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Risk-Based Assessment of Appropriate Fuel Hydrocarbon Cleanup Strategies for Site 390, Marine Corps Air Station (MCAS) El Toro, California

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Submitted to the U.S. Navy, Southwest Division,
Naval Facilities Engineering Command, San Diego, California

May 1998

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J. Wharton
D. Bishop

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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).

One of the important recommendations of the California LUFT cleanup study was to identify a series of LUFT demonstration sites and to form a panel of experts made up of scientific professionals from universities, private industry, and Federal and State regulatory agencies. This panel would provide professional interpretations and recommendations regarding LUFT evaluations and closures at demonstration sites.

1.2. LUFT Demonstration Cleanup Program

1.2.1. Background

As a result of this recommendation, ten Department of Defense (DoD) sites were selected. 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, as well as a number of Regional Water Quality Control Boards (RWQCB) and the diverse hydrogeologic settings in California where fuel hydrocarbon contaminant (FHC) cleanup problems occur. The El Toro Marine Corps Air Station (MCAS), Site 390, within the Santa Ana RWQCB, is one of the sites selected to participate in the DoD Petroleum Hydrocarbon Cleanup Demonstration (PHCD) Program. This program will be referred to as the DoD LUFT Demonstration Cleanup Program.

The other sites selected and their corresponding RWQCB region are:

- Army Presidio at San Francisco, San Francisco RWQCB.
- Barstow Marine Corps Logistic Center, Lahontan RWQCB.
- Camp Pendleton Marine Corps Base, San Diego RWQCB.
- Castle Air Force Base, Central Valley RWQCB.
- China Lake Naval Weapons Center, Lahontan RWQCB.
- George Air Force Base, Lahontan RWQCB.
- Port Hueneme Naval Construction Battalion Center, Los Angeles RWQCB.
- Travis Air Force Base, San Francisco RWQCB.
- Vandenberg Air Force Base, Central Coast RWQCB.

The Expert Committee (EC) selected to evaluate the selected demonstration 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) 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.

1.2.2. Risk-Based Corrective Action

The LLNL/UC recommendations report concluded that risk-based corrective action (RBCA) provides a framework to link cleanup decisions to risk. The DOD LUFT Demonstration Cleanup Program provides a series of sites where the application of risk-based cleanup approaches can be demonstrated.

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:

<u>Receptor</u>: 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 California LUFT cleanup study 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 ground water 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 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,

[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.

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 Demonstration Cleanup Program Steps

The demonstration program process can be summarized in the following nine steps:

Step 1: Site scoping meeting with site staff, regulators, and EC staff representatives. Develop and discuss site conceptual model. Identify and discuss pathways and receptors of concern.

Step 2: Risk-based corrective action training for DoD Petroleum Hydrocarbon Cleanup Demonstration Program (PHCDP) participants.

Step 3: Site staff and contractors prepare the data package. EC staff reviews available data and identifies data gaps needed to apply a risk-based cleanup approach.

Step 4: EC visits site and receives briefing, onsite characterization, conceptual model, and pathways and receptors of concern. Site tour is included in this briefing. Following the EC's visit, a site characterization report is prepared by the EC containing recommendations for further data collection, if needed (See Appendix A).

Step 5: EC staff applies a risk-based cleanup approach to the Site using best available data.

Step 6: EC staff evaluates the natural attenuation potential for the Site using best available data. An estimate of the time to clean up and the uncertainty associated with this estimate will be made. Sampling and monitoring procedures to support intrinsic bioremediation for the Site will be identified.

Step 7: Based on the concept of applied source, pathways, and receptors as to potential hazards, site-specific findings regarding natural attenuation potential, and discussion with regulators, the EC shall provide its recommendations for an appropriate risk-management strategy at the Site and the set of actions needed to achieve site closure. The EC will present its recommendations at an appropriate forum.

Step 8: The EC will provide a DoD LUFT Demonstration Cleanup Program overall evaluation comparing the effectiveness of risk-based cleanup approaches at each site in the program. An estimation of the cost savings using risk-based protocols will be compared to baseline approaches. An estimation of the value of the remediated water will be made.

Step 9: The EC Staff will produce a DoD Risk Execution Strategy for Clean-Up of the Environment (RESCUE) implementation guide and accompanying procedures manual (Phase I, Petroleum) that can be used in California and in other states by military bases.

2. Site Overview

2.1. Background

MCAS El Toro is situated in a semi-urban agricultural area in southern California, approximately 8 miles southeast of the city of Santa Ana and 12 miles northeast of the city of Laguna Beach. The land to the south and northeast of the Site is used mainly for commercial, light-industrial, and residential purposes. Other surrounding land uses are predominately agricultural production.

2.1.1. Site History

Site 390 is located in the southeastern quadrant of MCAS El Toro and on the north side of Building 390. Two former underground storage tanks (USTs), 390A and 390B and the former pump dispenser island located 30 feet from the tanks, were reportedly installed in 1955 (County of Orange, 1997). The USTs were single wall cylinders constructed of carbon steel installed without spill containment, and had storage capacity of 500 gallons and 2,000 gallons, for Tanks 390A and 390B, respectively. According to documents provided to the EC, both tanks reportedly stored diesel fuel, but subsequent testing indicated that gasoline may also have been stored in one or both of the tanks.

