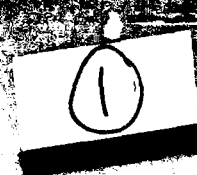




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McClellan Air Force Base

Davis Global Communications Site

Risk Assessment Report

Delivery Order 5055

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**Final
Risk Assessment Report
for Davis Site**

Prepared for

**McClellan Air Force Base
Contract No. F04699-90-D-0035
Delivery Order 5055
Line Item 0017**



Prepared by

CHM HILL

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EXECUTIVE SUMMARY

Executive Summary

This preliminary risk assessment for the Davis Global Communications Site (Davis Site) addresses both human health risks and ecological effects associated with contaminants detected at the Davis Site. To complete the RA, information developed through the remedial investigations conducted at the site were used to:

- Identify contaminants of potential concern (COPCs) at the Davis Site
- Identify potential exposure pathways from the contaminants of potential concern to human and ecological receptors
- Estimate contaminant concentrations to which receptors could become exposed through the potential exposure pathways
- Estimate contaminant intake rates through the potential exposure pathways
- Characterize potential risks to humans and wildlife associated with estimated intake rates

This preliminary risk assessment was based on a reasonable maximum exposure (RME) scenario, and was developed in accordance with applicable federal, state, and Installation Restoration Program (IRP) guidance (IRP, 1991). In developing the RME scenario, conservative assumptions were used that estimated exposures to site contaminants well above average exposure levels, but still within the range of possible exposures.

COPCs that were evaluated in the risk assessment were volatile organic compounds (VOCs) detected in soil gas and groundwater, and petroleum hydrocarbons and polynuclear aromatic hydrocarbons detected both in subsurface soil and in stockpiled soils. Generally, exposures to these contaminants were based on the highest concentrations detected at the site.

Exposure scenarios developed to evaluate risks to human health considered onsite workers potentially exposed by inhalation to emissions of VOCs emitted from soil gas or groundwater from the site production well, dermal contact with VOCs in groundwater, or soil ingestion and dermal contact with contaminants in excavated soils.

Because of zoning restrictions in Yolo County, the site is not likely to be used for residential housing in the event of a mission change. Nevertheless, at the request of regulatory agencies, a hypothetical residential exposure scenario was evaluated, involving

ingestion, inhalation, and dermal contact with VOCs detected in groundwater monitoring wells. This hypothetical scenario assumes that individuals living at the site would use untreated groundwater for drinking water or other purposes.

Ecological resources potentially at risk are limited. However, two special-status species could use certain features of the site—Swainson's hawk and the burrowing owl. Certain remediation activities could result in small losses in foraging habitat for Swainson's hawk. Burrowing owls using the stockpiled soils for nesting could potentially become exposed to petroleum hydrocarbons detected in the soil. With minimal dilution and ventilation in the burrows, hydrocarbon contaminants in the soil could volatilize and reach equilibrium concentrations in air, resulting in potential inhalation exposures.

Risks to human health are expressed either as increased lifetime cancer risks or as potential for adverse noncancer health effects. Estimated health risks to humans are summarized in Table S-1. The results do not indicate the presence of conditions posing any imminent or substantial danger to human health or the environment. EPA generally considers action to be warranted at a site where increased lifetime cancer risks exceed one in ten thousand (1×10^{-4}) or a noncancer hazard index exceeds one (unless applicable and appropriate relevant requirements (ARARs) are exceeded or adverse ecological effects are associated with the site). Generally, action is not required for risks falling within 1×10^{-4} to one in one million (1×10^{-6}); however, judgment is on a case-by-case basis. Risks less than 1×10^{-6} typically are not of concern to regulatory agencies.

Based on these results, the preliminary risk assessment indicates that some action may be required to reduce future risks to human health associated with contaminants in groundwater. However, there are significant uncertainties in the risk estimates associated with contaminants in water from the site production well. Additional monitoring from the site production well may be warranted to better evaluate the presence and concentrations of ethylene dibromide and trihalomethanes (such as chloroform) in water.

Under current conditions, further action is not indicated to reduce human health risks associated with direct contact exposures (soil ingestion and dermal contact) to petroleum hydrocarbon contaminants in soil or inhalation exposures from emissions of VOCs from soil gas in the air. Should the site be developed for residential use in the future, further evaluation of petroleum hydrocarbon constituents could be required to address potential risks to human health.

Diesel hydrocarbon concentrations in some samples from the stockpiled soils exceeded an ecological benchmark level for inhalation exposure, suggesting the presence of some risks to burrowing owls. Significant uncertainties are associated with the estimation of ecological exposures and with the benchmark level development, and the ecological risk assessment methodology tends to overestimate the risks associated with petroleum hydrocarbons in soil.

Table S-1 Summary of Estimated Human Health Risks Davis Global Communications Site							
Receptor	Affected Media	Exposure Route	Cancer Risk Estimates			Noncancer Effects	
			Increased Lifetime Cancer Risk ^a	Contaminants Principally Contributing to Risks	Hazard Index ^b	Contaminants Principally Contributing to Noncancer Effects	
Onsite worker – outdoors	Soil gas, groundwater	Inhalation	3 x 10 ⁻⁷	Tetrachloroethene (PCE) in soil gas	<1	N/A	
Onsite worker – excavation	Soil	Soil ingestion and dermal contact	3 x 10 ⁻⁹	bis(2-ethylhexyl)phthalate in soil	<1	N/A	
Onsite worker – indoors (Building 4708)	Soil gas, groundwater	Inhalation and dermal contact with water	3 x 10 ⁻⁵	PCE in soil gas, ethylene dibromide (EDB), and chloroform in groundwater	<1	N/A	
Hypothetical future onsite resident ^c	Groundwater, soil gas, soil	Ingestion, inhalation and dermal contact	7 x 10 ⁻³	PCE and trichloroethene (TCE) in groundwater	>1	PCE, Petroleum hydrocarbons	

^aNumerical risk estimates are not predictions of actual health outcomes. These estimates are calculated in a manner that overestimates risk, and thus any actual risks are likely to be lower than these estimates, and may even be zero. EPA generally considers action to be warranted at a site when cancer risks exceed 1 x 10⁻⁴. Generally, action is not required for risks falling within 1 x 10⁻⁴ to 1 x 10⁻⁶ (unless ARARs are exceeded or adverse ecological effects are associated with the site); however, this is judged on a case-by-case basis. Risks less than 1 x 10⁻⁶ generally are not of concern to regulatory agencies.

^bHazard index greater than one indicates that there is some potential for adverse noncancer health effects associated with exposure to the contaminants of concern.

^cFuture residential use of the site is not likely, based on zoning requirements in Yolo County. Hypothetical scenario was included at regulatory agency request to evaluate aquifer nondegradation requirements.

Note: Health risk estimates based on reasonable maximum exposure (RME) scenarios.

^aNumerical risk estimates are not predictions of actual health outcomes. These estimates are calculated in a manner that overestimates risk, and thus any actual risks are likely to be lower than these estimates, and may even be zero. EPA generally considers action to be warranted at a site when cancer risks exceed 1×10^{-4} . Generally, action is not required for risks falling within 1×10^{-4} to 1×10^{-6} (unless ARARs are exceeded or adverse ecological effects are associated with the site); however, this is judged on a case-by-case basis. Risks less than 1×10^{-6} generally are not of concern to regulatory agencies.

^bHazard index greater than one indicates that there is some potential for adverse noncancer health effects associated with exposure to the contaminants of concern.

^cFuture residential use of the site is not likely, based on zoning requirements in Yolo County. Hypothetical scenario was included at regulatory agency request to evaluate aquifer nondegradation requirements.

Note: Health risk estimates based on reasonable maximum exposure (RME) scenarios.

The soil piles are not significant habitat and could be removed or graded with insignificant impacts to owl populations, thereby mitigating this potential ecological impact. Ecological impacts could be associated with a groundwater remedial action alternative that includes an irrigation end-use option. A storage pond would be constructed as a part of the irrigation system, which could attract waterfowl. Potential impacts to waterfowl could include botulism outbreaks and selenium toxicity under certain conditions. However, adherence to proper management practices should reduce surface-water problems to waterfowl to insignificant levels.

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ACRONYMS AND ABBREVIATIONS

Acronyms and Abbreviations

AFB Air Force Base
ARAR applicable or relevant and appropriate requirement

bgs below ground surface

Cal/EPA California Environmental Protection Agency
CARB California Air Resources Board
CDFG California Department of Fish and Game
CNDDDB California Natural Diversity Data Base
COPC contaminant of potential concern
CPT cone penetrometer test

DTSC Department of Toxic Substances Control

EBD ethylene dibromide
EPA U.S. Environmental Protection Agency

FFSRA Federal Facilities Site Remediation Agreement
FS feasibility study

HEAST Health Effects Assessment Summary Tables
HI hazard index
HQ hazard quotient

IRIS Integrated Risk Information System
IRP Installation Restoration Program
ITC International Technology Corporation

NOAA National Oceanic and Atmospheric Administration

PCE tetrachloroethene
PNA polynuclear aromatic hydrocarbon

RME reasonable maximum exposure
RWQCB Regional Water Quality Control Board
RI remedial investigation
RI/FS remedial investigation/feasibility study
RfC reference concentration
RfD reference dose

SF slope factor
SVAB Sacramento Valley Air Basin
SVMW soil vapor monitoring well

TCE	trichloroethene
THM	trihalomethane
TPH	total petroleum hydrocarbon
UCL	upper confidence limit
USGS	U.S. Geological Survey
VOC	volatile organic compound
WHR	Wildlife-Habitat Relationships

Chapter 1
INTRODUCTION

Chapter 1

Introduction

1.1 Purpose of the Risk Assessment

This report presents the human health and ecological risk assessment of the McClellan Air Force Base (McClellan AFB) Davis Global Communications Site (Davis Site), located in Yolo County, California. The primary purpose of the risk assessment is to give risk managers an understanding of the actual and potential risks to human health and the environment posed by the Davis Site. That information will be useful in determining whether remedial action is warranted. This risk assessment (RA) report is a companion document to the Working Copy Remedial Investigation/Feasibility Study (RI/FS) report prepared for the Davis Site (CH2M HILL, 1993a).

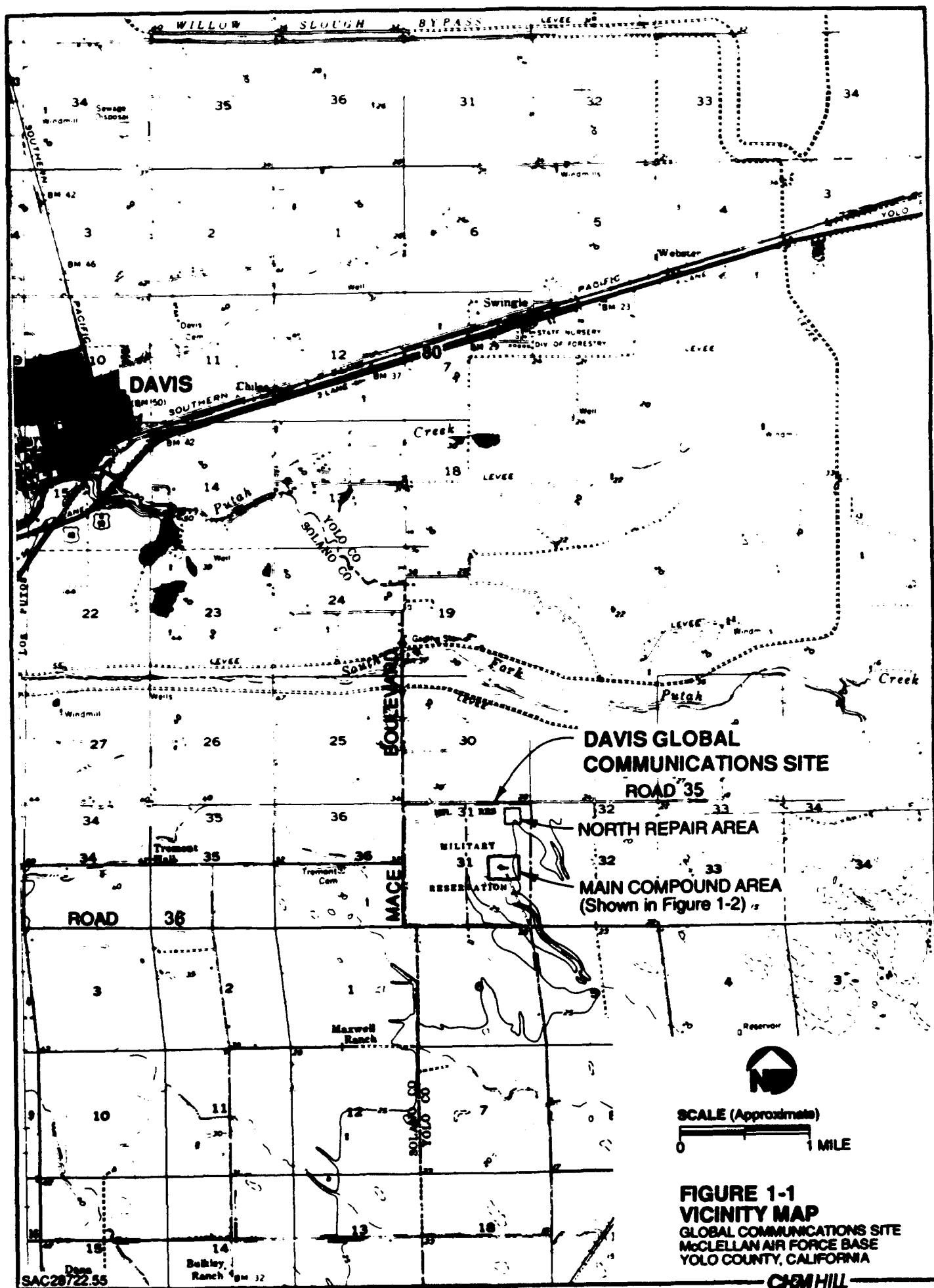
The purpose of the RI/FS was to provide an implementable strategy for remediation that complies with the schedule outlined in the Federal Facilities Site Remediation Agreement (FFSRA). This strategy must also be approved by McClellan AFB, the Regional Water Quality Control Board (RWQCB), and Department of Toxic Substances Control (DTSC). The RI/FS and RA reports and recommendations have been structured to be compatible with programmed intermediate remedial actions as well as remedial actions currently being implemented. The RI/FS report also provides an account of the remedial investigations performed at the Davis Site since 1985. The RA has been developed from information compiled by the RIs performed at the site. It is based on current site conditions and assumes that no action will be taken in the future to remediate contamination detected at the Davis Site.

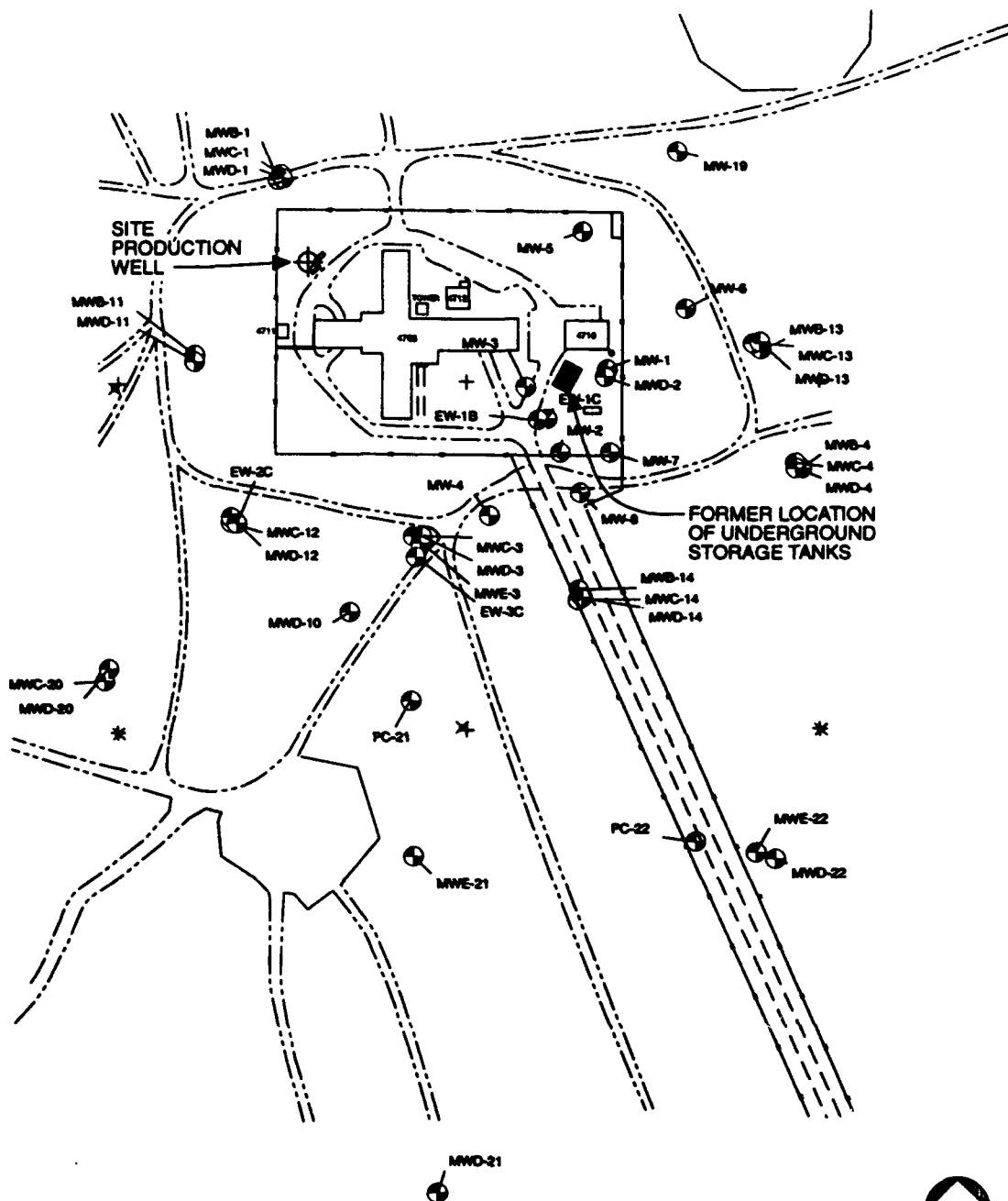
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1.2 Site History

The Davis Site is an annex of McClellan AFB in Sacramento, located approximately 4 miles south of the City of Davis, as shown in Figure 1-1. The site encompasses approximately 316 acres in Yolo County and is surrounded by farmland. A 320-acre parcel on the west side of the site was ceded to Yolo County in 1973 for development as Wilson Park. Parts of Wilson Park are now leased to an archery club, a horseshoe club, and a dog training club. The remainder is open grassland.

The Davis Site consists of the fenced main compound area (approximately 8 acres), communication antennae, and undeveloped grasslands, as shown in Figure 1-2. The site is staffed with approximately 12 people 24 hours a day by the 2049th Communications Squadron, which operates out of McClellan AFB, approximately 20 miles to the northeast. Further information on the site and surrounding areas appears in Chapter 2.





SITE MAP

Showing former underground storage tank
location and monitoring well locations

FIGURE 1-2
DAVIS SITE MAP
DAVIS GLOBAL COMMUNICATIONS SITE
McCLELLAN AIR FORCE BASE
YOLO COUNTY, CALIFORNIA

In 1985, three underground storage diesel-fuel tanks and associated piping were discovered to be leaking diesel fuel. The tanks were drained and removed in 1988. However, during the course of the field investigation for hydrocarbon contamination, volatile organic compounds (VOCs) were detected in groundwater samples. The source of these VOCs is unknown; however, measurable levels have been detected in the vadose zone and in the groundwater beneath the site. Site field investigation activities by J. H. Kleinfelder and Associates, International Technology Corporation (ITC), and CH2M HILL, and groundwater monitoring activities by Radian Corporation have been conducted at the site since 1985. Additional information concerning these site investigation activities is presented in Chapter 3. The RI/FS report contains a complete summary of the site investigations.

1.3 Risk Assessment Approach

As described in the scope of work for Delivery Order 5055, a preliminary risk assessment addressing both human health risks and ecological effects was prepared for the Davis Site. To be consistent with this requirement, the RA was based on a series of conservative assumptions, simplified models, and interpretations of site investigation data that tend to overstate the magnitude of health risks associated with contaminants detected at the site. Numerical risk estimates developed in this report are not predictions of actual health outcomes or ecological effects. These estimates have been calculated in a manner that overestimates risk, and thus any actual risks are likely to be lower than these estimates, and may even be zero. Figure 1-3 presents a conceptual overview of the RA process for both human health and ecological effects.

1.3.1 Human Health Risk Assessment

The objectives of the human health risk assessment were as follows:

- Identify chemicals of potential concern at the site
- Identify feasible exposure pathways from sources of the chemicals of potential concern to human populations
- Estimate chemical concentrations that individuals could become exposed to through the identified exposure pathways
- Estimate chemical intake rates through the identified exposure pathways
- Characterize potential risks to human health associated with estimated intake rates
- Discuss uncertainties in the estimated health risks

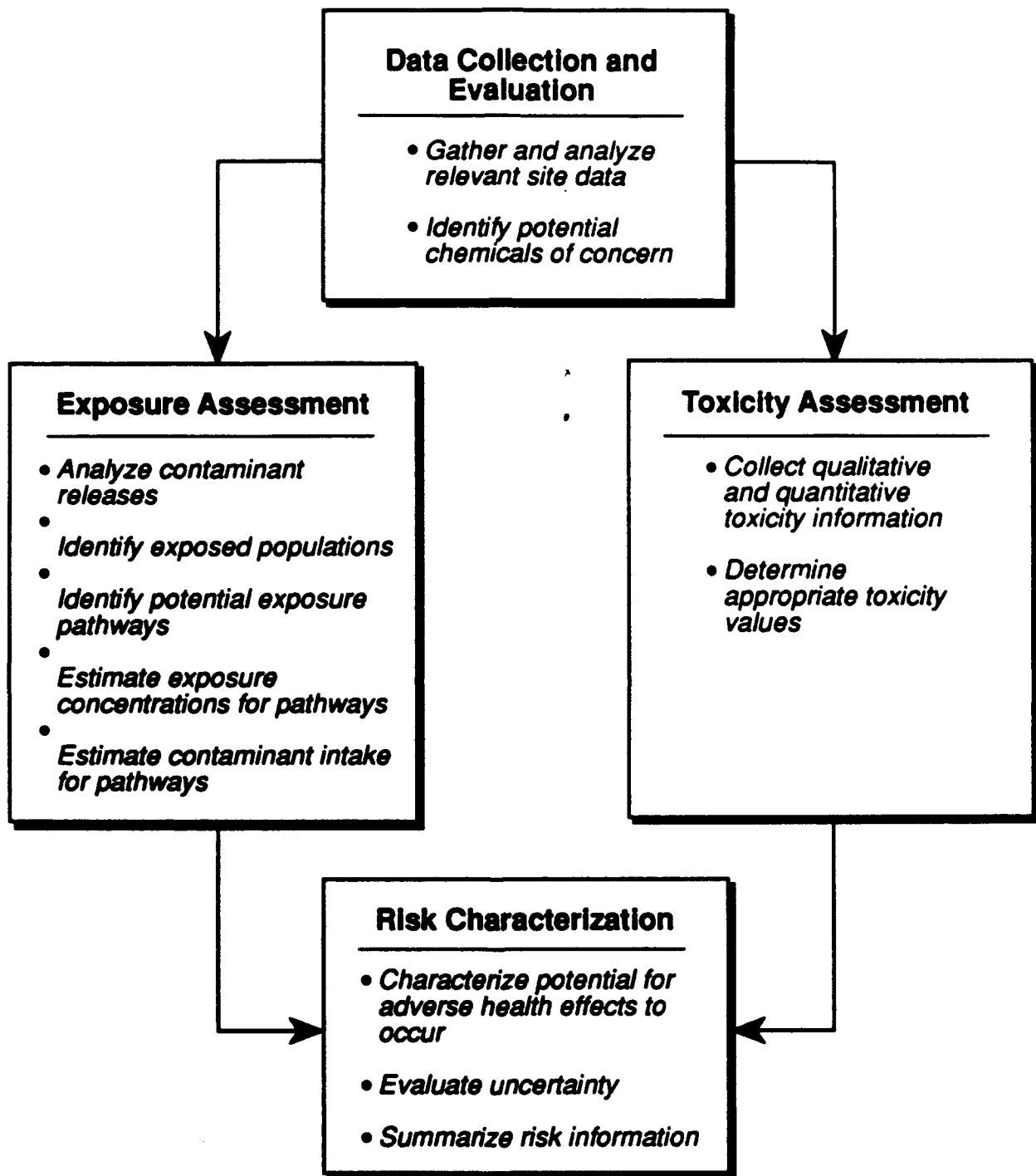


FIGURE 1-3
ELEMENTS OF RISK ASSESSMENT
DAVIS GLOBAL COMMUNICATIONS SITE
MCLELLAN AIR FORCE BASE
YOLO COUNTY, CALIFORNIA

Source: EPA, 1989

CH2M HILL

The following steps were involved in the human health risk assessment:

- **Selection of Contaminants of Potential Concern (COPCs)**—The process of identifying and selecting for inclusion into the RA those contaminants of greatest potential health concern (i.e., the contaminants that are most toxic, mobile, persistent, or prevalent of those detected) from among the entire set of contaminants associated with the Davis Site.
- **Exposure Assessment**—The description of potentially exposed populations; frequencies and durations of potential exposure; plausible exposure pathways; and concentrations of contaminants in air, water, or soil that exposed populations might come into contact with through the identified exposure pathways.
- **Toxicity Assessment**—The characterization of the toxicological properties and health effects of contaminants with special emphasis on defining their dose-response relationships.
- **Risk Characterization**—The combining of results of the exposure and toxicity assessments and comparison of these with toxicity criteria established by the regulatory agencies to provide numerical estimates of risks. Characterization of health risks also includes discussion of uncertainties in the risk estimates created from the use of conservative assumptions or data interpretations.

The human health risk assessment was prepared in accordance with applicable federal and state agency guidelines (U.S. EPA, 1989a, 1991a, 1991b; Cal-EPA, 1992) and Installation Restoration Program (IRP) guidance (IRP, 1991).

1.3.2 Ecological Risk Assessment

The general purposes of the ecological and human health risk assessments are the same. The objective of both evaluations is to define the existing or baseline risk and then identify site conditions that will result in acceptable risk levels. Although there are many similarities in data requirements and analyses between the human health and ecological risk assessments, the two differ in receptors and associated pathways and, in practice, often differ in types of activities that produce risk. Whereas the human health assessment deals largely with contaminants released from the site, the ecological risk assessment also addresses physical alteration of habitat caused by remediation.

An ecological risk assessment addresses a series of issues. The first is an evaluation of existing ecological damage (if any) or the likelihood of damage at or near the site. This is done by comparing onsite levels of contaminants to concentrations known from laboratory tests or measurements at other sites to cause ecological effects such as mortality or reduced reproduction in indigenous populations. Ecological damage can also

be identified by examining the populations onsite and observing effects such as elevated tissue concentrations of site contaminants, incidences of mortality, altered species composition, and abundance of the biological communities in affected areas. If damage due to onsite contaminants is observed or predicted, the ecological risk assessment should define levels of the contaminants of concern that would reduce the effects to acceptable levels.

The ecological assessment must also address effects produced by remediation. This entails evaluating the expected ecological conditions resulting from specified cleanup levels and other remediation activities, such as physical disturbance or other alteration of habitat. The risk assessment should then compare the predicted conditions to acceptable conditions given site-specific characteristics. If remediation would result in residual ecological effects (either from contaminants remaining onsite or from remediation activities), the assessment should evaluate measures to eliminate or minimize those effects.

Finally, the assessment must address ecological resources that are regulated by various government agencies. The evaluation involves identifying such resources and then determining the level of protection provided by the recommended remediation. As with other aspects of the ecological risk assessment, the effects of residual contamination as well as habitat alteration must be considered.

The ecological assessment was prepared based on several agency guidance documents (U.S. EPA, 1989b, 1989c, 1992a, and 1992b) and other publications (Maughan, 1993 and Suter, 1993).

1.3.3 Document Overview

Each chapter begins with a brief discussion of its content and how that content fits into the structure of the report. Chapter 1 provides a history of the site, including current operations, and a description of the risk assessment approach. Chapter 2 presents a summary of site background information used to define the setting in which health risks and ecological effects were characterized. Chapter 3 provides a summary of the site characterization data, and integrates these data in a conceptual model. Chapter 4 is a summary of the human health risk assessment; Chapter 5 is a summary of the ecological risk assessment. Chapter 6 presents the findings and recommendations from both the human health and ecological risk assessments. Supporting documentation, including data interpretations, models, assumptions, calculations, and detailed technical information, is included as appendixes. These appendixes are cross-referenced with this narrative to facilitate review of this report.

Chapter 2
SITE BACKGROUND

Chapter 2

Site Background

Certain characteristics of the Davis Site are described in this chapter. This information was subsequently used in the RA in developing the site conceptual model and in identifying exposure pathways from contaminant sources detected at the site to human populations or wildlife. Pertinent site background information is briefly summarized in this chapter; a more detailed presentation of the site features and land use can be found in Appendix B, Site Background Information.

2.1 Site Features

Climate in the area of the Davis Site is moderate, with mild winters and hot, dry summers. Approximately 90 percent of the rainfall occurs between November and April with little or no precipitation from late spring to early fall. Prevailing winds are usually oriented along the major axis of the Sacramento Valley, approximately following a southeast-northwest pattern. Wind speeds average nearly 10 miles per hour much of the year (CH2M HILL, 1993b; Yolo County, 1983). Average wind speed is a parameter used in estimating contaminant concentration in air from emission sources in soil.

Most of the soils surrounding the Davis Site are considered prime agricultural farmland by the Soil Conservation Service. Soils underlying the site consist of Brentwood silty clay loam (0 to 2 percent slope), Marvin silty clay loam (no slope rating), Pescadero silty clay (no slope rating), and Capay silty clay (no slope rating). Surface water at the site consists of ephemeral rainwater pools onsite and agricultural drainage ditches along the site boundary. There are no permanent ponds or creeks within 1 mile of the site, nor any direct connections to Putah Creek, which is located approximately 1.5 miles north of the site.

During earlier investigations, as many as seven different coarse-grained units were defined as aquifers beneath the Davis Site. These aquifers have been given letter designations A through G, sequentially increasing with depth. Because of the effects of agricultural groundwater withdrawals near the site, groundwater levels, flow directions, and velocities appear to change significantly throughout the year.

The Davis Site is an area of frequently disturbed annual grasses surrounded by actively cultivated fields. Except for structures, gravel drives, and other man-made site features, there is little or no variation in the uniform annual grassland habitat. Within or immediately adjacent to the site there are virtually no trees, shrubs, topographical relief, significant wetlands, or other feature that could produce edge conditions or represent uncommon habitat. Although Wilson Park, which borders the western edge of the site, may eventually be landscaped to include surface water and a variety of vegetation, the ecological characteristics of the park are currently identical to conditions at the Davis Site.

Small mammals, birds, and insects, together with associated predator species, are the most obvious animal components of the site community. California ground squirrels, black-tailed hares, and mice are common. Raptors (i.e., hawks, owls, and harriers) were observed onsite, and there was evidence of mammalian predators (coyote or fox). Except for owls, as noted below, the population density of predators is likely low because of the relatively low prey abundance and frequent human disturbance. Similarly, the marginal habitat and extensive activity associated with the site and surrounding agricultural lands likely preclude the presence of mammals and birds (such as deer or short-eared owl) intolerant of human disturbance.

However, certain ecological resources should be noted in the planning and implementation of remedial action at the site. There are two special-status species (threatened, endangered, or special concern) whose range and general habitat requirements are met at the Davis Site. These include the Swainson's hawk and the burrowing owl. The ranges of other special-status species include the Davis Site, but because of non-contaminant-related site conditions, the site was judged not capable of supporting these species. Swainson's hawk has several known breeding locations within 10 miles of the Davis Site (CNDDDB, 1993), so it is likely this species forages over the area. However, because the area apparently has relatively low prey density and is subject to frequent human disturbance, the site is most likely not a primary feeding area for the Swainson's hawk.

In contrast to the special-status Swainson's hawk, the burrowing owl, which is a California Special Concern species, is common within the Davis Site. More than a dozen owls were observed on the site and, because both juveniles and adults were seen, it is likely that they are successfully breeding in the area. The abundance of ground squirrel burrows (which the owls use for cover and breeding), lack of cultivation, and the birds' tolerance for human activity most likely account for their relatively common presence.

Two small areas (in combination less than 1 acre) east of the compound accumulate seasonal rainfall. These two areas do not exhibit the characteristics of vernal pools, retain water for significant periods, or support vegetation characteristic of wetlands. Consequently, they do not represent unique resources and most likely do not qualify as federally protected wetlands.

The closest features that demonstrate significant ecological variability or uniqueness are Putah Creek and its associated riparian habitat. The creek is approximately a mile north of the site and supports extensive emergent vegetation, trees, and shrubs. The creek and corridor represent significant habitat and variability in an area of annual grassland and intense cultivation. The Putah Creek system is too distant from the Davis Site to be affected by it, but the creek could be a factor in the ecology of the site by supporting animals that occasionally use the site for migration or foraging.

2.2 Land Uses

The Davis Site is surrounded on three sides by agricultural land devoted to a variety of crops, including row tomatoes, field corn, and alfalfa. Wilson Park is adjacent to the western border of the site. This 320-acre parcel was formerly part of the Global Communications Site. McClellan AFB ceded the parcel to Yolo County in 1973 for development as a park. Parts of Wilson Park are now leased to an archery club, a horse club, and a dog-training club. The remainder of the park is grassland (CH2M HILL, 1992). Most of the park (170 acres) will remain in native grasslands and oak trees. One reason that the park has remained largely undeveloped is the lack of a water supply for irrigation (CH2M HILL, 1993c).

