ADDENDUM – Proposed

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Subject: Proposed Addendum to the Draft Feasibility Study Report, Former Unocal Edmonds Bulk Fuel Terminal

1. Introduction

On May 21, 2014, Ecology provided its draft comments on the Draft Feasibility Study Report that Chevron Environmental Management Company (Chevron), submitted for the Former Unocal Edmonds Bulk Fuel Terminal (FS Report) ARCADIS reviewed those comments and, with Chevron, participated in a follow-up meeting with Ecology on June 17, 2014. At that meeting, Ecology agreed to allow Chevron to develop and evaluate an additional remedial alternative to address contamination in the vicinity of the Washington State Department of Transportation (WSDOT) stormwater line area.

This proposed addendum to the FS Report sets forth an additional remedial alternative for the Unocal Edmonds Bulk Fuels Terminal site as part of the recent Draft Feasibility Report submitted on January 30, 2014.

Alternative 6 consists of:

- Excavation of the Detention Basin 2 (DB-2) vicinity and,
- Installation of a soil and groundwater treatment system using dual phase extraction technology (DPE) to address impacts remaining in the vicinity of the Washington State Department of Transportation (WSDOT) stormwater line area.

Although groundwater monitoring data shows compliance with groundwater cleanup levels in all previously established points of compliance for the last 9 to 25 consecutive quarters, with exception of monitoring well MW-510, Chevron has proposed this DPE system to ensure constituents of concern (COCs) are not leaving the Lower Yard in the only remaining area where dissolved phase concentrations exist above cleanup standards. Implementation of this strategy involves pilot testing, installation and operation of a DPE system within the WSDOT stormwater line area. The DPE system will remediate remaining soil impacts surrounding the WSDOT stormwater line, and act as a groundwater intercept system ensuring that off-site migration of dissolved phase COCs, or light non-aqueous phase liquids (LNAPL) does not occur. Details describing “Excavation of the Detention Basin 2 (DB-2) Vicinity” can be found in 2013 Draft Feasibility Study (Remedial Alternative 1 or Remedial Alternative 4). This proposed addendum presents further detail for the proposed DPE system in the WSDOT stormwater line area including a description of the technology, a basis for preliminary system design and a discussion detailing system components. Based on groundwater modeling and environmental engineering calculations, this alternative will meet Minimum Requirements for Cleanup listed in WAC 173-340-360(2). A layout of the site with the proposed DPE system is shown on Figure 1.

ARCADIS has carefully reviewed the Disproportionate Cost Analysis (DCA) conducted by Ecology (ECYDCA, Ecology 2014) and used it as a template to conduct a comprehensive DCA to incorporate and evaluate Alternative 6. The DCA shows that this alternative is Permanent to the Maximum Extent Practicable.

2. Proposed Remedial Alternative 6: Excavation with MNA and Soil and Groundwater Treatment using DPE

DPE is a remedial technology which relies on mass transfer and subsequent extraction to reduce mass of residual LNAPL within vadose zone and smear zone soils in the subsurface. Residual LNAPL is defined as LNAPL that is occluded by the aqueous phase, occurring as immobile ganglia surrounded by aqueous phase in the pore space or as immobile, non-water entrapped LNAPL that does not drain from the pore spaces (White 2004). Historical soil and groundwater concentrations and historical occurrence of measureable LNAPL observed prior to lower yard excavation activities are indicative of residual LNAPL.

Mass transfer of residual LNAPL occurs to both the dissolved phase and vapor phase. However, mass transfer is highly preferential to the vapor phase due to the volatile nature of its components. Dissolved phase mass transfer is limited by the component’s solubility in water. Successful DPE application relies on the ability to improve mass transfer to the vapor phase through three mechanisms: 1) lowering the water table to expose the residual LNAPL to surrounding vapor; 2) drawing vapor through the impacted area; and 3) removing the vapor phase from the subsurface and treating both soil vapor and groundwater ex-situ.

Groundwater modeling of this technology shows that drawdown rates required for effective DPE implementation, DPE will contain groundwater in the area of remaining impacts (within the vicinity of WSDOT stormwater line); therefore not allowing groundwater with exceedances above cleanup levels to leave the Lower Yard.

DPE systems typically use a network of remediation wells adequately spaced to dewater the target zone through the operation of pneumatic pumps. The groundwater is pumped to a remediation compound housing a groundwater treatment train that may include an oil water separator, bag filters, particulate sand filters, an air stripper and granular activated carbon vessels prior to discharge to the existing storm sewer under a NPDES permit. Soil vapor is collected using a regenerative or positive displacement blower sized to induce vacuum from the remediation well on surrounding soils. The vapor stream passes through a condensation knock out tank before treatment by either a catalytic oxidizer or granular activated carbon and vented to ambient air under a Puget Sound Clean Air Agency (PSCAA) permit.

2.1 Implementation

To provide engineering information necessary to develop a preliminary design, evaluate constructability, estimate costs, and plan for field implementation, ARCADIS developed calculations based upon assumed implementation activities. The calculations assumed the following remedial approach: DPE technology will lower the water table approximately eight feet within the target treatment zone, thereby capturing and dewatering the residual LNAPL over a broad interval in the subsurface (i.e., smear zone); and introduce atmospheric air into soil pores in the residual LNAPL zone, and removing residual LNAPL through a combination of soil vapor extraction (SVE) and enhanced aerobic biodegradation.

Standard hydrogeological and environmental engineering calculations were used to predict remediation quantities such as groundwater extraction rates, groundwater elevations, chemical fluxes, and timeframes of remediation. Parameters used in the calculations were based on site-specific measurements and standard literature values for constants. However, site heterogeneity required that several parameters estimated during calculations. To best manage the uncertainty in predicted quantities, a DPE pilot study will be performed in a portion of the target cleanup zone to collect field data needed to complete the final design.

2.1.1 Groundwater Extraction Rate Required to Dewater the Target Treatment Zone

The long-term, average groundwater extraction rate required to lower the water table within the target treatment zone was estimated at 21 gallons per minute (gpm) combined using the site MODFLOW model. Figure 2 shows the MODFLOW model groundwater contours predicted during DPE system operation. The MODFLOW groundwater model predicts that groundwater gradient across the Site will be altered towards the DPE wells during DPE operation. The extraction rate of 21 gpm will effectively drawdown the groundwater table and induce groundwater to flow towards the DPE wells. The site model was calibrated under steady-state conditions using average water levels measured over several tidal cycles (ARCADIS, 2013). The preliminary system design accommodates a pumping rate of 40 gpm to ensure the system can handle variations in groundwater flux. DPE pilot testing will include a groundwater pumping test to help optimize the final design.

2.1.2 Number and Spacing of DPE Wells

The preliminary design consists of an array of eleven groundwater extraction wells spaced approximately 60 feet apart oriented along the alignment of the stormwater line. Figure 3 shows a conceptual spacing of remediation wells. The water table in this area is approximately five feet below ground surface (bgs) and the extraction wells are assumed to be 35 feet deep and pump at a rate between two and three gpm each. A preliminary well design is provided as Figure 4.

The Theis (1935) well hydraulics equation with superposition was used to predict potentiometric drawdown between wells in the array and validate the well spacing and design concept. As shown, potentiometric drawdown of eight feet can theoretically be achieved within the extraction well array within approximately 120 days of startup pumping. A cross section location diagram and a conceptual cross section of proposed well spacing with groundwater drawdown in relation to soil samples where remaining impacts exceed site CULs is shown on Figure 5 and Figure 6 respectively.

2.1.3 Evaluation of Dissolved TPH Plume Stability

Stability of the dissolved TPH plume associated with the LNAPL smear zone was evaluated by calibrating a fate-and-transport model to site data. First the site MODFLOW model (ARCADIS, 2013) was used to predict the location and potential migration direction of dissolved TPH in groundwater using particle tracking. Then the BIOSCREEN-AT model was used to predict changes in dissolved TPH concentrations along MODFLOW-predicted groundwater flowpaths. Calibration inputs for the BIOSCREEN-AT model are included in Appendix A.

Fate and transport mechanisms simulated in BIOSCREEN-AT include advection, dispersion, hydrophobic-sorption-based retardation, and in-situ biodegradation. Model parameters were based on field measurements and standard values, except for the chemical biodegradation rate which was estimated during calibration (Appendix A).

Because TPH in groundwater can be a mixture of up to hundreds of individual chemicals, and most environmental models simulate transport of only a single chemical, a simplified approach was used in this evaluation based on technical guidance published by the Total Petroleum Hydrocarbon Criteria Working Group (Gustafson et al., 1997). In this approach, the TPH mixture is represented by a single hypothetical reference chemical with average fate and transport properties based on known properties for individual gasoline- and diesel-range hydrocarbon chemicals. The TPH chemical properties shown in Appendix A are average values based on standard literature references.

The BIOSCREEN-AT model was calibrated by holding all parameters in Appendix A constant and adjusting the chemical biodegradation rate until simulated TPH concentrations were consistent with measured TPH concentrations at a downgradient monitoring well along the MODFLOW-predicted flow path.

The TPH biodegradation rate in groundwater in the target treatment zone was calculated to be 2.8 years expressed as a half-life. This is a reasonable result because it is within the middle-range of published degradation rates for hydrocarbon chemicals in groundwater. This rate represents the overall average biodegradation rate for all of the soluble TPH chemicals in the mixture, and was used to estimate timeframes of remediation below.

A steady-state dissolved phase condition is defined in this context as dissolved concentrations in which the rate of residual LNAPL dissolution into groundwater is balanced by the rate of in-situ biodegradation in groundwater. Soon after a release, the LNAPL dissolution rate often exceeds the in-situ biodegradation rate and the resulting dissolved phase extent may expand. Given enough time under normal conditions, most dissolved hydrocarbons in groundwater tend to stabilize. When the rate of in-situ biodegradation exceeds the rate of residual LNAPL dissolution the extent dissolved phase concentrations can shrink.

Modeling results show that the dissolved phase concentrations of TPH reached a steady-state condition within approximately 10 years after LNAPL first reached the water table, and have remained at steady-state since then. This result is supported by groundwater monitoring data collected at compliance well locations, which show non-detect or stable TPH concentrations below the CUL over time in groundwater samples.

In summary, modeling results and site characterization and monitoring data indicate that dissolved TPH concentrations at compliance well locations will likely not increase in the future due to a combination of naturally-occurring mechanisms including in-situ biodegradation which have stabilized the dissolved TPH plume.

2.1.4 Estimated Timeframe of Remediation of Soil and Groundwater

Timeframes of remediation under natural conditions and with DPE engineering controls were evaluated using a multi-phase LNAPL depletion model based on technical guidance published by the Interstate Technology Regulatory Council (ITRC, 2009). The model considers mass transfer between the LNAPL, aqueous, and vapor phases, and can account for mass loss due to combinations of naturally occurring and engineered conditions in both soil and groundwater.

The LNAPL depletion model is illustrated on Figure 7 and involves a smear zone with residual LNAPL present both above and below the water. In the model, the residual LNAPL serves as a long-term source of dissolved (aqueous) and vapor-phase COCs. The residual LNAPL mass is modeled as continuously depleted by natural processes such as dissolution into groundwater, volatilization into soil vapor above the water table, and biodegradation both above and below the water table. When DPE technology is used to treat the site, the residual LNAPL smear zone will be above the lowered water table and substantial mass will be removed via soil vapor extraction and enhanced aerobic biodegradation due to the introduction of oxygen. The LNAPL depletion model is mass-balanced across the LNAPL, aqueous, and vapor phases, and calculates dissolved-phase TPH concentrations in groundwater based on LNAPL mass in soil using a site-specific empirical correlation coefficient. The model also estimates the depletion of LNAPL mass in soil under natural attenuation conditions and through DPE implementation.

Input parameters were based on field measurements and standard values, except for the residual LNAPL saturation which was estimated using site data during calibration Appendix A. An in-situ chemical biodegradation half-life of 2.8 years was used in the LNAPL depletion model based on results of the fate and transport modeling described above. Also similar to the above, the TPH mixture is represented by a single hypothetical reference chemical with average fate and transport properties based on known properties for individual gasoline- and diesel-range hydrocarbon chemicals (Gustafson 1997).

Modeling results show that under natural conditions dissolved TPH concentrations in groundwater and TPH concentration in soil in the target treatment zone will continue to decrease in the future. This result compares favorably with published rates of LNAPL source zone depletion measured at other sites (e.g., Sale and Zimbron, 2013). TPH depletion modeling through remediation by DPE is shown on Figures 8 and 9.

Under the DPE remediation scenario, the LNAPL depletion model shows that dissolved TPH concentrations in groundwater in the target treatment zone can be remediated below the CUL within approximately six years while TPH concentrations in soil will reach the CUL within approximately 5 years. Residual LNAPL depletion model calibration inputs are included in Appendix A.

2.2 Recommended Remedial Alternative

The preliminary design is based on the standard engineering calculations and modeling discussed above and includes a discussion of the basis of design in terms of well spacing, conveyance piping, and system components. Each DPE well will be equipped with a pneumatic pump connected to an air supply line and groundwater discharge conveyance piping. The top of the well casing will be fitted with a connection to vapor extraction conveyance piping from the vacuum blower. Conveyance piping will be trenched below ground surface to a minimum depth of 18 inches, and will connect to treatment equipment that will be housed in a newly-constructed building located adjacent to the existing equipment shed in the southern area of the Lower Yard. The location of the equipment shed was chosen based on the preliminary layout of the Edmonds Crossing project; however, the equipment shed can be relocated to accommodate the actual layout of the Edmonds Crossing project. A preliminary system location in relation to the layout is shown on Figure 10. Wells will be constructed of 4-inch schedule 40 PVC with 0.02-inch wire wrapped screen from 5 to 35 feet bgs. Below the well screen will be three feet of solid casing that will act as a silt collection sump to decrease the occurrence of pump fouling. A typical well construction detail is presented on Figure 4. Well construction details may change based on field observations during the time of drilling.