2.1.2. Summary of Site Investigation Activities

Three site investigations have been conducted at Site 390 since 1993. The first investigation occurred in conjunction with removals of the two USTs in 1993. Data from this work consists primarily of inspector’s field notes on the conditions of the USTs, and analytical data on soil concentrations for fuel hydrocarbons (Lindsey, 1997). These data confirmed that a release from at least one of the two USTs had occurred.

In 1995, Bechtel National installed two soil borings near the former USTs to a depth of approximately 100 feet bgs, with soil samples collected at five foot intervals (Bechtel, 1996b). These samples were tested for fuel hydrocarbons, including TPH as gasoline, and the four principal aromatic compounds of concern, benzene, toluene, ethylbenzene, and xylenes (BETX). In 1996, OHM Remediation Services Company completed a third site investigation program (OHM, 1997). Six soil borings in the vicinity of the USTs and the former dispenser island were completed, with soil samples collected at five foot intervals between about 70 to 160 feet bgs. In addition, three groundwater monitor wells were installed to a depth of approximately 200 feet bgs, with a screen interval of approximately 50 feet. One of the wells (MW-02) was installed upgradient of the former USTs and two wells (MW-01 and MW-03) were installed downgradient, assuming that the groundwater direction is to the northwest. Subsequent sampling events have confirmed that these two monitor wells are located downgradient of the former USTs, although MW-03 may be located cross gradient to the Site, based on the May 1997 sampling event that showed a distinctly westerly groundwater direction. As of May 1997, three groundwater sampling rounds had been completed for the three groundwater monitor wells.

2.2. Site 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, c) identify the dominant fate and transport characteristics of the Site, (3) specify potential exposure pathways, and (4) identify potential receptors that may be impacted by the contamination. A well developed conceptual model for Site 390 has not been presented in documents shown to the EC. A limited conceptual model that included narrative descriptions of the geologic and hydrogeologic conditions as well as a diagram were provided. However, sufficient data have been collected to develop a more complete site conceptual model. A summary of key components of this Site conceptual model are provided in this section.

2.2.1. Geology and Hydrogeology

The regional and local geology for MCAS El Toro are described in several documents (see Bechtel, 1996a; Jacobs, 1993; among others). The Site is situated on alluvial fan deposits derived mainly from the Santa Ana Mountains which are located northeast of the Site. Based on the inferred depositional history at the Site, unsaturated and saturated soils beneath the Site consist of a heterogeneous mixture of silts and clays, interbedded with sands and fine gravels, ranging in thickness up to 500 feet in the western portion of the Tustin Plain. Silts and clays appear to predominate in the central and northwestern portion of the Site, while sands predominate nearing the foothills. The various stratigraphic units underlying the Site are summarized by Jacobs (1993). The unsaturated soils encountered during installation of monitor wells consisted of unconsolidated clays and silts with interbedded sands and gravels, consistent with alluvial deposits.

The hydrogeological characteristics of the Site have also been summarized in several documents (Jacobs, 1993, Bechtel, 1996a, JMM, 1988). The Site is located within the boundaries of the Irvine Groundwater Subbasin, located southeast and adjacent to the Main Orange County Groundwater Basin. Depth to groundwater varies historically and seasonally. According to the Jacobs report (Jacobs, 1993), depth to groundwater in 1992 in the vicinity of Sites 390A and 390B was on the order of 150 feet bgs. In the northeastern portion of the Site, the depth to groundwater was 240 feet bgs, while at the southwestern boundary of the Site, the depth to groundwater decreased to 85 feet bgs. Groundwater elevations were measured in 1996 by OHM Remediation Services Because of the heterogeneous stratigraphy, it appears that groundwater flows in a single, large-scale heterogeneous flow pattern, with some potential for vertical gradients. However, Bechtel (Bechtel, 1996a) proposed that the saturated zone consists of three distinct hydrostrategraphic units, namely, a shallow zone, a fine-grained intermediate zone, and a deeper zone which is hydraulically connected to the principal aquifer or principal water producing zone in the basin. Bechtel stated that the intermediate zone appears to hydraulically separate the two main water-bearing zones.

Groundwater direction and flow rate are heavily influenced by seasonal events (recharge due to rain, agricultural irrigation, and irrigation of the golf course located upgradient from the former UST sites. Regional groundwater flow has been towards the west and northwest since the 1940s according to Bechtel (Bechtel, 1996a). Hydraulic gradients have reportedly ranged from 0.004 to 0.008 ft/ft. The stratigraphic and gradient data indicate that average linear groundwater velocities beneath the MCAS El Toro vary between 0.02 to 1.9 feet per day (0.0012 to 0.13 miles per year) (JMM, 1988 as reported in Bechtel, 1996a).

The potential for vertical flow between the shallow and deeper aquifer units beneath the Site has been evaluated by various consultants (Jacobs, 1993; Bechtel, 1996a). Evaluation of the hydrogeologic and geochemical data suggests that the two units are distinct, and that the shallow unit is only weakly influenced by pumping in the deeper aquifer unit. However, the intermediate zone, designated as a confining layer, is “leaky”, according to Bechtel (Bechtel, 1996a), which suggests the potential for migration of contaminants from the intermediate to the deeper aquifer unit.

