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University of California
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Risk-Based Assessment of Appropriate Fuel Hydrocarbon Cleanup Strategies for the Castle Airport Petroleum, Oils, and Lubricants Fuel Farm Area (PFFA)

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Submitted to:

U.S. Air Force Center for Environmental Excellence, Environmental Restoration Directorate Technology Transfer Division, Brooks Air Force Base, Texas

October 1998

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**University of Calfornia, Santa Barbara
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****Malcolm Pernie Corporation, Emeryville, California
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Table of Contents

Appendix

1. Program Overview

1.1. Introduction

In June 1994, the State Water Resource Control Board (SWRCB) contracted with the Lawrence Livermore National Laboratory/University of California (LLNL/UC) Leaking Underground Fuel Tank (LUFT) Team to study the cleanup of LUFTs in California. The study consisted of data collection and analysis from LUFT cases and a review of other studies on LUFT cleanups. Two final reports were submitted to the SWRCB in October and November 1995. These reports were entitled: *Recommendations To Improve the Cleanup Process for California's Leaking Underground Fuel Tanks (LUFTs)* (Rice et al., 1995a), and *California Leaking Underground Fuel Tank (LUFT) Historical Case Analysis* (Rice et al., 1995b).

1.2. LUFT Demonstration Cleanup Program

1.2.1. Background

The LLNL/UC LUFT Recommendations Report also recommended that a series of LUFT sites be identified where the application of risk-based LUFT cleanup approaches could be demonstrated. As a result, ten Department of Defense (DoD) sites were selected to participate in a DoD Petroleum Hydrocarbon Cleanup Demonstration (PHCD) Program. This program will be referred to as the DoD LUFT Cleanup Demonstration Program. Site selection was coordinated through the California Military Environmental Coordination Committee (CMECC) Water Process Action Team (PAT). Sites were selected to represent each branch of the military services with bases in California, and as many of the California Regional Water Quality Control Boards (RWQCBs) and diverse hydrogeologic settings in California where fuel hydrocarbon (FHC) contaminant cleanup problems occur as possible. The Castle Airport petroleum fuel farm area (PFFA), within the Central Valley RWQCB, is one of the sites selected to participate in the DoD Petroleum Hydrocarbon Cleanup Demonstration (PHCD) Program.

The other sites selected and their corresponding RWQCB region are:

- Barstow Marine Corps Logistic Center, Tank 325 Site (Lahontan RWQCB).
- Camp Pendleton Marine Corps Base, Area 43 Gas Station Site (San Diego RWQCB).
- China Lake Naval Weapons Center, Navy Exchange Gas Station Site (Lahontan RWQCB).
- El Toro Marine Corps Air Station, Underground Storage Tanks 390A/B (Santa Ana RWQCB).
- George Air Force Base, Operable Unit 2 (Lahontan RWQCB).
- Port Hueneme Naval Construction Battalion Center, Navy Exchange Service Station Site (Los Angeles RWQCB).
- U.S. Army, Presidio of San Francisco, Building 637 area (San Francisco Bay RWQCB)
- Travis Air Force Base, North/South Gas Station Sites (San Francisco Bay RWQCB).
- Vandenberg Air Force Base, Base Exchange Gas Station Site (Central Coast RWQCB).

To oversee this process and provide guidance to sites participating in the DoD LUFT Cleanup Demonstration Program, a committee of experts was formed. This panel is comprised of scientific professionals from universities, private industry, and Federal regulatory agencies. The Expert Committee (EC) provides professional interpretations and recommendations regarding the application of risk based LUFT cleanup approaches and closures at demonstration sites. The EC members selected to evaluate the DoD LUFT Cleanup Demonstration Program sites are:

- Dr. Stephen Cullen, UC, Santa Barbara, Institute for Crustal Studies, Hydrogeologist; member of LLNL/UC LUFT Team with expertise in vadose zone FHC transport mechanisms and passive bioremediation processes.
- Dr. Lorne G. Everett, UC, Santa Barbara, Hydrogeologist; Director, Vadose Zone Research Laboratory and member of LLNL/UC LUFT Team, Chief Hydrologist with Geraghty & Miller, Inc., with expertise in vadose zone FHC transport mechanisms and passive bioremediation processes.
- Dr. Paul Johnson, Arizona State University, Chemical Engineer; primary author of *American Society for Testing and Materials (ASTM) Risk Based Correction Action (RBCA*) guidance, with expertise in chemical fate and transport.
- Dr. William E. Kastenberg, UC, Berkeley, Professor and Chairman, Department of Nuclear Engineering; member of the National Academy of Engineering; member of LLNL/UC LUFT Team, with expertise in environmental decision making and decision analysis processes.
- Dr. Michael Kavanaugh, Former Chairman, National Research Council Alternatives for Groundwater Cleanup Committee; member of the National Academy of Engineering; Vice President, Malcolm Pirnie, Inc., with expertise in evaluation of groundwater remediation alternatives and environmental decision making processes.
- Dr. Walt McNab, LLNL, Environmental Scientist, with expertise in the evaluation of passive bioremediation processes.
- Mr. David W. Rice, LLNL, Environmental Scientist; Project Director SWRCB LUFT Re-evaluation Project; LLNL/UC LUFT Team member; DoD FHC Demonstration Program Director and Expert Committee Chairman.
- Mr. Matthew Small, U.S. EPA Region IX, Hydrogeologist; Co-Chairman of U.S. EPA Remediation by Natural Attenuation Committee, with expertise in risk-based corrective action and passive bioremediation.

It should be recognized that the Expert Committee membership represents a range of professional opinions and biases. For this reason, documents prepared by the expert committee were reviewed and discussed by all the members of the expert committee and any findings, conclusions, and recommendations are reached through consensus.

1.2.2. Risk-Based Corrective Action

For a risk to exist, there must be a source of a hazard, a receptor, and a pathway that connects the two. All three factors must be addressed to determine whether a LUFT release poses a risk to human health, safety, or the environment. If the source, pathway, or receptor are at all times absent, there is, by definition, no risk. The distinction between sources, pathways, and receptors may be context-dependent in many cases and therefore must be carefully defined. For purposes of the present assessment, definitions of these terms are developed by working backward from the receptor to the source:

Receptor: Human or ecological risk receptors which may potentially be subject to damage by exposure to hydrocarbons via ingestion, inhalation, or absorption. This definition also specifically includes water-supply wells because it must be assumed that humans will be ingesting the water from these wells.