Extracted vapor and groundwater conveyance piping will connect to the system compound located within the southern portion of Lower Yard as shown on Figure 1. The system compound will consist of a system enclosure to house the groundwater and extracted vapor treatment equipment. Extracted vapor will flow through an 11 leg manifold with each leg consisting of an air flow meter, flow control valve, vacuum gauge and sampling port. A main header will connect the manifold to an air/water separator prior to the blower. Vapor from the blower will discharge into a catalytic oxidizer for treatment prior to discharge to the atmosphere. Accumulated water from the separator will be transferred using a Moyno progressive cavity or similar pump, to the oil water separator that is part of the groundwater treatment equipment. A QED AP4 downhole pneumatic pump or similar pump will draw down the water table and transfer water to an oil water separator housed within the treatment compound. Each well head will be fitted with a cycle counter, flow control valve, pressure regulator and pressure gauge to quantify pumping volume and individual well pumping rates. Each groundwater pumping well will be completed with a well vault fitted with a mechanical float to shut off the well if pipe failure or leaks occur at the well head. Groundwater conveyance lines will be installed within secondary containment lines.

Groundwater will be pumped through the conveyance lines to the oil/water separator where baffles will remove any collected LNAPL. The oil water separator will be controlled with automatic float switches pumping water in batches through in-line particulate filters before being treated using an air stripper. Water will then be pumped to polishing treatment in liquid GAC beds (two sets of two in series). Treated water will be discharged to Willow Creek or Detention Basin 1 (DB-1) under a National Pollutant Discharge Elimination System (NPDES) permit. Cost estimates for the DPE system are presented in Table 1. A typical process and instrumentation diagram (P&ID) for these treatment trains are presented on Figure 11.

Power for the treatment building and equipment will be connected to the existing power service drop located between Detention Basins-1 and -2 (DB-1 and DB-2) near the north side of the Lower Yard. Electrical conduit will be placed in a trench as shown on Figure 2.

2.2.1 System Pilot Testing

Prior to system installation a pilot test will be conducted to test modeling assumptions and confirm the conceptual design of the DPE system. Specifically, the test will be used to determine vapor exchange rate and confirm pumping rates for the desired drawdown. The scope of work for the pilot study will include installing one DPE test well, along with 3 piezometers. The piezometers will be located 5-, 15-, and 30- feet away from the test well. The piezometer will be equipped with a transducer and vacuum gauge. Step- and constant-rate tests will be performed over a maximum 72-hour period. A trailer equipped with equipment for vapor extraction (vacuum blower, moisture separator, and catalytic oxidizer) and operating a groundwater pneumatic pump (compressor) will be mobilized to the site. Details of the pilot test will be included in a pilot test work plan.

2.3 Evaluation of Remedial Alternative 6

This section evaluates the proposed remedial alternative in the context of the requirements of MTCA. Requirements are defined based on WAC 173-340-360 and include the following considerations:

2.3.1 Threshold Requirements

Cleanup actions are subject to the threshold requirements set forth in WAC 173-340-360 (2)(a). Under the threshold requirements, the cleanup action will:

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

For cleanup actions that meet the threshold requirements, the selected action will:

- Use permanent solutions to the maximum extent practicable
- Provide for a reasonable restoration timeframe
- Consider public concerns

2.3.2 Protect human health and the environment and comply with cleanup standards

Excavation of DB-2 along with soil and groundwater remediation through implementation of a DPE system will be protective of human health and the environment through compliance with the agreed order. As described above, the DPE system installed within the vicinity of the WSDOT stormwater line will dewater soils exposing residual LNAPL to induced vapor flow. The System will remediate soils to below CULs and ensure that off-site migration of dissolved phase COCs and LNAPL does not occur. Soil vapor extraction within the WSDOT stormwater line area will mitigate the soil vapor pathway. ARCADIS intends to submit an Additional Soil Vapor Investigation Work Plan to address comments from Ecology regarding soil vapor data submitted in the FS; however, if these concerns cannot be adequately addressed through additional data collection, the DPE system can be modified to remediate these risks.

As discussed in the Draft CULs and Remediation Levels Report (ARCADIS 2013b), the selected RELs and CULs are consistent with MTCA. Additionally, numerous state and federal laws will apply to this alternative related to environmental protection, health and safety, transportation, and disposal. Proposed alternative 6 can be implemented in compliance with these laws.

2.3.3 Provide for compliance monitoring

This Alternative will include compliance monitoring as required by WAC 173-340-410 and 173-340-720 through 173-340-760. Compliance monitoring will consist of protection, performance, and confirmation monitoring to determine the short- and long-term safety and effectiveness of the remediation system, as summarized below:

- Periodic sampling and monitoring of the remediation system will occur to ensure that human health and the environment are adequately protected during construction, operation, and maintenance periods. Induced vacuum and extracted vapor concentrations will be monitored periodically to ensure the system adequately captures soil vapor and mitigates the vapor intrusion pathway.

- Performance monitoring confirms that the cleanup action is performing in a manner that will allow for cleanup standards to be attained. Routine operation, maintenance and monitoring of the remediation system will be performed to track remedial progress and required operational compliance. For this alternative, performance monitoring will include programs designed to: assess mass removal rates in the dissolved phase and vapor phase, assess rates of natural attenuation, provide data necessary to confirm that LNAPL migration is not continuing in areas with soil TPH concentrations exceeding residual saturation, and confirm that groundwater with exceedances above CULs in the area of the WSDOT stormwater line (the only remaining areas of groundwater impacts in the Lower Yard) does not leave the Lower Yard.

- Confirmation monitoring will verify the long-term effectiveness of the remediation system following completion of remedial activities.

In addition to meeting compliance monitoring criteria listed above, this alternative will also fulfill the requirements from the 2nd amendment to the purchase and sale agreement (PSA) with WSDOT, which include:

- Following construction, a construction completion document will be prepared and submitted confirming that the system was constructed in accordance with Ecology approved plans and specs;

- A proposed hydraulic capture zone will be provided;

- Following start-up; methodology for calculating and performing confirmation field measurements will be provided and implemented.

- A system operation and monitoring report (indicating system's hydraulic capture zone is calculated and confirmed by field measurement) will be prepared and submitted.

- A report documenting that the treated groundwater meets permit requirements will be submitted.

2.3.4 Use permanent solutions to the maximum extent possible

MTCA states that when selecting an alternative, preference will be given to "permanent solutions to the maximum extent practicable." "Permanent" is defined in WAC 173-340- 200 as a cleanup action in which the cleanup standards of WAC 173-340-700 through 173-340-760 are met without further action being required at the site being cleaned up, or at any other site involved with the cleanup action, other than the approved disposal of any residue from the treatment of hazardous substances. This remedial alternative meets the definition of a permanent solution as impacts to soil and groundwater will be physically and/or biologically removed from the site. Residual LNAPL within the soils surrounding the WSDOT stormwater line will be removed through physical extraction, volatilization and biodegradation while soils within the DB-2 area will be permanently removed through excavation.

2.3.5 Disproportionate cost analysis

Following the DCA conducted by Ecology (Ecology, 2014), ARCADIS revised its disproportionate cost analysis to:

- Incorporate Remedial Alternative 6 (Details included in this addendum), and
- Revise the DCA previously published in the Draft FS report per comments from Ecology.

Per comments received from Ecology on the FS report, the most permanent alternative in the evaluation should be chosen as the baseline for comparison in the DCA to identify a cleanup action which will be permanent to the maximum extent practicable. Therefore, this DCA focuses on comparison of Remedial Alternative 6 (Excavation of DB-2 and DPE system) to Remedial Alternative 4 (Excavation of DB-2 and WSDOT stormwater line area) which was selected as the permanent to the maximum extent practicable remedy by Ecology (Ecology, 2014).

Procedure

The revised DCA was conducted in two passes:

1. First pass: The evaluation criteria were weighted using the qualitative assessment described below and the alternatives were assessed using the rankings published in the previously submitted Draft FS report plus consideration of public concerns. The analysis is represented in Table 2a.
2. Second pass: ARCADIS used the rankings assigned by Ecology in their DCA and weighted the evaluation criteria. The analysis is represented in Table 2b.

Per Ecology comments (Ecology, 2014) this two pass approach was used to assess robustness and a weighted sum was calculated by multiplying the ranking of each criterion for each alternative by the weight assigned to the criterion. The lowest sum is the alternative that is permanent to the maximum extent practicable.

Weighting

Per WAC 173-340-360(3)(e)(ii)(C), the department has the discretion to favor or disfavor qualitative benefits and use that information in selecting a cleanup action." A scale of 1 to 10 was used; with the criteria of most importance in selecting a remedy was assigned a weight of 10.

Disproportionate Cost Analysis

The summary of the DCA of the two passes is listed in the table below, and the comparison of Alternative 6 to Alternative 4 (Chosen by Ecology as the Preferred Remedy at the Site) is described in the following sections:

DCA Weighted Sums	Remedial Alternative 4	Remedial Alternative 6
Pass 1	114	**102**
Pass 2	106	**96**

Both Alternatives include excavation of DB-2 and differ only in the remediation of the area in the vicinity of the WSDOT stormwater line.

2.3.5.1 Protectiveness:

This criterion was selected as one of the two most important criteria that a cleanup action must meet and was assigned a weight of 10 by Ecology.

With proper implementation, both alternatives are adequately protective of human health and the environment during implementation and after the remedial action has been completed. MTCA describes protectiveness as the overall protectiveness of human health and the environment, including the degree to which existing risks are reduced, time required to reduce risk at the facility and attain cleanup standards, on-site and off-site risks resulting from implementing the alternative, and improvement of the overall environmental quality (Washington State Department of Ecology 2007).

Alternative 6 offers lower on-site (less construction on-site) and off-site (lower quantity of disposal off-site) risks but relatively longer time frame required to reduce environmental risk at the facility. The DPE portion of the system requires considerable dewatering to expose residual LNAPL in the smear zone. As described in Section 2, groundwater modelling indicates that in order to achieve the required drawdown in the WSDOT stormwater line area, groundwater elevations will be effected throughout the Lower Yard. Figure 2 shows the anticipated effect of dewatering throughout the Lower Yard. This effectively ensures that throughout remediation, Alternative 6 will contain groundwater impacts in the vicinity of WSDOT stormwater line and ensure that groundwater with exceedances above CULs does not leave the Lower Yard. Data has shown that excavation will also result in the eventual cleanup of groundwater to below the groundwater CULs; however, during that timeframe excavation does not protect against discharge to surface water.

Considering Alternative 4 offers swift achievement of soil cleanup levels and relatively swift achievement of groundwater CULs, but does not protect against potential discharges to surface water while monitoring natural attenuation, and Alternative 6 offers a comparative level of protectiveness with the added groundwater containment of remaining impacts in the vicinity of WSDOT stormwater line, only with a slightly longer time frame, both alternatives were ranked 1 in protectiveness.

2.3.5.2 Permanence:

This criterion was selected as an important criterion that a cleanup action must meet and was assigned a weight of 8 by Ecology.

Both alternatives permanently remove and/or treat the impacted media at the Site. According to WAC 173-340-360(3)(f)(ii), permanence refers to the degree to which the alternative permanently reduces the toxicity, mobility or 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 the waste treatment process, and the characteristics, and quantity of treatment residuals generated.

- Alternative 4 will permanently remove impacted soil from the vicinity of WSDOT stormwater line and dispose of-Site. Alternative 6 will treat impacted media, and destroy contaminants prior to discharge in the environment.

- Alternative 4 will focus on the area of contamination and remediate all media encountered within that area (soil, residual LNAPL, and groundwater); however, Alternative 6 will achieve the treatment and destruction of contaminants within the highly mobile media (soil vapor, and groundwater) beyond the depth of excavation offered by Alternative 4.

- Excavation has nearly the same time frame to Alternative 6 for remediation and because the technique is a “dig and haul” process it offers a low risk of treatment process going wrong. However excavation of contaminated materials adjacent to a stormwater line conveying stormwater to Puget Sound presents a risk of breach in the stormwater line pipe and offers a relatively lower degree of irreversibility of the waste treatment process compared to Alternative 6.

- Alternative 4 will generate approximately 12,000 tons of non-hazardous soil to be disposed of from WSDOT stormwater line excavation whereas Alternative 6 will produce an estimated 20 tons of spent granular activated carbon. The activated carbon will be transported off-site to a handling facility and reactivated. Reactivation destroys sorbed COCs and allows for the reactivated carbon to be reused. Alternative 4 will also generate significant quantities of water from excavation dewatering in the vicinity of the WSDOT stormwater line to be treated and discharged.

- Both Alternatives 4 and 6 offer a high degree of permanence. Alternative 4 has the advantage of degree of permanence being achieved in a relatively near future by permanently removing contaminants from the facility but not from the environment (landfilling) whereas Alternative 6 has the advantage of destroying contaminants permanently not only from the facility but from the environment. Therefore both alternatives are ranked 1.

2.3.5.3 Cost:

This criterion was selected as an important criterion that balances the overall benefit of a cleanup action and was assigned a weight of 8 by Ecology.

The cost of Alternative 4 is the highest ($5.5 - $8.6 MM) and ranked as 5 in both DCA Passes 1 and 2. The cost of Alternative 6 ($2.3 to 3.9 MM) is qualitatively ranked as 2 in DCA Pass 3 and is ranked as 2.25 in DCA Pass 2, which is the direct ratio to the cost of Alternative 4. The cost of Alternative 6 includes the cost to completion of cleanup action including the operation and maintenance of the remediation system for 6 years.

2.3.5.4 Effectiveness over the long term:

This criterion was selected as one of the two most important criteria that a cleanup action must meet and was assigned a weight of 10 by Ecology.

According to WAC 173-340-360(3)(f)(iv), long-term effectiveness includes the degree of certainty that the alternative will be successful, the reliability of the alternative during the period of time hazardous substances are expected to remain on-site at concentrations that exceed cleanup levels, the magnitude of residual risk with the alternative in place, and the effectiveness of controls required to manage treatment residues or remaining wastes.