The only apparent residential area is the El Macero area, which is bounded by Mace Boulevard to the west and Interstate 80 to the north and is located approximately 4 miles to the northwest of the Davis Site. The Davis Migrant Center, a migrant farm-worker camp, is immediately to the southeast of the site (approximately one-half mile from the main compound) at the intersection of Road 36 and Road 105. The Migrant Center reportedly is hydrologically downgradient of the Davis Site (ITC, 1992). Aerial photography indicates that structures (possibly including residences) are located immediately to the southeast and south of Wilson Park, approximately 1,500 to 1,800 feet from the border of the site.

Yolo County's General Plan promotes the conservation and preservation of agricultural land. Residential land uses in agricultural areas are limited to dwellings for the preservation of the family farm or for farm employees only, with population densities and locations of dwellings limited by County ordinances. Yolo County may prohibit development of residential land uses in agriculturally-designated parcels (Yolo County, 1983). Future land use plans for the Davis Site have not yet been specified but are expected to remain unchanged.

Chapter 3
SITE CHARACTERIZATION SUMMARY

Chapter 3

Site Characterization Summary

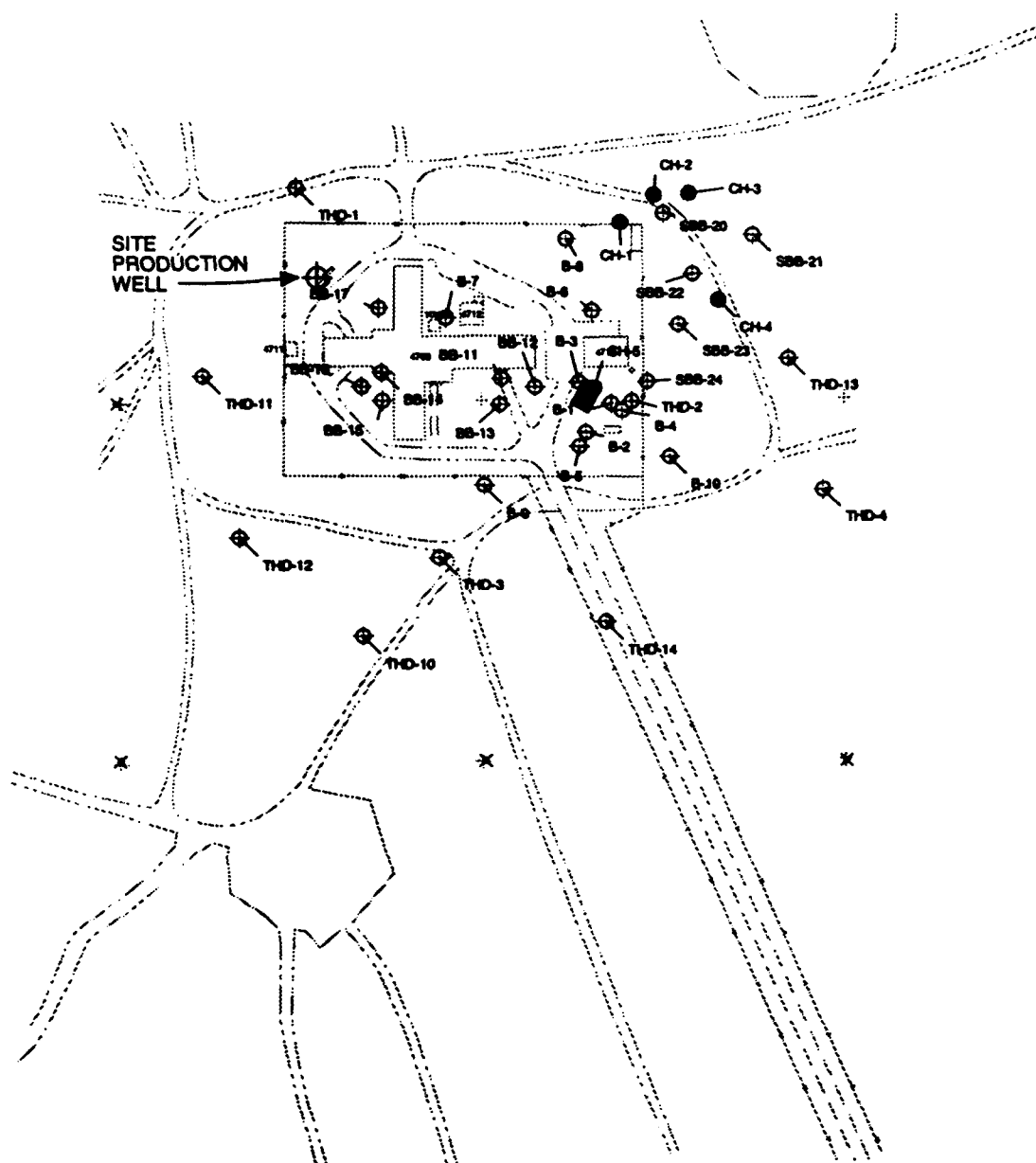
Three site investigations have been performed at the Davis Site since 1985. In addition, groundwater has been sampled quarterly since July 1992. A treatability study for petroleum-contaminated soils is also being performed at the site. These investigations are briefly summarized in this chapter. Data collected during these investigations, and site background information presented in Chapter 2 and Appendix B, have been synthesized in a site conceptual model.

This conceptual model describes contaminant sources at the Davis Site, pathways of contaminant migration from those sources, and receptors (locations of human or wildlife populations that could potentially become exposed to contaminants at the site). This conceptual model was the basis for developing scenarios that define conditions under which exposures could potentially occur, and for estimating the potential magnitude of exposure. A more detailed description of the site conceptual model can be found in Appendix C, Site Conceptual Model. Appendix C also presents a table of investigative activities in chronological order, on a "per media" basis (soil, groundwater, and soil gas, in that order).

Figures 3-1a through 3-1d and Figure 3-2 present the sampling locations from the current and previous investigations of the site:

- Figures 3-1a and 3-1b present locations related to soil sampling activities. These include soil samples, geophysical borings, soil vapor monitoring wells (SVMWs) where soil samples were collected, and soil pile samples.
- Figures 3-1c and 3-1d present locations related to groundwater sampling activities. These include groundwater monitoring wells, Hydropunch samples, and extraction wells.
- Figure 3-2 includes locations related to soil gas sampling activities. These include shallow soil gas samples from both CH2M HILL's and ITC's investigations, SVMWs, and groundwater monitoring wells where soil gas samples were collected.

The data used to identify contaminants of potential concern (COPCs) and estimate exposures to human or wildlife populations are discussed in Chapters 4 and 5. Further details concerning the investigations at the site are presented in the RI/FS report (CH2M HILL, 1993a).



LEGEND

- ⊕ SOIL BORINGS
 - B-1 through B-10 (Kleinfelder, 1985)
 - BB-11 through B-17 (ITC, August through September, 1985)
 - SBB-18 through SBB-24 (ITC, December, 1990)
 - THD-1 through THD-4 (ITC, November, 1990, Geophysical Logs)
 - THD-11 through THD-14 (ITC, November 1990, Geophysical Logs)
- SOIL VAPOR MONITORING WELL SAMPLED FOR SOIL
 - CH-1 through CH-5 (CH2M HILL, November, 1992)

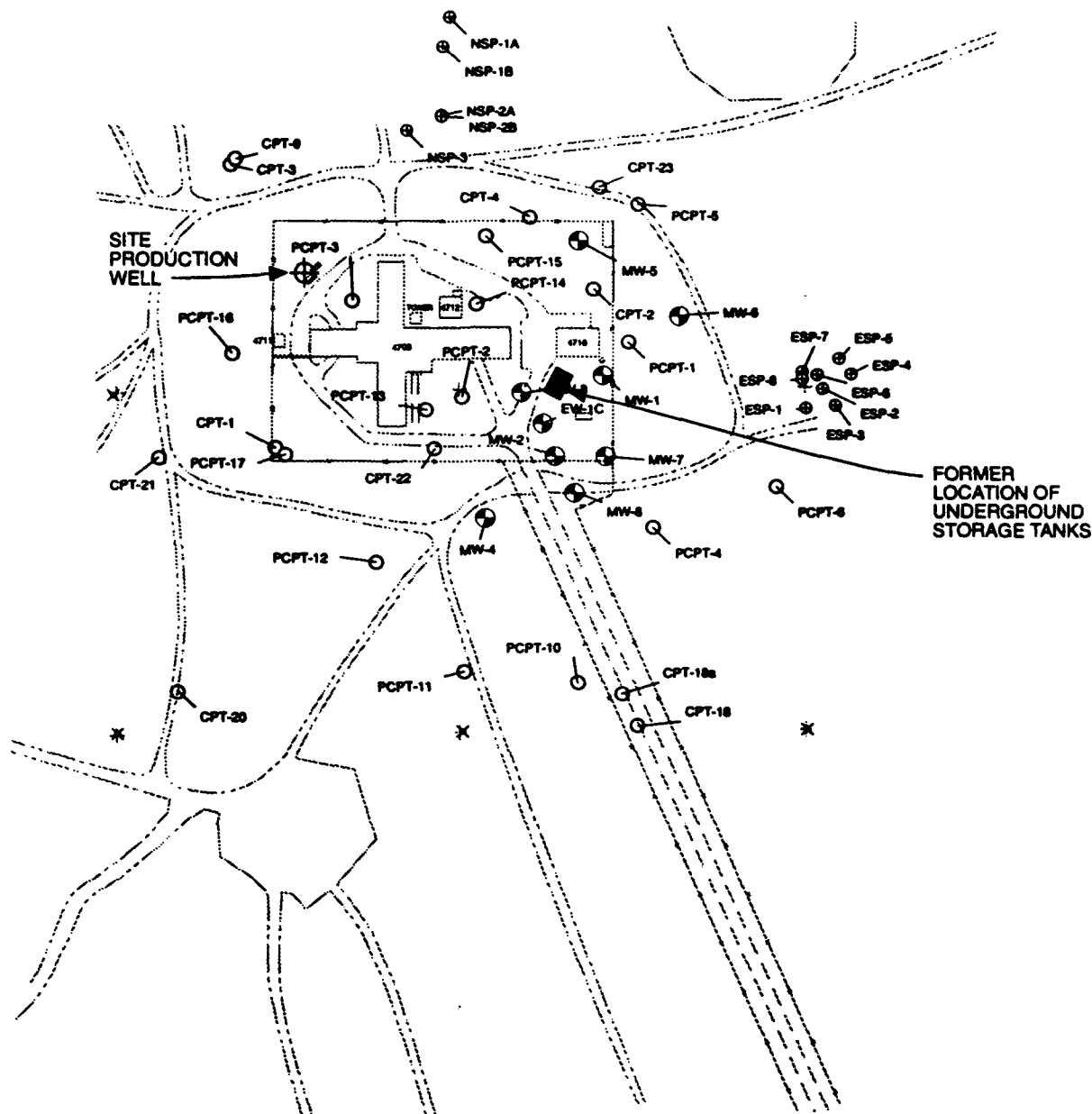
NOTE: Locations based on IRPIMS data



SCALE (Approximate)

0 250 FEET

FIGURE 3-1a
SOIL SAMPLING LOCATIONS
 DAVIS GLOBAL COMMUNICATIONS SITE
 MCCLELLAN AIR FORCE BASE
 YOLO COUNTY, CALIFORNIA



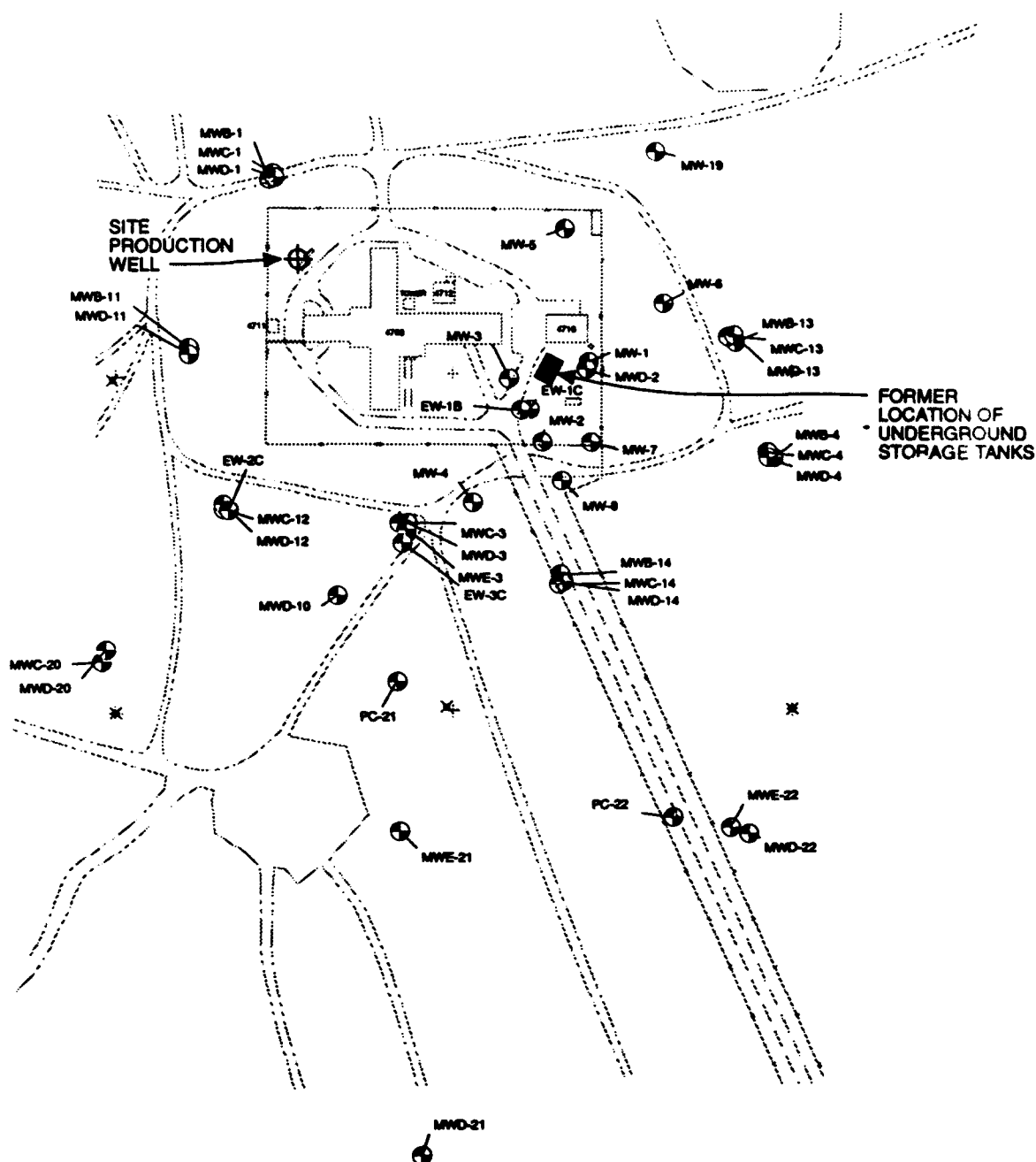
LEGEND

- CONE PENETROMETER SOUNDINGS
 - CPT-1 through CPT-4 (ITC, May 1989)
 - PCPT-1 through PCPT-5 (ITC, May 1989)
 - PCPT-6 through PCPT-7 (ITC, January 1990)
 - PCPT-10 through PCPT-17 (ITC, January 1990)
 - CPT-9 (ITC, January 1990)
 - CPT-18, CPT-18a, CPT-20 through CPT-23 (CH2M HILL, November 1992)
- ⊕ GROUNDWATER MONITORING WELL SAMPLED FOR SOIL
 - MW-1 through MW-8 (ITC, August 1987)
 - EW-1C (CH2M HILL, May 1993)
- ⊗ EX SITU SOIL PILES
 - ESP-1 through ESP-8; NSP-1A, -1B; NSP-2A, -2B; NSP-3 (CH2M HILL, November 1992)

NOTE: Locations based on IRPIMS data



FIGURE 3-1b
CONE PENETROMETER SOUNDINGS
AND GROUNDWATER WELLS
SAMPLED FOR SOIL
 DAVIS GLOBAL COMMUNICATIONS SITE
 McCLELLAN AIR FORCE BASE
 YOLO COUNTY, CALIFORNIA



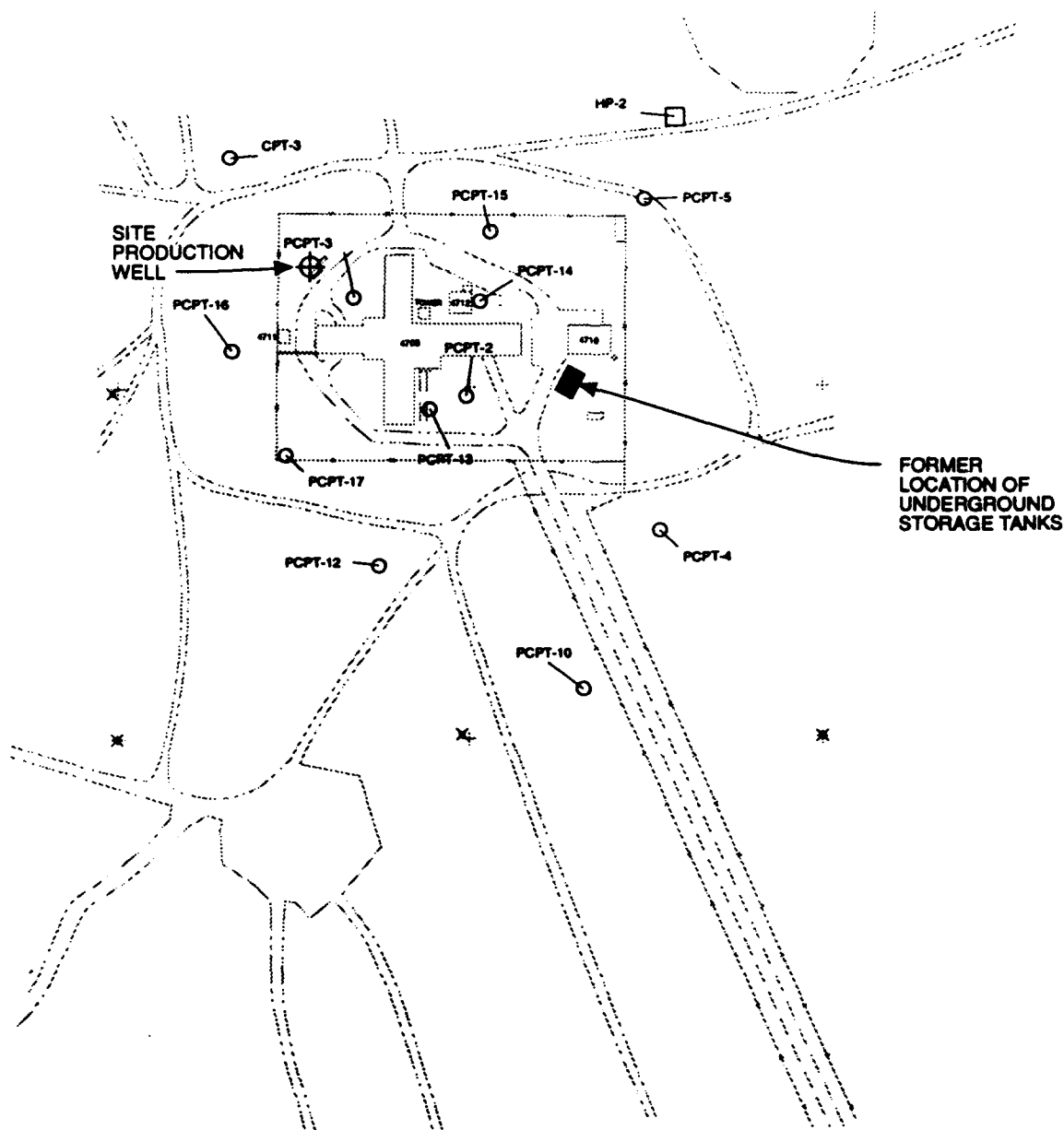
LEGEND

- 
GROUNDWATER MONITORING WELL
 MW-1 through MW-8 (ITC, August 1987)
 Cluster Wells: MWB-1, -4, -11, -13, -14; MWC-1, -3, -4, -12, -13, -14;
 MWD-1, -2, -3, -4, -10, -11, -12, -13, -14; MWE-3
 (ITC, October through January 1991)
 MW-19, MWC-20, MWD-20, -21, -22; MWE-21, -22; and Piezometers PC-21,
 PC-22 (CH2M HILL, April through June 1993)
- 
EXTRACTION WELL
 EW-1B, EW-1C, EW-2C, EW-3C (CH2M HILL, April through May 1993)



SCALE (Approximate)
 0 250 FEET

FIGURE 3-1c
GROUNDWATER
SAMPLING LOCATIONS
 DAVIS GLOBAL COMMUNICATIONS SITE
 McCLELLAN AIR FORCE BASE
 YOLO COUNTY, CALIFORNIA



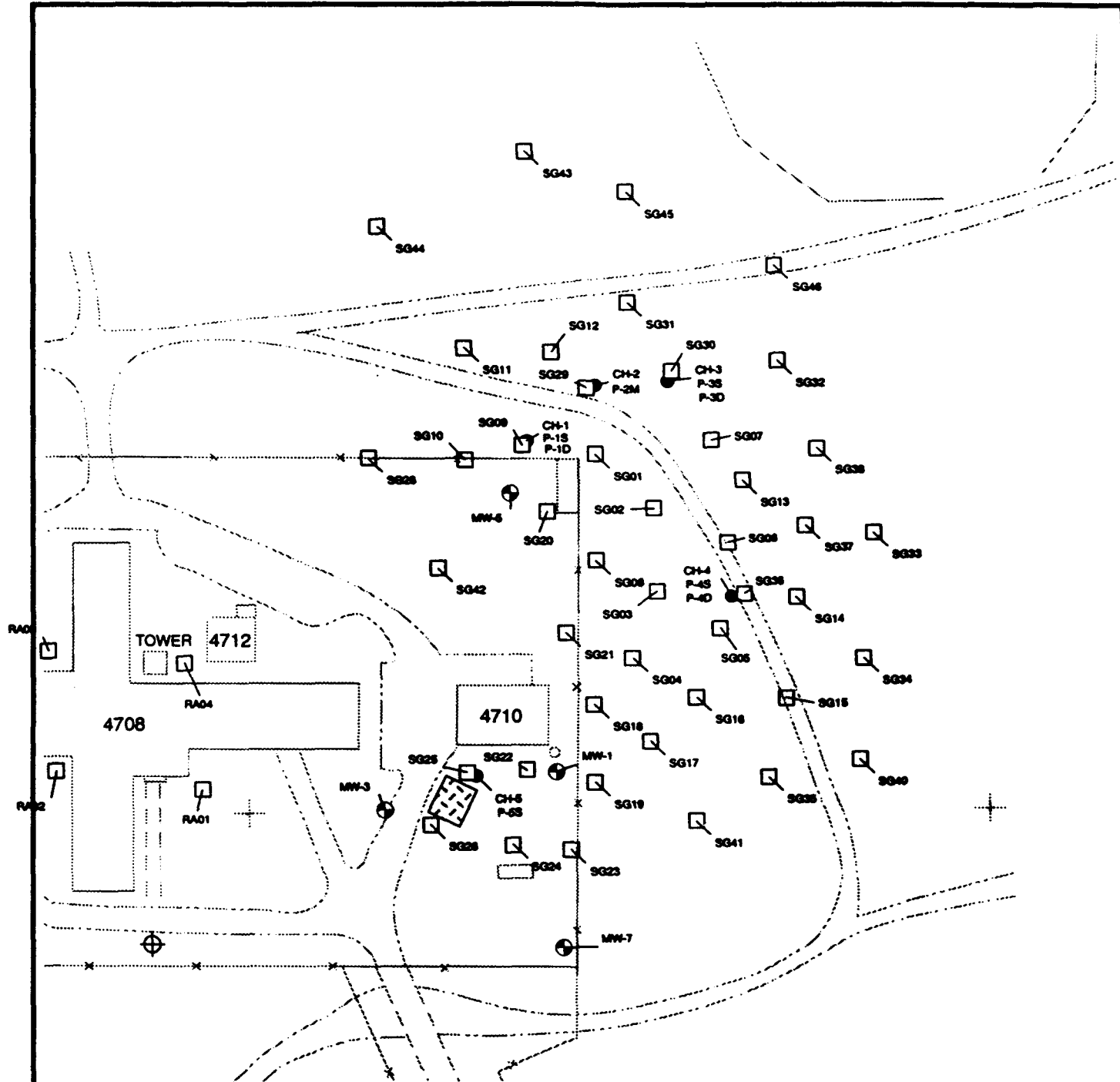
LEGEND

- CONE PENETROMETER SOUNDINGS
CPT-3, PCPT-2 through PCPT-5 (ITC, May 1989)
PCPT-10, PCPT-12 through PCPT-17 (ITC, January 1990)
- HYDROPUNCH
HP-2 (CH2M HILL, April 1993)

NOTE: Hydropunch samples were taken at the sounding locations.



FIGURE 3-1d
HYDROPUNCH LOCATIONS
DAVIS GLOBAL COMMUNICATIONS SITE
MCLELLAN AIR FORCE BASE
YOLO COUNTY, CALIFORNIA



LEGEND

- SHALLOW SOIL GAS SAMPLE LOCATIONS
SG-1 through SG-46 (CH2M HILL, September 1992) and
Risk Assessment Soil Gas Survey Locations RA01 through
RA04 (CH2M HILL, November 1992)
- ⊕ GROUNDWATER MONITORING WELL
MW-1, MW-3, MW-5, MW-7 (Sampled for soil gas by
CH2M HILL, August 1992)
- SOIL VAPOR MONITORING WELL
CH-1 through CH-5, including Piezometers P-1S, P-1D,
P-2M, P-3S, P-3D, P-4S, P-4D, P-5S (CH2M HILL,
November 1992)

▨ BACKFILL AREA



SCALE (Approximate)
0 100 FEET

FIGURE 3-2
SOIL GAS SAMPLING LOCATIONS
DAVIS GLOBAL COMMUNICATIONS SITE
MCLELLAN AIR FORCE BASE
YOLO COUNTY, CALIFORNIA

CH2M HILL

3.1 Summary of Previous Investigations

Ten borings drilled by J. H. Kleinfelder and Associates in 1985 identified soil contamination in the vicinity of three underground diesel-fuel tanks. The tanks were exposed, and damage to at least one tank and associated piping was evident. The tanks were then drained and covered with clean fill dirt and were finally removed in 1988.

In 1987 an investigation performed by ITC confirmed the presence of hydrocarbon contamination in the vicinity of the storage tanks to a depth of 55 feet below ground surface (bgs) and determined that the groundwater beneath the site had been contaminated with VOCs. In subsequent investigations by ITC, trichloroethene (TCE) and tetrachloroethene (PCE) were detected in soil gas to depths of 10 feet and in groundwater as deep as 118 feet bgs.

3.2 Summary of Current Investigations

CH2M HILL has conducted field investigation activities since June 1992, including the following:

- Seventy-one shallow soil gas samples were collected at depths ranging from 5 to 20 feet bgs to assist in the location of soil vapor monitoring wells.
- Six cone penetrometer test (CPT) soundings were advanced in November 1992 to investigate site stratigraphy.
- Five SVMWs and adjacent piezometers were installed in November 1992 to investigate the vadose zone contaminant and hydrogeologic properties.
- SVMWs were sampled for VOCs, and air permeability tests were performed to provide estimates of hydraulic conductivity in the vadose zone.
- Four groundwater extraction wells were installed in April and May 1993 to capture contaminated groundwater from the B and C aquifers.
- In May and June 1993, seven new groundwater monitoring wells and two groundwater piezometers were installed to aid in estimating the nature and extent of groundwater contamination.
- Short-duration pump tests were performed during well development to estimate aquifer properties.
- Two CPT soundings were advanced, and a test hole was drilled in April 1993 to provide guidance for locating a proposed injection well. Core

sampling, geophysical logging, and abandonment of the test hole occurred in June 1993.

- Existing soil piles were sampled for petroleum hydrocarbons.
- Aquifer testing was conducted in August 1992 and January 1993.
- Groundwater levels were measured biweekly during 1992 and monthly during 1993.

Other field activities at the Davis Site are being conducted by Radian Corporation, Engineering-Science Incorporated (ESI), and ITC. Radian is responsible for groundwater sampling from the monitoring wells onsite. This sampling has been performed on a quarterly basis since July 1992. ESI is performing a treatability study using in situ bioventing to remediate hydrocarbon contamination. ITC is evaluating an innovative technology involving drilling a horizontal well for use in groundwater extraction.

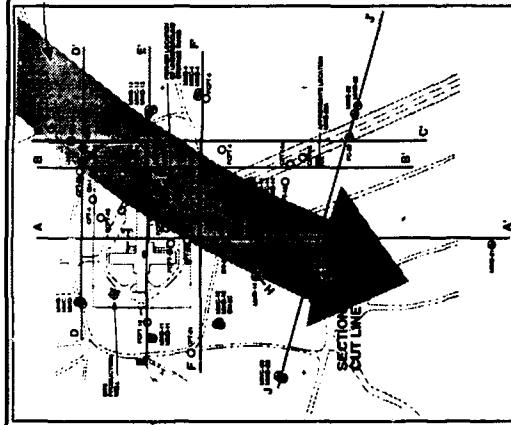
3.3 Conceptual Model

Contaminants detected at the site consist principally of diesel-range petroleum hydrocarbons and low-molecular weight polynuclear aromatic hydrocarbons (PNAs) in soil, aromatic and chlorinated VOCs in soil gas, and chlorinated VOCs in groundwater. Figure 3-3 depicts the conceptual model of sources and contaminant migration pathways for the Davis Site. Figure 3-4 presents the potential exposure pathways and receptor populations.

3.3.1 Petroleum Hydrocarbon Contamination in Soil

Petroleum hydrocarbon contamination was detected in soil samples from 30 to 65 feet bgs. The contamination is found mainly at the interface of a silty sand layer and a clay layer at a depth of 30 to 40 feet bgs, which represents approximate mean annual high groundwater depth. A second slug of contamination is found around 60 feet bgs in lean clay. This appears to correspond to the depth of low annual groundwater. Because the petroleum hydrocarbons float on the groundwater surface, contaminant distribution at these depths may represent deposition for the hydrocarbons in soil related to groundwater levels. Petroleum hydrocarbon constituents would not be likely to migrate readily from the locations where they were initially deposited in soil (USAF, 1989).

Two soil piles at the site are believed to have been generated during removal of the underground tanks. However, the actual source of the soil is unknown. Additional material such as construction debris has been added to the piles from other sources. The soil piles potentially serve as shelter and nesting sites for burrowing owls,



- LEGEND**
- VADOZE ZONE CONTAMINATION
 - COARSE-GRAINED MATERIALS
 - FINE-GRAINED MATERIALS
 - VOC CONTAMINATION
 - VOC TRANSPORT THROUGH COARSE GRAINED MATERIALS



VERTICAL EXAGGERATION 2:1
(Approximate)

FIGURE 3-3
DAVIS SITE CONCEPTUAL MODEL
DAVIS SITE, CALIFORNIA
MAGILLAN AIR FORCE BASE
YOLO COUNTY, CALIFORNIA

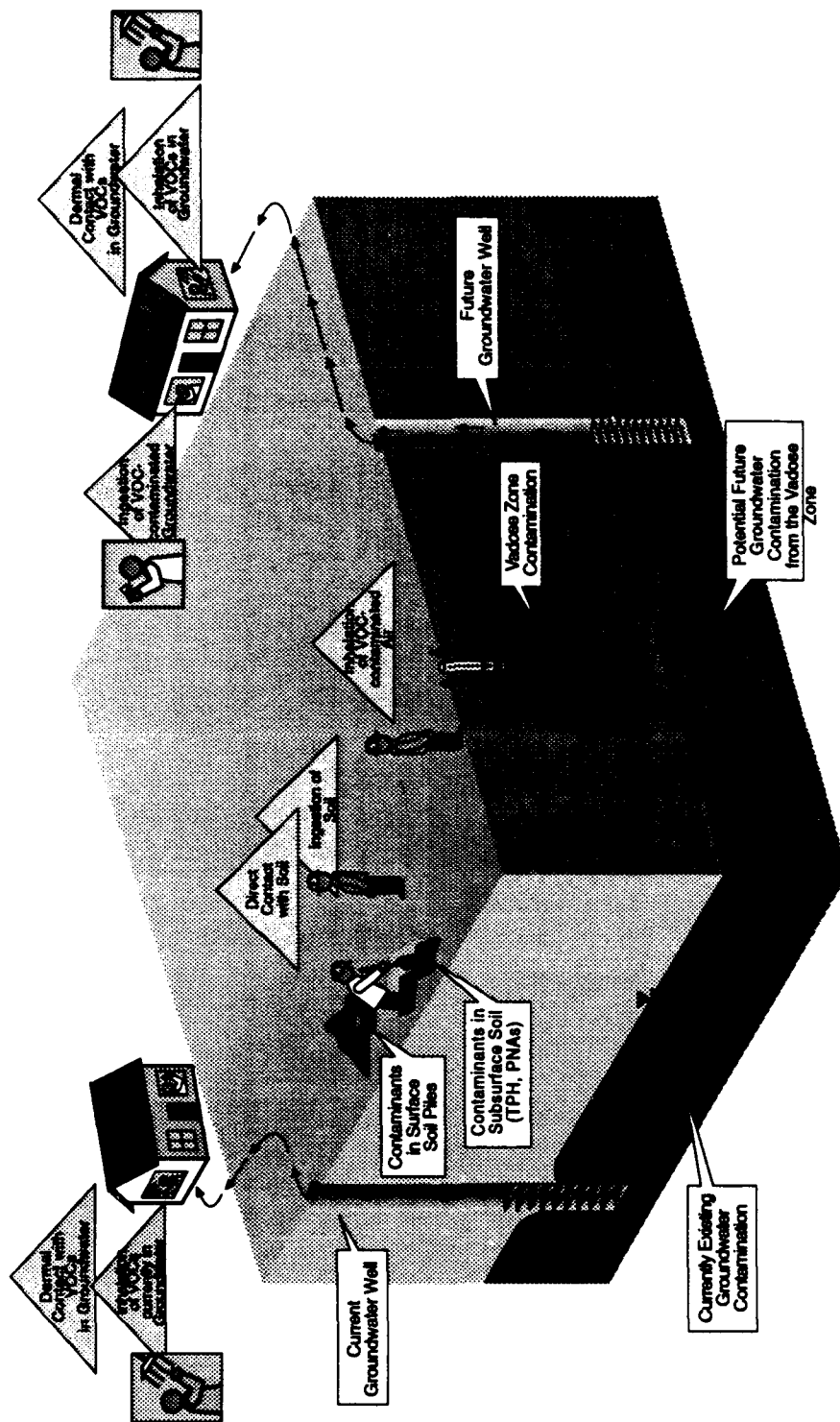


FIGURE 3-4
ILLUSTRATION OF
POTENTIAL EXPOSURE PATHWAYS
 DAVIS GLOBAL COMMUNICATIONS SITE
 MCCLELLAN AIR FORCE BASE
 YOLO COUNTY, CALIFORNIA

designated as a Species of Special Concern by the California Department of Fish and Game (CDFG). Therefore, petroleum hydrocarbon contamination detected in the soil piles was evaluated in the ecological risk assessment for the Davis Site.