Pathways: Physical migration routes of contaminants from sources to risk receptors. This definition specifically includes the groundwater environment downgradient of the source which provides a medium through which dissolved contaminants may migrate to water-supply wells, as well as to surface water bodies which may serve as ecological risk pathways. The definition also includes the vadose zone in the immediate vicinity of the source, where vapor migration routes to nearby human receptors may exist.

Sources: Points of entry of contaminants into possible exposure pathways. In the case of hydrocarbon releases associated with LUFT sites, separate-phase hydrocarbon product which can either dissolve into the aqueous phase or volatilize into the gaseous phase constitutes a source. Primary sources will include underground tanks and associated piping; secondary sources will include any separate-phase hydrocarbon or free-product material residing within sediment pores.

From a mathematical viewpoint, sources and receptors represent boundary conditions for the problem of interest (influx and outflux, respectively); pathways represent the problem domain. Thus, in some special situations, the dissolved plume in groundwater may represent a source, such as in the case of Henry's law partitioning of contaminants from the aqueous phase into the gaseous phase. On the other hand, hydrocarbons which have adsorbed onto sediment surfaces from the aqueous phase cannot be regarded as potential sources in most situations according to this definition, but rather exist as part of the pathway.

Risk characterization is defined as an information synthesis and summary about a potentially hazardous situation that addresses the needs and interests of decision makers and of interested and affected parties. Risk characterization is a prelude to cleanup decision making and depends on an iterative, analytic, and deliberative process. This process attempts to gather all relevant data so the decision makers may then choose the best risk-management approach.

1.2.3. The Appropriate Use of Passive Bioremediation

The LLNL/UC LUFT Cleanup Recommendations Report also concluded that with rare exceptions, petroleum fuel releases will naturally degrade (passively bioremediate) in California's subsurface environments. The DoD LUFT Demonstration Cleanup Program provides sites where the appropriate use of passive bioremediation can be evaluated.

Passive bioremediation can control groundwater contamination in two distinct ways:

- First, passive bioremediation substantially lowers the risk posed to downgradient risk receptors through plume stabilization[1].
- Second, passive bioremediation actively destroys fuel hydrocarbon mass in the subsurface, leading to remediation of contamination over time (e.g., eventual contaminant concentration decline and depletion of the dissolved hydrocarbon plume). From a risk-management

[1] Even in the presence of a continuous constant source of fuel hydrocarbons (e.g., dissolution of residual free-product components trapped in the soil matrix), a groundwater plume subject to passive bioremediation will reach a steady-state condition in which plume length becomes stable. This will occur when the rate of hydrocarbon influx from dissolution of the residual free-product source is balanced by the rate of mass loss via passive bioremediation, integrated across the entire spatial extent of the plume.

viewpoint, the stabilization of the dissolved plume and associated reduction in exposure potential is the most important contribution of passive bioremediation.

The role of passive bioremediation in controlling the behavior of dissolved hydrocarbon plumes may be evaluated through both primary and secondary field evidence.

- Primary evidence includes quantitative evaluation of plume stability or plume shrinkage based upon trends in historical groundwater contaminant concentration data.
- Secondary evidence includes indirect indicators of passive bioremediation, such as variations in key geochemical parameters (dissolved oxygen, nitrate, sulfate, iron, manganese, methane, alkalinity/carbon dioxide, Eh, pH) between measurements in fuel hydrocarbon-impacted areas and background.

Although primary evidence of plume stability or decline generally provides the strongest arguments to support natural attenuation at a given site, such evidence may not be available because adequate historical groundwater monitoring may not exist. In these cases, short-term monitoring data providing secondary lines of evidence, in conjunction with modeling, where appropriate, may support a hypothesis for the occurrence of passive bioremediation. Consequently, means for assessing the role of passive bioremediation in controlling risk by secondary lines of evidence should be fully explored at such sites.

Appropriate use of passive bioremediation as a remedial alternative requires the same care and professional judgment as the use of any other remedial alternative. This includes site characterization, assessment of potential risks, comparison with other remedial alternatives, evaluation of cost effectiveness, and the potential for bioremediation to reach remedial goals. Monitoring process and contingency planning must be considered as well.

Passive bioremediation may be implemented at a given petroleum release site either as a stand-alone remedial action or in combination with other remedial actions. The need for active source removal must also be addressed on a site-by-site basis. Source removal includes removing leaking tanks and associated pipelines and any remaining free product and petroleum fuel saturated soil, as much as economically and technically feasible. When properly used, passive bioremediation can help manage risk and achieve remedial goals.

1.2.4. The DoD LUFT Cleanup Demonstration Program Steps

The process used by the LUFT Cleanup Demonstration Program can be summarized in the following steps:

Step 1: An initial site scoping meeting was held with each site's staff, regulators, and DoD LUFT Cleanup Demonstration Program representatives to discuss site conceptual model and identify and discuss pathways and receptors of concern. Guidance was provided to assist the site staff and contractors in preparing a site-specific data package which was used to brief the DoD LUFT Cleanup Demonstration Program EC members.

Step 2: In parallel with the initial site scoping, training in risk-based cleanup approaches was offered for DoD LUFT Cleanup Demonstration Program participants.

Step 3: The DoD LUFT Cleanup Demonstration Program EC members next visited each site and were briefed on the site's characterization, conceptual model, and pathways and receptors of concern. A site tour was included in this briefing. A lead EC member was designated for each site. Following each site visit, the EC reviewed and identified additional data needed to apply a risk-based LUFT cleanup approach. A site characterization letter report was prepared containing recommendations for further data collection, if needed (See Appendix A). Sampling and monitoring procedures to support evaluations of passive bioremediation processes which may be occurring at the site were also identified.

Step 4: Once the best available data had been provided, the EC members considered how a risk-based cleanup approach may be applied to the site and prepared its recommendations for an appropriate risk-management strategy at the site and the set of actions needed to achieve site closure. Included in this process was an evaluation of the appropriate use of natural attenuation as a remedial alternative at the site. Whenever possible, an estimate of the time to cleanup and the uncertainty associated with this estimate was also made.

