equivalency factor as described in WAC 173-340-708(8).
(f) cPAH cleanup screening levels based on practical quantitation limit (PQL) for individual cPAHs.

TABLE 2-7
INDOOR AIR ANALYTICAL RESULTS
PEDERSON'S FRYER FARMS RI/FS

	Published Residential Indoor Air Background Concentration (b)	MTCA Method B Screening Level for Air	Area A IA-A-20111108 LUK-160-01 11/8/2011 (a)	Area B IA-B-20111108 LUK-160-01 11/8/2011 (a)	Area F IA-F-20111108 LUK-160-01 11/8/2011 (a)	Area F VC-F LUI-160-02 09/15/2011	Area F Dup VC-X (e) LUI-160-04 09/15/2011	Area G IA-G-20111108 LUK-160-01 11/8/2011 (a)	Area G VC-G LUI-160-01 09/15/2011	Outdoor VC-O LUI-160-03 09/15/2011
BTEX (µg/m3)										
EPA TO-15 SIM/TO-15 (a)										
Benzene	10 µg/m^3	0.32 (c)	**17**	**11**	4.6 U	**4.7 J**	**5.1 J**	8.8 U	**8.6**	**0.80**
Ethylbenzene	8.6 µg/m^3	460 (d)	**160**	**340**	**250**	**8.5 J**	**8.2 J**	**43000**	**32**	**0.37**
Toluene	51 µg/m^3	2300 (d)	**830**	**1600**	**430**	**26 J**	**23 J**	**86000**	**55**	**2.7**
m,p-Xylene	27 µg/m^3	--	**800**	**1800**	**1500**	**26 J**	**26 J**	**210000**	**120**	**1.3**
o-Xylene	10 µg/m^3	--	**230**	**500**	**480**	**15 J**	**15 J**	**63000**	**34**	**0.46**
Total Xylenes	37 µg/m^3	46 (d)	**1030**	**2300**	**1980**	**41**	**41**	**273000**	**154**	**1.76**

U = Indicates the compound was undetected at the reported concentration.

J = Indicates the analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

Bold = Detected compound.

Box = Exceedance of screening level.

-- = A background concentration range or screening level is not available.

(a) The 11/08/11 samples were analyzed by standard TO-15. On 11/08/11 site operations included spraying several Christmas trees with fire retardant, which greatly influenced indoor air concentrations.

(b) Residential background concentration data are based on the 90th percentile values from a subsurface vapor intrusion study published in Ground Water Monitoring & Remediation (Dawson and McAlary 2009).

(c) Screening level is MTCA Method B carcinogen standard formula value.

(d) Screening levels are MTCA Method B non-carcinogen standard formula values.

(e) VC-X is the duplicate sample to VC-F

TABLE 2-8
SOIL GAS ANALYTICAL RESULTS
PEDERSON'S FRYER FARMS RI/FS

	Published Residential Indoor Air Background Concentration (a)	MTCA Method B Screening Level for Soil Gas	Area A SG-A LUK-159-01 11/08/2011	Area B SG-B LUK-159-02 11/08/2011	Area F SG-F LUI-160-04 11/08/2011	Area G SG-G LUI-160-03 11/08/2011
BTEX (µg/m3) **EPA TO-15 SIM**						
Benzene	10 µg/m^3	3.2 (b)	0.96 U	0.96 U	**38** J	0.96 U
Ethylbenzene	8.6 µg/m^3	4600 (c)	**3.1**	**6**	**52** J	**1.7**
Toluene	51 µg/m^3	23000 (c)	**10**	**17**	**68** J	**1.5**
m,p-Xylene	27 µg/m^3	--	**20**	**33**	**200** J	**3.5**
o-Xylene	10 µg/m^3	--	**6**	**11**	**53** J	**1.7**
Total Xylenes	37 µg/m^3	460 (c)	**26**	**44**	**253**	**5.2**

U = Indicates the compound was undetected at the reported concentration.
J = Indicates the analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
Bold = Detected compound.
Box = Exceedance of screening level.
-- = A background concentration range or screening level is not available.
(a) Residential background concentration data are based on the 90th percentile values from a subsurface vapor instrusion study published in *Ground Water Monitoring & Remediation* (Dawson and McAlary 2009).
(b) Screening level is MTCA Method B carcinogen standard formula value.
(c) Screening levels are MTCA Method B non-carcinogen standard formula values.

3.0 CLEANUP REQUIREMENTS

This section identifies regulatory cleanup requirements through the development of preliminary site cleanup standards, RAOs, and the identification of other potentially applicable laws and regulations. Cleanup requirements are addressed for site soil, groundwater, and indoor air.

3.1 TERRESTRIAL ECOLOGICAL EVALUATION

Unless exclusion applies to a site, a terrestrial ecological evaluation is required by the MTCA. A terrestrial ecological evaluation determines whether a release of hazardous substances to soil may pose a threat to the terrestrial environment; characterizes threats to terrestrial plants or animals; and establishes site-specific cleanup standards for the protection of terrestrial plants and animals.

Most of the site is paved (asphalt and gravel) or is covered with buildings and will continue to be throughout implementation of the remedial technologies. The standard point of compliance for soil contaminated with hazardous substances for the site is 15 ft BGS under WAC 173-340-7490(4)(b). Area A is against a building (Area A building). The underlying hazardous soil contamination detected during the RI did not typically exceed MTCA CULs until 25 ft BGS and deeper, which is below the point of compliance. The one location at Area A with soil contamination exceeding MTCA CULs is around soil boring A-5 (immediately adjacent to the Area A building) where concentrations of GRO were found just above CULs at 10 ft BGS. Area C is partially fenced and is against a building. Petroleum hydrocarbons in soil were detected during the RI at Area C at depths above the point of compliance but concentrations were below MTCA CULs. Area F is partially fenced and is against buildings. Detections of hazardous soil contamination underlying the graveled area from the RI were above the point of compliance at 10 ft BGS (MW-35S) with concentrations just above the GRO and benzene CULs. Detections of soil contamination underlying the building were above the point of compliance at 1.5 ft and 4.5 ft BGS with concentrations exceeding GRO and BTEX CULs. Both Area F locations where subsurface contamination exceeds MTCA CULs are fully fenced and will likely be fenced during remediation activities.

Because the site is almost entirely paved or covered with buildings or other physical barriers that will prevent ecological receptors from being exposed to soil contamination (as discussed above), and because existing site contamination is already below the standard point of compliance or will be after completion of remediation (i.e., the remedial alternatives discussed later in this report do not include alternatives that include leaving contaminated soil above the standard point of compliance), the site qualifies for an exclusion under WAC 173-340-7491(1)(a)&(b). Per WAC 173-340-7491(1), no further evaluation is required if a site meets any of the exclusion criteria under WAC 173-340-7491(1)(a) through (d). Because the site meets at least one of these criteria, the cleanup standards for the site do not include any terrestrial ecological considerations or criteria.

3.2 CLEANUP STANDARDS

This section develops preliminary site cleanup standards for chemical constituents that were detected in affected site media. Cleanup standards consist of 1) CULs defined by regulatory criteria that are adequately protective of human health and the environment and, 2) the point of compliance at which the CULs must be met. The cleanup standards developed in this section are used as the basis for developing media-specific RAOs for the cleanup action.

3.2.1 DEVELOPMENT OF CLEANUP LEVELS

The CULs for affected media will be selected by Ecology and presented in the CAP. However, it is necessary to identify proposed (or preliminary) CULs to develop, and evaluate the effectiveness of, cleanup action alternatives for the FS.

Cleanup levels for affected media developed under MTCA represent the concentration of COCs that are protective of human health and the environment for identified potential exposure pathways, based on the highest beneficial use and the reasonable maximum exposure for each affected media. The process for developing CULs consists of identifying the highest beneficial use and reasonable maximum exposure for affected media, determining those that represent the greatest risk to human health or the environment, and determining the CULs for the COC in affected media.

Numerical CULs are only developed for site groundwater, soil, soil gas, and indoor air because these are the only media that are affected by site releases. Cleanup levels are presented below.

3.2.1.1 Groundwater

As described in Section 3.2.2 of the RI report, the highest beneficial use for groundwater is considered drinking water. The MTCA Method A CULs for groundwater are considered applicable and are used as preliminary CULs. Per Section 3.3 of the RI report, the COC in groundwater include GRO, DRO, ORO, benzene, and xylenes. These COC and the associated preliminary CULs are provided in Table 3-1.

3.2.1.2 Soil

As described in Section 3.2.1 of the RI, the highest beneficial use for soil is considered unrestricted land use. The MTCA Method A CULs for soil are considered applicable and are used as preliminary CULs. Per Section 3.3 of the RI, the COC in soil include GRO, DRO, ORO, BTEX, and naphthalene. These COC and the associated preliminary CULs are provided in Table 3-2.

The soil to vapor pathway was also considered for BTEX constituents. Supplemental RI field activities included VI sampling (sub-slab soil gas and indoor air) as described in Section 2.1 and 2.4. The VI assessment concluded that under existing site conditions, VI is not a complete and significant pathway for contaminant migration from the subsurface to indoor air. Therefore, the remediation of soil will be evaluated in this FS in the context of protecting direct contact and groundwater, but not the VI pathway. However, in the event that the CAP involves confirmation VI sampling of sub-slab soil gas and co-located indoor air, SLs and CULs are presented in the following two sections as a basis for considering additional remedial actions.

3.2.1.3 Soil Gas

Although MTCA regulations do not provide tabulated soil gas cleanup values or methods for calculating soil gas CULs, Ecology guidance (Ecology website 2009) provides SLs for "sub-slab" (including depths up to 15 ft BGS) soil gas concentrations that are "expected to not result in exceedance of the air cleanup level in an overlying structure under most circumstances." Based on this guidance, the soil gas SL of 3.2 $\mu g/m^3$ benzene for sub-slab soil gas concentrations would generally be used as remediation levels for the final cleanup.

3.2.1.4 Indoor Air

Per WAC 173-340-750, CULs to protect air quality shall be based on estimates of the reasonable maximum exposure expected to occur under both current and future site use conditions when vapors are likely to enter and accumulate in structures. Current land use is considered "unrestricted" in MTCA terms. However, the site is adjacent to vacant properties and may be redeveloped as a residential property in the future. Residential site use will generally require the most protective air CULs; those CULs are defined by MTCA Method B formula values. The most stringent of the applicable criteria, adjusted to the practical quantitation limit or background concentrations, if appropriate, was identified as the Method B standard formula value for air (CLARC, 2012). The standard MTCA Method B cleanup level for benzene is 0.32 $\mu g/m^3$; however, it is proposed that the remediation level be modified to 17 $\mu g/m^3$, the upper range of background concentrations observed in buildings at the site.

3.2.2 POINTS OF COMPLIANCE

Under MTCA, the point of compliance is the point or location on the site where the CULs must be attained. The point(s) of compliance for affected media will be selected by Ecology and presented in the site CAP. However, it is necessary to identify proposed point(s) of compliance to develop, and evaluate the effectiveness of, cleanup action alternatives in the FS. As a result, the proposed points of compliance for soil, groundwater, and indoor air are identified in this section.

3.2.2.1 Groundwater

The standard point of compliance for groundwater, as established under WAC 173-340-720(8), is throughout the site. The standard point of compliance is proposed for the site. The existing deep well network (and any replacement or supplementary wells as needed due to the selected final remedy) at the site will be used to monitor remedial action performance and post-remedial groundwater quality at the site.

3.2.2.2 Soil

The point of compliance for soil, as established under WAC 173-340-740(6), for sites where soil CULs are based on the protection of groundwater, is throughout the site. The point of compliance where the soil CUL is based on protection from vapor, is throughout the site from the ground surface to the uppermost groundwater saturated zone. MTCA recognizes that for those cleanup actions that involve containment of hazardous substances, the soil CULs will typically not be met throughout the site [WAC 173-340-740(6)(f)]. However, MTCA also recognizes that such cleanup actions may still comply with cleanup standards. The determination of the adequacy of soil cleanup will be based on the remedial action alternative's ability to comply with groundwater and indoor air cleanup standards for the site, to meet performance standards designed to minimize human or environmental exposure to affected soil, and to provide practicable treatment of affected soil. Performance standards to minimize human and environmental exposure to affected soil may include institutional controls that limit activities that interfere with the protectiveness of the remedial action. Specific actions are described in subsequent sections of this report.

3.2.2.3 Indoor Air

The standard point of compliance for air, as established under WAC 173-340-750(6), is throughout the site. For indoor air, air inhalation is determined to be the only potentially significant exposure pathway; therefore, the points of compliance for air (if required) will be indoor air spaces at the site. In the context of evaluating indoor air impacts associated with the VI pathway, indoor air and co-located soil gas samples (VI confirmation samples) may be collected.

3.3 REMEDIAL ACTION OBJECTIVES

RAOs define the goals of the cleanup that must be achieved to adequately protect human health and the environment. RAOs must address all affected media, and a cleanup alternative must achieve all RAOs to be considered a viable cleanup action. RAOs can be either action-specific or media-specific. Action-specific RAOs are based on actions required for environmental protection that are not intended to achieve specific chemical criteria. Media-specific RAOs incorporate the preliminary CULs developed in Section 3.1.1. Based on the CSM presented in Section 2.5 and the cleanup standards developed in Section 3.1, the action-specific and media-specific RAOs identified for the site consist of:

- **RAO-1**: Prevent direct human contact with soil containing hazardous substances above the direct contact soil CUL. RAO-1 is applicable across the entire site.
- **RAO-2**: Prevent contaminated soil containing concentrations of COC above soil CULs from impacting groundwater. RAO-2 is applicable across the site.
- **RAO-3**: Prevent human ingestion of site groundwater containing concentrations of COC above the groundwater CULs. RAO-3 is applicable to Area A, where deep groundwater contamination exists.

A summary of the applicability of each RAO per area of concern is provided below:

REMEDIAL ACTION OBJECTIVES (RAOs)	AREA A	AREA B	AREA C	AREA E	AREA F	AREA G
RAO-1_Direct Human Contact with Soil	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
RAO-2_Soil Impacting Groundwater	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
RAO-3_Human Ingestion of (deep zone) Groundwater	**Yes**	No	No	No	No	No

RAO-1 and RAO-2 are applicable to all current areas of concern. RAO-3 is primarily applicable to Area A, the only location with associated deep groundwater contamination of concern. A number of the locations have seasonal shallow groundwater contamination, and although shallow groundwater is not considered an aquifer requiring treatment, RAO-2 will be addressed at such locations. An RAO protective of indoor air is not specifically defined; however, the RAOs address the sources (soil and shallow groundwater) that impact soil gas which should reduce the potential for VI to impact indoor air quality. As mentioned above, if needed, VI confirmation samples will be collected and evaluated.

Each of these RAOs can be achieved through treatment (including active treatment and natural attenuation) or removal of the petroleum-contaminated media (soil or groundwater), or by preventing exposure to the contaminated media (soil, soil gas, and groundwater) through containment or institutional controls. Each of the cleanup action alternatives described in Section 5.0 achieve the above RAOs and meet all of the MTCA threshold requirements (described in Section 6.1); each alternative is therefore a viable cleanup alternative under MTCA. The degree to which each cleanup action alternative meets the threshold requirements and other requirements listed in WAC 173-340-360(2) will be determined by applying the specific evaluation criteria identified in MTCA (see Section 6.1).

3.4 POTENTIALLY APPLICABLE LAWS

In accordance with MTCA, all cleanup actions conducted under MTCA shall comply with applicable state and federal laws (WAC 173-340-710(1). MTCA defines applicable state and federal laws to include legally applicable requirements and those requirements that are relevant and appropriate. Collectively, these requirements are referred to as applicable or relevant and appropriate requirements (ARARs). This section provides a brief overview of potential ARARs for the site cleanup. The primary ARAR is the MTCA cleanup regulation (WAC 173-340), especially with respect to the development of CULs and procedures for development and implementation of a cleanup under MTCA. Other than MTCA, the primary ARARs that may pertain to the cleanup action include the following:

- Federal Maximum Contaminant Levels (40 CFR Part 141)
- Washington Clean Air Act, Chapter 70.94 RCW
- Solid and Hazardous Waste Management (RCW 70.105; Chapter 173-303 WAC; 40 CFR 241, 257; Chapter 173-350 and 173-351 WAC) and Land Disposal Restrictions (40 CFR 268; WAC 173-303-340)
- Washington Industrial Safety and Health Act (RCW 49.17) and the Federal Occupational Safety and Health Act (29 CFR 1910, 1926)
- State Environmental Policy Act (RCW 43.21C and Chapter 197-11 WAC)
- Construction Stormwater General Permit (RCW 90.48) (33 U.S.C. Section 1251 et seq.).

State and federal groundwater and air quality criteria are considered in the development of CULs. State Dangerous Waste Regulations may be applicable to contaminated soil removed from the site during cleanup activities due to contamination characteristics.

Substantive State Environmental Policy Act requirements will be addressed concurrent with the site CAP to the degree applicable for the selected cleanup action.

TABLE 3-1
GROUNDWATER PRELIMINARY CLEANUP LEVELS AND APPLICABLE SITE AREAS
PEDERSON'S FRYER FARMS RI/FS

	Groundwater Preliminary Cleanup Levels (a)	Area A	Area B	Area C	Area E	Area F	Area G
TOTAL PETROLEUM HYDROCARBONS (mg/L)							
NWTPH-Dx							
Diesel Range Organics	0.5	X				X	
Lube Oil	0.5	X					
NWTPH-Gx							
Gasoline Range Organics	0.8/1.0 (b)	X				X	X
BTEX (µg/L) **Method SW8021B / SW8260B**							
Benzene	5					X	
Toluene							
Ethylbenzene							
m, p-Xylene	1000 (c)					X	
o-Xylene	1000 (c)					X	

(a) Preliminary cleanup levels are the screening criteria for the determined constituents of concern. MTCA Method A CULs were used as screening criteria.
(b) MTCA Method A cleanup level is 0.8 ug/L if benzene is present and 1.0 ug/L if benzene is not present.
(c) Cleanup level cannot be exceeded by the sum of individual xylene concentrations.

TABLE 3-2
SOIL PRELIMINARY CLEANUP LEVELS AND APPLICABLE SITE AREAS
PEDERSON'S FRYER FARMS RI/FS

	Soil Preliminary Cleanup Levels (a)	Area A	Area B	Area C	Area E	Area F	Area G
TOTAL PETROLEUM HYDROCARBONS (mg/kg)							
NWTPH-Dx							
Diesel Range Organics	2000	X		X	X		
Lube Oil	2000			X	X		
NWTPH-Gx							
Gasoline Range Organics	30/100 (b)	X	X			X	X
BTEX (mg/kg)							
Method SW8021B							
Benzene	0.03	X	X			X	X
Toluene	7					X	
Ethylbenzene	6		X			X	
m, p-Xylene							
o-Xylene							
Total Xylenes	9 (c)		X			X	
PAHs (mg/kg)							
Method 8270C							
Naphthalene							
2-Methylnaphthalene							
1-Methylnaphthalene							
Total Naphthalenes	5 (d)	X			X		

(a) Preliminary cleanup levels are the screening criteria for the determined constituents of concern. MTCA Method A CULs for Unrestricted Land Uses were used as screening criteria.

(b) Preliminary cleanup level is 30 mg/kg if benzene is present and 100 mg/kg if benzene is not present.

(c) Preliminary cleanup level cannot be exceeded by the sum of individual xylene concentrations.

(d) Preliminary cleanup level cannot be exceeded by the sum of Naphthalene, 2-Methylnaphthalene, and 1-Methylnaphthalene.

4.0 SCREENING OF REMEDIAL TECHNOLOGIES

The purpose of the FS is to develop and evaluate cleanup action alternatives to enable an appropriate cleanup action to be selected for the site. Cleanup action alternatives are an assemblage of one or more cleanup activities that, taken as a whole, will achieve all the RAOs for the site. This section discusses the results of two FS pilot tests and aquifer conditions (Section 4.1) and the breadth of remedial technologies (Section 4.2) considered for implementation and identifies the remedial technologies that are carried forward for development of the cleanup action alternatives in Section 5.0.

4.1 RI PILOT TESTS AND AQUIFER CONDITIONS

The scope of work in the RI/FS work plan included two pilot tests and the collection of monitored natural attenuation (MNA) parameters in support of the FS remedial technologies screening process. Sections 4.1.1 and 4.1.2 discuss the applicability of each pilot test to the site, how they were conducted, the results, and the implications to FS remedial technology screening. Section 4.1.3 discusses the site MNA parameter results, their significance to the biodegradation process for petroleum contamination, and implications for relevant remedial technologies.

4.1.1 VACUUM ENHANCED FREE PRODUCT RECOVERY PILOT TEST

Light nonaqueous phase liquid (LNAPL) has historically been detected at two Area A wells (MW-17 and MW-20) in the form of free product. The maximum observed thickness of the free product was 1.34 ft at well MW-17 during a 2003 groundwater monitoring event (EPI 2005). Well MW-17 was screened through the former excavation area (Area A source zone) and potentially acted as a downward vertical contaminant migration pathway; it was abandoned in 2011 (Landau Associates 2011c). Throughout the summer of 2005, a free product recovery field event was conducted at MW-17 and approximately 11.3 gallons of LNAPL was removed (EPI 2005). Groundwater monitoring during recent RI activities identified only 0.01 ft of free product (Landau Associates 2011c). The decrease in LNAPL since the pre-RI monitoring events suggests that the bulk of recoverable free phase LNAPL mass has been removed or otherwise attenuated and that the remaining LNAPL mass may mostly be comprised of immobile LNAPL globules, dispersed in the pore space of the surrounding ablation till. However, to further evaluate the remaining mass of LNAPL at Area A and to comply with MTCA requirements for free product removal to the maximum extent practicable [WAC 173-340-450(4)], Landau Associates conducted a vacuum-enhanced free product recovery pilot test during the RI.

The vacuum-enhanced free product recovery pilot test was conducted in July 2011 at deep zone well MW-25D. Well MW-25D is located in the former Area A excavation and is screened beneath the excavation, in native soil (ablation till, or Unit 3). The pilot test system was comprised of a blower/vacuum unit and a groundwater pump. Hose from the blower/vacuum unit was attached to the top of the well with an airtight connection. The purpose of the blower/vacuum unit was to apply a high vacuum to the subsurface surrounding the well screen to increase groundwater recharge (and product, if present) to the well and to attempt to recover subsurface LNAPL. The groundwater pump was placed in the well to create a cone of depression and a gradient toward the well to extract any available floating free product at the pump intake. Depending on if the vacuum was applied in addition to the groundwater pump, the draw down could reach up 6 ft from the static water level to the pump intake. Extracted groundwater was collected into a 6,000-gallon Baker tank.

During the pilot test, water level and free product measurements were collected at surrounding wells MW-7R, MW-19, MW-20, and MW-27D. Water levels decreased in all wells except MW-27D, which increased approximately 0.5 ft. After the pump test was complete, the tank of extracted groundwater was observed to have a slight sheen and a strong hydrocarbon odor, but no measurable free product was detected or observed. The lack of recoverable free product supports the assessment that the remaining LNAPL mass is likely dispersed as immobile globules (not free product) caused by years of smearing from precipitation recharge. Therefore, the application of a remedial technology including product extraction is not a practical remedial alternative at Area A.

4.1.2 CLEAR WATER INJECTION PILOT TEST

In August 2011, Landau Associates conducted a clear water injection[17] pilot test in accordance with the RI/FS work plan. The pilot test consisted of injecting a minimum of 1,500 gallons of potable water (clear water) into select monitoring wells to determine injection rates per subsurface condition. Three wells were injected: MW-15 and MW-26S (shallow zone wells), and MW-25D (a deep zone well). Since these wells are screened at varying intervals and are distributed across the site, the results from this test gives site-wide insight into the ability of the subsurface media to receive an injection.

The clear water injection at each well was conducted in three steps. During Step 1, water was gravity-fed into the well from a tank. For Step 2 and Step 3, a pump was used to increase pressure at the wells to 10 pounds per square inch (psi) and then to greater than 10 psi, respectively[18]. Flow rates and total injection volumes were documented during each step and are presented in Appendix D. Surface conditions around each well (particularly shallow wells) were also monitored in order to ensure that the

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[17] In the RI/FS work plan, the pilot test was titled “enhanced passive bioremediation” pilot test. However, the applicability of the clear water injection pilot test can be applied to remedial technologies other than enhanced passive bioremediation; therefore, it is herein referred to as a clear water injection pilot test.

[18] The RI/FS work plan proposed that the pressure be increased to 20 psi at Step 3. Based on field conditions, it was determined that such a pressure increase was not practical.

injection fluid from the well permeated through the subsurface media rather than short circuiting to the ground surface. Short circuiting can occur when the pressure applied by the pump is too high for aquifer conditions, which can allow the injection fluid to follow a preferential pathway leading to the ground surface. No signs of short-circuiting were observed.

MW-15, which is located in Area G, is screened within the native, ablation till (Unit 3) of the shallow zone (Landau Associates 2011c). During Step 1, MW-15 accepted the clear water injection at rates between 12 and 17 gallons per minute (gpm). While injecting at 10 psi (Step 2), MW-15 accepted the injection at flow rate of 30 gpm or greater. The maximum pressure applied to MW-15 was 15 psi, which resulted in flow rates around 40 gpm. Higher pressures were not applied in order to prevent the shallow well from being compromised via a potential blow out. Injection flow rates at 40 gpm indicate that the subsurface has excellent potential to accept a donor solution. Within the MW-15 flow rate data sets per step there are some outliers, but they are not persistent enough to constitute a trend. Water levels in two adjacent wells, MW-30D and MW-33S, were monitored during the injection. Neither well experienced water level fluctuations. MW-30D is a deep zone well and was not expected to fluctuate during the test since MW-15 is a shallow zone well. However, the non-responsiveness of MW-33S indicates a tight soil formation and a lack of preferential pathways from MW-15 to MW-33S.

MW-26S and MW-25D are both located within the Area A former excavation. MW-26S is screened in the backfilled excavation, which is considered to be part of the shallow zone. Injecting into MW-26S serves to assess the ability of the backfilled excavation area to serve as a pseudo infiltration gallery for the surrounding native soil. As previously mentioned, MW-25D is screened in the ablation till of the deep zone beneath the former excavation area (Landau Associates 2011c).

MW-26S accepted approximately 11 gpm throughout Step 1. As the pump was engaged for Step 2 and Step 3, pumping rates increased to levels approaching 100 gpm. However, pressures greater than 5 psi could not be applied since the well was accepting the injection at such a fast rate. This indicates that the excavation backfill has the ability to accept a high volume of injection fluid very rapidly. Water levels were monitored at surrounding wells MW-1, MW-4, and MW-5; these wells are outside of the former excavation area. Of the three wells, MW-1 was the only well that demonstrated a notable water level change with an increase of 1.1 ft; however, with a large injection volume, it is anticipated that water levels in MW-4 and MW-5 would fluctuate.

MW-25D initially accepted between 14 and 19 gpm during the gravity fed injection (Step 1). As pressure was applied during Step 2 and Step 3, these rates increased to 18 to 28 gpm and 29 to 59 gpm, respectively. Water levels were monitored at MW-7R, MW-19, MW-20, and MW-27D. The injection did not have a significant impact on any of the wells except for MW-7R, which rose 3.3 ft.

The results from each clear water injection indicate the potential for a successful electron acceptor solution injection in former excavation areas (backfill) and in the native ablation till (Units 2 and 3). When injecting electron acceptor solution during *in situ* bioremediation, rates are expected to be lower than clear water injection rates because of increased injection fluid viscosity and the potential for partial plugging of the aquifer pore space. Injection rates for all wells greatly exceeded 10 gpm, which is generally considered acceptable for the implementation of *in situ* bioremediation[19]. Accordingly, flow rates at both sides of the site and various depths indicate that future site-wide injections would also be successful.

4.1.3 MONITORED NATURAL ATTENUATION PARAMETERS

Site MNA parameters were collected during the RI to evaluate the natural aquifer (or water-bearing zone) conditions. MNA parameters collected were reported in the RI report and include (but are not limited to) the following:

- Field Parameter: Dissolved oxygen (DO; O_2)
- MNA 1: Nitrate (NO_3), ferrous iron [Fe(II)], and sulfate (SO^{2-}_4)
- MNA 2: Dissolved manganese [Mn(II)] and methane (CH_4).

The above MNA parameters are either natural electron acceptors found in an aquifer or are the by-products of other natural electron acceptors once they are reduced in an aquifer. The natural electron acceptors listed above include DO, nitrate, and sulfate; carbon dioxide is also an important natural electron acceptor but was not measured. The above listed by-products of other natural electron acceptors include ferrous iron, dissolved manganese, and methane. The relationships between the by-product parameters and their respective natural electron acceptor are as follows: Ferrous iron [Fe(II)] is a by-product of ferric iron [Fe(III)]; dissolved manganese [Mn(II)] is a by-product of manganese [Mn(IV)]; methane is a by-product of carbon dioxide.

The natural electron acceptors are consumed by aquifer bacteria with carbon (e.g., petroleum hydrocarbons, peat, and natural organics) via a redox[20] reaction to obtain energy. These redox reactions can be compared to the process whereby humans obtain energy through consumption of food (electron donor) and oxygen (electron acceptor). Bacteria obtain the greatest energy yield by using oxygen as an acceptor, as it is highly oxidized and can, therefore, be reduced easily and to a large degree. When oxygen is depleted in an aquifer, bacteria sequentially use the less oxidized electron acceptors in sequential order: nitrate, manganese (IV), iron (III), sulfate, and carbon dioxide.

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[19] Landau Associates has extensive experience with *in situ* bioremediation injection work.

[20] Portmanteau for reduction-oxidation

DO is measured in the field (not analytically) during groundwater sampling. Due to the potential for introducing ambient air to the DO measuring device (the YSI Flow Cell) at the ground surface, DO can be a difficult electron acceptor to measure accurately. Therefore, the analytical results for the less oxidized electron acceptors may be more indicative of the aquifer conditions of a particular site water-bearing zone. Collectively, the MNA parameters help to evaluate whether a given water-bearing zone is aerobic or anaerobic. If it is anaerobic and the location has petroleum hydrocarbon contamination, then the MNA parameters help define if the anaerobic environment is slightly to moderately reducing (manganese/iron reducing to sulfate reducing), or if it is highly reducing (carbon dioxide reducing, with production of methane). Select site MNA parameter measurements and the associated aquifer conditions are presented in Table 4-1 for shallow and deep water-bearing zones throughout the site.

The site-wide MNA parameters indicate a range of aerobic to highly reduced anaerobic redox conditions. Both the shallow perched zone and deep water-bearing zone appear to be naturally aerobic, as indicated by relatively high DO levels and higher nitrate concentrations at locations without petroleum contamination. However, where petroleum contamination is present in the deep zone (Area A), aquifer conditions are typically anaerobic. Area A deep groundwater wells MW-25D (below the former excavation) and MW-27D (adjacent to and southwest of former excavation) exhibit sulfate reducing to carbon dioxide reducing conditions where methane is produced via the process of methanogenesis; the presence of methane indicates a highly reducing, anaerobic environments. Other Area A deep wells located within relatively close proximity of the former excavation (specifically MW-7R, MW-19, and MW-20) generally exhibit sulfate reducing conditions, which occur in slightly to moderately reducing anaerobic environments. This sulfate reduced region appears to transition to nitrate reducing conditions toward the perimeter of the dissolved phase petroleum plume (as indicated by results from MW-22) then to aerobic conditions with increased distance from the source in some areas (i.e., with decreasing mass of petroleum contamination). Sulfate reducing conditions are also evident elsewhere in the deep zone near MW-28D and MW-31D, where low level petroleum contamination has been detected and is attributed to Area A.

4.2 REMEDIAL TECHNOLOGY SCREENING

The following remedial technologies or response actions were screened for consideration in development of cleanup action alternatives for the Site and were compared to the applicable RAOs.

4.2.1 CAPPING

Capping would be achieved by maintaining a low permeability pavement and/or building cover to limit potential future human exposure to residual contaminated soil and minimize surface water infiltration and recharge in the affected area. Including a vapor barrier with the cap would prevent intrusion of soil vapor into site buildings; however, this would not be feasible for most of the existing onsite buildings. Capping would achieve RAO-1 and elements of RAO-2 and RAO-3, but would not prevent migration of groundwater. Because maintenance of permanent engineering controls at adjacent properties (e.g. offsite properties that are part of Area A) is an unacceptable long-term solution, capping is not carried forward as a viable remedial alternative.

4.2.2 INSTITUTIONAL CONTROLS

This technology would utilize restrictive covenants to achieve RAO-1 and RAO-3, by preventing site activities that could lead to direct contact with contaminated soil or groundwater, or the ingestion of contaminated groundwater. Because institutional controls may not be able to be applied to neighboring properties, institutional controls are not carried forward as a viable stand-alone remedial alternative. However, institutional controls may be considered as an aspect of a remedial alternative or a contingency action if remediation to the point of compliance cannot reasonably be achieved any other way.

4.2.3 EXCAVATION

Excavation and offsite disposal or treatment of petroleum-impacted soil is a viable and permanent soil remediation technology that would potentially achieve all RAOs though it would likely need to be combined with another technology to achieve RAO-3 in a reasonable timeframe. This technology could be implemented for source areas of all areas of concern where residual subsurface petroleum-contaminated soil exists. Excavation addresses all RAOs and is therefore carried forward as a viable remedial alternative and is described in Section 5.0.

4.2.4 MONITORED NATURAL ATTENUATION

MNA describes a reduction of contaminant toxicity, volume, concentration, mobility, and/or bioavailability through natural physical, chemical, or biological processes that occur without human intervention. MNA is not a “no action” approach, but requires demonstration that attenuation is occurring, an understanding of site-specific and contaminant-specific attenuation mechanisms, and performance monitoring. Processes that destroy or degrade contaminants are preferred. MNA is appropriate for sites with a low potential for contaminant migration (i.e., stable plumes) and where natural attenuation processes will achieve RAOs in a reasonable timeframe compared to more active treatment. MNA is rarely appropriate as a sole remedy without other active remedial measures (e.g., source control) and/or institutional controls (EPA 1998; 1999). Given high concentrations of petroleum contamination in soil at the site, MNA is not considered further as an independent remedy but natural attenuation may be considered as an aspect of a remedial alternative.

4.2.5 ENHANCED BIODEGRADATION

Biodegradation is a natural process in which petroleum hydrocarbons can be degraded into non-hazardous substances, such as carbon dioxide and water. The natural biological processes of biodegradation can be enhanced via stimulation to expedite petroleum hydrocarbon breakdown. *In situ* enhanced biodegradation would not be effective if substantial LNAPL were present. However, results from the free product recovery pilot test discussed in Section 4.1.1 indicated that remaining LNAPL is minimal and not mobile; therefore, remaining LNAPL should not inhibit enhanced biodegradation at the site.

Petroleum hydrocarbon biodegradation can be achieved either aerobically or anaerobically (Wiedemeier et al., 1999). Aerobic degradation is stimulated by the addition of DO, which is commonly introduced through air sparging, or via the injection of a slurry of oxygen release compound (ORC). Under anaerobic conditions, biodegradation can be stimulated through the injection of a nitrate or sulfate solution to enhance nitrate and sulfate reducing conditions. Under both aerobic and anaerobic conditions, the extent of microbial degradation is dependent on the achieved distribution of electron acceptors (e.g. oxygen, nitrate, manganese (IV), ferric iron (III), and sulfate). Electron acceptor (or natural attenuation parameter) data collected during the RI were presented in Section 4.1.3. The natural attenuation parameter data indicate that the deep water-bearing zone is naturally aerobic but is typically anaerobic where contamination is present.

Due to the naturally aerobic aquifer conditions at the site, aerobic biodegradation could be simulated in groundwater at Area A. However, the natural attenuation parameter data also indicated that the biodegradation occurring at the site includes degradation through both nitrate and sulfate reduction. Therefore, anaerobic degradation could also be stimulated, and may be preferable due to the relative ease of delivery and other positive factors associated with nitrate- and sulfate-based injection solutions compared to ORC.