3.3.2 VOCs in Soil Gas

Soil gas samples have been collected inside the main compound area and outside the perimeter fence surrounding the facility. Sampling depths have ranged from 5 to 40 feet bgs in areas where soil gas contaminants have been detected in previous investigations and near former underground diesel storage tanks. To evaluate potential exposures to onsite workers, four samples from a depth of 5 feet were collected around Building 4708.

Mass estimates based on the soil gas data indicate that the total estimated mass of contamination present in the vadose zone is 45 kilograms, with PCE accounting for more than 90 percent of the vadose zone mass. Approximately 45 percent of the contaminant mass estimated for the vadose zone is found between 26 and 40 feet bgs. VOCs in the vadose zone can migrate by leaching, or by volatilization followed by gaseous diffusion, or they can undergo degradation. Volatilization of VOCs from the soil surface to the air is a potential source of inhalation exposures, which was evaluated in the RA. Vadose zone modeling results indicate that the mass of PCE contamination now present in the vadose zone is potentially a significant long-term threat to the groundwater quality beneath the Davis Site.

3.3.3 VOCs in Groundwater

Dissolved contaminant mass in groundwater appears to be migrating downward to the lower aquifers (C and D aquifers) and laterally to the south. Highest groundwater flow velocities are reported to be approximately 5 feet per day to the south. The receptor wells closest to the site are located at the Davis Migrant Center, located one-half mile (approximately 2,600 feet) from the main compound area. Available information indicates that the wells at the Davis Migrant Center have not been sampled for VOCs (Taniguchi, 1993). Though PCE represents 90 percent of the contaminant mass in the vadose zone, TCE is the most prevalent contaminant in groundwater. This finding is probably the result of the higher soil organic carbon constant (k_{oc}) and lower solubility of PCE and the biodegradation of PCE to TCE, which is more mobile in soil.

The site production well, located northwest of Building 4708, is screened in both the C and D aquifers and has been sampled by McClellan AFB since 1986. Concentrations of PCE and TCE have been detected in this well, with levels remaining fairly constant throughout 1986 and 1987. Beginning in the fall of 1987, seasonal variations were observed, with concentrations rising in fall and winter months, and falling during spring and summer. This variation appears to be related to the pumping of offsite irrigation wells. During fall and winter when pumping for irrigation is low, the concentration gradient appears directed toward the production well. During spring and summer when

pumping for irrigation is at a maximum, contaminant concentrations appear to be drawn away from the production well (ITC, 1992). VOCs in groundwater used for irrigation are not likely to be accumulated into crops due to their low octanol-water partition coefficient (k_{ow}).

Other notable contaminants detected in the production well include trihalomethanes (chloroform, bromoform, chlorodibromomethane, and bromodichloromethane) and, beginning in 1991, ethylene dibromide (EDB). Water from the production well and samples typically are drawn prior to the point of chlorination. Trihalomethanes are formed from the reaction of chlorine with dissolved organic matter in water, suggesting that some samples had been drawn from already chlorinated water. EDB has been detected in groundwater most likely because of its use as an agricultural fumigant. EDB has been used as an additive in leaded gasoline. However, historical information indicates that diesel has been the only petroleum product stored at the site. Detected EDB in the production well is mostly likely unrelated to activities at the Davis Site.

Chapter 4
HUMAN HEALTH RISK ASSESSMENT

Chapter 4

Human Health Risk Assessment

One specific objective of the human health risk assessment is to analyze baseline risks and determine the need for action at the Davis Site. Baseline risks are those that might exist if no remediation or institutional controls were applied to the site (U.S. EPA, 1989a). This chapter presents a summary of the approach used in preparing the human health risk assessment and the results of this assessment. More details regarding assumptions, data interpretations, models, and calculations used in the RA are presented in the appendixes as a series of technical memorandums. The components of the human health risk assessment, along with the technical memorandums where more detailed information can be found, are:

- Identification of the contaminants of potential concern (COPCs) (Appendix D, Human Health Contaminants of Potential Concern)
- Exposure assessment (Appendix F, Air Pathway Analysis, and Appendix G, Exposure Assessment for Human Health Risk Assessment)
- Toxicity assessment (Appendix E, Toxicity Assessment for the Human Health Risk Assessment)
- Risk characterization

The numerical estimates of human health risk upon which the risk characterization is based appear in summary tables in Appendix A, Human Health Risk Assessment Summary Tables.

4.1 Identification of Contaminants of Potential Concern

The first step in the human health risk assessment was the identification and selection for inclusion into the risk assessment of those contaminants of greatest potential health concern (i.e., the contaminants that are most toxic, mobile, persistent, and/or prevalent of those detected at the Davis Site) from among the entire set of contaminants associated with the site. Identifying the COPCs serves to focus the RA on the most important contaminants (i.e., those presenting 99 percent of the total risk) detected at the site.

Factors considered in selecting COPCs for the RA (U.S. EPA, 1989a) are:

- Evaluation of the analytical methods
- Evaluation of data quality with respect to sample quantitation limits

- Evaluation of data quality with respect to qualifiers and codes
- Evaluation of data quality with respect to blanks
- Evaluation of tentatively identified contaminants
- Comparison of potential site-related contaminants with background (primarily for inorganic contaminants)

Evaluation of data for the risk assessment was based on the *EPA Guidance for Data Usability in Risk Assessment* (U.S. EPA, 1992c). Several of these factors were addressed before the RA for the Davis Site was begun. Analytical methods and sample quantitation limits used in the various site investigations have been specified in work plans approved by the appropriate regulatory agencies (CH2M HILL, 1992; Radian, 1992). Prior to use in the RA, data underwent validation with respect to qualifiers, codes, and blanks; data not meeting data quality objectives specified in the approved work plans were rejected. Tentatively identified contaminants consisted of total petroleum hydrocarbons (TPH) and diesel-range hydrocarbons, analyzed by EPA Method 418.1 and Modified Method 8015, respectively, and these results were used as-is in the RA. Site-related contaminants were not compared with background in this RA. Generally, contaminants consisted of those with no appreciable natural background concentrations (such as chlorinated VOCs in groundwater).

Concentrations of metals detected in soil were evaluated by comparison with background levels published in the literature. Summary statistics of the metals concentrations detected in soil at the Davis Site and elemental background data are presented in Appendix C. Background data were not available from these sources for antimony, cadmium, hexavalent chromium, thallium, and silver. Other literature sources, discussed further in Appendix C, were used to evaluate concentrations of these metals detected in soil at the Davis Site.

Concentrations of metals detected in soil at the Davis Site fell within a defined geochemical baseline level (Severson, et al., 1987) or within the range of observed concentrations in western U.S. soils (Shacklette and Boergnan, 1984), with the exception of antimony, cadmium, and thallium. Metals with concentrations that fell within these background levels were excluded as contaminants of potential concern in the risk assessment. Antimony, cadmium, and thallium are discussed below in further detail. Concentrations of hexavalent chromium reported in soil are likely to have been laboratory artifacts, as discussed in Appendix C, and also were excluded as contaminants of potential concern.

Based on direct comparison of Davis Site data with numerical values published for background concentrations, antimony, cadmium, and thallium could be considered elevated in soil at the Davis Site, and therefore could be included as contaminants of potential concern in the risk assessment. However, as discussed in Appendix D, activities typically responsible for elevated levels of these metals in soil are unlikely to

have occurred at the Davis Site. Based on the evaluations presented in Appendixes C and D, these metals were excluded as contaminants of potential concern.

Table 4-1 lists the COPCs detected in soil, soil gas, and groundwater samples. The rationale for selection of these contaminants for inclusion in the RA is presented in Appendix D, Contaminants of Potential Concern to Human Health.

4.2 Exposure Assessment

Exposure refers to the potential contact of an individual with a contaminant. Exposure assessment is the estimation of the magnitude, frequency, duration, and routes of exposure to a contaminant. Human exposure to contaminants is typically evaluated by estimating the amount of a contaminant that could come into contact with the lungs, gastrointestinal tract, or skin during a specified period of time. This exposure assessment is based on scenarios that define human populations potentially exposed to COPCs originating from the site. The potential pathways of exposure, frequency and duration of potential exposures, rates of contact with air, water, and soil and the concentrations of contaminants in air, groundwater, or soil are evaluated in the assessment of human intake of COPCs. Contaminant intakes and associated risks have been quantified for all exposure pathways considered potentially complete. This section describes the assumptions, data, and methods used to evaluate the potential for human exposure to COPCs originating from the Davis Site. That evaluation involves the following steps:

- Identification of potentially exposed populations
- Identification of potential exposure pathways and selection of complete exposure pathways
- Evaluation of the environmental fate and transport of contaminants in soil and groundwater
- Development of exposure scenarios
- Estimation of exposure point concentrations used to quantify contaminant intakes
- Quantification of contaminant intakes for each exposure pathway

Exposure scenarios form the basis for estimating human exposures to contaminants detected at the Davis Site. An exposure scenario considers the sources of the contaminant substances that could come into contact with the subject population. Exposure prediction models based on the fate and transport of the contaminant substances are then used to evaluate the pathways from the sources to the subject population. Generally, these were relatively simple models combining multiplicative factors that

Table 4-1 Summary of Contaminants of Potential Concern Davis Global Communications Site		
Contaminants of Potential Concern in Soil	Contaminants of Potential Concern in Soil Gas	Contaminants of Potential Concern in Groundwater
Benzyl butyl phthalate bis(2-ethylhexyl) phthalate di-N-butyl phthalate Dibenzofuran Diesel hydrocarbons Fluorene 2-Methylnaphthalene Naphthalene Petroleum hydrocarbons Phenanthrene Pyrene	Benzene 1,1-Dichloroethane 1,1-Dichloroethene cis-1,2-Dichloroethene Ethylbenzene m,p-Xylene (sum of isomers) o-Xylene (1,2-dimethylbenzene) Tetrachloroethene (PCE) Toluene 1,1,1-Trichloroethane Trichloroethene (TCE) Trichlorofluoromethane 1,1,2-Trichloro-1,2,2-trifluoroethane Vinyl chloride	Acetone Bromodichloromethane Bromoform Chlorodibromomethane Chloroform 1,4-Dichlorobenzene 1,1-Dichloroethene Ethylene dibromide Methyl ethyl ketone Methyl isobutyl ketone Tetrachloroethene Toluene Trichloroethene Trichlorofluoromethane 1,1,2-Trichloro-1,2,2-trifluoromethane Vinyl chloride

RDD10012A23.WP5-1

predict an individual's exposure as a function of several input variables (such as body weight, inhalation rate, and exposure frequency), in accordance with EPA guidance.

The exposure scenarios for this RA were based on an estimate of the reasonable maximum exposure (RME). The RME is defined as the highest exposure that is reasonably expected to occur at a site. RMEs are estimated for individual exposure pathways. If a population is exposed via more than one pathway, the combination of exposures across pathways must also represent an RME. The intent of the RME is to develop a conservative estimate of exposure (i.e., well above the average case) that is still within the range of possible exposures (U.S. EPA, 1989a). Specific factors in the RME exposure scenario included the 90 or 95 percentile values for input variables such as inhalation rate, exposure frequency and exposure duration, and exposure concentrations based on the upper 95 percent confidence limit (UCL) of mean concentrations or the highest concentrations detected at the site (U.S. EPA, 1989b).

4.2.1 Potential Exposure Scenarios

The exposure scenarios evaluated in the risk assessment are presented in Table 4-2. The exposure scenarios are identified by receptor, as follows:

- Onsite worker, outdoors—a worker at the site responsible for work activities located largely outdoors
- Onsite worker, excavation—a construction worker performing work onsite (such as installation of subsurface utilities) that requires excavation of soil
- Onsite worker, indoors (Building 4708)—a worker responsible for work activities located primarily in the main building at the site
- Hypothetical future resident—a mission change at the site in which the site is developed for agricultural use and a farm residence is placed onsite

Note that in most cases multiple exposure pathways are associated with a scenario. Health risks for each scenario were aggregated across the exposure scenarios identified in Table 4-2. The development of these exposure scenarios is described in Appendix G, Exposure Assessment for the Human Health Risk Assessment.

4.2.2 Air Pathway Analysis

VOCs detected in soil gas or groundwater at the Davis Site can volatilize into air, potentially resulting in inhalation exposures. The potential magnitude of VOC concentrations in air from soil gas or groundwater was evaluated in Appendix F, Air Pathway Analysis. The following two air exposure pathways were evaluated in the RA:

Table 4-2 Summary of Exposure Scenarios			
Receptor	Location/Media	Exposure Route	Basis for Exposure Concentration
Onsite worker – outdoors	Onsite soil gas Groundwater	Inhalation	Area-averaged, based on maximum VOC concentration in soil gas in each source area. ^a Maximum concentration in water from site production well.
Onsite worker – excavation	Onsite subsurface soil	Soil ingestion Dermal contact with soil ^c	95% UCL of the mean concentration calculated from all soil samples. ^b
Onsite worker – indoors (Building 4708)	Onsite soil gas Groundwater	Inhalation Dermal contact	Maximum VOC concentration in soil gas in samples near Building 4708. Maximum concentration in water from site production well.
Hypothetical future resident	Groundwater, onsite soil gas, onsite soil	Ingestion Inhalation Dermal contact	Maximum concentrations of TCE and PCE detected in MW-3. Maximum concentration of vinyl chloride detected in any monitoring well. 95% UCL of mean concentration calculated from all soil samples. Maximum VOC concentration in soil gas from samples near Building 4708.
^a See Appendix F, Air Pathway Analysis, for the area-averaging method used to calculate exposure concentration. ^b Concentrations in samples reported as not detected assumed to be present at one-half the detection limit for purposes of calculating the mean. ^c Intake from dermal contact with soil assumed to be equivalent to intake from soil ingestion.			
Note: Risks are summed across multiple pathways or media as shown in this table to estimate RME.			

- Inhalation exposures of outdoor workers to VOC emissions from soil gas, and VOCs volatilized from production well water used for sprinkler irrigation
- Inhalation exposures of workers in Building 4708 to VOCs migrating indoors from soil gas

Shallow soil gas sampling and sampling from SVMWs performed in 1992 by CH2M HILL provided the data used to evaluate potential inhalation exposures of outdoor workers. Concentrations detected in soil gas were converted to VOC emissions from the soil surface using simple models that relate concentration in soil gas, diffusion coefficient in air, soil porosity, and depth in soil to surface emissions. Monthly water use rates and sampling data from the production well were used to estimate potential inhalation exposures associated with sprinkler irrigation. VOC concentrations in water were converted to emission rates in air using a default factor expressing the water-to-air transfer efficiency. Concentrations in both outdoor and indoor air were estimated using box modeling techniques where concentration in air within a defined box is proportional to the emission rate and wind speed across the source area (or ventilation rate in a building). The emissions estimation and box modeling methodologies, and detailed calculations are presented in Appendix F.

4.2.3 Quantification of Contaminant Intake

The intakes calculated in this section are expressed as the amount of contaminant at the exchange boundary (i.e., skin,¹ lungs, or gastrointestinal tract) and available for absorption. Estimates of contaminant intakes based on RME scenarios are presented in this section. Contaminant intakes were estimated for both adults and children and for both current and potential future land use. Calculations and input parameters used for estimating intake rates through the inhalation, soil ingestion, groundwater ingestion, and dermal contact with soil and groundwater pathways were obtained from EPA (U.S. EPA, 1989a; 1990; 1991a). The calculated intake rates are combined with toxicity criteria values (discussed in Section 4.3) in order to characterize potential health risks.

The calculations used to estimate exposure or intake from contact with contaminants in soil have the same general components: (1) a variable representing contaminant concentration, (2) variables describing the characteristics of the exposed population, and (3) a variable that defines the time frame over which exposure occurs. The general mathematical relationship between these variables and contaminant intake in humans is:

Where:

¹In keeping with EPA guidance, intake for dermal exposure pathways is estimated in terms of absorbed dose and not quantity of contaminant at the exchange boundary.

$$I = \frac{C \times CR \times EF \times ED}{AT \times BW} \quad (1)$$

- I = Intake (mg/kg-day)
- C = Average concentration in the contaminated medium contacted over the exposure period (either mg/kg, mg/l or mg/m³)
- CR = Contact rate; the quantity of contaminated medium contacted per unit time (e.g., mg/day)
- EF = Exposure frequency (days/year)
- ED = Exposure duration (years)
- AT = Averaging time; period over which exposure is averaged (days)
- BW = Body weight (kg)

The calculated intake rates are combined with toxicity criteria values (discussed in Section 4.3) in order to characterize potential health risks.

4.3 Toxicity Assessment

The toxicity assessment determines the relationship between the magnitude of exposure to a contaminant and the adverse health effects. Where possible, this assessment provides a numerical estimate of the increased likelihood and/or severity of adverse effects associated with contaminant exposure (U.S. EPA, 1989a).

For purposes of the toxicity assessment, the COPCs have been classified into two broad categories: carcinogens and noncarcinogens. This classification has been selected because health risks are calculated quite differently for carcinogenic and noncarcinogenic effects, and separate toxicity values have been developed for carcinogenic and noncarcinogenic effects. These toxicity values represent the potential magnitude of adverse health effects associated with exposure to contaminants, and are developed by EPA and the Department of Toxic Substances Control (DTSC). Toxicity studies with laboratory animals or epidemiological studies of human populations provided the data used to develop these toxicity values. These values represent allowable levels of exposure based upon the results of toxicity studies or epidemiological studies. In the risk characterization process, the toxicity values were then combined with the exposure estimates (developed in Appendix G, Exposure Assessment for Human Health Risk Assessment) to estimate adverse effects from contaminants potentially originating from the Davis Site.

Noncarcinogenic effects were evaluated using either reference doses (RfDs) or reference concentrations (RfGs), developed by EPA. The RfD is a health-based criterion, expressed as contaminant intake rate in units of mg/kg-day, used in evaluating noncarcinogenic effects. Unless evidence to the contrary exists, if a carcinogenic response occurs at the exposure levels studied (typically high doses), it is assumed that responses will occur at all lower doses. Exposure to any level of a carcinogen is then considered to have a finite risk of inducing cancer. Estimates of cancer are calculated using slope factors (SFs), which defines the cancer risk due to lifetime exposure to a carcinogen (in units of risk per mg/kg/day).

The toxicity values used to characterize health risks are presented in Appendix E, Toxicity Assessment for the Human Health Risk Assessment. The characterization of health risks for COPCs at the Davis site is presented in Section 4.4.

4.4 Risk Characterization

Risk characterization involves estimating the magnitude or probability of potential adverse health effects under study. This is accomplished by combining the results of the dose-response and exposure assessments to provide numerical estimates of potential health effects. These values represent comparisons of exposure levels with appropriate RfDs and estimates of excess cancer risk. Risk characterization also considers the nature and weight of evidence supporting these estimates, as well as the magnitude of uncertainty surrounding them.

Although the risk assessment produces numerical estimates of risk, these numbers do not predict actual health outcomes. The estimates are calculated to overestimate risk, and thus any actual risks are likely to be lower than these estimates, and may even be zero.

The numerical risk estimates are presented in Table 4-3. Appendix A contains summary tables showing the numerical risk estimates for each COPC in each exposure scenario. Generally, EPA considers action to be warranted at a site when cancer risks exceed 1×10^{-4} . The need for action for risks falling within 1×10^{-4} to 1×10^{-6} is judged on a case-by-case basis (unless ARARs are exceeded or adverse ecological effects are associated with the site). Risks less than 1×10^{-6} generally are not of concern to regulatory agencies. A hazard index (the ratio of contaminant intake to the RfD) greater than one indicates some potential for adverse noncancer health effects associated with exposure to the contaminants of concern (U.S. EPA, 1991c).

Table 4-3 shows that exposures to noncarcinogenic contaminants are below regulatory concern in all scenarios except hypothetical future residential use. Estimated cancer risks associated with inhalation of VOCs emitted from soil by workers outdoors and direct contact with contaminants in soil also are below regulatory concern. Figure 4-1 presents the contributions of individual carcinogens to inhalation risks of outdoor

Table 4-3 Summary of Estimated Human Health Risks Davis Global Communications Site							
Receptor	Affected Media	Exposure Route	Cancer Risk Estimates			Noncancer Effects	
			Increased Lifetime Cancer Risk ^a	Contaminants Principally Contributing to Risks	Hazard Index ^b	Contaminants Principally Contributing to Noncancer Effects	
Onsite worker – outdoors	Soil gas, groundwater	Inhalation	3 x 10 ⁻⁷	Tetrachloroethene (PCE) in soil gas	<1	N/A	
Onsite worker – excavation	Soil	Soil ingestion and dermal contact	3 x 10 ⁻⁹	bis(2-ethylhexyl)phthalate in soil	<1	N/A	
Onsite worker – indoors (Building 4708)	Soil gas, groundwater	Inhalation and dermal contact with water	3 x 10 ⁻⁵	PCE in soil gas, ethylene dibromide (EDB), and chloroform in groundwater	<1	N/A	
Hypothetical future onsite resident ^c	Groundwater, soil gas, soil	Ingestion, inhalation and dermal contact	7 x 10 ⁻³	PCE and trichloroethene (TCE) in groundwater	>1	PCE, Petroleum hydrocarbons	

^aNumerical risk estimates are not predictions of actual health outcomes. These estimates are calculated in a manner that overestimates risk, and thus any actual risks are likely to be lower than these estimates, and may even be zero. EPA generally considers action to be warranted at a site when cancer risks exceed 1 x 10⁻⁴. Generally, action is not required for risks falling within 1 x 10⁻⁴ to 1 x 10⁻⁶ (unless ARARs are exceeded or adverse ecological effects are associated with the site); however, this is judged on a case-by-case basis. Risks less than 1 x 10⁻⁶ generally are not of concern to regulatory agencies.

^bHazard index greater than one indicates that there is some potential for adverse noncancer health effects associated with exposure to the contaminants of concern.

^cFuture residential use of the site is not likely, based on zoning requirements in Yolo County. Hypothetical scenario was included at regulatory agency request to evaluate aquifer nondegradation requirements.

Note: Health risk estimates based on reasonable maximum exposure (RME) scenarios.

^aNumerical risk estimates are not predictions of actual health outcomes. These estimates are calculated in a manner that overestimates risk, and thus any actual risks are likely to be lower than these estimates, and may even be zero. EPA generally considers action to be warranted at a site when cancer risks exceed 1×10^{-4} . Generally, action is not required for risks falling within 1×10^{-4} to 1×10^{-6} (unless ARARs are exceeded or adverse ecological effects are associated with the site); however, this is judged on a case-by-case basis. Risks less than 1×10^{-6} generally are not of concern to regulatory agencies.

^bHazard index greater than one indicates that there is some potential for adverse noncancer health effects associated with exposure to the contaminants of concern.

^cFuture residential use of the site is not likely, based on zoning requirements in Yolo County. Hypothetical scenario was included at regulatory agency request to evaluate aquifer nondegradation requirements.

Note: Health risk estimates based on reasonable maximum exposure (RME) scenarios.

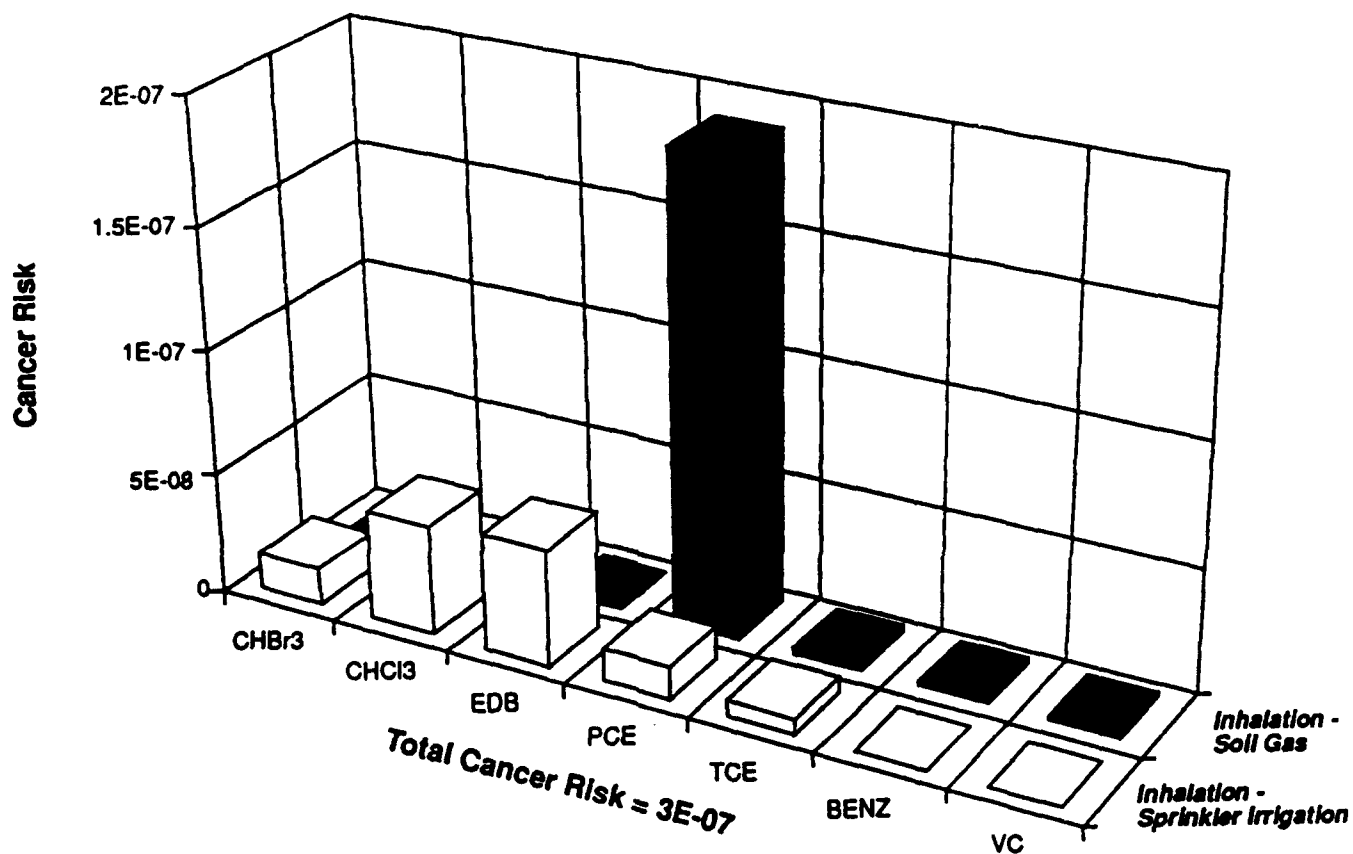


FIGURE 4-1
CONTRIBUTION TO TOTAL CANCER RISK -
OUTDOOR WORKER INHALATION
 DAVIS GLOBAL COMMUNICATIONS SITE
 McCLELLAN AIR FORCE BASE
 YOLO COUNTY, CALIFORNIA

workers and shows that PCE emitted from soil provides the largest contribution to total risk.

For indoor workers, the contribution of individual carcinogens to total cancer risk is important in understanding the nature of risks posed by the site and the uncertainties in those risk estimates. Figure 4-2 presents the contributions of individual carcinogens to total risk of indoor workers. This figure shows that cancer risks in this scenario are driven by the presence of trihalomethanes (THMs) and EDB in production well water. THMs detected in the production well are bromodichloromethane, bromoform, chlorodibromomethane, and chloroform. More than 80 percent of the total risk in this scenario is associated with these compounds.

THMs were detected consistently in samples collected at the production well between November 1986 and September 1988. THMs are formed from the reaction of dissolved organic matter and chlorine during the chlorination of water. The absence of THMs during other sampling periods may reflect a change in sampling method in which samples are collected prior to the point of chlorination. Therefore, it is possible that these contaminants, although not in groundwater, may be present at the point of use and potentially represent sources of human exposure. EDB has been detected in the two most recent sampling rounds, in September 1991 and October 1992. EDB formerly was used as a lead scavenger in antiknock gasoline and as an agricultural soil fumigant. As discussed in Section 3.3.3, EDB in groundwater is probably unrelated to activities at the Davis Site.

The contributions to total risks for the hypothetical future resident scenario are shown in Figure 4-3. Figure 4-3 shows that PCE in groundwater provides the largest contribution to total risk in this scenario. In evaluating the significance of this risk estimate, it must be stressed that there is no current pathway of exposure to residents from contaminants in drinking water, based on the available information and that this scenario assumed use of untreated water. However, groundwater supplies some drinking water needs in Yolo County, and there could be health risk concerns should groundwater at the Davis Site be developed as a residential supply in the future. In this light, it is notable that PCE and TCE concentrations in several samples of groundwater from the Davis Site exceed drinking water standards.

The hazard index for contaminants in soil (principally associated with petroleum hydrocarbons) exceeded 1.0, suggesting that there is some potential for noncancer adverse health effects associated with petroleum hydrocarbon contaminants in soil. The contaminants are found principally in subsurface soil, and there would be very little potential for exposure unless the soil were excavated. However, if the site were to be developed for residential use, these results suggest the need for further evaluation of areas with TPH concentrations exceeding 1,200 mg/kg in soil.