The EC's risk-based site-specific assessment of appropriate fuel hydrocarbon cleanup strategies is provided in draft to each site to provide an opportunity for site regulators and other stakeholders to comment. After considering the offered comments, the EC members prepare a final site-specific risk-management strategies report which was delivered to each site.

Step 5: Finally, once all the sites had been evaluated, the EC will prepare a final program report, which is a summary of DoD LUFT Cleanup Demonstration Program findings and lessons learned in applying risk-based cleanup at California DoD sites, including conclusion and recommendations to both the DoD and SWRCB. In addition to the final program report, the DoD LUFT Cleanup Demonstration Program lessons learned are provided in the DoD *Risk Execution Strategy for Clean-Up of the Environment* implementation guide (RESCUE) Road Map) that can be accessed by DoD sites through the world-wide-web. A discussion of the cost savings using risk-based cleanup protocols will be provided in a separate document.

2. Site Overview

2.1. Background and Site History

Castle Airport (the former Castle Air Force Base) is located in Merced County, California. It occupies approximately 3,000 acres about 5 miles northwest of the city of Merced, CA. Castle AFB was officially closed in September 1995, and parts of the base have been leased to public and private entities.

Environmental investigations, underground storage tank removal, and soil and groundwater remediation options are still in progress. The petroleum fuel farm area (PFFA) is one of these active areas.

According to documents supplied to the EC, the PFFA was built in the 1940s to provide intermediate storage of petroleum fuels at the former Castle Air Force Base (Parsons Engineering Science, 1997). As at other fuel farm sites of a similar age and purpose, underground storage tanks (USTs), above ground storage tanks (ASTs), pipelines, and rail lines have been installed at the PFFA. Some of these still remain. The PFFA also includes areas that were formerly used for vehicle maintenance and equipment washdown, and the PFFA is located in the vicinity of a wastewater treatment plant and associated sewer lines.

Use of the existing facilities by public and private entities is encouraged, thus it is likely that the facility will remain intact in the short-term.

2.2. Expert Committee Reports for Castle Airport

This letter is the second of two deliverables; it focuses on recommendations for risk-based management and remediation strategies appropriate for the Castle Airport PFFA. The first report identified whether or not the EC feels that there is sufficient data to create a site conceptual model adequate to make RBCA decisions (Appendix A). It should be noted that the EC letters do not address whether or not the existing data satisfy legal or regulatory requirements.

In brief, the first letter report concludes that the available data is sufficient to support risk-based decisions under current site conditions, but that the data is not sufficient to be used in making risk-based decisions for unrestricted future land use scenarios. Table 1 contains the EC recommendations for data gathering, for a range of possible immediate and future risk-management options.

Table 1. Example supplemental data needs—risk management option matrix.

Example management options	Supplemental data needs
• Continued operation of pump and treat system, with site access limited to remediation system operators.	• Integrity of existing primary sources. • Characterization of concrete sump area where oil sheen appears on the water.
• Continued operation of pump and treat system, leasing and future use of PFFA for fuel storage and transfer, with site access limited to PFFA workers, no construction activities allowed.	• Integrity of existing primary sources. • Characterization of concrete sump area where oil sheen appears on the water. • Soil gas survey along preferential pathways (sewers, pipelines, etc.).
• Continued operation of pump and treat system, remediation of vadose zone contaminants by bioventing/soil vapor extraction, leasing of PFFA, with site access limited to PFFA workers, construction activities allowed.	• Integrity of existing primary sources. • Characterization of concrete sump area where oil sheen appears on the water. • Soil gas survey along preferential pathways (sewers, pipelines, etc.).
• Discontinue operation of pump and treat system, natural attenuation in the vadose zone and groundwater, unlimited site access (if site-specific target level determination shows this to be acceptable).	• Integrity of existing primary sources. • Characterization of concrete sump area where oil sheen appears on the water. • Soil gas survey along preferential pathways (sewers, pipelines, etc.). • Detailed soil gas survey involving increased vertical resolution and analyses for contaminants and respiration gases. • Additional soil borings near all primary sources with increased vertical resolution and analyses for contaminants, as well as moisture content and permeability measurements. • Continued groundwater monitoring with emphasis on data necessary to demonstrate natural attenuation. • Installation of sentinel well system.

To date, the EC has not received any additional data or formal feedback from any parties since the preparation of the first letter report. The recommendations in this report reflect site information made available to the EC at the time of the writing of the first letter report.

3. Risk-Based Cleanup

The result of a risk-based analysis (whether it be the ASTM RBCA approach or some other variant) includes:

- A rapid assessment of the urgency of response based on considerations of the possible time and severity of impact; this helps to quickly identify appropriate initial response actions (abatement, containment, monitoring, etc.) and can help regulatory staff prioritize/manage their case loads.
- A determination of whether or not site conditions are acceptable.
- If conditions are not acceptable—defining remedial goals for the site. These include both cleanup levels and a target time frame within which these numeric standards should be achieved.

Risk-based cleanup approaches applied to LUFT releases has received considerable attention on the national level and is being promoted by the U.S. EPA. Many states are re-evaluating their cleanup policies and guidelines, and a considerable investment in the training of state regulators has been made.

This report follows the sequence of activities outlined in the *ASTM E1739-95 Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites*. Below, sections of this letter report address:

1. Site characterization.
2. Site classification and appropriate initial response actions.
3. Tier 1 analysis.
4. Tier 1—Tier 2 transition considerations.
5. Corrective action options.

4. Site Conceptual Model

4.1. Site Characterization Requirements

ASTM E1739-95 outlines guidelines for site characterization requirements. In general, the goal is to collect sufficient data to be able to classify a site, select an appropriate initial response action, and at a minimum conduct a Tier 1 analysis. Specific site characterization requirements often include:

- A review of historical records of site activities and reported releases.
- Identification of chemicals of concern (COC).

- Locations and values of maximum COC concentrations in soil and groundwater.
- Locations of human and environmental receptors in immediate and surrounding area.
- Identification of chemical migration pathways.
- Determination of current and future use of the site and any impacted resources.
- Determination of local and regional hydrogeologic conditions (if groundwater is, or is likely to be, impacted).
- Qualitative assessment of ecological impacts.