Alternative 4 offers excavation, a technology which has been effectively used on-site and provides a higher degree of certainty that the alternative will be successful. Alternative 6 will remove COCs from the soil and groundwater through DPE. DPE has been successfully employed as a remediation at petroleum hydrocarbon impacted sites. Groundwater modeling of Alternative 6 shows that drawdown rates required for DPE will remediate residual LNAPL in soil and dissolved phase COC concentrations in the vicinity of the WSDOT stormwater line. The time period for achieving remediation goals by Alternative 6 (treatment and operation of DPE for 6 years) is relatively higher than Alternative 4 and increases the residual risk with the alternative in place for Alternative 4. Therefore Alternative 4 is ranked 1 (shows highest effectiveness over the long term) and Alternative 6 is ranked 2.

2.3.5.5 Management of short-term risks:

This criterion is not a primary criterion for a cleanup action but helps determine the feasibility of the cleanup action and was assigned a weight of 4 by Ecology.

According to WAC 173-340-360(3)(f)(v), management of short-term risks relates to the risk to human health and the environment associated with the alternative during construction and implementation, and the effectiveness of measures that will be taken to manage such risks.

- Both Alternative 4 and Alternative 6 include earthwork associated with excavation of DB-2 (3,000-5,800 cubic yards of impacted soils to be removed and disposed of). In addition to that, Alternative 4 involves significant earthwork (~ 8,000 cubic yards of soils to be excavated) and contaminated materials (soil, groundwater and residual LNAPL) to be handled and disposed off-site) during construction. Alternative 6 will include limited earthwork (trenching, drilling and piping for the system) in addition to the construction work conducted for DB-2 excavation.

- Alternative 4 includes additional technical requirements for excavation and management of risks:
  - Hazards associated with stormwater line pipe breach,
  - Potential risk of a stormwater line breach and potential discharge to Puget Sound,
  - Sheet pile installation, and
  - Significant engineering design to ensure that the shoring and dewatering infrastructure is sufficient for implementation.
- Alternative 6 short term risks include risks associated with trenching and installation of the remediation system and operation and maintenance of the remediation system.

Overall, the management of short-term risk is seen to be slightly more effective and easily implemented for Alternative 6. Therefore, Alternative 6 was assessed to be ranked a 4 compared to the ranking of 5 for Alternative 4.

2.3.5.6 Technical and Administrative Implementability:

This criterion is not a primary criterion for a cleanup action but helps determine the feasibility of the cleanup action and was assigned a weight of 4 by Ecology.

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

- Both Alternative 4 and Alternative 6 include post remediation groundwater monitoring to evaluate either MNA or efficient treatment operation but; do not include any engineering controls (environmental covenants, vapor barriers) or periodic reviews associated with them.
- Alternative 4 offers less administrative concerns (excavation being widely accepted as a easily implementable and effective cleanup action widely accepted by public and Ecology) but more complicated construction work due to the excavation activities being performed below the water table adjacent to the stormwater line conveying stormwater to Puget Sound.
- Alternative 6 offers easier technical implementation and higher administrative concerns relative to Alternative 4 as the DPE alternative is implemented over a 6 year period. Remediation through DPE however is an accepted remedial approach widely used to

remove petroleum hydrocarbon related impacts within soils and groundwater. Modeling calculations show that DPE is a technically feasible alternative and can be implemented using standard equipment widely available within the environmental remediation industry. Regularly scheduled maintenance is required to continue operation of the system increasing the administrative requirements of this alternative when compared to Alternative 4.

Overall, the technical and administrative implementability of Alternative 6 was assessed to be equivalent relative to Alternative 4 and was ranked as 3.

2.3.5.7 Consideration of Public Concerns:

Ecology emphasized the importance of public participation and concerns more-so on this Site because the Lower Yard will become the property of the State of Washington and is planned to be used as a ferry terminal. Ecology assigned a weight of 6 to this criterion.

According to WAC 173-340-360(3)(f)(vii), this criterion evaluates whether the community has concerns regarding the alternative and, if so, the extent to which the alternative addresses those concerns. This process includes 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. In this case, the community's with interest include WSDOT (prospective buyer of this property) and Edmonds Citizens Awareness Group (ECAC).

Both Alternatives 4 and 6 meet the expectations of cleanup action by Ecology. Alternative 4 removes contaminated materials and move them off-site from both areas of remediation (DB-2 and WSDOT stormwater line area) whereas Alternative 6 removes contaminated materials from DB-2 area and treats contaminated media from the WSDOT stormwater line area. Both alternatives will meet the cleanup goals. Both alternatives will not leave impacts on-site at the time of completion (no vapor barriers or environmental covenants in place) and will receive a higher degree of public approval. Alternative 6 has additional advantages over complete removal, excavation and replacement of the WSDOT stormwater line in relation to public concerns. Construction of the DPE system will require less site traffic and hydrocarbon impacted materials transport from the site, reducing the number of loads associated with off-site disposal. Construction equipment on-site will be limited to a small excavator for minimal trenching activities reducing noise and dust. Installation and operation of the DPE system will also keep critical stormwater infrastructure in place while still addressing remediation goals.

Because WSDOT and ECAC have expressed concerns regarding environmental covenants and indicated a preference for excavation to address the contamination in the WSDOT stormwater line area, we expect Alternative 4 will be more readily accepted by WSDOT, ECAC and the public, relative to Alternative 6. Therefore Alternative 4 is ranked the highest (1) and Alternative 6 is ranked below that (2).

2.4 Provide for a reasonable restoration time frame

WAC 173-340-360(4) contains guidance for evaluating reasonable restoration timeframes. Preference is given for alternatives that can be implemented in a shorter period of time if other factors such as permanence and costs are equal. Under the DPE remediation scenario, the LNAPL depletion model shows that TPH concentrations in soil and dissolved TPH concentrations in groundwater in the target treatment zone can be remediated below the CUL within approximately 5 years and 6 years respectively. Both Alternative 4 and Alternative 6 provide for a reasonable restoration time frame.

2.5 Consider community concerns

Ecology has addressed community concerns throughout the history of this project. Ecology will consider additional issues or concerns as part of the cleanup action selection process, per WAC 173-340-600. Public comments on the project and the final FS Report will be solicited from the community during the formal comment period, following Ecology input. Common community concerns include noise and traffic, short- and long-term risks, and timeframe of any proposed cleanup actions.

2.6 Expectations of cleanup action alternatives

2.6.1 Waste/Hazardous substances treatment

Ecology expects that treatment technologies will be used for sites that contain liquid wastes, areas impacted with high concentrations of hazardous substances, highly mobile materials, and/or discrete areas of hazardous substances (Washington State Department of Ecology 2007).

For Alternative 6, only minimal volumes of soil related to system trenching and installation will be removed from the Site. Groundwater collected from the DPE will be sent to an on-site treatment system, any potential LNAPL that may be recovered, will be stored, and eventually disposed of at an appropriate waste disposal facility. Treated groundwater will be discharged to DB-2 or Willow Creek under a NPDES permit. Spent granular activated carbon will be periodically removed from the site and sent to a facility for reactivation and re-use. Remediation through DPE effectively destroys and removes contaminated materials to below CULs.

2.6.2 Use of engineering controls at large Sites

Per WAC 173-340-37(3), Ecology recognizes the need to use engineering controls, such as containment, for sites or portions of sites that contain large volumes of materials where treatment is impracticable.

Alternative 6 proposes to use groundwater containment to control the migration of hazardous substances and to remediate soils near the WSDOT stormwater line. Groundwater collected from the DPE system will be sent to an on-site system for treatment, any potential LNAPL that may be recovered, will be stored, and eventually disposed of at an appropriate waste disposal facility. Treated groundwater will be discharged to DB-2 or Willow Creek. Regular groundwater monitoring events will continue during system operation to monitor compliance at POC wells. Soil vapor will be extracted and treated on-site initially using engineering controls through a catalytic oxidizer. The vapor concentrations will be destroyed by the oxidizer before being discharge to the atmosphere. There will be no need for engineering controls following completion of DPE system operation and excavation of DB-2 as impacted soils will be removed and site groundwater concentrations will be below CULs.

2.6.3 Minimize stormwater contamination and off-site migration

To minimize the potential for migration of hazardous substances, Ecology expects that active measures will be taken to prevent precipitation and subsequent runoff from coming into contact with impacted soil and waste materials. When such measures are impracticable, such as during active cleanup, Ecology expects that site runoff will be contained and treated prior to release from the Site (Washington State Department of Ecology 2007).

Alternative 6 propose to use DPE as a strategy for migration of hazardous substances. Groundwater collected from the DPE will be sent to an on-site system for treatment. Treated groundwater will be discharged to DB-2 or Willow Creek. Regular groundwater monitoring events and system operation and maintenance will continue under this alternative during system operation to monitor mass removal and compliance at POC wells. Critical safety devices will be in place on system components to shut down the remediation system and contain any untreated groundwater from release to surface water and the stormwater collection system if DPE system failure occurs.

2.6.4 Minimize direct contact and migration by consolidating hazardous substances

When hazardous substances remain on-site at concentrations that exceed CULs, Ecology expects those hazardous substances will be consolidated to the maximum extent practicable where needed to minimize the potential for direct contact and migration of hazardous substances (Washington State Department of Ecology 2007).

Under Alternative 6 consolidation will not be required. All impacted soil will either be removed from the site or remediated in place. Groundwater will be collected and treated on-site prior to discharge under an NPDES permit.

2.6.5 Avoid Surface Water Contamination through Control of Runoff and Control of Groundwater Discharge or Migration

Ecology expects that for facilities adjacent to a surface water body, active measures will be taken to prevent or minimize releases to surface water via surface runoff and groundwater discharges in excess of CULs. Ecology expects that dilution will not be the sole method for demonstrating compliance with cleanup standards in these instances (Washington State Department of Ecology 2007).

Alternative 6 will control groundwater discharge through containment of groundwater only in the area where there is a threat of groundwater above cleanup levels leaving the Lower Yard. Groundwater modeling shows that at the designed pumping rates of 21 gpm from the DPE system, groundwater flow paths will be directed towards the remediation system pumping wells containing all off-site migration.

2.6.6 Use of natural attenuation

Ecology (2007) expects that natural attenuation of hazardous substances may be appropriate at sites where:

- Source control has been conducted to the maximum extent practicable.
- Impacts that remain on-site during the restoration timeframe do not pose an unacceptable threat to human health or the environment.
- Site data show that natural biodegradation or chemical degradation is occurring and will continue to occur at a reasonable rate at the site.
- Appropriate monitoring requirements are conducted to ensure that the natural attenuation process is taking place and that human health and the environment are protected.

Analytical and biogeochemical data indicate that natural attenuation is occurring at the Site. Natural attenuation will be enhanced through implementation of the DPE system and depletion time frames are significantly increased. Remediation time frame are reduced from an estimated 56 to 60 years, when relying on a strictly MNA approach, to 5 to 6 years with implementation of DPE. Regular groundwater monitoring events would continue under this alternative and will be designed, in part, to evaluate the ongoing rate of enhanced natural attenuation throughout the remedial action period.

3. Conclusion

Disproportionate cost analysis indicates Alternative 6, Excavation of the DB-2 and DPE is the alternative that is Permanent to the Maximum Extent Practicable. The alternative is relatively easy to implement, offers easier short-term risk management procedures, addresses the public’s concerns both locally and regionally, removes and/or destroys contaminants permanently and will cost approximately half of Alternative 4 cost. The increased incremental cost of Alternative 4 over Alternative 6 is disproportionate to the degree of benefits achieved. Therefore Chevron recommends Alternative 6 as the preferred remedy for the remaining impacts at this Site.

References

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Ecology, 2014. Review Letter, Unocal Edmonds Bulk Terminal - Review of Draft Feasibility dated, May 21, 2014.

Gustafson, J.B., J.G. Tell, and D. Orem. 1997. Selection of Representative TPH Fractions Based on Fate and Transport Considerations. Total Petroleum Hydrocarbon Criteria Working Group Series. Volume 3.

Interstate Technology Regulatory Council (ITRC). 2009. Evaluating Natural Source Zone Depletion at Sites with RESIDUAL LNAPL. Prepared by the ITRC RESIDUAL LNAPL Team. Washington DC.

Sale, T. and J. Zimbron. 2013. Natural Losses of RESIDUAL LNAPL: Processes and Implications. REMTEC 2013. Westminster, Colorado.

White, M.D., M Oostom and RJ Lenhard 2004. A Practical Model for Mobile, Residual and Entrapped LNAPL in Water-Wet Porous Media. Ground Water Vol. 42 No. 5 pp 734-746.