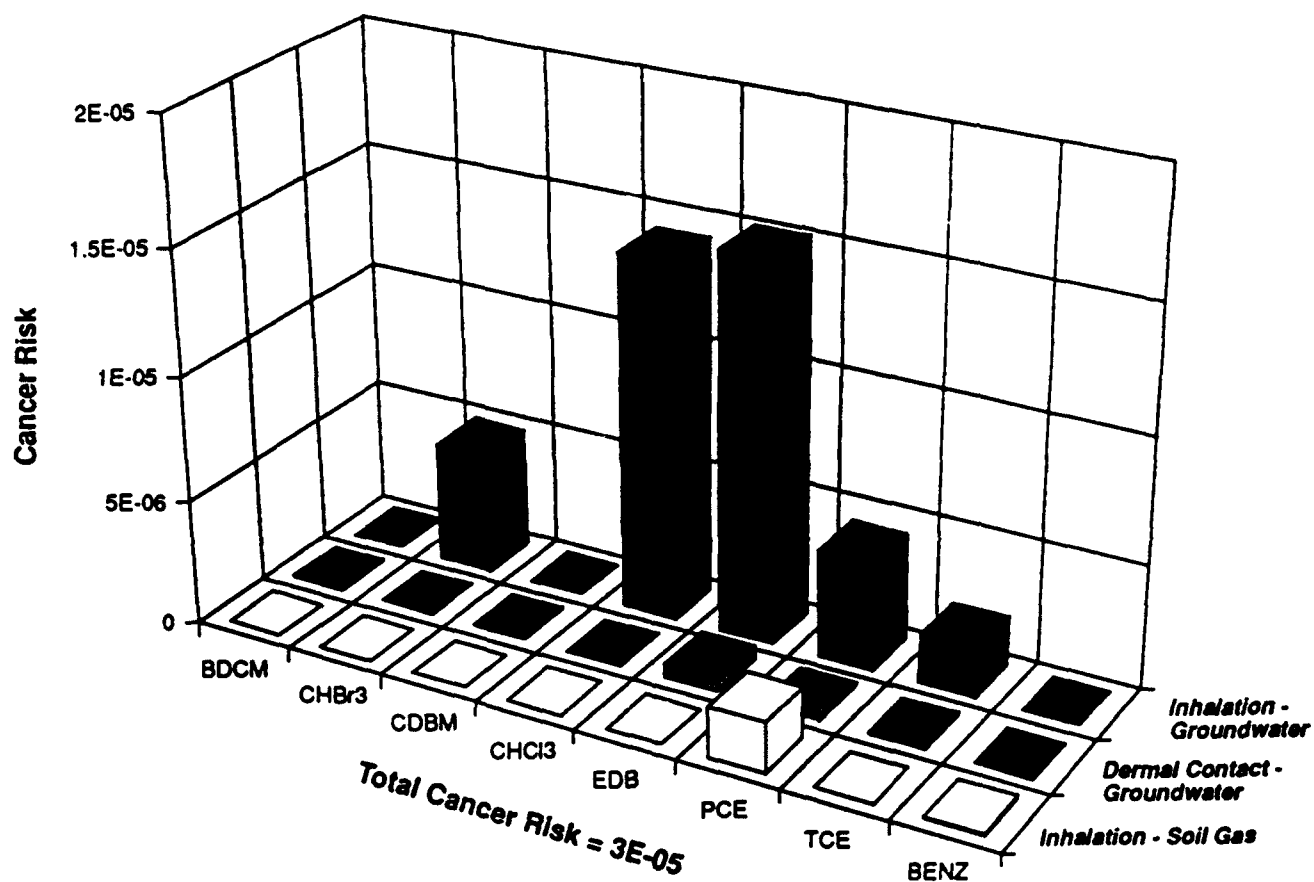


FIGURE 4-2
CONTRIBUTION TO TOTAL CANCER RISK -
INDOOR WORKER INHALATION
 DAVIS GLOBAL COMMUNICATIONS SITE
 MCCLELLAN AIR FORCE BASE
 YOLO COUNTY, CALIFORNIA

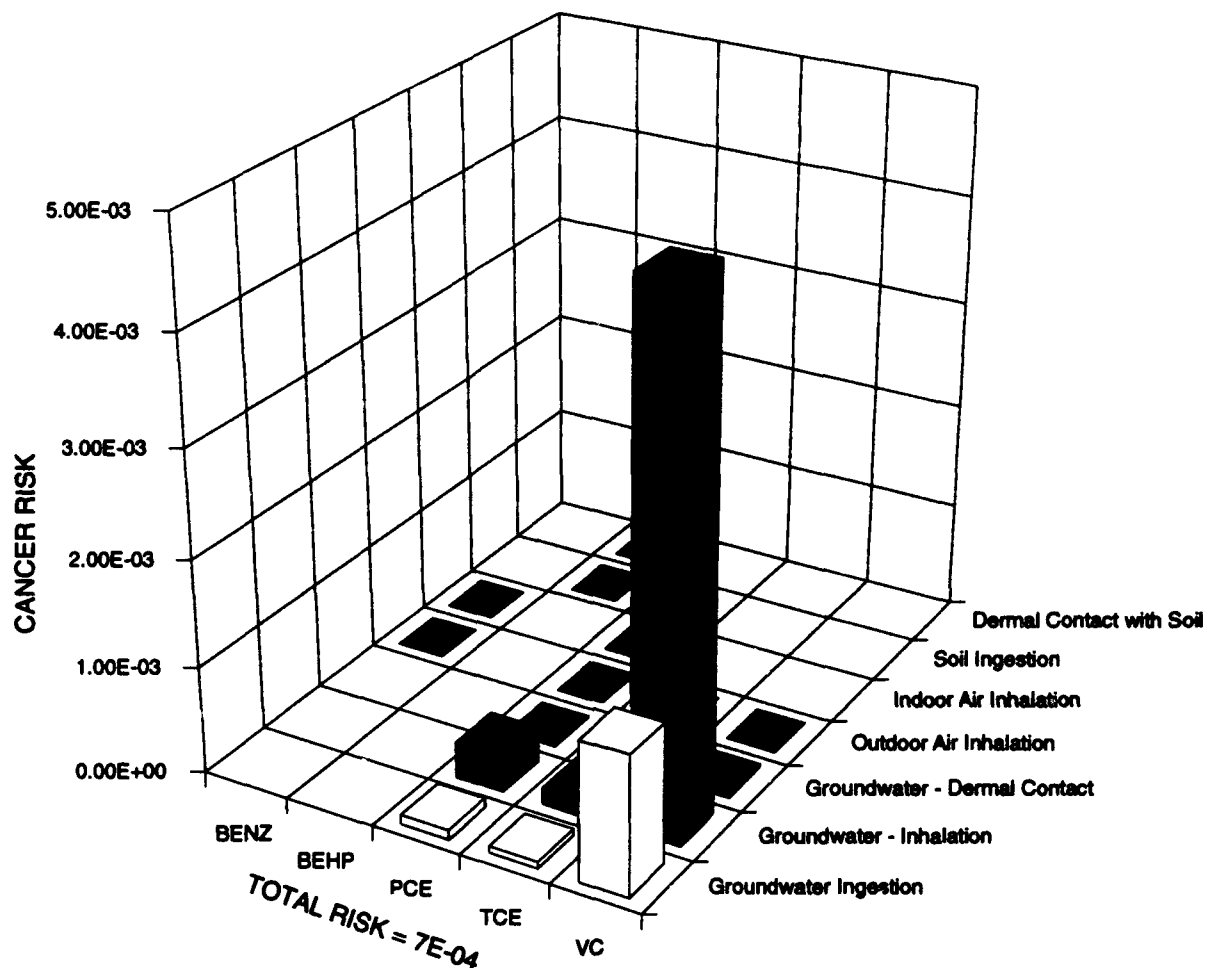


FIGURE 4-3
CONTRIBUTION TO TOTAL CANCER RISK-
HYPOTHETICAL FUTURE RESIDENT
 DAVIS GLOBAL COMMUNICATIONS SITE
 MCCLELLAN AIR FORCE BASE
 YOLO COUNTY, CALIFORNIA

4.5 Uncertainties

An important component of the RA process is the discussion of the uncertainties associated with the assumptions and methodologies employed in the analysis. Some level of uncertainty is introduced each time an assumption is made. The aggregation of several assumptions also magnifies the uncertainties in the numerical risk estimates. Sources of uncertainties in the exposure assessment include (1) assumptions as to what constituted complete exposure pathways, based on the site setting; (2) applicability of the models, data interpretations, and sampling and analytical data used to estimate exposure concentrations; and (3) the transport, fate, and intake parameters used to estimate exposure concentrations and intake rates. Most often, the sampling and analytical data and the toxicity assessment provide the largest contributions to overall uncertainty in the RA. Sources of uncertainties in the toxicity assessment include those associated with extrapolation of adverse effects from laboratory animals to humans and from high levels of exposure to low levels.

Several exposure pathways assumed to be complete in the RA actually may not be complete, based on consideration of the site setting. For example, risks have been calculated assuming future residential use of the site in the event of a mission change. However, the likelihood of residential use in the future is negligible, based on zoning restrictions in Yolo County. In the indoor worker scenario, exposures from several pathways are superimposed to calculate total health risks. This does not account for individuals who do not use the shower each workday at the site, and thus would have lower exposure. Intake parameters, such as inhalation rate, the number of days per year exposed, and number of years, all tend to be upper bound estimates, resulting in a cumulative overestimation of exposure.

Emissions of VOCs and concentrations in air were estimated as steady-state, assuming that measured concentrations of VOCs in soil or groundwater do not change over time. This neglects fate processes that would deplete VOC mass in soil over time, resulting in lower levels of exposure in the future. In estimating concentrations in air, the box model assumes that the receptor (i.e., potentially exposed individual) is directly over the emissions source. This overestimates exposure concentrations in air because such concentrations decrease with increasing distance from an area source.

Toxicity criteria for many compounds are based on the results of studies in laboratory animals. Because the contaminant concentrations encountered by humans in the environment are typically much lower than those used in laboratory studies, the use of animal toxicity data for human health criteria introduces uncertainty. Extrapolation of high-to-low dose data and animal-to-man data is done conservatively, to ensure that adverse health effects in humans are not underestimated. Thus, the toxicity criteria tend to overestimate the magnitude of potential adverse health effects associated with exposure to a given contaminant.

Chapter 5
ECOLOGICAL RISK ASSESSMENT

Chapter 5

Ecological Risk Assessment

This ecological risk assessment addresses a number of questions related to the current and future ecological health of the Davis Site. These questions are posed and discussed in a sequential fashion in the following sections of this chapter and are summarized in Table 5-1. For several of the elements, additional detail is contained in technical memorandums included as appendixes.

5.1 Ecological Endpoints

An ecological endpoint is an expression of the desired ecological condition of a site either under existing site conditions or following remediation. It can be considered an ecological goal or an objective of site cleanup. The endpoint must be realistic (i.e., it cannot be a trout spawning area for a desert site), achievable, and measurable so that achievement of the goal can be evaluated. Given these constraints, a broad statement such as "support a balanced indigenous biological community" must be broken down into several site-specific endpoints to be useful in the site remediation process.

Ecological endpoints are most effective when represented as an assessment endpoint and an associated measurement endpoint. The assessment endpoint is the expected ecological characteristic to be achieved; the measurement endpoint establishes a method to judge achievement of the characteristic. For example, an assessment endpoint for a contaminated stream might be support of a self-sustaining trout population. The measurement endpoint could be successful hatching of a given percentage of trout eggs, or compliance with water quality criteria for specific site contaminants demonstrated in laboratory studies to support successful egg hatching.

The more directly related to specific ecological resources, the more useful endpoints are for ecological risk assessment and overall site remediation. If they are tied to the important and visible ecological resources onsite, it is easier to incorporate them into the site cleanup considerations. Endpoints linked to special status species, recreational resources, or resources demonstrably linked to the critical ecological processes fall into this category.

At the Davis Site, the critical ecological resources are the burrowing owl and Swainson's hawk. Protection of these species and enhancement of their habitat are the assessment endpoints for the Davis site. The other ecological resources onsite are limited, and any attempt to develop new resources is unrealistic. The measurement endpoint for the Swainson's hawk is to maintain or increase the total forage habitat value onsite. The critical onsite habitat requirement for the borrowing owl is cover and nesting habitat, particularly existing burrows. Therefore, ensuring adequate quantity

Table 5-1 Questions Addressed by Ecological Risk Assessment		
Primary Questions	Working Questions	Where Addressed in This Chapter
Is there an existing risk to ecological resources at or near the site from exposure to contaminants?	Is there evidence of ecological damage?	5.5 Ecological Risk and Effect Levels
	Do ecological resources exist, or potentially exist, that are sensitive to the contaminants found onsite?	5.1 Ecological Endpoints and 5.2 Hazard Identification
	Are there exposure pathways from the contaminated media to the ecological receptor?	5.2 Hazard Identification and 5.3 Exposure Assessment
	If there are receptors and pathways, are the expected concentrations or doses at the point of exposure at levels reported to pose a risk?	5.4 Toxicity Assessment and 5.5 Ecological Risk and Effects Levels
If there is an existing risk to resources, what remediation goals would result in reduced levels of risk?	What concentrations at exposure points result in ecological risk levels?	5.4 Toxicity Assessment
	What concentrations in environmental media will ensure that concentrations at exposure points are within acceptable limits?	5.1 Ecological Endpoints and 5.5 Ecological Risk and Effects Levels
Would the proposed remediation adversely affect any ecological resources in the area? If so, what mitigation measures are available?	Would any cleanup activities, including construction or operation of remediation facilities, adversely affect any resources potentially occurring in the area?	5.6 Evaluation of Remediation
	If impacts to resources could occur, how can they be avoided or minimized?	5.6 Evaluation of Remediation
Is the proposed remediation in compliance with all applicable ecological resource-related regulations?	Are there ecological resources associated with the site that are protected or otherwise regulated?	5.7 Compliance with Ecological ARARs
	Will the remediation goals and proposed action protect the regulated resources to the extent mandated by applicable regulations?	5.7 Compliance with Ecological ARARs
	Will any proposed remediation activities adversely affect any regulated ecological resource?	5.7 Compliance with Ecological ARARs

and quality of areas of burrows is the measurement endpoint for the owl protection and enhancement endpoint.

5.2 Hazard Identification

There are two aspects of hazards identification in an ecological risk assessment; one deals with the cause and the other with the receptor. At the Davis Site, a hazard could be caused by exposure to site contaminants or by alteration of habitat critical to an identified ecological resource. The other aspect of hazard identification involves consideration of the ecological character of the site to determine which resources are potentially vulnerable to contaminants or remediation activities. This process involves an appraisal of the ecological requirements of the resources such as food sources for mammals, the water requirements of plants, or suitable breeding sites for birds. If any of the critical needs for resources identified as ecological endpoints are susceptible to damage from contamination or remediation, a potential hazard exists. The two types of hazards are not independent because the nature of the contaminant affects the ecological resource at risk, and the resources associated with the site determine what compounds are toxic and what activities are disruptive. Consequently, hazard identification is an iterative process.

5.2.1 Contaminants of Potential Concern

The determination of ecological COPCs involves consideration of both pathways and concentrations for each potentially contaminated medium onsite. The potentially contaminated media at the Davis Site are soils, groundwater, and soil gas. In addition, surface water could become a medium of concern if a groundwater treatment effluent holding pond is constructed as part of the remediation. Evaluation of each of these media, considering the ecological characteristics of the site, reveals limited exposure pathways for soils, surface water, and soil gas (see Appendix I, Ecological Contaminants of Potential Concern). Unless the groundwater reaches the surface as part of remediation, there is no ecological exposure pathway involving onsite groundwater.

Soil gas could represent a significant exposure pathway to animals closely associated with the soil, particularly burrowing animals. However, evaluation of aromatic and chlorinated VOCs detected in soil gas revealed that onsite levels were significantly below ecological benchmarks (see Appendix I). Consequently, no ecological contaminants of concern were identified in soil gas.

Soils at depth, which is where most of the onsite contamination was identified, are not part of an ecological pathway, except for the soil piles resulting from tank excavation. Diesel-range petroleum hydrocarbons, characterized as TPH using Method 418.1 and modified Method 80145, were the only contaminants identified in the soil piles (see Appendix C, Site Conceptual Model). Comparison of TPH concentrations in the soil piles to ecological benchmarks (i.e., concentrations reported to be associated with

ecological effects) revealed little or no risk as a result of ingestion. However, onsite concentrations exceeded levels estimated to cause inhalation risk (see Appendix I). Because inhalation in a soil burrow could be a critical pathway, diesel in soil piles was retained as a contaminant of concern.

A pond constructed to temporarily hold effluent as part of a groundwater treatment and spray irrigation system could be an exposure pathway for both aquatic organisms and semi-aquatic birds, such as waterfowl. The treatment process would reduce the concentrations of organic compounds in the effluent to levels expected to protect ecological receptors. However, the natural groundwater levels of several elements in the effluent would be above ecological benchmarks and thus these elements are ecological contaminants of potential concern. The likelihood of the selected remedial action alternative including a pond is small, because other end-use alternatives are preferable. However, to retain the option of a pond in an end-use alternative, this assessment considers potential ecological effects associated with a pond.

The ecological COPCs for each medium at the Davis Site are summarized in Table 5-2.

Table 5-2 Ecological Contaminants of Potential Concern Davis Global Communication Site	
Medium	Contaminants
Soil	TPH
Groundwater	Antimony Iron Lead Nickel Selenium Thallium
Soil gas	None
Notes: Diesel is a COPC only in the soil piles. Groundwater contaminants are COPCs only if extracted water is held in a storage pond.	

5.2.2 Resources Potentially at Risk

Ecological resources associated with the site are limited. Consequently, the resources potentially at risk are limited (see Appendixes B, Site Background Information, and H, Site Ecological Characterization). However, two special-status species, the burrowing owl and Swainson's hawk, could utilize certain features of the site.

The owl could be at risk from contaminated soil and potentially be adversely affected by site contaminants. Food sources or other ecological requirements of the owl are not threatened by onsite conditions or potential remediation activities, but other habitat requirements could potentially be vulnerable. The owl uses existing burrows, primarily those of California ground squirrels, for shelter and also for nesting. With minimal dilution and ventilation in the burrows, the air could reach equilibrium with volatile or semi-volatile contaminants in the soil. If a burrowing owl remains in the burrow for extended periods, such as during breeding season, there could be significant exposure through inhalation. This could pose a risk to individual birds and also to population breeding success.

A risk to the hawk could result from remediation-related activities that reduce the size or quality of foraging habitat. Although the foraging habitat onsite is marginal for the Swainson's hawk, some loss could be associated with developing a ± 1 -acre effluent holding pond.

There is also potential for risk to aquatic organisms and waterfowl from exposure to extracted groundwater. An aquatic community inhabiting a pond used to temporarily hold the groundwater treatment plant effluent could be at risk. More importantly, the pond could pose risk to waterfowl and shorebirds. As evidenced from the March 1993 field reconnaissance (see Appendix H), even temporary standing water in annual grassland habitat attracts waterfowl. The effluent holding pond could attract birds for relatively long periods, especially during the breeding season. Intake of contaminants originating in the groundwater effluent through ingestion of aquatic vegetation or invertebrates could pose a risk to these birds.

5.3 Exposure Assessment

An ecological exposure assessment is the evaluation of contact between a receptor and a contaminant. The approach to ecological exposure assessment at the Davis Site is to quantify the contaminant at the exposure point for the ecological receptor. In many situations, this process can involve complex fate and transport evaluations, ecological modeling, and prediction of future conditions. At the Davis Site, most of the contaminant concentrations at exposure points were measured and are summarized in Appendix C, Site Conceptual Model. The ecological contaminants of concern are also discussed further in Appendix I.

Surface water concentrations for the groundwater treatment effluent holding pond could not be measured at the point of exposure. These concentrations were estimated based on measurement of onsite groundwater (CH2M HILL, 1993b) and are summarized in Table 5-3.

Table 5-3 Exposure Concentrations in Groundwater	
Contaminant of Concern	Estimated Average Concen- trations in Pond ($\mu\text{g/l}$)
Antimony	82
Iron	5,549
Lead	55
Nickel	347
Selenium	27
Thallium	83

The air concentration of contaminants within burrows could not be measured and was estimated from measured soil concentrations. The estimations were based on equilibrium partitioning between the soil and air within the burrows. There was no allowance of mixing with ambient air or ventilation, and the estimates were thus conservative. The procedure used to estimate concentrations is given in Appendix I.

5.4 Toxicity Assessment

The objective of the toxicity assessment is to evaluate the toxicological characteristics of the COPCs as they relate to site-specific conditions. The results of the assessment are then used to determine existing risk and develop ecological effect levels for use in establishing remediation goals. The toxicity of the COPCs is assessed below for inorganic and organic compounds.

The inorganic compounds onsite are of concern in surface waters only. The U.S. EPA (1986) has established water quality criteria for acute and chronic toxicity for each of the inorganic COPCs (Table 5-4). California has also developed water quality standards for many contaminants (California Water Resources Control Board, 1992). However, for the Davis Site COPCs, the California standards are either identical to the EPA values or are not available.

In addition to aquatic toxicity, selenium can pose a threat to wildlife that use aquatic habitat. Evaluations of toxicity values for such wildlife species can result in lower criteria than those generated exclusively for protection of aquatic life. Waterborne selenium concentrations of $10 \mu\text{g/l}$ have been associated with impaired hatchability in shorebirds, and concentrations of 10 to $20 \mu\text{g/l}$ have been associated with teratogenic effects (Skorupa and Ohlendorf, 1991). Estimates have shown that birds could accumulate enough selenium within a week or two of feeding on invertebrates in pools

Table 5-4 Water Quality Criteria		
Contaminants of Potential Concern	Acute Criteria	Chronic Criteria ($\mu\text{g/l}$)
Antimony	88 ^a	30 ^a
Iron	n/a	1,000
Lead	197 ^b	8 ^b
Nickel	2,549 ^b	283 ^b
Selenium	20	5
Thallium	1,400 ^c	40 ^c
^a Proposed. ^b Hardness dependent, calculated at 200 mg/l total hardness. ^c No criteria developed; number is lowest observed effect. Source: U.S. EPA, 1986 and 1992c.		

containing 10 to 30 $\mu\text{g/l}$ of selenium to affect reproductive success (CH2M HILL, 1993d). Peterson and Nebeker (1992) calculate a level of 1 $\mu\text{g/l}$ selenium as a threshold limit for birds and mammals with food habits conducive to bioaccumulation from aquatic systems.

The only organic compound identified as a COPC is diesel-range petroleum hydrocarbons. As described in Appendix I, ecological toxicity data for diesel are not extensive. The estimated protection level in soil for mammals from ingestion exposure pathway is 170 mg/kg. The estimated concentration considered protective of mammals in burrows from the inhalation exposure pathway is 400 mg/kg. Ecological toxicity data are unavailable to characterize risks to terrestrial birds from exposure to petroleum-contaminated soil. However, the toxicity of petroleum hydrocarbons to birds is most often associated with contact with free petroleum hydrocarbon product. A qualitative review of the toxicity of petroleum hydrocarbon to birds indicates that the concentrations detected in the soil piles are not likely to pose a significant risk to burrowing owls.

5.5 Ecological Risk and Effect Levels

The objectives of this element of the ecological risk assessment are to first define the existing risks and then to establish ecological effect levels for the contaminants potentially associated with those risks. The definition of existing risks is based on observation of existing biological conditions and evaluation of measured onsite contaminant concentrations and levels known to produce adverse effects. Consideration of ecological effect levels integrates toxicity information, exposure pathways, and other ecological characteristics of the site to establish levels for contaminants that are compatible with site conditions and ecological endpoints. Because establishing existing risk and effect levels

is, at best, an inexact science, discussions of uncertainty associated with each of these efforts are included.

5.5.1 Existing Risk

Although no specific studies were conducted to evaluate existing ecological damage, the survey of resources did not identify any contaminant-related effects. The site and adjacent area appear to support an ecological community that would be expected given conditions in surrounding areas and the level of human activity and disturbance onsite. The condition of the California ground squirrel and other small mammal populations appears to be within the expected range, and there is at least a presence of predators. The burrowing owl population meets or exceeds that in similar areas, and there is some evidence of successful breeding at or near the site. The owls have apparently been onsite for at least 5 months; they most likely would not have remained onsite for an extended period if conditions, including food source and quality/quantity of burrows, were not suitable.

Results of the evaluation of risk based on concentration of contaminants are generally consistent with the indication of little or no existing risk based on ecological observations. In situ shallow soil gas and soils piles resulting from tank excavation are the only potentially contaminated media now constituting a pathway to ecological receptors (see Appendix I). Concentrations of aromatic and chlorinated VOCs in soil gas are significantly below ecological benchmarks for all detected compounds, so no risk is expected. The maximum concentration of diesel in soil piles is slightly greater than the benchmark for ingestion. Consequently, the soil piles could pose some risk to individuals in the most contaminated areas. However, most of the samples were below the benchmark based on ingestion by mammals. Therefore, mammals could avoid the most contaminated areas and still inhabit the soil piles at relatively unaffected densities and conditions. Ground squirrels appear to be inhabiting the piles. It is unlikely that there would be a significant risk to ground squirrels on a population or community level because of their ubiquitous nature. This would be true for other mammals also, so there is not considered to be a risk on a population or community level for common species.

The effects on burrowing owls would also appear to be minimal according to available toxicity data for petroleum hydrocarbon exposure to birds. However, the status of the population makes the potential impairment of approximately 25 percent of prime shelter and breeding habitat a concern. It is impossible to quantify the risk because of the uncertainty of the toxicity information as it relates to owls, but there may be some potential risk to the population from diesel in the soil piles.

Results of the analysis of existing risk based on both existing damage and comparison to benchmarks are uncertain. No detailed population studies were conducted to statistically verify the absence of population effects. However, such studies were deemed unnecessary because observations and comparison to benchmarks both support the con-

clusion of no existing damage. The selection of benchmarks for diesel included a high degree of uncertainty. The only toxicity information readily available was calculated from small mammal inhalation data to estimate acceptable soil concentrations, and this information was not directly applicable to the site-specific ecological endpoints for burrowing owls. Also, the estimation of air concentrations assumed that the diesel went from a soil to soil pore water to soil gas. In the relatively dry soils of the Davis Site, the equilibrium between soil and pore water may never be reached and the soil gas concentration could be lower than predicted. Consequently, the determination of some potential risk to owls from diesel in soil piles is by necessity neither quantitative nor precise.

5.5.2 Ecological Effect Levels

The only onsite compound potentially posing an ecological risk is diesel in the tank excavation soil piles; thus, ecological effect levels related to cleanup are needed for diesel only. As discussed above, the evaluation of risk from diesel is based on several assumptions and is highly uncertain. Therefore, establishing precise numerical effect levels involves a high degree of uncertainty. However, it would be likely that maximum diesel concentrations in the soil piles would pose little or no risk to mammals, owls or other ecological resources.

Although exposure to surface water presents no current risks, creation of a pond for temporary storage of groundwater treatment effluent could pose a risk. Ecological effect levels associated with surface water depend on the operation of the effluent system and the ecological receptors. For aquatic receptors, if the pond is operated in a truly temporary mode and filled for no more than a few consecutive days, acute water quality criteria (Table 5-4) are acceptable effect levels. However, if the pond remains full for extended periods, chronic water quality criteria (Table 5-4) are more appropriate.

The effluent holding pond represents a potential pathway and risk for waterfowl and shorebirds as well as aquatic organisms. As discussed above, recent literature indicates that water quality criteria for aquatic life may not be protective of birds, at least for selenium. A pond situated in the annual grassland habitat of the Davis Site could likely attract ducks, and they could be at risk from selenium contamination. Consequently, a selenium effect level for waterfowl is warranted. Recent research, as summarized in the above toxicity assessment, indicates that selenium levels above 5 $\mu\text{g/l}$ and perhaps levels above 1 $\mu\text{g/l}$ can produce significant impacts to wildlife. Because the effluent holding pond will be small (~ 1 acre), the promulgated water quality standard of 5 $\mu\text{g/l}$ is an appropriate ecological effect level for selenium at the Davis Site.

5.6 Evaluation of Remediation

This section of the RA summarizes the potentially significant ecological issues associated with site remediation (ecological effects of remediation are addressed in detail in Appendix J, Ecological Effects of Remediation). Remediation alternatives under consideration are summarized, followed by a discussion of the ecological implications of each. The potential effects of contaminants remaining onsite following remediation are addressed as well as any alteration of ecological resources resulting from remediation activities, including construction and operation of facilities. Where potential impacts are identified, measures to avoid or minimize the effects are discussed.

The remediation alternatives under consideration for the Davis Site are No Action and the Proposed Action (CH2M HILL, 1993a). The Proposed Action would be carried out in two phases with the first planned as an interim measure until the Remedial Action Plan is approved and implemented. This phase consists of groundwater treatment and in situ soil management (i.e., spreading of the soil piles remaining onsite from tank excavation). The second phase, implementation of the Remedial Action Plan, would be an expansion and continuation of the first-phase activities plus a soil vapor extraction system. All of the potential ecological implications of remediation would result from the first phase; the second phase would not create any new ecological impacts or risk. Consequently, this evaluation of remediation focuses on the first phase.

5.6.1 No-Action Alternative

There are very few ecological effects associated with the No Action Alternative. As discussed throughout this ecological risk assessment and the technical memorandums in the appendixes, there is little or no existing or baseline ecological risk, and this condition is expected to continue under the No-Action Alternative. There is no exposure route via groundwater, surface water, or the contaminated soils at depth. There are potential surface soil and soil gas exposure routes, but with the exception of the soil piles from the tank excavation, there is no surface soil contamination, and soil gas concentrations are significantly below ecological benchmarks. The estimation of little or no existing risk using measured concentrations is supported by observed ecological conditions onsite. No construction is associated with No Action, so existing ecological resources would not be altered.

Under the No-Action Alternative, the effects of leaving the soil in place are uncertain. Conservative calculations indicate animals spending significant time in burrows could be at risk from inhalation of diesel. Only an estimated 25 percent of the stockpiled soil contains levels of diesel that could cause a risk. Therefore, even if there is a risk from the maximum concentration, species that are well established would not be affected at the population level. There could be some effect to the burrowing owl because the species is not abundant in the region, and breeding impairment from diesel contamina-

tion could potentially have minor population implications. Even without action, the existing level of risk should be reduced with time as the diesel volatilizes and dissipates.

5.6.2 Proposed Action Alternative

The Proposed Action would eliminate the potential risk from contamination by grading the soil stockpiled onsite. The grading would eliminate the areas of maximum concentrations by redistributing and diluting the soil. The result would be levels no higher than the existing mean concentration, which is below levels known to have ecological effects. In fact, the process of grading and exposing soils to the atmosphere would significantly reduce diesel concentrations, thus eliminating possible risk from inhalation or ingestion. Finally, and perhaps most importantly, grading the soil piles would prevent burrow construction in contaminated soil. It would no longer be possible to construct a burrow totally within the soil remaining from tank excavation. At most, the entrance to a burrow could exist in such soils, but the interior, where the inhalation risk exists, would be within uncontaminated surface soils.

With onsite reinjection as the groundwater treatment effluent option, the Proposed Action would not produce any long-term ecological effects because there would be no significant taking or long-term disruption of habitat or other ecological resources. The disruption associated with constructing the groundwater treatment and disposal facilities is of short duration and does not involve any significant ecological resources.

If it were necessary to use spray irrigation for effluent disposal, there could be impacts from the associated facilities. The taking of approximately 1 acre of Swainson's hawk foraging habitat for the effluent holding pond would have few population effects. Furthermore, the irrigation and cultivation of 55 acres of alfalfa would more than compensate for the loss of an acre of marginal foraging habitat. The habitat lost for the pond is not considered significant for any other species, and the creation of the alfalfa fields and associated edge habitat would be a positive impact for most species.

The creation of an effluent holding pond could also create aquatic biota and waterfowl risks. The existing groundwater onsite contains relatively high concentrations of inorganic compounds that are not related to site contamination. Levels of antimony, iron, lead, nickel, selenium, and thallium significantly exceed water quality criteria for protection of aquatic life from chronic exposure. Thus, the pond could most likely not support a self-sustaining aquatic community. This impact is not considered significant because there is currently no aquatic habitat on the site so there would be no loss of an existing resource, and the pond would be created as a part of the treatment system rather than to provide habitat values. The predicted water quality in the effluent holding pond would meet criteria for protection from acute exposure so the pond could support short-lived aquatic organisms.

The pond could present a more serious hazard to waterfowl and shorebirds. The accumulation of inorganic compounds in the aquatic food chain, particularly selenium and

the enrichment-produced bacterial conditions, could significantly affect birds using the habitat (see Appendix J, Ecological Effects of Remediation). The inorganic compounds could have toxic effects, and the enrichment of the pond could result in botulism outbreaks in waterfowl.

Impacts to waterfowl and shorebirds could be mitigated by pond management to control enrichment and discourage waterfowl use, particularly during breeding season. However, in an area of limited habitat for these birds, it may not be possible to totally exclude them from the effluent pond. Therefore, these measures could lessen the impact but most likely would not eliminate the possibility of effects on waterfowl and shorebirds.

5.7 Compliance with Ecological ARARs

The Migratory Bird Treaty Act (MBTA) and California Department of Fish and Game (CDFG) regulations protecting Species of Special Concern are ARARs for protection of burrowing owls using the tank excavation soil piles. All of the other ARARs dealing with ecological resources at the Davis Site are related to possible remediation activities. The construction and operation of a groundwater treatment effluent holding pond could trigger the need to protect migratory birds under the MBTA and to meet water quality criteria under the Clean Water Act. The construction of the pond could also remove an acre of Swainson's hawk foraging area and thus fall under the California Endangered Species Act (14 CCR 670) and possibly the Federal Endangered Species Act (50 CFR 17.11) because the species is a candidate for federal listing. Finally, two areas onsite could potentially fall under the justification of the Clean Water Act §404 (Wetlands Protection). Preliminary determinations indicate the areas are not jurisdictional wetlands, but if any remediation activity is proposed for the area, a formal delineation should be performed.

Mitigation of impacts is possible for all of the potential ARARs listed above so that the specific regulations could be met. The pond could be constructed and managed so as not to provide aquatic habitat, and adherence to water quality criteria would not be an issue. If a 1-acre effluent pond were constructed, approximately 55 acres of alfalfa would be cultivated, more than compensating for the forage area lost and satisfying Swainson's hawk ARARs.

Chapter 6
FINDINGS AND CONCLUSIONS

Chapter 6

Findings and Conclusions

6.1 Human Health Risk Assessment

Results of the human health risk assessment do not indicate the presence of conditions posing imminent or substantial danger to human health. There could be some concern for human health in the unlikely event of the site being developed for residential use. However, there are significant uncertainties in the risk estimates associated with contaminants in the site production well that are unrelated to possible release sources from the site. Additional monitoring from the site production well may be warranted to better evaluate the presence and concentrations of EDB and trihalomethanes (such as chloroform) in water. Further action is not indicated to reduce human health risks associated with contaminants in soil or inhalation exposures to VOCs detected in direct contact (soil ingestion and dermal contact) with petroleum hydrocarbon soil gas.

6.2 Ecological Risk Assessment

Diesel hydrocarbon concentrations in some samples from the stockpiled soils exceeded an ecological benchmark level for inhalation exposure, suggesting the potential for some risk to burrowing owls. Significant uncertainties are associated with the estimation of ecological exposures and with the benchmark level development, and the ecological risk assessment tends to overestimate the risks associated with petroleum hydrocarbons in soil. However, the soil piles do not represent significant habitat and could be removed or graded with insignificant impacts to owl populations.

Ecological impacts could be associated with a groundwater remedial action alternative that includes an irrigation end-use option. A storage pond would be constructed as a part of the irrigation system, which could attract waterfowl and other federally protected birds. Potential impacts to birds could include botulism outbreaks and selenium toxicity under certain conditions. However, adherence to proper management practices should reduce to insignificant levels surface-water problems to birds.

Chapter 7
WORKS CITED

Chapter 7

Works Cited

Cal-EPA. 1992. Revised Screening Procedure for the Preliminary Endangerment Assessment. Memorandum from Jeffrey J. Wong, Office of the Science Advisor, to Bill Ryan, Site Mitigation Program, Department of Toxic Substances Control. Sacramento, CA. December 7.

California Water Resources Control Board. 1992. Draft Amendments of the Water Quality Control Plan for Inland Surface Waters of California. March 27.

CH2M HILL. 1992. Davis Global Communications Site Remedial Investigations Work Plan. Prepared for McClellan AFB. September.

CH2M HILL. 1993a. Working Copy Remedial Investigation/Feasibility Study for the Davis Global Communications Site. Prepared for McClellan Air Force Base. September.

CH2M HILL. 1993b. Davis Global Communications Site Remediation Initial Study. Prepared for McClellan Air Force Base. June 21, 1993.

CH2M HILL. 1993c. Davis Global Communications Site Intermediate Remedial Design Report. Prepared for McClellan Air Force Base. March.

CH2M HILL. 1993d. Ecological Risk Assessment for Kesterson Reservoir. Prepared for U.S. Bureau of Reclamation, Mid-Pacific Region. May.

CNDDDB. 1993. Unpublished report generated by the California Natural Diversity Data Base. California Department of Fish and Game, Sacramento, CA.

Dollarhide, Joan, EPA Environmental Criteria and Assessment Office. 1992. Memo to Carol Sweeney, EPA Region X. March 23.

IRP. 1991. Handbook to Support the Installation Restoration Program (IRP) Statements of Work. Volume I: Remedial Investigation/Feasibility Studies (RI/FS). May.

International Technology Corporation. 1992. Preliminary Groundwater Remedial Investigation Report. Davis Global Communications Site, McClellan AFB. Volume I. April.

Maughan, J. T. 1993. Ecological Assessment of Hazardous Waste Sites. New York, NY: Van Nostrand Reinhold.

Peterson, J. A., and A. V. Nebeker. 1992. "Estimation of Waterborne Selenium Concentrations that are Toxicity Thresholds for Wildlife. *Archives of Environmental Contamination and Toxicology*. 23:154-162.

Radian Corporation. 1992. Draft Final Quality Assurance Project Plan, Installation Restoration Program, Stage 3. McClellan Air Force Base. March.