When sufficient historical data is available, then one can also:

- Determine the extent of COC above Tier 1 action levels with time.
- Determine the changes in COC concentration over time.

After collecting this data a site conceptual model is rapidly formulated and used for the basis of future decision making.

4.2. Components of the Castle Airport Conceptual Model

A well defined conceptual model of a site contains sufficient information to: (1) identify sources of the contamination, (2) determine the nature and extent of the contamination, (3) identify the dominant fate and transport characteristics of the site, (4) specify potential exposure pathways, and (5) identify potential receptors that may be impacted by the contamination.

4.2.1. Primary Sources

According to documents supplied to the EC, the PFFA was built in the 1940s to provide intermediate storage of petroleum fuels at the former Castle Air Force Base. As at other fuel farm sites of a similar age and purpose, underground storage tanks (USTs), above ground storage tanks (ASTs), pipelines, and rail lines have been installed at the PFFA. Some of these still remain. The PFFA also includes areas that were formerly used for vehicle maintenance and equipment washdown, and the PFFA is located in the vicinity of a wastewater treatment plant and associated sewer lines.

The fuel storage tanks, pipelines, and rail lines are clearly the potential primary sources with the largest capacity. Other potential primary sources have been present in the area, although these are smaller in size; they include oil/water separators, rinse areas, and sewer lines.

Most of the USTs have been removed; four USTs by Building 502 were removed in June 1996. Four large ASTs (3,000,000 gallons cumulative capacity) are still present at the PFFA. A pipeline leading to the PFFA from a refinery is operational, although it is currently not in use.

For the most part, chemicals used in this area include petroleum products, such as jet fuel, diesel, and gasoline. Smaller volumes of solvents were likely present in vehicle maintenance areas, and pesticides were likely present at the Entomology Yard.

While the available historic information is sufficient to identify possible primary sources of contamination at the PFFA (USTs, ASTs, pipeline, rail line, wash down area, maintenance area, etc.), the historic data provided to the EC is not sufficient to estimate the location, magnitude, or timing of any specific releases at the PFFA.

In the absence of this data, therefore, it is necessary to extrapolate from experience at other fuel storage sites of similar size and age, and to assume that leaks and spills occurred at some time from some of the storage tanks, pipelines, and other petroleum/solvent storage containers. It is unreasonable to assume otherwise based on experience. This is a conservative hypothesis that can be tested by review of soil, soil gas, and groundwater sampling data.

While historic information concerning specific releases would be helpful and corroborative for other site characterization data, this lack of information does not hinder the RBCA decision making at the site.

4.2.2. Secondary Sources and the Extent of Contamination

Remedial investigations at the PFFA have included soil sampling, groundwater sampling, and soil gas survey data. Each of these is addressed below.

Soil borings have been drilled at many locations within the PFFA (an exact number was not available, but there appear to have been >60). For the most part discrete soil samples appear to have been collected at fixed depths, and on average approximately four to five soil analyses were conducted within 0 to 60 ft below ground surface (bgs) at each location. Most borings had samples collected from depths of 20, 40, and 60 ft bgs, and a few samples were collected from depths of 5, 10, 15, 20, 25, 30, and 50 ft bgs. Some field screening of soil samples appears to have occurred, but the boring logs suggest that this was not done consistently. Instead the data seem to suggest that samples were collected at fixed intervals without regard for location-specific conditions. In the absence of real-time field screening of the soil cores, this level of vertical resolution would be considered sparse at most sites.

The chemical analyses data show that soil contamination exists at the PFFA, but the data is unusual in that it does not suggest the extensive soil contamination common to fuel storage sites of similar age and use. Whether or not this is an artifact of the sparse vertical sampling or is representative of actual conditions at the site, cannot be determined. However, the soil, soil gas, and groundwater data (to be discussed) collectively suggest that, if wide-spread soil contamination does exist, then it is confined to a narrow vertical region of the unsaturated zone. Regions where continuous vertically-distributed soil contamination is present are isolated, suggesting that releases occurred in only a few locations. Free-product is not detected on site, and the documents available to EC make no mention of any ever being detected in PFFA monitor wells. Soil contaminant concentrations are low relative to those expected of soils through which petroleum liquids had drained (generally TPH>5,000 mg/kg). This suggests that any releases that did occur in the past were small in volume or slow in rate, and that natural attenuation mechanisms may have played a role in minimizing their impacts.

It should be noted, however, that soil samples have not been collected adjacent to all of the primary sources due to access restrictions. Thus the data is not sufficient to assess whether or not releases from the ASTs have occurred.

Groundwater data generally support the soil concentration data. The magnitude of the dissolved aromatic (e.g., benzene) and chlorinated hydrocarbon (e.g., trichloroethylene [TCE]) concentrations suggest that residually-contaminated soils are not in intimate contact with groundwater at this time. It is hypothesized that the dissolved TCE plume resulted from leaking sewer lines as well as other releases that occurred outside of the PFFA.

Soil gas data reveal relatively high concentrations (>1,000 ppm_v) of contaminant vapors extending over a much larger continuous area than one would expect from the groundwater or soil data. Considering the data collectively, the soil gas data might be explained by the following scenario: liquid fuel leaking slowly from a source (or sources) in the past percolated down to the groundwater table and spread laterally in a thin layer due the high permeability soils; then, when the water table lowered (current groundwater elevation is approx. 60 ft bgs compared with historic levels of 20 ft bgs), a thin zone of residual soil contamination is left and held in place by capillary forces. Data suggest that this region might reside in the 20 to 40 ft bgs region.

Contaminants typically of concern detected at significant concentrations (from a regulatory perspective) include aromatic compounds (e.g., benzene, toluene, etc.) and chlorinated solvents (e.g., TCE and PCE). Groundwater benzene and TCE concentrations exceed MCL and California MCL target levels. Soil gas vapor concentrations could be in the explosive range and they do exceed worker health standards for some individual constituents.

While the soil, groundwater, and soil gas data are not entirely self-consistent, the data are sufficient to paint a reasonable picture of the extent and magnitude of contaminants in groundwater and soil vapor at the site, and to lead to a reasonable hypothesis concerning the soil contamination distribution. The actual extent of soil contamination at the site is less certain, but this is often the case at these type of sites.