Attachments

Tables

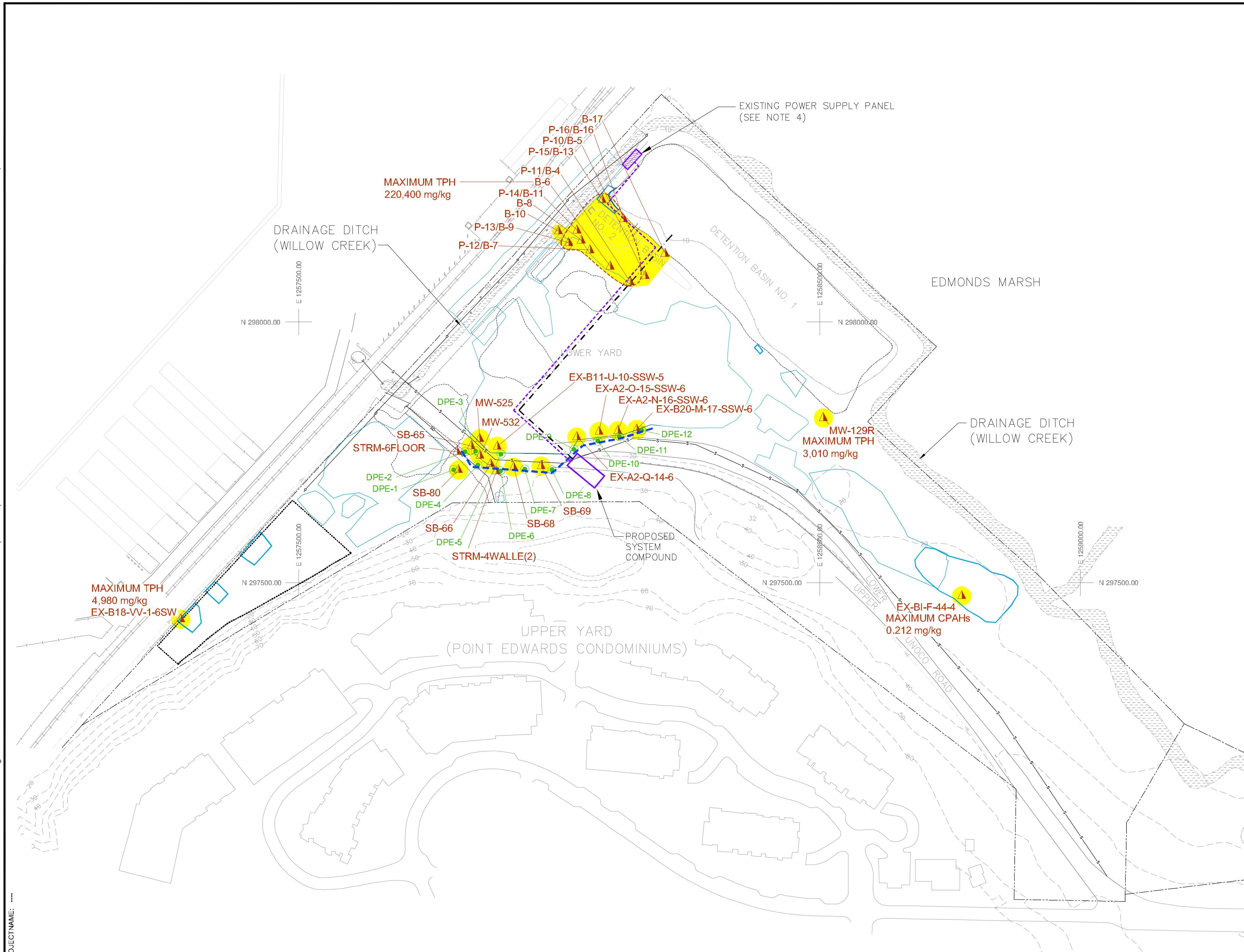
Table 1 Cost Estimate for Alternative 6: Excavation and MNA and DPE
Table 2-a Disproportionate Cost Analysis Pass 1
Table 2-b Disproportionate Cost Analysis Pass 2

Figures

Figure 1 Site Plan
Figure 2 MODFLOW Groundwater Extraction Model
Figure 3 Proposed DPE System Layout
Figure 4 DPE Well Detail
Figure 5 DPE Model Cross Section A - A’ Location
Figure 6 DPE Drawdown Model Cross Section A - A’
Figure 7 Residual LNAPL Depletion Conceptual Model
Figure 8 Predicted TPH Concentration in Groundwater
Figure 9 Predicted TPH Concentration in Soil
Figure 10 Future Use of Lower Yard with Proposed DPE Layout.
Figure 11 DPE Process and Instrumentation Diagram

Appendix

Appendix A Pumping Analysis



LEGEND:

- ESTIMATED LNAPL BOUNDARY
- SOIL SAMPLE COLLECTION LOCATION WITH CONCENTRATIONS OF TOTAL TPH AND/OR CPAHS EXCEEDING APPLICABLE SITE CULs AND/OR RELs.
- AREA WITH REMAINING SOIL IMPACTS EXCEEDING SITE CULs AND/OR RELs
- 2001 AND 2003 SOIL EXCAVATIONS BELOW GROUNDWATER TABLE
- LOWER YARD PROPERTY BOUNDARY
- 2007/2008 EXCAVATION BOUNDARIES
- WSDOT STORM DRAIN LINE
- POINT EDWARDS STORM DRAIN LINE
- PROPOSED DUAL PHASE EXTRACTION WELL (DPE)
- PROPOSED ELECTRICAL CONDUIT TRENCHING
- PROPOSED PIPE TRENCHING
- TREATED GROUNDWATER DISCHARGE LINE
- PROPOSED GWCDPE SYSTEM COMPOUND

NOTES:

1. 20-MIL POLYETHYLENE SHEETING INSTALLED UPON COMPLETION OF PHASE I EXCAVATION. SHEETING REACHES TO APPROXIMATELY 7.5 FEET ABOVE MEAN SEA LEVEL.
2. HORIZONTAL DATUM: WASHINGTON STATE COORDINATE SYSTEM NORTH ZONE (NAD 83/98).
   VERTICAL DATUM: N.A.V.D. 88
   UNITS: U.S. SURVEY FEET
   HORIZONTAL AND VERTICAL CONTROL ESTABLISHED BY GPS VIA VERTICAL REFERENCE STATION NETWORK (VRSN).
3. SOUTHEAST PORTION OF WSDOT STORM DRAIN LINE HAS NOT BEEN SURVEYED.
4. LOCATION OF EXISTING POWER SUPPLY PANEL HAS NOT BEEN SURVEYED.

0 200' 400'

GRAPHIC SCALE

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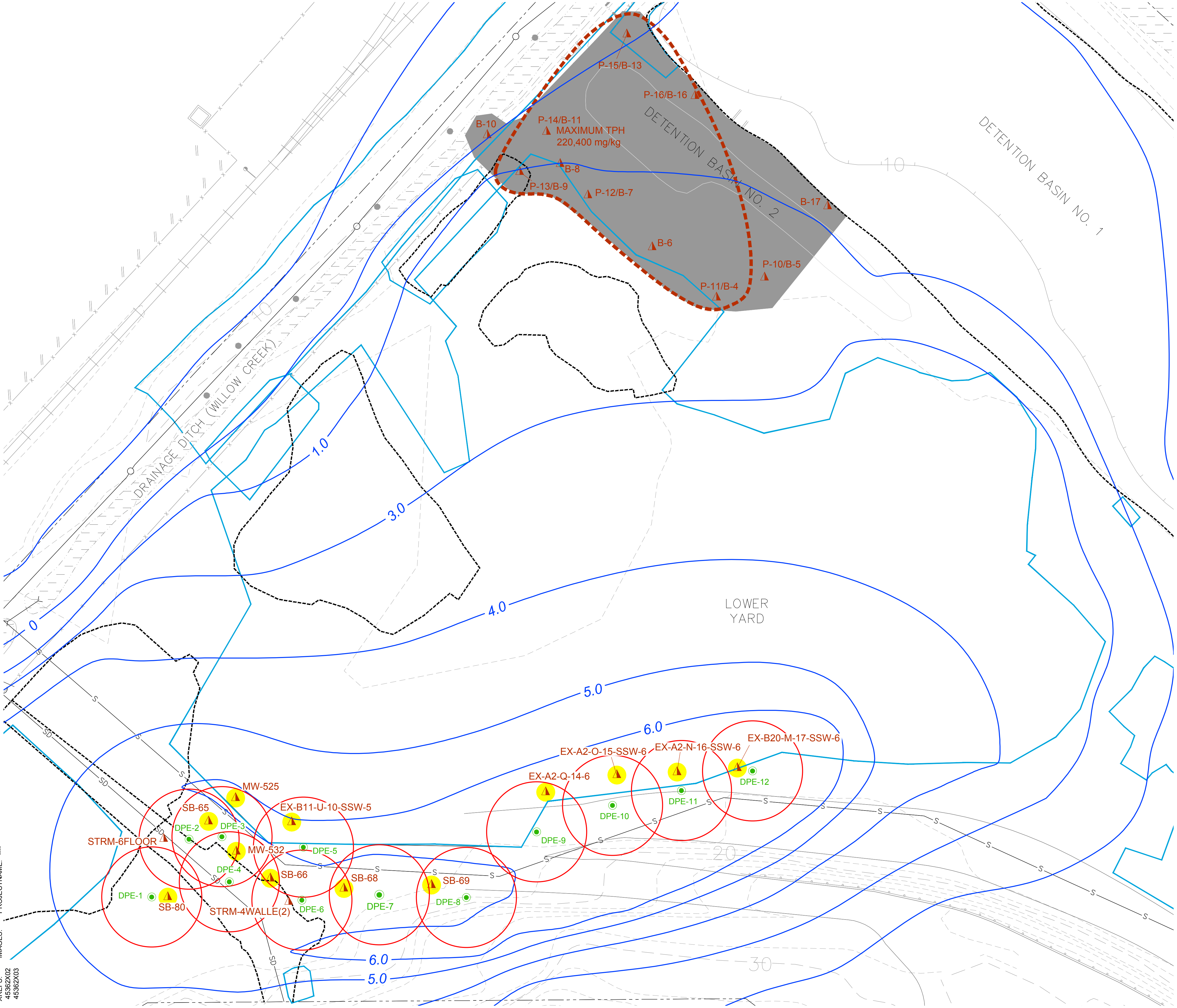
SITE PLAN

ARCADIS

FIGURE
1



LEGEND:

ESTIMATED LNAPL BOUNDARY

SOIL SAMPLE COLLECTION LOCATION WITH CONCENTRATIONS OF TOTAL TPH AND/OR CPAHS EXCEEDING APPLICABLE SITE CULs AND/OR RELs.

AREA OF EXCAVATION

AREA WITH REMAINING SOIL IMPACTS EXCEEDING SITE CULs AND/OR RELs

2001 AND 2003 SOIL EXCAVATIONS BELOW GROUNDWATER TABLE

LOWER YARD PROPERTY BOUNDARY

2007/2008 EXCAVATION BOUNDARIES

S — WSDOT STORM DRAIN LINE

SD — POINT EDWARDS STORM DRAIN LINE

1.0 — GROUNDWATER CONTOURS – PRESENTED AS POTENTIOMETRIC DRAWDOWN @ 21 GPM TOTAL

DPE-12 — PROPOSED DUAL PHASE EXTRACTION WELL (DPE)

DPE ROI – 30 FOOT RADIUS

NOTES:

1. HORIZONTAL DATUM: WASHINGTON STATE COORDINATE SYSTEM NORTH ZONE (NAD 83/98).
VERTICAL DATUM: N.A.V.D. 88
UNITS: U.S. SURVEY FEET
HORIZONTAL AND VERTICAL CONTROL ESTABLISHED BY GPS VIA VERTICAL REFERENCE STATION NETWORK (VRSN).

2. SOUTHEAST PORTION OF WSDOT STORM DRAIN LINE HAS NOT BEEN SURVEYED.

0 60' 120'

GRAPHIC SCALE

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MODFLOW GROUNDWATER EXTRACTION MODEL

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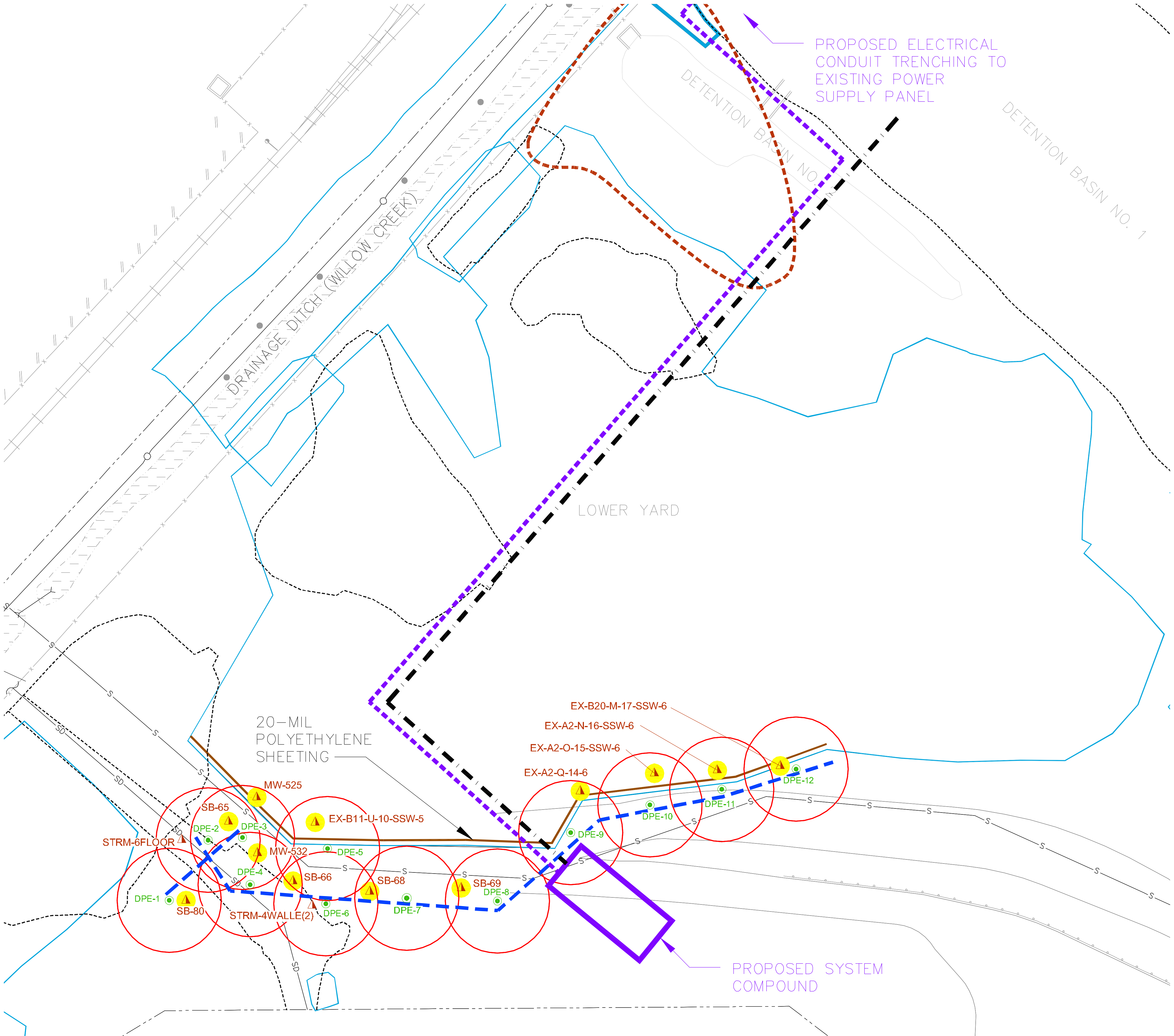
FIGURE
2



LEGEND:

- ESTIMATED LNAPL BOUNDARY
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- DPE ROI – 30 FOOT RADIUS
- PROPOSED ELECTRICAL CONDUIT TRENCHING
- PROPOSED PIPE TRENCHING
- TREATED GROUNDWATER DISCHARGE LINE

NOTES:

1. 20–MIL POLYETHYLENE SHEETING INSTALLED UPON COMPLETION OF PHASE I EXCAVATION. SHEETING REACHES TO APPROXIMATELY 7.5 FEET ABOVE MEAN SEA LEVEL.
2. HORIZONTAL DATUM: WASHINGTON STATE COORDINATE SYSTEM NORTH ZONE (NAD 83/98). VERTICAL DATUM: N.A.V.D. 88 UNITS: U.S. SURVEY FEET HORIZONTAL AND VERTICAL CONTROL ESTABLISHED BY GPS VIA VERTICAL REFERENCE STATION NETWORK (VRSN).
3. SOUTHEAST PORTION OF WSDOT STORM DRAIN LINE HAS NOT BEEN SURVEYED.
4. LOCATION OF EXISTING POWER SUPPLY PANEL HAS NOT BEEN SURVEYED.