The clear water injection test described under Section 4.1.2 served as a pilot test for the assessment of delivery of a media to the subsurface for remedial alternatives such as enhanced biodegradation. The pilot test was conducted at three locations at the site representing shallow (native soil and backfill) and deep (beneath backfilled area, within native soil) groundwater zones. High injection rates were achieved at all three locations indicating that the application of enhanced biodegradation would be feasible at the site.

Enhanced biodegradation is a low-energy, low-impact technology that would achieve RAO2 and RAO3. Therefore, enhanced biodegradation is carried forward as a viable remedial alternative for groundwater (and potentially for smear zone soils) and is described in Section 5.0.

4.2.6 *IN SITU* CHEMICAL OXIDATION

ISCO is a technology that stimulates a rapid oxidation reaction within contaminated subsurface, which oxidizes and degrades contaminants. ISCO is conducted by injecting an oxidant and often an accompanying catalyst. The injected oxidant may be delivered as a liquid, slurry, or a gas. The oxidant is "applied using a number of points/wells such that there is adequate overlap of horizontal and vertical "effective zones" where an oxidant is in contact with contaminants" (ITRC 2005). The ISCO reaction is often so rapid that the associated radius of influence of an injection typically remains relatively close to the point of injection, which is typically limited compared to that of a more passive injection technology such as *in situ* biodegradation injection[21]. As a result of the rapidness and relatively limited radii of influence, ISCO injections typically yield a short period of effectiveness and reactivity. Additionally, ISCO may only successfully target subsurface preferential pathways, so once equilibrium is re-established in the subsurface after an injection, groundwater on boundaries of (or beyond) the radius of influence can back-diffuse into the radius of influence confusing the extent to which the injection effectively remediated the subsurface.

Different commercial ISCO oxidants are available with varying benefits and limitations that are typically dependent on subsurface conditions. The majority of the commercially available oxidants can only be applied to the saturated zone for groundwater treatment. However, for the site, it is important that the ISCO oxidant of choice be applicable to both the vadose and saturated zones as to address all RAOs. Two ISCO oxidants that meet these criteria include an oxidant slurry mixture applied via subsurface injection called RegenOx® (by Regenesis) and gas oxidant ozone (applied via gas-phase injection and sparging). While other oxidants could supplement or be substituted for these two technologies to further address groundwater, the FS will primarily focus on the ISCO application of RegenOx and ozone; they are screened in the following two subsections.

4.2.6.1 *In Situ* Chemical Oxidation using RegenOx

RegenOx is an oxidant that is applied as slurry to the vadose zone and saturated zone (groundwater); other similar types of slurry oxidants are commercially available. RegenOx can be applied in a number of ways and thus can be paired with a number of other remedial technologies. It can

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[21] The injectant (or electron acceptor) applied for *in situ* biodegradation typically is a water-based solution and therefore allows for a broader delivery and propagation than an ISCO oxidant.

be applied *in situ* via direct-injection or via injection wells (typically used for deeper soil or groundwater only injection targets); *ex situ* applications also exist such as during excavations or *ex situ* soil mixing. A significant benefit to the application of RegenOx is that the reaction occurs rapidly compared to *in situ* biodegradation technologies while sustaining oxidation and enhancing subsequent aerobic bioremediation; however, the radius of influence associated with the reaction is smaller than that of *in situ* biodegradation injections thus requiring a greater number of injection points/wells. RegenOx produces a less energetic reaction (less heat and pressure) than some other common oxidants such as Fenton's reagent, but, conversely, may require a larger quantity of the oxidant to achieve the same level of contamination destruction.

As a supplemental technology, ORC is often used to stimulate biodegradation of residual petroleum contamination as a "polishing" step with the final application or after the final application of RegenOx. As discussed, RegenOx reactions are rapid chemical processes, whereas ORC reactions are slow biodegradation processes. RegenOx is best at targeting high concentrations of contaminants (the source contaminant mass) whereas ORC is best at targeting low-level concentrations of contaminants (the residual, dissolved phase contaminants). If injection wells are used for oxidant application, both RegenOx and ORC have the potential to foul the injection well screens, therefore, requiring close inspection of the well screens during injection events and possibly the need to inject clear water to clear the screens.

ISCO using RegenOx would address all RAOs, and treatment results could potentially be enhanced by the addition of ORC. Since it has the potential to be practicable at most areas of concern at the site, this technology will be further evaluated in Section 5.0.

4.2.6.2 *In Situ* Chemical Oxidation using Ozone (Ozone Sparging)

Ozone is a gas with a very high oxidation potential that is typically applied via ozone gas injection to the vadose zone or ozone sparging to the groundwater zone (collectively ozone sparging hereafter). Ozone is commonly applied at lower oxidant doses since the "ozone degrades to oxygen and promotes aerobic biodegradation in combination with the ozone oxidation process" (ITRC 2005). Ozone is applied continuously rather than in batch (ITRC 2005) and, therefore, ISCO remediation using ozone would likely take longer than application of RegenOx. However, ozone would have a higher certainty of success due to the ability to take advantage of the higher gas-phase permeability for soil with ozone (than liquid permeability using liquid oxidant slurry). A benefit to ozone is that the constant delivery of ozone versus periodic liquid oxidant injection events reduces the incidents of contaminant concentration rebound in groundwater between injection events.

The ozone would be sparged to the subsurface via sparge wells with designed vertical injection intervals. Ozone can be generated from oxygen contained in a vessel (concentration of 5 to10 percent by weight) or from atmospheric air (concentration of about 1 percent by weight) (ITRC 2005). At the site, a prefabricated ozone generator would be installed and operated. A manifold system would distribute the ozone from the ozone generator to the injection wells. The ozone generator equipment can be rented, which could become expensive depending on the required treatment time, or purchased which is also expensive. It is important that the generator be appropriately sized for the application. Similarly, injection well locations and screen placement must be evaluated adequately for the application given the site subsurface conditions. The ozone generator and injection equipment (the ozone equipment) would run continuously during remediation limiting the ability for field personnel to constantly monitor the operation of the equipment. Therefore, the ozone equipment would need to be contained and secured which would require security measures such as fence installation, and may warrant the use of remote telemetry.

Ozone sparging would address all RAOs. Since it has the potential to be practicable at most areas of concern at the site, this technology will be further evaluated in Section 5.0.

4.2.7 *IN SITU* SOIL WASHING

In situ soil washing using a surfactant and/or alcohol solution is a remediation technology comprised of injecting the solution, flooding contaminated subsurface, and extracting the effluent. A benefit of soil washing is that the injection solution decreases the interfacial tension of the contamination and increases the apparent aqueous solubility of the contamination by about two to three orders of magnitude or greater, making it easier to extract (ITRC 2003). The most significant benefit of soil washing is that it is a rapid process. Extraction is included in the overall design for soil washing. Extraction is a key element to soil washing because it is important to control the horizontal and/or vertical migration of the solubility-enhanced contamination to prevent migration to clean areas of the subsurface, and to control, capture, and recirculate the surfactant which is often very expensive and sometimes itself toxic. Designing the extraction well network is dependent upon proper delineation of the contaminant source zone and LNAPL distribution. Additionally, hydraulic parameters for the water-bearing zone must be well known and defined. As presented in Section 2.3 site hydrogeology is fairly discontinuous and the degree of saturation of the water-bearing units appears to be heavily dependent on infiltration of precipitation. Therefore, the extraction design would need to account for seasonal variation to target season-specific hydraulic parameters and to determine the target depth for extraction well screens. Selection of the surfactant/alcohol solution is a process that requires laboratory batch and column studies and field trials (ITRC 2003). Soil washing is expensive as it includes design studies for the hydraulic parameters and surfactant/alcohol solution selection, cost for the solution, injection and extraction well installation (then decommissioning), and disposal of the extracted effluent. Additionally, it may be difficult to permit the injection since there is some inherent risk to injecting the solution (some of which are fairly toxic) and dispersing the contamination. Because site hydrology is so variable and recapture of the solution could not be guaranteed, *in situ* soil washing will not be considered further in the FS.

4.2.8 SOIL VAPOR EXTRACTION

This technology applies a vacuum to the subsurface and induces subsurface airflow to volatilize and remove volatilized gasoline constituents (e.g., BTEX and other lighter-end petroleum fractions) from vadose zone soil. Extracted soil gas is treated at the surface using a catalytic oxidation system or granular activated carbon. SVE is often paired with air sparging to also address groundwater contamination or with dual-phase extraction to address smear zone soils.

Site soils (backfill material at former excavation areas and ablation till) are fairly permeable, which would support volatilization and extraction of the gasoline constituents. SVE is typically of little use with less volatile constituents, such as diesel or heavy oil so would not necessarily be of use site wide (i.e., at areas with significant diesel impacts). Implementation of SVE can be particularly useful, at some areas of concern with subsurface contamination extending beneath adjacent buildings because vapor can be extracted to remediate soil where other technologies that require direct physical or chemical contact are less feasible or impractical. At several areas of the site, SVE would achieve RAO1 and RAO2. SVE would need to be paired with other remedial alternatives to achieve these two RAOs site wide. Therefore, SVE is carried forward as a viable remedial alternative and is described in Section 5.0.

4.2.9 DUAL-PHASE EXTRACTION

Dual-phase extraction typically involves depressing the groundwater table via groundwater pumping to create a cone of gradient toward an extraction well to enhance free product removal. It can also be used to dewater a portion of the soil column that is normally saturated to allow use of SVE to remediate a smear zone. As discussed above under Section 4.1.1, a vacuum-enhanced groundwater/product extraction pilot test was conducted to assess the extractability of free phase LNAPL at Area A. Groundwater was readily recovered, but the extracted groundwater did not contain measurable free product. Between the results of the pilot test and the lack of free product measured at Area A monitoring wells, it appears that that extractable free phase LNAPL may no longer be present at Area A. Also, because DRO are so prevalent in Area A, dual-phase extraction would not be helpful in conjunction with SVE in this area. Consequently, dual-phase extraction is not a practical technology for remediation at the site and is not carried forward in the FS.

4.2.10 SUMMARY OF TECHNOLOGIES UNDER FURTHER CONSIDERATION

In summary, nine remedial technologies were screened but only five will be further evaluated in Section 5.0. The five remaining technologies include the following:

- Excavation
- Enhanced Biodegradation
- ISCO: Using RegenOx
- ISCO: Using Ozone Sparging
- SVE.

It is anticipated that Area A (the only location with attributed deep groundwater contamination) may include an MNA component with the final selected remedy for that area of concern or use MNA as a contingent action for cleanup of residual groundwater contamination.

TABLE 4-1
MONITORED NATURAL ATTENUATION PARAMETERS GROUNDWATER ANALYTICAL RESULTS AND AQUIFER CONDITIONS
PEDERSON'S FRYER FARMS RI/FS

Water Bearing Zone	Area	Well ID	Lab ID	Date Collected	Dissolved Oxygen (mg/L)	Nitrate (mg/L) Method EPA300.0		Manganese (mg/L) EPA Method 200.8	Ferrous Iron (mg/L)	Sulfate (mg/L) Method EPA300.0		Methane (mg/L)		Aquifer Conditions		
														Aerobic	Anaerobic	
															Slightly/Moderately Reducing	Highly Reducing
S	A	MW-01	26582-4	6/3/2011	9.82	0.9	U	--	--	**5.2**		--				X
S	A	MW-02	26582-1	6/3/2011	7.08	**1.8**		--	**0.8**	**9.3**		--		X		
S	A	MW-04	26596-4	6/5/2011	3.11	**1.0**		**0.35**	0	**4.2**		**0.0359**		X		
S	A	MW-26S	26524-1	6/1/2011	2.50	0.90	U	**2.2**	0	**4.3**		--			X	
			30108-3	12/1/2011	9.78	0.90	U	--	**2**	**5.6**		--			X	
S	B	MW-08	26533-8	6/2/2011	8.90	0.90	U	--	0	**9.3**		--		X		X
S	F	MW-11	26524-2	6/1/2011	5.62	0.90	U	--	0	**12**		--		X		X
S	F	MW-35S	26524-4	6/1/2011	2.73	0.90	U	--	**2**	1.2	U	--				X
			30034-1	11/28/2011	2.79	0.90	U	--	0	1.2	U	--				X
S	G	MW-15	26533-5	6/2/2011	5.47	0.90	U	**0.81**	**2**	**2.7**		0.0260	U		X	
S	G	MW-34S	26524-6	6/1/2011	2.68	0.90	U	--	0	**6.6**				X		
D	A	MW-7R	26596-3	6/5/2011	2.04	0.90	U	--	0	**3.0**		--			X	
D	A	MW-19	26596-5	6/5/2011	5.79	0.90	U	--	**2**	**4.1**		--			X	
D	A	MW-20	26596-1	6/5/2011	1.81	0.90	U	--	**2.4**	1.2	U	--				X
D	A	MW-22	26582-3	6/3/2011	7.55	**1.1**		--	0	**6.1**		--		X		
D	A	MW-25D	26582-2	6/3/2011/	0.88	0.90	U	**2.9**	**2.5**	1.2		**6.89**				X
			30108-5	12/1/2011	1.07	0.90	U	--	**1**	9.7		**--**				X
D	A	MW-27D	26582-5	6/3/2011	1.30	0.90	U	**3**	**2**	**3.0**		**4.91**				X
D	A/B	MW-09	26533-12	6/2/2011	2.36	**4.7**		--	0	**9.7**		--		X		
D	A/B	MW-28D	26533-11	6/2/2011	0.78	0.90	U	--	**2.5**	1.2	U	--				X
			30059-3	11/29/2011	7.01	0.90	U	--	**3**	1.2	U	--				X
D	C	MW-31D	26533-2	6/2/2011	1.79	0.90	U	--	**3**	1.2	U	--				X
D	F	MW-29D	26533-3	6/2/2011	6.17	**1.3**		--	0	**11**		--		X		
			30059-4	11/29/2011	7.23	**1.4**		--	0	**11**		--		X		
D	G	MW-30D	26533-7	6/2/2011	4.16	**1.1**		--	0	**10**		--		X		
D	--	MW-32D	26533-4	6/2/2011	4.49	**2.4**		--	0	**16**		--		X		

S = Shallow Zone
D = Deep Zone
-- = Not analyzed
U = Indicates the compound was undetected at the reported concentration.
Bold = Detected compound. DO is always detected and is therefore not bolded.

5.0 DESCRIPTION OF REMEDIAL ALTERNATIVES

This section provides a detailed evaluation of the remedial technologies considered applicable for use at the site and packages these technologies into site-wide remedial alternatives. The development of the remedial alternatives accounted for the unique aspects of each area of concern including the impacted media, applicable RAOs, the type of historical petroleum releases, and the proximity to building foundations. RAO-01 and RAO-02 apply to all areas of concern, and RAO-3 only applies to Area A. All areas of concern except for Area A have petroleum impacts from either a gasoline source (a lighter hydrocarbon) or from a diesel and/or heating oil source (heavier hydrocarbons); Area A has impacts from gasoline, diesel, and heating oil, which reduces or eliminates the applicability of certain technologies. Petroleum impacts from all areas of concern except for Area C extend beneath buildings; the extent of Area C contamination is limited and localized outside of an adjacent building. Since the areas of concern are unique, the remedial alternatives consist of a group of technologies that cumulatively address all areas of concern. The alternatives and a summary of their details are as follows:

- Alternative 1: ISCO Injection and Excavation
  - Injection of RegenOx:
    - Shallow and Deep Soil at Area A
    - Primary Remedial Action for Groundwater at Area A
    - Shallow Soil at Area G
  - Injection of ORC: Secondary Remedial Action for Groundwater at Area A
  - Excavation: Soil at Area B, Area C, Area E, and F
- Alternative 2: Ozone Sparging and Excavation
  - Ozone Sparging
    - Shallow and Deep Soil at Area A, Area B, Area F, and Area G
    - Groundwater at Area A
  - Excavation: Soil at Area C and Area E
- Alternative 3: Excavation and Enhanced Biodegradation
  - Excavation: Site-wide Shallow Soil
  - Enhanced Biodegradation:
    - Deep soil at Area A
    - Groundwater at Area A
- Alternative 4: SVE, Excavation, and Enhanced Biodegradation
  - SVE: Shallow Gasoline-Impacted Soil (specifically Area B, Area F, and Area G)
  - Excavation: Shallow Diesel-Impacted Soil (Area A, Area C, and Area E)

- Enhanced Biodegradation:
  - Deep Soil at Area A
  - Groundwater at Area A

A description of these alternatives is presented below. Alternative descriptions are organized by alternative, the media (e.g., soil and groundwater) that the alternative addresses, followed by the specific technologies and their applicability to specific areas of concern. Within each technology-specific subsection there will be a discussion of the conceptual approach, how the alternative meets the RAOs for the areas of concern, and a presentation of a cost estimate for each technology. The alternative sections end with a cost estimate for implementation of the entire alternative.

All cost estimates presented in this FS are considered preliminary with a relative accuracy within the range of -30 to +50 percent (-30/+50%). Detailed cost estimates for each alternative are provided in Appendix E and a summary of alternative costs are provided in Table 5-1. Cost estimates account for the physical constraints per area of concern to the extent practical for the FS; physical constraints were presented in Section 2.7.

These cost estimates are intended solely for use as a basis for comparison of costs between alternatives. Costs such as permitting costs associated with working on the Pipeline Road parcel or potential confirmation VI samples are not included. An updated cost estimate will be developed for the selected cleanup action during the design phase.

5.1 ALTERNATIVE 1: *IN SITU* CHEMICAL OXIDATION INJECTION AND EXCAVATION

Alternative 1 is comprised of injection of an oxidant for rapid petroleum mass reduction in soil and groundwater, injection of an ORC to stimulate biodegradation of residual petroleum in groundwater, and excavation to remediate soil where it is more readily accessible or where ISCO injections are impractical. Alternative 1 consists of the following major components:

- **Injection of RegenOx (Soil and Groundwater):** Inject RegenOx into the vadose zone to treat contaminated shallow soil within and surrounding former excavations of Area A and Area G., Injectthe saturated zone to treat the deep extents of the smear-zone soil contamination as well as groundwater in the deep water-bearing zone at Area A.
- **Injection of ORC (Groundwater):** Inject ORC directly into the saturated zone to treat residual petroleum contamination in groundwater at Area A. This is a secondary component to RegenOx and promotes long-term biodegradation to target remaining low concentration dissolved phase contaminants.
- **Excavation (Soil):** Excavate contaminated shallow soil from Area B, Area C, Area E, and Area F, haul the contaminated soil off site to an appropriate disposal facility, and backfill the excavations with imported clean fill.

5.1.1 *IN SITU* CHEMICAL OXIDATION USING REGENOX AND OXYGEN RELEASE COMPOUND

RegenOx and ORC are applied to the contaminated subsurface via direct-injection points created at time of drilling. Grids of injection points would be defined for the Area A vadose zone, the Area A saturated zone, and the Area G vadose zone. Each injection grid and associated injection point release depth would target the known extent of contamination. For cost estimating purposes, it is assumed that the extent of soil and groundwater contamination is as shown on Figure 5-1. Based on estimated spacing of 10 ft there will be approximately the following number of injection points per area:

- Area A vadose zone – 32 injection points
- Area A saturated zone – 110 injection points
- Area G vadose zone – 7 injection points.

The spacing of the injection points will be offset by 5 ft for each event. Example injection point grid layouts for Area A and Area G are shown on Figures 5-2 and 5-13, respectively.

Given the rapid reaction of ISCO using RegenOx (plus ORC for Area A saturated zone), it is anticipated that the injection programs for both Area A and Area G (collectively) would be complete within 0.5 to 2 years. For cost estimating purposes, approximately 85 soil confirmation samples will be collected via drilling during and/or after completion of the injection program for performance and compliance monitoring purposes. Four quarters of performance groundwater monitoring would be collected with an additional four quarters of compliance groundwater monitoring after the injection programs. One additional monitoring well for the Area A deep water-bearing zone would be installed.

ISCO using RegenOx and ORC is expected to achieve RAO-1 through RAO-3 for Area A, and would achieve RAO-1 and RAO-2 for Area G.

5.1.2 EXCAVATION

Excavation of shallow contaminated soil would be performed at Area B, Area C, Area E, and Area F and the assumed lateral limits of each excavation (for cost estimating purposes) are shown on Figures 5-5, 5-8, 5-9, and 5-10, respectively. The actual extent of excavation would be based on the results of field screening and soil compliance monitoring conducted during excavation. Due to the proximity of buildings and foundations, some demolition would be required for Area B, Area E, and Area F. An engineered shoring system would have to be designed and installed for Area C excavation work due to the proximity to a building. The assumed vertical limits of the excavations range between approximately 8 ft BGS (Area C) and up to 15 ft BGS (Area B).

Based on the limits shown on Figures 5-5, 5-8, 5-9, and 5-10, approximately 970 cubic yards (yd^3) of soil would be excavated, all of which would be contaminated soil requiring treatment or disposal at a facility licensed to accept petroleum-contaminated soil (likely the Pierce County regional landfill). Based on the volume, depth, and locations of the excavations, it is anticipated that the design (including shoring design), permitting, excavation, and filling of the remedial excavations would take approximately 3 to 6 months to complete. For cost estimating purposes, approximately 26 soil confirmation samples will be collected during or after excavations for performance and compliance monitoring purposes. Any residual contamination remaining in site soil following excavation is expected to naturally attenuate. Confirmation VI sampling may be necessary at some locations but has not been included in the cost estimate.

Excavation achieves all Area B, Area C, Area E, and Area F RAOs (RAO-1 and RAO-2). Excavation achieves RAO-1 by removing contaminated soil with concentrations above direct contact soil CULs. Soil contamination from Area B, Area C, Area E, and Area F have the potential to impact seasonal shallow perched groundwater, and if the excavation work is successful at removing all or the majority of the impacted soil, it is expected that the shallow perched zones (if currently impacted) would naturally attenuate; this would address RAO-2.

5.1.3 ALTERNATIVE 1 TOTAL COST ESTIMATE

The estimated cost to implement Alternative 1 is $2,058,000 (-30/+50%) as summarized in Table 5-1.

5.2 ALTERNATIVE 2: OZONE SPARGING AND EXCAVATION

Alternative 2 is comprised of continuous injections of ozone to oxidize and reduce the petroleum mass in soil and groundwater, and excavation to remediate soil where it is more readily accessible or where ozone injection is impractical. Alternative 2 consists of the following major components:

- **Ozone Sparging (Soil):** Inject ozone into vadose zone to treat shallow contaminated soil at Area A, Area B, Area F, and Area G.
- **Ozone Sparging (Deep Soil/Groundwater):** Inject ozone into the contaminated deep saturated/water-bearing zone at Area A to target groundwater and smear zone soil contamination.
- **Excavation (Soil):** Excavate contaminated shallow soil from Area C and Area E, haul the contaminated soil off site to an appropriate disposal facility, and backfill the excavation cavities with clean soil.

5.2.1 OZONE SPARGING – SOIL AND GROUNDWATER

Ozone sparging would be applied via sparge wells to the vadose zone of Area A, Area B, Area F, and Area G, and the saturated zone and deep water-bearing zone of Area A. Sparge well networks would be defined for the contaminated zones of each area. For cost estimating purposes, it is assumed that the extent of soil and groundwater contamination is as shown on Figure 5-1. Each sparge well network and associated well screen placement would be designed to target the extent of contamination. Based on estimated radii of influence of about 20 ft for groundwater and 10 ft for soil, there will be approximately the following number of sparge wells (and type) per area:

- Area A vadose zone/saturated zone – 15 dual nested sparge wells
- Area A groundwater – 25 sparge wells
- Area B vadose zone – 10 sparge wells
- Area F vadose zone – 6 sparge wells
- Area G vadose zone – 2 sparge wells.

Example sparge well network layouts with the associated radii of influence are shown on Figures 5-3, 5-6, 5-11, and 5-14.

Ozone generator/sparge units will inject ozone to a manifold system which directs ozone to the sparge well networks. The ozone generator/sparge unit is an automated system that generates ozone from atmospheric or containerized oxygen and injects the ozone to the subsurface in a continuous stream. Since the ozone generator/sparging unit is automated, it is anticipated to require minimal operations and maintenance. In addition to oxidation of the contaminant mass directly by ozone or indirectly by hydroxyl radical (a reaction product of ozone), ozone sparging promotes aerobic biodegradation when ozone degrades to molecular oxygen. It is estimated that (collectively) all areas would be treated within 2 to 3 years. The ozone trailer can be rented or purchased, but due to the treatment time estimate, it assumed that purchase of the trailer would be less expensive than renting one.

For cost estimating purposes, approximately 100 soil confirmation samples will be collected via drilling throughout the sparging program for performance and compliance monitoring purposes. Up to 12 quarters of performance groundwater monitoring would be collected with an additional 4 quarters of compliance groundwater monitoring after completion of the sparging programs. One additional monitoring well for the Area A deep water-bearing zone would be installed.

Ozone sparging is expected to achieve RAO-1 through RAO-3 for Area A, and would achieve RAO-1 and RAO-2 for Area B, Area F, and Area G.

5.2.2 EXCAVATION

Excavation of shallow soil contamination would be applied to Area C and Area E only. Note that because of the limited extent and shallow depth of contamination, the only remedial alternative under consideration for Area C and Area E is excavation. Therefore, the applicability of this remedial technology to Area C and Area E was previously presented under Section 5.1.3. Based on the limits shown on Figure 5-8 and 5-9, the approximate soil volume that would be excavated is 55 cubic yards (yd^3). Based on the volume, depth, and locations of the excavations, it is anticipated that the design (including shoring design), permitting, excavation, and filling of the remedial excavations would take less than 3 to 6 months to complete. For cost estimating purposes, approximately 14 soil confirmation samples will be collected during excavations for performance and compliance monitoring purposes.

Applicable RAOs (RAO-1 and RAO-2) would be achieved.

5.2.3 ALTERNATIVE 2 TOTAL COST ESTIMATE

The estimated cost to implement Alternative 2 is $1,547,000 (-30/+50%), as summarized in Table 5-1.

5.3 ALTERNATIVE 3: EXCAVATION AND ENHANCED BIODEGRADATION

Alternative 3 is comprised of excavation and enhanced biodegradation to remediate site wide shallow soil, deep soil, and deep groundwater contamination. Alternative 3 consists of the following major components:

- **Excavation (Soil):** Excavate site-wide contaminated shallow soil, haul the contaminated soil off site to an appropriate disposal facility, and replace the excavated cavities with clean soil.
- **Enhanced Biodegradation (Soil and Groundwater):** Inject electron acceptor into the vadose zone of the former excavation area at Area A.

5.3.1 EXCAVATION

Excavation of shallow soil contamination would be applied to all areas of concern. The application of excavation was previously discussed for all areas of concern except for Area A and Area G, which are discussed in this section. For cost estimating purposes, the assumed lateral limits of the excavation for Area A and Area G are as shown on Figure 5-4 and 5-15; the actual extent would be based on the results of field screening and soil compliance monitoring conducted during excavation. Due to the proximity of the old building foundation to Area A, some demolition would likely be required. An engineered shoring system would have to be designed and installed for Area G excavation work due to its proximity to the main facility building. The assumed vertical limit of the excavation is 25 ft BGS for Area A and is 17 ft BGS for Area G.

Based on the limits shown on Figures 5-4 and 5-15, Area A and Area G excavations will generate approximately 2800 yd^3 and 240 yd^3 of soil, respectively. The total volume of soil to be excavated for all areas for Alternative 3 would be 4,010 yd^3, all of which would be contaminated soil requiring treatment or disposal at a facility licensed to accept petroleum-contaminated soil (likely Pierce County regional landfill). Based on the volume, depth, and locations of the excavations, it is anticipated that the design (including shoring design), permitting, excavation, and filling of the remedial excavations would take approximately 5 to 6 months to complete. For cost estimating purposes, approximately 50 soil confirmation samples will be collected during or after completion of the excavations for performance and compliance monitoring purposes. Any residual contamination remaining in site soil following excavation is expected to naturally attenuate. Confirmation VI sampling may be necessary at some locations but has not been included in the cost estimate.

Excavation achieves RAO-1 and RAO-2 for all areas.

5.3.2 ENHANCED BIODEGRADATION

Enhanced biodegradation would be applied by injection of an electron acceptor solution into the vadose zone of the former excavation area of Area A, as shown on Figure 5-4. Enhanced biodegradation will consist of the following main components:

- **Soil:** Inject electron acceptor into injection wells screened in the bottom of the Area A former excavation area fill. This will target deeper vadose zone soils (below the practical limits of excavation in this area) and the smear zone above the groundwater table. While remediation of vadose zone soils is typically not an applicable use of enhanced biodegradation, the presence of the man-made "basin" of permeable fill (the fill basin) created by the former UST excavation presents an opportunity to use the basin as an infiltration gallery in which the electron acceptor can saturate/infiltrate through to the underlying vadose zone soils. The number of injection events will be determined based on concentration data from adjacent shallow zone monitoring wells. Targeting the smear zone within the former excavation area/source zone will achieve RAO-2.
- **Groundwater:** Infiltrate electron acceptor from the Area A fill basin down to the deep water-bearing zone to directly remediate groundwater contamination. This is an iterative process where contaminant rebound typically occurs between injection events as long as sorbed contaminant mass or LNAPL remains sorbed within the treatment zone. This occurs because, upon depletion of electron acceptor, groundwater concentrations return to equilibrium with remaining petroleum mass present in these non-aqueous phases. Treatment will be complete when petroleum contamination no longer rebounds and the injected electron acceptor is depleted. Targeting groundwater via infiltration will achieve RAO-3.

Under this alternative, injection of electron acceptor would be used to stimulate microbial degradation of petroleum constituents into non-hazardous substances. The electron acceptor would be periodically injected into (and would infiltrate from) the Area A fill basin to the vadose zone, saturated zone, and to the deep water-bearing zone to stimulate aerobic or anaerobic treatment of contaminated soil and groundwater. Soil contamination below the groundwater table (saturated zone) and just above the groundwater (smear zone) is treated through two avenues. First, as groundwater contaminant concentrations decrease, LNAPL petroleum and petroleum sorbed to soil dissolves and partitions into the aqueous phase where it can be degraded. Second, injections can be timed to occur during periods of high groundwater to target the smear zone. Vadose zone soils higher above the water table generally will not be substantially treated by this technology; however, periodic injection and saturation of this zone should decrease contaminant mass through flushing and biodegradation. For cost estimating purposes, it is assumed that the extent of soil and groundwater contamination is as shown on Figure 5-1. The final well network design would consist of approximately nine injection wells and two additional monitoring wells, also shown on Figure 5-4.

Aerobic bioremediation typically involves air sparging or the addition of an oxygen-releasing compound available in various formulations; however, the mass of oxygen delivered to the water-bearing zone is limited by the relatively low aqueous solubility of oxygen (< 10 mg/L at typical groundwater temperatures). Stimulation of anaerobic bioremediation through addition of nitrate and/or sulfate electron acceptor has advantages over addition of oxygen for stimulation of aerobic bioremediation. Nitrate and sulfate salts used to create injection solutions are highly soluble in water (approximately 200,000 and 40,000 times more soluble than oxygen, respectively). This higher solubility allows a higher initial concentration of nitrate/sulfate than oxygen at the injection point and greater extent and longevity of treatment. Nitrate and sulfate are also weaker oxidizing agents than oxygen, which means that the natural demand for these compounds represented by natural aquifer organics and reduced metals is much less than the demand for oxygen. As a result of this lower natural demand, added nitrate/sulfate remains more available for enhancing the petroleum degradation process than with added oxygen. For the purpose of the FS, the aquifer will be treated as anaerobic and would therefore use a nitrate/sulfate electron acceptor solution.

Nitrate and sulfate are regulated as groundwater contaminants; therefore, aquifer redox conditions and the extent of the injectant must be monitored to ensure nitrate and sulfate do not persist beyond areas of the contamination. Nitrate has a drinking water maximum contaminant level of 10 mg/L. Sulfate has a secondary maximum contaminant levels, based on suggestions for cosmetic or aesthetic water quality, of 250 mg/L. Where aquifer conditions are naturally nitrate- to sulfate-reducing (i.e., anaerobic), these compounds will be degraded under natural conditions if not fully consumed within the zone of contamination. However, because nitrate and sulfate will persist under aerobic conditions, additional consideration of extent of injectant is required where these compounds are injected to a petroleum contaminated zone within a naturally aerobic zone.

Based on these factors, it is anticipated, that anaerobic bioremediation would initially be stimulated at Area A through injection/infiltration of nitrate and/or sulfate solution into the Area A fill basin which should address the entire dissolved phase groundwater plume. Progress monitoring of groundwater would be conducted to monitor contaminant biodegradation and nitrate concentrations for the purposes of maintaining concentrations below the maximum contaminant level. As petroleum mass decreases and persistence of nitrate/sulfate becomes a concern and the natural aerobic conditions of the aquifer begin to be reestablished, application of ORC or air sparging could then be used to stimulate aerobic bioremediation within the plume. The delivery methods for ORC (delivered as slurry) and oxygen (air) are different that nitrate/sulfate solution. Oxygen release compound would need to be delivered through injection wells and air through sparge wells that actually penetrate the deep groundwater-bearing zone.

An optimal injection frequency for anaerobic or aerobic electron acceptors of 2 to 4 times per year is anticipated, but is dependent on the groundwater analytical results from progress monitoring. Injections during wet periods of the year will most effectively treat contamination present in the upper portion of the smear zone above the average groundwater table elevation. As bacteria utilize the injected electron acceptor, petroleum hydrocarbon (electron donor) mass will be degraded and concentrations will decrease. However, contaminant concentrations will rebound as injected electron acceptor becomes depleted and contaminant in the sorbed or LNAPL phase partition and dissolve into the aqueous phase. Remediation will be complete when contaminant levels no longer rebound and remain below the acceptable CUL. Beginning after the first injection, monthly performance groundwater sampling would be conducted until proper dosing and frequency of the nitrate or sulfate solution is determined; quarterly performance groundwater monitoring would likely be conducted thereafter. After the final injection event, there would be four final quarters of compliance groundwater monitoring.

Enhanced biodegradation remediation is expected to achieve RAO-2 and RAO-3 for Area A within 2 to 5 years, depending on ability to maintain an optimal injection schedule and aquifer permeability and heterogeneity.

5.3.3 ALTERNATIVE 3 TOTAL COST ESTIMATE

The estimated present worth to implement Alternative 3 is $1,756,000 (-30/+50%), as summarized in Table 5-1.

5.4 ALTERNATIVE 4: SOIL VAPOR EXTRACTION

Alternative 4 is comprised of SVE, excavation, and enhanced biodegradation to remediate site wide shallow soil, deep soil, and deep groundwater contamination. Alternative 4 consists of the following major components:

- **SVE (Soil)**: Volatilize, capture, and treat contamination from the soil. This only applies to Area B, Area F, and Area G where gasoline constituents are the primary contaminant of concern.
- **Excavation (Soil):** Excavate contaminated shallow soil from Area A, Area C, and Area E, hauling the contaminated soil off site to an appropriate disposal facility, and backfilling the excavations with clean fill.
- **Enhanced Biodegradation (Soil and Groundwater):** Injecting electron acceptor into the vadose zone of the former excavation area at Area A.

5.4.1 SOIL VAPOR EXTRACTION

Soil vapor extraction systems would be installed in the contaminated vadose zones of Area B, Area F, and Area G. The application of SVE would promote volatilization of gasoline constituents (e.g., BTEX and other lighter-end petroleum fractions) that are sorbed to soil and would collect the vapors and contaminated soil gas. Granular activated carbon would be used to treat the extracted soil gas prior to discharge to the atmosphere. For cost estimating purposes, it is assumed that the extent of soil and groundwater contamination is as shown on Figure 5-1. The final design of the SVE system for Area B, Area F, and Area G would consist of approximately five, four, and one vertical SVE wells, respectively; SVE well networks are shown on Figures 5-7, 5-12, and 5-16.

Due to the high soil permeability of the backfilled former excavation areas and lower permeability of the native lacustrine deposits that may be encountered, it is anticipated that SVE would need to be conducted for approximately 3 years for all areas (cumulatively). Although initial gasoline constituent removal may occur at a rapid rate, this initial rate would decline to a smaller diffusion-limited rate likely after the first few months of operation. After that time, gasoline constituent removal would continue, but it would take a few more years to reduce contaminant concentrations below CULs. For cost estimating purposes, it is assumed that SVE would be conducted for up to 3 years after which follow up confirmation sampling would be performed to determine whether continued operation of the SVE system would be needed to attain soil CULs. The cost estimate for this alternative includes costs for the confirmation sampling including 20 performance/confirmation samples, but does not include costs for any additional operation of the SVE system if CULs are not attained within this timeframe. Confirmation VI sampling may be necessary at some locations but has not been included in the cost estimate.