Severson, R.C., et al. 1987. Analyses of bottom material collected at nine areas in the western United States for the DOI irrigation drainage task group. U.S. Geol. Surv. Open-file Report 87-490.

Shacklette, H., and J. Boergnen. 1984. Element concentrations in soils and other surficial materials of the conterminous United States. U.S. Geol. Surv. Prof. Paper 1270.

Skorupa, J. P., and H. M. Ohlendorf. 1991. "Contaminants in Drainage Water and Avian Risk Thresholds." *The Economics and Management of Water and Drainage in Agriculture*, A. Dinar and D. Zilbermand, eds. Boston, MA: Kluwet Academic Publishers.

Suter, G. W. 1993. *Ecological Risk Assessment*. Boca Raton, FL: Lewis Publishers.

Taniguchi, Wayne, Yolo County Health Department. 1993. Personal communication to John Lowe, CH2M HILL, August 11.

USAF. 1989. Installation Restoration Program Toxicology Guide. Prepared for the Henry G. Armstrong Aerospace Medical Research Laboratory, Air Force Systems Command, Wright-Patterson AFB, by Oak Ridge National Laboratory.

U.S. EPA. 1986. Quality Criteria for Water. Office of Water Regulation and Standards. EPA/440/5-86/001.

U.S. EPA. 1989a. *Risk Assessment Guidance for Superfund. Human Health Evaluation Manual Part A, Final*. OSWER Directive 9285.701A. Office of Solid Waste and Emergency Response. Washington, DC.

U.S. EPA. 1989b. Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference. EPA/600/3-89/013.

U.S. EPA. 1989c. *Risk Assessment Guidance for Superfund: Environmental Evaluation Manual*. EPA/540-1-69001A.

U.S. EPA. 1989d. *Risk Assessment Guidance for Superfund. Human Health Risk Assessment. U.S. EPA Region IX Recommendations*. December 15 (Interim Final).

U.S. EPA. 1990. *Exposure Factors Handbook*. Office of Research and Development. EPA/600/8-89/043. Washington, DC.

U.S. EPA. 1991a. *Risk Assessment Guidance for Superfund. Volume 1, Human Health Evaluation Manual. Supplemental Guidance "Standard Exposure Factors."* Draft Final, March 25. OSWER Directive 9285.6-03.

U.S. EPA. 1991b. *Risk Assessment Guidance for Superfund. Volume I, Development of Risk-based Preliminary Remediation Goals*. Interim. Publication 9285.7-01B. December.

U.S. EPA. 1991c. *Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions*. Memorandum from Don. R. Clay, April 22, 1991. Office of Solid Waste and Emergency Response. OSWER Directive 9355.0-30.

U.S. EPA. 1992a. *Framework for Ecological Risk Assessment*. EPA/630/R-92001.

U.S. EPA. 1992b. *Eco Update*. Office of Solid Waste and Emergency Response. Publication 9345.0-05I, Intermittent Bulletin Vol. 1, No. 4. May.

U.S. EPA. 1992c. *Guidance for Data Usability in Risk Assessment (Part A)*. Final. Publication 9285.7-09A. April.

U.S. EPA. 1992d. *Quality Criteria for Water 1992*. Poster, Office of Water Regulations and Standards, Washington, DC.

Yolo County. 1983. *Yolo County General Plan and Referenced Environmental Impact Report*.

RESPONSE TO COMMENTS

PREPARED FOR: Davis Global Communications Site
Final Risk Assessment Report

PREPARED BY: John Lowe/CH2M HILL, Sacramento

DATE: February 21, 1994

SUBJECT: Ecological Exposure Criteria for Petroleum Hydrocarbons in
Soil—Response to Comments from Cal/EPA Office of Scientific
Affairs (OSA)

PROJECT: SWE28722.55.15

Introduction

This technical memorandum is an addendum to Appendix I, Ecological Contaminants of Potential Concern, for the Davis Global Communications Site Risk Assessment (CH2M HILL, 1994). The purpose of this technical memorandum is to respond to comments from the California Environmental Protection Agency (Cal/EPA), Office of Scientific Affairs (OSA), dated December 1, 1993, concerning Appendix I of the Draft Risk Assessment Report, dated November 3, 1993. OSA's comments concerning Appendix I focused on the characterization of ecological risks to burrowing owls that could use as habitat soil piles at the site that are contaminated with petroleum hydrocarbons. Responses to comments from OSA on all other aspects of the Risk Assessment, except Appendix I, were presented in the Draft Final Risk Assessment Report, dated January 5, 1994. Responses to comments concerning Appendix I were deferred pending further evaluation of the ecological risks associated with petroleum hydrocarbon-contaminated soils.

The draft guidance for ecological risk assessment, dated October 1992, has been consulted in preparation of this technical memorandum. The provisional reference doses for diesel and other fuels have been withdrawn as a basis for estimating ecological criteria in soil. Toxicity data more appropriate to the exposure pathways and species of concern at the Davis Site have been considered in developing soil criteria. Appropriate uncertainty factors have been applied to effect levels reported in the toxicity studies to convert these levels to no observed adverse effects levels (NOAELs). All parameters for the soil ingestion criterion have been documented.

The ecological impacts to burrowing owls associated with potential exposure to petroleum-contaminated soils have been reevaluated. On the basis of this review, we have concluded the following: (1) there is no meaningful methodology to extrapolate to birds from concentrations in soil considered acceptable for mammals, and (2) there are no data available to estimate exposure of birds to the contaminants in soil at the

Davis Site. Therefore, we have not performed a quantitative assessment of ecological risks, but instead have presented a qualitative assessment of potential ecological effects of petroleum-contaminated soils to burrowing owls.

This technical memorandum replaces the text in Appendix I starting with the fourth paragraph on page I-2, the entire text on page I-3, and the first paragraph of page I-4.

Identification of Ecological Contaminants of Concern in Soil

As discussed in Appendix I (page I-2, third paragraph), the only soil-related concern for ecological receptors is soil presumably excavated during the removal of underground diesel fuel storage tanks and stockpiled onsite. These soils represent potential pathways of exposure via ingestion, inhalation, and dermal contact, particularly for animals burrowing into the soil piles. Species that could potentially be exposed to petroleum hydrocarbon contaminants via these pathways include burrowing mammals, such as ground squirrels, and burrowing owls that could use existing ground squirrel burrows for shelter and nesting. Ingestion of contaminated food or water was not considered an exposure pathway to these species; much of the diet for these species is unlikely to be affected by petroleum hydrocarbons in the stockpiled soils. Ecological criteria for petroleum hydrocarbons were developed in Appendix I to evaluate whether the hydrocarbon contaminants detected in the soil piles could be contaminants of potential concern. The following subsection provides a reevaluation of these soil criteria, in response to OSA comments.

Estimation of Soil Criteria for Mammals—Ingestion Exposure

Ecological criteria (as mg/kg in soil) for ingestion exposure by burrowing mammals were calculated as follows (Kappleman, 1993):

$$\text{Soil criterion (mg/kg)} = \frac{EL \times BW}{IR \times CF} \quad (1)$$

A description of the parameters and their values is presented in Table 1.

Table 1 Soil Criterion for Ingestion Exposure Parameter Values			
Parameter	Description	Units	Value
EL	Ecological effect level	mg/kg BW	Derived below
BW	Animal body weight	kg	0.25
IR	Ingestion rate	mg/day	3,000
CF	Conversion factor	kg/mg	1×10^{-6}
Source: Hallenbeck and Cunningham, 1986			

Assumptions used in deriving the soil criterion for the ingestion exposure pathway were:

- Absorption from the gastrointestinal tract of ingested contaminants in soil is the same as that for food items.
- Contaminant levels in food or soil are assumed to be the same; therefore, the proportion of food and soil consumed is irrelevant.
- Body weight and ingestion rates for rats are assumed to be representative for small burrowing mammals (i.e., ground squirrels). Ground squirrels are likely to have proportionally higher body weights and ingestion rates compared with rats. However, the differences are not likely to significantly influence the values derived for soil criterion.

Derivation of the ecological effect level in mammals is described below.

Derivation of Ecological Effect Level. A brief discussion of the oral toxicity of middle distillate ("diesel range") petroleum hydrocarbons is presented as a basis for the ecological effect level used in Equation 1.

The acute oral LD_{50} of No. 6 fuel oil (Bunker C or Residual Fuel Oil No. 6) in rats has been estimated to be 5.1 g/kg body weight (BW) (USAF, 1989). A dose of 25 g/kg BW of No. 6 fuel oil produced complete mortality. The acute oral LD_{50} of No. 2 fuel oil (diesel oil, Fuel Oil No. 2, or home heating oil) in rats ranged from 12 to 17.5 g/kg BW. No. 2 oil caused from 70 to 100 percent mortality with doses of 16.5 to 21 g/kg BW. Mortality generally was observed 2 to 3 days following dosing. Higher toxicity appears to be associated with higher boiling-point hydrocarbons. Signs of toxicity included alopecia, lethargy, diarrhea, and dermal irritation. Necropsy revealed evidence of hemorrhagic gastroenteritis and pneumonia with abscess formation. A "marketplace" sample of diesel fuel reportedly had an LD_{50} of 7.5 g/kg BW in rats and produced 90 percent mortality at a dose of 16.6 g/kg BW. Longer term oral toxicity studies in mammals do not appear to be available for petroleum hydrocarbon products (USAF, 1989).

Subchronic (90-day) inhalation toxicity studies have been performed with kerosene-based jet fuels (JP-4 and JP-5) and marine diesel in rats. These inhalation studies are of less value in evaluating ecological effects associated with ingestion of petroleum hydrocarbons in soil because the inhalation exposure concentrations are not likely to resemble the profile of weathered hydrocarbons present in soil, as are present at the Davis Site. Therefore, acute oral toxicity data were used as the basis for the ecological effects level for small burrowing mammals.

Derivation of the ecological effect level from toxicity data is based on the procedure used for development of Reference Doses (RfDs):

$$RfD = \frac{\text{Effect level}}{UF} \quad (2)$$

where UF refers to uncertainty factors. The effect level can be a NOAEL or LOAEL (lowest observed adverse effect level) obtained from either a chronic or subchronic toxicity study. The selection of uncertainty factors depends on factors such as the type of effect level and duration of the study. For example, a UF = 10 is used to correct a LOAEL to a NOAEL, and a further UF = 10 is used to adjust from a subchronic to chronic exposure. In human health risk assessment, a UF = 10 is used to adjust a NOAEL estimated in laboratory animals for use in man. RfDs typically are not developed from median effect levels (i.e. LD₅₀s) obtained from acute toxicity studies.

The lowest LD₅₀ value (5.1 g/kg BW, or 5,100 mg/kg BW) identified from the available oral toxicity data was selected as the basis for the ecological effect level. Uncertainty factors were applied to this toxicity level as follows:

- Median Effect Level to LOAEL—There is no guidance on UF values for this extrapolation. On the basis of the available dose-response information presented previously, a UF = 5 appears to be appropriate.
- LOAEL to NOAEL—U.S. EPA recommends a UF = 10 to convert a LOAEL to a NOAEL.
- Acute to Chronic Exposure—No guidance exists for terrestrial organisms for extrapolating levels of toxicity observed in acute exposure studies to chronic exposures. Studies with aquatic organisms indicate that the acute to chronic ratio (ACR) varies with chemical (Slooff et al., 1986). According to Calabrese and Baldwin, 1993, the ACR appears to be quantitatively similar for aquatic as well as terrestrial organisms. They recommend using an ACR of 50, based on consideration of the available data; therefore, the UF = 50 for this extrapolation.

Because the toxicity data were developed in rats, an uncertainty factor for interspecific extrapolation was not considered necessary. The LD_{50} was then divided by the product of these UFs (equalling 2,500). The resulting ecological effect level for exposure of burrowing mammals to diesel-range petroleum hydrocarbons was 2.04 mg/kg BW a day. Using Equation 1, the corresponding concentration in soil is 170 mg/kg.

Estimation of Soil Criteria for Mammals—Inhalation Exposure

Subchronic (90-day) inhalation toxicity studies have been performed with kerosene-based jet fuels (JP-4 and JP-5) and marine diesel in rats, mice, and dogs. Concentrations ranging from 50 to 750 mg/m³ in air have produced dose-related histopathological changes in the livers and kidneys of rats. Dose-dependent renal and liver toxicity has been observed in rats exposed for 90 days to 50 or 300 mg/m³ marine diesel fuel. Similar results have been observed in rats exposed for 90 days to 150 or 750 mg/m³ JP-5 (USAF, 1989). No. 2 fuel oil (the product most likely stored in underground tanks at the site) is probably closer in boiling point and toxicity to jet fuel than marine diesel. Therefore, the LOAEL for concentrations in air volatilized from petroleum hydrocarbon contaminants in the soil piles is considered to be 150 mg/m³. Using an UF = 10, as described previously, converts this value to a NOAEL of 15 mg/m³. An uncertainty factor for interspecific extrapolation was not considered necessary, because the toxicity data were developed in rats.

Assuming that concentration in air inside burrows is at equilibrium with concentrations in soil, concentration in soil can be estimated using the series of calculations presented in Attachment 1. As shown in Attachment 1, there is significant uncertainty in the estimated concentration in soil associated with an equilibrium NOAEL concentration in air. The concentration in soil increases with higher molecular weight, lower volatility components in diesel. The lower volatility components are likely to predominate in diesel-contaminated soil that has been allowed to weather for several years. While the concentration in soil corresponding to the NOAEL in air was probably lower in past years, under current conditions at the site, the diesel concentration in soil corresponding to the NOAEL in air is considered to be approximately 400 mg/kg (see the calculations presented in Attachment 1).

Estimation of Soil Criteria for Birds

Birds can be affected by petroleum products through external oiling, ingestion, egg oiling, and habitat changes (Albers, 1991). Adverse effects have been observed in aquatic birds exposed to free petroleum hydrocarbon product in water and tidal areas. Exposures to traces of petroleum hydrocarbon contaminants in soil have not been reported to produce adverse effects in terrestrial birds.

External oiling of birds disrupts feather structure and causes matting of feathers and irritation of the eyes. Mortality often results from hypothermia and drowning. Petroleum hydrocarbons can be ingested through preening or ingestion of contaminated food. Ingestion of petroleum hydrocarbons is seldom lethal; however, the

sublethal effects (including inflammation and hemorrhaging of the digestive tract, pneumonia, and hormonal imbalances) can promote lethality from other causes, including starvation, disease, predation, and reproductive failure. Bird embryos are highly sensitive to petroleum hydrocarbon exposure. Contaminated nesting materials and oiled plumage are mechanisms for transferring oil to the surfaces of egg shells. Generally, higher toxicity is associated with higher molecular weight components in petroleum hydrocarbons; weathered aviation kerosene reportedly produced insignificant increases in mortality in exposed duck embryos. Dose-response information for petroleum hydrocarbon exposure to birds is limited. Mallard ducks receiving from 1 to 3 percent South Louisiana crude oil in the diet exhibited alterations in adrenocortical activity, increased naphthalene metabolizing activity of hepatic microsomes, and decreased egg hatchability (Albers, 1991; Albers and Gay, 1982; Hooper et al., 1987). Dose-response information is not available to evaluate potential inhalation exposures associated with emissions of volatile organic compounds from petroleum hydrocarbons in soil or water.

The potential pathways of exposure to burrowing owls could be ingestion of soil through preening and inhalation of petroleum hydrocarbon constituents volatilizing into burrows. Information for quantitatively evaluating either exposure or toxicity of petroleum hydrocarbon constituents in soil to burrowing owls is not available. However, toxicity of petroleum hydrocarbons to birds is most often associated with exposure to free hydrocarbon product. Ingestion of trace concentrations sorbed to soil particulates is not likely to produce significant adverse effects or decreased fertility, or increase the susceptibility of burrowing owls to starvation, disease, or predation. Exposures to embryos are not likely to occur, since free product is not present to cause oiled plumage in adult birds. It is not certain if inhalation exposures could be associated with significant adverse effects. An important consideration is that burrowing owls would not shelter or nest continuously in the burrows, reducing the potential duration of inhalation exposure.

Conclusions

The soil criteria estimated in this technical memorandum were compared with the maximum diesel hydrocarbon concentration estimated in the soil piles (180 mg/kg). While this concentration exceeds the soil ingestion criterion for mammals, the 95 percent upper confidence level of the mean concentration (UCL = 91 mg/kg, mean = 55 mg/kg) is less than the soil criterion. There is uncertainty in the soil criterion for mammals based on inhalation exposure; however, since the diesel contamination in soil has weathered over time, it is likely that the measured concentrations fall below the inhalation criterion. On the basis of this evaluation, diesel hydrocarbons in the soil piles would not be an ecological contaminant of concern for mammals.

Information was not available to quantify the risks to burrowing owls from diesel-contaminated soil. However, a qualitative review of the toxicity of petroleum products to birds suggests that the concentrations of diesel contaminants in the soil piles are not likely to pose a significant risk to burrowing owls.

References

- Albers, P. H. 1991. Oil Spills and the Environment: a Review of Chemical Fate and Biological Effects of Petroleum, *The Effects of Oil on Wildlife*, ed J.W. White. Sheridan Press, Hanover, PA.
- Albers, P. H., and M. L. Gay. 1982. Unweathered and Weathered Aviation Kerosene: Chemical Characterization and Effects on Hatching Success of Duck Eggs. *Bull. Environ. Contam. Toxicol.* 28:430-434.
- Calabrese, E. J., and L. A. Baldwin. 1993. *Performing Ecological Risk Assessments*. Lewis Publishers, Chelsea, MI.
- CH2M HILL. 1994. Draft Final Risk Assessment Report for Davis Site. Prepared for McClellan Air Force Base, Contract No. F04699-90-D-0035, Delivery Order 5055, Line Item 0016. January 5.
- Hallenbeck, W. H., and K. M. Cunningham. 1986. *Quantitative Risk Assessment for Environmental and Occupational Health*. Lewis Publishers, Chelsea, MI.
- Hooper, T. D., K. Vermeer, and I. Szabo. 1987. *Oil Pollution of Birds: An Annotated Bibliography*. Technical Report Series No. 34, Canadian Wildlife Service, Pacific and Yukon Region, British Columbia.
- Kappleman, W. B. 1993. Pine Street Canal Ecological Assessment: A Case Study, *Ecological Assessment of Hazardous Waste Sites*, ed. J. T. Maughan. Van Nostrand Reinhold, New York.
- Slooff, W., J. A. Van Oers, and D. DeZwart. 1986. Margins of Uncertainty in Ecotoxicological Hazard Assessment. *Environ. Toxicol. Chem.* 5:841-852.
- U.S. Air Force. 1989. *Installation Restoration Program Toxicology Guide, Volume 4*. Harry G. Armstrong Aerospace Medical Research Laboratory, Aerospace Medical Division, Air Force Systems Command, Wright-Patterson Air Force Base, OH. Prepared by Oak Ridge National Laboratory, Oak Ridge, TN.

Attachment 1 **Conversion of Concentration in Air to** **Equivalent Concentration in Soil**

$$C_{water} = \frac{C_{air}}{H} \quad (1)$$

$$H = \frac{H'}{RT} \quad (2)$$

$$C_{soil} = C_{water} \times K_d \quad (3)$$

$$K_d = K_{oc} \times f_{oc} \quad (4)$$

The steps involved with this calculation are as follows:

1. Convert the NOAEL concentration in air (15 mg/m³) to mole/m³:

$$C(\text{mole/m}^3) = \frac{C(\text{mg/m}^3) \times 0.001 \text{ g/mg}}{\text{MW g/mole}} \quad (5)$$

Diesel fuel, a mixture of hydrocarbons ranging from C₁₀ to C₁₉ (USAF, 1989), has no single value for molecular weight (MW). A range of surrogate aromatic hydrocarbons within that range of carbon numbers (naphthalene, C₁₀; methylnaphthalene, C₁₁; and anthracene, C₁₄) were used as surrogate MWs for this calculation:

Surrogate	Molecular weight (g/mole)	Concentration (mole/m ³)
Naphthalene	128	0.00012
Methylnaphthalene	142	0.00011
Anthracene	178	0.000084

2. Convert Henry's Law constant (H) to a dimensionless form (Eq. 2). Parameters in this equation are R = 8.2E-05 atm-m³/mole-°K, and T = 305 °K. Dimensional Henry's Law constants (H') for the surrogate hydrocarbons were obtained from USAF, 1989:

Surrogate	H' (atm-m ³ /mole)	H (dimensionless)
Naphthalene	4.82E-04	0.0193
Methylnaphthalene	4.4E-04	0.0178
Anthracene	5.9E-05	0.00236

3. Calculate the equilibrium concentration in soil moisture (Eq. 1) and convert units to $\mu\text{g/ml}$:

$$C(\mu\text{g/ml}) = C(\text{mole/m}^3) \times MW(\text{g/mole}) \times 10^6 \mu\text{g/g} \times \text{m}^3/10^6 \text{ml} \quad (6)$$

Surrogate	Concentration in Water	
	mole/m ³	$\mu\text{g/ml}$
Naphthalene	0.0062	0.8
Methylnaphthalene	0.0062	0.9
Anthracene	0.036	6.3

4. Calculate K_d (Eq. 4). The fraction of organic carbon in soil (f_{oc}) at the Davis Site is assumed to be 0.005. Values for K_{oc} for the surrogate hydrocarbons were obtained from USAF, 1989.

Surrogate	K_{oc} (ml/g)	K_d (ml/g)
Naphthalene	962	4.81
Methylnaphthalene	3,570	17.85
Anthracene	13,500	67.5

5. Calculate the equivalent concentration in soil (Eq. 3)

Surrogate	Concentration in Soil ($\mu\text{g/g}$)
Naphthalene	3.8
Methylnaphthalene	16.1
Anthracene	425

DEPARTMENT OF TOXIC SUBSTANCES CONTROL

REGION 1

10161 CROYDON WAY, SUITE 3
SACRAMENTO, CA 95827-9106

(916) 255-3545

February 14, 1994



Ms. Doris Bajka
SM-ALC/EMR
5050 Dudley Boulevard, Suite 3
McClellan Air Force Base, California 95652-1389

APPROVAL OF THE DRAFT FINAL REMEDIAL INVESTIGATION/FEASIBILITY
STUDY (RI/FS) REPORT FOR THE DAVIS GLOBAL COMMUNICATIONS SITE

Dear Ms. Bajka:

The Department of Toxic Substances Control and the California Regional Water Quality Control Board, Central Valley Region (Agencies) have reviewed the response to the Agencies' comments on the Draft RI/FS report, which were contained in the Draft Final RI/FS Report, dated January 7, 1994.

The responses adequately address the Agencies' comments and we approve the RI/FS report.

If you have any questions or comments regarding this matter, please contact Mr. Mark Malinowski at (916) 255-3717.

Sincerely,

Eric Hong, P.E.
Chief
Federal Facilities Unit
Office of Military Facilities

cc: Mr. Alex MacDonald
Regional Water Quality Control Board
Central Valley Region
3443 Routier Road, Suite A
Sacramento, California 95827-3098

Mr. Tom To
Director of Environmental Health
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CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD

CENTRAL VALLEY REGION

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27 January 1994

Mr. Mark Malinowski
Department of Toxic Substances Control
Region 1
10151 Croydon Way, Suite 3
Sacramento, CA 95827-2106

**DRAFT FINAL RISK ASSESSMENT REPORT, DAVIS GLOBAL COMMUNICATIONS SITE,
MC CLELLAN AIR FORCE BASE**

Regional Board staff have reviewed the subject report and have determined that our comments on the draft version of the report have been adequately addressed. We have no additional comments.

If you have any questions regarding this matter, please call me at (916) 255-3025.


ALEXANDER MACDONALD
Project Engineer

AMM

cc: Ms. Doris Bajka, Environmental Management, McClellan Air Force Base

Davis Global Communications Site Baseline Risk Assessment Agency Comments and Responses			Page 1 of 7
Comment		Response	
Comments from California Department of Toxic Substance Control, Office of Scientific Affairs (December 1, 1993)			
General Comments			
1.	The document we reviewed makes frequent reference to other reports of characterizations at the site, documents not examined by OSA. We assume that sampling of environmental media, analytical chemistry data, and quality assurance procedures described in these documents and summarized in the document reviewed by OSA were adequately reviewed by regional staff. If deficiencies or data gaps are encountered with respect to adequacy for risk assessment, these are noted in our comments.	All documents used in developing the risk assessment have undergone agency review. The RI/FS report is undergoing review at the same time as the risk assessment. Comments on the RI/FS report do not affect data used in the risk assessment.	
2.	The document was reviewed for scientific content. In general, minor grammatical or typographical errors that do not affect the interpretation have not been noted. However, these should be corrected in the final version of the document.	Comment noted.	
3.	Future changes in the document should be clearly identified. Although this may be accomplished in several ways, OSA favors the method used by CH2M HILL to identify comments and responses for the RCRA Facility Investigation Workplan for the Long Beach Naval Complex. A document was prepared with side-by-side comments and responses, showing specific references to any changes made in text or tables from the draft to the final document.	Comment noted.	
4.	We find the draft risk assessment adequate, although we require the changes enumerated below. The most important deficiency in the risk assessment is the inappropriate omission of vinyl chloride as a contaminant of potential concern in groundwater.	Vinyl chloride in groundwater has been incorporated into the risk assessment, as discussed below.	
Specific Comments			
1.	Guidance Documents, Sec. 1.3.2, p. 1-7: For ecological risk assessment, please make use of the attached draft guidance for OSA dated October 1992. Note especially the recommended methods for determining acceptable concentrations of contaminants for ecological receptors.	Comment noted.	

**Davis Global Communications Site Baseline Risk Assessment
Agency Comments and Responses**

Page 2 of 7

Comment	Response
2. Contaminants of Potential Concern (COPCs), Sec. 4.1, p. 4-1 ff., and Appendix D: Inorganic chemicals are nowhere mentioned. If an agreement was reached with DTSC not to assess inorganics, please state this or attach correspondence. Do not eliminate as a COPC any substance classified by USEPA as a Group A or B carcinogen. This would include 1,2-dichloroethane, chloroform, and others. Only a small amount of effort is required to add these substances and their potency factors into the spreadsheets for estimating intakes and risks. Table D-6 should be updated to include any additional carcinogens. Vinyl chloride was detected in nearly 10% of samples of groundwater (Table D-3), yet was not included as a COPC in groundwater. This is a major oversight, resulting in an underestimation of risks from ingestion of groundwater by an order of magnitude or more. Whether or not the non-degradation policy of Cal/EPA is met at this site has no bearing on the estimation of baseline risk. Also, the last two columns of Table D-3 contain many zeros. This cannot possibly be correct for substances with frequency of detection greater than zero. Please fix this.	Inorganic compounds. Inorganic compounds (metals) were addressed by comparison with literature values for background concentrations in soil. This comparison is presented on page C-9 in the conceptual site model (Appendix C). The rationale for inclusion or exclusion of metals as contaminants of potential concern is presented on page D-2 of Appendix D. A summary of these evaluations is presented on page 4-2, Section 4.1. Other carcinogens. A review of the data presented in Appendix D indicates that chloroform and 1,2-dichloroethane in soil (and soil gas) are the only Group B carcinogens that could have been excluded from the risk assessment in error. Methylene chloride detected in soil should not be considered a COPC because of the substantial possibility of laboratory contamination, and because this contaminant was not detected in soil gas. The increased lifetime cancer risks from chloroform and 1,2-dichloroethane in soil gas and groundwater were calculated for the hypothetical future resident scenario; these calculations show these two VOCs contribute less than one percent to the total site risk, particularly when risks from vinyl chloride are considered. The results of this comparison show that risks from these two VOCs are small relative to more toxic compounds (vinyl chloride) or compounds more widespread in groundwater and soil gas (TCE and PCE). Inclusion of these compounds as COPCs would not change the findings of this risk assessment. Calculations supporting this response are presented as Attachment 1. The exposure scenario characterizing the hypothetical future onsite resident has been revised to include vinyl chloride in groundwater. The highest concentration detected in any monitoring well (410 µg/l) has been used as the exposure concentration for characterizing vinyl chloride risks. Tables S-1, A-9, A-10, A-11, A-12, and Figure 4-3 have been revised to include estimated risks associated with vinyl chloride. Nondegradation policy. Comment noted. Table D-3. Zeros shown in this table for chemicals with frequencies of detection greater than zero were artifacts created when importing data from the sampling and analysis database. These zeros have been removed from this table.

**Davis Global Communications Site Baseline Risk Assessment
Agency Comments and Responses**

Page 3 of 7

Comment	Response
3. Exposure Assessment, Sec. 4.2, p. 4-4 ff., and Appendices F and G: In Table 4-2, onsite workers are shown to be potentially exposed to volatile organic chemicals (VOCs) in groundwater via inhalation but not ingestion. How is that possible? Footnote C to this table contains an unsubstantiated assertion that dermal intake is equivalent to ingestion intake. Please provide support for this statement. We do not understand how inhalation of VOCs in indoor air can be a significant pathway for the occupational setting but not the residential setting. This seems to be an oversight. Nothing in Appendix F leads us to believe that residents would not be exposed to VOCs arising from soil gas. Change Tables G-1 and G-2 to reflect all the relevant pathways to which future residents might be exposed. Exposure of residents via inhalation of indoor air is mentioned on page G-17. Is this consistent? In Table G-1, we find the last two columns for residents to be inconsistent. If a pathway is not feasible, it need not be assessed. On the other hand, if the Air Force has agreed with the Department to assess a hypothetical future residential scenario, it is pointless to state that these exposures are infeasible.	Onsite worker exposure pathways. The water supply for onsite workers is obtained from the onsite production well. Onsite personnel have used bottled water for drinking since 1982, due to silt problems with the well, detection of VOCs in water from the well and preferred taste. Water from the onsite production well is not used for human consumption, as described on page B-7. Drinking water ingestion was not included as an exposure pathway for the onsite worker scenario based on this information. Dermal vs. ingestion intake. The rationale for Footnote c is presented on page G-20, which refers to an EPA interim guideline for dermal exposure assessment for soils. The assumptions in this interim guideline were compared with DTSC's dermal exposure assessment methodology presented in the draft Preliminary Endangerment Assessment (PEA) guidance, as shown in Attachment 2 to these responses. Based on this comparison, dermal exposures to contaminants in soil were calculated for the hypothetical future resident scenario using the methodology in the draft PEA guidance. Revised risks estimates based on this methodology are presented in Tables A-9 and A-16. Detailed calculations using the PEA methodology are presented in Table G-16. The hazard index for noncarcinogens in soil exceeds 1.0 for this scenario when dermal exposures are recalculated. This has been reflected in Tables S-1 and 4-3, and is discussed in Section 4.4. Comparison of the intakes for a worker exposure scenario showed that there is little difference between soil ingestion and dermal contact exposure pathways. The risks from the onsite worker (excavation) scenario have not been revised, based on the calculations presented in Attachment 2. Inhalation exposures to VOCs, both in indoor and outdoor air, have been calculated for the hypothetical future resident scenario. The risks from these pathways have been summed with risks associated with contaminants in groundwater and soil. Tables S-1, 4-3, and A-9, and Figure 4-3 have been revised to account for these exposure pathways. Detailed calculations are presented in Tables A-14, A-15, G-14, and G-15. Tables G-1 and G-2 have been revised to accommodate changes in these exposure scenarios. Table G-1 has been revised so that feasible exposure pathways have been included in the risk assessment.

**Davis Global Communications Site Baseline Risk Assessment
Agency Comments and Responses**

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Comment	Response
It seems that excavation workers would be exposed to VOCs in soil gas via inhalation as well as direct contact with soil. Elimination of the inhalation pathway for excavation workers in Tables G-1 and G-2 seems to be incorrect.	OSA correctly notes that excavation workers could potentially be exposed to contaminants in soil gas through inhalation. However, we are not aware of an acceptable methodology for estimating inhalation exposures associated with contaminants that could become exposed during excavation. The potential magnitude of exposure would depend upon the concentrations of VOCs encountered during excavation, the surface area exposed during excavation, and the duration that workers are in proximity to contaminated soils. This poses a different problem from estimating soil ingestion exposure in that workers can simply be assumed to have direct contact with soil for specified periods of time without describing in detail how this contact would occur. It is less feasible to calculate worker inhalation exposures without specifying site conditions and the exposure scenario in further detail. A worst-case approximation of the potential concentrations in air associated with soil gas contaminants was made using the emissions estimation and box modeling methodology presented in Appendix F. Emissions were estimated from the highest VOC concentration (541 µg/l PCE) in soil gas at a depth of 0.1 foot in the soil. Concentrations in air from an area 10 meters on a side were estimated using the box model. The resulting steady-state concentration was approximately 10 µg/m³ (equivalent to 5×10^{-5} increased lifetime cancer risk, with the default assumptions for worker exposure). The actual risks to workers would be far lower, if more reasonable assumptions were used to estimate the frequency and duration of exposure. Also, it is unlikely that this concentration would persist over time, unless VOC concentrations in underlying soils were quite high. It is also notable that this worst case concentration is well below the Cal/OSHA Permissible Exposure Limit of 170 mg/m³. Comment noted. Revision has been made in the text. Comment noted. Revisions have been made in the text.
"Gastrointestinal" is misspelled on page G-11. The discussion of dermal contact with COPC in groundwater on pages G-16 and G-17 show an exposure time (ET) of 0.25 hr. We presume this refers to bathing; therefore, please mention bathing in the text. Also, "C" should be "C_{so}" in Equation (12) on page G-17.	