2.2.2. Distribution of Contaminants in Soil and Ground Water

The contaminants identified in the soil and ground water at the Site consist of volatile aromatic hydrocarbons, primarily BETX, and TPH as diesel, as gasoline and as JP-5. Data reported by OHM indicate the presence of JP-5 and gas range petroleum hydrocarbons (C6 to C13) in soil samples only. No other chemical contaminants were reported.

The extent of fuel hydrocarbon (FHC) contamination in the soils has been determined based on the soil boring investigations completed by Bechtel National Inc. (1996c), and others (OHM, no reference, and Jacobs, 1993). The data reported by OHM (EC Briefing Documents, 1997) indicate that fuel hydrocarbons have migrated to a depth of at least 110 feet below ground surface (bgs), based on the data from SB-02, drilled beneath the location of the former dispenser island (Maximum observed concentration at that depth is 7600 mg/kg, TPH-g, with non-detect (ND) below that depth down to 143 feet bgs). BETX results show a migration depth in this boring of at least 143 feet bgs compared to a measured depth to groundwater in MW-01 and MW-03 of about 160 feet bgs. However, the BETX soil concentration in SB-02 at a depth of 143 feet bgs were less than 0.1 mg/kg. These soil data confirm that FHCs have been released from the former USTs, but the amount of FHCs currently present in the unsaturated soils beneath the Site does not appear to represent a significant threat to groundwater quality. Soils data from the other borings, (SB-03, SB-04, and SB-06) which extend to 165 feet bgs support this conclusion.

Understanding the extent of contamination in the ground water beneath the Site is based on three rounds of ground water sampling (September 1996, January 1997, and May 1997) (see EC Briefing Package, 1997; OHM data, 1996). Results of the first round of sampling show limited impacts of FHC releases from the Site. In MW-01, the September 1996 sampling round showed benzene and xylenes at concentrations of 4 and 1.9 µg/L, respectively. BETX and TPH concentrations in the other two wells were nondetectable (ND). This well appears to be directly downgradient from the Site. Because MW-02 appears to be directly upgradient of the Site, and no benzene was detected (detection limit presumed to be 0.1 µg/L), it appears that the Site is the probable source of the benzene. Subsequent sampling events in January and May of 1997 show non-detect levels for benzene and all other FHCs in the three monitor wells at the Site.

The results of the ground water sampling program indicate that the ground water beneath this Site has not been significantly impacted by FHCs released from the USTs. No MTBE was detected in any of the groundwater samples. It appears that BETX reached the groundwater at some time since the release of the FHCs, possibly due to drilling and well installation activities. However, recent sampling has shown the BETX concentrations to be below detection limits, suggesting that if any FHCs had reached the shallow groundwater unit, natural biodegradation is reducing the concentration of these compounds. Further, soil samples between 110 feet to 142 feet do not indicate that fuel hydrocarbons are present near the water table.

There are some uncertainties in the possible extent of contamination in the groundwater because of the apparent variability in the direction of groundwater flow. The gradient appears to be mostly westerly based upon water level measurements collected during three sampling rounds at Former UST Sites 390 A&B. The data show that the direction can shift between westerly and northwesterly and suggest that information based on three wells may not be sufficient to reduce the uncertainties in the direction of groundwater flow. It is likely that combining the water elevation data from the three monitor wells on Site 390 with data from other investigations on MCAS El Toro would reduce the uncertainties on this issue. If the predominate groundwater direction beneath the Site has been directly to the west, it is possible that the current monitor well network has missed some portion of the impacted groundwater (For example, see Figure 6, EC Briefing Package, 1997 and information provided to the EC by Bernie Lindsey, OHM

Information Packages, 1997). Under this scenario, MW-01 is located at the northern edge of a potential BETX impacted zone of groundwater. MW-01 is no longer directly downgradient of MW-02. On the other hand, if the impact of BETX on the groundwater had been significant enough to represent a secondary source of contamination, this would likely have been detected in MW-01. An additional groundwater monitor well located to the southeast of MW-01 would resolve this issue. However, given the magnitude of the TPH levels and BETX levels in the soils above the groundwater, and the lack of any detectable contamination in MW-01 or MW-03, such additional investigations are not necessary. The data collected to date are sufficient to apply a risk-based approach to cleanup at this Site.

3. Risk Analyses and Management

3.1. Sources

3.1.1. Primary Sources

Site 390 contains the footprints of two former underground storage tanks (USTs) (sites designated as 390A and 390B), a former pump dispenser island and piping and appurtenances associated with the fuel dispenser and storage system. Releases of FHCs from this system have been confirmed based on (1) observations on the physical integrity of the USTs when they were removed in 1993, indicating significant corrosion of UST 390A, (2) visual observations of petroleum stained soil noted beneath the USTs, and (3) results of soil sampling adjacent to and beneath the USTs and the former dispenser island, the latter being removed in 1996.