4.2.3. Transport Mechanisms and Transport Media

The PFFA site is largely paved and only a few exposed grassy areas are present. One of these, located over the past UST pit near Building 502, is watered regularly. The site is underlain by silty sand in the 0 to 20 ft bgs interval, and a silt layer exists between 20 and 35 bgs. Below this, at least within depths of interest, the soil is largely composed of sands.

Groundwater is currently at a depth of about 60 ft bgs, but at times within the past 50 years has been within 20 ft of ground surface. Seasonal groundwater fluctuations average a few feet. The regional groundwater flow direction appears to be to the west and northwest. Groundwater flow directions in the PFFA are influenced by operating pump and treat groundwater recovery wells, but the flow direction currently does not deviate greatly from the regional flow. However, changes in pumping rates and the addition of other pumping wells could alter this. Data and modeling suggest that groundwater leaving the PFFA is captured downgradient by operating pump and treat systems.

Estimates of the aquifer hydraulic conductivity range fall in the 100 to 1,000 ft/day range, based on short-term aquifer tests. When combined with hydraulic gradient estimates (approx. 0.0025 ft/ft) and reasonable porosity estimates, the estimated groundwater velocity at the PFFA is approximately 3 ft/day.

The existing data at the site is sufficient to identify groundwater flow and vapor migration as the two primary mechanisms for contaminant migration away from the PFFA site. There must also be some vertical component of transport in the vadose zone, presumably by infiltration, or else there would not be the petroleum hydrocarbon impacts to groundwater.

4.2.4. Exposure Media

Contaminants are currently present in soil, groundwater, and soil gas. Any or all of these could be exposure media if future land use is unrestricted. However, for current site usage, soil gas/air is the most likely potential exposure media.

4.2.5. Receptors

Currently, access to the site is limited, and it appears that when workers are present, then they are only present for short periods of time. With respect to near-term future uses, it is presumed that on-site workers may be present as well as the occasional construction worker. There are no indications that the PFFA is impacting or is likely to impact any sensitive ecological receptors. The PFFA is impacting a resource (groundwater), which from a regulatory perspective, might be considered to be a receptor.

5. Site Classification and Initial Response

5.1. Conclusions

Given the available site data, the conceptual model developed above, and using the example site classification approach presented in ASTM E1739-95, the EC concludes the following:

- As there is a pump and treat system in operation, and it appears that this system is capturing dissolved contaminants emanating from the PFFA, it is unlikely that water-supply wells will be impacted, or that additional resource impact will occur.
- There are high soil vapor concentrations present at depth, but no known enclosed spaces within which they might accumulate.
- The most immediate concerns are: a) construction worker safety during any excavations, and b) the prevention of any future releases from the PFFA.

5.2. Classification and Initial Response Action(s)

This site would most likely be classified as a Class 3 site ("long-term threat to human, health, safety, or environmental receptors"). Thus, the recommended initial response actions are:

- Continue to operate and monitor the performance of the pump and treat system.
- Restrict site access in areas with high soil gas concentrations.
- Restrict the construction/installation of any possible vapor migration conduits or enclosed spaces where vapors might accumulate (basements, sewers, etc.).

5.3. Assumptions/Restrictions

It should be noted that this classification, and the conclusions and recommendations are based on available data, current land use, and existing site conditions. Should any of these change, the site classification and initial response should be revised as appropriate.

6. Tier 1 Analysis

6.1. Purpose

The purpose of the Tier 1 analysis is to determine if the concentrations of chemicals of concern at the site exceed risk-based screening levels. Concentrations falling below the screening levels are not of concern. Exceedences indicate that there may be potential for adverse impact; but, more site-specific assessment would be necessary to determine the potential for such impacts to occur.

6.2. Risk-Based Screening Levels

Risk-based screening levels (RBSLs) are generally listed in a Tier 1 Look-Up Table, and represent values below which there are no unacceptable risks of adverse impacts. In the absence of California-specific values for soils and groundwater, it is assumed here that the *de facto* groundwater RBSLs are the California drinking water standards. While appropriateness of these values can be debated, it is recognized that in current practice the drinking water standards are the initial values against which all measured groundwater concentrations are compared.

Normally, RBSLs for other possible exposure pathways (e.g., volatilization-inhalation) would be used as well; however, the analysis below will show that the absence of such values in this case does not affect the conclusions or recommendations.

6.3. Tier 1 Conclusions

Given the available site data, the conceptual model developed above, and using the example site classification approach presented in ASTM E1739-95, the EC concludes the following:

- Given that this is a closure base and use of the land and facilities is being encouraged (and at this point not restricted), use of the groundwater and construction activities must be considered.
- Existing groundwater concentrations exceed Tier 1 RBSLs.
- Total hydrocarbon soil gas concentrations, being in the percent levels at depth, exceed any foreseeable Tier 1 soil gas levels.

7. Tier 1 Decision Point

7.1. Background

Whenever Tier 1 RBSLs are exceeded the user has two primary options:

1. Institute remedial measures to achieve the generic cleanup goals.
2. Develop site-specific cleanup levels, and then compare site conditions to these new values.

In most situations the preferred alternative is the one projected to be the most cost-effective.

7.2. Analysis

One important factor at this site is that it is a closure base, and the EC is not aware of any current or planned land use restrictions. Another important factor is that the PFFA lies over a larger dissolved chlorinated solvent plume that has already been targeted for remediation, and an effective groundwater capture and treatment system is in operation.

Given these considerations and experiences with other Tier 2 analyses, the EC feels that the most cost-effective option at this time is to pursue option #2, above.

8. Selecting and Implementing a Remedial Action Plan

8.1. Groundwater Contamination

The dissolved groundwater contamination originating from the PFFA is currently being captured and treated by the existing pump and treat system put in place to deal with the larger-scale chlorinated solvent contamination problem. The use of this system for also dealing with the PFFA plume should be continued, at least until chlorinated solvent remedial goals are met.

At the time when the chlorinated solvent remedial goals are met, then an assessment of the effectiveness of natural attenuation should be evaluated for treatment of chemicals of concern originating from the PFFA, provided that their concentrations still exceed Tier 1 RBSLs.

It is not feasible at this time to assess the effectiveness or appropriateness of natural attenuation because the pump and treat system is affecting the local hydrology and dissolved oxygen concentrations. However, it can be said that the hydrogeologic conditions at this site fall within the range of conditions included in the LLNL/UC LUFT benzene plume study, and it is expected that dissolved BTEX plume growth would be limited by natural processes to within 400 ft of the source zone.