Soil vapor extraction would achieve RAO-1 and RAO-2 for Area B, Area F, and Area G. Soil vapor extraction would achieve RAO-1 by removing sorbed gasoline constituents from contaminated soil using a method that requires minimal human contact with the soil itself. The target depths of the SVE wells would address soil contamination within the typical shallow seasonal perched groundwater zone, thereby addressing RAO-02. Regular monitoring of the SVE system intake air stream would identify trends in subsurface vapor concentrations and provide an indicator for when active extraction could be terminated.

5.4.2 EXCAVATION

Excavation of shallow soil contamination would be applied to Area A, Area C, and Area E only. Shallow soil excavation work for these areas of concern was presented in previous sections. Based on the limits of excavation previously presented, (and shown on Figures 5-4, 5-8, and 5-9), the Area A, Area C, and Area E excavations will generate a total of approximately 2,860 yd^3, all of which would be contaminated soil requiring treatment or disposal at a facility licensed to accept petroleum-contaminated soil (likely Pierce County regional landfill). Based on the volume, depth, and locations of the excavations, it is anticipated that the design (including shoring design for Area C), permitting, excavation, and filling of the remedial excavations would take approximately 4 to 6 months to complete. For cost estimating purposes, approximately 30 soil confirmation samples will be collected during excavations for performance and compliance monitoring purposes. Any residual contamination remaining in site soil following excavation is expected to naturally attenuate.

Excavation achieves RAO-1 and RAO-2 for Area A, Area C, and Area E.

5.4.3 ENHANCED BIODEGRADATION

The application of enhanced biodegradation for Alternative 4 is identical to the application for Alternative 3. Please refer to Section 5.3.2 (and Figure 5-4) for a description of this technology and its applicability to Area A deep soil and groundwater.

5.4.4 ALTERNATIVE 4 TOTAL COST ESTIMATE

The estimated cost to implement Alternative 4 is $1,667,000 (-30/+50%), as summarized in Table 5-1.

Legend

🟨 Soil Contamination

🟦 Groundwater Contamination

🟩 Smear Zone (40' to 55')

▨ Former Excavation Area

0 50 100

Scale in Feet

Data Source: ESRI World Imagery

Note
1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

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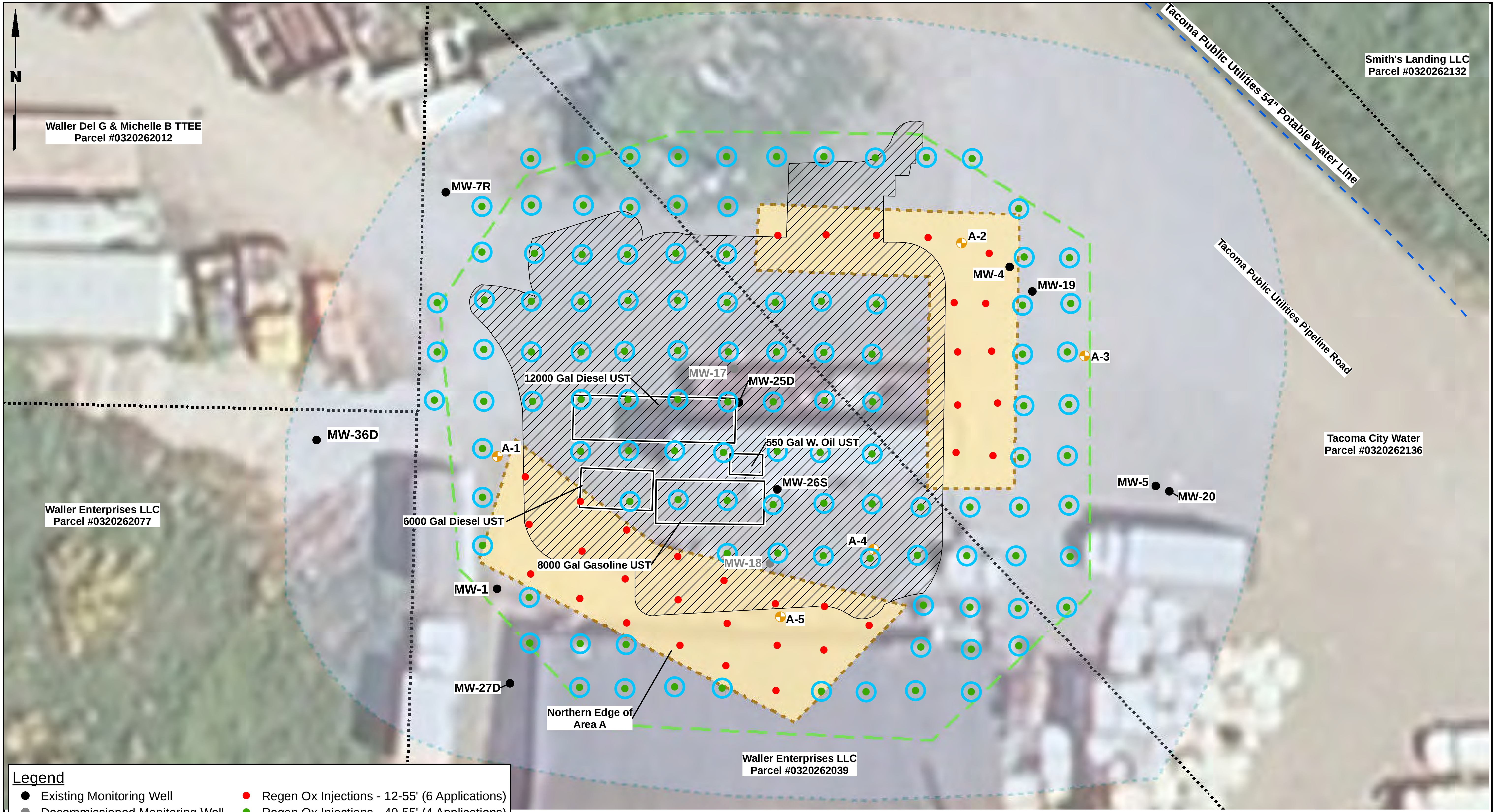
Pederson's Fryer Farms
Pierce County, Washington

Approximate Extent of Site Contamination

Figure
5-1



Legend

- ● Existing Monitoring Well
- ● Decommissioned Monitoring Well
- ⋯ Tax Parcel
- ▨ Former Excavation Area and USTs
- ▭ Groundwater Contamination
- ▭ Shallow Soil Contamination
- ▭ Smear Zone (40' to 55')
- ● Regen Ox Injections - 12-55' (6 Applications)
- ● Regen Ox Injections - 40-55' (4 Applications)
- ○ ORC Injections - 40-55' (1 Application)

Note
1. Injection points offset 5ft per injection event.
2. First round of ORC injections in source area to correspond with last round of Regen Ox injections.
3. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Data Source: Pierce County GIS, ESRI World Imagery.

Y:\Projects\136006\010\013\Supplemental RI & FS\MapDocs\Fig5-2-AreaAAlternative1.mxd 5/2/2012 NAD 1983 StatePlane Washington South FIPS 4602 Feet

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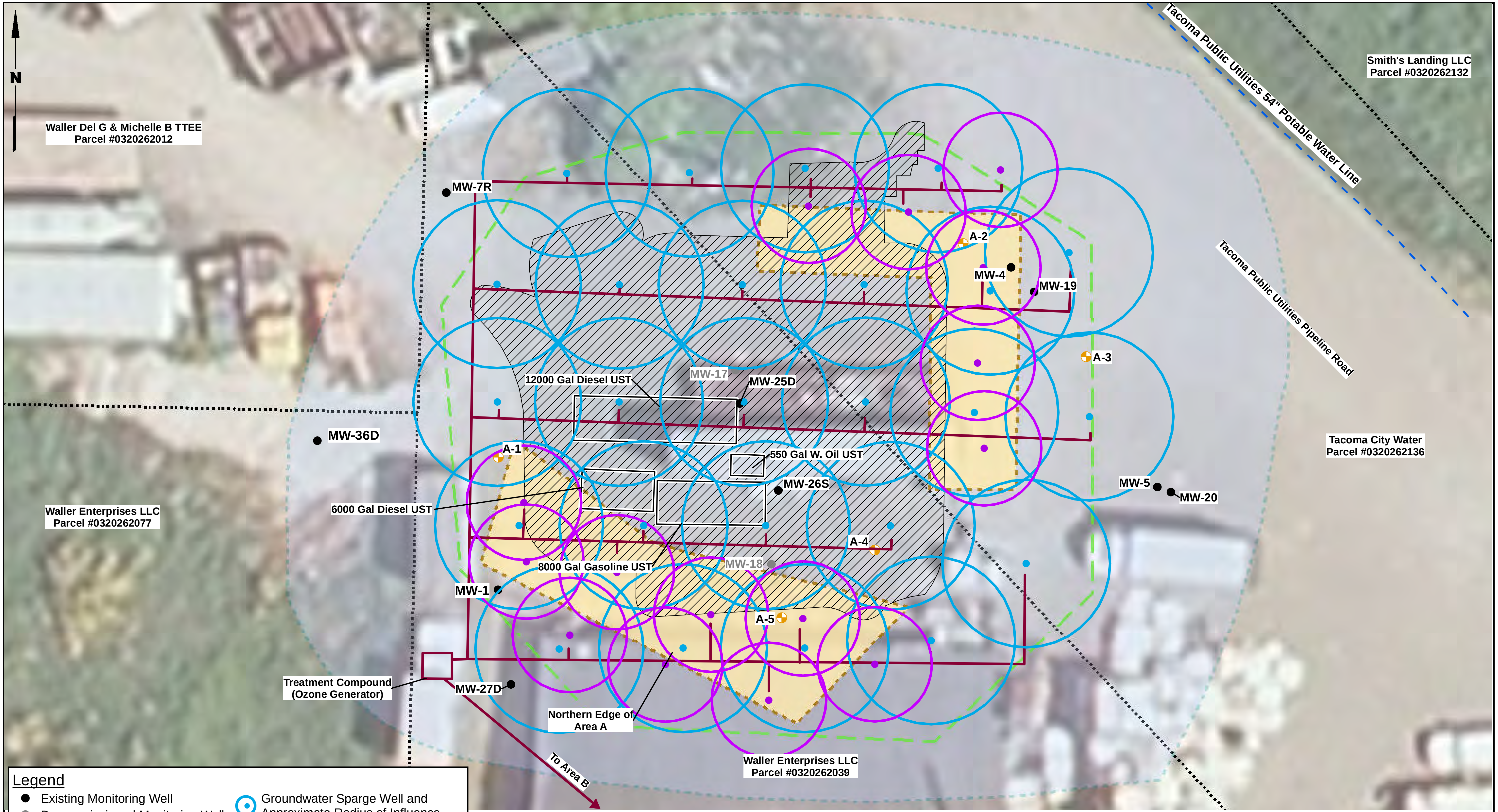
Pederson's Fryer Farms
Pierce County, Washington

Area A
Alternative 1 - ISCO Injection

Figure
5-2



Legend

- ● Existing Monitoring Well
- ● Decommissioned Monitoring Well
- ⋯ Tax Parcel
- ▨ Former Excavation Area and USTs
- ▭ Groundwater Contamination
- ▭ Shallow Soil Contamination
- ▭ Smear Zone (40' to 55')
- ⊙ Groundwater Sparge Well and Approximate Radius of Influence
- ⊙ Nested Vadose Zone Sparge Well and Approximate Radius of Influence

Note

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

0 10 20

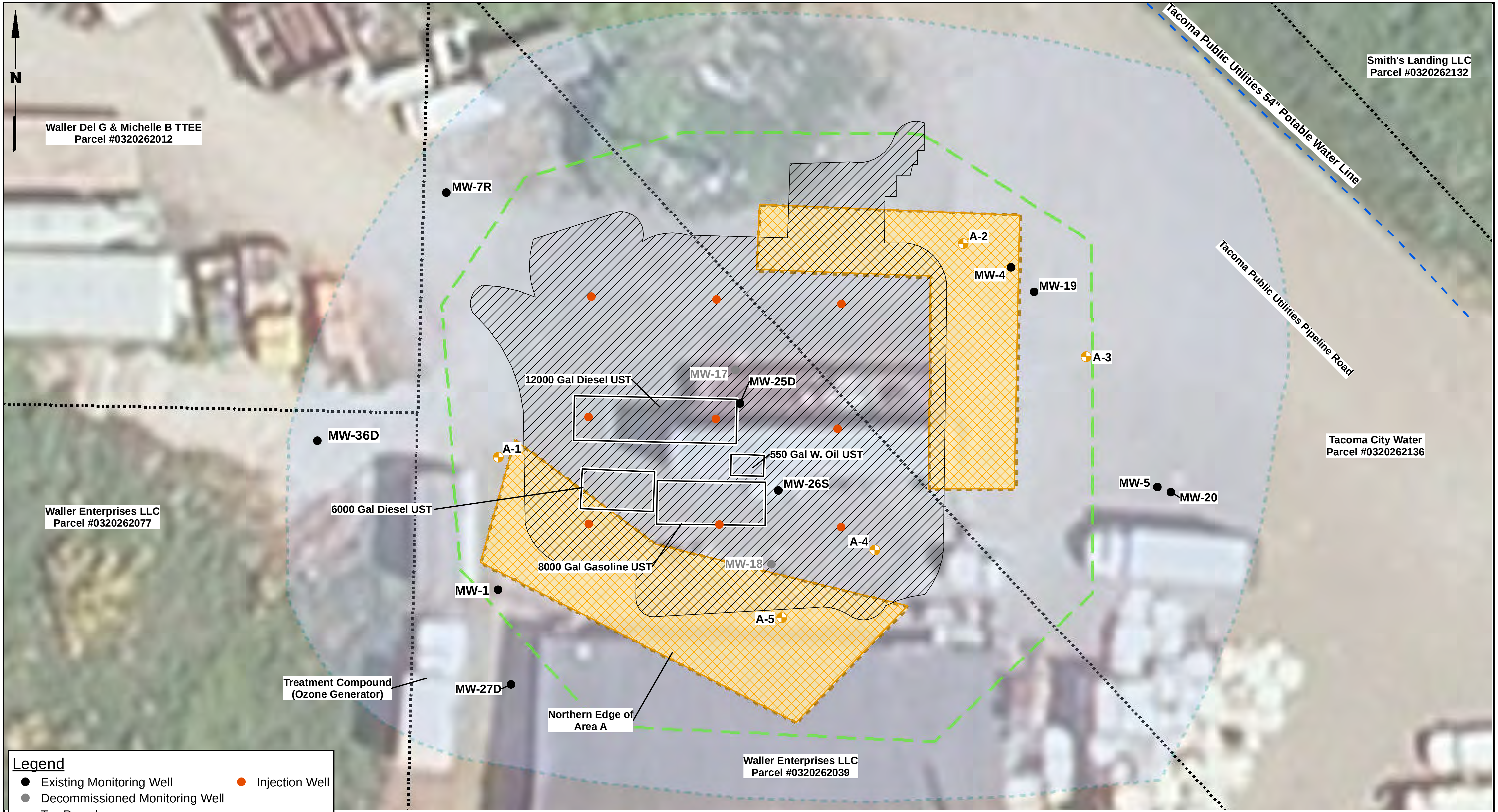
Scale in Feet

Data Source: Pierce County GIS, ESRI World Imagery.

Y:\Projects\136006\010\013\Supplemental RI & FS\MapDocs\Fig5-3-AreaAAlternative2.mxd 5/2/2012 NAD 1983 StatePlane Washington South FIPS 4602 Feet

LANDAU ASSOCIATES

Pederson's Fryer Farms Pierce County, Washington	**Area A** **Alternative 2 - Ozone Sparging**	Figure 5-3



Legend

- ● Existing Monitoring Well
- ● Decommissioned Monitoring Well
- ⋯ Tax Parcel
- ▨ Proposed Excavation Area
- ▨ Former Excavation Area
- ▭ Groundwater Contamination
- ▭ Shallow Soil Contamination
- ▭ Smear Zone (40' to 55')
- ● Injection Well

Note
1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

0 10 20
Scale in Feet

Data Source: Pierce County GIS, ESRI World Imagery.

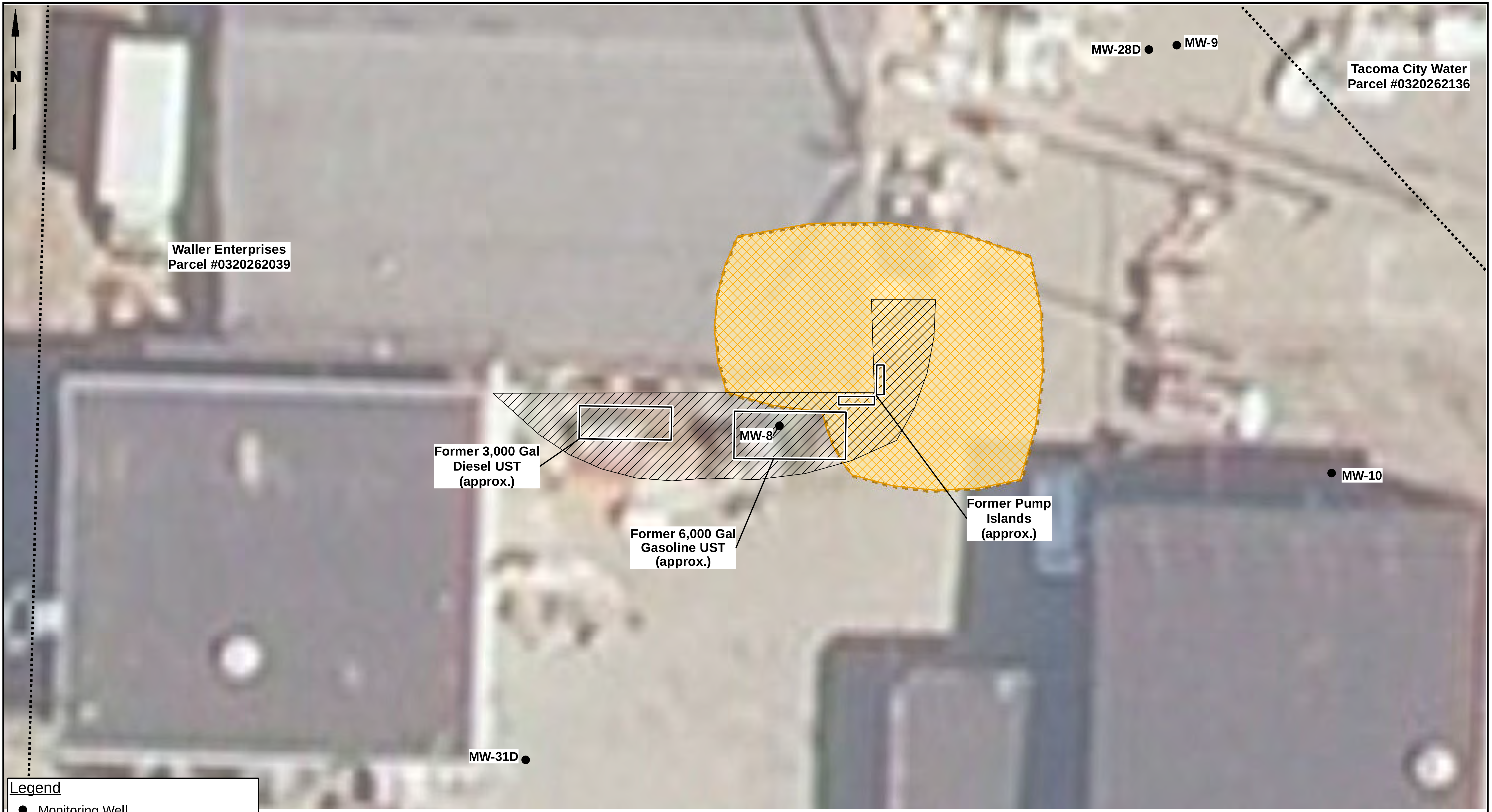
LANDAU ASSOCIATES

Pederson's Fryer Farms
Pierce County, Washington

Area A
Alternatives 3 & 4 - Excavation and Enhanced Biodegradation

Figure
5-4

Y:\Projects\136006\010\013\Supplemental RI & FS\MapDocs\Fig5-4-AreaAAlternatives3&4.mxd 5/2/2012 NAD 1983 StatePlane Washington South FIPS 4602 Feet



Legend

● Monitoring Well
----- Tax Parcel
▨ Former Excavation Area and USTs
🟨 Above MTCA Method A CUL
▨ Proposed Excavation Area
▢ Soil Contamination

Note
1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Data Source: Pierce County GIS, ESRI World Imagery.

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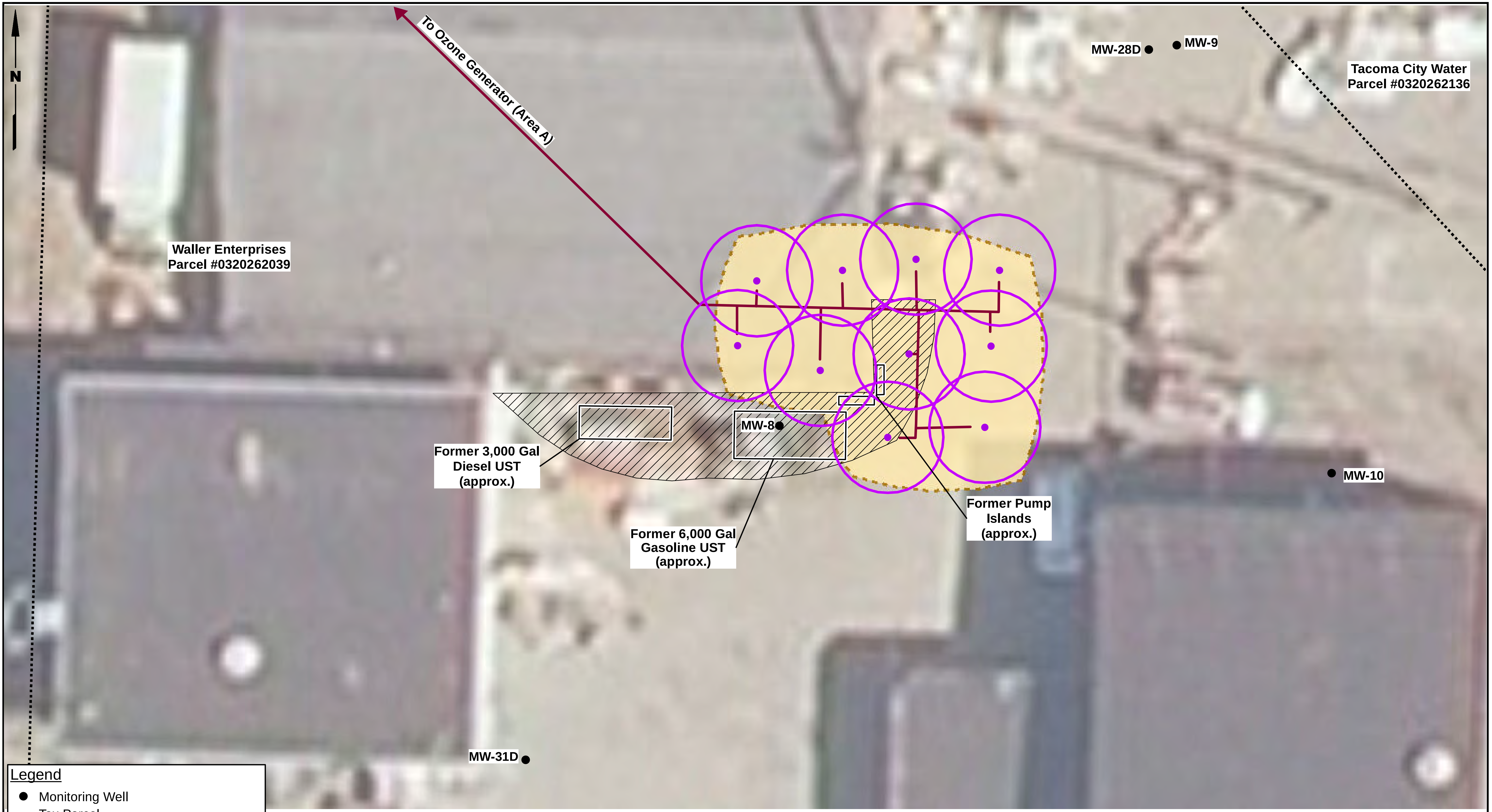
LANDAU
ASSOCIATES

Pederson's Fryer Farms
Pierce County, Washington

Area B
Alternatives 1 & 3 - Excavation

Figure
5-5



Legend
- ● Monitoring Well
- - - - - Tax Parcel
- ▨ Former Excavation Area and USTs
- 🟨 Above MTCA Method A CUL
- ⊙ Vadose Zone Sparge Well and Approximate Radius of Influence
- ▨ Soil Contamination

Note
1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

0 24
Scale in Feet

Data Source: Pierce County GIS, ESRI World Imagery.

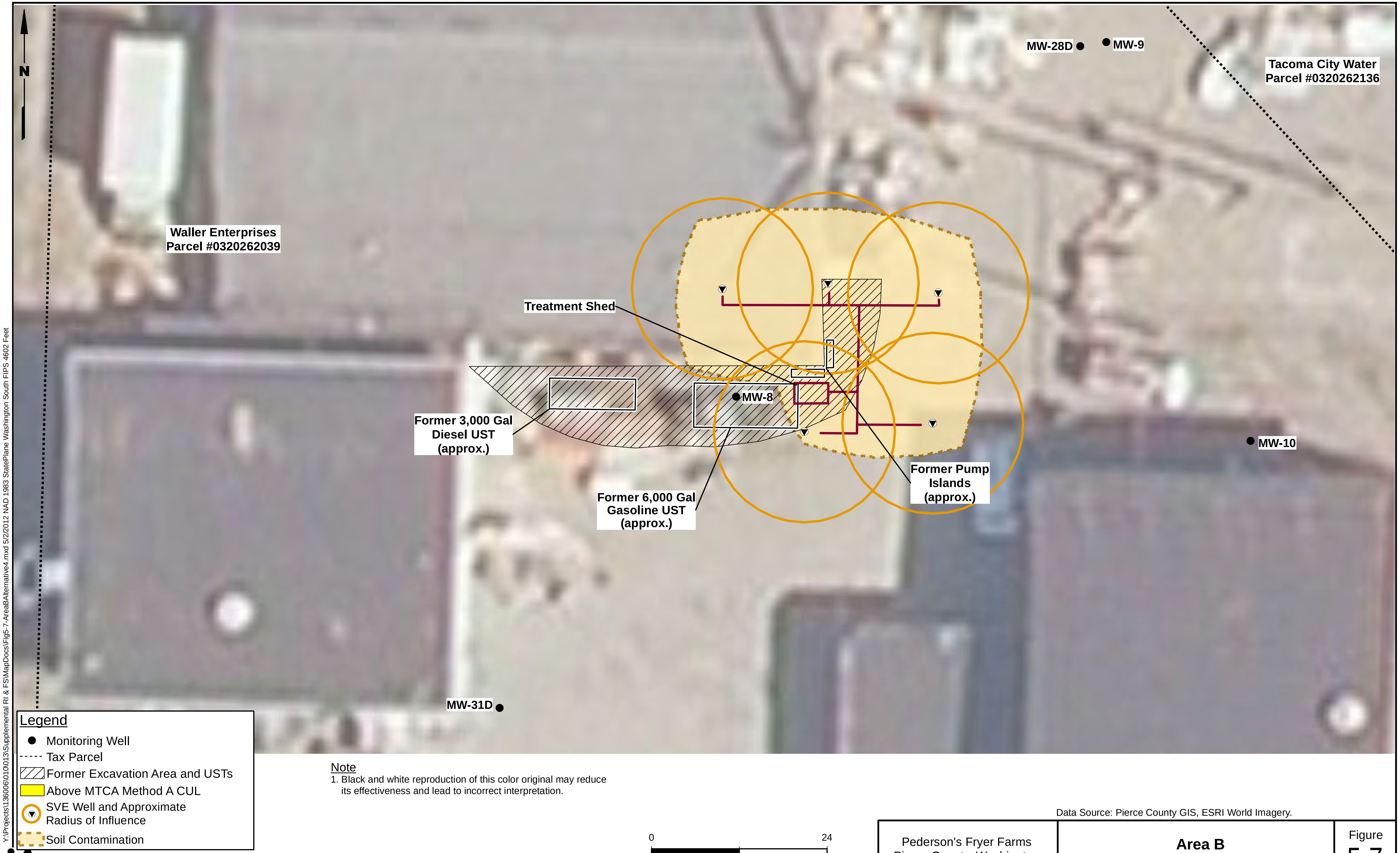
LANDAU ASSOCIATES

Pederson's Fryer Farms
Pierce County, Washington

Area B
Alternative 2 - Ozone Sparging

Figure
5-6

Y:\Projects\136006\010\013\Supplemental RI & FS\MapDocs\Fig5-6-AreaBAlternative2.mxd 5/2/2012 NAD 1983 StatePlane Washington South FIPS 4602 Feet



Y:\Projects\136006\010013\Supplemental RI & FS\MapDocs\Fig5-7-AreaBAlternative4.mxd 5/2/2012 NAD 1983 StatePlane Washington South FIPS 4602 Feet

Note
1. Black and white reproduction of this color original may reduce
its effectiveness and lead to incorrect interpretation.

0 24
Scale in Feet

Data Source: Pierce County GIS, ESRI World Imagery.

Landau Associates

Pederson's Fryer Farms
Pierce County, Washington

Area B
Alternative 4 - SVE

Figure
5-7

Legend

- ● Monitoring Well
- ● Temporary Monitoring Well
- ----- Tax Parcel
- ▨ Former Excavation Area
- 🟨 Above MTCA Method A CUL
- ▨ Proposed Excavation Area
- ▭ Soil Contamination

Notes

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

0 10
Scale in Feet

Data Source: Pierce County GIS, ESRI World Imagery.

Pederson's Fryer Farms
Pierce County, Washington

Area C
Alternatives 1, 2, 3, & 4 - Excavation

Figure
5-8

Landau Associates

Y:\Projects\136006\010\013\Supplemental RI & FS\MapDocs\Fig5-8-AreaCAlternatives1234.mxd 5/2/2012 NAD 1983 StatePlane Washington South FIPS 4602 Feet

Legend

- ----- Tax Parcel
- — UST Piping
- ▨ Former Excavation Area
- 🟨 Above MTCA Method A CUL
- ⬚ Soil Contamination
- ▩ Proposed Excavation Area

Notes

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

0 20
Scale in Feet

Data Source: Pierce County GIS, Bing Maps Aerial Imagery 2010.

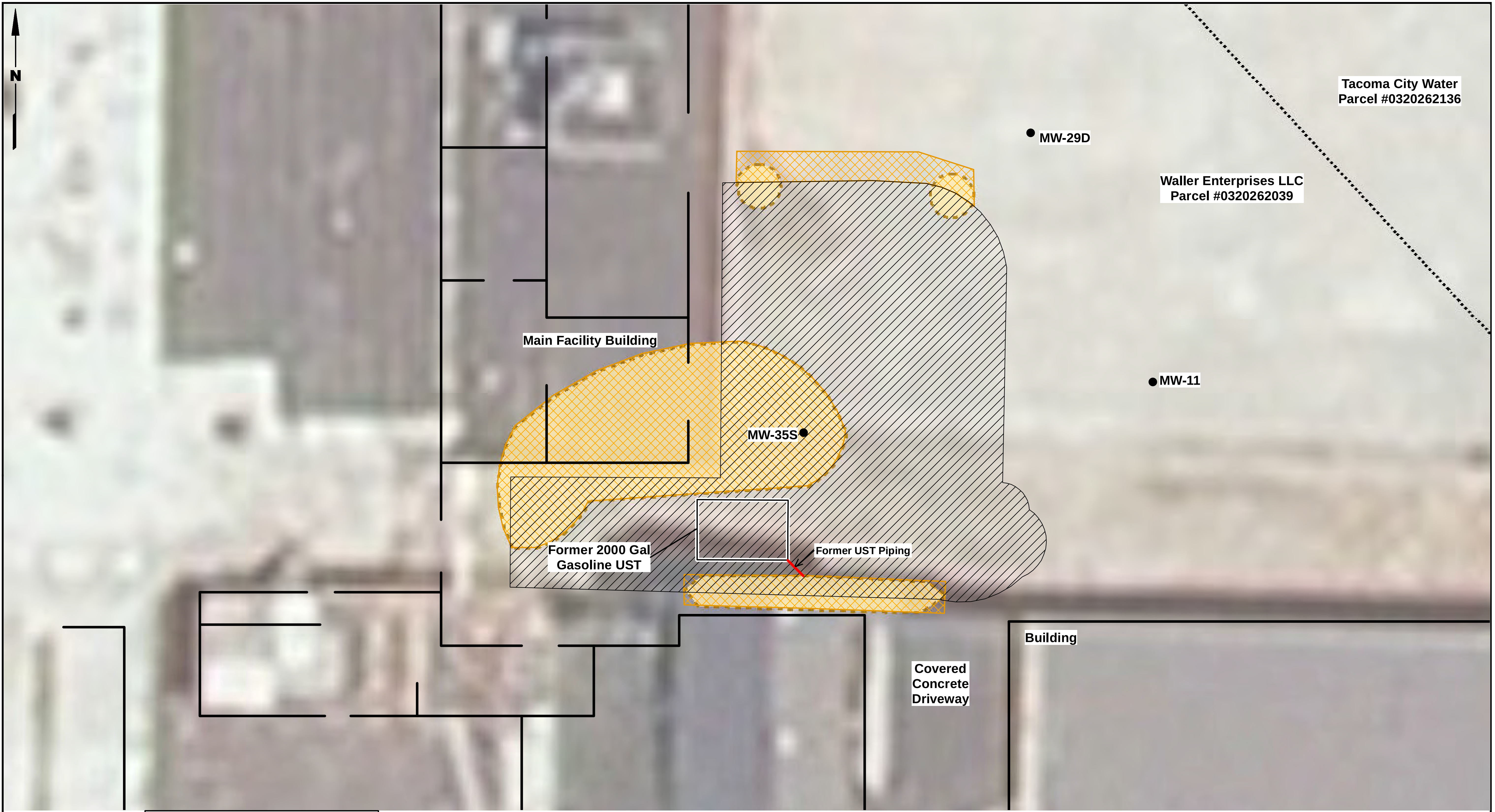
Pederson's Fryer Farms
Pierce County, Washington

Area E
Alternatives 1, 2, 3, & 4 - Excavation

Figure
5-9

LANDAU ASSOCIATES

Y:\Projects\1360006\010\013\Supplemental RI & FS\MapDocs\Fig5-9-AreaEAlternatives1234.mxd 5/2/2012 NAD 1983 StatePlane Washington South FIPS 4602 Feet



Legend
- ● Existing Monitoring Well
- ----- Tax Parcel
- ▨ Former Excavation Area and UST
- 🟨 Above MTCA Method A CUL
- ▭ Soil Contamination
- ▨ Proposed Excavation

Note
1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Data Source: Pierce County GIS, ESRI World Imagery.