The apparent primary source of FHC releases at this Site is the fuel dispenser system. It is unclear if releases occurred from all components of the system or from the USTS only. Based on statements regarding the condition of the underground piping, past leaks from this component of the system as well as the USTs appear likely. As of 1996, all components of the system as well as subsurface soils of unspecified volume were removed or excavated from the Site. Based on Figure 3 provided to the EC (Bechtel, 1996c), the amount of excavated soil appears to be approximately 200 cubic yards, assuming excavation to approximately 10 feet bgs. Approximately five cubic yards of this soil was contaminated and removed from the Site. Thus, the primary source or sources of the soil and ground water contamination have been removed.

3.1.2. Secondary Sources

Secondary sources are defined as free or residual petroleum hydrocarbons in the unsaturated or saturated subsurface soils that represent an on-going continuing source of contamination of the soil or groundwater. To address this issue, one must evaluate soil data obtained during the three site investigations at Site 390. Eight soil borings with discrete soil samples have been completed on the Site by various contractors. Soil samples were also taken during installation in 1996 of three ground water monitor wells. These soil samples do not indicate the presence of free or residual product in the unsaturated zone, but the results do indicate that petroleum hydrocarbons, as characterized by Total Petroleum Hydrocarbons (TPH) as diesel, and petroleum hydrocarbons identified as JP-5 and “gas” have migrated through the unsaturated zone to a depth of at least 110 ft beneath the Site in soil boring SB02, directly beneath the former dispenser island. Results of soil sampling in recent (1996) soil borings in the vicinity of the USTs (e.g., SB05 and SB04) show low levels (generally less than 1 mg/kg) of benzene, ethylbenzene, toluene and xylenes (BETX) at depths down to 146 ft bgs. Soil samples taken from monitor well MW-03 showed even lower levels of BETX (less than 0.1 mg/kg) in the sample taken at 168 ft bgs and nondetect (ND) in the sample taken at 192 ft bgs.

The data do not support an hypothesis that BETX and other petroleum hydrocarbons present in the unsaturated zone beneath the Site represent a significant secondary source that threatens to impact ground water in the water table aquifer.

3.2. Exposure Pathways

Human health or ecological risks arise when a complete exposure pathway exists connecting a point of chemical release to a potential receptor. At this Site, potential exposure pathways include the following:

- Inhalation of FHC vapors migrating through the vadose zone.
- Inhalation of FHC constituents via volatilization during irrigation or domestic use.
- Ingestion of FHC constituents present in the water table aquifer.

In the site assessment documents, Bechtel (Bechtel, 1996c) has considered a number of potential exposure pathways for several exposure scenarios. The primary exposure pathways of concern are inhalation due to migration of FHC vapors from the subsurface, volatilization of FHCs from irrigation sprays and ingestion of contaminated ground water.

According to Bechtel's EC briefing package the nearest downgradient agricultural well is approximately two miles downgradient of the Site. Regional ground water flow appears historically to be in the north-northwest direction (Bechtel, 1996a). The closest agricultural irrigation well (TIC-55) is located cross gradient, approximately 8,000 feet west-northwest of the Former UST 390 A&B Site. TIC-55 is pumped periodically at a flow rate of approximately 900 gallons per minute. The closest municipal supply well is over five miles downgradient of the Site, and not directly in the path of flow passing beneath the Site. Furthermore, this municipal supply well draws water from the deeper aquifer unit, which has not likely been impacted by FHC releases from Site 390, given the very low to ND levels of FHCs in the groundwater beneath the Site.

3.3. Receptors

Bechtel (EC Briefing Package, 1997) reports that potential receptors include onsite construction and industrial/commercial workers for current conditions. Future potential receptors include these two groups plus future onsite residents. As noted, however, future land use scenarios do not suggest that Site 390 will be used for residences.

Given the low levels of BETX and other FHCs in the soil and ground water at the Site, however, it does not appear that Site 390 poses significant current or future risks to any potentially exposed populations under realistic exposure scenarios.

3.4. Fate and Transport of Contaminants

Two transport mechanisms are of concern at this Site, namely, the migration of FHCs towards the groundwater in the unsaturated zone, and the horizontal and vertical migration of FHCs once they have reached the groundwater. Data are not sufficient to determine if FHCs are still migrating downward in the unsaturated soils. Given that the primary sources have been removed, however, and given the relatively low levels of FHCs in the unsaturated soils, significant continued migration in the unsaturated soils appears unlikely. Furthermore, concentrations of benzene in soil vapor are expected to be quite low, based on the small number of detections of benzene concentrations in soils above 1 mg/kg. Data collected by OHM on nutrients in soils, soil organic carbon content, and bacterial densities in the unsaturated zone soils also suggest that conditions are suitable for natural biodegradation to occur. These results support the likelihood of biodegradation in the unsaturated zone, but do not demonstrate that such degradation is occurring.

In the groundwater, the last two rounds of groundwater sampling have indicated that FHCs are no longer present in the shallow aquifer unit beneath the Site at detectable levels. Results of the recent ground water sampling indicate that if any FHCs from the two USTs reached the ground water, it is likely that intrinsic or natural biodegradation rates are sufficient to reduce the benzene levels below analytical detection limits. FHCs in the groundwater may migrate at a rate similar to the rate of groundwater flow, depending upon the extent to which the FHCs adsorb onto aquifer solids. Typically, the soil organic carbon content of soils in southern California is low (less than 0.1 percent), and consequently, there is only modest (less than 20 percent) retardation of the lower molecular weight FHCs such as BETX. Assuming no retardation, and no natural degradation, mobile FHCs that may have reached the groundwater beneath the Site will migrate at a maximum rate of about 0.1 mile per year. Given that the nearest irrigation well is two miles downgradient of the Site, no benzene would reach this well for at least 20 years, assuming no preferential pathways. Because benzene and other aromatics in the concentrations found at this Site are likely to degrade long before they would migrate this distance, the threats to human health, safety, and the environment from FHC releases at Site 390 are minimal.