**Davis Global Communications Site Baseline Risk Assessment
Agency Comments and Responses**

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Comment	Response
The parameter values shown on page G-20 are appropriate for a long-term occupational setting. However, OSA recommends an exposure duration of 30 days for the excavation worker. Using this value should lead to lower estimates of risk and hazard for the excavation worker.	We agree that a lower exposure frequency for construction workers is more reasonable. However, the results from the risk assessment for the onsite worker (excavation) scenario indicate that risks to workers from soil ingestion and dermal contact with soil would fall below a 10^{-4} to 10^{-5} risk level (or a hazard index of less than one) with the current, conservative assumptions. We do not feel that revising the exposure assumptions for this scenario is required at this time to evaluate the potential risks to workers associated with contaminants in soil.
4. Toxicity Assessment, Sec. 4.3, p. 4-6, and Appendix E: Cal/EPA does not consider 1,1-dichloroethene to be carcinogenic. Do not use the reference concentrations published in the California Air Pollution Control Officers Association (CAPCOA) Manual of 1992, as shown in the current version of Table E-3. Use only IRIS and HEAST as sources of toxicity criteria for toxic effects considered to exhibit thresholds. Convert RfCs from IRIS to dose units multiplying by 20 m³/70 kg-day. Do not eliminate any COPC for lack of a toxicity criterion for threshold effects. Use the surrogate chemical approach. Propose surrogates for each COPC without a published criterion or call OSA for consultation.	1,1-Dichloroethene. Comment noted. Please note that IRIS and HEAST are the sources for RfDs and RfCs in Table E-3. To our recollection, we did not use the reference concentration published in the CAPCOA manual. The value used to characterize noncancer health risks associated with 1,1-dichloroethene is one recommended by Dr. Gerald Hiatt at U.S. EPA Region IX. The derivation of this value is presented on pages E-5 and E-14. In the used lifetime cancer risks were not calculated for 1,1-dichloroethene. Concentrations of 1,1-dichloroethene detected at the site were not associated with exposures exceeding a hazard quotient of one. RfC to RfD conversions. The conversion described by OSA is presented on page E-3 of the risk assessment. Chemicals were not eliminated from consideration in the risk assessment. Non-cancer effects from inhalation exposure were not evaluated for several contaminants as described on page E-5. Increased lifetime cancer risks were estimated for all of the potential carcinogens listed on page E-5. In all other cases, noncancer effects from inhalation exposures were evaluated by comparison with the oral RfD for that chemical.
5. Risk Characterization, Sec. 4.4, p. 4-8: Risks should be recalculated for all receptors exposed to groundwater, to reflect the inclusion of vinyl chloride as a COPC. The residential setting should reflect exposures to VOCs in shallow soil via inhalation following infiltration of indoor air spaces.	The exposure scenario characterizing the hypothetical future onsite resident has been revised to include vinyl chloride in groundwater. The highest concentration detected in any monitoring well (410 µg/l) has been used as the exposure concentration for characterizing vinyl chloride risks. Tables S-1, A-9, A-10, A-11, A-12, and Figure 4-3 have been revised to include estimated risks associated with vinyl chloride. Inhalation exposure pathways, both indoors and outdoors, and pathways associated with direct contact with soil have been included in this scenario. See Tables A-13 through A-16 and the associated spreadsheets in Attachment G-1 for the results from these pathways.

RDD10013173.WP5-5

**Davis Global Communications Site Baseline Risk Assessment
Agency Comments and Responses**

Page 6 of 7

Comment	Response
6. Ecological Risk, Sec. 5, p. 5-1 ff., and Appendix I: The ecological assessment is generally well conceived; however, we have several difficulties with the toxicity criteria for diesel fuels derived in Appendix I: (shown below) We cannot evaluate the derivation of the soil criterion (Eqn. 1, p. I-2) without values for the parameters of body weight and soil ingestion. Soil criteria should be based on a no-observed-effect-level (NOEL), not a lowest-observed-effect-level (LOEL). An uncertainty factor of 10 is customarily used to estimate a NOEL from a LOEL. Applying this to the information on page I-2 yields a soil criterion of 203 mg/kg for diesel. We find no equation for the transformation of USEPA's LOEL for diesel vapor of 150 mg/m³ to a safe dose of 63 mg/kg. Please show the derivation. It would appear that an uncertainty factor of 10 will be required for the inhalation pathway as well. Both OSA and USEPA Region IX have expressed serious reservations about the utility of the "provisional" reference doses for diesel and other fuels produced in 1992 by a contractor to the USEPA Environmental Criteria and Assessment Office. These draft reference doses were never made final by USEPA. Furthermore, OSA knows of no situation in which their use has been approved in California or elsewhere. We suggest the authors give careful examination to these draft criteria before they are used. These difficulties amount to major uncertainties in the estimates of existing risk described in Section 5.5.1. If acceptable doses in small mammals can be extrapolated to birds such as burrowing owls, and if these acceptable doses are approximately tenfold lower than those given in Appendix I, then estimates of existing risk ought to be considerably higher than those expressed in Section 5.5.1. In particular, the assertion of minimal risk to burrowing owls (top p. 5-9) would seem to be an underestimation for birds which might try to use the excavated soil piles as habitat.	Evaluation of ecological impacts potentially associated with petroleum hydrocarbons in soil is ongoing. A completed evaluation will be presented in the final risk assessment report. Responses to the subsequent comments will be provided following completion of this evaluation. Until that time, the existing text in Chapter 5 and Appendix I will be retained in the risk assessment.

**Davis Global Communications Site Baseline Risk Assessment
Agency Comments and Responses**

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Comment		Response
Comments from the California Regional Water Quality Control Board, Central Valley Region, October 8, 1993		
1.	Table 4-2. The hypothetical future resident would also be exposed to contaminants in soil gas as it leaves the soil column. This would be similar to the onsite worker - indoor scenario.	This exposure pathway has been included into the hypothetical future residential exposure scenario.
2.	Table 4-2. The hypothetical future resident evaluation should also include vinyl chloride in determining the risks due to exposure to contaminants found in ground-water.	Vinyl chloride in groundwater has been included into this exposure scenario.
3.	Page 5-6, Table 5-3. Are the concentrations presented in this table total or dissolved concentrations? What were the analytical methods used to analyze the samples from which the concentrations were obtained? These concentrations appear to be very high if dissolved concentrations are presented.	These results are total concentrations in groundwater, based on the groundwater monitoring database maintained by Radian. Analytical methods specified in the McClellan QAPP have been used to analyze for metals in these samples.

Attachment 1

Contribution to Total Risk from 1,2-Dichloroethane and Chloroform

McClellan Air Force Base

Davis Global Communications Center

Reasonable Maximum Exposure

Hypothetical Future Land Use

Chemical	Symbol	Estimated Cancer Risk by Exposure Pathway						Chemical Specific Risk
		Groundwater Ingestion	Groundwater - Inhalation	Groundwater - Dermal Contact	Outdoor Air Inhalation	Indoor Air Inhalation	Soil Ingestion	Dermal Contact with Soil
Benzene	BENZ							
bis(2-ethylhexyl)phthalate	BEHP							
Tetrachloroethene	PCE	8.98E-05	3.37E-04	1.24E-05	3.19E-07	3.31E-06	1.52E-08	1.39E-07
Trichloroethene	TCE	6.16E-05	1.54E-04	2.84E-06	3.80E-09			3.05E-08
Vinyl chloride	VC	1.30E-03	4.87E-03	2.73E-05	1.66E-09			4.43E-04
Total Cancer Risk		1.45E-03	5.37E-03	4.25E-05	3.28E-07	3.45E-06	1.52E-08	2.19E-04
								6.20E-03
								6.86E-03

1,2-Dichloroethane	1.48E-07	5.55E-07	2.25E-10	2.46E-10	1.67E-12			7.03E-07
Chloroform	1.38E-05	3.18E-05	3.54E-07	2.61E-10	1.77E-12			4.60E-05
Total	1.40E-05	3.23E-05	3.54E-07	5.07E-10	3.45E-12			4.67E-05

Percent of Total Pathway

Risk

0.96

0.60

0.83

0.15

0.00

0.00

0.00

0.68

Attachment 2					
DTSC Dermal Exposure Assessment Methodology - Draft PEA Guidance Document					
Algorithm:					
$(C_s \times SA \times AF \times ABS \times EF \times ED \times 10^{-6}) / (BW \times AT \times 365)$					
Parameters:					
Parameter	Description	Units	Value		
			Adult	Child	
C _s	Concentration in Soil	mg/kg	1	1	
SA	Exposed Skin Surface Area	cm ² /day	5800	2000	
AF	Soil Adherence Factor	mg/cm ²	1	1	
ABS	Absorption Fraction		0.15	0.15	
	(Default value for PNAs presented)				
EF	Exposure Frequency	days/year	100	350	
ED	Exposure Duration	years	24	6	
BW	Body Weight	kg	70	15	
Intake Calculations:					
	Case		Intake (mg/kg-day)		
			Adult	Child	Sum
	AT = 70 years (carcinogen)		1.17E-06	1.64E-06	2.81E-06
	AT = ED (noncarcinogen)		3.41E-06	1.92E-05	2.26E-05
Soil Ingestion Intake Methodology (Based on EPA PRG Methodology, Adapted by Draft PEA Guidance)					
Algorithm					
$(C_s \times 10^{-6} \times EF \times IF) / (AT \times 365)$					
Parameter	Description	Units	Value		
C _s	Concentration in Soil	mg/kg	1		
EF	Exposure Frequency	days/year	350		
IF	Ingestion Factor	mg-yr/kg-day	114		
Intake Calculations:					
	Case		Intake (mg/kg-day)		
	AT = 70 years (carcinogen)		1.56E-06		
	AT = ED (noncarcinogen)		3.64E-06		
Comparison of Exposure Pathways @ 1 mg/kg in Soil					
			Intake (mg/kg-day)		
			Dermal Contact	Soil Ingestion	
	AT = 70 years (carcinogen)		2.81E-06	1.56E-06	
	AT = ED (noncarcinogen)		2.26E-05	3.64E-06	

Davis Site Risk Assessment - Attachment 3
VOC Emissions from Soil Gas and Outdoor Air Concentrations

Locxref	Logdate	Anmcode	Sacode	Sbd	Sed	Parameter Name	Parvq	PARVALCONV	LABDLCONV	UNITCONV	Diffusion Coefficient (cm ² /s)	Total Porosity (PT)	Air Filled Porosity (PA)	Depth in Soil (cm)
				0		PCE		541.0000			0.08968	0.4	0.2	2.52984

Davis Site Risk Assessment - Attachment 3
VOC Emissions from Soil Gas and Outdoor Air Concentrations

Locxref	Logdate	Anmcode	Sacode	Sbd	Sed	Parameter Name	Soil Gas Conc. (g/cm ³)	Emissions (g/cm ² ·s)	Emissions (g/m ² ·s)	C g (g/m ³)	C (mg/m ³)
				0		PCE	5.41E-07	4.36E-10	4.36E-06	9.47E-06	9.47E-03

Davis Site Risk Assessment - Attachment 3
VOC Emissions from Soil Gas and Outdoor Air Concentrations
Parameters

Symbol	Description	Units	Value
L	Length of Side	m	10
V	Annual average windspeed	m/s	2.3
H	Box Height	m	2
A	Area	m ²	100

Appendix A
HUMAN HEALTH RISK ASSESSMENT SUMMARY TABLES

Table A-1 Summary of Estimated Cancer Risks Davis Global Communications Site Reasonable Maximum Exposure Onsite Worker (Outdoors) - Production Well Data and VOCs in Soil Gas				
Contaminant	Symbol	Cancer Risk by Exposure Pathway		
		Inhalation Sprinkler Irrigation	Inhalation Soil Gas	Total
Benzene	BENZ	0.00E+00	1.82E-09	1.82E-09
Bromoform	CHBr3	1.52E-08	0.00E+00	1.52E-08
Chloroform	CHCl3	1.05E-08	0.00E+00	1.05E-08
Ethylene dibromide	EDB	4.76E-08	0.00E+00	4.76E-08
Tetrachloroethene	PCE	1.35E-08	1.90E-07	2.04E-07
Trichloroethene	TCE	6.13E-09	2.26E-09	8.39E-09
Vinyl Chloride	VC	0.00E+00	9.89E-10	9.89E-10
Total		9.30E-08	1.93E-07	2.86E-07

Table A-2 Calculation of Health Risks Associated with Inhalation of Outdoor Air Davis Global Communications Site Reasonable Maximum Exposure Onsite Worker - VOC emissions from sprinkler irrigation				
Carcinogenic Contaminant	Concentration in Air (mg/m³)	Estimated Increased Lifetime Cancer Risk	Percent of Total Pathway Risk	Hazard Quotient
Acetone	4.86E-05			9.51E-05
Bromodichloromethane	3.08E-06			3.02E-05
Bromoform	5.57E-05	1.52E-08	33.46	5.45E-04
Chlorodibromomethane	1.04E-05			1.02E-04
Chloroform	7.94E-06	1.05E-08	23.24	1.55E-04
1,4-Dichlorobenzene	4.40E-06			4.30E-06
1,1-Dichloroethene	3.56E-06			7.73E-04
Methyl ethyl ketone	7.11E-07			4.64E-07
Methyl isobutyl ketone	8.53E-06			
Tetrachloroethene	3.79E-06	1.35E-08	29.79	7.42E-05
Toluene	4.74E-07			9.28E-07
Trichloroethene	8.77E-06	6.13E-09	13.51	
Trichlorofluoromethane	7.11E-07			6.96E-07
1,1,2-Trichloro-1,2,2-trifluoromethane	1.67E-05			4.25E-07
Total Risk and Hazard Index		4.54E-08		1.78E-03

Table A-3
Calculation of Health Risks Associated with Inhalation of Outdoor Air
Davis Global Communications Site
Reasonable Maximum Exposure
Onsite Worker - Inhalation of VOC Emissions from Soil Gas

Carcinogenic Contaminant	Concentration in Air (mg/m³)	Estimated Increased Lifetime Cancer Risk	Percent of Total Pathway Risk	Hazard Quotient
Benzene	2.61E-07	1.82E-09	0.93	0.00E+00
1,1-Dichloroethane	2.90E-09	0.00E+00	<0.01	5.68E-09
1,1-Dichloroethene	7.40E-07	0.00E+00	<0.01	1.61E-04
cis-1,2-Dichloroethene	2.00E-08	0.00E+00	<0.01	3.91E-07
Dichlorodifluoromethane	1.70E-08	0.00E+00	<0.01	3.33E-08
m,p-Xylene (Sum of Isomers)	1.55E-06	0.00E+00	<0.01	1.51E-07
o-Xylene (1,2-Dimethylbenzene)	1.55E-06	0.00E+00	<0.01	1.52E-07
Tetrachloroethene (PCE)	5.33E-05	1.90E-07	97.40	1.04E-03
Toluene	2.25E-06	0.00E+00	<0.01	4.40E-06
Trichloroethene (TCE)	3.24E-06	2.26E-09	1.16	0.00E+00
1,1,1-Trichloroethane	5.72E-08	0.00E+00	<0.01	3.73E-08
1,1,2-Trichloro-1,2,2-Trifluoroethane	1.49E-07	0.00E+00	<0.01	3.77E-09
Vinyl Chloride	5.24E-08	9.89E-10	0.51	0.00E+00
Total Risk and Hazard Index		1.95E-07		1.21E-03

Table A-4 Calculation of Health Risks Associated with Ingestion of Soil Davis Global Communications Site Reasonable Maximum Exposure Onsite Worker (excavation) - Concentrations in subsurface soil				
Carcinogenic Contaminant	Concentration in Soil (mg/kg)	Estimated Increased Lifetime Cancer Risk	Percent of Total Pathway Risk	Hazard Quotient
Benzyl Butyl Phthalate	0.07	0.00E+00	<0.01	1.64E-07
DI-n-Butyl Phthalate	0.22	0.00E+00	<0.01	1.07E-06
Dibenzofuran	0.39	0.00E+00	<0.01	4.80E-05
Diethyl Phthalate	0.00	0.00E+00	<0.01	1.60E-10
bis(2-Ethylhexyl) Phthalate	0.70	1.71E-09	100.00	1.71E-05
Fluorene	1.51	0.00E+00	<0.01	1.84E-05
2-Methylnaphthalene	10.81	0.00E+00	<0.01	1.32E-04
Naphthalene	4.79	0.00E+00	<0.01	5.85E-05
Petroleum Hydrocarbons	1197.16	0.00E+00	<0.01	7.32E-02
Phenanthrene	3.82	0.00E+00	<0.01	0.00E+00
Pyrene	0.10	0.00E+00	<0.01	1.67E-06
Total Risk and Hazard Index		1.71E-09		7.35E-02

Table A-5 Summary of Estimated Cancer Risks Davis Global Communications Site Reasonable Maximum Exposure Onsite Worker (Building 4708) - Production Well Data and VOCs in Soil Gas					
Contaminant	Symbol	Cancer Risk by Exposure Pathway			
		Inhalation Soil Gas	Dermal Contact Groundwater	Inhalation Groundwater	Total
Benzene	BENZ	8.11E-08	0.00E+00	0.00E+00	8.11E-08
Bromodichloromethane	BDCM	0.00E+00	3.94E-08	0.00E+00	3.94E-08
Bromoform	CHBr3	0.00E+00	1.94E-08	4.80E-06	4.82E-06
Chlorodibromomethane	CDBM	0.00E+00	5.79E-08	0.00E+00	5.79E-08
Chloroform	CHCl3	0.00E+00	7.31E-09	3.34E-06	3.34E-06
Ethylene dibromide	EDB	0.00E+00	5.49E-07	1.51E-05	1.56E-05
Tetrachloroethene	PCE	1.97E-06	1.57E-07	4.28E-06	6.40E-06
Trichloroethene	TCE	0.00E+00	3.57E-08	1.94E-06	1.98E-06
Total		1.97E-06	8.66E-07	2.94E-05	3.23E-05

Table A-6 Calculation of Health Risks Associated with Inhalation of Indoor Air Davis Global Communications Site Reasonable Maximum Exposure Onsite Worker - Building 4708				
Carcinogenic Contaminant	Concentration in Air (mg/m³)	Estimated Increased Lifetime Cancer Risk	Percent of Total Pathway Risk	Hazard Quotient
Benzene	1.16E-05	8.11E-08	3.96	
1,1-Dichloroethene	4.22E-06			9.17E-04
m,p,-Xylene (Sum of Isomers)	2.10E-05			2.06E-06
Tetrachloroethene (PCE)	5.53E-04	1.97E-06	96.04	1.08E-02
Toluene	1.67E-05			3.27E-05
Total Risk and Hazard Index		2.05E-06		1.18E-02

Table A-7
Calculation of Carcinogenic Risk Associated with Inhalation of VOCs in Groundwater
Davis Global Communications Site
Reasonable Maximum Exposure
Current Land Use, Onsite Worker - Production Well Data

Carcinogenic Contaminant	Concentration in Water (ug/l)	Estimated Concentration in Air (ug/m³)	Estimated Increased Lifetime Cancer Risk	Percent of Total Pathway Risk	Hazard Quotient
Acetone	41	20.5	0.00E+00	<0.01	3.01E-02
Bromodichloromethane	2.6	1.3	0.00E+00	<0.01	9.54E-03
Bromoform	47	23.5	4.80E-06	16.33	1.72E-01
Chlorodibromomethane	8.8	4.4	0.00E+00	<0.01	3.23E-02
Chloroform	6.7	3.35	3.34E-06	11.34	4.92E-02
1,4-Dichlorobenzene	3.71	1.855	0.00E+00	<0.01	1.36E-03
1,1-Dichloroethene	3	1.5	0.00E+00	<0.01	2.45E-01
Ethylene dibromide	2.3	1.15	1.51E-05	51.21	0.00E+00
Methyl ethyl ketone	0.6	0.3	0.00E+00	<0.01	4.40E-04
Methyl isobutyl ketone	7.2	3.6	0.00E+00	<0.01	0.00E+00
Tetrachloroethene	3.2	1.6	4.28E-06	14.54	2.35E-02
Toluene	0.4	0.2	0.00E+00	<0.01	2.94E-04
Trichloroethene	7.4	3.7	1.94E-06	6.59	0.00E+00
Trichlorofluoromethane	0.6	0.3	0.00E+00	<0.01	2.20E-04
1,1,2-Trichloro-1,2,2-trifluoromethane	14.1	7.05	0.00E+00	<0.01	1.34E-04
Total Risk			2.94E-05		5.64E-01

Table A-8
Calculation of Health Risks Associated with Dermal Contact with Groundwater (Cal/EPA Methodology)
Davis Global Communications Site
Reasonable Maximum Exposure
Current Land Use, Onsite Worker - Production Well Data

Carcinogenic Contaminant	Concentration in Water (ug/l)	Estimated Increased Lifetime Cancer Risk	Percent of Total Pathway Risk	Hazard Quotient
Acetone	41	0.00E+00	<0.01	1.31E-05
Bromodichloromethane	2.6	3.94E-08	4.55	4.24E-05
Bromoform	47	1.94E-08	2.24	3.44E-04
Chlorodibromomethane	8.8	5.79E-08	6.69	9.65E-05
Chloroform	6.7	7.31E-09	0.84	3.35E-04
1,4-Dichlorobenzene	3.71	0.00E+00	<0.01	1.29E-04
1,1-Dichloroethene	3	0.00E+00	<0.01	3.00E-03
Ethylene dibromide	2.3	5.49E-07	63.39	0.00E+00
Methyl ethyl ketone	0.6	0.00E+00	<0.01	1.24E-07
Methyl isobutyl ketone	7.2	0.00E+00	<0.01	0.00E+00
Tetrachloroethene	3.2	1.57E-07	18.17	8.64E-04
Toluene	0.4	0.00E+00	<0.01	5.06E-06
Trichloroethene	7.4	3.57E-08	4.12	0.00E+00
Trichlorofluoromethane	0.6	0.00E+00	<0.01	1.91E-06
1,1,2-Trichloro-1,2,2-trifluoromethane	14.1	0.00E+00	<0.01	6.35E-07
Total Risk		8.66E-07		4.83E-03

Table A-9

Summary of Estimated Cancer Risks
McClellan Air Force Base
Davis Global Communications Center
Reasonable Maximum Exposure
Hypothetical Future Land Use

		Estimated Cancer Risk by Exposure Pathway							
Chemical	Symbol	Groundwater Ingestion	Groundwater - Inhalation	Groundwater - Dermal Contact	Outdoor Air Inhalation	Indoor Air Inhalation	Soil Ingestion	Dermal Contact with Soil	Chemical Specific Risk
Benzene	BENZ				3.06E-09	1.36E-07	1.52E-08	2.74E-08	1.39E-07
bis(2-ethylhexyl)phthalate	BEHP								4.27E-08
Tetrachloroethene	PCE	8.98E-05	3.37E-04	1.24E-05	3.19E-07	3.31E-06			4.43E-04
Trichloroethene	TCE	6.16E-05	1.54E-04	2.84E-06	3.80E-09				2.19E-04
Vinyl chloride	VC	1.30E-03	4.87E-03	2.73E-05	1.66E-09				6.20E-03
Total Cancer Risk		1.45E-03	5.37E-03	4.25E-05	3.28E-07	3.45E-06	1.52E-08	2.74E-08	6.86E-03

Table A-10
Calculation of Health Risks Associated with Ingestion of Groundwater
McClellan Air Force Base
Davis Global Communications Center
Reasonable Maximum Exposure
Residential Well, Hypothetical Future Land Use - MW-3, 9/28/92 data

Chemicals	Concentration in Water (ug/L)	Estimated Increased Lifetime Cancer Risk	Percent of Total Pathway Risk	Hazard Quotient
Tetrachloroethene	150	8.98E-05	6.19	4.11E-01
Trichloroethene	350	6.16E-05	4.25	0.00E+00
Vinyl chloride	410	1.30E-03	89.56	0.00E+00
Total Risk or Hazard Index		1.45E-03		4.11E-01

Table A-11
Calculation of Health Risks Associated with Inhalation of VOCs in Groundwater
McClellan Air Force Base
Davis Global Communications Center
Reasonable Maximum Exposure
Residential Well, Hypothetical Future Land Use - MW-3, 9/28/92 data

Chemicals	Concentration in Water (ug/L)	Estimated Concentration in Air (ug/m3)	Estimated Increased Lifetime Cancer Risk	Percent of Total Pathway Risk	Hazard Quotient
Chemicals	Concentration in Water (ug/L)	Estimated Concentration in Air (ug/m3)	Estimated Increased Lifetime Cancer Risk	Percent of Total Pathway Risk	Hazard Quotient
Tetrachloroethene	150	75	3.37E-04	6.28	1.54E+00
Trichloroethene	350	175	1.54E-04	2.87	0.00E+00
Vinyl chloride	410	205	4.87E-03	90.85	0.00E+00
Total Risk			5.37E-03		1.54E+00

Table A-12
Calculation of Health Risks Associated with Dermal Contact with Groundwater (Cal/EPA Methodology)
McClellan Air Force Base
Davis Global Communications Center
Reasonable Maximum Exposure
Residential Well, Hypothetical Future Land Use - Production Well Data

Chemicals	Concentration in Water (ug/L)	Estimated Increased Lifetime Cancer Risk	Percent of Total Pathway Risk	Hazard Quotient
Chemicals	Concentration in Water (ug/L)	Estimated Increased Lifetime Cancer Risk	Percent of Total Pathway Risk	Hazard Quotient
Tetrachloroethene	150	1.24E-05	29.16	5.67E-02
Trichloroethene	350	2.84E-06	6.67	0.00E+00
Vinyl chloride	410	2.73E-05	64.17	0.00E+00
Total Risk and Hazard Index		4.25E-05		5.67E-02

Table A-13
Calculation of Health Risks Associated with Ingestion of Soil
McClellan Air Force Base
Davis Global Communications Site
Reasonable Maximum Exposure
Hypothetical Future Resident

Chemicals	Concentration in Soil (mg/kg)	Estimated Increased Lifetime Cancer Risk	Percent of Total Pathway Risk	Hazard Quotient
2-Methylnaphthalene	10.81	0.00E+00	<0.01	9.85E-04
Benzyl butyl phthalate	0.07	0.00E+00	<0.01	1.22E-06
Di-n-butyl phthalate	0.22	0.00E+00	<0.01	7.96E-06
Dibenzofuran	0.39	0.00E+00	<0.01	3.58E-04
Diethylphthalate	0.00	0.00E+00	<0.01	1.19E-09
Fluorene	1.51	0.00E+00	<0.01	1.37E-04
Naphthalene	4.79	0.00E+00	<0.01	4.36E-04
Petroleum Hydrocarbons	1197.16	0.00E+00	<0.01	5.45E-01
Phenanthrene	3.82	0.00E+00	<0.01	0.00E+00
Pyrene	0.10	0.00E+00	<0.01	1.24E-05
bis(2-ethylhexyl)phthalate	0.70	1.52E-08	100.00	1.27E-04
Total Risk and Hazard Index		1.52E-08		5.47E-01

Table A-14
Calculation of Health Risks Associated with Inhalation of Outdoor Air
McClellan Air Force Base
Davis Global Communications Site
Reasonable Maximum Exposure
Hypothetical Future Resident - Inhalation of VOC Emissions from Soil Gas

Chemicals	Concentration in Air (mg/m3)	Estimated Increased Lifetime Cancer Risk	Percent of Total Pathway Risk	Hazard Quotient
1,1,1-Trichloroethane	5.72E-08	0.00E+00	<0.01	5.22E-08
1,1,2-Trichloro-1,2,2-Trifluoroethane	1.49E-07	0.00E+00	<0.01	5.28E-09
1,1-Dichloroethane	2.90E-09	0.00E+00	<0.01	7.95E-09
1,1-Dichloroethene	7.40E-07	0.00E+00	<0.01	2.25E-05
Benzene	2.61E-07	3.06E-09	0.93	0.00E+00
Dichlorodifluoromethane	1.70E-08	0.00E+00	<0.01	4.66E-08
m,p-xylenes (sum of isomers)	1.55E-06	0.00E+00	<0.01	2.12E-07
o-xylene (1,2-Dimethylbenzene)	1.55E-06	0.00E+00	<0.01	2.13E-07
Tetrachloroethene (PCE)	5.33E-05	3.19E-07	97.40	1.46E-03
Toluene	2.25E-06	0.00E+00	<0.01	6.15E-06
Trichloroethene (TCE)	3.24E-06	3.80E-09	1.16	0.00E+00
Vinyl chloride	5.24E-08	1.66E-09	0.51	0.00E+00
cis-1,2-Dichloroethene	2.00E-08	0.00E+00	<0.01	5.48E-07
Total Risk and Hazard Index		3.28E-07		1.49E-03

Table A-15
Calculation of Health Risks Associated with Inhalation of Indoor Air
McClellan Air Force Base
Davis Global Communications Site
Reasonable Maximum Exposure
Hypothetical Future Resident

Chemicals	Concentration in Air (mg/m3)	Estimated Increased Lifetime Cancer Risk	Percent of Total Pathway Risk	Hazard Quotient
1,1-Dichloroethene	4.22E-06			1.28E-04
Benzene	1.16E-05	1.36E-07	3.96	2.88E-06
m,p-xylene (sum of isomers)	2.10E-05			1.51E-02
Tetrachloroethene (PCE)	5.53E-04	3.31E-06	96.04	4.57E-05
Toluene	1.67E-05			
Total Risk and Hazard Index		3.45E-06		1.53E-02

Table A-16
Calculation of Health Risks Associated with Dermal Contact with Soil (Cal/EPA Methodology)
McClellan Air Force Base
Davis Global Communications Site
Reasonable Maximum Exposure
Hypothetical Future Resident

Chemicals	Concentration in Soil (mg/kg)	Estimated Increased Lifetime Cancer Risk	Percent of Total Pathway Risk	Hazard Quotient
2-Methylnaphthalene	1.00	0.00E+00	<0.01	1.09E-04
Benzyl butyl phthalate	0.07	0.00E+00	<0.01	1.46E-06
Di-n-butyl phthalate	0.22	0.00E+00	<0.01	9.55E-06
Dibenzofuran	0.39	0.00E+00	<0.01	4.29E-04
Diethylphthalate	0.00	0.00E+00	<0.01	1.43E-09
Fluorene	1.51	0.00E+00	<0.01	1.65E-04
Naphthalene	4.79	0.00E+00	<0.01	5.23E-04
Petroleum Hydrocarbons	1197.16	0.00E+00	<0.01	6.54E-01
Phenanthrene	3.82	0.00E+00	<0.01	0.00E+00
Pyrene	0.10	0.00E+00	<0.01	1.49E-05
bis(2-ethylhexyl)phthalate	0.70	2.74E-08	100.00	1.52E-04
Total Risk and Hazard Index		2.74E-08		6.55E-01

Appendix B
SITE BACKGROUND INFORMATION

PREPARED FOR: Davis Global Communications Site Risk Assessment

PREPARED BY: John Lowe/CH2M HILL

DATE: August 18, 1993

SUBJECT: Site Background Information

PROJECT: SAC28722.55.15

Introduction

This technical memorandum presents site background information for the Davis Global Communications Site. It includes a description of conditions at the site and surrounding the site, as well as information used to identify potential pathways of exposure from contaminant sources detected at the Davis Site.

Site Background

Site Description

The Davis Site is located approximately 20 miles southwest of McClellan Air Force Base (McClellan AFB). It lies in a predominantly agricultural area near the Yolo-Solano County border, approximately 5 miles south of Interstate Highway 80 and 2 miles south of Davis, California. Figure B-1 shows McClellan AFB and the Davis Site locations. The Davis Site is operated 24 hours a day by up to 12 personnel of the 2049th Communications Squadron, which operates out of McClellan AFB. Linked to McClellan AFB by Intersite Microwave Radio, the Davis Site has radio transmitters and antennae that provide long-range radio transmission capabilities.

The Davis Site is largely surrounded by farmland. However, immediately adjacent to the site on the west is Wilson Park, a 320-acre parcel that was formerly part of the Global Communications Site.

The Davis Site currently occupies approximately 316 acres. Operational facilities and controls are located within a fenced compound near the center of the site. Outside the fence are more than 2 dozen antennae and transmitters. An access road to the controlled-access compound area runs to County Road 36, which borders the southern edge of the site (CH2M HILL, 1992). Figure B-2 presents a 1987 aerial photograph showing the site, the main compound, and the surrounding features.