0 10 20
Scale in Feet

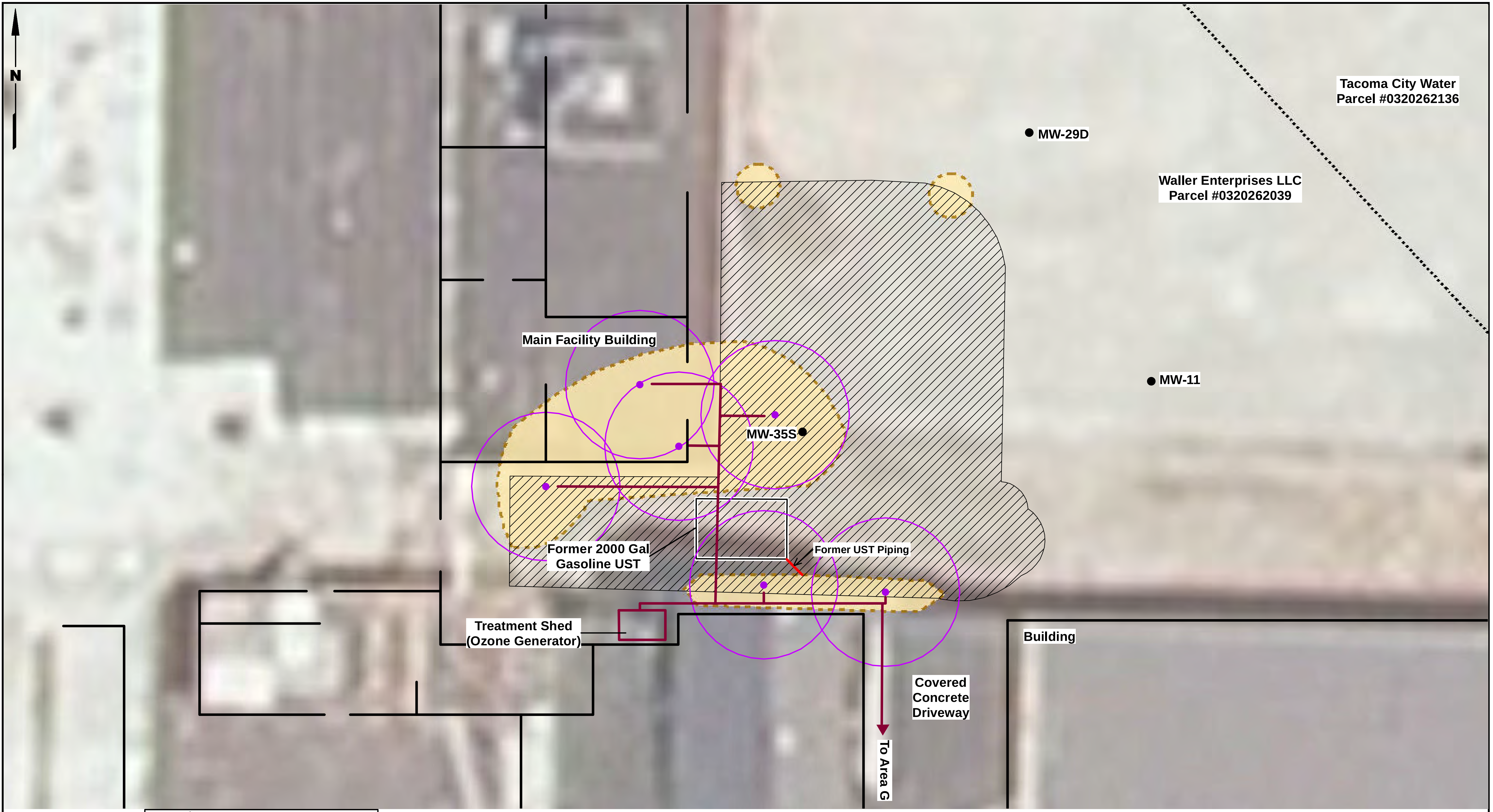
LANDAU ASSOCIATES

Pederson's Fryer Farms
Pierce County, Washington

Area F
Alternatives 1 & 3 - Excavation

Figure
5-10

Y:\Projects\136006\010013\Supplemental RI & FS\MapDocs\Fig5-10-AreaFAlternatives1&3.mxd 5/2/2012 NAD 1983 StatePlane Washington South FIPS 4602 Feet



Legend

- ● Existing Monitoring Well
- ----- Tax Parcel
- ▨ Former Excavation Area and UST
- 🟨 Above MTCA Method A CUL
- ▨ Soil Contamination
- ◉ Vadose Zone Sparge Well and Approximate Radius of Influence

Note

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Data Source: Pierce County GIS, ESRI World Imagery.

0 10 20

Scale in Feet

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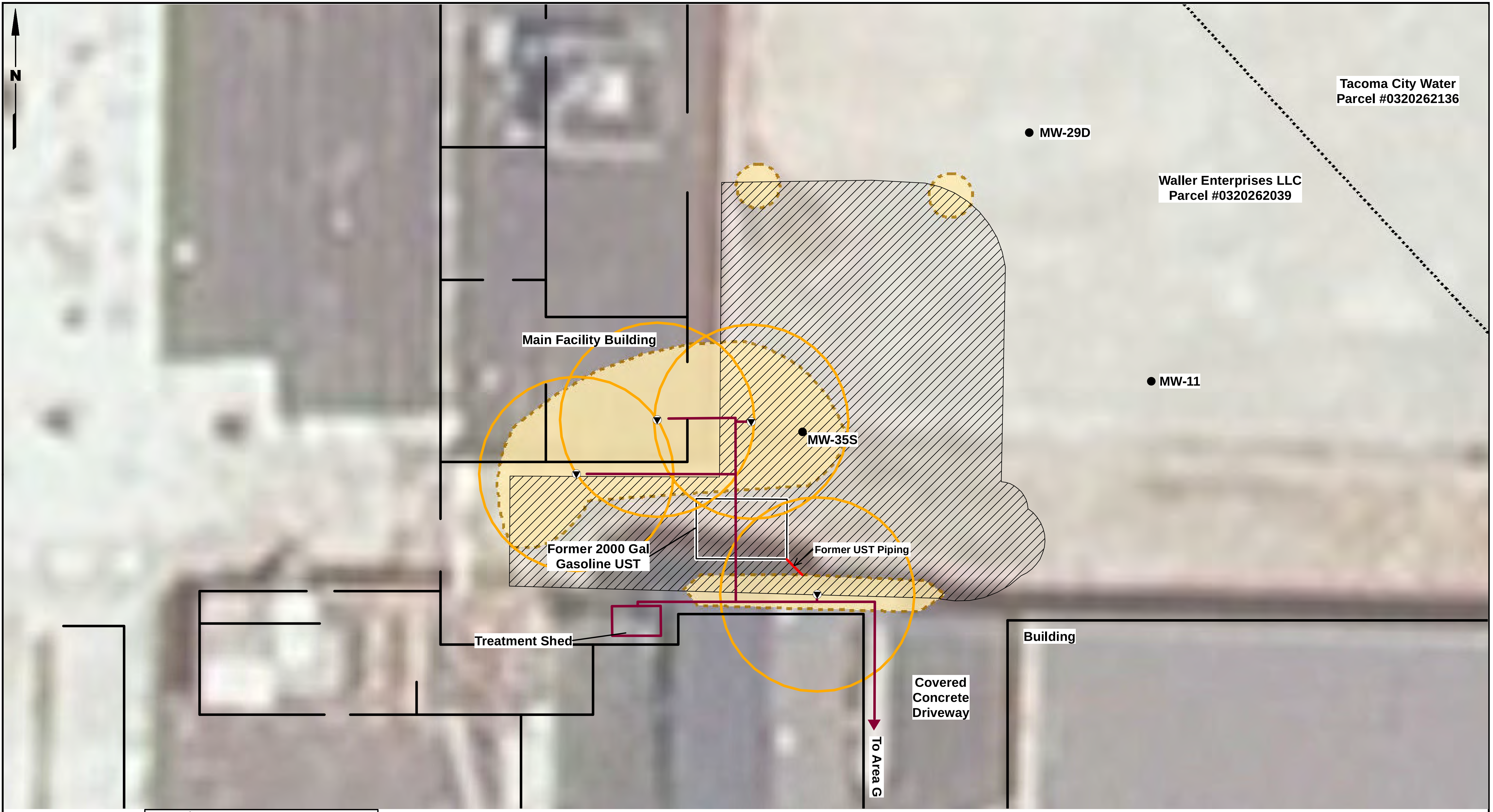
LANDAU ASSOCIATES

Pederson's Fryer Farms
Pierce County, Washington

Area F
Alternative 2 - Ozone Sparging

Figure
5-11



Y:\Projects\136006\010\013\Supplemental RI & FS\MapDocs\Fig5-12-AreaFAlternative4.mxd 5/2/2012 NAD 1983 StatePlane Washington South FIPS 4602 Feet

Legend

- ● Existing Monitoring Well
- - - - - Tax Parcel
- ▨ Former Excavation Area and UST
- 🟨 Above MTCA Method A CUL
- ▨ Soil Contamination
- ▼ SVE Well and Approximate Radius of Influence

Note

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Data Source: Pierce County GIS, ESRI World Imagery.

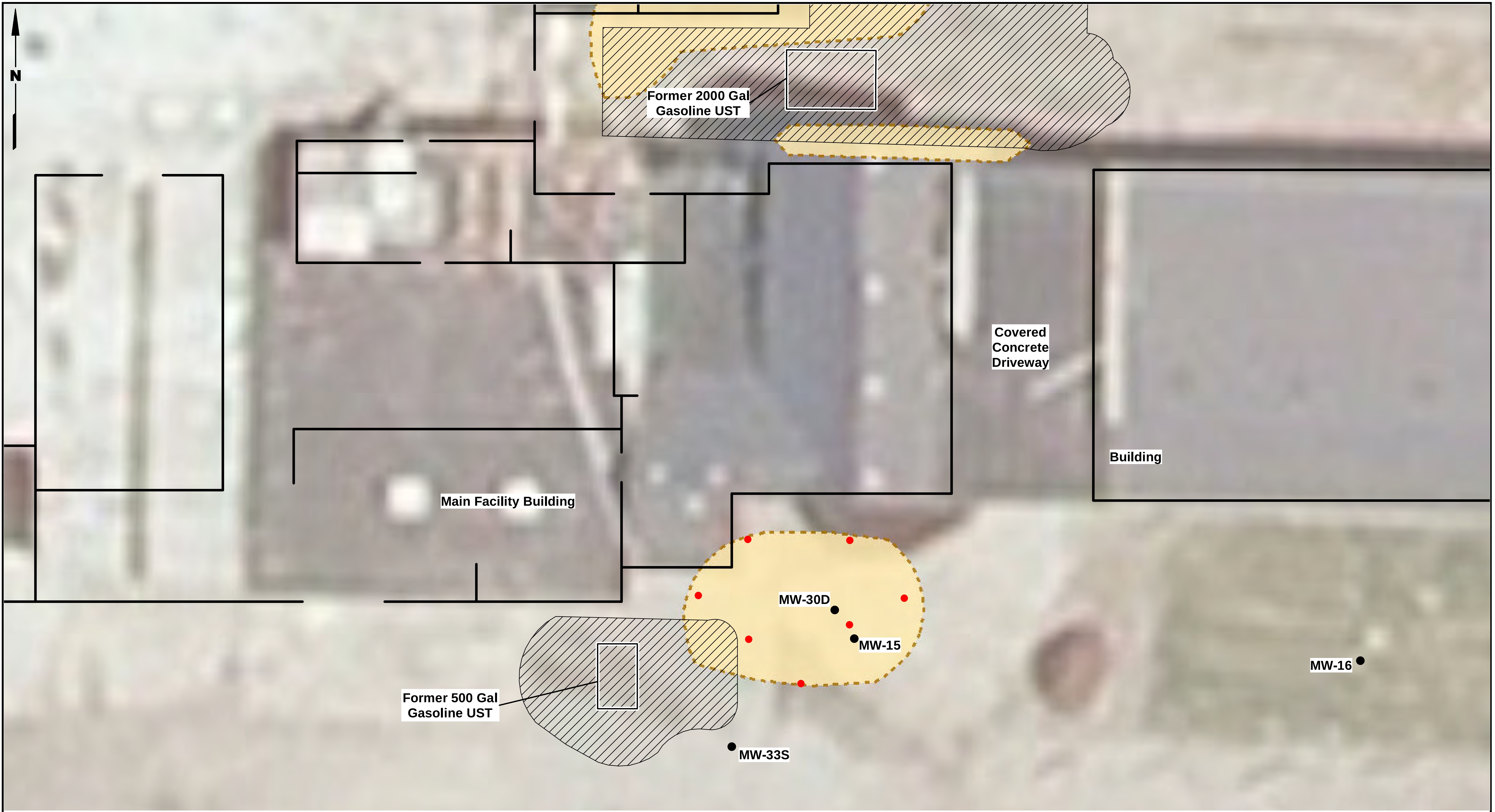
0 10 20
Scale in Feet

LANDAU ASSOCIATES

Pederson's Fryer Farms
Pierce County, Washington

Area F
Alternative 4 - SVE

Figure
5-12



Legend
- ● Existing Monitoring Well
- ⋯ Tax Parcel
- ▨ Former Excavation Area and UST
- 🟨 Above MTCA Method A CUL
- ▭ Soil Contamination
- 🔴 RegenOx Injections - 10-15' (4 Applications)

Notes
1. Injection points offset 5 ft per injection event.
2. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

0 10 20
Scale in Feet

Data Source: Pierce County GIS, Bing Maps Aerial Imagery 2010.

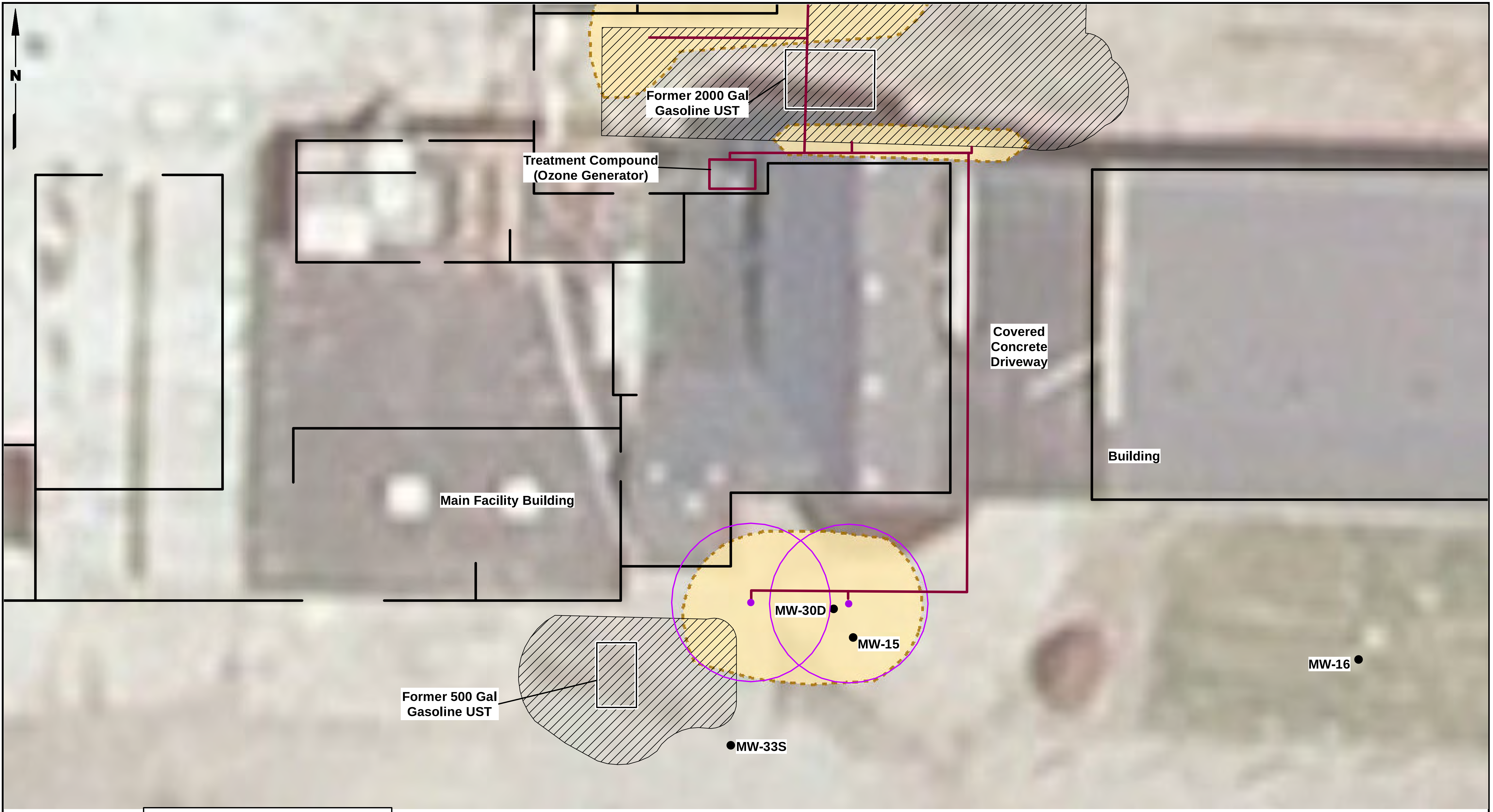
LANDAU ASSOCIATES

Pederson's Fryer Farms
Pierce County, Washington

Area G
Alternative 1 - ISCO Injection

Figure
5-13

Y:\Projects\136006\010\013\Supplemental RI & FS\MapDocs\Fig5-13-AreaGAlternative1.mxd 5/2/2012 NAD 1983 StatePlane Washington South FIPS 4602 Feet



Legend

- ● Existing Monitoring Well
- ⋯ Tax Parcel
- ▨ Former Excavation Area and UST
- 🟨 Above MTCA Method A CUL
- ⬚ Soil Contamination
- ◎ Vadose Zone Sparge Well and Approximate Radius of Influence

Note

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Data Source: Pierce County GIS, Bing Maps Aerial Imagery 2010.

0 10 20

Scale in Feet

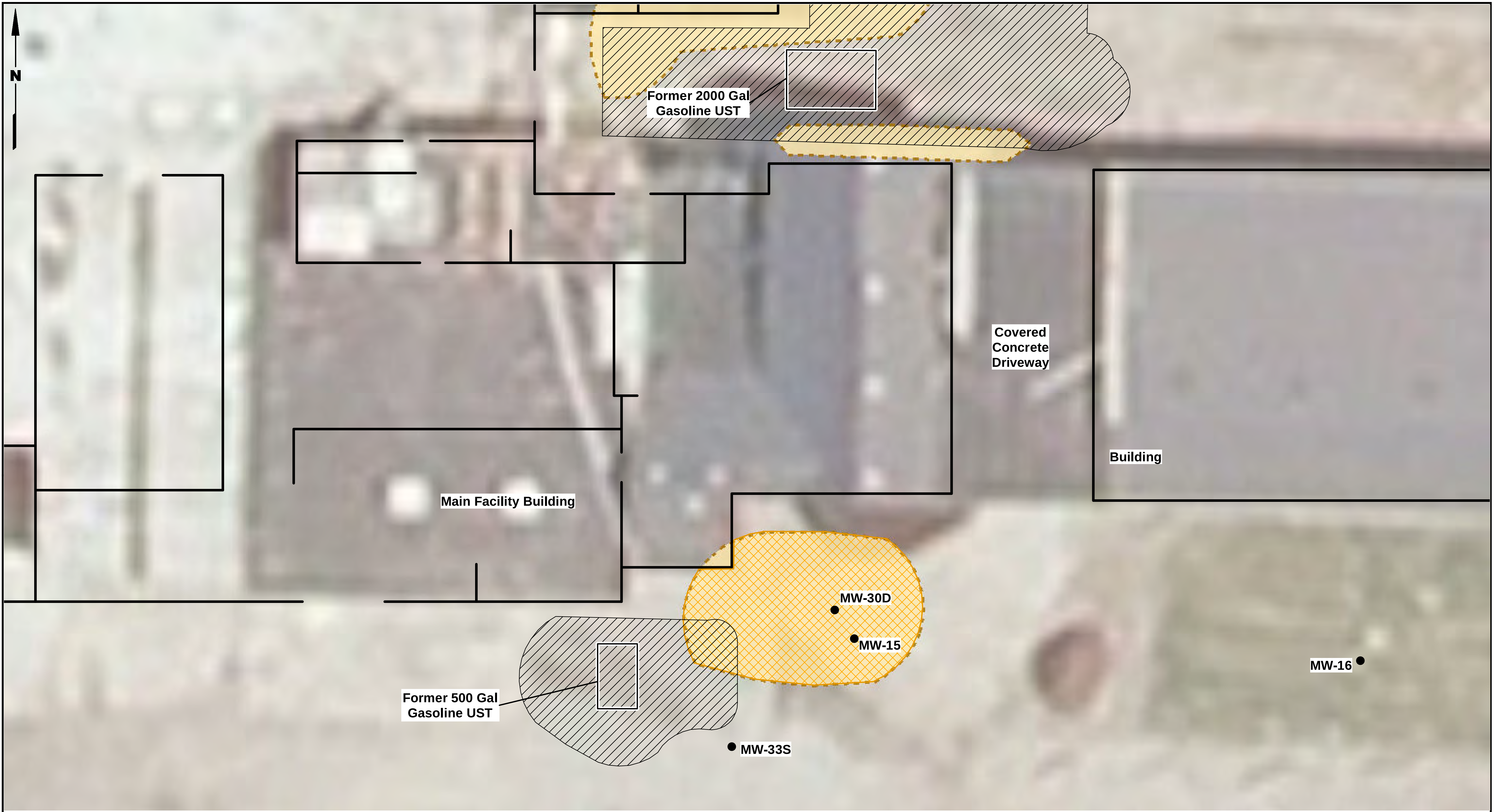
LANDAU ASSOCIATES

Pederson's Fryer Farms
Pierce County, Washington

Area G
Alternative 2 - Ozone Sparging

Figure
5-14

Y:\Projects\136006\010\013\Supplemental RI & FS\MapDocs\Fig5-14-AreaGAlternative2.mxd 5/2/2012 NAD 1983 StatePlane Washington South FIPS 4602 Feet



Legend
- ● Existing Monitoring Well
- ⋯ Tax Parcel
- ▨ Former Excavation Area and UST
- 🟨 Above MTCA Method A CUL
- ⬚ Soil Contamination
- ▨ Proposed Excavation Area

Note
1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

0 10 20
Scale in Feet

Data Source: Pierce County GIS, Bing Maps Aerial Imagery 2010.

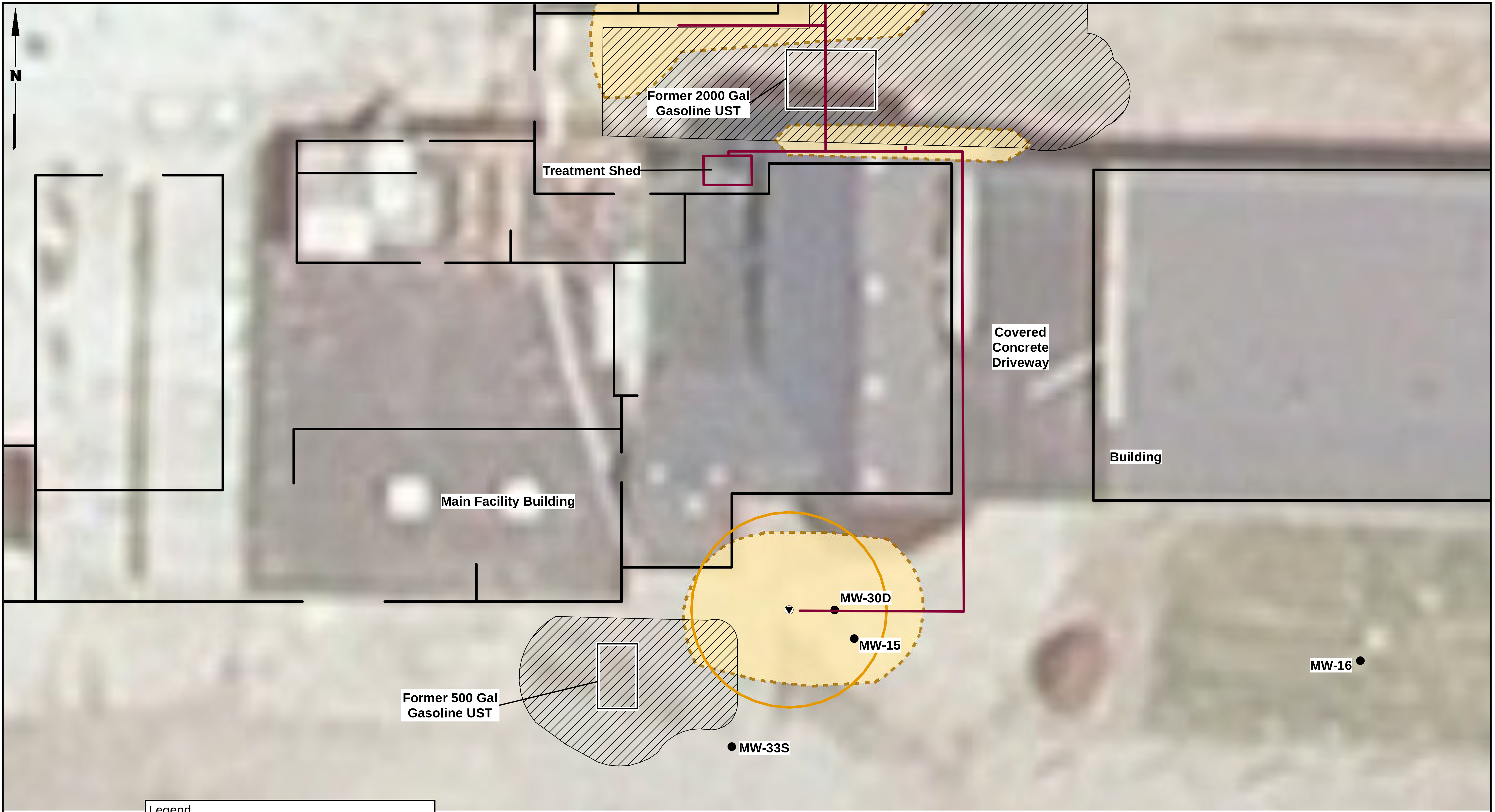
Pederson's Fryer Farms
Pierce County, Washington

Area G
Alternative 3 - Excavation

Figure
5-15

Landau Associates

Y:\Projects\136006\010013\Supplemental RI & FS\MapDocs\Fig5-15-AreaGAlternative3.mxd 5/2/2012 NAD 1983 StatePlane Washington South FIPS 4602 Feet



Legend
- ● Existing Monitoring Well
- ⋯ Tax Parcel
- ▨ Former Excavation Area and UST
- 🟨 Above MTCA Method A CUL
- ▨ Soil Contamination
- ◉ SVE Well and Approximate Radius of Influence

Note
1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

0 10 20
Scale in Feet

Data Source: Pierce County GIS, Bing Maps Aerial Imagery 2010.

Y:\Projects\136006\010\013\Supplemental RI & FS\MapDocs\Fig5-16-AreaGAlternative4.mxd 5/2/2012 NAD 1983 StatePlane Washington South FIPS 4602 Feet

LANDAU ASSOCIATES

Pederson's Fryer Farms
Pierce County, Washington

Area G
Alternative 4 - SVE

Figure
5-16

TABLE 5-1
ALTERNATIVES COST ESTIMATE SUMMARY(1)
PEDERSON'S FRYER FARMS RI/FS

Alternative Number	**Alternative Name**	**Estimated Cost**
1	*In Situ* Chemical Oxidation (ISCO) Injection and Excavation	**$ 2,058,000**
2	Ozone Sparging and Excavation	**$ 1,547,000**
3	Excavation and Enhanced Biodegradation	**$ 1,756,000**
4	Soil Vapor Extraction (SVE), Excavation, and Enhanced Biodegradation	**$ 1,667,000**

1) All estimated costs are considered order of magnitude estimates with a relative accuracy range of -30 to +50 percent. Use should be limited to the comparative evaluation of alternatives. More accurate costs will be developed during the design and implementation phases of the cleanup.

6.0 DETAILED EVALUATION OF ALTERNATIVES

This section evaluates and compares the adequacy of each alternative relative to the evaluation criteria specified in MTCA, as applicable. Section 6.1 presents a description of the evaluation criteria against which the alternatives are evaluated. Section 6.2 presents an evaluation of the alternatives against these criteria. Section 6.3 presents the disproportionate cost analysis (DCA) conducted to determine which alternative is permanent to the maximum extent practicable.

As previously discussed in Section 5.0, all cleanup action alternatives achieve the applicable RAOs presented in Section 3.3. Additionally, each alternative meets all of the MTCA threshold requirements, as discussed in Section 6.2.1 below. As a result, each alternative is considered a viable cleanup alternative under MTCA.

6.1 MODEL TOXICS CONTROL ACT EVALUATION CRITERIA

MTCA specifies the evaluation criteria against which cleanup action alternatives are compared. MTCA requires that cleanup alternatives be compared to a number of criteria to evaluate the adequacy of each alternative in achieving the intent of the regulations, and as a basis for comparing the relative merits of the developed cleanup alternatives.

6.1.1 MODEL TOXICS CONTROL ACT THRESHOLD REQUIREMENTS

As specified in WAC 173-340-360(2), all cleanup actions are required to meet the following threshold requirements:

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

6.1.2 REQUIREMENT FOR PERMANENT SOLUTION TO THE MAXIMUM EXTENT PRACTICABLE

WAC 173-340-200 defines a permanent solution as one in which cleanup standards can be met without further action being required at the original site or any other site involved with the cleanup action, other than the approved disposal site of any residue from the treatment of hazardous substances. Ecology recognizes that permanent solutions may not be practicable for all sites and provides criteria for determining whether a cleanup action is permanent to the "maximum extent practicable" in WAC 173-340-360(3)(f). These criteria include:

- ***Overall protectiveness*** of human health and the environment, including the degree to which existing risks are reduced, the time required to reduce the existing risks and attain cleanup standards, risks from implementation, and improvement of overall environmental quality
- ***Permanence***, as the degree of reduction in toxicity, mobility, and volume of hazardous substances, including the adequacy of the alternative in destroying the hazardous substances, the reduction or elimination of hazardous substance releases and sources of releases, the degree of irreversibility of waste treatment process, and the characteristics and quantity of treatment residuals generated
- ***Cost***, including capital costs and operation and maintenance costs
- ***Long-term effectiveness***, including the degree of certainty that the alternative will be successful, long-term reliability, the magnitude of residual risk, and the effectiveness of controls required to manage treatment residues and remaining waste
- ***Management of short-term risks***, including the protection of human health and the environment associated with the alternative during construction and implementation
- ***Implementability***, including consideration of whether the alternative is technically possible, availability of necessary offsite 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
- ***Consideration of public concerns***, including the extent to which the alternative addresses such concerns. This process includes identifying and addressing concerns from individuals, community groups, local governments, tribes, federal and state agencies, or any other organization that may have an interest in or knowledge of the site.

Ecology provides a procedure referred to as a DCA [WAC 173-340-360(3)(e)] to determine whether a cleanup action is permanent to the maximum extent practicable. The purpose of the DCA is to determine if the incremental increase in cost of a cleanup alternative over that of a lower cost alternative is justified by the incremental increase in benefits to human health and the environment. If the incremental increase in costs is determined to be disproportionate to the benefits, the more expensive alternative is considered impracticable and the lower cost alternative is determined to be permanent to the maximum extent practicable. This process provides a mechanism for balancing the permanence of the cleanup action with its costs, while ensuring that human health and the environment are adequately protected.

6.1.3 REQUIREMENT FOR A REASONABLE RESTORATION TIMEFRAME

WAC 173-340-360(4)(b) specifies that the following factors be considered when determining whether a cleanup action provides for a reasonable restoration timeframe:

- Potential risks to human health and the environment
- Practicability of achieving a shorter restoration timeframe

- Current use of the site, surrounding areas, and associated resources that are, or may be affected by releases from the site
- Availability of alternate water supplies
- Likely effectiveness and reliability of institutional controls
- Ability to control and monitor migration of hazardous substances from the site
- Toxicity of the hazardous substances at the site
- Natural processes that reduce concentrations of hazardous substances and have been documented to occur at the site or under similar site conditions.

6.1.4 REQUIREMENT FOR CONSIDERATION OF PUBLIC CONCERNS

Consideration of public concerns is an inherent part of the site cleanup process under MTCA (see WAC 173-340-600). Ecology will publish a notice in the Site Register when the draft CAP is received (WAC 173-340-515(4)(d)). There will be a formal public review and comment period of 30 days for the draft CAP, during which time comments from the public may be submitted. Those comments will be considered and addressed as applicable in the final CAP.

6.2 EVALUATION OF ALTERNATIVES

This section provides an evaluation of the cleanup alternatives with respect to the MTCA criteria as discussed in Section 6.1 (Evaluation Criteria). The evaluation of each cleanup alternative against the MTCA criteria is summarized in Table 6-1 and presented in the following sections.

6.2.1 THRESHOLD REQUIREMENTS

Under the MTCA, a cleanup alternative shall meet the following threshold requirements: it must protect human health and the environment, comply with cleanup standards, comply with applicable state and federal laws, and provide for compliance monitoring. Compliance with the threshold requirements for a cleanup action under the MTCA is presumed by definition to be protective of human health and the environment once the cleanup action meets the cleanup standards for all affected media. Also, any cleanup action performed in accordance with the requirements of MTCA is assumed to be in compliance with cleanup standards and applicable state and federal laws. The following sections identify how each cleanup alternative complies with the threshold requirements.

6.2.1.1 Protection of Human Health and the Environment

Alternatives 1 through 4 protect human health and the environment through *in situ* treatment of petroleum contamination in soil and groundwater or removal of contaminated soil and disposal at an offsite licensed disposal facility.

6.2.1.2 Compliance with Cleanup Standards

Through the various cleanup technologies employed, and achievement of the applicable RAOs (Section 3.3), Alternatives 1 through 4 all comply with MTCA soil and groundwater cleanup standards by achieving or maintaining CULs at the identified points of compliance. Development of draft and final SLs and CULs take into account compliance with federal and state cleanup ARARs (see Section 6.2.1.3 below).

6.2.1.3 Compliance with State and Federal Laws

Through compliance with identified ARARs (Section 3.4) and compliance with MTCA regulations, Alternatives 1 through 4 all comply with state and federal laws.

6.2.1.4 Provisions for Compliance Monitoring

Compliance monitoring requirements [WAC 173-340-410(1)] include protection monitoring (during construction, operation, and maintenance of the cleanup action), performance monitoring (to confirm the cleanup action has attained CULs), and confirmation monitoring (to confirm the long-term effectiveness of the cleanup action).

Protection monitoring would be provided for Alternatives 1 through 4 through appropriate health and safety protocols outlined under a site-specific health and safety plan.

The excavation components of Alternatives 1 through 4 include soil sampling for both performance and confirmation monitoring. The SVE component of Alternative 4 includes performance monitoring through sampling of influent extracted soil vapor and the treated effluent air stream. Interim soil sampling may be conducted during the course of chemical oxidation in vadose zone soils (Alternative 1 and 2) to determine progress and effectiveness of the injections. The *in situ* groundwater injection components of Alternatives 1 through 4 include performance groundwater sampling during the course of the remedial action.

Alternatives 1 through 4 all include confirmation groundwater monitoring and soil sampling throughout the site after completion of the remedial action. Confirmation soil gas and indoor air sampling may also be conducted as necessary after cleanup actions are completed.

6.2.2 REQUIREMENT FOR A REASONABLE RESTORATION TIMEFRAME

The MTCA identifies a number of factors to be considered when establishing a reasonable restoration timeframe, as described in Section 6.1.3. A cleanup action is considered to have achieved restoration once cleanup standards have been met. An evaluation of the cleanup alternatives with regard to achieving a reasonable restoration timeframe is presented in Table 6-1 and is discussed below, except that the practicability of achieving a shorter restoration timeframe is addressed as part of the DCA evaluation presented in Section 6.3.

Restoration timeframe estimates are interpreted to begin at the initiation of remediation work, assuming all permitting and/or site access components have been completed. All four cleanup alternatives are anticipated to achieve restoration in a reasonable timeframe and range from approximately 1.5 to 5 years. The restoration timeframe is typically driven by the groundwater restoration component of the remedial alternative.

Alternative 1 is estimated to achieve cleanup standards following treatment of soil and groundwater throughout the affected area, which is anticipated to require approximately 1.5 to 3.5 years from the initiation of the ISCO remediation work, including 1 year of compliance groundwater monitoring. Alternative 2 would achieve cleanup standards following treatment of soil and groundwater throughout the affected area, which is anticipated to require approximately 3 to 4 years from the initiation of the ozone sparging work, including 1 year of compliance groundwater monitoring. Alternatives 3 and 4 would achieve cleanup standards following treatment of soil and groundwater throughout the affected area, which is anticipated to require approximately 4 to 5 years from the initiation of the enhanced bioremediation work. The SVE component of Alternative 4 is anticipated to be completed within approximately 3 years. All the alternatives include an excavation component, which can be implemented relatively quickly (approximately 3 months) compared to other technologies within the given alternative.