4. Risk-Based Corrective Action

4.1. Background

As noted in the Introduction to this Report (Step 5), the EC is tasked with applying a risk-based corrective cleanup approach to the MCAS El Toro Site 390, based on available data. The current primary guide to the application of RBCA to petroleum release sites in the U.S. is the use of the ASTM Standard, ES 38-94. California uses a form of risk-based evaluation in dealing with cleanup decisions at these sites, but the State has rejected the use of the ASTM Standard because of concerns regarding the use of the risk-based screening levels presented in the ASTM Standard. However, for the purposes of recommending a remedial strategy for this Site to MCAS El Toro, the ASTM Standard is a useful framework for analysis. The following section presents a RBCA approach to Site 390.

4.2. Initial Site Assessment

The initial site assessment has been summarized above. Soil and groundwater sampling have been completed at Site 390, and the nature and extent of FHC contamination has been determined. The impacted media have been identified. Sources, potential pathways and potential receptors have been documented.

4.3. Site Classification and Initial Response Action

Table 3 in the ASTM Standard provides a classification scheme to determine the appropriate classification for Site 390. The four major classifications are: (1) immediate threat to human health, safety, and the environment; (2) short-term (0 to 2 years) threat to human health, safety, and the environment; (3) long-term (> 2 years) threat to human health, safety, or the environment, and (4) no demonstrated long-term threats.

The characteristics of this Site relevant to classification are:

A. Is the shallow aquifer unit a potential source of drinking water? **(Yes)**

The total dissolved solids is less than 1,000 mg/L, and the yield is well above 200 gallons per day. Thus, the shallow aquifer is a potential source of drinking water.

B. Are the subsurface soils impacted below a depth of 3 feet? **(Yes)**

FHCs have been detected in unsaturated soils to a depth of 145 feet bgs.

C. Are the subsurface soils impacted within 50 feet of the groundwater elevation? **(Yes)**

FHCs have been detected within a few feet of the recently monitored groundwater elevation of about 160 feet bgs. Thus, FHCs have impacted soils near or at the groundwater elevation.

D. Has groundwater been impacted? **(Yes)**

Benzene and xylene were detected in the shallow groundwater unit. However, the levels were low (less than 5 µg/L), and subsequent sampling events have shown ND levels of BETX.

E Are there potable water-supply wells within 2 year travel time of Site 390, based on the estimated average groundwater velocity? **(No)**

The nearest drinking water-supply well is reportedly five miles distance from Site 390, and not in the flow path from the Site. For an average groundwater velocity measured at MCAS El Toro of this Site poses no threats to drinking water-supply wells.

F. Are there non-potable water-supply wells within 2 year travel time of Site 390, based on the estimated average groundwater velocity? **(No)**

The nearest water-supply well is two miles downgradient, which is about 20 years travel time downgradient of the Site, at a minimum. It is highly unlikely that FHCs released at Site 390 will every reach this well.

Based on these data, Site 390 is classified between category 3 and 4. No immediate actions are called for at this Site, beyond the remedial actions that have already been completed (removal of primary source, groundwater monitoring).

4.4. Tier I Evaluation

Table 4 in the ASTM Standard provides an example list of risk-based screening levels (RBSL) which can be used to compare conditions at the site under investigation to the screening level analysis in the Standard. ASTM states that Table 4 is an example table, and should not be used without consideration of site-specific conditions. For the purposes of this report, however, this Table will be used as a basis for determining whether or not site-specific target cleanup levels should be developed.

For deep soils contamination, where contamination may leach to the groundwater, Table 4 of the ASTM suggests RBSLs for benzene of 1.72 mg/kg and 5.78 mg/kg for residential and commercial use respectively, for the 10^{-4} risk level. For the 10^{-6} risk level, these values decrease to 0.017 and 0.06 mg/kg, for residential and commercial use, respectively.

Benzene levels in subsurface soils exceeded the RBSL for commercial land use and the 10^{-4} risk level of 5.8 mg/kg in four out of a total of 101 soil samples, based on soil data presented in the EC information (EC Briefing Package, 1997). Nine of 101 samples exhibited benzene levels above the RBSL for residential land use and the 10^{-4} risk level of 1.7 mg/kg. For the RBSLs corresponding to a 10^{-6} risk level, 18 and 27 samples out of 101 soils samples exceeded the RBSLs for commercial and residential land use, respectively. These results indicate that the FHCs present in the unsaturated soils are not likely to represent a significant threat to human health, safety and the environment. Based on expected future land use of predominantly commercial uses at the MCAS El Toro, the RBSLs for 10^{-4} risk level are appropriate comparative criteria for evaluating the need for remedial action for the unsaturated soils at Site 390.