0 60' 120'

GRAPHIC SCALE

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PROPOSED DPE SYSTEM LAYOUT

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FIGURE
3

CITY: EMV, CA DIV/GROUP: ENVCAD DB: ASR LD: PIC: PM: TM: LYR: ON=*; OFF=*REF*
G:\ENVCAD\Emeryville\ACT\B0045362\0005\00004\DPE RemAltEval\DWG\B0045362 D04.dwg LAYOUT: 4 SAVED: 8/4/2014 3:31 PM ACADVER: 18.1S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 8/4/2014 3:48 PM BY: REYES, ALEC
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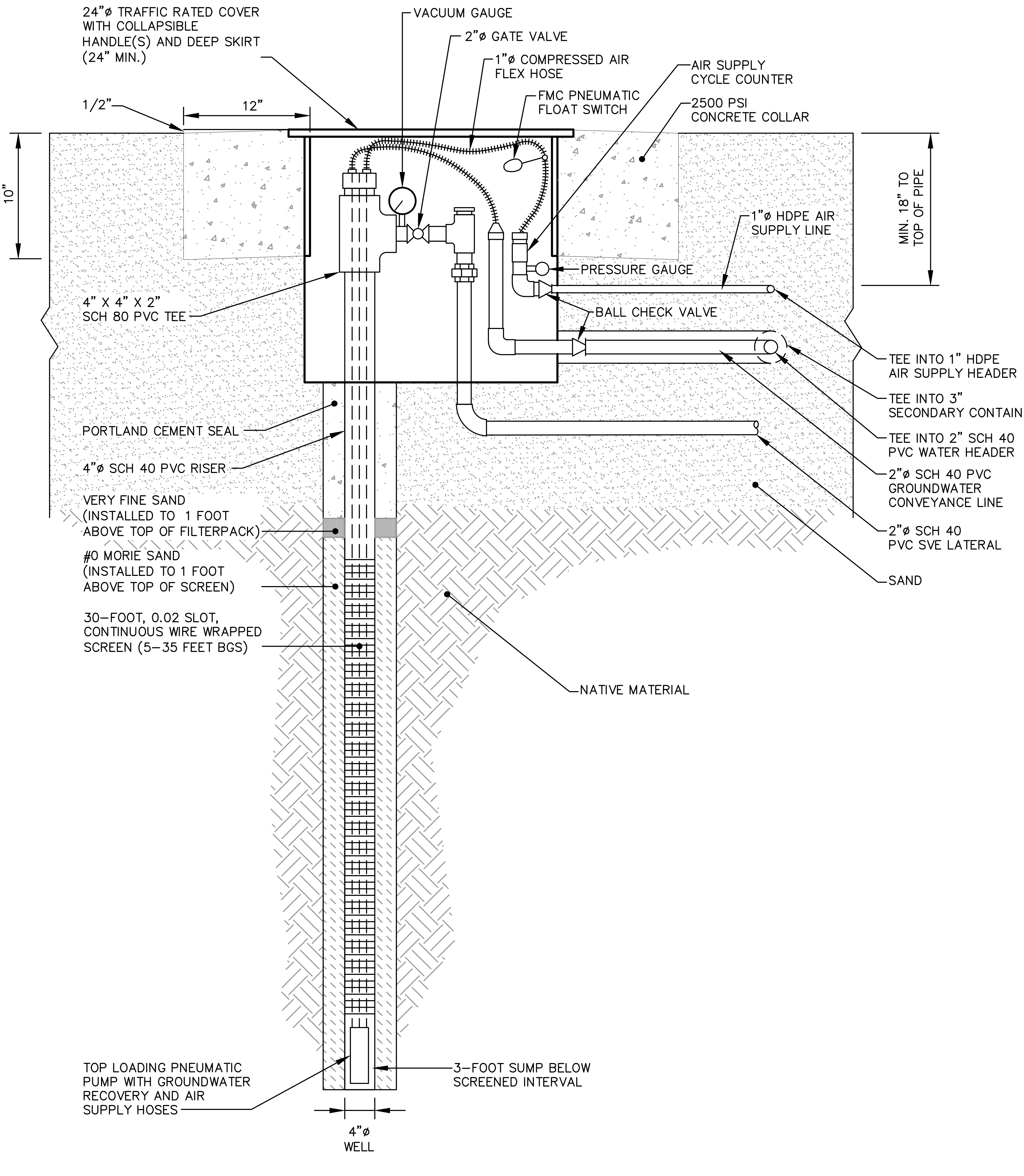

DUAL-PHASE EXTRACTION WELL CONNECTION DETAIL

NOT TO SCALE

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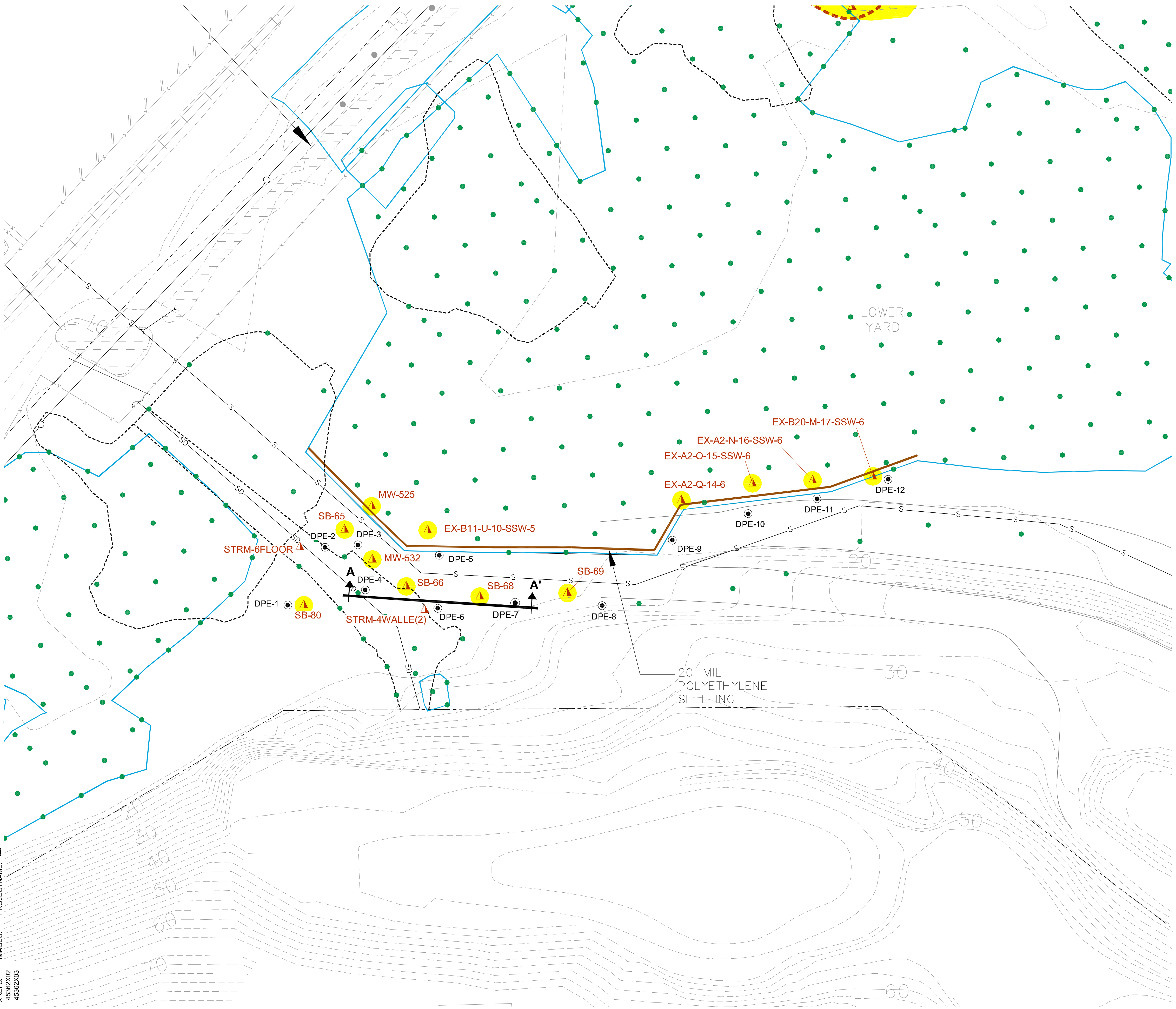
DPE WELL DETAIL

ARCADIS

FIGURE
4



LEGEND:

- ESTIMATED LNAPL BOUNDARY
- SOIL SAMPLE COLLECTION LOCATION WITH CONCENTRATIONS OF TOTAL TPH AND/OR CPAHS EXCEEDING APPLICABLE SITE CULs AND/OR RELs.
- SOIL SAMPLE COLLECTION LOCATION WITH CONCENTRATIONS OF TOTAL TPH AND / OR CPAHs NOT EXCEEDING APPLICABLE SITE CULs AND / OR RELs.
- AREA WITH REMAINING SOIL IMPACTS EXCEEDING SITE CULs AND/OR RELs
- 2001 AND 2003 SOIL EXCAVATIONS BELOW GROUNDWATER TABLE
- LOWER YARD PROPERTY BOUNDARY
- 2007/2008 EXCAVATION BOUNDARIES
- S — WSDOT STORM DRAIN LINE
- SD — POINT EDWARDS STORM DRAIN LINE
- 1.0 — GROUNDWATER CONTOURS – PRESENTED AS POTENTIOMETRIC DRAWDOWN
- DPE-12 — PROPOSED DUAL PHASE EXTRACTION WELL (DPE)
- A — A' CROSS-SECTION LOCATION

NOTES:

1. 20-MIL POLYETHYLENE SHEETING INSTALLED UPON COMPLETION OF PHASE I EXCAVATION. SHEETING REACHES TO APPROXIMATELY 7.5 FEET ABOVE MEAN SEA LEVEL.
2. HORIZONTAL DATUM: WASHINGTON STATE COORDINATE SYSTEM NORTH ZONE (NAD 83/98).
   VERTICAL DATUM: N.A.V.D. 88
   UNITS: U.S. SURVEY FEET
   HORIZONTAL AND VERTICAL CONTROL ESTABLISHED BY GPS VIA VERTICAL REFERENCE STATION NETWORK (VRSN).
3. SOUTHEAST PORTION OF WSDOT STORM DRAIN LINE HAS NOT BEEN SURVEYED.

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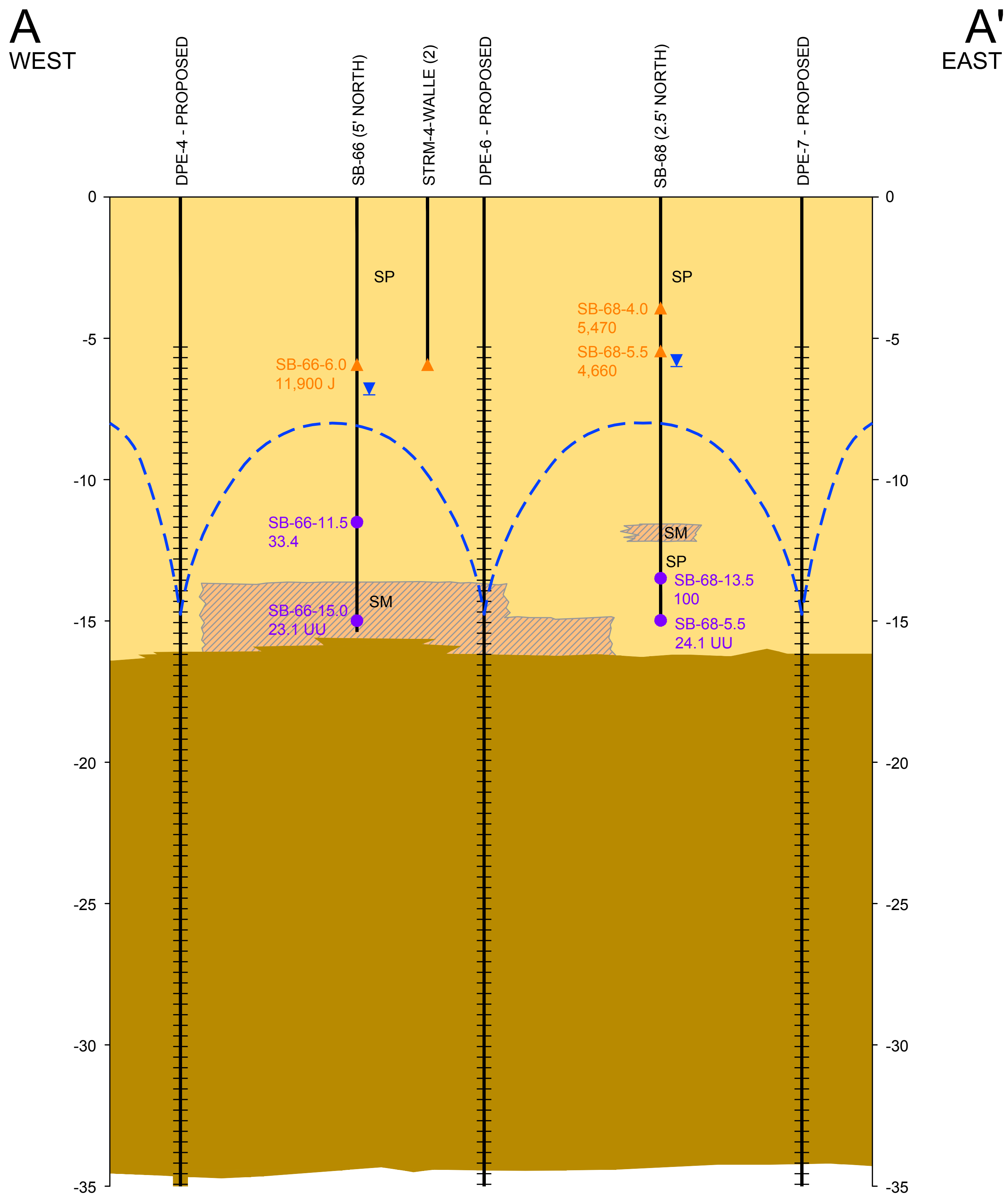
DPE MODEL CROSS-SECTION A-A' LOCATION