6.2.3 PERMANENT SOLUTIONS TO THE MAXIMUM EXTENT PRACTICABLE

As described in Section 6.1.2, the MTCA requires that cleanup actions be permanent to the maximum extent practicable and identifies a number of criteria to evaluate whether this requirement is achieved. Evaluation of the practicability of a given alternative is based on the comparative evaluation of whether the incremental increase in cost associated with increasingly protective cleanup actions is substantial and disproportionate to the incremental increase in environmental benefit. If the incremental cost is determined to be substantial and disproportionate to the incremental increase in environmental benefit, the cleanup alternative is considered impracticable and eliminated from further consideration. The remainder of this section provides a comparison of the cleanup alternatives to the permanence criteria. The criteria are summarized in Section 6.1.2. The evaluation of practicability is addressed in Section 6.3.

6.2.3.1 Overall Protectiveness

As indicated in Section 6.1.2, overall protectiveness of human health and the environment is a measure of the degree to which existing risks are reduced, the time required to reduce existing risk at the site and attain cleanup standards, the onsite and offsite risks resulting from implementation, and the improvement of overall environmental quality. All four alternatives for the site are protective of human health and the environment and reduce the risk of direct contact to human and ecological receptors and the potential risk of groundwater consumption. The differences lie in the technologies used to achieve that protectiveness, their ability to succeed in reducing existing risks, and the time required to do so. Alternatives 1 and 2 achieve protection through *in situ* destruction of petroleum hydrocarbons in both soil and groundwater, primarily through chemical oxidation (although both also have relatively small excavation components). Alternative 3 achieves protection through the removal and offsite disposal of contaminated vadose zone soil and *in situ* enhanced biodegradation of petroleum hydrocarbons in smear zone soil and groundwater. Alternative 4 has a large excavation component for areas of the site with diesel-range organics, and for areas of the site with only gasoline-range organics protective measures are provided through soil vapor extraction and aboveground treatment of the extracted vapor.

The overall protectiveness of Alternatives 1 and 2 is relatively high because both significantly and rapidly reduce existing site risk associated with direct contact with soil and potential groundwater consumption, and improve environmental quality through the destruction and reduction of contaminant mass by chemical treatment (and limited focused excavation). The protectiveness of Alternatives 3 and 4 is lower than Alternatives 1 and 2 because site risk associated with groundwater is reduced more slowly (due to the lengthier enhanced biodegradation timeframe) and because excavation may not remove all soil contamination beneath building foundations and in deeper soil intervals. Flushing and saturating the deeper soil intervals with an electron acceptor solution also may not adequately clean up the deeper vadose zone soils. Alternative 1 is anticipated to reach cleanup standards and reduce risk at the site within approximately 6 months to 2.5 years; Alternative 2 is anticipated to reach cleanup standards in 2 to 3 years; Alternatives 3 and 4 are anticipated to reach cleanup standards within 3 to 4 years.

Alternatives 1 and 2 have the least onsite and offsite risk resulting from implementation because treatment will occur with processes that do not have any significant potential to spread contamination or create hazardous by-products. Alternatives 3 and 4 have the potential to temporarily increase onsite and offsite risks; they have the potential of spreading contaminated soil during construction through windblown or mechanically spread dust or dirt, or spills during transportation. However, these risks can be appropriately managed through proper design, implementation, and monitoring.

6.2.3.2 Permanence

As indicated in Section 6.1.2, permanence is the degree of reduction in toxicity, mobility, and volume of hazardous substances, including the adequacy of the alternative in destruction, reduction, or elimination of hazardous substances. All four alternatives provide a high degree of permanence through destruction, treatment, or removal of soil and groundwater contamination. Little to no residual contamination or treatment residuals are expected to be left on site after completion of the cleanup under any of the alternatives, although complete removal through excavation-based cleanup options is not assured in areas that are more difficult to access.

Treatment of soil and groundwater by oxidant injections and ozone sparging in Alternatives 1 and 2 provide permanent reduction in contaminant mass, and thereby reduce toxicity and mobility. Treatment of soil by SVE in Alternative 4 also provides permanent reduction in contaminant mass by extraction and eventual destruction of the contaminant (during thermal desorption of the granular activated carbon filter media), and thereby reduces toxicity and mobility. Excavation of contaminated soil in Alternative 3 (and to a lesser extent in excavation associated with the other three alternatives) provides a permanent reduction in the volume of hazardous substances on the site and mobility of the substances by disposal at an engineered solid waste landfill. However, it does not reduce the overall toxicity or volume of the hazardous substances in the affected medium.

The adequacy of Alternatives 3 and 4 in eliminating petroleum contamination at the site is less than for Alternatives 1 and 2 due to the uncertainties in the ability to remove contaminated soil at deeper intervals where excavation is not practicable. Alternative 4 is better suited for removal of contamination beneath buildings where SVE is performed than under Alternative 3 where excavation may not adequately be able to reach those same areas.

6.2.3.3 Cost

As indicated in Section 6.1.2, cost includes capital costs as well as operation and maintenance costs. Itemized cost estimates for each of the cleanup alternatives are provided in Appendix E. Estimated costs are as follows:

- Alternative 1 (ISCO and Excavation) - $2,058,000
- Alternative 2 (Ozone Sparging and Excavation) - $1,547,000
- Alternative 3 (Excavation and Enhanced Biodegradation) - $1,756,000
- Alternative 4 (SVE, Excavation, and Enhanced Biodegradation) - $1,667,000.

These estimated cleanup costs are consistent with an order of magnitude cost estimate. These costs are used as the cost basis for the DCA presented in Section 6.3.

6.2.3.4 Long-Term Effectiveness

As indicated in Section 6.1.2, long-term effectiveness includes the degree of certainty that the alternative will be successful, the long-term reliability, the magnitude of residual risk, and the effectiveness of controls required to manage treatment residues and remaining waste. All four of the alternatives are expected to be effective over the long term as they all have a relatively high degree of certainty in the success and reliability of the technologies being employed. The residual risk after completion of the cleanup is also anticipated to be low under any of the alternatives.

Although all four alternatives are anticipated to be effective over the long term, the degree of long term effectiveness is affected by the technology employed and the relative certainty that the alternative will be successful. Alternatives 1 and 2 have the highest degree of long-term effectiveness of the four alternatives, because they both use *in situ* destruction/detoxification technologies, which have a higher precedence compared to removal and offsite disposal [as indicated under WAC3-340-360(3)(e)(iv)]. Alternative 1 has a relatively high certainty of success due to the injection of a highly reactive oxidant that will be delivered to all areas where contamination is present during multiple injection events. Alternative 2 has an even higher certainty of success due to the ability to take advantage of the higher gas-phase permeability for soil with ozone (than liquid permeability using a liquid oxidant slurry). Alternative 3 has a moderately high certainty for success due to complete removal of petroleum-contaminated soil and biologically stimulated destruction of contaminants in groundwater; however, there is a higher probability of not being able to remove all contamination beneath buildings and at deeper soil intervals where excavation may become impracticable. Flooding and saturation with an electron acceptor solution may also not adequately remediate these deeper soil intervals. Because Alternative 4 uses SVE to address some of the areas beneath buildings using a higher precedent technology than excavation, this alternative is considered to have a higher long-term effectiveness than Alternative 3

6.2.3.5 Management of Short-Term Risks

As indicated in Section 6.1.2, management of short-term risks includes the protection of human health and the environment associated with the alternative during construction and implementation. The degree of short term risk of the four alternatives is fairly variable due to the significant difference between the construction and/or implementation technologies and methodologies of the alternatives. The ability to manage those risks is also variable.

The short-term risks associated with Alternative 1 are moderately high, but manageable. The risks are primarily related to multiple injection events and a large quantity of injection locations using drilling equipment, injection of a highly reactive chemical solution at high injection pressures, and the potential for off-gassing and surfacing of the injected oxidant solution. The limited excavation and hauling activities associated with this alternative also presents small risks. These risks are manageable with proper health and safety procedures, planning, and careful monitoring during the injection events and excavation.

The short term risks for Alternative 2 are fairly limited with construction consisting of installation of sparge wells, trenching and pipe installation, and hookup of pre-constructed remediation system (ozone generator) compounds. There is some risk associated with working with ozone, which is a toxic gas, but due to subsurface injection, the rapid decay of ozone, and rapid dilution that would occur with any aboveground releases, the risk of significant exposure and inhalation are minimal. The limited excavation and hauling activities associated with this alternative also presents small risks. Each of these risks are very manageable with proper health and safety precautions, planning, and monitoring.

Alternatives 3 and 4 present moderately high levels of short-term risk due to potential accidents, worker exposure to hazardous substances during excavation of contaminated soil, shoring and excavation activities, and the transport of contaminated soil for treatment or disposal. There is low risk involved with the installation of a small number of groundwater injection wells and the injection events which involve solutions of water and relatively innocuous chemicals. The short term risks associated with the SVE component of Alternative 4 (drilling SVE wells, minimal system construction, and operations and maintenance activities) are lower than that of excavation in the same area that would occur under Alternative 3. The short-term risks associated with Alternatives 3 and 4 can be effectively managed through appropriate design and construction controls, including site-specific health and safety protocols, and monitoring during construction.

6.2.3.6 Technical and Administrative Implementability

As indicated in Section 6.1.2, implementability includes consideration of whether the alternative is technically possible, availability of necessary offsite 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. The challenges related to implementability of the four alternatives is fairly variable due to the significant difference between the construction and/or implementation techniques, how site conditions specifically impact those techniques, and different permitting and site access requirements. The ability to manage those challenges is also variable.

Alternative 1 has moderate technical challenges related simply to the high quantity of injection events and oxidant injection points, and the associated physical access required to reach all the injection points. The depth necessary for many of the oxidant injection points combined with potential geologic constraints present more difficult challenges. Direct-push drilling and delivery of the oxidant slurry in deeper, more compact soils may be difficult or impossible and alternate drilling techniques may be needed which are slower and more costly. There may also be technical challenges related to preferential flow paths and associated treatment in vadose and saturated soil intervals; however, this should be adequately accounted for by offsetting injection points during each injection event. The small quantity of excavation associated with this alternative should present minimal technical challenges. Administrative challenges for Alternative 1 are related to filing a high number of "start cards" for all the injection points, obtaining underground injection control permits, and obtaining access to adjacent property and public rights-of-way for injection events; however, these are relatively easily managed.

Alternative 2 will be performed using relatively straight forward construction techniques (vertical drilling and trenching and minimal excavation). Similar to Alternative 1, there may be technical challenges related to delivery of the ozone in preferential flow paths and associated treatment. However, due to higher gas-phase permeability, this should be easily managed through pulsing or other strategies. Security measures for the remediation systems are also a consideration. Administrative challenges for Alternative 2 are related to potential air permitting requirements and obtaining access to adjacent property and public rights-of-way for installation of semi-permanent injection wells and distribution piping. These administrative considerations are relatively easily managed.

Alternatives 3 and 4 have significant technical challenges related to the depths of excavation in Area A (i.e., 25 ft or greater) to reach some of the contaminated soil, the location of contamination beneath site buildings that may be difficult or unfeasible to reach with excavation equipment, the shoring that would be required for excavation near buildings or subsurface utilities, and/or demolition that may be required to remove soil beneath buildings. Alternative 4 has slightly less challenges because it includes less excavation related activities near buildings. There are also potential issues with monitoring and containing injected nitrate (which is a regulated substance in groundwater) for enhanced biodegradation for both alternatives. Careful attention would be needed to ensure that nitrate is not injected in quantities/concentrations higher than what will be utilized during biodegradation processes within the groundwater plume, and contingency plans will be required to capture or degrade the nitrate if it is not adequately removed in the plume. Administrative challenges for Alternatives 3 and 4 include those associated with excavation related permits (grading permits and possible stormwater permits and associated plans) and underground injection control permits. An air permit may also be necessary for implementation of Alternative 4. Security measures for the SVE systems are also a consideration. Both alternatives may also have administrative challenges related to obtaining access to the adjacent public right-of-way for large scale excavation. The technical and administrative challenges for these two alternatives are manageable, but possibly more difficult than for the other two alternatives.

6.3 MODEL TOXICS CONTROL ACT DISPROPORIONATE COST ANALYSIS

As discussed in Section 6.1.2, MTCA requirements for remedy selection include the requirement to use permanent solutions to the maximum extent practicable. MTCA defines permanent cleanup actions as those in which cleanup standards are met without further action being required. MTCA specifies that the evaluation of whether or not a cleanup action uses permanent solutions to the maximum extent practicable be based on a disproportionate cost analysis consistent with the requirements of WAC 173-340-360(3)(e). In that analysis, cleanup alternatives are arranged from most to least permanent based on the criteria specified in WAC 173-340-360(3)(f).

The DCA compares the relative environmental benefits of each alternative against those provided by the most permanent alternative evaluated. Costs are disproportionate to benefits if the incremental cost of the more permanent alternative exceeds the incremental benefits achieved by the lower cost alternative [WAC 173-340-360(3)(e)(i)]. Alternatives that exhibit disproportionate costs are considered “impracticable.” Where the benefits of two alternatives are equivalent, MTCA specifies that the least costly alternative shall be selected [WAC 173-340-360(3)(e)(ii)(C)].

The DCA is performed below, using the information presented in Section 6.2 and Table 6-1. The benefits of each alternative are ranked under the criteria of the disproportionate cost analysis [WAC 173-340-360(3)(f)] in Section 6.3.1. The costs are compared against these benefits and the relationship between the costs and benefits determined in Section 6.3.2. This analysis defines which alternative is permanent to the maximum extent practicable.

Relative rankings for the alternatives were determined by assigning a value on a scale from 1 to 10, where 10 is the highest benefit/value, for each criterion, multiplying each value by a weighting factor, and summing the weighted values to determine an overall alternative benefit ranking score. Weighting factors are based on Ecology guidance and Ecology-accepted weighting factors that have been used for similar sites. The six evaluation criteria and associated weighting factors are:

- Overall protectiveness: 30 percent
- Permanence: 20 percent
- Long-term effectiveness: 20 percent
- Short-term risk management: 10 percent
- Implementability: 10 percent
- Considerations of public concerns: 10 percent.

6.3.1 COMPARATIVE EVALUATION OF ALTERNATIVES

The DCA is based on a comparative analysis of the alternatives against the six evaluation criteria. Relative rankings of each alternative for the six criteria are discussed below and summarized in Table 6-2. The following provides the comparative evaluation of the alternatives.

6.3.1.1 Overall Protectiveness

Alternative 1 was ranked highest for protectiveness with a score of 10 based on the relative certainty that multiple injections of liquid chemical oxidant (RegenOx) will oxidize and destroy petroleum hydrocarbon mass and stimulation of aerobic biodegradation with ORC injections for residual hydrocarbons in groundwater. Alternative 1 also has the shortest estimated time period required for treatment. Alternative 2 was given a score of 9 for protectiveness because of similar certainty that hydrocarbons mass in soil and groundwater will be oxidized and destroyed, but Alternative 2 was ranked slightly lower than Alternative 1 because of a longer restoration timeframe. Alternatives 3 and 4 were given a ranking of 7 because removal of much of the contaminated soil at the site through excavation and biodegradation of contaminated groundwater provides a relatively high level of certainty that protectiveness will be achieved. However, because some of the contaminated soil at the site is located beneath site buildings, Alternative 3 may not provide the ability to remove all the contaminated soil beneath those buildings, resulting in potential exposure to residual contamination. Alternative 4 uses SVE to address contamination beneath certain buildings, but is a slower process with a longer restoration timeframe. Also, both Alternatives 3 and 4 have some uncertainty in the ability to address deeper vadose zone and smear zone soils in area A because excavation below a certain depth becomes impracticable and flushing and saturating those zones with electron acceptor solution may not provide adequate cleanup of soil in that zone.

6.3.1.2 Permanence

Alternatives 1 and 2 were ranked highest for permanence with a score of 10 because they both reduce the volume and toxicity of hazardous materials at the site through *in situ* treatment and destruction of petroleum hydrocarbons in contaminated soil and groundwater. Mobility of the contaminants may be increased on a short-term basis during implementation of Alternative 1 due to enhanced soil desorption mechanisms, but the rapid destruction of the desorbed contaminant makes this a minimal concern. Alternative 3 was assigned a score of 6 because it permanently degrades groundwater contamination and removes contaminated soil from the site. However, contaminated soil that is excavated and disposed of at a licensed solid waste landfill, while reducing the mobility of the contaminant through containment, does not reduce the toxicity or volume of the hazardous substances in the affected media; it only moves it to a location more protective of human health and the environment. Alternative 4 is similar to Alternative 3 for the groundwater and the soil that is excavated, except that those areas treated by SVE permanently reduce the volume, toxicity, and mobility of the soil through capture of the volatile organics on a granular activated carbon media and eventual destruction of the contaminant during thermal desorption of the granular activated carbon. Therefore, Alternative 4 was given a permanence score of 7.

6.3.1.3 Long-Term Effectiveness

Because none of the alternatives reuse or recycle [identified as having the highest precedence under WAC3-340-360(3)(e)(iv) for "assessing the relative degree of long-term effectiveness"], none of the alternatives were given the highest score of 10.

Alternatives 1 and 2 are considered the most effective in the long term because of the high degree of certainty of success compared to the other alternatives, and the use of a destruction and detoxification technology. Alternative 1 was given a score of 8 and Alternative 2 was given a slightly higher score of 9 because delivery of a gaseous oxidant is more likely to come into contact with more contaminant mass in the soil matrix than a liquid oxidant due to higher gas-phase permeability. The constant delivery of ozone versus periodic liquid oxidant injection events reduces the incidents of contaminant concentration rebound in groundwater between injection events. Alternatives 3 and 4 were given lower scores due to the use of the lower precedent actions of "off-site disposal in an engineered, lined, and monitored facility" for excavated soil, and because of the higher potential for leaving residual contamination at the site after cleanup. Alternative 3 was given a long-term effectiveness score of 5. Alternative 4 was given a slightly higher score of 6 because of the additional *in situ* treatment of some areas with SVE and the associated destruction of the contaminant, and the smaller likelihood of leaving residual contamination beneath buildings.

6.3.1.4 Management of Short-Term Risks

Alternative 2 is given the highest score of 9 with respect to short-term risk because risks are limited to the installation of sparge wells, minimal remediation system construction and operations and maintenance activities, and working with a toxic gas (ozone); all of which are easily and effectively managed with standard health and safety procedures and monitoring. Alternative 1 is given a score of 6 because of the potential risks associated with multiple injection events and injection locations involving a reactive chemical compound under pressure, the risk of potential off-gassing, and the risk of surfacing of the oxidant liquid compound. Alternative 3 is also given a score of 6 because large-scale excavation, shoring activities, and handling and transportation of contaminated soil pose the greatest physical hazard and chemical exposure risks during construction. Alternative 4 is assigned a higher score of 7 because of the risks associated with performing SVE (drilling SVE wells, minimal system construction and operations and maintenance activities) are lower than that of excavation in the same area that would occur under Alternative 3.

6.3.1.5 Technical and Administrative Implementability

Alternative 2 is given the highest score of 8 for implementability because it requires the least complex construction techniques (vertical drilling and trenching and minimal large scale excavation), and minimal administrative challenges (potential air permitting). Alternative 2 may have technical challenges related to treating soil and groundwater through and around preferential flow paths. Alternative 1 is given a score of 6 because of technical challenges related to the multitude of oxidant injection points and associated depths, multiple injection events, potential geologic constraints (i.e., difficulty with direct-push drilling and delivering the oxidant slurry in deeper, more compact soils), and administrative challenges related to obtaining enderground injection control permits. Alternative 1 may also have technical challenges related to treating soil and groundwater around and through preferential flow paths. Alternative 3 is given a score of 6 because of the difficulty associated with the depth of excavation, the shoring required, demolition or other difficult excavation methods to remove soil beneath buildings, potential issues with monitoring and containing injected nitrate in groundwater, and administrative challenges with excavation related permits (grading and possible stormwater permits) and underground injection control permits. Alternative 4 is given a slightly higher score of 7 because there is less excavation near and around buildings. An air permit may also be necessary for implementation of Alternative 4. Each alternative may have administrative challenges related to access onto neighboring property (including the adjacent public right-of-way).

6.3.1.6 Consideration of Public Concerns

Specific public concerns regarding the cleanup alternatives are not yet known and will be solicited and responded to during the draft CAP public comment period. However, for the purposes of this FS, it is assumed that the greatest public concern would be protection of human health and the environment[22]. Therefore, each alternative addresses human health and the environment and each alternative considers other potential concerns, as applicable. All alternatives are given a ranking of 10 for consideration of public concerns. Beyond the ranking criteria of this FS, it is assumed that public concerns will be adequately addressed in the planning stages for implementation of the preferred alternative that will be outlined in the draft CAP.

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[22] This concern is reflected in the other criterion above such as Protectiveness and Permanence; implementation logistics may also be a concern to neighboring property owners.

6.3.1.7 Comparison of Overall Benefits (Relative Benefit Scores)

Based on higher overall scores in the areas of permanence, long-term effectiveness, management of short-term risk, and implementability, Alternative 2 has the highest weighted overall benefit score. The rank and relative benefit scores for each alternative are presented in Table 6-2, and are as follows:

- Alternative 1 Relative Benefit Score: 8.8
- Alternative 2 Relative Benefit Score: 9.2
- Alternative 3 Relative Benefit Score: 6.5
- Alternative 4 Relative Benefit Score: 7.1.

6.3.2 CONCLUSIONS AND SUMMARY OF THE DISPROPORTIONATE COST ANALYSIS

As required by MTCA for remedy selection, the costs and benefits associated with the evaluated remedial alternatives are compared using a DCA. The DCA compares the relative environmental benefits of each alternative against those provided by the most permanent alternative evaluated. Costs are disproportionate to benefits if the incremental cost of the most permanent alternative exceed the incremental degree of benefits achieved over a lower cost alternative [WAC 173-340-360(3)(e)(i)]. Alternatives that exhibit such disproportionate costs are considered “impracticable.” Where the benefits of two alternatives are equivalent, MTCA specifies that the lower cost alternative shall be selected [WAC 173-340-360(3)(e)(ii)(C)].

The estimated costs, and the benefits presented in Section 6.3.1, are summarized for each alternative in Table 6-2. Table 6-2 also summarizes the overall benefits and costs for each alternative using relative benefit score developed for each alternative in Section 6.3.1. Figure 6-1 provides a graphical comparison between the costs of each alternative and the relative benefits, using the costs developed in Appendix E and benefit rankings developed in Table 6-2. A comparison of the relative cost-to-benefit ratios between the alternatives is also depicted on Figure 6-1.

The DCA indicates that Alternative 2 (Ozone Sparging and Excavation) yields the greatest overall benefit of the four alternatives evaluated for the site, as indicated in the previous section. Alternative 2 also has the lowest cost-to-benefit ratio (1.7), compared to the Alternatives 1, 3, and 4 (2.3, 2.7, and 2.3, respectively; see Figure 6-1). Because this is the most permanent alternative, the relative benefits and costs for the other alternatives are compared to Alternative 2 to determine which alternative is permanent to the maximum extent practicable.

Alternative 1 (Oxidant Injection and Excavation) has only a slightly lower overall benefit ranking than Alternative 2 (approximately 5 percent lower); however, the cost is approximately 33 percent higher for Alternative 1 compared to Alternative 2. Therefore, the incremental cost increase considered disproportionate to its benefits and Alternative 1 is considered impracticable and discarded from further consideration.

The costs for Alternative 3 (Excavation and Enhanced Biodegradation) and Alternative 4 (SVE, Excavation, and Enhanced Biodegradation) are only slightly higher than that of Alternative 2 (Alternative 4 is less than 10 percent higher, and Alternative 3 is less than 15 percent higher). However, Alternatives 3 and 4 have significantly lower overall benefits rankings (approximately 30 percent and 23 percent lower, respectively). Consequently Alternatives 3 and 4 are also considered impracticable and are discarded from further consideration.

In summary, Alternative 2 (Ozone Sparging and Excavation) has the highest overall benefit (i.e., is the most permanent alternative), has a similar cost to the other lower cost alternatives, and has the highest cost-to-benefit ratio. Based on these factors and the evaluation discussed above, Alternative 2 is considered to be permanent to the maximum extent practicable, and is recommended as the preferred remedial action for the site.

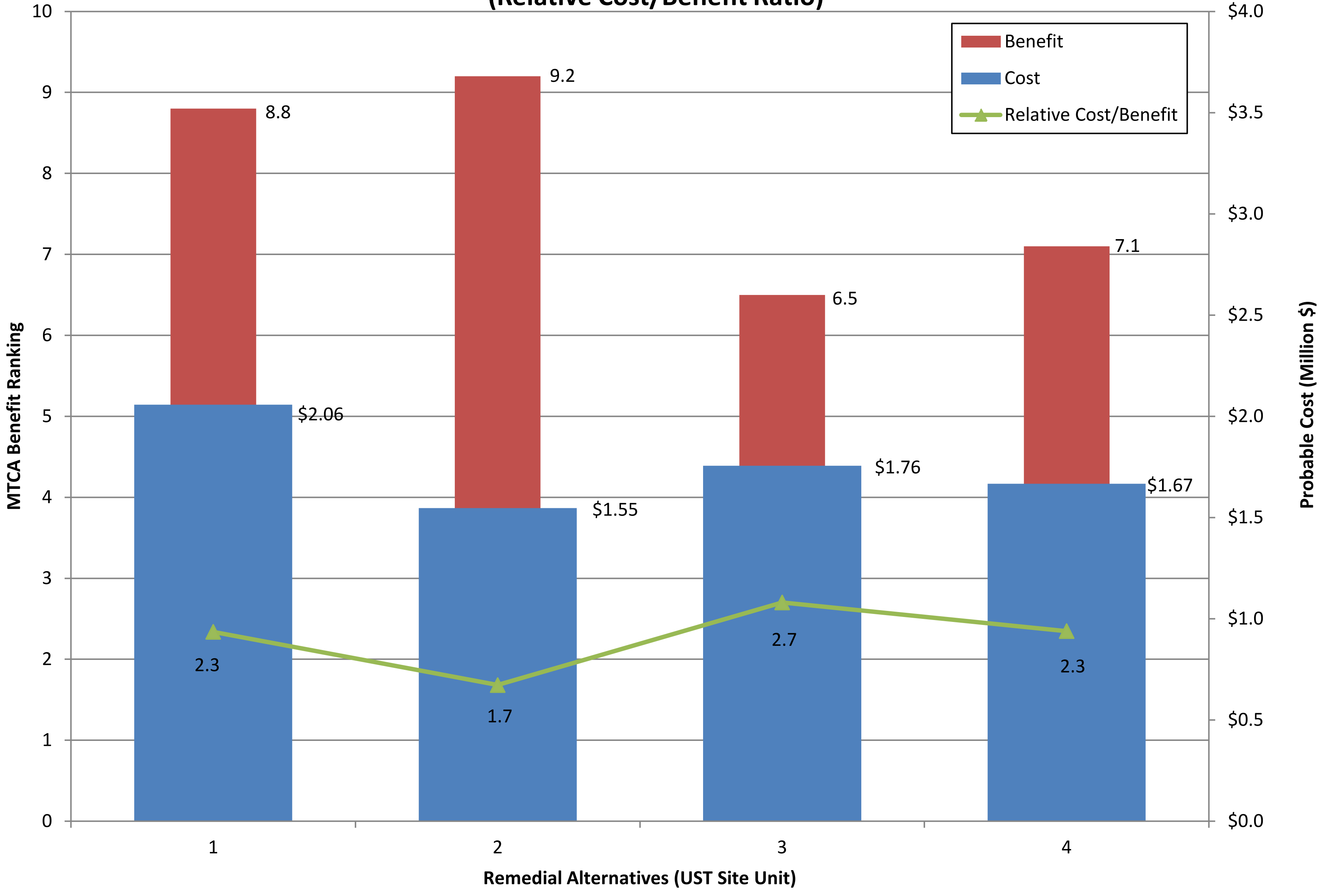

Figure 6-1 - Disproportionate Cost Analysis
(Relative Cost/Benefit Ratio)

TABLE 6-1
SUMMARY OF MTCA ALTERNATIVES EVALUATION
PEDERSON'S FRYER FARMS RI/FS

Alternative Number	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Alternative Name	**In Situ Chemical Oxidatio (ISCO)**	**Ozone Sparging**	**Excavation**	**SVE**
Alternative Description	Injection of chemical oxidants to remediate petroleum contamination in soil in Areas A and G and groundwater in Area A; focused excavation in areas B, C , E, and F where contamination is shallower and less extensive.	Sparging ozone to oxidize petroleum contamination in soil in Areas A, B, F, and G and groundwater in Area A; focused excavation in areas C and E where contamination is shallower and less extensive.	Excavation of petroleum contaminated soils as deep as 25 feet bgs, site wide. Enhanced biodegradation of deep vadose zone soils and groundwater in Area A.	Soil vapor extraction in gasoline impacted areas (Areas B, F, & G). Excavation of petroleum contaminated soils in Area A, C, & E. Enhanced biodegradation of deep vadose zone soils and groundwater in Area A.
Individual Ranking Criteria				
1 Meets Remedial Action Objectives	Yes	Yes	Yes	Yes
2 Compliance With MTCA Threshold Criteria [WAC 173-340-360(2)(a)]				
-Protect human health and the environment	Yes	Yes	Yes	Yes
-Comply with cleanup standards	Yes	Yes	Yes	Yes
-Comply with applicable state/federal laws	Yes	Yes	Yes	Yes
-Provide for compliance monitoring	Yes	Yes	Yes	Yes
3 Restoration Time Frame [WAC 173-340-360(2)(b)(ii) and WAC 173-340-360(4)]	Up to 3.5 years	Up to 4 year	Up to 5 year	Up to 5 year
-Potential risk to human health and environment	Moderate	Moderate	Moderate	Moderate
-Practicability of achieving shorter restoration time	See DCA in Table 6-2	See DCA in Table 6-2	See DCA in Table 6-2	See DCA in Table 6-2
-Current use of site, surrounding area, and resources	Former industrial w/surrounding rural, residential, and commercial	Former industrial w/surrounding rural, residential, and commercial	Former industrial w/surrounding rural, residential, and commercial	Former industrial w/surrounding rural, residential, and commercial
-Future use of site, surrounding area, and resources	Unknown w/surrounding rural, residential, and commercial	Unknown w/surrounding rural, residential, and commercial	Unknown w/surrounding rural, residential, and commercial	Unknown w/surrounding rural, residential, and commercial
-Availability of alternative water supplies	Yes	Yes	Yes	Yes
-Likely effectiveness/reliability of institutional controls	Not Applicable	Not Applicable	Not Applicable	Not Applicable
-Ability to monitor/control migration of hazardous substances	High	High	High	High
-Toxicity of hazardous substances at the site	Moderate	Moderate	Moderate	Moderate
-Natural processes that reduce concentrations	No	No	No	No
Overall Reasonable Restoration Time Frame	Yes	Yes	Yes	Yes

TABLE 6-2
SUMMARY OF MTCA OVERALL BENEFIT RANKINGS AND DISPROPOTIONATE COST ANALYSIS
PEDERSON'S FRYER FARMS RI/FS

Alternative Number **Alternative Name**	**Alternative 1** **ISCO Injection and Excavation**	**Alternative 2** **Ozone Sparging and Excavation**	**Alternative 3** **Excavation and Enhanced Biodegradation**	**Alternative 4** **Soil Vapor Extraction, Excavation, and Enhanced Biodegradation**
Alternative Description	Injection of chemical oxidants to remediate petroleum contamination in soil in Areas A and G and groundwater in Area A; focused excavation in areas B, C , E, and F where contamination is shallower and less extensive.	Sparging ozone to oxidize petroleum contamination in soil in Areas A, B, F, and G and groundwater in Area A; focused excavation in areas C and E where contamination is shallower and less extensive.	Excavation of petroleum contaminated soils as deep as 25 feet BGS, site wide for offiste disposal. Enhanced biodegradation of deep vadose zone soils and groundwater in Area A.	Soil vapor extraction in gasoline impacted areas (Areas B, F, & G). Excavation of petroleum contaminated soils in Area A, C, & E. Enhanced biodegradation of deep vadose zone soils and groundwater in Area A.

Relative Benefits Ranking for DCA
[WAC 173-340-360(2)(b)(i) and WAC 173-340-360(3)(f)]

	Alternative 1 Comparative Benefit Rating	Score	Weighting Factor	Weighted Score	Alternative 2 Comparative Benefit Rating	Score	Weighting Factor	Weighted Score	Alternative 3 Comparative Benefit Rating	Score	Weighting Factor	Weighted Score	Alternative 4 Comparative Benefit Rating	Score	Weighting Factor	Weighted Score
-Overall Protectiveness	High	10	0.3	3	High	9	0.3	2.7	Medium High	7	0.3	2.1	Medium High	7	0.3	2.1
-Permanence	High	10	0.2	2	High	10	0.2	2	Medium	6	0.2	1.2	Medium High	7	0.2	1.4
-Long Term Effectiveness	Medium High	8	0.2	1.6	High	9	0.2	1.8	Medium	5	0.2	1	Medium High	6	0.2	1.2
-Manageability of Short Term Risk	Medium High	6	0.1	0.6	High	9	0.1	0.9	Medium	6	0.1	0.6	Medium High	7	0.1	0.7
-Implementability	Medium	6	0.1	0.6	Medium High	8	0.1	0.8	Medium	6	0.1	0.6	Medium High	7	0.1	0.7
-Consideration of Public Concerns	High	10	0.1	1	High	10	0.1	1	High	10	0.1	1	High	10	0.1	1
Comparitive Overall Benefit				**8.8**				**9.2**				**6.5**				**7.1**

Disproportionate Cost Analysis	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Overall Weighted Benefit Score	8.8	9.2	6.5	7.1
Estimated Remedy Cost	$2,058,000	$1,547,000	$1,756,000	$1,667,000
Most practicable permanent solution	No	**Yes**	No	No
Lowest Cost Alternative	No	**Yes**	No	No
Relative Cost/Benefit Ratio (divided by 10,000)	2.3	1.7	2.7	2.3
Incrimental Increase/Decrease in Relative Benefit to Most Permanent Alternative	-4%	--	-29%	-23%
Incremental Increase/Decrease in Cost Compared to Most Permanent Alternative	33%	--	14%	8%
Costs Disproportionate to Incremental Benefits	Yes	**No**	Yes	Yes
Remedy Permanent to the Maximum Extent Practicable?	No	**Yes**	No	No
Preferred Alternative	**No**	**Yes**	**No**	**No**

7.0 SUMMARY AND CONCLUSIONS

The site RI (including supplemental RI) defined and documented physical characteristics, source areas, the nature and extent of impacted media, and the migration pathways for contaminants. Data from the RI were used in the FS process to develop and evaluate remedial alternatives for the site.

The FS developed remedial alternatives for each area of the site to clean up contaminated media defined in the RI, evaluated the alternatives against criteria defined by MTCA, provided a comparative analysis of the alternatives to determine the relative environmental benefits of each, and compared the relative benefits of each against their costs to determine the alternative that uses the most permanent solutions to the maximum extent practicable.

7.1 PREFERRED ALTERNATIVE

The preferred alternative for a site is an assemblage of the most practicable alternatives for each area or media of concern at the site. Based on the DCA, Alternative 2 uses permanent solutions to the maximum extent practicable and has been identified as the preferred remedial alternative for the site. Alternative 2 consists of the following elements:

- Area A (soil and groundwater)
  - Ozone sparging in vadose zone and smear zone soils and groundwater
- Area B
  - Ozone sparging in vadose zone soil
- Area C
  - Excavation and offsite disposal of vadose zone soil
- Area E
  - Excavation and offsite disposal of vadose zone soil
- Area F
  - Ozone sparging in vadose zone soil
- Area G
  - Ozone sparging in vadose zone soil.