4.5. Conclusions

Because so few unsaturated soil samples (less than 5 percent) had benzene levels exceeding the likely target RBSL, and because two of the three groundwater monitoring events indicated that BETX was below detection limits in the groundwater in the shallow aquifer, Site 390 is a strong candidate for site closure, with no further action required.

5. Summary and Recommendations

5.1. Sources

The primary sources of the documented FHC releases at Site 390 are the former USTs, and associated appurtenances. These primary sources have been removed, along with five cubic yards of soil contaminated with FHCs. Soil samples collected eight soil borings, with samples taken at five foot intervals, did not indicate the presence of secondary sources sufficient to threaten groundwater quality.

5.2. Pathways and Receptors

At Site 390, potential exposure pathways include:

- Inhalation of FHC vapors migrating through the vadose zone.
- Inhalation of FHC constituents via volatilization during irrigation or domestic use.
- Ingestion of FHC constituents present in the water table aquifer.

The primary exposure pathways of concern are inhalation due to migration of FHC vapors from the subsurface, volatilization of FHCs from irrigation sprays, and ingestion of contaminated ground water.

The nearest downgradient agricultural well is approximately two miles downgradient of the Site. The closest municipal supply well is over five miles downgradient of the Site, and not directly in the path of flow water passing beneath the Site. Furthermore, this municipal supply well draws water from the deeper aquifer unit, which has not likely been impacted by FHC releases from Site 390.

Thus, the only potential complete pathways at this Site are vapor migration and volatilization during irrigation use.

5.3. RBCA Analysis

Application of the ASTM Standard to Site 390 indicates that this Site is a low-risk site, classified as a Category 3 or 4 site. Benzene levels in the unsaturated soils exceed RBSLs for commercial land use and 10^{-4} risk levels in 4 percent of the soil samples collected. These preliminary RBCA analysis indicates that this Site is a strong candidate for closure with no further action required.

5.4. Recommendations

The EC recommends that the MCAS El Toro prepare the necessary document to request closure of Site 390, with no further action required. Justification for no further action at this Site is based on the following findings:

A. Primary sources of FHC releases have been removed including soil immediately beneath the former USTs.

B. No evidence for significant secondary sources was found.

C. Benzene and TPH as gasoline levels in unsaturated soils do not represent a significant threat to groundwater quality.

D. Concentrations of benzene in the soils and groundwater are at low or ND levels, which indicates that potential receptors would be exposed to benzene concentrations well below levels of concern.

E. Although some uncertainty exists regarding the direction of groundwater flow, sufficient groundwater quality data have been collected to demonstrate that this is a very low-risk site.

6. References

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Appendix A

Site Assessment Review Letter Report

Lawrence Livermore National Laboratory

SITE ASSESSMENT REVIEW TO APPLY RISK BASED CORRECTIVE ACTION AT SITE 390 MARINE CORPS AIR STATION EL TORO, CALIFORNIA

The Expert Committee (EC), established under the California Department of Defense (DOD) Petroleum Hydrocarbon Cleanup Demonstration (PHCD) Program, has reviewed the methods and findings of various reports prepared for the Marine Corps Air Station (MCAS), El Toro, California to address contamination of the soil and ground water at Site 390 (Site), due to past releases of petroleum hydrocarbons from two former underground storage tanks and underground piping. Enclosed is our assessment of the adequacy of the site characterization and site conceptual model as a basis for applying a risk-based corrective action methodology for selecting the appropriate risk management strategy at the Site.

This letter represents the first of two deliverable documents as part of our assessment. It is intended solely as a review of the existing Site data and risk characterization models. Recommendations regarding additional data, if any, needed to complete our assessment are provided.

SITE CONCEPTUAL MODEL

A well defined conceptual model of a site contains sufficient information to: a) identify sources of the contamination, b) determine the nature and extent of the contamination, c) identify the dominant fate and transport characteristics of the site, d) specify potential exposure pathways, and e) identify potential receptors that may be impacted by the contamination. For Site 390, the EC was provided a briefing package containing a summary of information on the Site including a site description and history, past subsurface investigations and remedial actions, soil and ground water sampling results, and an analysis of potential exposure pathways and receptors. In addition, the EC has been provided with supplemental materials, included in the list of references attached to this letter.

Sources

Site 390 contains the footprints of two former underground storage tanks (USTs) (sites designated as 390A and 390B), a former pump dispenser island and piping and appurtenances associated with the fuel dispenser and storage system. Releases of petroleum hydrocarbons from this system have been confirmed based on; 1) observations on the physical integrity of the USTs when they were removed in 1993, indicating significant corrosion of UST 390A, 2) visual observations of petroleum stained soil noted beneath the USTs, and 3) results of soil sampling adjacent to and beneath the USTs and the former dispenser island, the latter being removed in 1996.

The apparent primary source of the petroleum releases at this Site is the fuel dispenser system. It is unclear if releases occurred from all components of the system or from the USTs only. Based on statements regarding the condition of the underground piping, past leaks from this component of the system, as well as the USTs, appear likely. As of 1996, all components of the system, as well as subsurface soils of unspecified volume were removed or excavated from the Site. Based on Figure 3 in the briefing package provided to the EC (Bechtel, 1996c), the amount of excavated soil appears to be approximately 200 cubic yards (cu yd), assuming excavation to approximately 10 feet below ground surface (bgs). Thus, the primary source or sources of the soil and ground water contamination have been removed.