8.2. Soil Contamination

Soil sample data suggest that near the former Building 502 UST location, residual hydrocarbon contamination is located in a fairly thin stratigraphic region. Soils are permeable, soil gas concentrations are high, groundwater levels are lower than historical highs, and respirometry data from a bioventing pilot test are promising. Thus, the EC recommends that the use of soil vapor extraction and bioventing be considered to accelerate the remediation of vadose zone soils. Until soil gas concentrations are lowered, land use restrictions, especially with respect to digging, trenching, or other construction, should be put in place.

The probability of success associated with this approach seems to outweigh the risks of leaving soil contamination in place (e.g., it will have more impact on groundwater and be harder to treat if the water table rises) and the costs and logistics involved with restricting land use.

9. Other Considerations

9.1. Site Characterization

As stated earlier, this analysis is limited by the data provided to the EC. As pointed out in the first letter report, there are areas of the PFFA that have not received adequate characterization. In particular, regions near the above-ground storage tanks (ASTs) have not been characterized as well as other areas of the PFFA. Thus, soil contamination may exist that requires further consideration.

Despite the data/knowledge gaps, the EC feels that its recommendations are fairly robust in the sense that the recommendations are protective whether or not unknown contamination exists at the site. For example, even if unknown contamination exists and is migrating to groundwater, the existing groundwater pump and treat system captures and treats all of the water flowing from the PFFA. In the event that use of the pump and treat system were to be discontinued, then knowledge of the conditions near the ASTs would become more important.

9.2. Prevention

As use of the existing facilities by private or public parties is being encouraged, and given the magnitude of the storage and throughput capacity of the PFFA, it is recommended that the integrity of all remaining sources be verified prior to their use to prevent significant future releases.

10. References

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Appendix A
Castle Airport Petroleum, Oils, and Lubricants Fuel Farm Area (PFFA) Site Assessment Review Letter Report

Lawrence Livermore National Laboratory

ASSESSMENT OF THE ADEQUACY OF AVAILABLE SITE CHARACTERIZATION DATA FOR APPLICATION OF RISK-BASED CORRECTIVE ACTION (RBCA) AT THE CASTLE AIRPORT PETROLEUM, OILS, AND LUBRICANTS FUEL FARM AREA (PFFA)

BACKGROUND

The Expert Committee (EC), established under the California Department of Defense Petroleum Hydrocarbon Cleanup Demonstration Program, has reviewed the methods and findings of various reports prepared for the Castle Airport (formerly Castle Air Force Base) Petroleum, Oils, and Lubricants Fuel Farm Area (PFFA). Enclosed is the EC's assessment of the adequacy of the existing site characterization data and proposed site conceptual model for making risk-based corrective action (RBCA) decisions at this site.

RBCA decisions are generally based on the urgency of response and the severity of potential adverse impacts at a given site. To assess these, the decision-maker relies on a conceptual site model, which in turn is built up from knowledge of:

- primary sources (e.g., storage tanks, pipelines, etc.),
- secondary sources (e.g., soils containing residual contamination, free product)
- transport mechanisms and transport media (e.g., groundwater, vapor migration, lithology, etc.),
- possible exposure media (e.g., air, drinking water, etc.), and
- current and future potential receptors (e.g., humans, sensitive ecological species, sensitive resources, etc.)

The <u>evaluation of current and future potential receptors</u> requires knowledge of current and future site usage, as well as any use restrictions that exist, or are to be put in place.

This letter is the first of two deliverables; it focuses on whether or not the EC feels that there is sufficient data in each of the knowledge areas identified above to create a site conceptual model (or support an existing one) adequate to make RBCA decisions. The EC review and this letter <u>do not</u> address whether or not the existing data satisfy legal or regulatory requirements.

The second deliverable will focus on recommendations for risk-based management and remediation strategies appropriate for the Castle Airport PFFA.

COMPONENTS OF THE CONCEPTUAL MODEL

Primary Sources

According to documents supplied to the EC, the PFFA was built in the 1940's to provide intermediate storage of petroleum fuels at the former Castle Air Force Base. As at other fuel farm sites of a similar age and purpose, underground storage tanks (USTs), above ground storage tanks (ASTs), pipelines, and rail lines have been installed at the PFFA. Some of these still remain. The PFFA also includes areas that were formerly used for vehicle maintenance and equipment washdown, and the PFFA is located in the vicinity of a wastewater treatment plant and associated sewer lines.

The fuel storage tanks, pipelines, and rail lines are clearly the potential primary sources with the largest capacity. Other potential primary sources have been present in the area, although these are smaller in size; they include oil/water separators, rinse areas, and sewer lines.

Most of the USTs have been removed; the documents provided indicate that four operating USTs may still be present. Four large ASTs (3,000,000 gallons cumulative capacity) are still present at the PFFA. A pipeline leading to the PFFA from a refinery is operational, although it is currently not in use.

For the most part, chemicals used in this area include petroleum products, such as jet fuel, diesel, and gasoline. Smaller volumes of solvents were likely present in vehicle maintenance areas, and pesticides were likely present at the Entomology Yard.

While the available historic information is sufficient to identify possible primary sources of contamination at the PFFA (USTs, ASTs, pipeline, rail line, wash down area, maintenance area, etc.), the historic data provided to the EC is not sufficient to estimate the location, magnitude, or timing of any specific releases at the PFFA.

In the absence of this data, therefore, it is necessary to extrapolate from experience at other fuel storage sites of similar size and age, and to assume that leaks and spills occurred at some time from some of the storage tanks, pipelines, and other petroleum/solvent storage containers. It is unreasonable to assume otherwise based on experience. This is a conservative hypothesis that can be tested by review of soil, soil gas, and groundwater sampling data. We address this issue next.

While historic information concerning specific releases would be helpful and corroborative for other site characterization data, at this time the EC does not feel that this lack of information will hinder RBCA decision-making at the site.

However, a critical input to the RBCA process would be the status (e.g., integrity) and intended future use plans for any remaining storage tanks, transfer lines, sewers and pipelines at the PFFA, as these might continue to act as sources for contamination at the site.