7.2 IMPLEMENTATION OF SITE CLEANUP

Once this FS is finalized, selection of a cleanup action alternative for the site will be selected by Ecology. The selected cleanup action will be presented in the site draft CAP, which will describe the cleanup action and specify cleanup standards and compliance monitoring requirements. Following public review of the draft CAP, the cleanup will progress into a series of implementation phases: engineering and design, permitting, construction, and long-term compliance monitoring (as applicable).

8.0 USE OF THIS REPORT

This supplemental remedial investigation and feasibility study report has been prepared for the exclusive use of Ecology for specific application to the Pederson's Fryer Farms site. No other party is entitled to rely on the information, conclusions, and recommendations included in this document without the express written consent of Landau Associates. Further, the reuse of information, conclusions, and recommendations provided herein for extensions of the project or for any other project, without review and authorization by Landau Associates, shall be at the user's sole risk. Landau Associates warrants that within the limitations of scope, schedule, and budget, our services have been provided in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions as this project. We make no other warranty, either express or implied.

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APPENDIX A

IDW Disposal Documentation

www.emeraldnw.com

EMERALD RECYCLING
WASTE ACCEPTANCE FORM

See Emerald's list of generic profiles for further instructions.
Please complete all portions of this form for approval.

A COPY OF THIS FORM MUST ACCOMPANY EACH SHIPMENT

Generator Name: PEDERSON'S FRYER FARMS

Generator Address: 2901 72ND STREET EAST,
TACOMA, WA 98404

Industry Type: FARM

Waste Name/Description:
IDW WATER (LANDAU ASSOCIATES)

Process Generating Waste:
SITE INVESTIGATION

Composition (include percentages for each constituent and account for 100% of waste):
NON-REGULATED WATER

Physical State at 70°F:
☐ Solid ☐ Sludge
☒ Liquid ☐ Powder

pH:
☐ ≤2 ☐ 10-12.5
☐ 2-4 ☐ ≥12.5
☒ >4 - <10 ☐ N/A

Flashpoint:
☐ ≤100 ☐ >200
☐ 101-139 ☒ No flash
☐ 140-200

Odor (describe):
NONE

Metals Constituents: ☒ Not suspected ☒ Data report attached* ☐ MSDS attached*

Other regulated contaminants: ☒ Not suspected ☒ Data report attached* ☐ MSDS attached*

Shipping and volume information:

Standard shipping container: ☒ Drum ☐ Tote ☐ Bulk

Estimated volume per shipment: 3 X 55 DRUM

Estimated volume per year: 3 X 55 DRUM

Request Submitted by: MARK FOSTER Date: 2/27/2012

Broker Name (if appropriate): Landau Assoc.

Profile Number Assigned: G00707 Destination Facility: ☒ Airport Way ☐ Vancouver

Approved by: Sheila Smith Digitally signed by Sheila Smith DN: cn=Sheila Smith, o=Emerald Services, Inc., ou=Environmental, email=[illegible], c=US Date: 2012.03.01 11:11:38 -08'00' Approval Date: 3/1/12 Exp. Date: 3/1/14

Special handling instructions:

**All correspondence, data reports, and MSDSs corresponding to this WAF are included with the original WAF only. The original WAF is filed in the facility operating record.*

IN CASE OF EMERGENCY [illegible]

NON-HAZARDOUS WASTE MANIFEST

Please print or type (Form designed for use on elite (12 pitch) typewriter)

NON-HAZARDOUS WASTE MANIFEST

1. Generator's US EPA ID No. EXEMPT

Manifest Document No. 010

2. Page 1 of 1

3. Generator's Name and Mailing Address
LANDAU ASSOCIATES
950 PACIFIC AVENUE, STE 515
TACOMA, WA 98402

Site Address:
PEDERSON & FRYER FARMS
2911 72ND STREET EAST
TACOMA, WA 98404

LAUREN MCINTIRE

4. Generator's Phone ([illegible])

5. Transporter 1 Company Name: EMERALD SERVICES, INC.
6. US EPA ID Number: WAD0593516[illegible]
A. State Transporter's ID
B. Transporter 1 Phone: (206) 832-3000

7. Transporter 2 Company Name
8. US EPA ID Number
C. State Transporter's ID
D. Transporter 2 Phone

9. Designated Facility Name and Site Address
EMERALD SERVICES INC - AIRPORT
7500 AIRPORT WAY S.
SEATTLE, WA 98134
10. US EPA ID Number: WAD0583671[illegible]
E. State Facility's ID
F. Facility's Phone: (206) 832-3093

11. WASTE DESCRIPTION	12. Containers No.	Containers Type	13. Total Quantity	14. Unit Wt./Vol.
a. Non regulated waste solid., ERG#	8	DM	5800	P
b. Material NOT Regulated by DOT - Liquid	3	DM	100	
c.				
d.				

G. Additional Descriptions for Materials Listed Above
1)G04706 SOIL, SAND, KITTY LITTER W/ OIL, DIESEL, AND OTHER NON
2)G00707 Non-Hazardous Wastewater for DAF treatment

H. Handling Codes for Wastes Listed Above
1)NA

15. Special Handling Instructions and Additional Information
I certify that this material is not regulated nor mixed with waste regulated as a Dangerous waste under WAC173-303,40CFR261or40CFR761. All used oil meets the definition under WAC173-303-515&40CFR279. Generator agrees to indemnify and hold harmless Emerald Services or its subsidiary for any damages, costs, attorneys and expert fees arising from or related to the above certification.

16. GENERATOR'S CERTIFICATION: I hereby certify that the contents of this shipment are fully and accurately described and are in all respects in proper condition for transport. The materials described on this manifest are not subject to federal hazardous waste regulations.

Printed/Typed Name
Signature
Date Month 5 Day 7 Year 12

17. Transporter 1 Acknowledgement of Receipt of Materials
Printed/Typed Name
Signature
Date Month 5 Day 7 Year 12

18. Transporter 2 Acknowledgement of Receipt of Materials
Printed/Typed Name
Signature
Date Month Day Year

19. Discrepancy Indication Space

20. Facility Owner or Operator: Certification of receipt of the waste materials covered by this manifest, except as noted in item 19.
Printed/Typed Name
Signature
Date Month Day Year

GENERATOR
TRANSPORTER
FACILITY
NON-HAZARDOUS WASTE

APPENDIX B

Supplemental RI Boring Logs

Soil Classification System

MAJOR DIVISIONS			GRAPHIC SYMBOL	USCS LETTER SYMBOL[1]	TYPICAL DESCRIPTIONS [2][3]
COARSE-GRAINED SOIL (More than 50% of material is larger than No. 200 sieve size)	GRAVEL AND GRAVELLY SOIL (More than 50% of coarse fraction retained on No. 4 sieve)	CLEAN GRAVEL (Little or no fines)	○	**GW**	Well-graded gravel; gravel/sand mixture(s); little or no fines
			○	**GP**	Poorly graded gravel; gravel/sand mixture(s); little or no fines
		GRAVEL WITH FINES (Appreciable amount of fines)	▥	**GM**	Silty gravel; gravel/sand/silt mixture(s)
			▨	**GC**	Clayey gravel; gravel/sand/clay mixture(s)
	SAND AND SANDY SOIL (More than 50% of coarse fraction passed through No. 4 sieve)	CLEAN SAND (Little or no fines)	░	**SW**	Well-graded sand; gravelly sand; little or no fines
			░	**SP**	Poorly graded sand; gravelly sand; little or no fines
		SAND WITH FINES (Appreciable amount of fines)	▥	**SM**	Silty sand; sand/silt mixture(s)
			▨	**SC**	Clayey sand; sand/clay mixture(s)
FINE-GRAINED SOIL (More than 50% of material is smaller than No. 200 sieve size)	SILT AND CLAY (Liquid limit less than 50)		▥	**ML**	Inorganic silt and very fine sand; rock flour; silty or clayey fine sand or clayey silt with slight plasticity
			▨	**CL**	Inorganic clay of low to medium plasticity; gravelly clay; sandy clay; silty clay; lean clay
			▨	**OL**	Organic silt; organic, silty clay of low plasticity
	SILT AND CLAY (Liquid limit greater than 50)		▥	**MH**	Inorganic silt; micaceous or diatomaceous fine sand
			▨	**CH**	Inorganic clay of high plasticity; fat clay
			▨	**OH**	Organic clay of medium to high plasticity; organic silt
	HIGHLY ORGANIC SOIL		▨	**PT**	Peat; humus; swamp soil with high organic content

OTHER MATERIALS	GRAPHIC SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
PAVEMENT	■	**AC** or **PC**	Asphalt concrete pavement or Portland cement pavement
ROCK	▨	**RK**	Rock (See Rock Classification)
WOOD	▨	**WD**	Wood, lumber, wood chips
DEBRIS	▨	**DB**	Construction debris, garbage

NOTES:

1. USCS letter symbols correspond to symbols used by the Unified Soil Classification System and ASTM classification methods. Dual letter symbols (e.g., SP-SM for sand or gravel) indicate soil with an estimated 5-15% fines. Multiple letter symbols (e.g., ML/CL) indicate borderline or multiple soil classifications.
2. Soil descriptions are based on the general approach presented in the *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)*, outlined in ASTM D 2488. Where laboratory index testing has been conducted, soil classifications are based on the *Standard Test Method for Classification of Soils for Engineering Purposes*, as outlined in ASTM D 2487.
3. Soil description terminology is based on visual estimates (in the absence of laboratory test data) of the percentages of each soil type and is defined as follows:

Primary Constituent:	> 50% - "GRAVEL," "SAND," "SILT," "CLAY," etc.
Secondary Constituents:	> 30% and ≤ 50% - "very gravelly," "very sandy," "very silty," etc.
	> 15% and ≤ 30% - "gravelly," "sandy," "silty," etc.
Additional Constituents:	> 5% and ≤ 15% - "with gravel," "with sand," "with silt," etc.
	≤ 5% - "trace gravel," "trace sand," "trace silt," etc., or not noted.

LANDAU ASSOCIATES

Pederson's Fryer Farms
Tacoma, Washington

Soil Classification System and Key

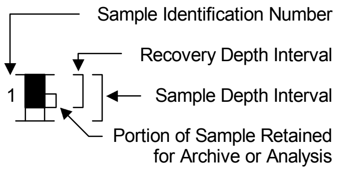
Figure
A-1
(1 of 2)

Drilling and Sampling Key

SAMPLER TYPE

Code	Description
a	3.25-inch O.D., 2.42-inch I.D. Split Spoon
b	2.00-inch O.D., 1.50-inch I.D. Split Spoon
c	Shelby Tube
d	Grab Sample
e	Single-Tube Core Barrel
f	Double-Tube Core Barrel
g	Other - See text if applicable
1	300-lb Hammer, 30-inch Drop
2	140-lb Hammer, 30-inch Drop
3	Pushed
4	Rotosonic
5	Air Rotary (Rock)
6	Wash Rotary (Rock)
7	Other - See text if applicable

SAMPLE NUMBER & INTERVAL



Field and Lab Test Data

Code	Description
PP = 1.0	Pocket Penetrometer, tsf
TV = 0.5	Torvane, tsf
PID = 100	Photoionization Detector VOC screening, ppm
W = 10	Moisture Content, %
D = 120	Dry Density, pcf
-200 = 60	Material smaller than No. 200 sieve, %
GS	Grain Size - See separate figure for data
AL	Atterberg Limits - See separate figure for data
VST	Vane Shear Test
GT	Other Geotechnical Testing
CA	Chemical Analysis

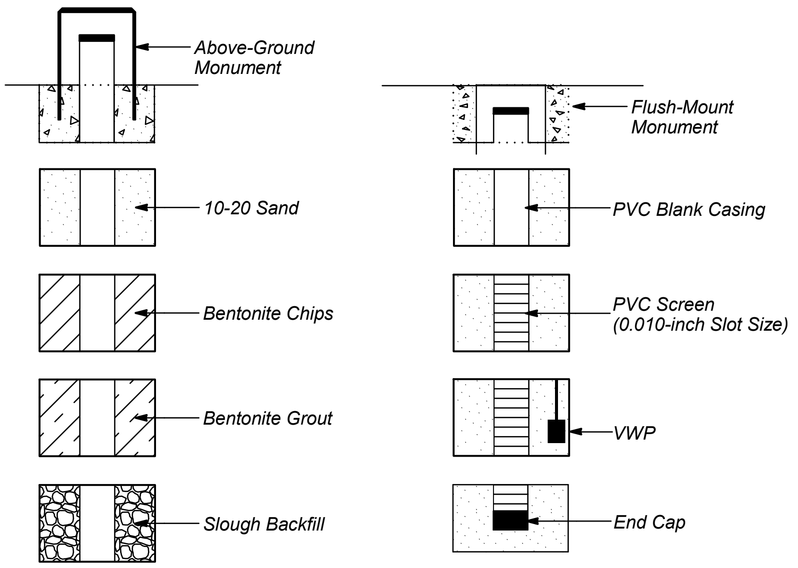
Groundwater

▽ Approximate water elevation at time of drilling (ATD).

▼ Approximate water elevation at other time(s). When multiple water levels are obtained other than ATD, only a representative range is shown. See text for additional information.

Note: Groundwater levels can fluctuate due to precipitation, seasonal conditions, and other factors.

Well Log Graphics



LANDAU ASSOCIATES

Pederson's Fryer Farms
Tacoma, Washington

Soil Classification System and Key

Figure
A-1
(2 of 2)

MW-24d

SAMPLE DATA

Depth (ft): 0, 5, 10, 15, 20, 25, 30, 35

Elevation: 395, 390, 385, 380, 375, 370, 365

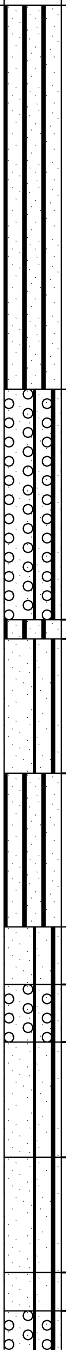
Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)
Run 1	i4		
S-1	d		0.8
S-2	d		0.8
Run 2	i4		
S-3	d		0.7
S-4	d		1.2
Run 3	i4		
S-5	d		0.5
S-6	d		0.4
S-7	d		0.5
Run 4	i4		
S-8	d		0.2
S-9	d		0.2
S-10	d		0.3
Run 5	i4		
S-11	d		0.3

SOIL PROFILE

Drilling Method: Rotosonic

Ground Elevation (ft): 398.79

Drilled By: Boart Longyear

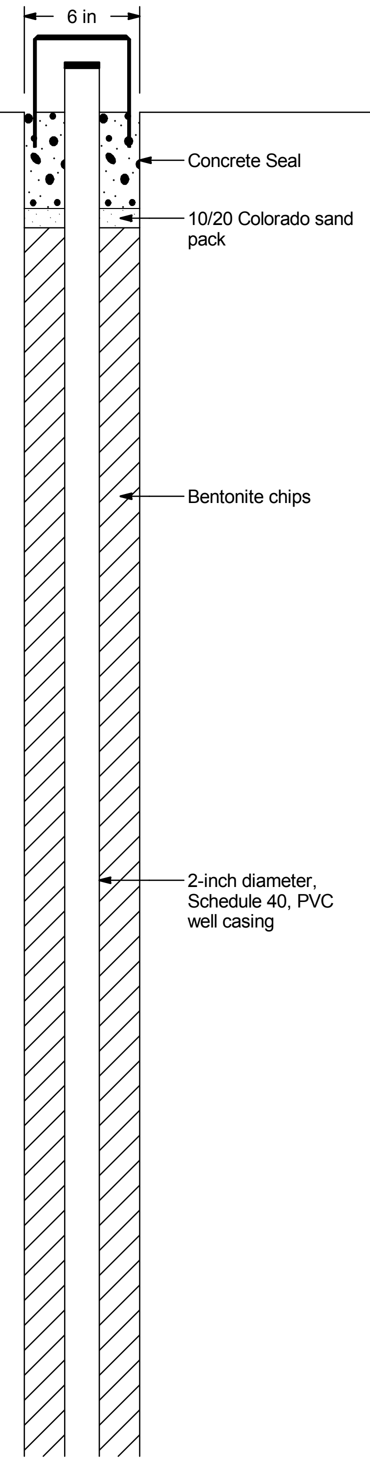


USCS Symbol	Description
SM	Brown, silty, fine to medium SAND with gravel and abundant organics; no odor or sheen (loose, damp) **(UNIT 1)** - grades without organics and dense - 8 to 9 ft BGS: sour odor - fragments of moderately cemented matrix-supported gravel
GP-GM	Light brown, sandy GRAVEL with silt and cobble; no odor or sheen (dense, moist) **(UNIT 2)** - interbeds of silty, gravelly, fine to coarse SAND
SM	Brown, silty, fine to medium SAND with trace gravel; no odor, organic sheen (loose, damp)
SP-SM	Gray with reddish-brown mottling, very gravelly, fine to coarse SAND with silt; no odor or sheen (medium dense, moist)
SM	Grayish-brown, silty, gravelly, fine to coarse SAND; no odor or sheen (medium dense, moist)
SP-SM	Grayish-brown, gravelly, fine to coarse SAND with silt; no odor or sheen (medium dense, moist) **(UNIT 3)**
GP-GM	Grayish-brown, sandy GRAVEL with silt; no odor or sheen (medium dense, moist)
SP-SM	Grayish-brown, very gravelly, medium to coarse SAND with silt; no odor or sheen (medium dense, moist) - grading siltier 28.5 to 30 ft BGS
SP-SM	Grayish-brown, gravelly, fine to coarse SAND with silt; cemented matrix supported gravel fragments; no odor or sheen (medium dense, moist)
SP-SM	

GROUNDWATER

Water Level: Groundwater not encountered.

Monitoring Well Detail (DOE#: BCR216)



Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.
4. **DOE Unique Well Number: BCR216**

LANDAU ASSOCIATES

Pederson's Fryer Farms Tacoma, Washington	Log of Monitoring Well MW-24d	Figure A-2 (1 of 2)

MW-24d

SAMPLE DATA

SOIL PROFILE

GROUNDWATER

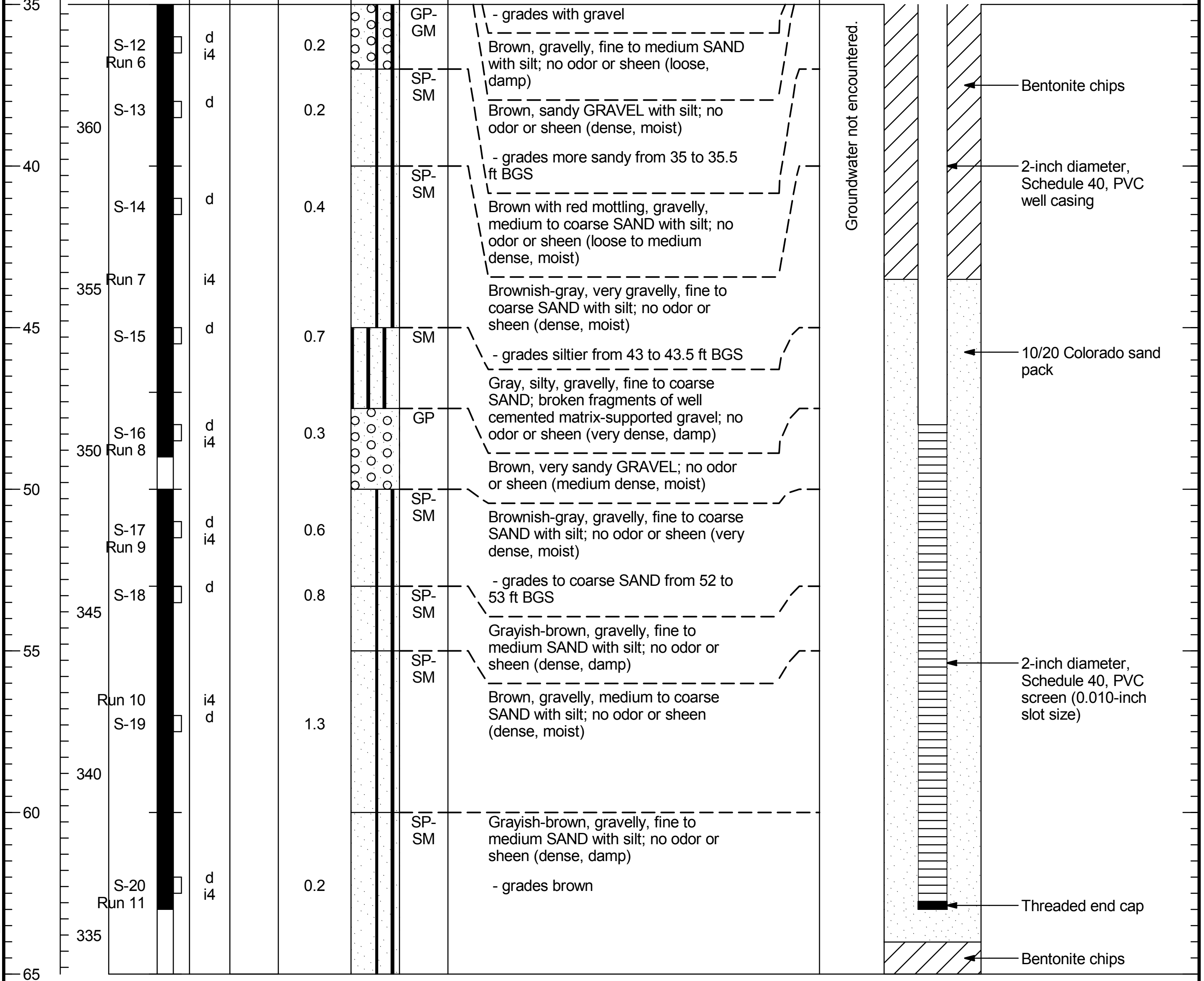
Drilling Method: Rotosonic

Ground Elevation (ft): 398.79

Drilled By: Boart Longyear

Monitoring Well Detail
(DOE#: BCR216)

Elevation	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)
	S-12 Run 6	d i4		0.2
	S-13	d		0.2
360				
	S-14	d		0.4
355	Run 7	i4		
	S-15	d		0.7
350	S-16 Run 8	d i4		0.3
	S-17 Run 9	d i4		0.6
	S-18	d		0.8
345				
	Run 10 S-19	i4 d		1.3
340				
	S-20 Run 11	d i4		0.2
335				



GP-GM - grades with gravel

SP-SM Brown, gravelly, fine to medium SAND with silt; no odor or sheen (loose, damp)

Brown, sandy GRAVEL with silt; no odor or sheen (dense, moist)

- grades more sandy from 35 to 35.5 ft BGS

SP-SM Brown with red mottling, gravelly, medium to coarse SAND with silt; no odor or sheen (loose to medium dense, moist)

Brownish-gray, very gravelly, fine to coarse SAND with silt; no odor or sheen (dense, moist)

SM - grades siltier from 43 to 43.5 ft BGS

Gray, silty, gravelly, fine to coarse SAND; broken fragments of well cemented matrix-supported gravel; no odor or sheen (very dense, damp)

GP Brown, very sandy GRAVEL; no odor or sheen (medium dense, moist)

SP-SM Brownish-gray, gravelly, fine to coarse SAND with silt; no odor or sheen (very dense, moist)

- grades to coarse SAND from 52 to 53 ft BGS

SP-SM Grayish-brown, gravelly, fine to medium SAND with silt; no odor or sheen (dense, damp)

SP-SM Brown, gravelly, medium to coarse SAND with silt; no odor or sheen (dense, moist)

SP-SM Grayish-brown, gravelly, fine to medium SAND with silt; no odor or sheen (dense, damp)

- grades brown

Boring Completed 09/20/11
Total Depth of Boring = 65.0 ft.

Monitoring Well Completed 09/22/11
Elevation at Top of Protective Casing = 401.93 ft.
Elevation at Top of Monitoring Well Casing = Not Measured
Total Depth of Monitoring Well = 63.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.
4. **DOE Unique Well Number: BCR216**

136006.01 3/2/12 N:\PROJECTS\136006.010_MASTER.GPJ WELL LOG W/ ELEVATION

LANDAU ASSOCIATES

Pederson's Fryer Farms
Tacoma, Washington

Log of Monitoring Well MW-24d

Figure
A-2
(2 of 2)

MW-36d

SAMPLE DATA

Depth (ft)	Elevation	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)
0	405	S-1	d		0.7
5	400	Run 1	i4		
		S-2	d		1.0
10	395				
		S-3 Run 2	d i4		0.0
15	390				
		S-4	d		0.1
		Run 3 S-5	i4 d		0.0
20	385				
		Run 4	i4		
25	380				
		S-6	d		0.0
		S-7	d		0.0
		Run 5 S-8	i4 d		
30	375				
		S-9	d		0.1
		Run 6	i4		
35					

SOIL PROFILE

Drilling Method: Rotosonic

Ground Elevation (ft): 405.16

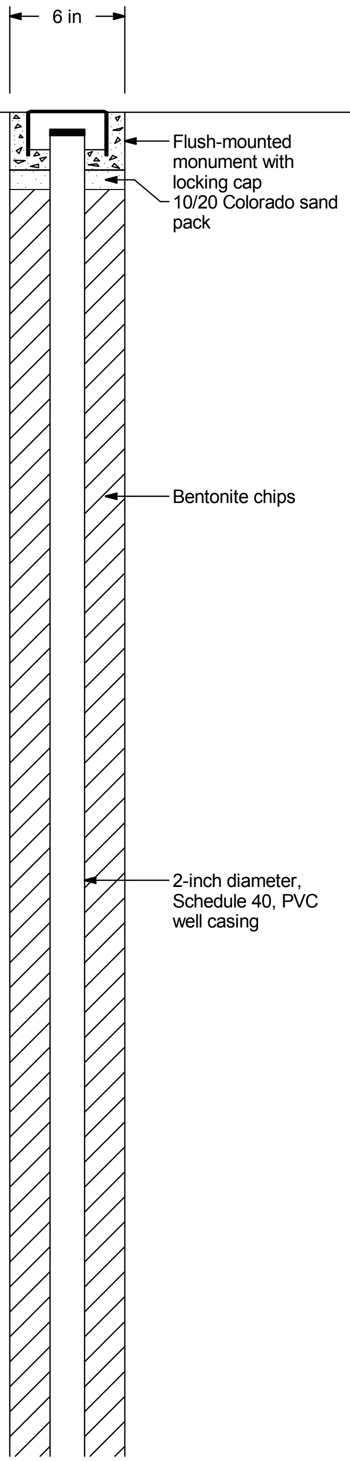
Drilled By: Boart Longyear

USCS Symbol	Description
SM	Brown, silty, fine to medium SAND with gravel and organics; no odor or sheen (loose, damp) **(UNIT 1)** - grades gray and brown mottled, with trace gravel, medium dense and moist; slight sour odor - grades reddish-brown mottling and less silty - grades grayish-brown with matrix supported gravel; no odor
GM	Grayish-brown, sandy, silty GRAVEL; no odor or sheen (medium dense to dense, moist) **(UNIT 2)** - grades dense
SP	Grayish-brown, fine to medium SAND with trace gravel; no odor or sheen (dense, moist)
GM	Grayish-brown, silty, sandy GRAVEL; no odor or sheen (dense, moist)
SP-SM	Grayish-brown, fine to medium SAND with silt and trace gravel; no odor or sheen (medium dense, damp) **(UNIT 3)**
SP	Gray, fine to medium SAND with trace gravel; no odor or sheen (medium dense, moist) - grades brown with gray mottling
SP-SM	- grades gray

GROUNDWATER

Water Level: Groundwater not encountered.

Monitoring Well Detail
(DOE#: BCR214)



Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.
4. **DOE Unique Well Number: BCR214**

LANDAU ASSOCIATES

Pederson's Fryer Farms
Tacoma, Washington

Log of Monitoring Well MW-36d

Figure
A-3
(1 of 2)

MW-36d

SAMPLE DATA

SOIL PROFILE

GROUNDWATER

Drilling Method: Rotosonic

Ground Elevation (ft): 405.16

Drilled By: Boart Longyear

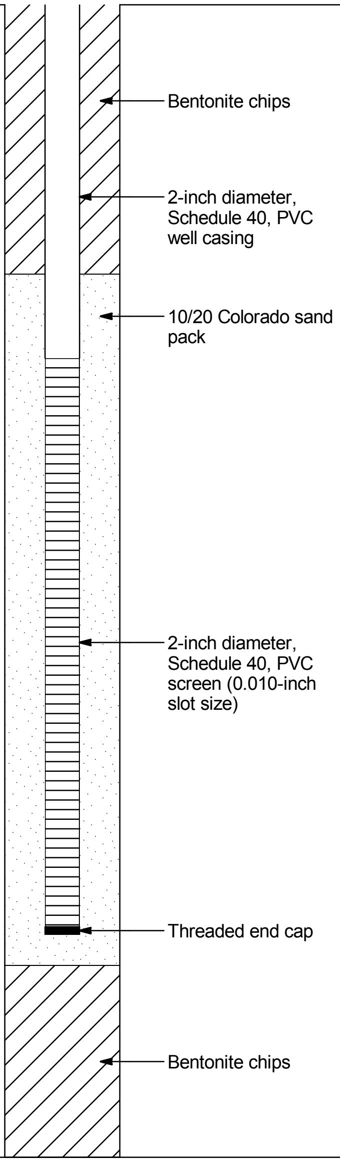
Depth (ft)	Elevation
35	370
40	365
45	360
50	355
55	350
60	345
65	
70	

Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)
S-10	d		0.1
S-11	d		0.0
Run 7	i4		
S-12	d		108
Run 8	i4		
S-13	d		86.2
Run 9	i4		
S-14	d		1.7
S-15	d		0.3
Run 10	i4		
S-16	d		0.8
S-17	d		0.1
Run 11	i4		
S-18	d		0.2
S-19	d		0.3

USCS Symbol	Description
SP-SM	Gray, very gravelly, fine to coarse SAND with silt; no odor or sheen (dense, moist)
SP	Gray, fine to coarse SAND with gravel; slight hydrocarbon odor, no sheen (medium dense, moist)
SP-SM	Gray, very gravelly, fine to coarse SAND with silt; strong hydrocarbon odor, sheen (loose to medium dense, moist) - very strong odor from 43 to 45 ft BGS
SP	Gray, gravelly, fine to medium SAND; slight to moderate hydrocarbon odor, no sheen (medium dense, moist)
SP-SM	Gray, gravelly, medium to coarse SAND with silt; slight to moderate hydrocarbon odor, no sheen (dense, moist) - stronger hydrocarbon odor from 52 to 53 ft BGS
SM	Grayish-brown, silty, gravelly, fine to medium SAND; no odor or sheen (dense, damp)
SP	Grayish-brown, gravelly, medium to coarse SAND; no odor or sheen (dense, moist)
SP-SM	Grayish-brown, gravelly, medium to coarse SAND with silt; no odor or sheen (dense, moist) - grades very gravelly, dense to very dense and damp

Water Level: Groundwater not encountered.

Monitoring Well Detail
(DOE#: BCR214)



Boring Completed 09/19/11
Total Depth of Boring = 65.0 ft.

Monitoring Well Completed 09/19/11
Elevation at Top of Protective Casing = 404.86 ft.
Elevation at Top of Monitoring Well Casing = Not Measured
Total Depth of Monitoring Well = 60.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.
4. **DOE Unique Well Number: BCR214**

LANDAU ASSOCIATES

Pederson's Fryer Farms
Tacoma, Washington

Log of Monitoring Well MW-36d

Figure
A-3
(2 of 2)

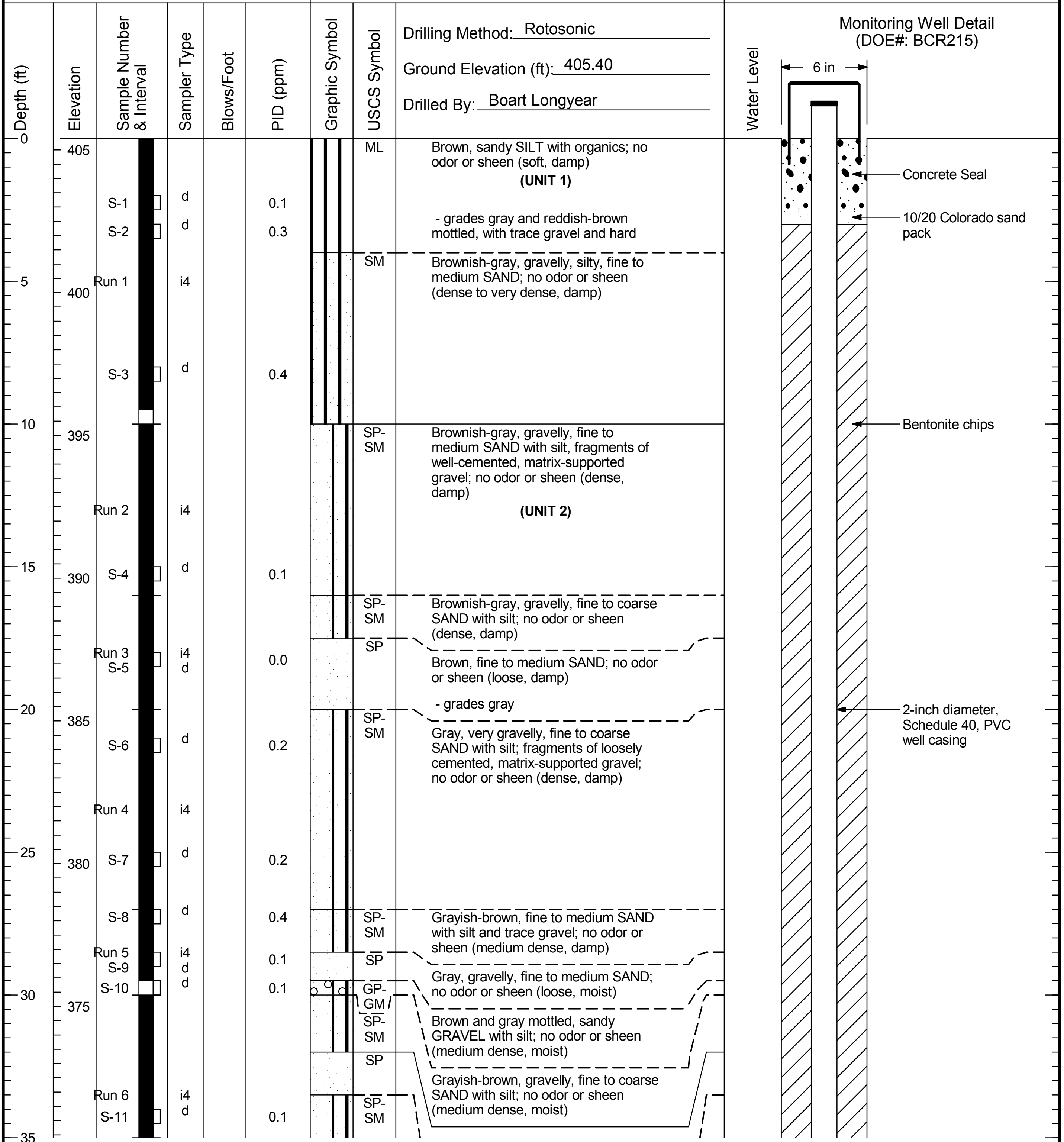
MW-37d

Drilling Method: Rotosonic

Ground Elevation (ft): 405.40

Drilled By: Boart Longyear

Monitoring Well Detail
(DOE#: BCR215)



Brown, sandy SILT with organics; no odor or sheen (soft, damp)

(UNIT 1)

- grades gray and reddish-brown mottled, with trace gravel and hard

Brownish-gray, gravelly, silty, fine to medium SAND; no odor or sheen (dense to very dense, damp)

Brownish-gray, gravelly, fine to medium SAND with silt, fragments of well-cemented, matrix-supported gravel; no odor or sheen (dense, damp)

(UNIT 2)

Brownish-gray, gravelly, fine to coarse SAND with silt; no odor or sheen (dense, damp)

Brown, fine to medium SAND; no odor or sheen (loose, damp)

- grades gray

Gray, very gravelly, fine to coarse SAND with silt; fragments of loosely cemented, matrix-supported gravel; no odor or sheen (dense, damp)

Grayish-brown, fine to medium SAND with silt and trace gravel; no odor or sheen (medium dense, damp)

Gray, gravelly, fine to medium SAND; no odor or sheen (loose, moist)

Brown and gray mottled, sandy GRAVEL with silt; no odor or sheen (medium dense, moist)

Grayish-brown, gravelly, fine to coarse SAND with silt; no odor or sheen (medium dense, moist)

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.
4. **DOE Unique Well Number: BCR215**

LANDAU ASSOCIATES

Pederson's Fryer Farms
Tacoma, Washington

Log of Monitoring Well MW-37d

Figure
A-4
(1 of 2)

MW-37d

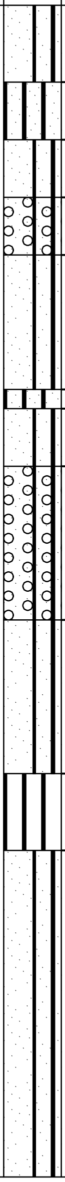
SAMPLE DATA

Depth (ft)	Elevation	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)
35	370	S-12	d		0.1
		S-13	d		0.7
		S-14 Run 7	d i4		0.2
40	365	S-15	d		0.0
		S-16 Run 8	d i4		0.1
45	360	S-17	d		0.3
		S-18	d		0.0
		Run 9	i4		
		S-19	d		0.0
50	355	S-20	d		0.0
		S-21 Run 10	d i4		0.0
55	350	S-22	d		0.7
60	345	Run 11	i4		
		S-23	d		0.0
65	340				

Boring Completed 09/20/11
Total Depth of Boring = 65.5 ft.