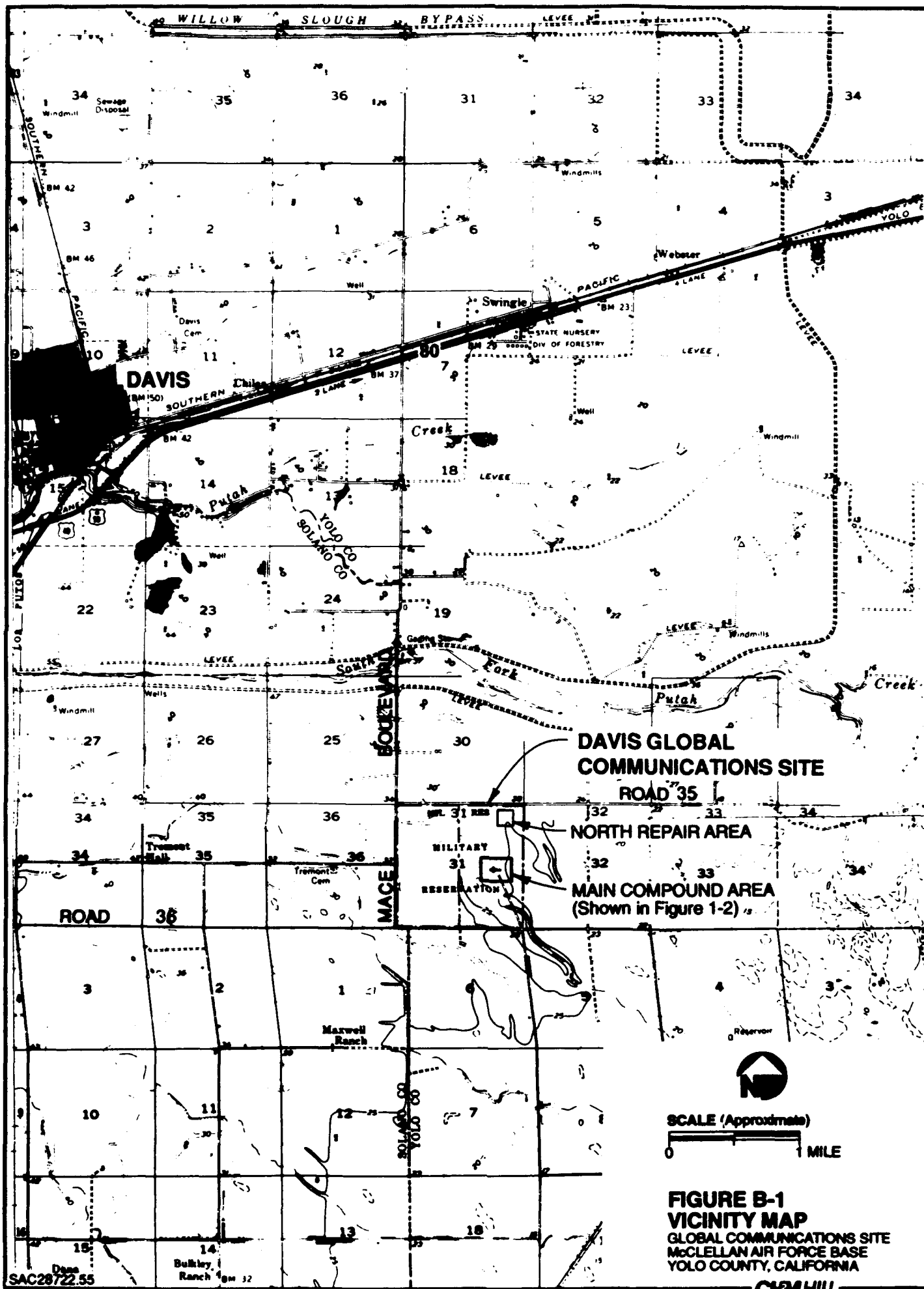


FIGURE B-1
VICINITY MAP
 GLOBAL COMMUNICATIONS SITE
 MCCLELLAN AIR FORCE BASE
 YOLO COUNTY, CALIFORNIA

CAM HILL

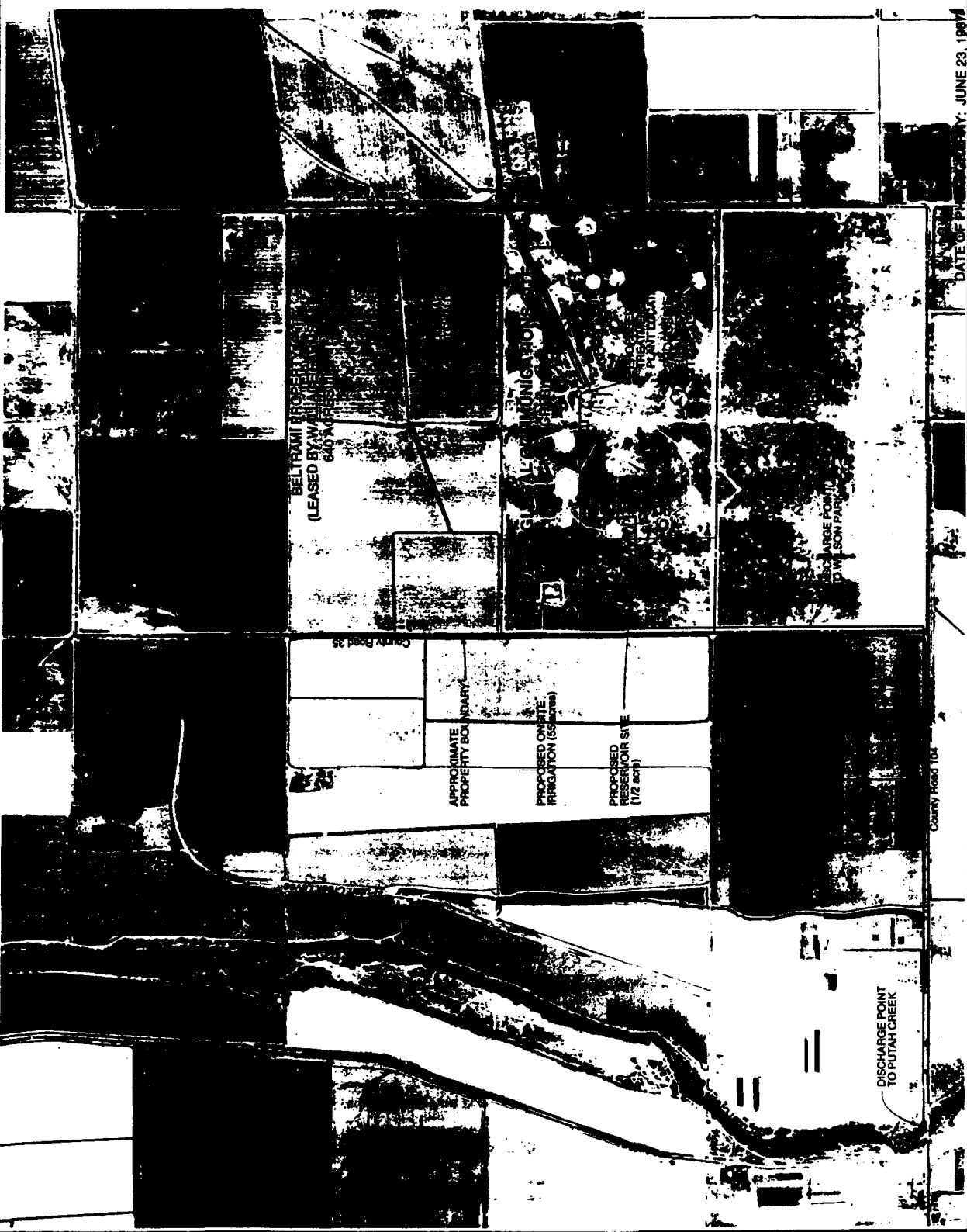


FIGURE B-2
DAVIS GLOBAL COMMUNICATIONS
SITE VICINITY
DAVIS GLOBAL COMMUNICATIONS SITE
DAVIS GLOBAL AIR FORCE BASE
YOLO COUNTY, CALIFORNIA

C&M/HIL

Climate

The Davis Site is located in Yolo County in the Sacramento Valley Air Basin (SVAB). The SVAB encompasses several counties extending north from Sacramento County to Shasta County and is bounded by the Sierra Nevada to the east and the Coastal Range to the west. Prevailing winds are usually oriented along the major axis of the Sacramento Valley, approximately following a southeast-northwest pattern. In the winter, northerly and southerly flow patterns are predominant during the day; calm conditions predominate during the late evening and early morning. During spring and summer, the predominant flow pattern is the Delta or sea breeze. Northerly winds and the sea breeze predominate in the fall. Full sea breeze conditions occur 29 percent of the year; northerly winds occur 20 percent of the year (California Air Resources Board [CARB], 1984). Wind speeds average near 10 miles per hour, or a little higher, from the southerly direction. Wind speeds from other directions are usually light. Only 10 percent of the time do winds exceed 16 miles per hour (Yolo County, 1983).

Climate in the SVAB is moderate, with mild winters and hot, dry summers. Monthly average temperatures range from 53°F to 54°F in January to 93°F to 98°F in July (University of California, Berkeley, undated). Mean annual precipitation from 1875 to 1975 in the SVAB was approximately 24 inches (Kahrl, 1978). Approximately 90 percent of the rainfall occurs between November and April, with little or no precipitation from late spring to early fall. Most of the rainfall is associated with Pacific storms, which are frequent in winter (National Oceanic and Atmospheric Administration [NOAA], 1989).

Soils

Most soils surrounding the Davis Site are considered prime agricultural farmland by the Soil Conservation Service. Soils underlying the Davis Site consist of Brentwood silty clay loam (0 to 2 percent slope), Marvin silty clay loam (no slope rating), Pescadero silty clay (no slope rating), and Capay silty clay (no slope rating).

Brentwood silty clay loam consists of well-drained clay formed from sedimentary rocks and found on alluvial fans, extending to depths in excess of 60 feet. Although the natural vegetation for this soil consists of annual grasses and forbs, very little land is left in its natural state because it is considered prime agricultural land.

Marvin silty clay soil is a poorly drained clay found on basin rims and also formed in alluvium from sedimentary rocks. This soil exceeds 60 feet in depth and supports annual grasses and forbs when uncultivated.

Pescadero silty clay is a poorly drained clay that is found in basins and formed in alluvium from sedimentary rock. Although this clay contains low amounts of sodium, it is usable for agriculture. Natural vegetation for Pescadero silty clay includes saltgrass, picklegrass, and other types of vegetation that can tolerate saline conditions.

A small amount of Capay silty clay is present in the southern section of the Davis site. This soil is found on basin rims and is moderately well drained. Natural vegetation includes annual grasses and forbs (CH2M HILL, 1993a).

Groundwater Resources

Site Hydrogeology

The stratigraphy underlying the site has been divided into five zones—A, B, C, D, and E. These zones are made up of coarse-grained and fine-grained materials. For convenience in discussion, the terms "B," "C," "D," and "E" zones have been retained and apply to the permeable units within each specific zone. The five zones extend to a depth of 245 feet below the site and apply only to the vicinity of the fenced compound. The zones are described in Table B-1. The zones include both permeable aquifer materials (sand and gravel) and low permeability aquitard materials (silt and clay). The low permeability zones, which generally exist across the site between aquifers, are termed aquitards and have been named the A-B, B-C, C-D, and D-E aquitards. The A zone (vadose zone) ranges from ground surface to 65 feet below ground surface (bgs) and contains the A-B aquitard; the B zone ranges from 65 to 95 feet bgs and contains the B water-bearing zone; the C zone ranges from 95 to 145 feet bgs and contains the B-C aquitard and the C water-bearing zone; the D zone ranges from 145 to 195 feet bgs and contains the C-D aquitard and the D aquifer; and the E zone ranges from 195 to 245 feet bgs and contains the D-E aquitard and the E aquifer.

Table B-1 Subsurface Definition		
Zone	Components of Zone	Depth Below Ground Surface (feet)
A	Vadose zone A-B aquitard	0 to 65
B	B aquifer	65 to 95
C	B-C aquitard C aquifer	95 to 145
D	C-D aquitard D aquifer	145 to 195
E	D-E aquitard E aquifer	195 to 245

Because of the effects of agricultural groundwater withdrawals near the site, groundwater flow directions and velocities appear to change significantly throughout the year. Winter conditions (minimal pumping) appear to be represented by high groundwater levels (30 to 40 feet bgs), and a relatively low horizontal gradient in the B aquifer of less than 0.0025 foot/foot. Flow directions vary from southwesterly to

northwesterly. Summer groundwater conditions (high volume agricultural pumping) are represented by groundwater flow to the south-southwest, significantly lower water levels (60 to 70 ft bgs), and steeper hydraulic gradient in the B aquifer up to 0.008 foot/foot. Water levels, flow directions, and gradients in the C aquifer are similar. Flow directions in the D aquifer ranged from northwest through west between December 1992 and March 1993 and southwest through east between April and July 1993.

Water Uses

Wells are the primary source of irrigation water for agriculture in Yolo County. Three water districts serve agriculture in Yolo County. Most cities and communities within the county have a public water supply. No domestic water is supplied from surface supplies (Yolo County, 1983). Several private water supply or irrigation wells appear near the site, as shown in Figure B-2.

The one production well onsite is screened in the C and D aquifers. Water pumped from the production well is used for turf irrigation at the site as well as for plumbing (toilets, faucets, and sinks). Drinking water at the Davis Site consists of bottled water; water from the onsite production well is not used for human consumption (CH2M HILL, 1992). Personnel at the site turned to bottled water in 1982 following decreased yield and silting problems with the production well. After the well had been retrofitted, personnel continued to use bottled water because of the preferred taste. Following detection of VOCs in water from the production well, the Air Force mandated the use of bottled water. Pumping rates from the production well for sanitary and turf irrigation purposes ranged from 200,000 to 600,000 gallons/month during 1988 and 1989, with higher extraction rates during the summer months (ITC, 1992).

Surface Water

Surface water at the site consists of ephemeral rainwater pools onsite and agricultural drainage ditches along the site boundary. There are no permanent ponds or creeks in the area nor any direct connections to Putah Creek, approximately 1.5 miles to the north. Surface-water rainwater pools are expected to be present during the winter months only (CH2M HILL, 1993a).

Vegetation and Wildlife

The Davis Site is an area of frequently disturbed annual grasses surrounded by actively cultivated fields. As described in detail in Appendix H, Site Ecological Characterization, except for structures, gravel drives, and other man-made site features, there is little or no variation in the uniform annual grassland habitat. Within or immediately adjacent to the site there are virtually no trees, shrubs, topographical relief, significant wetlands, or other feature that could produce edge conditions or represent uncommon habitat. Although Wilson Park, which borders the western edge of the site, may eventually be landscaped to include surface water and a variety of

vegetation, the ecological characteristics of the park are currently identical to conditions at the Davis Site.

Small mammals and insects, along with associated predator species, are the most obvious animal components of the site community. California ground squirrels, black-tailed hares, and mice are common. Raptors (i.e., hawks, owls, and harriers) were observed onsite and there was evidence of mammalian predators (coyote or fox). Except for owls, as noted below, the population density of predators is likely low due to relatively low prey abundance and frequent human disturbance. Similarly, the marginal habitat and extensive activity associated with the site and surrounding agricultural lands most likely precludes the occurrence of mammals and birds (such as deer or short-eared owl) intolerant of human disturbance.

There are, however, several ecological resources which should be noted in the planning and implementation of site cleanup. As described in Appendix H, there are several special status species (threatened, endangered, or special concern) whose range and general habitat requirements are met at the site. These species include the Swainson's hawk and the burrowing owl. The ranges of other special status species include the Davis Site, but as explained, because of noncontaminant-related site conditions, the site was judged not capable of supporting these species (Appendix H). Swainson's hawk has several known breeding locations within less than 10 miles of the Davis site (CNDDB, 1993) and thus it is likely this species forages over the area. However, because the area apparently has relatively low prey density and is subject to frequent human disturbance, the site is most likely not a primary feeding area for the Swainson's hawk.

In contrast to the special-status Swainson's hawk that only potentially and occasionally uses the site, the California Special Concern burrowing owl is common within the Davis Site. Over a dozen owls were observed on the site and since both juveniles and adults were seen, it is likely that they are successfully breeding in the area. The abundance of ground squirrel burrows (which the owls use for cover and breeding), lack of cultivation, and the birds' tolerance for human activity most likely account for their relatively common presence.

Two small areas (in combination less than 1 acre) east of the compound accumulate seasonal rainfall. These two areas do not exhibit the characteristics of vernal pools, retain water for significant periods, or support vegetation characteristic of wetlands. Consequently, they are not unique resources and most likely do not qualify as federally protected wetlands.

The closest feature that demonstrates significant ecological variability or uniqueness is Putah Creek and its associated riparian habitat. The creek is approximately a mile north of the site and supports extensive emergent vegetation, trees, and shrubs. The creek and corridor represent significant habitat and variability in an area of annual grassland and intense cultivation. The Putah Creek system is too distant from the Davis site to be affected by the site; however, the creek could be a factor in the site's ecology by supporting animals that occasionally use the site for migration or foraging.

Land Uses and Populations

Existing Land Uses

As described previously, the site is surrounded on three sides by agricultural land. Wilson Park is next to the western border of the site. The park is a 320-acre parcel that was formerly part of the Global Communications Site. McClellan AFB ceded the parcel to Yolo County in 1973 for development as a park. Currently, part of Wilson Park is leased to an archery club, a horse club, and a dog-training club. The remainder of the park is grassland (CH2M HILL, 1992). Yolo County has developed a master plan for the park, which is presented in Figure B-3. As shown on the plan, most of the park (170 acres) will remain in native grasslands and oak trees. One reason that the park has remained largely undeveloped is its lack of a water supply for irrigation (CH2M HILL, 1993b).

The only apparent residential area is the El Macero area, which is bounded by Mace Boulevard to the west and Interstate 80 to the north and is located approximately 4 miles to the northwest of the site. The Davis Migrant Center, a migrant farm-worker camp, is located immediately to the southeast of the site (approximately one-half mile from the main compound) at the intersection of Road 36 and Road 105, as shown in Figure B-2. The Migrant Center reportedly is hydrologically downgradient of the Davis Site (ITC, 1992). Aerial photography (Figure B-2) indicates that structures (possibly including residences) are located immediately to the southeast and south of Wilson Park, approximately 1,500 to 1,800 feet from the border of the site.

Future Land Uses

Yolo County's General Plan promotes the conservation and preservation of agricultural land. Residential land uses in agricultural areas are limited to dwellings for the preservation of the family farm or for farm employees only, with population densities and locations of dwellings limited by county ordinances. Yolo County may prohibit development of residential land uses in agriculturally designated parcels (Yolo County, 1983). Future land use plans for the site have not yet been specified; however, use of the site is expected to remain unchanged.

Works Cited

CARB. 1984. *California Surface Wind Climatology*. California Air Resources Board. Sacramento, CA.

CH2M HILL. 1992. Davis Global Communications Site Remedial Investigations Work Plan. Prepared for McClellan AFB. September.

CH2M HILL. 1993a. Davis Global Communications Site Remediation Environmental Assessment. Prepared for McClellan AFB. April.

CH2M HILL. 1993b. Davis Global Communications Site Intermediate Remedial Design Report. Prepared for McClellan AFB. March.

CNDDDB. 1993. Unpublished report generated by the California Natural Diversity Data Base. California Department of Fish and Game, Sacramento, CA.

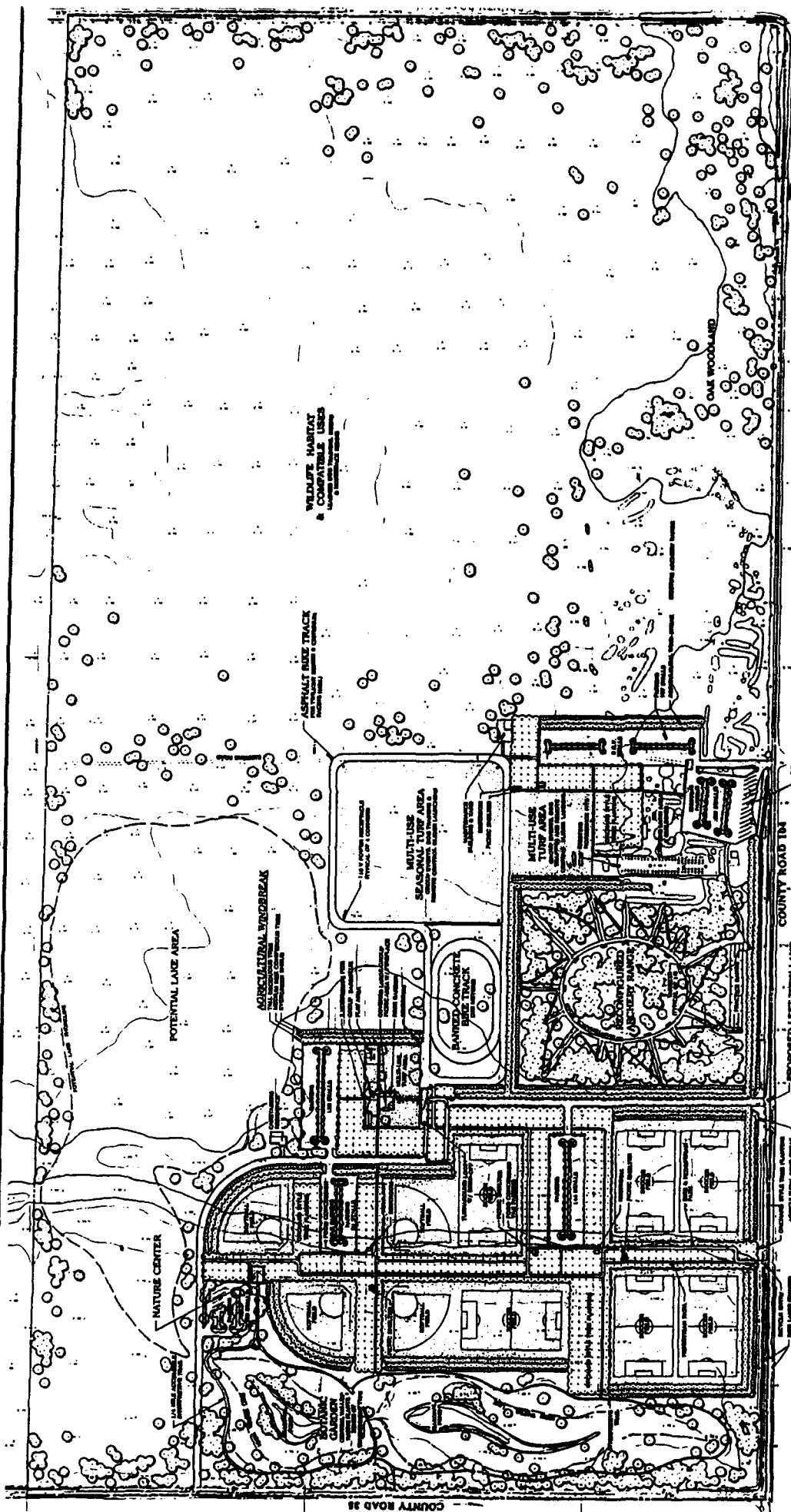
ITC. 1992. Preliminary Groundwater Remedial Investigation Report. Davis Global Communications Site, McClellan AFB. Volume I. April.

Kahrl, W. L. 1978. *The California Water Atlas*.

NOAA. 1989. *Climatological Data Summary for California*. Vol. 93, No. 13. National Oceanic and Atmospheric Administration.

University of California at Berkeley, Division of Agricultural Sciences. Undated. Average Daily Air Temperature and Precipitation in California.

Yolo County. 1983. Yolo County General Plan and Referenced Environmental Impact Report.



GRAPHIC SCALE: 0' 20' 40'

NOTE: MASTER PLAN WAS PREPARED
BY EARTH ART, SACRAMENTO,
CALIFORNIA, FOR YOLO COUNTY.



FIGURE B-3
WILSON PARK MASTER PLAN
DRAFT FINAL COMMUNICATIONS SITE
MACLELLAN LUNGE BASE
YOLO COUNTY, CALIFORNIA

C&M/HILL

SAC20722.05.12 DECEMBER, 1992

Appendix C
SITE CONCEPTUAL MODEL

PREPARED FOR: Davis Global Communications Site Risk Assessment

PREPARED BY: John Lowe/CH2M HILL

DATE: August 18, 1993

SUBJECT: Site Conceptual Model

PROJECT: SAC28722.55.15

Introduction

The conceptual model for the Davis Global Communications Site provides a current understanding of the contaminants detected at the site, their potential migration pathways, and the potential for exposure to human populations or ecological receptors. The conceptual model was initially developed in the Remedial Investigation (RI) Work Plan (CH2M HILL, 1992) to provide a framework for the site field investigation. Additional details have been added to the model throughout the course of the investigation. Appendix B, Site Background Information, and site characterization data collected during the RI have been synthesized in the conceptual model to evaluate contaminant sources, migration pathways, and potential receptors for contaminant exposure. The results from the conceptual model were used to develop exposure scenarios (a scenario is a collection of sources, pathways, and receptors) for which contaminant exposures were estimated. The estimation of contaminant exposures is presented in Appendix G, Exposure Assessment for Human Health Risk Assessment.

Description of Contaminant Sources

Contaminants detected at the site consist principally of diesel-range petroleum hydrocarbons and low-molecular weight polynuclear aromatic hydrocarbons (PNAs) in soil, aromatic and chlorinated volatile organic compounds (VOCs) in soil gas, and chlorinated VOCs in groundwater. Site investigation activities in soil and groundwater are summarized in Table C-1.

Contamination in Soil

Petroleum Hydrocarbons in Soil

Petroleum hydrocarbon contamination at the Davis site was discharged to soil from three 25,000-gallon leaking underground fuel storage tanks located in the southeast

Table C-1 Summary of Investigation Activities					Page 1 of 5
Investigation Activity	Designation	Total Depth (feet bgs)	Analyses Performed	Contractor (Date Sampled)	Reference
Soil Borings, CPT Soundings, Soil Sampling during Drilling of Monitoring Wells, and Sampling of Soil Piles					
B- Series Soil Borings	B-1 through B-10	38.5 to 56.5	EPA418.1 (TPH) SW8240 (VOCs)	Kleinfelder (10/85)	ITC
BB- Series Soil Borings	BB-11 through BB-17	71.5 to 84.5	SW8015 (TFH Diesel) SW8020 (BTEX)	ITC (8/87-9/87)	ITC
Soil Samples Collected from MW- Series Monitoring Wells	MW-1 through MW-8	80.5 to 84.0	EPA 602 (BTEX) SW8015 (TFH Diesel) SW8020 (BTEX)	ITC (9/87-10/87)	ITC
Tank Pull Grab Samples	EM3952 through EM3963	not measured	SW6010 (ICP Metals)) SW8010 (VOCs) SW8015 (TFH Diesel) SW8020 (BTEX) SW8270 (Semi VOCs)	McClellan (5/88)	ITC
1st Round CPT Soundings	CPT-1 through CPT-4 and PCPT-1 through PCPT-5	119 to 125	NA	ITC (55/89)	ITC
SBB- Series Soil Borings	SBB-18 through SBB-24	155.5	SW8015 (TFH Diesel) SW8240 (VOCs)	ITC (12/89)	ITC
Stratigraphic Soil Borings	THD-1 through THD-4	280	Geophysical Logging	ITC (4/89)	ITC
2nd Round CPT Soundings	PCPT-6, -7, and -10 through -17	48 to 168	NA	ITC (1/90)	

Table C-1
Summary of Investigation Activities

Page 2 of 5

Investigation Activity	Designation	Total Depth (feet bgs)	Analyses Performed	Contractor (Date Sampled)	Reference
Soil Borings, CPT Soundings, Soil Sampling during Drilling of Monitoring Wells, and Sampling of Soil Piles (Continued)					
Soil Samples Collected from SVMWs	CH-2 through CH-5	61.5 to 71.5	ASTM D 2216 (Moisture Content) ASTM D 2937 (Bulk Density) ASTM D (Specific Gravity) EPA 418.1 (TPH) SW6010 (ICP Metals) SW7421 (Lead) SW7471 (Mercury)	CH2M HILL (11/92)	CH2M
Grab Samples from Ex Situ Soil Piles	ESP-1 through ESP-9 and NSP-1A, NSP-1B, NSP-2A, NSP-2B, and NSP-3	0 to 1	EPA 418.1 (TPH) SW8015 (TFH Diesel)	CH2M HILL (11/92)	CH2M
Cone Penetrometer Soundings	CPT-18 through CPT-23	50 to 100	NA	CH2M HILL (11/92)	CH2M
Cone Penetrometer Soundings	CPT-24 through CPT-25	72 to 73	NA	CH2M HILL (4/93)	CH2M
Soil Samples from Extraction Well	EW-1C	141	EPA8020/8010 (VOCs/BTEX)	CH2M HILL (5/93)	CH2M
Test Hole for Reinjection Well	TH-1	270	Geophysical Logging	CH2M HILL (6/93)	CH2M
Groundwater Sampling from Monitoring Wells, Hydropunch, and the Site Production Well					
MW- Series Wells	MW-1 through MW-8	58 to 81	SW8015 (TFH Diesel)	ITC ((10/87, 1/88, 4/88,	IRPMS

Table C-1 Summary of Investigation Activities						Page 3 of 5
Investigation Activity	Designation	Total Depth (feet bgs)	Analyses Performed	Contractor (Date Sampled)	Reference	
1st Phase Hydropunch	PCPT(H)-2 through PCPT (H)-5	38 to 118	SW8010 (VOCs) SW8020 (BTEX)	ITC (5/89)	ITC	
2nd Phase Hydropunch	H-10 through H-17	72 to 110	SW8010 (VOCs) SW8020 (BTEX)	ITC (1/90)	ITC	
Cluster Wells (21 wells)	MWB-1, -4, -11, -13, -14	66 to 89	SW8010 (VOCs)	ITC (5/90 to 1/91)	ITC	
	MWC-1, -3, -4, -12, -13, -14	93 to 110	SW8015 (TFH Diesel)			
	MWD-1, -2, -3, -4, -10, -11, -12, -13, -14	127 to 181	SW8020 (BTEX)			
	MWE-3	204 to 224				
MW- Series	see above	see above	SW8010 (VOCs) SW8015 (TFH Diesel) SW8020 (BTEX)	ITC (2/91)	ITC	
Comprehensive Sampling	All wells listed above (with exceptings as advised by ITC)	see above	SW8010 (VOCs) SW8015 (TFH Diesel) SW8020 (BTEX)	Radian 1/91, 5/91, 7/92, 10/92, 2/93, 4/93, 7/93	Radian	

Table C-1
Summary of Investigation Activities

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Investigation Activity	Designation	Total Depth (feet bgs)	Analyses Performed	Contractor (Date Sampled)	Reference
Remedial Investigation Wells	PZ-21, PZ-22	82 to 101	SW8010 (VOCs)	CH2M HILL (4/93 to 5/93) (Sampled by Radian)	CH2M and Radian
	MW-19, EWB-1	50 to 100	SW8015 (TFH Diesel)		
	MWC-20, EWC-1, EWC-2, EWC-3	72 to 141	SW8020 (BTEx)		
	MWD-20, MWD-21, MWD-22	143 to 167			
	MWE-21, MWE-22	196 to 218			
Hydropunch	HP-2		SW8010 (VOCs)	CH2M HILL 6/93)	CH2M
Shallow Soil Gas Sampling, SVMWs, and Groundwater Wells Sampled for Soil Gas					
1st Phase Soil Gas Sampling	MC-1 through MC-67, PW-1, PW-2, PW-3 and NR-1 through NR-29 (94 samples)	10	Analyzed using PhotoVac tip or analyzed for TCE, PCE, VC, and benzene using a mobile lab and non-standard methods	ITC (4/89)	ITC
Shallow Soil Gas Sampling	SG-1 through SG-46 (67 samples)	5, 10, and 20	SW8021 (VOCs using Mobile GC) TO14 (VOCs using GCMS)	CH2M HILL (9/92)	CH2M
Risk Assessment Samples	RA-01 through RA-04	5 to 20	SW8021 (VOCs using Mobile GC) TO14 (VOCs using GCMS)	CH2M HILL (9/92)	CH2M

Table C-1
Summary of Investigation Activities

Page 5 of 5

Investigation Activity	Designation	Total Depth (feet bgs)	Analyses Performed	Contractor (Date Sampled)	Reference
Sampling SVMWs and Selected Groundwater Monitoring Wells and Piezometers	CH-1 through CH-6 MW-1, MW-3, MW-5, MW-7	14 to 38	TO14 (VOCs using GCMS) D3416 ATM Gases	CH2M HILL (12/92)	CH2M
	P-1S, P-2M, P-3S, P-4S, P-5S	14 to 20			

quadrant of the site, south of Building 4710. The tanks were used to store diesel fuel for the generator housed in Building 4710. In February 1985, approximately 52 cubic yards of soil above the tanks was removed and found to be saturated with petroleum product. The pipelines from the tanks were found to be leaking and the tanks showed deformation. In May 1985, a replacement 20,000-gallon aboveground tank was installed north of Building 4710, and the underground tanks were emptied. In December 1985, investigations revealed that soils adjacent to the underground tanks were contaminated with petroleum hydrocarbons. In May 1988, the underground tanks were removed and the excavation was backfilled with clean soil. Subsequent investigations have been performed by IT Corporation and CH2M HILL to determine the extent of the petroleum hydrocarbon contamination.

Petroleum hydrocarbon contamination was detected in soil samples from 30 to 65 feet below ground surface (bgs) during drilling of Soil Vapor Monitoring Well CH-5 in November 1992. The soil contamination is found mainly at the interface of a silty sand layer and a clay layer at a depth of 30 to 40 feet bgs, which represents approximate mean annual high groundwater depth. Since the petroleum hydrocarbons float on the groundwater surface, this depth may represent a layer of deposition for the hydrocarbons in soil related to groundwater levels and changes in lithology from a coarse-grained to a fine-grained matrix. A second slug of contamination is found around 60 feet bgs in lean clay. This appears to correspond to the depth of low annual groundwater (CH2M HILL, 1993a).

Table C-2 is a summary of the contaminants detected in Davis Site soil related to the petroleum hydrocarbon contamination.

A treatability study is being conducted by Engineering Science, Inc. (ESI), to assess the potential long-term effectiveness of bioventing for removal of petroleum hydrocarbon contaminants in subsurface soil (CH2M HILL, 1993a). Though the potential for contact with contaminants in subsurface soil is small, the human health risk assessment addresses potential exposures and health risks to workers who may excavate in the area of the former underground storage tanks.

Two existing soil piles identified at the site are believed to have been generated during removal of the underground tanks. However, the actual source of the soil is unknown. Additional material such as construction debris has been added to the piles from other sources (CH2M HILL, 1992). The soil piles potentially serve as shelter and nesting sites for burrowing owls, designated as a Species of Special Concern by the California Department of Fish and Game (CDFG) (CH2M HILL, 1993b). Therefore, petroleum hydrocarbon contamination detected in the soil piles was evaluated in the ecological risk assessment for the Davis Site. Samples from a depth of 1 to 2 feet in the piles were collected and analyzed for total petroleum hydrocarbons (TPH) using EPA Modified Method 8015 and Method 418.1. A summary of the results from these samples appears in Table C-3.

Table C-2 Summary of Contaminants Related to Subsurface Petroleum Hydrocarbons in Soil Davis Global Communications Site								
Contaminant	Number of Detects	Total Number of Samples	Frequency of Detects	Summary of Concentrations Detected (mg/kg)				Coefficient of Variation
				Minimum	Maximum	Mean	Standard Deviation	
Acenaphthene	1	31	0.03	0.11	0.11	0.00	0.02	5.57
Anthracene	1	31	0.03	0.17	0.17	0.01	0.03	5.57
Benzyl butyl phthalate	5	31	0.16	0.07	2.40	0.15	0.50	3.34
bis(2-Ethylhexyl) phthalate	22	31	0.71	0.07	2.40	0.55	0.66	1.21
di-N-Butyl phthalate	10	31	0.32	2.40	7.00	1.66	2.54	1.53
Dibenzofuran	6	31	0.19	0.06	2.20	0.22	0.58	2.66
Diesel hydrocarbons	37	104	0.36	44	9,120	470	1,304	2.77
Diethyl phthalate	2	31	0.06	0.05	0.05	0.003	0.01	3.87
Fluorene	18	31	0.58	0.13	6.90	1.16	1.85	1.60
2-Methylnaphthalene	14	31	0.45	0.32	47	7.49	13	1.79
Naphthalene	10	31	0.32	0.16	21	3.08	6.14	1.99
Petroleum hydrocarbons	20	44	0.45	5.00	17,236	767	2,963	3.87
Phenanthrene	19	30	0.63	0.09	15	2.92	4.62	1.58
Pyrene	5	31	0.16	0.19	0.70	0.06	0.15	2.69

Table C-3 Summary of Petroleum Hydrocarbons in Soil Piles Davis Global Communications Site					
Contaminant	Number of Detects	Total Number of Samples	Frequency of Detects	Summary of Concentrations Detected (mg/kg)	
				Minimum	Maximum
Total Petroleum Hydrocarbons (Method 418.1)	16	16	1	4.4	640
Diesel Hydrocarbons (Modified Method 8015)	7	14	0.5	18	180

Metals in Soil

Concentrations of metals detected in soil were evaluated by comparison with background levels published in the literature. Data sources for defining background levels were Shacklette and Boergnen, 1984, which provided ranges and summary statistics of elemental concentrations in surface soils in the western U.S.; Severson et al., 1986, which provided ranges of elemental concentrations in soils in the San Joaquin Valley of California; and Severson et al., 1987, which defined a "geochemical baseline," or the expected 95-percent range of elemental concentrations developed from the data presented in Shacklette and Boergnen, 1984. Summary statistics of the metals concentrations detected in soil at the Davis Site and elemental background data are presented in Tables C-4 and C-5. Background data were not available from these sources for antimony, cadmium, hexavalent chromium, thallium, and silver. Other literature sources, discussed further below, were used to evaluate concentrations of these metals detected in soil at the Davis Site.