The existence of secondary sources, defined as free or residual petroleum hydrocarbons present in the unsaturated or saturated subsurface soils in zones where continued contamination of the soil or ground water may occur, has not been addressed. Eight soil borings with discrete soil samples have been completed on the Site by various contractors. Soil samples were also taken during installation of the three ground water monitoring wells, installed in 1996. These soil samples do not indicate the presence of free or residual product in the unsaturated zone, but the results do indicate that petroleum hydrocarbons, as characterized by Total Petroleum Hydrocarbons (TPH) as diesel, and petroleum hydrocarbons identified as JP-5 and "gas" have migrated through the unsaturated zone to a depth of at least 110 ft beneath the Site in soil boring SB02, directly beneath the former dispenser island. Results of soil sampling in nearby soil borings (e.g. SB05 and SB04) identify low levels (less than 1 mg/kg) of benzene, ethylbenzene, toluene and xylenes (BETX) at depths down to 146 ft bgs. Soil samples taken from monitoring well MW-03 showed even lower levels of BETX (less than 0.1 mg/kg) in the sample taken at 168 ft bgs and ND in the sample taken at 192 ft bgs. No estimates were provided on the mass of BETX and other petroleum hydrocarbons that may still be present in the unsaturated zone.

The data do not support an hypothesis that BETX and other petroleum hydrocarbons present in the unsaturated zone beneath the Site represent a significant secondary source that threatens to impact ground water in the water table aquifer. Without continuous soil sampling, however, it is not possible to rule out the possible presence of a secondary source that could pose a continuing threat to the ground water. This is due to the highly heterogeneous nature of alluvial sediments , the consequent wide variability in permeability and hydraulic conductivity with depth (up to seven orders of magnitude variability in permeability with depth) as reported by Bechtel (Bechtel, 1996a) and others, and the potential for petroleum hydrocarbons to accumulate in low permeability horizons within the unsaturated zone.

Nature and Extent of Contamination

The contaminants identified in the soil and ground water at the Site consist of volatile aromatic hydrocarbons, primarily BETX, and TPH as diesel. Data reported by OHM indicate the presence of JP-5 and gas range petroleum hydrocarbons (C6 to C13) in soil samples only. No other chemical contaminants were reported. It is likely that other gasoline constituents are present in the soil and ground water, because the TPH measurement encompasses a limited range of alkanes present in the gasoline. However, the aromatic hydrocarbons represent the constituents of fuel hydrocarbons posing the predominate potential risks to human health and the environment because of their relative mobility in the unsaturated and saturated zones beneath the site.

The extent of fuel hydrocarbon (FHC) contamination in the soils has been specified based on the soil boring investigations completed by Bechtel National Inc. (1996c), and others (OHM, no reference, and Jacobs, 1993). As noted above, these soil results do not suggest significant amounts of FHCs present in the unsaturated zone beneath the Site. Uncertainties exist because of the multiple layers of soils with highly variable permeability, characteristic of alluvial sediments.

The extent of contamination in the ground water is not defined. An upgradient well and two downgradient wells were installed in 1996, and only two rounds of ground water sampling have been completed. Data on only one of these two sampling events were available for review by the EC. Review of results of the second round of sampling is requested prior to preparation of our final report on the Site. Results of the first round of sampling show only limited impacts of releases from the Site, with a benzene result of 1.9 μg/L in MW-01. This well appears to be directly downgradient from the Site. Because MW-02 appears to be directly upgradient of the Site, and no benzene was detected (detection limit presumed to be 0.1 μg/L), it appears that the Site is the probable source of the benzene. Other sources nearby cannot be completely ruled out. Based on the Site visit, it was apparent that Site 390 is in close proximity to a former oil-water separation wastewater plant. Nonetheless, the results of the ground water sampling program do not suggest that the ground water beneath this Site has been heavily impacted by FHCs. These ground water results support a conceptual model of a modest release of FHCs, and the probability that aerobic degradation of BETX compounds will likely occur given the low levels of BETX and no identification of other FHCs in the ground water beneath the Site.

Fate and Transport of Constituents

Two transport mechanisms are of concern at this Site, namely, the vertical migration of FHCs towards the ground water in the unsaturated zone, and the horizontal and vertical migration of FHCs once they have reached the ground water. No information was provided to the EC on the estimated magnitude of these mechanisms at the Site. It is recommended that this issue be addressed in subsequent evaluations conducted by the MCAS, El Toro for this Site.

With respect to fate and transport of the FHCs in the water table aquifer, hydrogeological data can be obtained from reports prepared by Bechtel (Bechtel, 1996a; Bechtel, 1996b) for other investigation sites within the MCAS, El Toro. Other investigations at the MCAS, El Toro (e.g., reports by Jacobs, 1993, and James M. Montgomery, 1990) also provide basin wide hydrogeological information. Application of hydrogeological information from these reports to Site 390 should provide a reasonable estimate of the potential rate of transport of FHCs that reach the ground water. Whether such an evaluation is necessary depends on the results of the second round of ground water sampling. If the monitoring results indicate higher levels of benzene than previously reported in MW-01 or MW-03, then the fate and transport issue must be addressed. Ground water velocities beneath the MCAS El Toro reportedly vary between 0.02 to 1.9 feet per day (JMM, 1990 as reported in Bechtel, 1996a). This result further highlights the significant degree of variability in hydrogeological parameters in the subsurface in the vicinity of the Site, and indicates that preferential pathways could lead to significant rates of migration of FHCs.