SOIL PROFILE

Drilling Method: Rotosonic
Ground Elevation (ft): 405.40
Drilled By: Boart Longyear



USCS Symbol: SP-SM, SM, SP-SM, GP-GM, SP-SM, SM, SP-SM, GP-GM, SP-SM, ML, SP-SM

- Grayish-brown, fine to medium SAND with gravel; no odor or sheen (medium dense, moist)

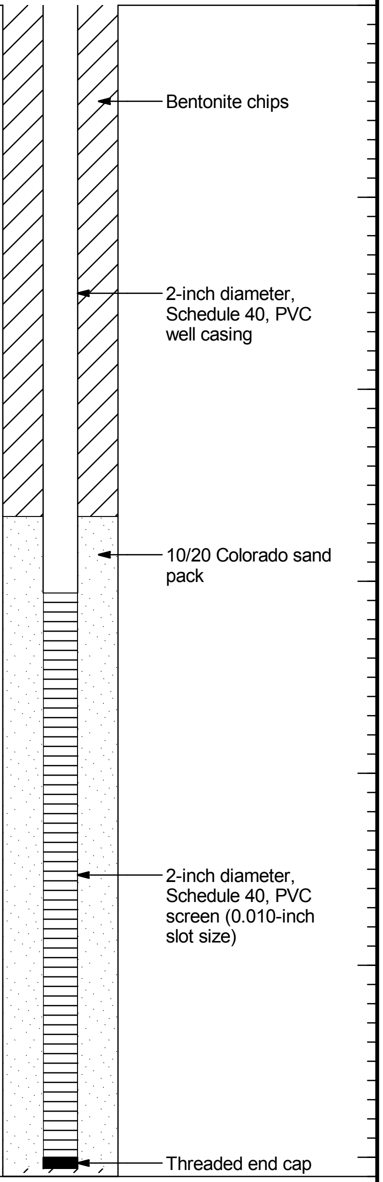
(UNIT 3)

- Grayish-brown, gravelly, fine to coarse SAND with silt; no odor or sheen (medium dense, moist)
- Gray, silty, fine to coarse SAND with gravel; no odor or sheen (dense, moist)
- Brown, gravelly, fine to coarse SAND with silt; no odor or sheen (dense, moist)
- Gray, very sandy GRAVEL with silt; no odor or sheen (very dense, moist)
- Gray, gravelly, fine to coarse SAND with silt; no odor or sheen (very dense, damp)
- Brown, very silty, fine to medium SAND with trace gravel; no odor or sheen (dense, damp)
- Gray, gravelly, medium to coarse SAND with silt; no odor or sheen (medium dense, moist)
- Brownish-gray, sandy GRAVEL with silt; no odor or sheen (dense, damp)
  - grades gray and moist
- Brownish-gray, gravelly, fine to medium SAND with silt; no odor or sheen (dense, damp)
- Gray, sandy SILT with trace gravel; no odor or sheen (medium stiff, moist to wet)
- Grayish-brown, gravelly, fine to medium SAND with silt; no odor or sheen (dense, damp)

GROUNDWATER

Water Level: ▽ 9/22/11

Monitoring Well Detail
(DOE#: BCR215)



Monitoring Well Completed 09/22/11
Elevation at Top of Protective Casing = 408.20 ft.
Elevation at Top of Monitoring Well Casing = Not Measured
Total Depth of Monitoring Well = 65.3 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.
4. **DOE Unique Well Number: BCR215**

LANDAU ASSOCIATES

Pederson's Fryer Farms
Tacoma, Washington

Log of Monitoring Well MW-37d

Figure
A-4
(2 of 2)

MW-38d

SAMPLE DATA

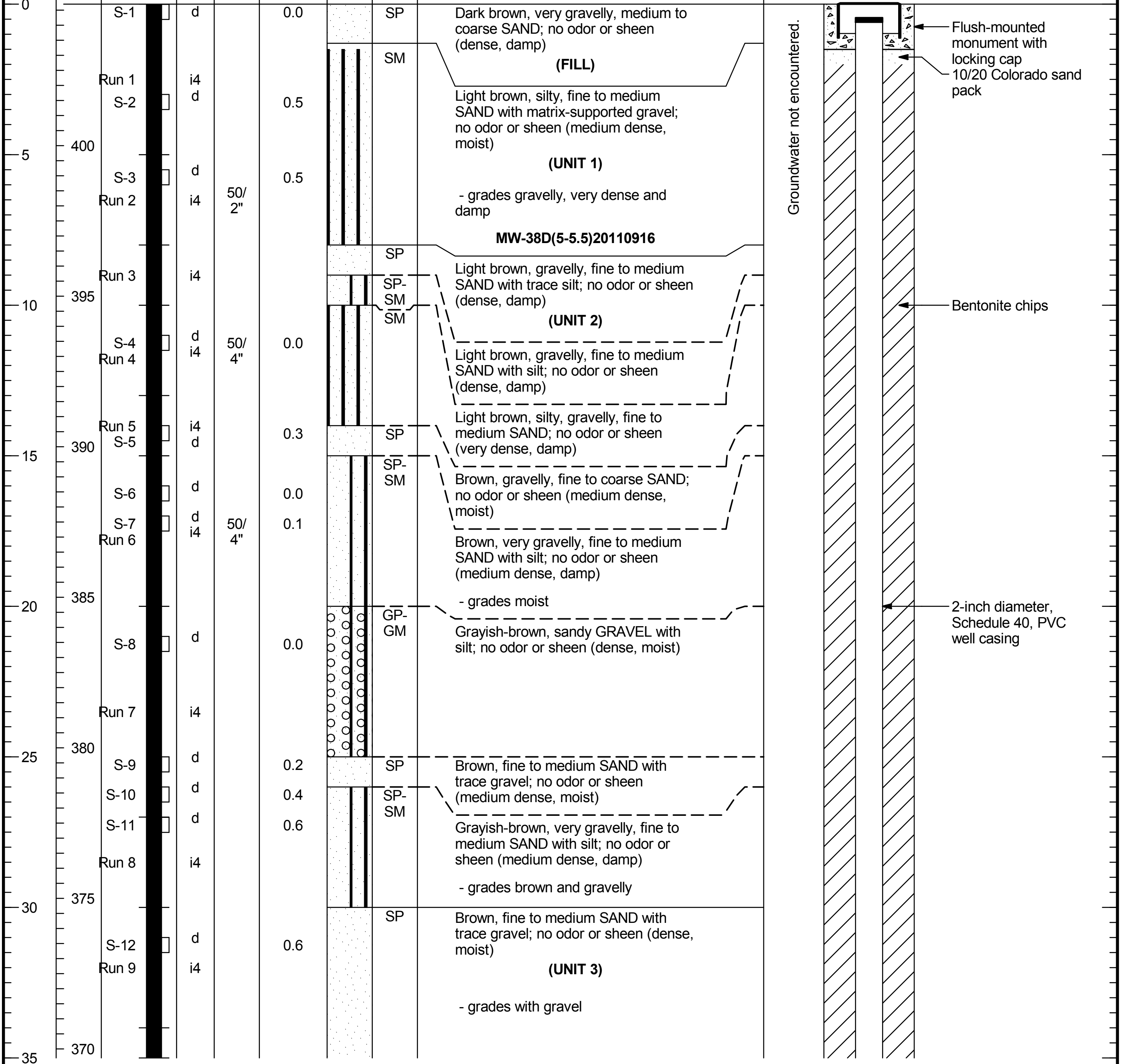
Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)
S-1	d		0.0
Run 1	i4		
S-2	d		0.5
S-3	d		0.5
Run 2	i4	50/ 2"	
Run 3	i4		
S-4	d	50/ 4"	0.0
Run 4	i4		
Run 5	i4		
S-5	d		0.3
S-6	d		0.0
S-7	d	50/ 4"	0.1
Run 6	i4		
S-8	d		0.0
Run 7	i4		
S-9	d		0.2
S-10	d		0.4
S-11	d		0.6
Run 8	i4		
S-12	d		0.6
Run 9	i4		

SOIL PROFILE

Drilling Method: Rotosonic

Ground Elevation (ft): 404.70

Drilled By: Boart Longyear



Dark brown, very gravelly, medium to coarse SAND; no odor or sheen (dense, damp)

(FILL)

Light brown, silty, fine to medium SAND with matrix-supported gravel; no odor or sheen (medium dense, moist)

(UNIT 1)

- grades gravelly, very dense and damp

MW-38D(5-5.5)20110916

Light brown, gravelly, fine to medium SAND with trace silt; no odor or sheen (dense, damp)

(UNIT 2)

Light brown, gravelly, fine to medium SAND with silt; no odor or sheen (dense, damp)

Light brown, silty, gravelly, fine to medium SAND; no odor or sheen (very dense, damp)

Brown, gravelly, fine to coarse SAND; no odor or sheen (medium dense, moist)

Brown, very gravelly, fine to medium SAND with silt; no odor or sheen (medium dense, damp)

- grades moist

Grayish-brown, sandy GRAVEL with silt; no odor or sheen (dense, moist)

Brown, fine to medium SAND with trace gravel; no odor or sheen (medium dense, moist)

Grayish-brown, very gravelly, fine to medium SAND with silt; no odor or sheen (medium dense, damp)

- grades brown and gravelly

Brown, fine to medium SAND with trace gravel; no odor or sheen (dense, moist)

(UNIT 3)

- grades with gravel

GROUNDWATER

Groundwater not encountered.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.
4. **DOE Unique Well Number: BCR213**

136006.01 3/2/12 N:\PROJECTS\136006.010_MASTER.GPJ WELL LOG W/ ELEVATION

LANDAU ASSOCIATES

Pederson's Fryer Farms
Tacoma, Washington

Log of Monitoring Well MW-38d

Figure
A-5
(1 of 2)

MW-38d

SAMPLE DATA

Depth (ft)	Elevation	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)
35		S-13	d		0.6
		S-14	d		0.8
		Run 10	i4		0.7
		S-15	d		
40	365				
		Run 11	i4		
45	360				
		S-16	d		1.2
		Run 12	i4		
		S-17	d		1.2
50	355				
		Run 13	i4		
		S-18	d		0.6
55	350				
		S-19	d		1.1
		Run 14	i4		
60	345				
		S-20	d		
		Run 15	i4		
		S-21	d		
65	340				
70					

SOIL PROFILE

Drilling Method: Rotosonic

Ground Elevation (ft): 404.70

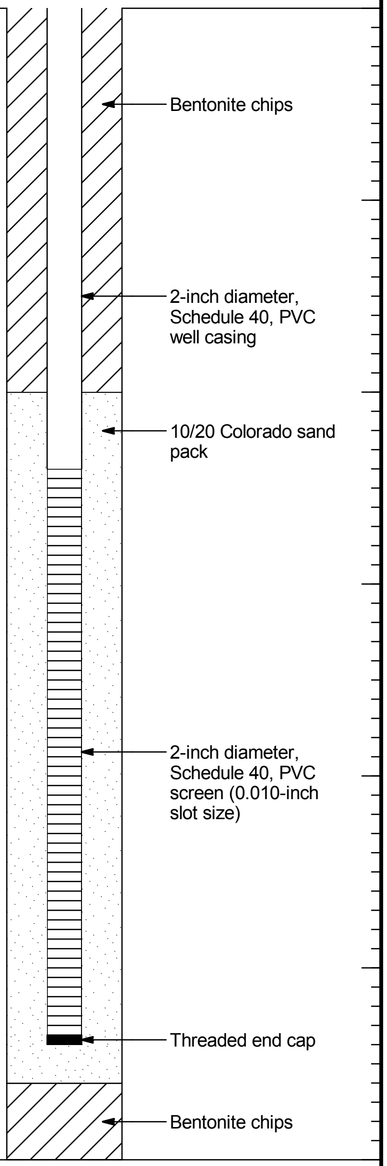
Drilled By: Boart Longyear

USCS Symbol	Description
SP	- grades gravelly
GP-GM	Brown, sandy GRAVEL with silt; no odor or sheen (dense, moist)
SP-SM	Brown, gravelly, fine to medium SAND with silt; no odor or sheen (dense, moist) - grades very dense and damp - grades reddish-brown mottling from 42 to 42.5 ft BGS - grades gray
SP	Grayish-brown, gravelly, fine to medium SAND; possible slight hydrocarbon odor, no sheen (dense, moist)
SP-SM	Gray, gravelly, fine to coarse SAND with silt; possible slight hydrocarbon odor, no sheen (very dense, moist) - grades fine to medium SAND and with gravel - grades gravelly and damp; no odor or sheen - grades grayish-brown

GROUNDWATER

Water Level: Groundwater not encountered.

Monitoring Well Detail
(DOE#: BCR213)



Boring Completed 09/16/11
Total Depth of Boring = 65.0 ft.

Monitoring Well Completed 09/19/11
Elevation at Top of Protective Casing = 404.33 ft.
Elevation at Top of Monitoring Well Casing = Not Measured
Total Depth of Monitoring Well = 62.3 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.
4. **DOE Unique Well Number: BCR213**

LANDAU ASSOCIATES

Pederson's Fryer Farms
Tacoma, Washington

Log of Monitoring Well MW-38d

Figure
A-5
(2 of 2)

MW-39d

SAMPLE DATA

Depth (ft)	Elevation	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)
0					
		S-1	d		0.0
	405				
5		S-2	d		0.0
	400				
		S-3	d		2.6
		S-4	d		
		Run 1	i4		0.0
		S-5	d		
10		S-6	d		
		Run 2	i4		
		S-7	d		0.0
	395				
		S-8	d		0.0
		Run 3	i4		
15					
	390				
		S-9	d		0.0
		Run 4	i4		
20		S-10	d		0.0
		S-11	d		0.0
	385				
		Run 5	i4		
		S-12	d		0.0
25					
	380	S-13	d		0.0
		Run 6	i4		
		S-14	d		0.0
30					
	375				
		Run 7	i4		
35					

SOIL PROFILE

Drilling Method: Rotosonic

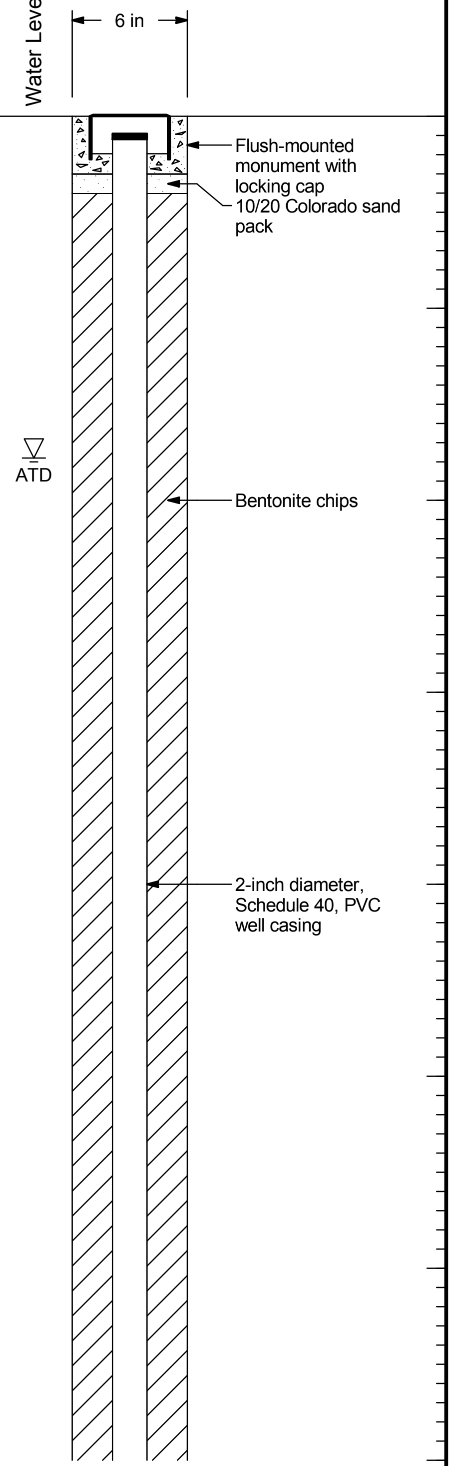
Ground Elevation (ft): 406.75

Drilled By: Boart Longyear

USCS Symbol	Description
ML	Light brown, sandy SILT with trace gravel; no odor or sheen (medium stiff, damp) - Air knife and vac truck used to clear utilities to 8 ft BGS, samples collected by hand **(UNIT 1)** - grades moist
SM	Light brown, silty, fine to medium SAND with trace gravel and gray silty interbeds; no odor or sheen (medium dense, moist)
SM	Grayish-brown, silty, fine SAND with trace matrix-supported gravel; no sheen, hydrocarbon odor from 8 to 8.5 ft BGS (medium dense, damp)
SP-SM	**Soil Sample:** **MW-39D(8-8.25)20110914** - grades fine to medium SAND and moist; hydrocarbon odor Brownish-gray, gravelly, fine to medium SAND with silt; no odor or sheen (loose, damp) **(UNIT 2)**
SP-SM	- grades grayish-brown and with trace gravel - grades without gravel - grades brownish-gray and gravelly
SM	Grayish-brown, very gravelly, fine to coarse SAND with silt; no odor or sheen (dense, moist)
SP-SM	- grades gray with brown mottling and damp Grayish-brown, silty, gravelly, medium to coarse SAND; no odor or sheen (medium dense, moist)
GM	Gray and brown mottled, gravelly, medium to coarse SAND with silt; no odor or sheen (medium dense, moist)
SM	Brown, silty GRAVEL with sand; no odor or sheen (medium dense, moist)
SP-SM	Grayish-brown, silty, gravelly, fine to coarse SAND; no odor or sheen (medium dense, damp) Grayish-brown, gravelly, fine to coarse SAND with silt; no odor or sheen (medium dense, moist)

GROUNDWATER

Monitoring Well Detail
(DOE#: BCR211)



Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.
4. **DOE Unique Well Number: BCR211**

136006.01 3/2/12 N:\PROJECTS\136006.010_MASTER.GPJ WELL LOG W/ ELEVATION

LANDAU ASSOCIATES

Pederson's Fryer Farms
Tacoma, Washington

Log of Monitoring Well MW-39d

Figure
A-6
(1 of 2)

MW-39d

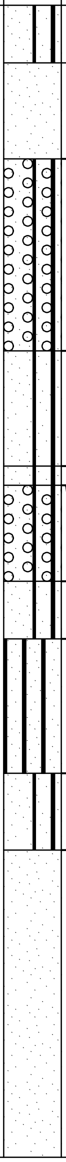
SAMPLE DATA · SOIL PROFILE · GROUNDWATER

Drilling Method: Rotosonic

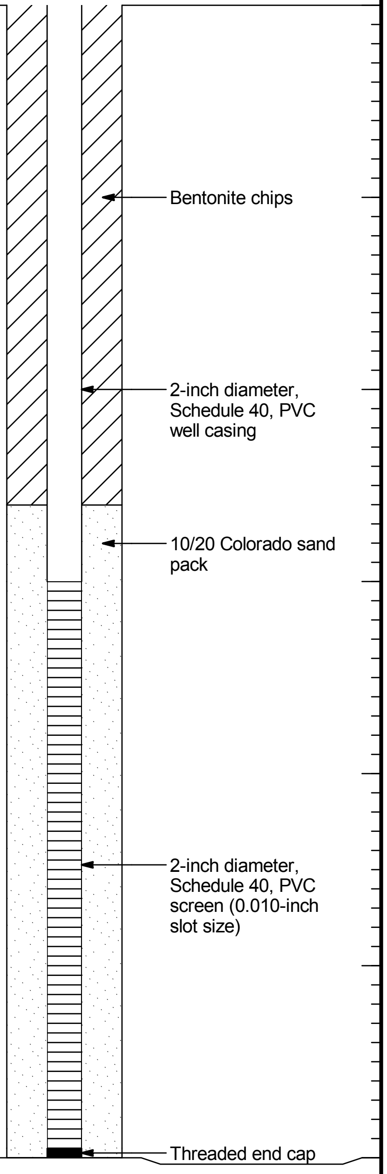
Ground Elevation (ft): 406.75

Drilled By: Boart Longyear

Depth (ft)	Elevation	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	USCS Symbol	Description	Water Level
35						SP-SM	- grades brownish-gray and very gravelly	
		S-15	d		0.0			
	370					SP	Gray, gravelly, fine to medium SAND with trace silt; no odor or sheen (medium dense, damp)	
		S-16	d		0.0			
							(UNIT 3)	
		Run 8 S-17	i4 d		0.0	GP-GM	Grayish-brown GRAVEL with silt and sand; no odor or sheen (medium dense, moist)	
40								
	365	S-18	d		0.0		- grades gray, sandy and dense	
		Run 9 S-19	i4 d		0.0	SP-SM	Gray, gravelly, fine to coarse SAND with silt; no odor or sheen (very dense, moist)	
45							- grades damp	
	360	S-20	d		0.0	SP-SM	Gray, fine to medium SAND with gravel and silt; no odor or sheen (dense, damp)	
		S-21 Run 10	d i4		0.0	GP-GM	Brown, very sandy GRAVEL with silt; no odor or sheen (very dense, moist)	
50						SP-SM	Grayish-brown, fine to medium SAND with silt and trace gravel; no odor or sheen (dense, moist)	
		S-22	d		0.0			
	355					SM	Grayish-brown, silty, fine to medium SAND with gravel; no odor or sheen (medium dense, moist)	
		Run 11	i4					
55		S-23	d		0.0	SP-SM	Grayish-brown, gravelly, fine to coarse SAND with silt; no odor or sheen (medium dense, moist)	
	350					SP	Brown, fine to medium SAND with gravel; no odor or sheen (medium dense, moist)	
		S-24 Run 12	d i4		0.0			∇ ATD
60							- grades gravelly	
	345							
		Run 13 S-25	i4 d		0.0			
65								
70								



Monitoring Well Detail
(DOE#: BCR211)



Boring Completed 09/14/11
Total Depth of Boring = 65.0 ft.

Monitoring Well Completed 09/14/11
Elevation at Top of Protective Casing = 406.23 ft.
Elevation at Top of Monitoring Well Casing = Not Measured
Total Depth of Monitoring Well = 65.5 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.
4. **DOE Unique Well Number: BCR211**

MW-40d

SAMPLE DATA

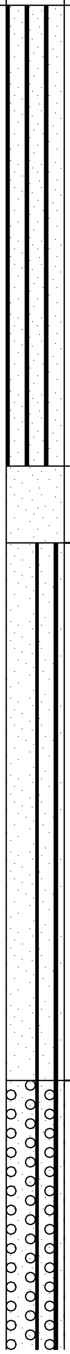
Depth (ft)	Elevation	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	USCS Symbol
0		S-1	d		0.0	SM
	405	S-2	d		0.0	
5						
		Run 1	i4			
	400	S-3	d		0.4	
10						
		S-4	d		5.3	
	395	S-5	d		2.1	SP
15		Run 2 S-6	i4 d	6	0.4	SP-SM
	390					
20						
	385					
25		Run 3 S-7	i4 d	50/ 0.5"	0.0	
	380	S-8	d		0.0	GP-GM
30						
		S-9	d		0.0	
	375	Run 4	i4	50/ 6"		
35						

SOIL PROFILE

Drilling Method: Rotosonic

Ground Elevation (ft): 408.43

Drilled By: Boart Longyear



SM — Light brown, gravelly, silty, fine to medium SAND; no odor or sheen (dense, damp)

- Air knife and vac truck used to clear utilities to 4 ft BGS, samples collected by hand

(FILL)

- grades gray; hydrocarbon odor, slight sheen

- grades with gravel and moist

- large wood piece, very strong hydrocarbon odor

- grades dark brown with light brown wood fragments and loose

SP — **MW-40D(10-10.25)20110915**

SP-SM — Gray, fine to medium SAND with trace gravel; hydrocarbon odor decreasing with depth, no sheen (medium dense, moist)

(UNIT 2)

Grayish-brown, very gravelly, fine to coarse SAND with silt; no odor or sheen (medium dense, damp)

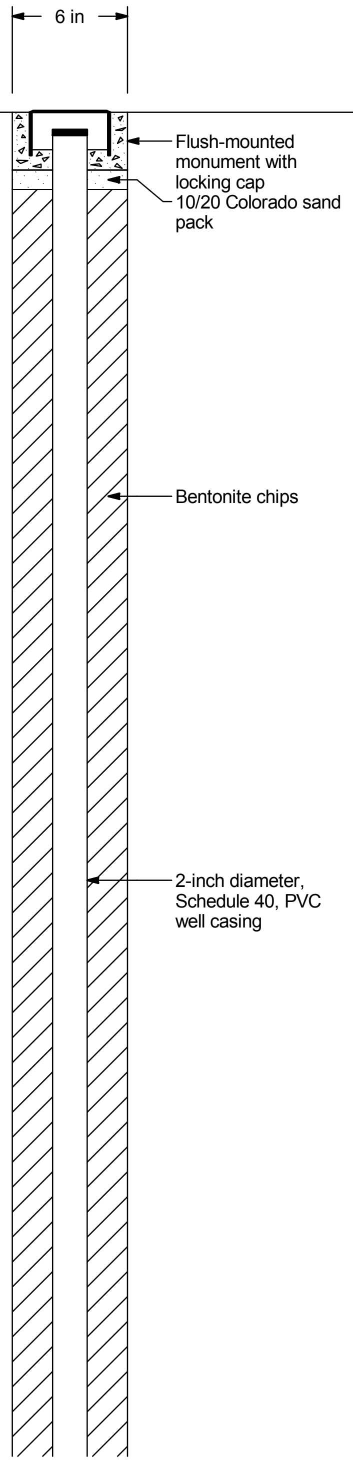
- gravel grades matrix-supported, dense, moist

GP-GM — Grayish-brown, sandy GRAVEL with silt; no odor or sheen (medium dense, moist)

GROUNDWATER

Water Level

Monitoring Well Detail
(DOE#: BCR212)



Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.
4. **DOE Unique Well Number: BCR212**

LANDAU ASSOCIATES

Pederson's Fryer Farms
Tacoma, Washington

Log of Monitoring Well MW-40d

Figure
A-7
(1 of 2)

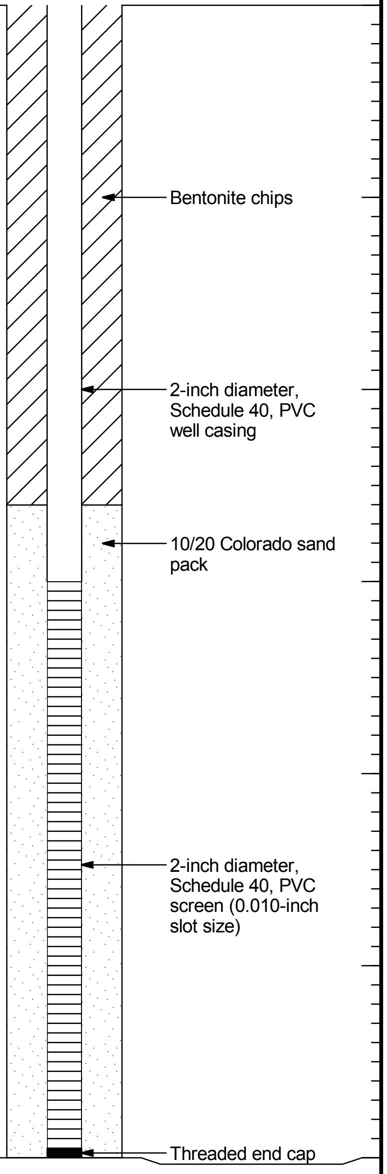
MW-40d

SAMPLE DATA / SOIL PROFILE / GROUNDWATER

Drilling Method: Rotosonic
Ground Elevation (ft): 408.43
Drilled By: Boart Longyear

Depth (ft)	Elevation	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	USCS Symbol	Description	Water Level
35		S-10	d		0.0	GP-GM	Grayish-brown, sandy GRAVEL with silt; no odor or sheen (medium dense, moist)	
	370	S-11 Run 5	d i4		0.0			
40						SP	Grayish-brown, fine to medium SAND with gravel; no odor or sheen (medium dense, moist) **(UNIT 3)**	
		S-12	d		0.0			
	365	S-13 Run 6	d i4		0.0		- grades without gravel	
45		S-14	d		0.0	SP-SM	Grayish-brown, gravelly, fine to coarse SAND with silt; no odor or sheen (medium dense, moist)	
						SP	Grayish-brown, gravelly, medium to coarse SAND with trace silt; no odor or sheen (medium dense, moist)	
	360	Run 7	i4			GP-GM	Grayish-brown, very sandy GRAVEL with silt; no odor or sheen (medium dense, moist)	
		S-15	d		0.0			
50		S-16	d		0.0	SP-SM	Grayish-brown, very gravelly, coarse SAND with silt; no odor or sheen (medium dense, moist)	
	355	Run 8	i4				- grades fine to coarse SAND with silt	
		S-17	d		0.0			
55								
						SP	Grayish-brown, gravelly, medium to coarse SAND; no odor or sheen (medium dense, moist)	∇ ATD
	350	Run 9	i4					
60		S-18	d		0.0	SM	Gray, silty, fine to medium SAND with gravel; no odor or sheen (medium dense, moist)	
						SP	Grayish-brown, gravelly, fine to medium SAND; no odor or sheen (medium dense, moist)	
		Run 10	i4					
	345							
		S-19	d		0.0			
65								
70								

Monitoring Well Detail
(DOE#: BCR212)



Boring Completed 09/15/11
Total Depth of Boring = 65.0 ft.

Monitoring Well Completed 09/16/11
Elevation at Top of Protective Casing = 408.09 ft.
Elevation at Top of Monitoring Well Casing = Not Measured
Total Depth of Monitoring Well = 65.2 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.
4. **DOE Unique Well Number: BCR212**

LANDAU ASSOCIATES

Pederson's Fryer Farms
Tacoma, Washington

Log of Monitoring Well MW-40d

Figure
A-7
(2 of 2)

MW-41d

SAMPLE DATA

Depth (ft): 0, 5, 10, 15, 20, 25, 30, 35

Elevation: 405, 400, 395, 390, 385, 380, 375

Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)
S-1	d		1.2
Run 1	i4		
S-2	d		1.3
S-3	d		1.4
S-4	d		1.8
Run 2	i4		
S-5	d		2.8
S-6	d		1.4
Run 3	i4		
S-7	d		0.5
S-8	d		0.9
Run 4	i4		
S-9	d		0.7
Run 5	i4		
S-10	d		0.7
Run 6	i4		
S-11	d		0.8

SOIL PROFILE

Drilling Method: Rotosonic

Ground Elevation (ft): 408.56

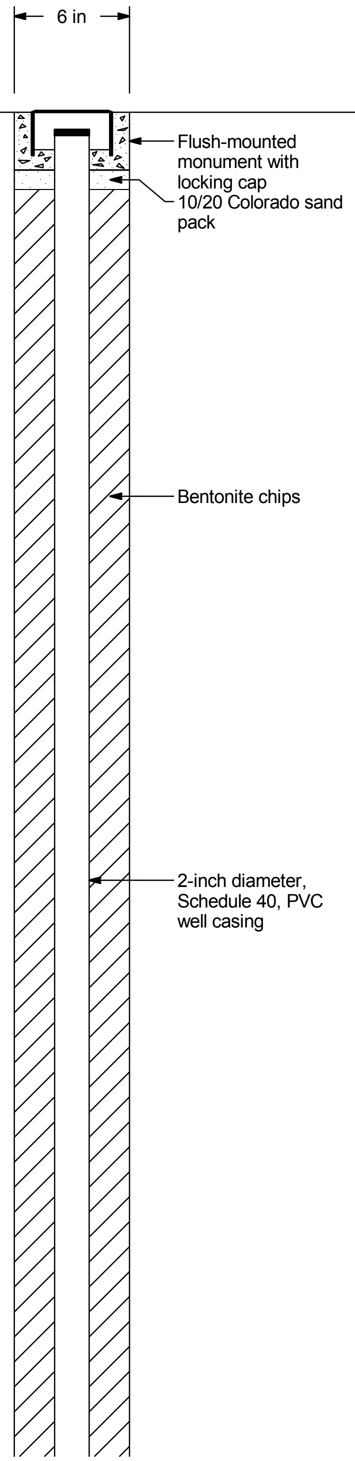
Drilled By: Boart Longyear

USCS Symbol	Description
AC	Asphalt concrete pavement
ML	Brown with dark brown and reddish-brown mottling, sandy SILT with trace gravel; no odor or sheen (very stiff, moist) **(UNIT 1)** - grades with gravel
SP-SM	Brownish-gray, very gravelly, fine to coarse SAND with silt; no odor or sheen (medium dense, damp) **(UNIT 2)**
SP-SM	Gray with reddish-brown mottling, gravelly, medium to coarse SAND with silt; unknown odor like burnt oil; no sheen (medium dense, damp)
SM	Grayish-red and brown mottled, silty, fine to medium SAND with gravel; same burnt oil odor, no sheen (medium dense, moist)
GP-GM	Gray with red mottling, very sandy GRAVEL with silt; same burnt oil odor, no sheen (medium dense, moist)
SP-SM	Reddish-brown and gray mottled, gravelly, fine to coarse SAND with silt; same burnt oil odor, no sheen (loose to medium dense, moist) - grades grayish-brown and dense; no odor or sheen - grades brown and gray mottled and very gravelly
GP	Brown, sandy GRAVEL with trace silt; no odor or sheen (dense, moist)
GP-GM	Brown, sandy GRAVEL with silt; no odor or sheen (dense, moist)
SP-SM	Brown, very gravelly, fine to coarse SAND with silt; no odor or sheen (dense, moist)

GROUNDWATER

Water Level

Monitoring Well Detail
(DOE#: BCR217)



Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.
4. **DOE Unique Well Number: BCR217**

LANDAU ASSOCIATES

Pederson's Fryer Farms
Tacoma, Washington

Log of Monitoring Well MW-41d

MW-41d

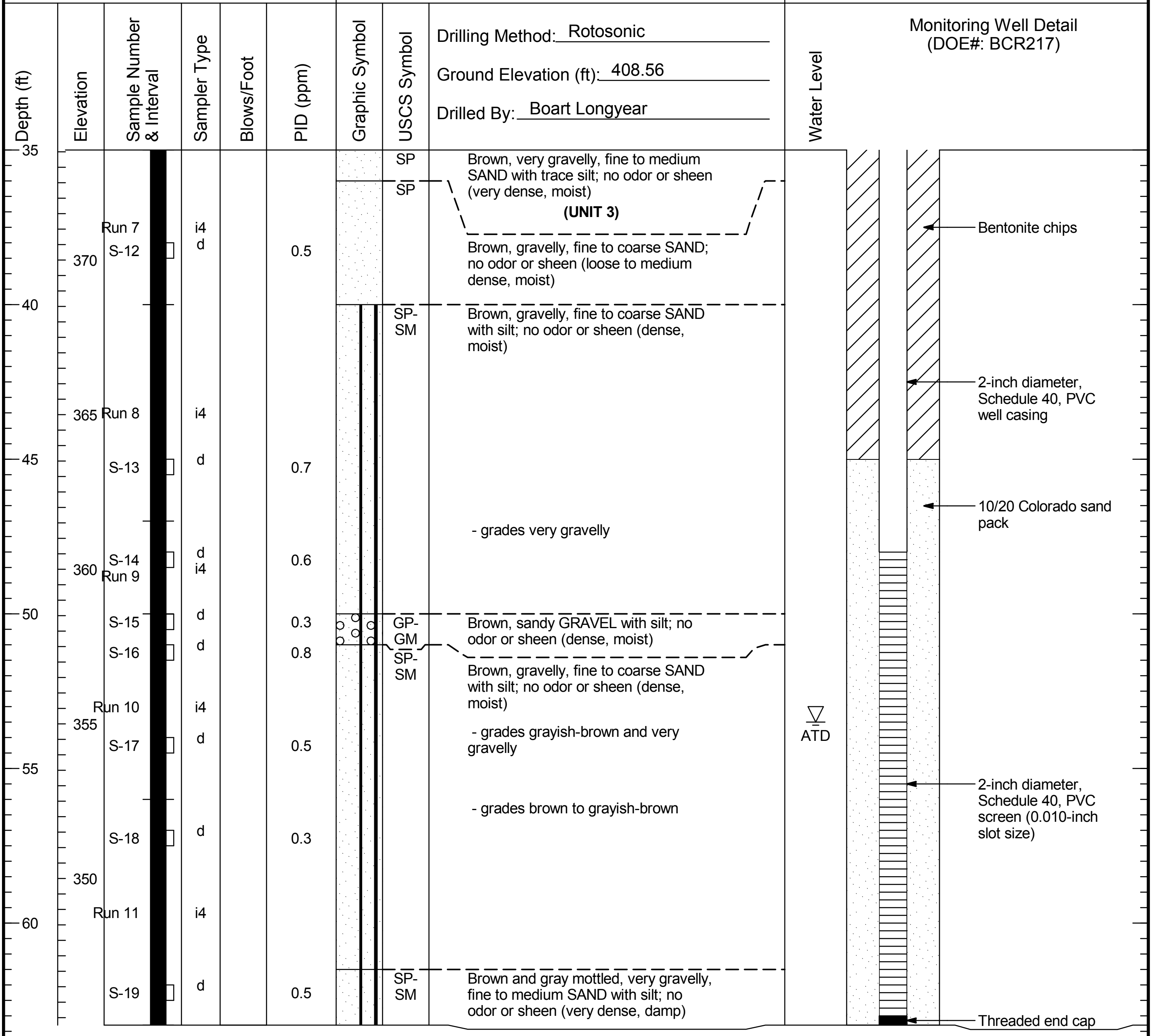
SAMPLE DATA | SOIL PROFILE | GROUNDWATER

Drilling Method: Rotosonic

Ground Elevation (ft): 408.56

Drilled By: Boart Longyear

Monitoring Well Detail
(DOE#: BCR217)



Elevation	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)
	Run 7	i4		
370	S-12	d		0.5
365	Run 8	i4		
	S-13	d		0.7
	S-14	d		0.6
360	Run 9	i4		
	S-15	d		0.3
	S-16	d		0.8
	Run 10	i4		
355	S-17	d		0.5
	S-18	d		0.3
350	Run 11	i4		
	S-19	d		0.5

USCS Symbol	Description
SP	Brown, very gravelly, fine to medium SAND with trace silt; no odor or sheen (very dense, moist) **(UNIT 3)**
SP	Brown, gravelly, fine to coarse SAND; no odor or sheen (loose to medium dense, moist)
SP-SM	Brown, gravelly, fine to coarse SAND with silt; no odor or sheen (dense, moist) - grades very gravelly
GP-GM	Brown, sandy GRAVEL with silt; no odor or sheen (dense, moist)
SP-SM	Brown, gravelly, fine to coarse SAND with silt; no odor or sheen (dense, moist) - grades grayish-brown and very gravelly - grades brown to grayish-brown
SP-SM	Brown and gray mottled, very gravelly, fine to medium SAND with silt; no odor or sheen (very dense, damp)

Boring Completed 09/21/11
Total Depth of Boring = 63.3 ft.