ARCADIS

FIGURE
5



LEGEND:

SP = POORLY GRADED SAND

SM = POORLY GRADED SAND

VASHON FORMATION

SAMPLE LOCATIONS WITH ANALYTICAL RESULTS LESS THAN SITE RELs/CULs

SAMPLE LOCATIONS WITH ANALYTICAL RESULTS GREATER THAN SITE RELs/CULs

WATER LEVEL AT TIME OF DRILLING

SB-68-5.5 — SAMPLE NAME
24.1 UU — TPH IN mg/kg

TPH TOTAL PETROLEUM HYDROCARBONS

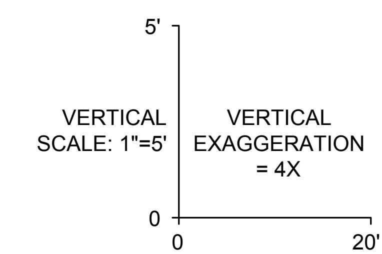
mg/kg MILLIGRAMS PER KILOGRAM

J ESTIMATED VALUE ANALYTICAL RESULT BELOW LABORATORY QUANTITATION LIMIT AND ABOVE EQUIPMENT DETECTION LIMIT

UU THE CONSTITUENTS MAKING UP THE TOTAL ARE NON-DETECTS

[ ] BRACKETED DATA INDICATES DUPLICATE SAMPLE.

ESTIMATED DRAWDOWN @ 21 GPM USING THEIS EQUATION



HORIZONTAL SCALE: 1"=20'

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DPE DRAWDOWN MODEL
CROSS SECTION A-A'

ARCADIS

FIGURE
6

CITY: EMV, CA GROUP: ENVCAD DB: ASR PP: ASR PM: TM: TR: LYR: ON=*;OFF=REF
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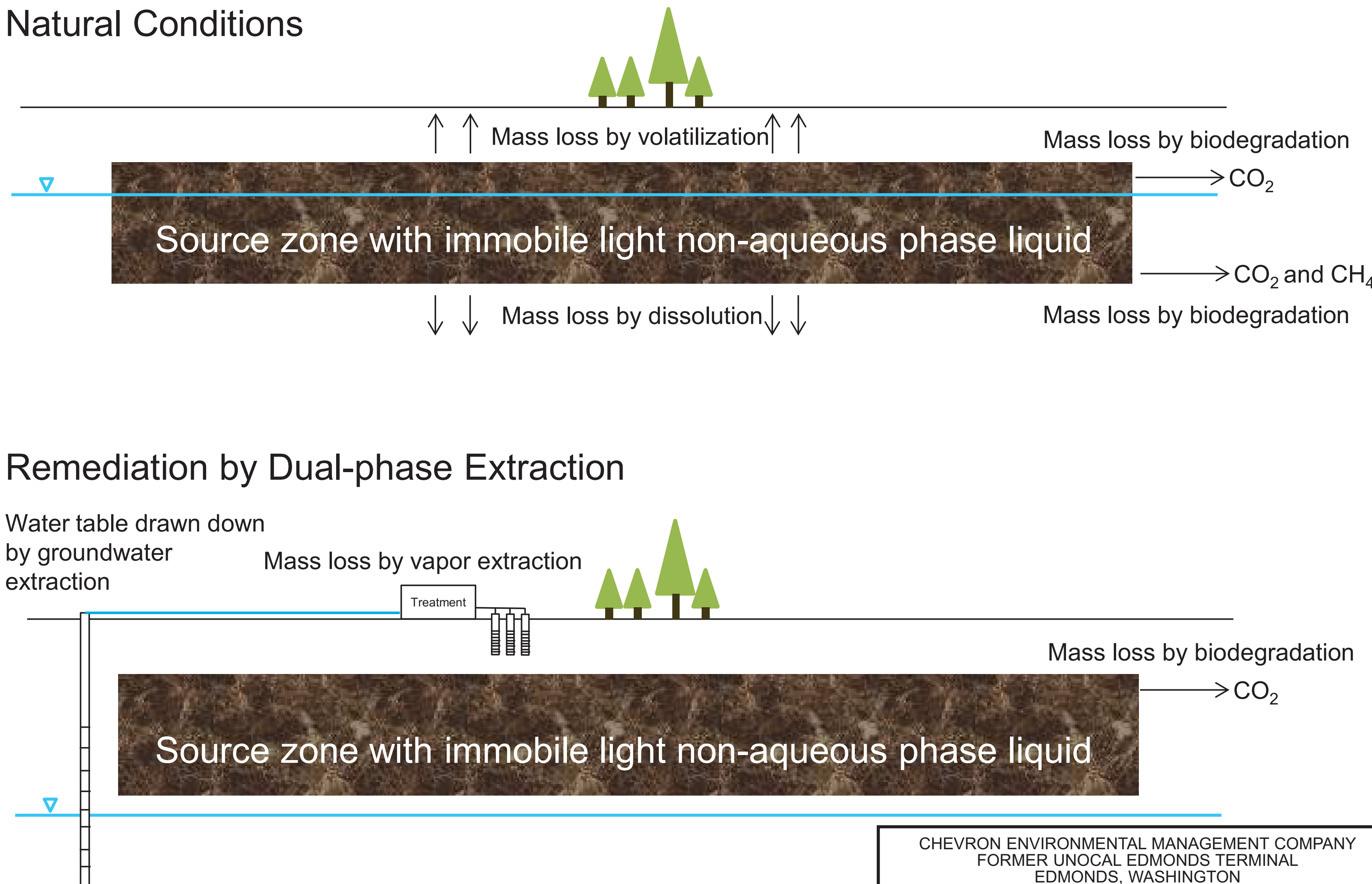

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RESIDUAL LNAPL DEPLETION CONCEPTUAL MODEL

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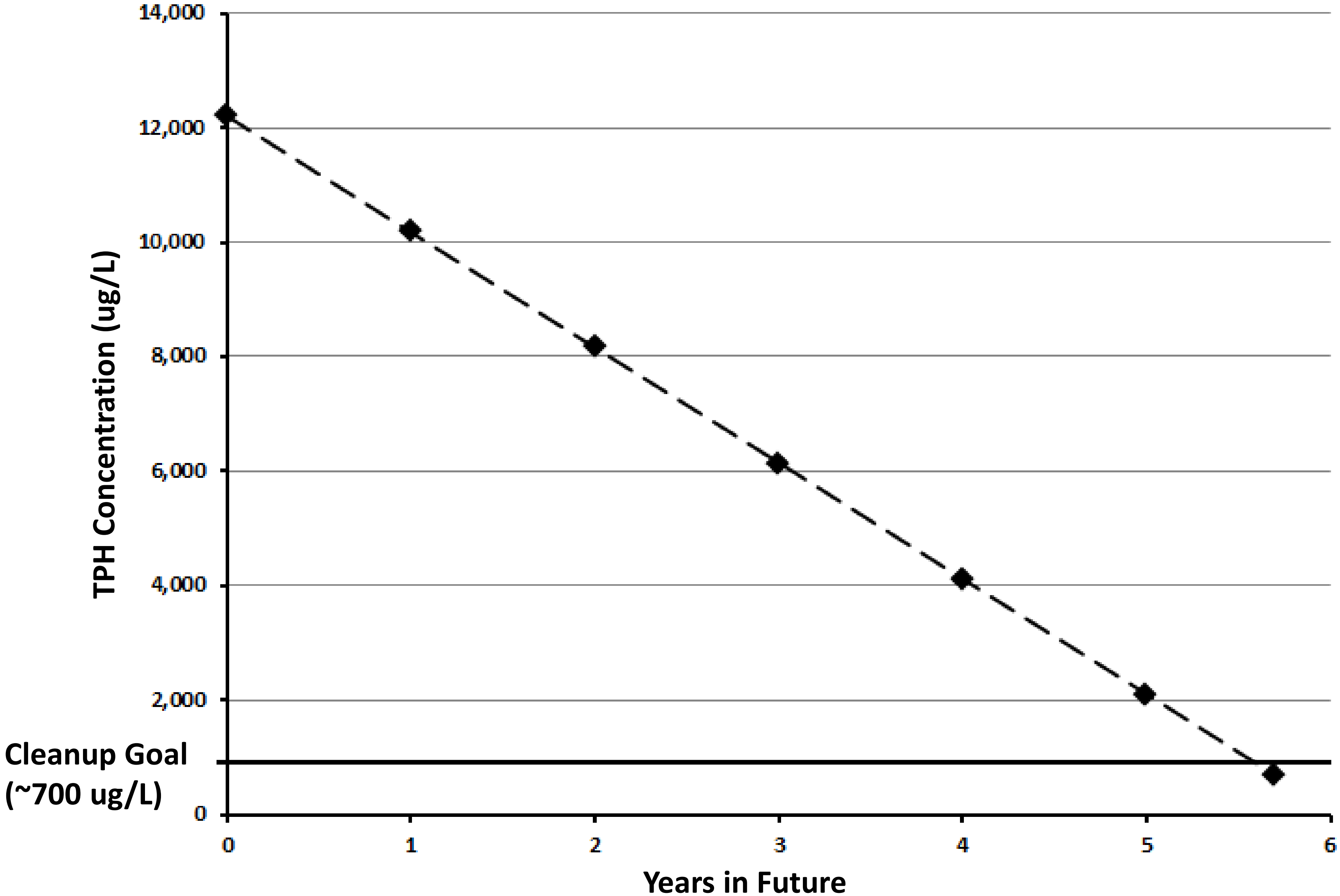
FIGURE
7

2 July 2014

Not to scale



Notes:

1. TPH concentrations predicted using a multi-phase NAPL Source Zone Depletion Model based on methods in ITRC (2011).
2. All model parameters were based on site data and standard literature values, except NAPL saturation which was estimated during calibration (S~0.1).
3. NAPL source zone depletion processes modeled include mass loss due to dissolution into groundwater, volatilization, and biodegradation.

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Predicted TPH Concentration in Groundwater with DPE

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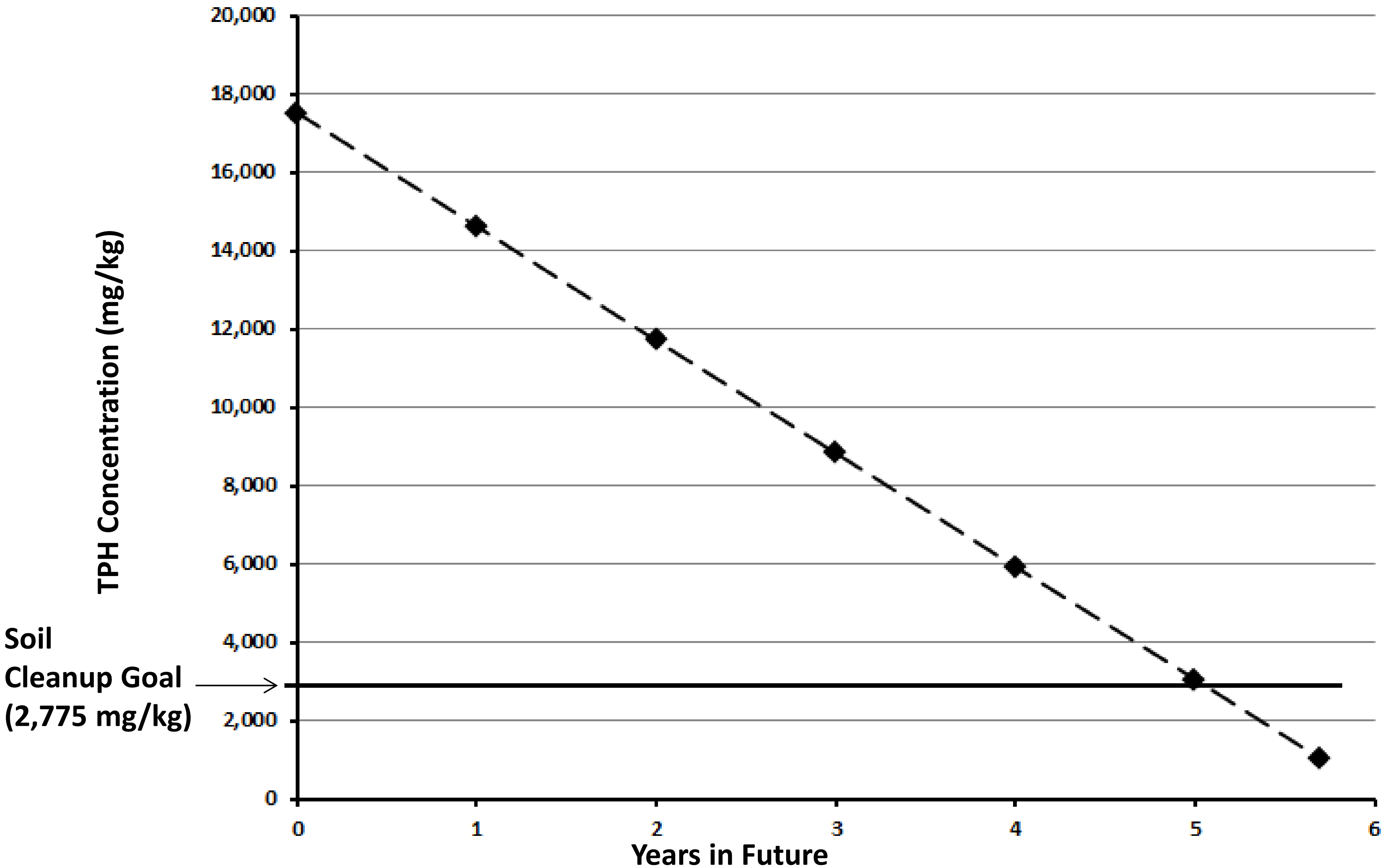
FIGURE
8



Notes:

1. TPH concentrations predicted using a multi-phase NAPL Source Zone Depletion Model based on methods in ITRC (2011).
2. All model parameters were based on site data and standard literature values, except NAPL saturation which was estimated during calibration (S~0.1).
3. NAPL source zone depletion processes modeled include mass loss due to dissolution into groundwater, volatilization, and biodegradation.