In addition, reports provided to the EC do not clearly show the locations of all past and present primary sources at the PFFA. A site plan view map showing these locations would be helpful in the development of the site conceptual model.

Secondary Sources and the Extent of Contamination

Remedial investigations at the PFFA have included soil sampling, groundwater sampling, and soil gas survey data. Each of these is addressed below.

Soil borings have been drilled at many locations within the PFFA (an exact number was not available, but there appear to have been >60). For the most part discrete soil samples appear to have been collected at fixed depths, and on average approximately four to five soil analyses were conducted within 0 to 60 ft below ground surface (bgs) at each location. Most borings had samples collected from depths of 20, 40, and 60 ft bgs, and a few samples were collected from depths of 5, 10, 15, 20, 25, 30, and 50 ft bgs. Some field screening of soil samples appears to have occurred, but the boring logs suggest that this was not done consistently. Instead the data seem to suggest that samples were collected at fixed intervals without regard for location-specific conditions. In the absence of real-time field screening of the soil cores, this level of vertical resolution would be considered sparse at most sites.

The chemical analyses data show that soil contamination exists at the PFFA, but the data is unusual in that it does not suggest the extensive soil contamination common to fuel storage sites of similar age and use. Whether or not this is an artifact of the sparse vertical sampling, or representative of actual conditions at the site cannot be determined. However, the soil, soil gas, and groundwater data (to be discussed) collectively suggest that if wide-spread soil contamination does exist, then it is confined to a narrow vertical region of the unsaturated zone. Regions where continuous vertically-distributed soil contamination is present are isolated, suggesting that releases occurred in only a few locations. Free-product is not detected on site, and the documents available to EC make no mention of any ever being detected in PFFA monitoring wells. Soil contaminant concentrations are low relative to those expected of soils through which petroleum liquids had drained (generally TPH >5,000 mg/kg). This suggests that any releases that did occur in the past were small in volume or slow in rate, and that natural attenuation mechanisms may have played a role in minimizing their impacts.

However, it should be noted that soil samples have not been collected adjacent to all of the primary sources due to access restrictions. Thus the data is not sufficient to assess whether or not releases from the ASTs have occurred.

Groundwater data generally support the soil concentration data. The magnitude of the dissolved aromatic (e.g., benzene) and chlorinated hydrocarbon (e.g., trichloroethane [TCE]) concentrations suggest that residually-contaminated soils are not in intimate contact with groundwater at this time. It is hypothesized that the dissolved TCE plume resulted from leaking sewer lines as well as other releases that occurred outside of the PFFA.

Soil gas data reveal relatively high concentrations (>1,000 ppm_v) of contaminant vapors extending over a much larger continuous area than one would expect from the groundwater or soil data. Considering the data collectively, the soil gas data might be explained by the following scenario: liquid fuel leaking slowly from a source (or sources) in the past percolated down to the groundwater table and spread laterally in a thin layer due the high permeability soils; then, when the water table lowered (current groundwater elevation is approximately 60 ft bgs compared with historic levels of 20 ft bgs), a thin zone of residual soil contamination is left and held in place by capillary forces. Data suggests that this region might reside in the 20 to 40 ft bgs region.

Contaminants typically of concern detected at significant concentrations (from a regulatory perspective) include aromatic compounds (e.g., benzene, toluene, etc.) and chlorinated solvents (e.g., TCE and PCE). Groundwater benzene and TCE concentrations exceed MCL and California MCL target levels. Soil gas vapor concentrations could be in the explosive range and they do exceed worker health standards for some individual constituents.

While the soil, groundwater, and soil gas data are not entirely self-consistent, the data are sufficient to paint a reasonable picture of the extent and magnitude of contaminants in groundwater and soil vapor at the site, and to lead to a reasonable hypothesis concerning the soil contamination distribution. The actual extent of soil contamination at the site is less certain, but this is often the case at these type of sites. The EC feel that some of the data has been over-interpreted and do not agree with the impacted soil regions defined by contour plots in the reports provided to the EC.

The EC feels that the secondary source data available is sufficient to support some risk-based corrective action decisions under the current site conditions and use; however, the data probably is not sufficient to be used for making risk-based decisions involving unrestricted future use scenarios.

During the site visit, it was noted that a sheen of oil was present on the water pooled in a near surface concrete collection basin. No note of this appears in the data provided to the EC. This suggests that not all possible secondary sources have been identified, characterized, and/or corrected. This possible secondary source should be investigated.

Transport Mechanisms and Transport Media

The PFFA site is largely paved, and only a few exposed grassy areas are present. One of these, located over the past UST pit, is watered regularly. The site is underlain by silty sand in the 0 to 20 ft bgs interval and a silt layer exists between 20 and 35 bgs. Below this, at least within depths of interest, the soil is largely composed of sands.

Groundwater is currently at a depth of about 60 ft bgs, but at times within the past 50 years has been within 20 ft of ground surface. Seasonal groundwater fluctuations average a few feet. The regional groundwater flow direction appears to be to the west and northwest. Groundwater flow directions in the PFFA are influenced by operating pump and treat groundwater recovery wells, but the flow direction currently does not deviate greatly from the regional flow. Changes in pumping rates and the addition of other pumping wells could alter this however. Data and modeling suggest that groundwater leaving the PFFA is captured down-gradient by operating pump and treat systems.

Estimates of the aquifer hydraulic conductivity range fall in the 100 to 1,000 ft/d range, based on short-term aquifer tests. When combined with hydraulic gradient estimates (approximately 0.0025 ft/ft) and reasonable porosity estimates, the estimated groundwater velocity at the PFFA is approximately 3 ft/d.

The existing data at the site is sufficient to identify groundwater flow and vapor migration as the two primary mechanisms for contaminant migration away from the PFFA site. There must also be some vertical component of transport in the vadose zone, presumably by infiltration, or else there would not be the petroleum hydrocarbon impacts to groundwater.

Data is sufficient to estimate site-specific groundwater transport rates under the current hydraulic conditions. The existing site data is sufficient to make generic vapor transport rate estimates, but is not sufficient to make site-specific vapor transport estimates. To do this, more detailed soil moisture profiles would be necessary as well as vertical profiles of soil gas oxygen and contaminant concentrations. In addition, the work to date has neglected the potential for soil gas vapors to migrate along man-made preferential pathways such as sewers, pipeline corridors, and utility lines. A soil gas survey along these preferential pathways should be considered as a safety precaution.