Balancing this transport, however, is the phenomenon of natural biodegradation in the subsurface. Unfortunately, no data have been collected to demonstrate whether or not biodegradation is occurring in the ground water at the Site. Some data were reported on soil nutrient content (orthophosphate and nitrogen species), soil organic carbon content, and bacterial densities in the unsaturated zone soils. These results support the likelihood of biodegradation in the unsaturated zone, but do not demonstrate that such degradation is occurring. No general mineral or geochemical data has been reported in the ground water, however. These data are not needed at this time, given the very low levels of BETX reported. However, should the second round of sampling indicate that the BETX contamination is increasing, then geochemical indicator data (dissolved oxygen, nitrate, oxidation-reduction potential, sulfate, pH) should be obtained from ground water sampling of the three monitoring wells.

Exposure Pathways

In Site assessment documents, Bechtel (Becthel, 1996c) has considered a number of potential exposure pathways for several exposure scenarios. The primary potential exposure pathways of concern are inhalation due to migration of FHC vapors from the subsurface, or volatilization of FHCs from irrigation sprays and ingestion of contaminated ground water. The EC agrees that these are the major potential pathways of concern. The role these potential pathways may play in the risk management of the site will be addressed in the EC's site specific risk management report and recommendations.

According to Bechtel's EC briefing package, (Bechtel, 1997), the nearest downgradient agricultural well is approximately two miles downgradient of the Site. Ground water flow appears historically to be in the north-northwest direction (Bechtel, 1996a). The closest municipal supply well is over five miles downgradient of the Site, and not directly in the path of flow passing beneath the Site.

An abandoned well was identified following the EC briefing (West, 1997). This well, designated W-3388 is only 500 feet away from Site 390, but is located upgradient of the Site. This well could be a conduit to transport contamination from the water table aquifer to deeper zones in the basin, but it is unlikely that any releases from Site 390 would reach this well.

Potential Receptors

Bechtel reports that potential receptors include on-site construction and industrial/commercial workers for current conditions. Future potential receptors include these two groups plus future on-site residents. As noted, however, future land use scenarios do not suggest that Site 390 will be used for residences.

Given the low levels of BETX and other FHCs in the soil and ground water at the Site, however, it does not appear that Site 390 poses significant current or future risks to any potentially exposed populations under realistic exposure scenarios.

ADDITIONAL DATA NEEDS

Site 390 appears to be a low risk site, and an excellent candidate for closure and designation of no further action. The data collected to date provide a reasonably thorough characterization of the nature and extent of contamination at the Site, and the potential fate and transport of these contaminants. These data have not yet been formulated into a document that supports a risk management strategy of no further action. This task should not be burdensome, however. The EC does not feel that any additional data are essential for closure of Site 390. At a minimum, however, the data collected to date must be organized and evaluated to demonstrate that the Site is a likely low risk site not requiring any further action.

Because Site 390 has been included in this DOD Demonstration Project, however, the EC does suggest that limited additional field data be collected, to provide conclusive evidence that the Site is a low risk site. First, we recommend that one continuous soil sampling program be completed in a soil boring near the location of the former UST 390A where the highest reported TPH reading was observed. The objective of this sampling program should be to assess the vertical distribution of FHCs from the surface to the ground water and to verify whether or not secondary sources exist. The Site is a good candidate to test the Site Characterization and Analysis Penetrometer System- Laser-Induced Fluorescence (SCAPS-LIF) system, developed by the Navy. Second, we recommend that geochemical parameters be measured in MW-02 and MW-01 to determine if biodegradation is occurring in the ground water beneath the Site. These two additional data collection steps are probably not essential to the future deposition of Site 390, but they would provide value to the final selection of the risk management strategy for the Site. Furthermore, they would provide useful information for completion of the DOD demonstration project report.

SUMMARY

Site assessment activities at Site 390 are nearly complete. Data from eight soil borings and three monitoring wells have provided a reasonably complete characterization of the nature and extent of FHC contamination at the Site and the potential for migration of the FHCs off of the Site. While uncertainties exist, the levels of contamination observed on the Site, and the conceptual model of the Site support a likely designation of a low risk site. Data collected to date, combined with additional ground water monitoring information should be adequate to provide a convincing basis for selecting a risk management strategy that includes no further action. Given that this Site has been included in the DOD demonstration program, the EC recommends that two additional sampling programs be completed, 1) a continuous soil sampling at a boring near the location of the former UST 390A, and 2) collection of geochemical data on two of the three monitoring wells during the next round of ground water sampling.

We appreciate this opportunity to review the site investigation activities at Site 390 on the MCAS, El Toro, and look forward to providing you our final recommendation on the appropriate risk management strategy for this Site.

Sincerely,

David W. Rice

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