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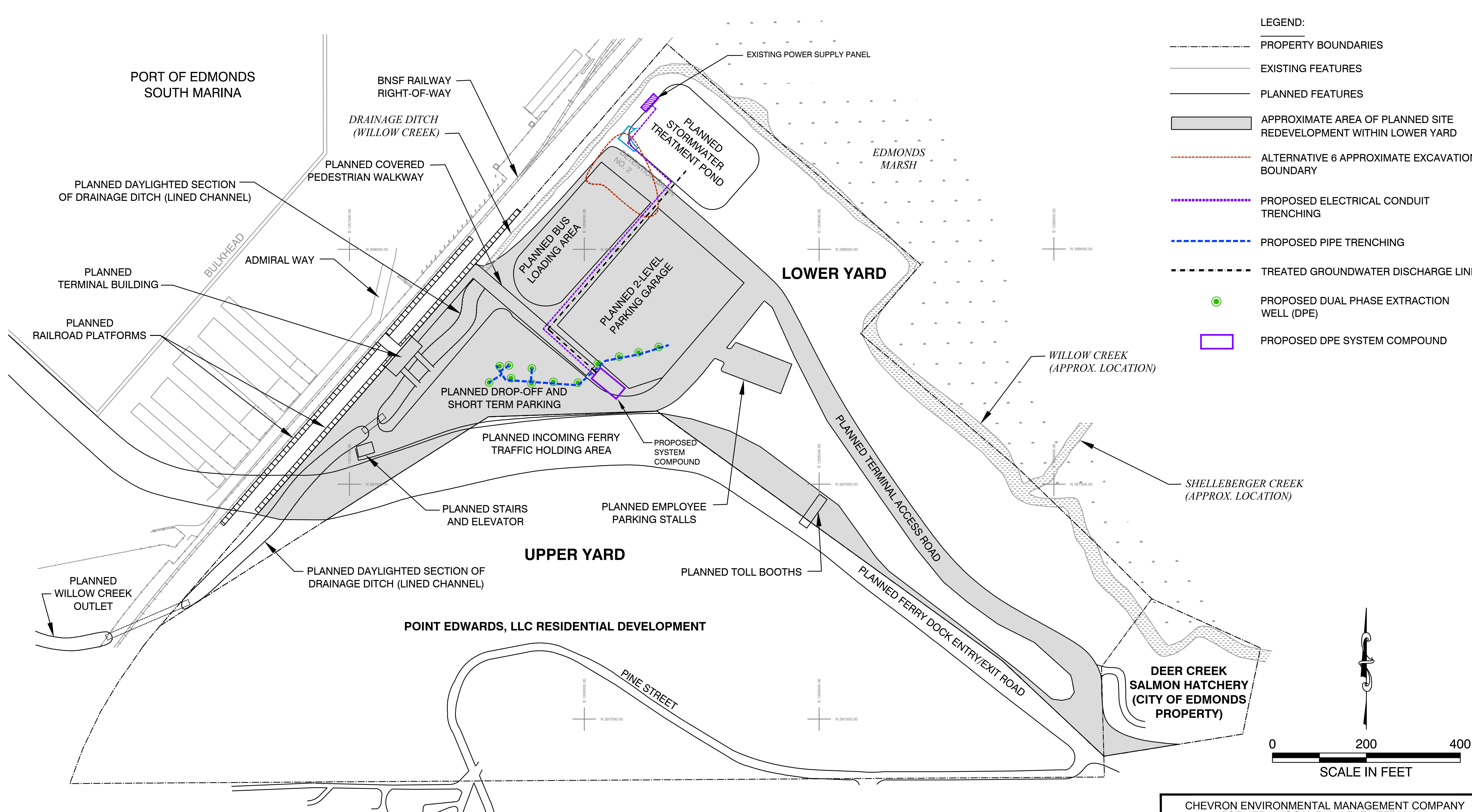
Predicted TPH Concentration in Soil with DPE

ARCADIS

FIGURE
9



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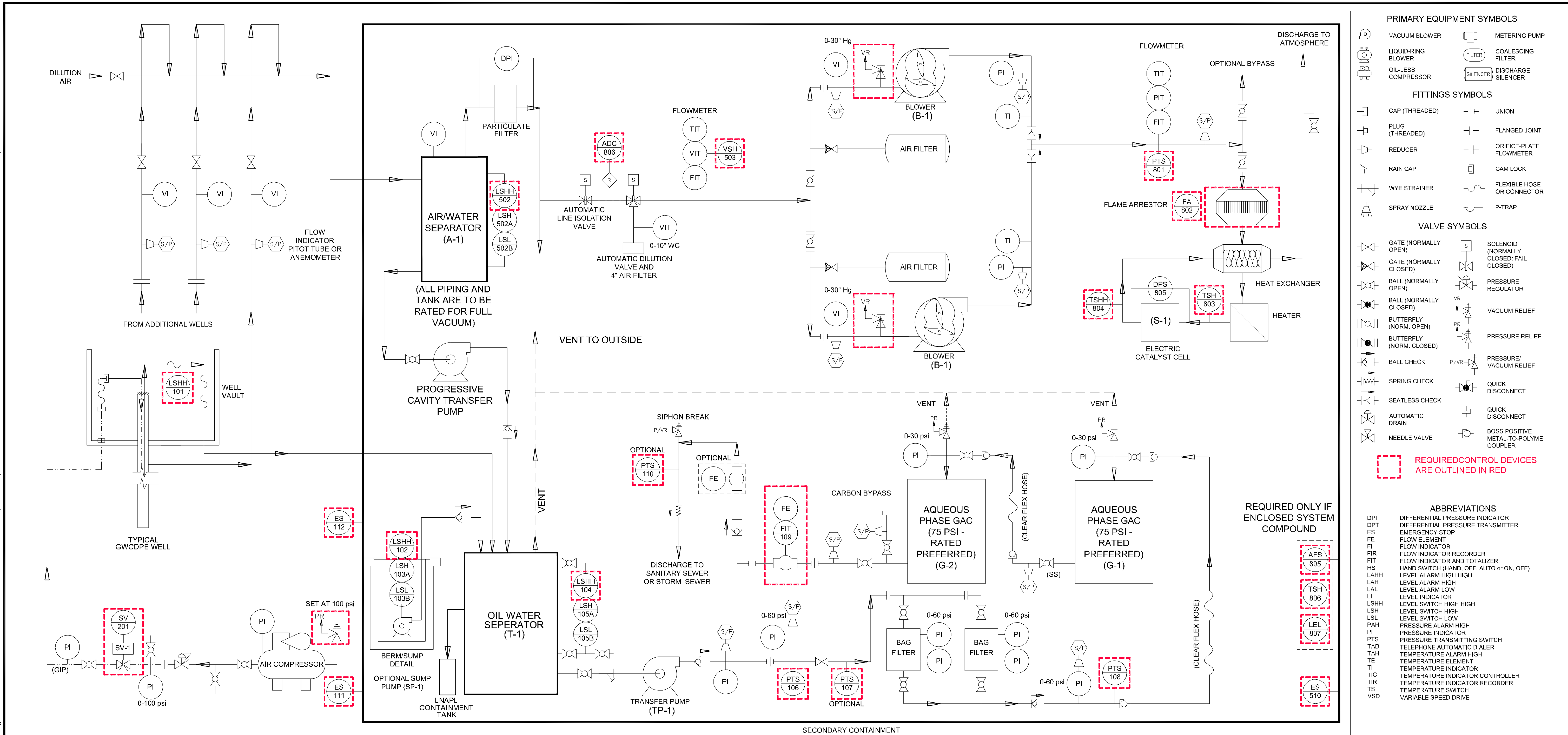
FUTURE USE OF LOWER YARD WITH PROPOSED DPE LAYOUT

ARCADIS

FIGURE
10



CONTROL UNIT	FUNCTION
LSHH 101	LEVEL SWITCH/ALARM HIGH HIGH: TURNS **OFF** ALL SYSTEMS
LSHH 102	LEVEL SWITCH/ALARM HIGH HIGH: TURNS **OFF** ALL SYSTEMS
LSH 103A	LEVEL SWITCH HIGH: TURNS **ON** SUMP PUMP (SP-1)
LSL 103B	LEVEL SWITCH LOW: TURNS **OFF** SUMP PUMP (SP-1)
LSHH 104	LEVEL SWITCH/ALARM HIGH HIGH: TURNS **OFF** ALL SYSTEMS

ALL HIGH HIGH OR LEL LEVEL SWITCHES ARE MANUAL RESET

CONTROL UNIT	FUNCTION
LSH 105A	LEVEL SWITCH HIGH: TURNS **ON** TRANSFER PUMP (TP-1)
LSL 105B	LEVEL SWITCH LOW: TURNS **OFF** TRANSFER PUMP (TP-1)
PTS 106	PRESSURE TRANSMITER SWITCH/ALARM HIGH: TURNS **OFF** ALL SYSTEMS
PTS 107	PRESSURE TRANSMITER SWITCH/ALARM HIGH: TURNS **OFF** ALL SYSTEMS
PTS 108	PRESSURE TRANSMITER SWITCH/ALARM HIGH: TURNS **OFF** ALL SYSTEMS
PTS 109	PRESSURE TRANSMITER SWITCH/ALARM HIGH: TURNS **OFF** ALL SYSTEMS

CONTROL UNIT	FUNCTION
ES 110	EMERGENCY STOP SWITCH (INTERNAL): TURNS **OFF** ALLSYSTEMS
ES 111	EMERGENCY STOP SWITCH (EXTERNAL): TURNS **OFF** ALLSYSTEMS
FIT 112	FLOW INDICATOR AND TOTALIZER
SV 201	SOLENOID VALVE: TURNS **ON/OFF** WELL PUMPS
PRV 202	PRESSURE RELIEF VALVE RELIEVES PRESSURE FROM AIR TANK

CONTROL UNIT	FUNCTION
LSHH 501	LEVEL SWITCH/ALARM HIGH HIGH: TURNS **OFF** ALL SYSTEMS
LSH 502	LEVEL SWITCH HIGH: TURNS **ON** SUMP PUMP (SP-1)
LSL 502	LEVEL SWITCH LOW: TURNS **OFF** SUMP PUMP (SP-1)
VSH 503	VACUUM SWITCH/ALARM HIGH HIGH: TURNS **OFF** ALL SYSTEMS
PTS 801	AIR PROVING SWITCH (PRESSURE SWITCH/ALARM LOW): TURNS **OFF** ALL SYSTEMS
FA 802	FLAME ARRESTOR: PREVENTS FLAMES FROM PROPOGATING UPSTREAM IN EVENT OF EXPLOSION

CONTROL UNIT	FUNCTION
TSH 803	TEMPERATURE SWITCH/ALARM LOW: CLOSES AUTOMATIC DILUTION VALVE (ADC) WHEN SYSTEM REACHES OPERATING TEMPERATURE RANGE
TSHH 804	TEMPERATURE SWITCH/ALARM HIGH HIGH: TURNS **OFF** ALL SYSTEMS
DPS 805	DIFFERENTIAL PRESSURE SWITCH/ALARM HIGH HIGH: TURNS **OFF** ALL SYSTEMS
AFS 151	AIR-FLOW SENSOR/ALARM HIGH HIGH: TURNS **OFF** ALL SYSTEMS
TSH 152	TEMPERATURE SWITCH/ALARM HIGH HIGH: TURNS **OFF** ALL SYSTEMS
LEL 153	LOWER EXPLOSIVE LIMIT /ALARM HIGH HIGH: TURNS **OFF** ALL SYSTEMS
ADC 806	AIR DILUTION CONTROL VALVE: OPENS AT HIGH TEMP TO COOL OXIDIZER CLOSES AT OPERATING TEMP

CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY
FORMER UNOCAL BULK FUEL TERMINAL
EDMONDS, WASHINGTON
PROPOSED ADDENDUM TO THE DRAFT FEASIBILITY REPORT

DPE PROCESS AND INSTRUMENTATION DIAGRAM

ARCADIS

FIGURE
11

Table 1
Cost Estimate for Remedial Alternative 6:
Excavation and MNA with DPE
Proposed Addendum to The Draft Feasibility Study Report
Former Unocal Edmonds Bulk Fuel Terminal
Edmonds, Washington