Exposure Media

Contaminants are currently present in soil, groundwater, and soil gas. Any, or all, of these could be exposure media if future land use is unrestricted. However, for current site usage, soil gas/air is the most likely potential exposure media.

Again, as above, future use plans for the site would be necessary to make any RBCA decisions under conditions different from the current conditions. The EC do not agree with the Preliminary Conceptual Site Model that neglects vapor migration along preferential pathways and into enclosed spaces.

Receptors

Currently, access to the site is limited, and it appears that when workers are present, then they are only present for short periods of time.

With respect to near-term future uses, it is presumed that on-site workers may be present as well as the occasional construction worker.

There are no indications that the PFFA is impacting, or is likely to impact any sensitive ecological receptors. The PFFA is impacting a resource (groundwater) and the time frame for anticipated beneficial use of this resource will be a key element in developing remedial goals and evaluating various remedial alternatives.

Again, as above, future use plans for the site would be necessary to make any RBCA decisions under conditions different from the current conditions.

DATA SUPPORTING REMEDIAL ALTERNATIVE SELECTION

Reports presented to the EC indicate that some data has already been collected to support remedial alternative selection. One groundwater sampling event involved analyses for indicators of biodegradation. Dissolved oxygen and other alternate electron acceptor concentrations are consistent with data at other sites where biodegradation of fuel hydrocarbons has been demonstrated to occur. The historical data is limited, however, and it is premature to draw any site-specific conclusions regarding rates and extent of biodegradation. The data do suggest that biodegradation is at this point an alternative for remediation of dissolved petroleum compounds in groundwater. There is no data suggesting biodegradation of TCE at the PFFA.

A pump and treat system is operation in, or near, the PFFA. Data and modeling suggest that hydraulic capture is being achieved. Thus, pump and treat as appears to be a viable alternative for preventing future groundwater contaminant migration.

A bioventing respirometry test has been conducted. Aerobic respiration rates in the vadose zone are similar to those at other sites where bioventing has been successful. The only issue not addressed is the potential for vapor migration induced by air injection. Presumably, soil vapor extraction is also a feasible option, given that the bioventing respirometry test achieved reasonable air injection rates.

RECOMMENDATIONS—ADDITIONAL DATA NEEDS

Data available to the EC from the site are sufficient to perform the RBCA classification and initial response selection steps. The existing data also is sufficient to develop an initial site conceptual model. The EC also did not have access to a plan view map clearly showing the location of all past and present primary sources at the PFFA, and feel that this would be very useful for discussing the site conceptual model.

The site currently does not pose any immediate threats to human health or sensitive ecological receptors, and the existing pump and treat systems are preventing future off-site migration of contaminants. Thus, immediate concerns are being addressed. The one notable exception is that the EC did not have access to information regarding the integrity of existing primary sources. If they have not been inspected already, the existing storage tanks, transfer lines, pipelines, and sewer lines should be inspected to insure that future leaks or spills do not occur.

Above, when discussing components of the site conceptual model, weaknesses in the data and supplemental data needs were identified. Whether or not additional site characterization data is needed, however, is linked with future use plans for the site and the specific risk management decisions being considered. At one extreme lies the option of complete engineered remediation of the site, and at the other extreme lies the option of complete additional data, provided that a robust remediation technology were used (i.e., one that was not sensitive to uncertainty in the contaminant distribution, such as soil vapor extraction or bioventing). The latter would require the most additional data collection. It also might not be an allowable option depending on the results of site specific target level development. Intermediate options do lie between these two extremes. Deciding what additional data (if any) is necessary requires one to balance uncertainties, restrictions, and restrictions on site use. As an example, Table 1 below presents a range of risk management scenarios, and the additional data necessary to pursue each option.

Common to all of these options is the need to a) characterize the integrity of any existing primary sources (e.g., the concrete water collection area with the oil sheen), b) conduct a soil gas survey along any existing preferential pathways (sewers, pipeline corridors, utility conduits, etc.), and c) investigate any secondary sources not characterized to date.

Sincerely,

David W. Rice
Program Director
Department of Defense Petroleum Hydrocarbon Cleanup Demonstration Program
Lawrence Livermore National Laboratory

Dr. Paul C. Johnson
Expert Committee Lead for Castle Airport Site
Department of Defense Petroleum Hydrocarbon Cleanup Demonstration Program
Arizona State University

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Parsons Engineering Science (1997), “Report to Lawrence Livermore National Laboratory On a Risk-Based Remediation of the Petroleum, Oils, and Lubricants Fuel Farm Area (PFFA), Castle Airport, California.”

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Table 1. Example supplemental data needs—risk management option matrix.

Example management options	Supplemental data needs
• Continued operation of pump and treat system, with site access limited to remediation system operators.	• Integrity of existing primary sources. • Characterization of concrete sump area where oil sheen appears on the water.
• Continued operation of pump and treat system, leasing and future use of PFFA for fuel storage and transfer, with site access limited to PFFA workers, no construction activities allowed.	• Integrity of existing primary sources. • Characterization of concrete sump area where oil sheen appears on the water, • Soil gas survey along preferential pathways (sewers, pipelines, etc.).
• Continued operation of pump and treat system, remediation of vadose zone contaminants by bioventing/soil vapor extraction, leasing of PFFA, with site access limited to PFFA workers, construction activities allowed.	• Integrity of existing primary sources. • Characterization of concrete sump area where oil sheen appears on the water. • Soil gas survey along preferential pathways (sewers, pipelines, etc.).
• Discontinue operation of pump and treat system, natural attenuation in the vadose zone and groundwater, unlimited site access (if site-specific target level determination shows this to be acceptable).	• Integrity of existing primary sources. • Characterization of concrete sump area where oil sheen appears on the water. • Soil gas survey along preferential pathways (sewers, pipelines, etc.). • Detailed soil gas survey involving increased vertical resolution and analyses for contaminants and respiration gases. • Additional soil borings near all primary sources with increased vertical resolution and analyses for contaminants as well as moisture content and permeability measurements. • Continued groundwater monitoring with emphasis on data necessary to demonstrate natural attenuation. • Installation of sentinel well system.