Monitoring Well Completed 09/22/11
Elevation at Top of Protective Casing = 408.25 ft.
Elevation at Top of Monitoring Well Casing = Not Measured
Total Depth of Monitoring Well = 63.3 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.
4. **DOE Unique Well Number: BCR217**

LANDAU ASSOCIATES

Pederson's Fryer Farms
Tacoma, Washington

Log of Monitoring Well MW-41d

Figure A-8 (2 of 2)

APPENDIX C

Project Database (on separate CD)

APPENDIX D

Clear Water Injection Pilot Test Field Record

TABLE D-1
CLEAR WATER INJECTION PILOT TEST FIELD RECORD
PEDERSON'S FRYER FARMS RI/FS

Well: MW-25D **Technicians:** AES & LKM **Date:** 8/3/2011 **Project:** 136006.010.013

	Water (gal)
Intended (1X)	**1500**
Actual	**1701**

Injection	Date	Time
Start	8/3/2011	0836
Finish	8/3/2011	0950

Well DTW	**Pre-injection**	**47.05' BGS @ 0730**
	Post-injection	**38.33' BGS @1043**

	Time	Water Tank				Well Pressure (psi)	Notes
		Tank Full Ht (ft)	Injected volume (gal)	Rate (GPM)	Tank Water Remaining (gal)		
Step1	836	8.33	0.00	---	3065.44	1.5	Pump off/gravity flow; casing air released before measuring psi
	841	7.95	139.84	27.97	2925.60	1.5	**Note, 30.8 gallons went down well casing
	846	7.75	213.44	14.72	2852.00	1.8	
	851	7.50	305.44	18.40	2760.00	1.9	
	856	7.25	397.44	18.40	2668.00	1.5	
	901	7.00	489.44	2.04	2576.00	1.5	
Step2	904	6.85	544.64	18.40	2520.80	5.0	Began to adjust psi to Step2 goal of 10 psi; did so cautiously
	909	6.60	636.64	18.40	2428.80	6.0	
	914	6.33	736.00	19.87	2329.44	7.0	
	919	5.96	872.16	27.23	2193.28	9.5	
	924	5.65	986.24	22.82	2079.20	9.1	At 0927, adjusted throttle to 13 psi to prep for Step3
Step3	931	5.10	1188.64	28.91	1876.80	15.0	Increased to 15 psi
	936	4.70	1335.84	29.44	1729.60	15.0	At 0942 increased to 20 psi at full throttle
	943	4.50	1409.44	10.51	1656.00	20.0	
	948	3.70	1703.84	58.88	1361.60	20.0	

Additional Notes

Monitored water levels at MW-7R (rose 3.27'), MW-19 (dropped 0.01'), MW-20 (rose 0.07'), and MW-27D (fluctuated by 0.01' to 0.02' up & down).

TABLE D-2
CLEAR WATER INJECTION PILOT TEST FIELD RECORD
PEDERSON'S FRYER FARMS RI/FS

Well: MW-26S **Technicians:** AES & LKM **Date:** 8/3/2011 **Project:** 136006.010.013

	Water (gal)
Intended (1X)	**1500**
Actual	**1545.6**

Injection	Date	Time
Start	8/3/2011	1052
Finish	8/3/2011	1135

Well DTW	**Pre-injection**	**28.06' BGS @ 1050**
	Post-injection	**24.84' BGS @ 1201 and increasing**

		Water Tank				Well Pressure (psi)	
	Time	**Tank Full Ht (ft)**	**Injected volume (gal)**	**Rate (GPM)**	**Tank Water Remaining (gal)**		**Notes**
Step1	1052	4.20	0.00	---	1545.60	0.0	Pump off/gravity flow; casing air released before measuring psi
	1057	4.05	55.20	11.04	1490.40	0.0	
	1102	3.90	110.40	1.23	1435.20	0.0	
	1107	3.75	165.60	11.04	1380.00	0.0	
	1112	3.60	220.80	11.04	1324.80	0.0	
Step2	1116	3.48	264.96	11.04	1280.64	5.0	
	1121	3.15	386.40	24.29	1159.20	5.0	Momentarily dropped below 5.0 psi, then re-adjusted to 5.0 psi
	1126	2.56	603.52	43.42	942.08	5.0	" "
	1131	1.48	1002.80	79.86	542.80	0.0	As we increase pump rpm, the pressure decreases to 0.0 psi
Step3	1132	0.75	1269.60	266.80	276.00	0.0	At 1133 adjusted pump from 1/4 to 1/3 throttle; no psi change
	1135	0.00	1545.60	92.00	0.00	3.0	Throttle to 3/4; went to 3.0 psi & maintained until tank emptied

Additional Notes

Filled the Baker tank with approx. 184 gallons of water since over-injected MW-25D.

When measuring MW-26S DTW post injection, water level indicator was very sensitive reflecting the rise in water in the well from injected water back flowing from the excavated back tub into well (path of least resistance).

Monitored water levels at MW-1 (rose 1.07'), MW-4 (dropped 0.06'), and MW-5 (no change).

TABLE D-3
CLEAR WATER INJECTION PILOT TEST FIELD RECORD
PEDERSON'S FRYER FARMS RI/FS

Well: MW-15 **Technicians:** AES & LKM **Date:** 8/3/2011 **Project:** 136006.010.013

	Water (gal)
Intended (1X)	**1500**
Actual	**1582.4**

Injection	**Date**	**Time**
Start	8/3/2011	1336
Finish	8/3/2011	1426

Well DTW	**Pre-injection**	**28.37' BGS @ 1323**
	Post-injection	**22.15' BGS @ 1513**

		Water Tank				**Well Pressure (psi)**	**Notes**
	Time	**Tank Full Ht (ft)**	**Injected volume (gal)**	**Rate (GPM)**	**Tank Water Remaining (gal)**		
Step1	1336	4.85	0.00	---	1778.00	0.0	Pump off/gravity flow; casing air released before measuring psi
	1341	4.65	73.60	14.72	1704.40	0.0	
	1346	4.48	136.16	12.51	1641.84	0.0	
	1351	4.25	220.80	16.93	1557.20	0.0	
Step2	1353	4.00	312.80	46.00	1465.20	7.0	From 1351 to 1353 adjusted to 7 psi
	1358	3.60	460.00	29.44	1318.00	7.0	
	1403	3.05	662.40	4.50	1115.60	7.0	Bumped up to about 10 psi at 1405
	1408	2.65	809.60	29.44	968.40	10.0	
	1410	2.40	901.60	46.00	876.40	10.0	
Step3	1411	2.17	986.24	84.64	791.76	15.0	Bumped up to about 15 psi at 1411
	1416	1.62	1188.64	40.48	589.36	14.5	
	1421	1.10	1380.00	38.27	398.00	15.0	
	1426	0.55	1582.40	40.48	195.60	15.0	

Additional Notes

Monitored water levels at MW-30D and MW-33S. The water levels did not change.

APPENDIX E

Remedial Alternatives Cost Estimates

TABLE E-1
REMEDIAL ALTERNATIVE COST ESTIMATES
PEDERSON'S FRYER FARMS RI/FS

ALTERNATIVE 1: ISCO Injection and Excavation

General Description: Injection of chemical oxidants to remediate petroleum contamination in soil in Areas A and G and groundwater in Area A; focused excavation in areas B, C , E, and F where contamination is shallower and less extensive.

ITEM	QUANTITY	UNIT	UNIT COST	TOTAL	COMMENTS
Work Plans/Design/Reporting/Other					
Cleanup action plan	1	LS	$ 20,000	$ 20,000	
Permits and Plans	1	LS	$ 20,000	$ 20,000	UIC permit, access agreements, SPCC plans, etc.
Construction contract documents and contractor procurement	1	LS	$ 15,000	$ 15,000	
Cleanup action report	1	LS	$ 20,000	$ 20,000	
Project Management	10%	pct	$ 1,866,000	$ 187,000	Assume ~10% of project costs
Ecology oversight	1	LS	$ 5,000	$ 5,000	
Task Subtotal				*$ 267,000*	
ISCO Injections (Areas A & G)					
Utility locate/clearing for injections	1	LS	$ 2,500	$ 2,500	Locate for each injection event (assume 6 events)
ISCO materials (Area A & G)					
Regenox	203280	lb	$ 2.16	$ 439,085	
ORC	16480	lb	$ 9.08	$ 149,638	$8.15/lb + $0.20/lb shipping + tax
Injection materials, equipment	6	Event	$ 1,000	$ 6,000	includes forklift, mixing tanks, pumps, etc.
Direct Push Injections of ISCO (Areas A & G)					
Direct Push Rig/Crew - Soil injections	6	Event	$ 42,000	$ 252,000	Assumes approximately 39 injection points (10 ft. spacing), 3 holes/day, 12 days/injection event, includes $90/hole Ecology fee
Direct Push Rig/Crew - Smear Zone and GW injections	4	Event	$ 63,000	$ 252,000	Assumes 110 injection points (10 ft. spacing), 6 holes/day, 18 days/injection event, includes $90/hole Ecology fee
Contingent ORC GW Injection - Direct Push Rig/Crew	*1*	*Event*	*$ 63,000*	*$ 63,000*	*Second ORC injection across GW plume. Assumes additional 110 injection points 1 year after initial injections*
Injection labor/oversight	156	day	$ 2,000	$ 312,000	2 person crew
Task Subtotal				*$ 1,476,000*	
Targeted Remedial Excavation (Areas B, C, E & F)					
Remedial excavation					
Contractor mobilization/demobilization	1	LS	$ 5,000	$ 5,000	
Utilities management	1	LS	$ 10,000	$ 10,000	Temporary utilities
Shoring	525	sf	$ 75	$ 39,375	slant-nail shoring ($75/sf) adjacent to each Bldg C foundation (assume 10'Wx15'D) and Bldg F foundation (assume 25'Wx15'D) and trench boxes for Area E
Demolition	500	sf	$ 10	$ 5,000	demolish portion of Bldg F to accommodate excavation; and foundation at Area B
Dewatering (incl. treatment and disposal)	0	LS	$ 10,000	$ -	assume will not be needed for shallow excavations
Concrete cutting and disposal	12	sf	$ 80	$ 960	Area E
Excavation - Area B	600	cy	$ 20	$ 12,000	In-place volume. Assume Area B = 30'Wx35'Lx15'D; assume no shoring needed next to foundation.
Excavation - Area C	20	cy	$ 20	$ 400	In-place volume. Assume Area C = 8'Wx8'Lx8'D.
Excavation - Area E	40	cy	$ 25	$ 1,000	In-place volume. Assume Area E = 20'Lx4'Wx12'D; including trench boxes
Excavation - Area F	310	cy	$ 20	$ 6,200	In-place volume. Assume Area F = 35'Wx20'Lx12'D
Haul and disposal	1455	ton	$ 58	$ 84,390	Assume 1.5 ton/cy. $20/ton haul, $38/ton treatment/disposal
Import backfill	970	cy	$ 20	$ 19,400	
Place and compact backfill	970	cy	$ 6	$ 5,820	
Re-pave surface	9	sy	$ 20	$ 180	
Construction oversight during field work	15	days	$ 1,000	$ 15,000	
Task Subtotal				*$ 205,000*	
Confirmation Sampling and Monitoring					
Excavation confirmation sample analysis (TPH/BTEX analysis)	26	samples	$ 350	$ 9,100	Quick turnaround, includes data validation/management
Geoprobe/HAS drilling/soil sampling	5	day	$ 7,500	$ 37,500	Assume geoprobe rig and HSA rig running for 5 days
Soil sampling/analysis	85	sample	$ 175	$ 14,875	TPH-G/BTEX and TPH-D analysis
Additional monitoring wells	1	wells	$ 3,500	$ 3,500	Includes mob/demob, tax, start card, well materials
Groundwater monitoring sampling/analysis	88	sample	$ 185	$ 16,280	8 qtrs @ 11 wells/qtr for TPH-G/BTEX and TPH-D analysis
IDW disposal	14	drum	$ 200	$ 2,800	soil cuttings and purge water
Sampling labor/oversight	13	day	$ 2,000	$ 26,000	5 days for soil, 8 days for groundwater, 2 person crew
Task Subtotal				*$ 110,000*	
			Total	$ 2,058,000	
Appropriate Cost Range (-30% - +50%)		**TOTAL**	**$ 1,441,000 to**	**$ 3,087,000**	

NOTES

1) All costs presented in this FS are considered to have a relative accuracy within the range of -30 to +50 percent, as shown above, and should be used primarily as a basis for comparison of costs between alternatives. More reliable costs will be developed during the design and implementation phases of the cleanup.
2) Costs do not include taxes or markup unless specifically identified.

TABLE E-2
REMEDIAL ALTERNATIVE COST ESTIMATES
PEDERSON'S FRYER FARMS RI/FS

ALTERNATIVE 2: OZONE SPARGING AND EXCAVATION

General Description: Sparging ozone to oxidize petroleum contamination in soil in Areas A, B, F, and G and groundwater in Area A; focused excavation in areas C and E where contamination is shallower and less extensive.

ITEM	QUANTITY	UNIT	UNIT COST	TOTAL	COMMENTS
Work Plans/Design/Reporting/Other					
Cleanup action plan	1	LS	$ 20,000	$ 20,000	
Permits and Plans	1	LS	$ 20,000	$ 20,000	Air NOI, access agreements, SPCC plans, etc.
Construction contract documents and contractor procurement	1	LS	$ 15,000	$ 15,000	
Cleanup action report	1	LS	$ 20,000	$ 20,000	
Project Management	10%	pct	$ 1,402,000	$ 140,000	Assume ~10% of project costs
Ecology oversight	1	LS	$ 5,000	$ 5,000	
Task Subtotal				*$ 220,000*	
Ozone Sparging (Areas A, B, F, & G)					
Install ozone sparge wells/distribution					
Utility locate/clearing	1	LS	$ 500	$ 500	
Drilling - deep groundwater sparge wells (Area A)	25	wells	$ 3,500	$ 87,500	Includes mob/demob, tax, start card
Drilling - dual nested sparge wells (Area A)	16	wells	$ 3,500	$ 56,000	Includes mob/demob, tax, start card
Drilling - shallow soil sparge wells (Areas B, F, & G)	18	wells	$ 2,000	$ 36,000	Includes mob/demob, tax, start card
IDW disposal	115	ton	$ 100	$ 11,500	soil cuttings, hauling and disposal
Well materials/construction (Areas A, B, F, & G)	59	wells	$ 1,000	$ 59,000	well casings, screens, caps, sand pack, bentonite seal
Aboveground completions	59	wells	$ 2,000	$ 118,000	vaults, valves, fittings, piping
Ozone distribution line trenching, piping, and backfilling	900	LF	$ 60	$ 54,000	Includes trench, ozone tubing, and conduit, repaving as needed
Oversight	30	day	$ 1,500	$ 45,000	assume 1 person crew overseeing drilling and installation
Ozone Generator Equipment					
Electrical drop and power	1	LS	$ 15,000	$ 15,000	
Ozone generator unit (Areas A & B)	1	LS	$ 460,000	$ 460,000	Containerized ozone sparge unit (Areas A & B), includes markup.
Ozone generator unit (Areas F & G)	1	LS	$ 95,000	$ 95,000	Mobile ozone sparge unit (Areas F & G), includes markup.
Monitoring equipment	1	LS	$ 5,000	$ 5,000	
Security measures	2	LS	$ 1,000	$ 2,000	Fenced compound for equipment.
Vendor startup and maintenance	1	LS	$ 45,500	$ 45,500	Startup services, maintenance services and kits
Operations and maintenance	36	month	$ 1,500	$ 54,000	assume 1 day O&M per month, 1 person crew
Task Subtotal				*$ 1,144,000*	
Targeted Remedial Excavation (Areas C & E)					
Remedial excavation					
Contractor mobilization/demobilization	1	LS	$ 5,000	$ 5,000	
Utilities management	1	LS	$ 10,000	$ 10,000	Temporary utilities
Shoring	150	sf	$ 100	$ 15,000	slant-nail shoring ($75/sf) adjacent to each Bldg C foundation (assume 10'Wx15'D) and trench boxes for Area E
Dewatering (incl. treatment and disposal)	0	LS	$ 10,000	$ -	assume will not be needed for shallow excavations
Concrete cutting and disposal	12	sf	$ 80	$ 960	
Excavation	55	cy	$ 20	$ 1,100	In-place volume. Assume Area C = 8'Wx8'Lx8'D; Area E = 20'Lx4'Wx12'D. Include concrete cutting.
Haul and disposal	82.5	ton	$ 58	$ 4,785	Assume 1.5 ton/cy. $20/ton haul, $38/ton treatment/disposal
Import backfill	55	cy	$ 20	$ 1,100	
Place and compact backfill	55	cy	$ 6	$ 330	
Re-pave surface	9	sy	$ 20	$ 180	
Construction oversight during field work	5	days	$ 1,000	$ 5,000	
Task Subtotal				*$ 43,000*	
Confirmation Sampling and Monitoring					
Excavation confirmation sample analysis (TPH/BTEX analysis)	14	samples	$ 350	$ 4,900	Quick turnaround, includes data validation/management
Geoprobe/HAS drilling/soil sampling	5	day	$ 7,500	$ 37,500	Assume geoprobe rig and HSA rig running for 5 days
Soil sampling/analysis	100	sample	$ 175	$ 17,500	TPH-G/BTEX and TPH-D analysis
Additional monitoring wells	1	wells	$ 3,500	$ 3,500	Includes mob/demob, tax, start card, well materials
Groundwater monitoring sampling/analysis	176	sample	$ 185	$ 32,560	16 qtrs @ 11 wells/qtr for TPH-G/BTEX and TPH-D analysis
IDW disposal	8	drum	$ 200	$ 1,600	soil cuttings and purge water
Sampling labor/oversight	21	day	$ 2,000	$ 42,000	5 days for soil, 16 days for groundwater, 2 person crew
Task Subtotal				*$ 140,000*	
			Total	$ 1,547,000	
Appropriate Cost Range (-30% - +50%)		**TOTAL**	**$ 1,083,000 to**	**$ 2,321,000**	

NOTES

1) All costs presented in this FS are considered to have a relative accuracy within the range of -30 to +50 percent, as shown above, and should be used primarily as a basis for comparison of costs between alternatives. More reliable costs will be developed during the design and implementation phases of the cleanup.
2) Costs do not include taxes or markup unless specifically identified.

TABLE E-3
REMEDIAL ALTERNATIVE COST ESTIMATES
PEDERSON'S FRYER FARMS RI/FS

ALTERNATIVE 3: EXCAVATION AND ENHANCED BIODEGRADATION

General Description: Excavation of petroleum contaminated soils as deep as 25 feet bgs, site wide for offiste disposal. Enhanced biodegradation of deep vadose zone soils and groundwater in Area A.

ITEM	QUANTITY	UNIT	UNIT COST	TOTAL	COMMENTS
Work Plans/Design/Reporting/Other					
Cleanup action plan	1	LS	$ 20,000	$ 20,000	
Permits and Plans	1	LS	$ 20,000	$ 20,000	Grading permit, general stormwater construction permit, access agreements, SPCC, SWPPP plans, etc.
Construction contract documents and contractor procurement	1	LS	$ 25,000	$ 25,000	Including shoring designs
Cleanup action report	1	LS	$ 20,000	$ 20,000	
Project Management	10%	pct	$ 1,592,000	$ 159,000	Assume ~10% of project costs
Ecology oversight	1	LS	$ 5,000	$ 5,000	
Task Subtotal				*$ 249,000*	
Remedial Excavation (Areas A, B, C, E, F & G)					
Remedial excavation					
Contractor mobilization/demobilization	1	LS	$ 10,000	$ 10,000	
Utilities management	1	LS	$ 10,000	$ 10,000	Temporary utilities
Shoring	925	sf	$ 75	$ 69,375	slant-nail shoring ($75/sf) adjacent to each Bldg C foundation (assume 10'Wx15'D), Bldg F foundation (assume 25'Wx15'D) and Bldg G foundation (assume 20'Wx20'D), and trench boxes for Area E
Contingent Shoring	480	sf	$ 75	$ 36,000	shoring may be necessary if excavation progresses toward Pipeline Road (assume 80'Wx60'D)
Demolition	1000	sf	$ 10	$ 10,000	demolish portion of Bldg F to accommodate excavation; and foundation at Area A/B
Dewatering (incl. treatment and disposal)	1	LS	$ 10,000	$ 10,000	assume may be needed for deeper excavation at Area A, includes water disposal
Concrete cutting and disposal	12	sf	$ 80	$ 960	Area E
Excavation - Area A	2800	cy	$ 20	$ 56,000	In-place volume. Assume Area A = 20'Wx80'Lx15'D (S/SW) + 20'WX90'Lx25'D (NE) + 1:1 slope
Excavation - Area B	600	cy	$ 20	$ 12,000	In-place volume. Assume Area B = 30'Wx35'Lx15'D; assume no shoring needed next to foundation.
Excavation - Area C	20	cy	$ 20	$ 400	In-place volume. Assume Area C = 8'Wx8'Lx8'D.
Excavation - Area E	40	cy	$ 25	$ 1,000	In-place volume. Assume Area E = 20'Lx4'Wx12'D; including trench boxes
Excavation - Area F	310	cy	$ 20	$ 6,200	In-place volume. Assume Area F = 35'Wx20'Lx12'D
Excavation - Area G	240	cy	$ 20	$ 4,800	In-place volume. Assume Area G = 25'Wx15'Lx17'D
Haul and disposal	6015	ton	$ 58	$ 348,870	Assume 1.5 ton/cy. $20/ton haul, $38/ton treatment/disposal
Import backfill	4010	cy	$ 20	$ 80,200	
Place and compact backfill	4010	cy	$ 6	$ 24,060	
Re-pave surface	9	sy	$ 20	$ 180	
Construction oversight during field work	45	days	$ 1,500	$ 67,500	
Task Subtotal				*$ 748,000*	
Enhanced Biodegradation (Area A Groundwater)					
Install injection wells wells/distribution					
Utility locate/clearing	1	LS	$ 500	$ 500	
Drilling - deep groundwater sparge wells (Area A)	11	wells	$ 3,500	$ 38,500	9 injection wells and 2 monitoring wells. Includes mob/demob, tax, start card, well construction materials
Aboveground completions	9	wells	$ 2,000	$ 18,000	vaults, valves, fittings, piping for injection wells
Electrical drop and power	1	LS	$ 10,000	$ 10,000	
Oversight	5	day	$ 1,500	$ 7,500	assume 1 person crew overseeing drilling and installation
Injection of Electron Acceptor					
Purchase equipment/supplies for injection system setup	1	LS	$ 25,000	$ 25,000	Pumps, mixing tanks, hoses, fittings, trailer
Materials and rentals for injection events	10	event	$ 23,000	$ 230,000	Water tank rental, water, electron acceptor (nitrate/sulfate), other rental equipment and materials
Labor	50	day	$ 2,000	$ 100,000	assume 5 days per event, 2 person crew, 3 events per year
Progress Monitoring					
Groundwater sampling/analysis	288	sample	$ 520	$ 149,760	groundwater monitoring monthly for 1 year, quarterly for 3 years @ 12 wells/qtr for TPH-G/BTEX, TPH-D, MNA parameter analysis
Sampling labor/oversight	48	day	$ 1,500	$ 72,000	1 day per monitoring event
Contingent nitrate reduction	1	LS	$ 50,000	$ 50,000	Contingent cost for injection of vegetable oil or groundwater recirculation to ensure reduction/containment of nitrate
Task Subtotal				*$ 701,000*	
Confirmation Sampling and Monitoring					
Excavation confirmation sample analysis (TPH/BTEX analysis)	50	samples	$ 350	$ 17,500	Quick turnaround, includes data validation/management
Additional/replacement monitoring wells	3	wells	$ 3,500	$ 10,500	Includes mob/demob, tax, start card, well materials
Groundwater monitoring sampling/analysis	52	sample	$ 185	$ 9,620	4 qtrs @ 13 wells/qtr for TPH-G/BTEX and TPH-D analysis
IDW disposal	14	drum	$ 200	$ 2,800	soil cuttings and purge water
Confirmation GW sampling labor	9	day	$ 2,000	$ 18,000	5 days for soil, 4 days for groundwater, 2 person crew
Task Subtotal				*$ 58,000*	
			Total	$ 1,756,000	
Appropriate Cost Range (-30% - +50%)		**TOTAL**	**$ 1,229,000 to**	**$ 2,634,000**	

NOTES

1) All costs presented in this FS are considered to have a relative accuracy within the range of -30 to +50 percent, as shown above, and should be used primarily as a basis for comparison of costs between alternatives. More reliable costs will be developed during the design and implementation phases of the cleanup.
2) Costs do not include taxes or markup unless specifically identified.

TABLE E-4
REMEDIAL ALTERNATIVE COST ESTIMATES
PEDERSON'S FRYER FARMS RI/FS

ALTERNATIVE 4: SOIL VAPOR EXTRACTION, EXCAVATION, AND ENHANCED BIODEGRADATION

General Description: Soil vapor extraction in gasoline impacted areas (Areas B, F, & G). Excavation of petroleum contaminated soils in Area A, C, & E. Enhanced biodegradation of deep vadose zone soils and groundwater in Area A.

ITEM	QUANTITY	UNIT	UNIT COST	TOTAL	COMMENTS
Work Plans/Design/Reporting/Other					
Cleanup action plan	1	LS	$ 20,000	$ 20,000	
Permits and Plans	1	LS	$ 20,000	$ 20,000	Air discharge permit, grading permit, general stormwater construction permit, access agreements, SPCC, SWPPP plans, etc.
Construction contract documents and contractor procurement	1	LS	$ 25,000	$ 25,000	Including shoring designs
Cleanup action report	1	LS	$ 20,000	$ 20,000	
Project Management	10%	pct	$ 1,510,600	$ 151,000	Assume ~10% of project costs
Ecology oversight	1	LS	$ 5,000	$ 5,000	
Task Subtotal				*$ 241,000*	
SVE System (Areas B, F, & G)					
SVE System Construction					
Contractor mobilization/demobilization	1	LS	$ 5,000	$ 5,000	
SVE well installation	12	wells	$ 4,500	$ 54,000	15ft deep, 4 inch diameter (5 Area B, 4 Area F, 3 Area G)
IDW disposal	24	drum	$ 200	$ 4,800	soil cuttings
Aboveground completions	12	wells	$ 2,000	$ 24,000	vaults, valves, fittings, piping
SVE distribution line trenching, piping and backfilling	180	LF	$ 60	$ 10,800	Includes trenching, bedding materials, piping, backfilling, and repaving as needed.
Equipment (shed, blower, compressor)	2	LS	$ 9,000	$ 18,000	
Security measures	1	LS	$ 1,000	$ 1,000	Fenced compound for equipment.
Electrical drop and power	1	LS	$ 15,000	$ 15,000	
Air discharge treatment	1	LS	$ 35,000	$ 35,000	Granular Activated Carbon and regeneration or disposal
Construction oversight	10	days	$ 1,500	$ 15,000	
Operations and maintenance	36	month	$ 1,500	$ 54,000	assume 1 day O&M per month, 1 person crew
Task Subtotal				*$ 236,600*	
Remedial Excavation (Areas A, C, & E)					
Remedial excavation					
Contractor mobilization/demobilization	1	LS	$ 10,000	$ 10,000	
Utilities management	1	LS	$ 10,000	$ 10,000	Temporary utilities
Shoring	525	sf	$ 75	$ 39,375	slant-nail shoring ($75/sf) adjacent to each Bldg C foundation (assume 10'Wx15'D) and Bldg F foundation (assume 20'Wx20'D) and trench boxes for Area E
Contingent Shoring	480	sf	$ 25	$ 12,000	shoring may be necessary if excavation progresses toward Pipeline Road (assume 80'Wx60'D)
Demolition	1000	sf	$ 10	$ 10,000	demolish portion of Bldg F to accommodate excavation; and foundation at Area A/B
Dewatering (incl. treatment and disposal)	1	LS	$ 10,000	$ 10,000	assume may be needed for deeper excavation at Area A, includes water disposal
Concrete cutting and disposal	12	sf	$ 80	$ 960	Area E
Excavation - Area A	2800	cy	$ 20	$ 56,000	In-place volume. Assume Area A = 20'Wx80'Lx15'D (S/SW) + 20'WX90'Lx25'D (NE) + 1:1 sloping
Excavation - Area C	20	cy	$ 20	$ 400	In-place volume. Assume Area C = 8'Wx8'Lx8'D.
Excavation - Area E	40	cy	$ 25	$ 1,000	In-place volume. Assume Area E = 20'Lx4'Wx12'D; including trench boxes
Haul and disposal	4290	ton	$ 58	$ 248,820	Assume 1.5 ton/cy. $20/ton haul, $38/ton treatment/disposal
Import backfill	2860	cy	$ 20	$ 57,200	
Place and compact backfill	2860	cy	$ 6	$ 17,160	
Re-pave surface	9	sy	$ 20	$ 180	
Construction oversight during field work	5	days	$ 1,000	$ 5,000	
Task Subtotal				*$ 478,000*	
Enhanced Biodegradation (Area A Groundwater)					
Install injection wells wells/distribution					
Utility locate/clearing	1	LS	$ 500	$ 500	
Drilling - deep groundwater sparge wells (Area A)	11	wells	$ 3,500	$ 38,500	9 injection wells and 2 monitoring wells. Includes mob/demob, tax, start card, well construction materials
Aboveground completions	9	wells	$ 2,000	$ 18,000	vaults, valves, fittings, piping for injection wells
Electrical drop and power	1	LS	$ 10,000	$ 10,000	
Oversight	5	day	$ 1,500	$ 7,500	assume 1 person crew overseeing drilling and installation
Injection of Electron Acceptor					
Purchase equipment/supplies for injection system setup	1	LS	$ 25,000	$ 25,000	Pumps, mixing tanks, hoses, fittings, trailer
Materials and rentals for injection events	10	event	$ 23,000	$ 230,000	Water tank rental, water, electron acceptor (nitrate/sulfate), other rental equipment and materials
Labor	50	day	$ 2,000	$ 100,000	assume 5 days per event, 2 person crew, 3 events per year

TABLE E-4
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ITEM	QUANTITY	UNIT	UNIT COST	TOTAL	COMMENTS
Progress Monitoring					
Groundwater sampling/analysis	288	sample	$ 520	$ 149,760	groundwater monitoring monthly for 1 year, quarterly for 3 years @ 12 wells/qtr for TPH-G/BTEX, TPH-D, MNA parameter analysis
Sampling labor/oversight	48	day	$ 1,500	$ 72,000	1 day per monitoring event
Task Subtotal				*$ 651,000*	
Confirmation Sampling and Monitoring					
Excavation confirmation sample analysis (TPH/BTEX analysis)	30	samples	$ 350	$ 10,500	Quick turnaround, includes data validation/management
Geoprobe/soil sampling	2	day	$ 2,500	$ 5,000	Geoprobe sampling in SVE remediation areas
Confirmation soil sample analysis (TPH/BTEX analysis)	20	samples	$ 175	$ 3,500	Analysis of geoprobe samples
Additional/replacement monitoring wells	3	wells	$ 3,500	$ 10,500	Includes mob/demob, tax, start card, well materials
Groundwater monitoring sampling/analysis	52	sample	$ 185	$ 9,620	4 qtrs @ 13 wells/qtr for TPH-G/BTEX and TPH-D analysis
IDW disposal	14	drum	$ 200	$ 2,800	soil cuttings and purge water
Confirmation GW sampling labor	9	day	$ 2,000	$ 18,000	5 days for soil, 4 days for groundwater, 2 person crew
Task Subtotal				*$ 60,000*	
			Total	$ 1,667,000	
Appropriate Cost Range (-30% - +50%)		**TOTAL**	**$ 1,167,000 to**	**$ 2,501,000**	

NOTES

1) All costs presented in this FS are considered to have a relative accuracy within the range of -30 to +50 percent, as shown above, and should be used primarily as a basis for comparison of costs between alternatives. More reliable costs will be developed during the design and implementation phases of the cleanup.
2) Costs do not include taxes or markup unless specifically identified.