Task Description	Quantity	Units	Unit Lower Cost ($)	Unit Upper Cost ($)	Total Lower Cost ($)	Total Upper Cost ($)	Assumptions / Descriptions
Pre-Design Costs							
Surveying - Establish Control Points, Base Mapping, As-builts, Etc	1	Lump Sum	$2,000	$3,000	$2,000	$3,000	
Engineering Design		Lump Sum	$10,000	$15,000	$19,000	$28,500	
DB-2 Excavation							
Remediation Activities							
Mobilization/Demobilization	1	Lump Sum	$50,000	$100,000	$50,000	$100,000	
Excavation Work	3,000-5,800	Cubic Yards	$10	$15	$30,000	$86,730	Lower cost based on anticipated minimum excavation of DB-2 and upper cost based on the assumption that DB2 was built on top of the former Slops pond and complete removal of DB-2 and replacement assumed.
Lab (soil)	50-60	Sample	$572	$572	$28,600	$34,320	
Lab (water)	6	Sample	$950	$950	$5,700	$5,700	
Excavation Water Mangement	1	Lump Sum	$10,000	$15,000	$10,000	$15,000	
Material Handling - Impacted Soils	3,000-5,800	Cubic Yards	$7	$11	$21,000	$63,602	
Material Stockpile Area & Management	1	Lump Sum	$10,000	$15,000	$10,000	$15,000	
Truck Loading Area	1	Lump Sum	$5,000	$7,500	$5,000	$7,500	
Odor/Dust Control System & Material	1	Month	$5,000	$7,500	$5,000	$7,500	
Transportation and Off-Site Disposal							
- Hazardous Soil	0	Tons	$250	$375	$0	$0	
- Non-Hazardous Soil	4,500-8,700	Tons	$60	$90	$270,000	$780,570	
Air Monitoring	1	Lump Sum	$8,000	$12,000	$8,000	$12,000	
Excavation Restoration Activities							
Furnish Backfill	4,500-8,700	Ton	$15	$20	$67,500	$173,460	
Placement & Compaction of Backfill	3,000-5,800	CY	$6	$10	$18,000	$57,820	
Management							
Project Management (8% of Overall Costs)	1	Lump Sum	$43,984	$111,256	$43,984	$111,256	
Construction Oversight and Health & Safety (12% of Construction Costs)	1	Lump Sum	$63,456	$163,104	$63,456	$163,104	
				$657,240			
WSDOT Stormdrain DPE System							
Pilot Testing							
Work Plan/Design/Contractor Coordination	1	Lump Sum	$10,176	$12,211	$10,176	$12,211	
Well Drilling	1	Lump Sum	$24,417	$29,300	$24,417	$29,300	
Pilot Test Data Collection	1	Lump Sum	$22,502	$27,003	$22,502	$27,003	
Data Evaluation	1	Lump Sum	$5,982	$7,179	$5,982	$7,179	
DPE Design, Installation, and Start Up							
CAP and Design	1	Lump Sum	$39,156	$46,988	$39,156	$46,988	
Permitting (Air and water)	1	Lump Sum	$7,856	$9,427	$7,856	$9,427	
Well Installation, Trenching and Pipe Installation							
Drilling Labor and Expenses	1	Lump Sum	$13,921	$16,705	$13,921	$16,705	
Drillling - Subcontractor Costs	12	Well	$4,209	$5,050	$50,504	$60,605	
Trenching/Piping Labor and Expenses	1	Lump Sum	$12,286	$14,743	$12,286	$14,743	
Trenching/Piping - Subcontractor Costs	450	linear foot	$392	$471	$176,481	$211,777	
Treatment System and Enclosure - Design and Installation							
Design and Build Labor and Expenses	1	Lump Sum	$22,741	$27,289	$22,741	$27,289	
System Equipment	1	Lump Sum	$300,000	$360,000	$300,000	$360,000	
Electrical	1	Lump Sum	$52,506	$63,008	$52,506	$63,008	
System Hookup and Startup							
Labor and Expenses	1	Lump Sum	$13,207	$15,849	$13,207	$15,849	
Subcontractor Costs	1	Lump Sum	$4,281	$5,137	$4,281	$5,137	
System Operation							
Monthly operation (Year 1)	12	month	$6,131	$7,357	$73,566	$88,280	
Monthly operation (Year 2- Year 3)	24	month	$4,861	$5,834	$116,675	$140,010	
Monthly operation (Year 4 - Year 6)	36	month	$3,384	$4,061	$121,824	$146,189	
Groundwater Monitored Natural Attenuation	1	Lump Sum	$80,000	$100,000	$80,000	$100,000	
				Complete Remedial Alternative 6 Subtotal Cost	**$1,810,000**	**$3,050,000**	
				Contingency (30%)	**$543,000**	**$915,000**	
				Complete Remedial Alternative 6 Cost	**$2,353,000**	**$3,965,000**	

Table 2a
Remedial Alternatives Evaluation (DCA-Pass 1) Chevron Environmental Management Company
Proposed Addendum to the Draft Feasibility Study Report
Former Unocal Edmonds Bulk Fuel Terminal
Edmonds, Washington

Disproportionate Cost Analysis: Pass 1 (Ecology Weighting, Chevron Rankings and Public Concerns Criterion Added)

Alternatives				Remedial Alternative 1	Remedial Alternative 2	Remedial Alternative 3	Remedial Alternative 4	Remedial Alternative 5	Remedial Alternative 6
Disproportionate Cost Analysis Parameter	DCA Parameter Abbreviation	Parameter Weight	**USES RANK IN FS REPORT EXCEPT CONSIDERATION OF PUBLIC CONCERNS.**	Excavation + MNA	Groundwater Containment Using Extraction Wells	Groundwater Containment Using Groundwater Extraction Trench	Excavation of DB-2 and WSDOT Storm Drain Line	Excavation of DB-2 and ISS (Near WSDOT Storm Drain Line)	Excavation of DB-2 and DPE (To address WSDOT Storm Drain Line contamiantion)
Protectiveness	PRO	10	Overall protectiveness of human health and the environment	3	5	4	1	2	1
Permanence	PER	8	The degree to which the alternative permanently reduces the toxicity, mobility or volume of hazardous substances	3	5	4	1	2	1
Cost	COS	8	The cost to implement the alternative	1	3	4	5	2	3
Effectiveness over the long term	ELT	10	The degree of certainty of success, the reliability of the alternative, the magnitude of residual risk, and the effectiveness of controls	3	5	4	1	2	2
Management of short-term risks	STR	4	The risk to human health and environment associated with construction and implementation of the alternatives	3	1	2	5	4	4
Technical and administrative implementability	TAI	4	Technical feasibility of the alternative and administrative requirements	2	1	3	5	4	3
Consideration of public concerns	PC	6	Whether the community has concerns regarding the alternative and, if so, the extent to which the alternative addresses those concerns.	4	5	5	1	5	2
WEIGHTED SUMS:				**136**	**202**	**194**	**114**	**134**	**102**

Legend

[shaded] Remedial alternative rejected by Ecology

Table 2b
Remedial Alternatives Evaluation (DCA-Pass 2)
Chevron Environmental Management Company
Proposed Addendum to the Draft Feasibility Study Report
Former Unocal Edmonds Bulk Fuel Terminal
Edmonds, Washington

Disproportionate Cost Analysis :Pass 2 (Ecology Weighting and Rankings, and Public Concerns Criterion Added)									
				Remedial Alternative 1	Remedial Alternative 2	Remedial Alternative 3	Remedial Alternative 4	Remedial Alternative 5	Remedial Alternative 6
Disproportionate Cost Analysis Parameter	DCA Parameter Abbreviation	Parameter Weight		Excavation + MNA	Groundwater Containment Using Extraction Wells	Groundwater Containment Using Groundwater Extraction Trench	Excavation of DB-2 and WSDOT Storm Drain Line	Excavation of DB-2 and ISS (Near WSDOT Storm Drain Line)	Excavation of DB-2 & DPE (To address WSDOT SD Line)
Protectiveness	PRO	10	Overall protectiveness of human health and the environment	3	5	5	1	3	1
Permanence	PER	8	The degree to which the alternative permanently reduces the toxicity, mobility or volume of hazardous substances	3	5	5	1	3	1
Cost	COS	8	The cost to implement the alternative	1.20	2.25	2.51	5.00	1.75	2.25
Effectiveness over the long term	ELT	10	The degree of certainty of success, the reliability of the alternative, the magnitude of residual risk, and the effectiveness of controls	3	5	5	1	3	2
Management of short-term risks	STR	4	The risk to human health and environment associated with construction and implementation of the alternatives	3	1	2	5	4	4
Technical and administrative implementability	TAI	4	Technical feasibility of the alternative and administrative requirements	3	3	3	3	5	3
Consideration of public concerns	PC	6	Whether the community has concerns regarding the alternative and, if so, the extent to which the alternative addresses those concerns.	3	5	5	1	5	2
WEIGHTED SUMS:				**136**	**204**	**210**	**106**	**164**	**96**

Legend

Remedial alternative rejected by Ecology (grey shading)

Appendix A

Theis Equation with Superposition
Predict Drawdown Between Two Pumping Wells

Input Parameters

K =	**7.06E-04**	cm/sec	Hydraulic conductivity
b =	**30**	feet	Aquifer thickness
r =	**14**	feet	Distance from well to point of interest
S =	**0.1**		Storage coefficient
t =	**120**	days	Elapsed Time
Target System Flowrate	**21**	gpm	From MODFLOW
Target System Drawdown	**8**	ft	Based on smear zone thickness
# Wells	**7**		Idealized, based on site map
Well Spacing	**60**	ft	Idealized, based on site map
del x	**4**	ft	Grid spacing for chart

Conversions / Calculations

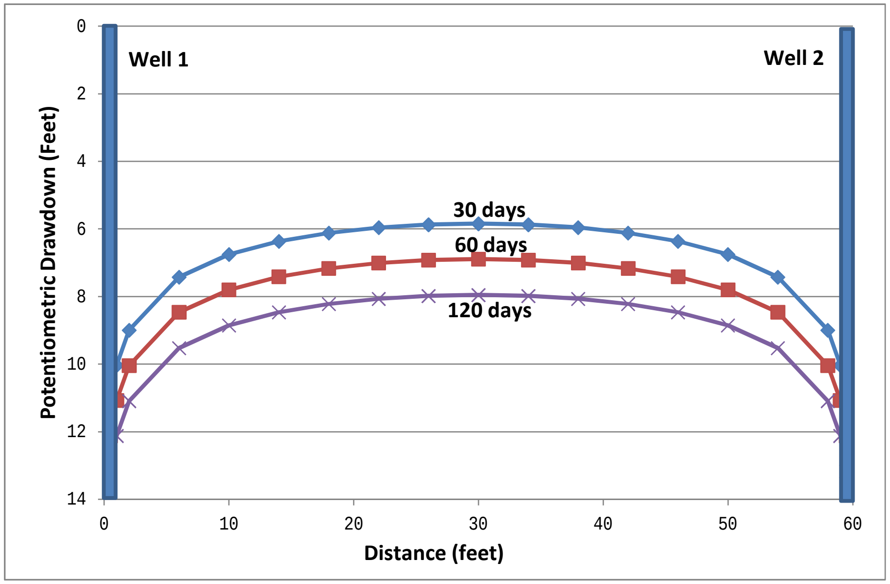
K =	2.0	ft/day	Hydraulic conductivity
T =	449.1	gpd/ft	Transmissivity
Q =	3.0	gpm	Pumping rate per well

Calculate Drawdown at Distance r at Time t

u =	0.001		
W(u) =	6.717		
s =	**5.14**	ft	Drawdown

Table of Drawdown Calculations for Chart

	Drawdown Calculations		
Distance (ft)	**t = 30 d**	**t = 60 d**	**t = 120 d**
0.5	11.08	12.1	13.2
1	10.0	11.1	12.1
2	9.0	10.0	11.1
6	7.4	8.5	9.5
10	6.8	7.8	8.9
14	6.4	7.4	8.5
18	6.1	7.2	8.2
22	6.0	7.0	8.1
26	5.9	6.9	8.0
30	5.8	6.9	8.0
34	5.9	6.9	8.0
38	6.0	7.0	8.1
42	6.1	7.2	8.2
46	6.4	7.4	8.5
50	6.8	7.8	8.9
54	7.4	8.5	9.5
58	9.0	10.0	11.1
59	10.0	11.1	12.1
59.5	11.1	12.1	13.2



Theis Assumptions
- Uniform, isotropic porous medium
- Uniform aquifer thickness
- Inifinite aquifer
- No recharge
- Fully penetrating pumping well
- Pumping well is 100% efficient
- All groundwater comes from aquifer storage
- Groundwater removed from aquifer storage is instantaneously discharged
- Laminar flow
- Potentiometric surface has no slope

Fate and Transport Parameters - TPH

Parameter	Value	Units	Source
Hydraulic Gradient	0.004	ft/ft	1
Hydraulic Conductivity	25	ft/day	1
Mobile Porosity	0.10	unitless	2
Source TPH Concentration (MW-525)	23	mg/L	1
Source Width	92	feet	1
Distance to Point of Compliance	142	feet	1
Dispersivity	0.5	feet	2
COC Retardation Factor	14.6	unitless	3
COC Organic Carbon Partition Coefficient (K_{oc})	8015	mL/g	2
Soil Bulk density	1.7	kg/L	2
Soil Fraction organic Carbon (f_{oc})	0.0001	unitless	2
Point of compliance TPH concentration (MW-20R)*	0.31	mg/L	1
COC Decay rate (half-life)	2.8	years	4

Notes
1. Site data
2. Literature/Assumed
3. Calculated
4. Estimated during calibration

* Point of compliance is also the calibration target

Evaluation Parameters

	Natural Conditions	Remediation
Source Zone Characteristics		
Length (feet)	60	
Width (feet)	334	
Thickness (feet)	10	
Depth to Source Zone (feet below ground surface)	4	
Depth of Water Table (feet below ground surface)	6	
Total Porosity (%)	35	
NAPL Characteristics		
Saturation (%)	25	
Density (grams /centimeter^3)	0.85	
Dissolution Mass Flux Below Water Table		
Hydraulic Conductivity (feet/day)	42	
Hydraulic Gradient (foot/foot)	0.006	
Estimated Solubility of TPH (micrograms/liter)	10,650	
Biodegradation Mass Flux Below Water Table		
Cumulative biodegradation rate constant (day^{-1})	0.007	0.007
half-life (days)	99	99
Submerged mass available for degradation (kg)	12.7	0.0
Vadose Zone Biodegradation Mass Flux		
Cumulative biodegradation rate constant (day^{-1})	0.01	0.01
half-life (days)	69	69
Unsubmerged mass available for degradation (kg)	6.6	20.2
Vadose Zone Volatilization Mass Flux		
Air phase diffusion coefficient (centimeters^2/second)	0.016	NA
Vapor concentration at source zone boundary (μg/m^3)	41,634,000	NA
Soil Vapor Extraction Flow Rate (feet^3/min)	NA	450
Extraction efficiency factor (β)	NA	0.1