Concentrations of cobalt, iron, mercury, and nickel detected in soil at the Davis Site slightly exceeded the geochemical baseline level, but fell within the observed range of concentrations reported for the western U.S. by Shacklette and Boergnen, 1984. Concentrations of all other elements detected in soil at the Davis Site fell within the geochemical baseline.

The range of detected concentrations of antimony in soil at the Davis Site (2.9 to 5.9 mg/kg) slightly exceeds the range of observed concentrations reported for soils in the western U.S. by Shacklette and Boergnen, 1984 (<1 to 2.6 mg/kg). The mean concentration in soil was calculated by assuming that samples reported as not-detected have concentrations present at one-half the detection limit. The mean concentration is 1.42 mg/kg, and falls within the observed range for soils in the western U.S. Elevated concentrations of antimony in soil may be associated with mining or smelting of nonferrous ores (such as copper) or sewage sludge applications to farmland (Kabata-Pendias and Pendias, 1992).

TABLE C-4 SUMMARY STATISTICS TABLE METALS-SOIL 1992 REMEDIAL INVESTIGATION										
Element	Concentrations Detected in Soil (units of mg/kg)									
	Range of Detection Limits		Number of Detects	Number of Samples	Frequency of Detection	Range of Concentrations Detected		Mean	Standard Deviation	Coefficient of Variation
ALUMINIUM	Minimum 6.99	Maximum 31	350	350	1	Minimum 12700	Maximum 32900	18914.29	5017.570	0.265
ANTIMONY	0.06	3.14	125	350	0.36	2.9	5.9	1.42	2.016	1.418
ARSENIC	0.7	4.57	24	24	1	4	9.6	6.66	1.748	0.262
BARIUM	0.02	0.7	350	350	1	104	343	219.02	61.767	0.282
BERYLLIUM	0.11	0.5	350	350	1	0.18	0.8	0.47	0.189	0.404
CADMIUM	0.27	1.2	350	350	1	4	7	5.12	0.813	0.159
CHROMIUM, HEXAVALENT	3.7	3.7	100	100	1	89.8	107	95.58	6.828	0.071
CHROMIUM, TOTAL	0.83	0.96	250	250	1	69.3	179	112.18	27.926	0.249
COBALT	1.31	5.8	350	350	1	21.9	27.4	24.92	1.887	0.076
COPPER	0.21	0.9	350	350	1	40	82.3	56.75	11.308	0.199
IRON	0.52	2.3	350	350	1	24200	50500	34950.00	5995.910	0.172
LEAD	0.09	0.4	28	28	1	4.8	8.5	6.80	1.065	0.157
MANGANESE	0.18	0.8	350	350	1	450	1030	698.29	146.919	0.210
MERCURY	0.02	0.1	13	14	0.93	0.05	0.53	0.16	0.132	0.862
NICKEL	1.74	7.7	350	350	1	167	348	231.14	47.810	0.207
SELENIUM	0.12	4.49	1	254	0.004	0.29	0.29	0.00	0.018	15.937
SILVER	0.45	0.54	125	350	0.36	0.57	0.81	0.25	0.339	1.359
THALLIUM	0.16	3.32	227	254	0.89	0.17	19	8.43	5.313	0.630
VANADIUM	0.43	1.9	350	350	1	43.4	100	67.69	13.556	0.200
ZINC	0.5	2.2	350	350	1	70.5	150	95.19	20.083	0.211
Notes: Source: Remedial Investigation/Feasibility Study for the Davis Global Communications Site (CH2M HILL, 1993)										

TABLE C-6 SUMMARY OF BACKGROUND CONCENTRATIONS OF METALS IN SOIL												
Soils Background Concentrations (units of mg/kg)												
Element	Shacklette and Boergnen, 1984 (Western U.S.)				Severson et al., 1986 (San Joaquin Valley)				Geochemical Baseline for Western U.S. (Severson et al., 1987)			
	Geometric Mean	Geometric Standard Deviation	Observed Range		Estimated Arithmetic Mean	Observed Range		Percentiles		Lower Bound	Upper Bound	
			Minimum	Maximum		Minimum	Maximum	2.5	97.5			
ALUMINUM	58000.00	2000.00	5000	>100,000	74000	32000	170000	56000	87000	NR	NR	
ANTIMONY	0.47	2.15	<1	2.6	0.62	NR	NR	NR	NR	NR	NR	
ARSENIC	5.50	1.98	<0.1	97	7	3.4	21	5.7	12	1.2	22	
BARIUM	580.00	1.72	70	5000	670	54	2300	120	1300	200	1700	
BERYLLIUM	0.68	2.30	<1	15	0.97	<1.0	3	0.7	1	NR	NR	
CADMIUM	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	
CHROMIUM, HEXAVALENT	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	
CHROMIUM, TOTAL	41.00	2.19	3	2000	56	11	410	57	320	8.5	200	
COBALT	7.1	1.97	<3	50	9	5	34	9	25	NR	NR	
COPPER	21.00	2.07	2	300	27	2	86	15	51	4.9	90	
IRON	21000.00	19500.00	1000	>100,000	26000	15000	85000	21000	49000	NR	NR	
LEAD	17.00	1.80	<10	700	20	7	96	10	43	5.2	55	
MANGANESE	380.00	1.98	30	5000	480	250	1400	330	710	97	1500	
MERCURY	0.046	2.33	<0.01	4.6	0.065	<0.2	2.5	0.014	0.37	0.0085	0.25	
NICKEL	15.00	2.10	<5	700	19	6.8	380	33	300	3.4	66	
SELENIUM	0.23	2.43	<0.1	4.3	0.34	<0.01	4.5	0.1	2.2	0.039	1.4	
SILVER	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	
THALLIUM	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	
VANADIUM	70.00	1.95	7	500	88	30	260	55	150	18	270	
ZINC	55.00	1.79	10	2100	65	27	230	47	120	17	180	
Notes:												
NR - Not Reported												

Concentrations of cadmium in soil worldwide appear to range from 0.06 to 1.1 mg/kg. A calculated worldwide mean in soil is reported to be 0.53 mg/kg, and apparently all higher values reflect anthropogenic impact on the cadmium status in topsoils (Kabata-Pendias and Pendias, 1992). The range of cadmium concentrations detected in soil at the Davis Site (4 to 7 mg/kg) appears to be consistent with concentrations associated with farmland amended with sewage sludge or fertilizer or under irrigation (reported to be 1 to 10 mg/kg) (Kabata-Pendias and Pendias, 1992; Chang et al., 1984; Shacklette et al, 1973; Williams et al., 1987).

Data characterizing background concentrations of hexavalent chromium in soil are limited. Generally, most chromium in soil occurs as trivalent chromium. Hexavalent chromium typically is unstable in soil and readily mobilized in both acid and alkaline soils (Bartlett and James, 1979; Bartlett and Kimble, 1976a and 1976b; Kabata-Pendias and Pendias, 1992). The range of concentrations detected and frequency of detection of hexavalent chromium and total chromium in soil are similar at the Davis Site. The available information on the behavior of chromium in soil suggests that this distribution in soil is unlikely. Hexavalent chromium is likely to be only a small fraction of total chromium in soil. Therefore, these results probably reflect artifacts in laboratory analyses rather than the actual distribution of chromium in soil at the Davis Site.

Background concentrations of thallium in U.S. soils are reported to range typically from 0.02 to 2.8 mg/kg. Soils with concentrations exceeding concentrations of 5 mg/kg are considered to be enriched in thallium. Anthropogenic impacts to thallium levels in soil include potash fertilizer works, nonferrous smelters, and bituminous coal production (Smith and Carson, 1977; Kabata-Pendias and Pendias, 1992). The mean concentration of thallium detected in soil at the Davis Site (8.43 mg/kg) would suggest that soils are enriched in thallium. However, elevated concentrations of thallium reported in soils collected for the McClellan IRP have in the past been concluded to be laboratory artifacts (ATSDR, 1993).

Background concentrations of silver in soils are reported to typically be less than one mg/kg. Soils rich in organic matter may have concentrations up to 5 mg/kg (Smith and Carson, 1977; Kabata-Pendias and Pendias, 1992). Comparison of these data with the concentrations detected in soil at the Davis Site indicates that silver concentrations at the site resemble background levels.

Soil Gas Contamination

Soil gas surveys performed in April 1989 by International Technology Corporation (ITC) revealed that plumes of trichloroethene (TCE) and tetrachloroethene (PCE) were present in subsurface soil in the northeast corner of the main compound, south-east of Building 4710 and around the site production well. In 1992, CH2M HILL collected shallow soil gas samples from 67 locations and depths over an area of approximately 4 acres. The samples were collected inside the main compound area and outside of the perimeter fence surrounding the facility at depths ranging from 5 to 40 feet bgs in areas where soil gas contaminants had been detected in previous

investigations and near former underground diesel storage tanks. To evaluate potential exposures to onsite workers, four samples from a depth of 5 feet were collected around Building 4708. All soil gas samples were analyzed in the field using EPA Method 8021. Approximately 15 percent of the field samples were analyzed in a fixed laboratory using Method TO-14. Samples were also collected from five soil vapor monitoring wells (SVMWs) installed to a depth of 70 feet at locations where elevated concentrations of VOCs were detected in soil gas.

The field and fixed laboratory analyses from both the shallow soil gas samples and SVMWs were used in the RA to evaluate potential inhalation exposures. A summary of the principal VOC contamination detected in soil gas is presented in Table C-6. The VOC contamination detected in shallow soil gas around Building 4708 is summarized in Table C-7.

Soil gas sampling data were used to develop mass estimates used in the evaluation of remedial action alternatives for vadose zone contamination. Vadose zone contaminant mass exists in three forms: sorbed onto the soil matrix, dissolved in pore water, and at present in soil gas. Soil gas results were input into equilibrium equations (Jury et al., 1983) to estimate the total contaminant mass. All three phases were considered when calculations were performed to estimate the total mass of contamination present. A complete discussion of the approach used for the vadose zone contaminant mass estimation is given in Appendix F of the RI/FS report. The total estimated mass of contamination present in the vadose zone is 45 kilograms, with PCE accounting for over 90 percent. Approximately 45 percent of the contaminant mass estimated for the vadose zone is found between 26 and 40 feet bgs. Because of this distribution of mass, the initial contaminant loading to the groundwater is the highest. Vadose zone transport modeling (described below) was used to predict VOC loading to the groundwater.

Groundwater Contamination

Dissolved contaminant mass in groundwater in the B aquifer appears to have decreased from 60 to 30 kg over a period from 1988 to 1993. This change can be partially accounted for by downward migration of contaminants. The total estimated mass of contamination in the saturated zone is 200 kg. Almost 95 percent of the total mass is present above the C/D aquitard beneath the site. Three of the B aquifer wells have exhibited major changes in contaminant concentrations over time. VOC concentrations in MW-1 have decreased tenfold over the past 5 years. Concentrations in MW-5 have decreased threefold in that time, and concentrations in MW-3 have shown a fourfold increase. Concentrations in wells in the C and D aquifers have increased over time, which is consistent with the general decrease in VOC mass in the B aquifer. Contamination in the lower aquifers appears to be migrating generally to the south (CH2M HILL, 1993a).

The principal VOC contaminants detected in onsite groundwater monitoring wells are summarized in Table C-8.

Table C-6
Principal Contaminants Detected in Soil Gas
Davis Global Communications Site

Contaminant	Number of Detects	Number of Samples	Frequency of Detects	Range of Concentrations (µg/l)	
				Minimum	Maximum
Benzene	33	92	0.36	0.00713	1.116
1,1-Dichloroethene	25	92	0.27	0.03	10.14
cis-1,2-Dichloroethene	8	25	0.32	0.01794	1.248
Ethylbenzene	21	92	0.23	0.00882	5.8
m-, p-Xylenes (sum of isomers)	37	92	0.40	0.004	16.3
o-Xylene (1,2-Dimethylbenzene)	22	92	0.24	0.01302	17.5
Tetrachloroethene (PCE)	68	92	0.74	0.02	541.2
Toluene	51	92	0.55	0.0074	25.9
1,1,1-Trichloroethane	10	25	0.40	0.01113	1.855
Trichloroethene (TCE)	42	92	0.46	0.01	50.35
1,1,2-Trichloro-1,2,2-Trifluoroethane	10	25	0.40	0.012	107.305
Vinyl chloride	1	92	0.01	0.0032	0.0032

Table C-7
Soil Gas Analytical Results Near Building 4708
Davis Global Communications Site

Sample	Contaminant (in µg/l)								
	Vinyl Chloride	1,1-DCE	TCE	PCE	Benzene	Toluene	Ethylbenzene	m- and p-Xylenes	o-Xylene
RA01-05	<0.01	<0.01	<0.01	2.8	0.05	0.08	<0.01	0.11	<0.01
RA02-05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
RA03-05A	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
RA03-05B	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
RA04-05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
RA05-05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Note: 1,1-DCE = 1,1-dichloroethene; TCE= trichloroethene; PCE = tetrachloroethene									

Table C-8 Contaminants Principally Detected in Groundwater Monitoring Wells					
Contaminant	Number of Detects	Number of Samples	Frequency of Detects	Range of Detected Concentrations (µg/l)	
				Minimum	Maximum
Benzene	24	310	0.08	0	11
Chloroethane	8	344	0.02	0	22
Chloroform	41	342	0.12	0	38
1,1-Dichloroethane	40	340	0.12	0	38
1,1-Dichloroethene	113	330	0.34	0	390
cis-1,2-Dichloroethene	55	167	0.33	0.41	410
trans-1,2-Dichloroethene	35	120	0.29	0	3,400
Diesel hydrocarbons	24	50	0.48	60	1,100
m- and p-Xylenes (sum of isomers)	9	98	0.09	0	3
Methylene chloride	27	337	0.08	0	320
Tetrachloroethene	151	312	0.48	0.12	1,400
Toluene	19	309	0.06	0	23
1,1,1-Trichloroethane	26	344	0.08	0	20.15
Trichloroethene	214	295	0.73	0.27	3,000
Vinyl chloride	30	340	0.09	0	410

The site production well, located northwest of Building 4708, is screened in both the C and D aquifers and has been sampled by McClellan AFB since 1986. Concentrations of PCE and TCE have been detected in this well, with levels remaining fairly constant throughout 1986 and 1987. Beginning in the fall of 1987, seasonal variations were observed, with concentrations rising in fall and winter months and falling during spring and summer. This variation appears to be related to the pumping of offsite irrigation wells. During fall and winter, when pumping for irrigation is low, the concentration gradient appears directed toward the production well. In spring and summer, when pumping for irrigation is at a maximum, contaminant concentrations appear to be drawn away from the production well (ITC, 1992). Other notable contaminants detected in the production well include trihalomethanes (chloroform, bromoform, chlorodibromomethane and bromodichloromethane) and, beginning in 1991, ethylene dibromide (EDB). Water drawn from the production well is chlorinated (Olgerson, 1993), and samples typically are drawn prior to the point of chlorination (Mulligan, 1993). Trihalomethanes are formed from the reaction of chlorine with dissolved organic matter in water, suggesting that some samples were drawn from already chlorinated water. EDB in groundwater is most likely due to its use as an agricultural fumigant and is unrelated to activities at the Davis Site.

Migration Pathways

Vadose Zone (Contaminants in Soil and Soil Gas)

Petroleum hydrocarbon constituents (total petroleum hydrocarbons and PNAs) do not appear to have migrated appreciably from the former locations of the underground storage tanks. Based on their physical and contaminant properties (high k_{oc} values and low solubilities), these constituents would not be likely to migrate appreciably in soil. As discussed previously, the distribution of petroleum hydrocarbons in soil appears related to changes in groundwater levels under the site. Petroleum hydrocarbons will undergo biodegradation under aerobic conditions; as discussed previously, bioventing is being evaluated at the Davis Site as a remedial action option for petroleum hydrocarbon contamination in soil.

VOCs in the vadose zone can migrate by leaching, or by volatilization followed by gaseous diffusion, or they can undergo degradation. Leaching refers to the downward movement of a dissolved contaminant, and takes place principally by mass flow of water through soil. Gaseous diffusion is the movement of contaminant in the gas phase through void in soil, driven by a concentration gradient. This can be a dominant transport mechanism in areas of low surface recharge and extensive vadose zones. It likely plays a less active role than leaching in subsurface contaminant transport at the Davis Site. VOCs that diffuse to the soil surface can be lost to the atmosphere as contaminant vapor. Degradation refers to the biological or contaminant transformation of a contaminant (Jury and Valentine, 1986). The potential for contaminants to migrate to points of exposure depends upon the magnitude and distribution of contaminant concentrations in soil, climatic conditions, physical and

contaminant properties of the contaminants, soil and aquifers present at the site, and locations of receptors relative to sources of contamination.

Vadose zone transport modeling using the VLEACH model predicted initial PCE loading to the groundwater of 270 grams/year (g/yr). This loading exponentially decays over time to approximately 20 g/yr after 200 years. Modeling input parameters and assumptions are discussed further in the RI/FS report. The impact to groundwater of this loading was calculated by estimating the groundwater underflow beneath the site and then performing mixing cell calculations to determine the concentration of PCE in the groundwater over time. The initial PCE concentration in groundwater was set equal to zero. The incremental impacts to the groundwater from the PCE residing in the vadose zone ranged from a maximum of 240 $\mu\text{g/l}$ after 200 years to a minimum of 150 $\mu\text{g/l}$ after 200 years. These values are well above the groundwater MCL for PCE of 5 $\mu\text{g/l}$. Therefore, the mass of PCE contamination that now resides in the vadose zone is potentially a significant long-term threat to the groundwater quality beneath the Davis Site (CH2M HILL, 1993a).

Volatilization of VOCs from the soil surface to the air represents a potential source of inhalation exposures. In general, contaminants with high Henry's Law constants¹ are more volatile, diffuse more readily through soil, and tend to move relatively independently of atmospheric conditions. Factors that limit volatilization include increased soil moisture content and increased adsorption to soil particles. Exposure concentrations in air resulting from steady-state volatilization from soil were estimated using simplified models, as discussed in Appendix F, Air Pathway Analysis.

Saturated Zone (Groundwater)

As discussed previously, contamination in the lower aquifers appears to be migrating generally to the south. Groundwater flow velocities and directions vary with changes in regional pumping practices. Highest groundwater flow velocities in the B, C, and D aquifers have been observed in the summer months, when highest pumping for agricultural use occurs. Groundwater flow velocities of 5 feet per day to the south have been reported (ITC, 1992). The receptor wells closest to the site are located at the Davis Migrant Center, one-half mile (approximately 2,600 feet) from the main compound.

Chlorinated VOCs are degraded in soil and groundwater by nonbiological fate processes and biodegradation. These processes are slow, with half-lives for several chlorinated VOCs ranging from 0.5 to 2.5 years. Mechanisms of transformation include hydrolysis, dehydrohalogenation (in the absence of electron donors), and reductive dehalogenation. Under methanogenic conditions (i.e., reducing and anaerobic), PCE is transformed sequentially to TCE, 1,1-dichloroethene, cis- or trans-1,2-dichloroethene, vinyl chloride, then ethene (Howard, 1990; Vogel, Criddle, and

¹Henry's law constant, the ratio of vapor concentration to the aqueous concentration, is an index of the partitioning of a chemical between dissolved and gaseous phases. The larger the value of Henry's constant, the more likely the contaminant is to move by vapor diffusion as opposed to liquid diffusion.

McCarty, 1987). All of the chlorinated VOC transformation products have been detected in groundwater at the Davis Site. PCE and TCE account for more than 80 percent of the total mass present in the saturated zone beneath the site. Though PCE represents 90 percent of the contaminant mass in the vadose zone, TCE is the most prevalent contaminant in groundwater. This finding is probably due to the higher soil organic carbon constant (k_{oc}) and lower solubility of PCE and the biodegradation of PCE to TCE, which is more mobile in soil.

Receptors

Potential receptors of exposure to contaminants detected at the site are onsite workers and visitors to the site, offsite residents, and individuals visiting Wilson Park.

Onsite Receptors

Onsite workers could potentially be exposed to VOCs emitted from the soil surface and VOCs volatilized from water drawn from the production well. While the production well does not supply drinking water to the site, water is used for sanitary and irrigation purposes. Showers are present at the site (Olgerson, 1993). Petroleum hydrocarbon constituents in soil are present at depth, posing little potential for exposure unless the soil is excavated.

Offsite Receptors

Offsite individuals using groundwater supply wells could potentially become exposed to contaminants migrating in groundwater, or could become exposed to concentrations of VOCs emitted into air from soil gas or production well water. The potential for offsite exposure is likely to be small; the closest residence to the main compound area, where most of the site contamination is located, is the Davis Migrant Center, approximately one-half mile away.

Works Cited

ATSDR. 1993. Public Health Assessment for McClellan Air Force Base, Sacramento, CA. Agency for Toxic Substances and Disease Registry, Center for Disease Control, U.S. Public Health Service. Atlanta, GA

Bartlett, R. J., and B. James. 1979. "Behavior of chromium in soils. III. Oxidation." *J. Environ. Qual.* 8: 31.

Bartlett, R. J., and J. M. Kimble. 1976a. "Behavior of chromium in soils. I. Trivalent forms." *J. Environ. Qual.* 5: 379-382.

- Bartlett, R. J., and J. M. Kimble. 1976b. "Behavior of chromium in soils. II. Hexavalent forms." *J. Environ. Qual.* 5: 383.
- CH2M HILL. 1992. Draft Final Work Plan, Davis Global Communications Site. McClellan Air Force Base. July.
- CH2M HILL. 1993a. Remedial Investigation/Feasibility Study for the Davis Global Communications Site. Working Copy. McClellan Air Force Base. October.
- CH2M HILL. 1993b. Davis Global Communications Site Remediation Environmental Assessment. Prepared for McClellan AFB. April.
- Chang, A. C., et al. 1984. "Accumulation of heavy metals in sewage sludge-treated soils." *J. Environ. Qual.* 13: 87.
- Howard, P. H. 1990. *Handbook of Environmental Fate and Exposure Data for Organic Chemicals. Volume II: Solvents.* Chelsea, MI: Lewis Publishers, Inc.
- ITC. 1992. Preliminary Groundwater Remedial Investigation Report. Davis Global Communications Site, McClellan AFB. Volume I. April.
- Jury, W. A., and R. L. Valentine. 1986. Transport Mechanisms and Loss Pathways for Contaminants in Soil. *Vadose Zone Modeling of Organic Pollutants.* Hern, S.C. and S.M. Melacon, eds. Chelsea, MI: Lewis Publishers, Inc.
- Kabata-Pendias, A., and H. Pendias. 1992. *Trace Elements in Soils and Plants*, 2nd Edition. CRC Press, Boca Raton, FL.
- Mulligan, H., McClellan Air Force Base, Environmental Management. 1993. Personal communication with John Lowe, CH2M HILL. August 9.
- Olgerson, MSgt., Davis Global Communications Center. 1993. Personal communication with John Lowe, CH2M HILL. August 6.
- Severson, R. C., et al. 1986. Chemical composition and variability of soils in the western San Joaquin Valley, California, in Toxic Substances in Agricultural Water Supply and Drainage. *Proceedings from the 1986 Regional Meetings sponsored by the U.S. Committee on Irrigation and Drainage.* Denver, CO.
- Severson, R. C., et al. 1987. Analyses of bottom material collected at nine areas in the Western United States for the DOI irrigation drainage task group. U.S. Geol. Surv. Open-file Report 87-490.
- Shacklette, H., and J. Boergnen. 1984. Element concentrations in soils and other surficial materials of the conterminous United States. U.S. Geol. Surv. Prof. Paper 1270.

Shacklette, H., et al. 1973. Lithium in surficial materials of the conterminous United States and partial data on cadmium. U.S. Geol. Surv. Circ. 673.

Smith, I. C., and B. L. Carson. 1977. *Trace Metals in the Environment*. Ann Arbor Scientific Publications, Ann Arbor, MI.

Vogel, T. M., C. S. Criddle, and P. L. McCarty. 1987. "Transformation of Halogenated Aliphatic Compounds. *Environ. Sci. Technol.* 21:722-736.

Williams, D. E., et al. 1987. Metal movement in sludge-amended soils: a nine-year study. *Soil Sci.* 143: 124.

Appendix D
CONTAMINANTS OF POTENTIAL CONCERN TO HUMAN HEALTH

PREPARED FOR: Davis Global Communications Site Risk Assessment

PREPARED BY: John Lowe/CH2M HILL

DATE: August 18, 1993

SUBJECT: Chemicals of Potential Concern for Human Health

PROJECT: SAC28722.55.15

Introduction

The process of identifying and selecting for inclusion into the risk assessment those contaminants of greatest potential health concern (i.e., those that are most toxic, mobile, persistent, or prevalent of the contaminants detected at the Davis Site) from among the entire set of contaminants associated with the site. The steps described in this technical memorandum were performed to organize the data collected in site investigations into a form appropriate for performing risk assessments. The purpose of identifying contaminants of potential concern (COPCs) is to focus the risk assessment on the most important contaminants (i.e., those presenting 99 percent of the total risk) detected at the site.

Factors considered in selecting COPCs for the risk assessment (U.S. EPA, 1989) were:

- Evaluation of the analytical methods
- Evaluation of data quality with respect to sample quantitation limits
- Evaluation of data quality with respect to qualifiers and codes
- Evaluation of data quality with respect to blanks
- Evaluation of tentatively identified compounds
- Comparison of potential site-related compounds with background (primarily for inorganic compounds)

Evaluation of data for the risk assessment was based on the *EPA Guidance for Data Usability in Risk Assessment* (U.S. EPA, 1992a). Several of these factors were addressed prior to initiating the risk assessment for the Davis Site. Analytical methods and sample quantitation limits used in the various site investigations were specified in work plans approved by the appropriate regulatory agencies (CH2M

HILL, 1992; Radian Corporation, 1992). Prior to use in the risk assessment, data underwent validation with respect to qualifiers, codes, and blanks; data not meeting data quality objectives specified in the approved work plans were rejected. Tentatively identified compounds consisted of total petroleum hydrocarbons (TPH) or diesel-range hydrocarbons, analyzed by EPA Method 418.1 and Modified Method 8015, respectively. These results were used as-is in the risk assessment, and the uncertainties associated with the resulting risk estimates have been discussed in the characterization of health risks. Site-related compounds were not compared with background in this risk assessment. Generally, contaminants consisted of those with no appreciable natural background concentrations (such as chlorinated VOCs in groundwater). Available site historical and investigative data did not reveal sources of metals releases to soils or groundwater. Therefore, metals were not considered site-related COPCs in the risk assessment.

Contaminants of Potential Concern in Soil

Summary statistics of the contaminants detected from all samples at all depths in soil at the Davis Site are presented in Table D-1. These results indicate that the contaminants detected in soil are principally petroleum hydrocarbons, low-molecular weight polynuclear aromatic hydrocarbons (PNAs), phthalates, and volatile organic compounds (VOCs). VOCs detected in solid soil samples are not viewed as meaningful for purposes of risk assessment (U.S. EPA, 1992b). Soil gas sampling and analytical data were used to characterize health risks associated with VOCs in soil. All of the VOCs detected in soil samples were detected in soil gas samples except for acetone and methylene chloride. The common laboratory contaminants acetone and methylene chloride were detected frequently in soil samples with relatively low variability from sample to sample. The documentation is not available to eliminate these contaminants based on comparison with blanks. However, in these cases, where no source was evident and no other constituents were detected, acetone and methylene chloride were considered to be laboratory artifacts. Similarly, no source for chloroform in soil is evident. At least one hot spot was detected (260 $\mu\text{g/kg}$ in one sample from 1985); however, chloroform was detected in a very limited number of soil gas samples. While chloroform is a probable human carcinogen, and therefore should be quantified in the risk assessment, the available data suggest that other carcinogenic VOCs (tetrachloroethene and trichloroethene) would be more influential in the risk assessment. Excluding chloroform as a COPC is addressed as an uncertainty in the risk assessment.

With the exception of acenaphthene, the other semivolatile organic compounds (PNAs, phthalates, and petroleum hydrocarbons) were included as COPCs in the risk assessment. Acenaphthene was detected in 1 of 31 samples from the site (3 percent of the samples). Acenaphthene is a noncarcinogenic contaminant; based on EPA risk assessment guidelines (U.S. EPA, 1989), noncarcinogenic contaminants detected in fewer than 5 percent of samples from a site can be excluded from a risk assessment.

Table D-1
Summary Statistics of Contaminants Analyzed in Soil
Davis Global Communications Site

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Contaminant	Sample Location of Highest Detect	Sample Date	Number of Detects	Number of Samples	Frequency of Detects	Summary of Contaminant Concentrations (ug/kg)				
						Minimum	Maximum	Mean	Standard Deviation	Coefficient of Variation
Acenaphthene	CH-5	24-Nov-92	1	31	0.03	110	110	3.55	19.76	5.57
Acenaphthylene				31				0.00		
Acetone	SBB-19	15-Dec-89	8	8	1.00	28	46	35.50	5.18	0.15
Aldrin				11				0.00		
Alpha BHC (alpha hexachlorocyclohexane)				11				0.00		
Aluminum	CH-5	24-Nov-92	10	10	1.00	12,700,000	32,900,000	20,110,000.00	5,734,389.44	0.29
Aniline (phenylamine, aminobenzene)				11				0.00		
Anthracene	CH-5	24-Nov-92	1	31	0.03	170	170	5.48	30.53	5.57
Antimony	CH-4	23-Nov-92	4	20	0.20	2,900	5,900	845.00	1,802.77	2.13
Arsenic	CH-5	24-Nov-92	20	20	1.00	4,000	9,600	7,315.00	1,367.78	0.19
Barium	CH-5	24-Nov-92	20	20	1.00	97,800	343,000	164,740.00	74,356.36	0.45
Benzene	EM3955	20-May-88	3	44	0.07	60	86	5.00	18.91	3.78
Benzidine				11				0.00		
Benzo(a)anthracene				31				0.00		
Benzo(a)pyrene				31				0.00		
Benzo(b)fluoranthene				31				0.00		
Benzo(g,h,i)perylene				31				0.00		
Benzo(k)fluoranthene				31				0.00		
Benzoic acid				11				0.00		
Benzyl alcohol				11				0.00		
Benzyl butyl phthalate	CH-2	23-Nov-92	5	31	0.16	70	2,400	150.97	504.28	3.34

Table D-1
Summary Statistics of Contaminants Analyzed in Soil
Davis Global Communications Site

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Contaminant	Sample Location of Highest Detect	Sample Date	Number of Detects	Number of Samples	Frequency of Detects	Summary of Contaminant Concentrations (ug/kg)				Coefficient of Variation
						Minimum	Maximum	Mean	Standard Deviation	
Beryllium	CH-4	23-Nov-92	20	20	1.00	370	800	505.50	115.42	0.23
Beta BHC (beta hexachlorocyclohexane)				11				0.00		
bis(2-Chloroethoxy) methane				31				0.00		
bis(2-Chloroethyl) ether (2-chloroethyl ether)				31				0.00		
bis(2-Chloroisopropyl) ether				11				0.00		
bis(2-Ethylhexyl) phthalate	EM3962	20-May-88	22	31	0.71	74	2,400	546.52	658.63	1.21
Bromodichloromethane				32				0.00		
Bromoform				32				0.00		
Bromomethane				32				0.00		
4-Bromophenyl phenyl ether				31				0.00		
Cadmium	CH-5	24-Nov-92	20	20	1.00	100	7,000	2,728.00	2,703.76	0.99
Calcium	CH-5	24-Nov-92	10	10	1.00	1,930,000	23,600,000	7,078,000.00	7,140,735.72	1.01
Carbazole				20				0.00		
Carbon disulfide				8				0.00		
Carbon tetrachloride				32				0.00		
Chlordane				11				0.00		
4-Chloroaniline				31				0.00		
Chlorobenzene				56				0.00		
Chloroethane				32				0.00		
2-Chloroethyl vinyl ether				12				0.00		
Chloroform	B-1	23-Oct-85	7	32	0.22	20	260	14.06	47.24	3.36

Table D-1
Summary Statistics of Contaminants Analyzed in Soil
Davis Global Communications Site

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Contaminant	Sample Location of Highest Detect	Sample Date	Number of Detects	Number of Samples	Frequency of Detects	Summary of Contaminant Concentrations (ug/kg)				Coefficient of Variation
						Minimum	Maximum	Mean	Standard Deviation	
Chloromethane				32				0.00		
4-Chloro-3-methylphenol				31				0.00		
2-Chloronaphthalene				31				0.00		
2-Chlorophenol				31				0.00		
4-Chlorophenyl phenyl ether				31				0.00		
Chromium, total	CH-5	24-Nov-92	20	20	1.00	48,800	179,000	85,265.00	34,544.24	0.41
Chrysene				31				0.00		
Cobalt	CH-2	23-Nov-92	20	20	1.00	12,500	27,400	19,625.00	5,540.46	0.28
Copper	CH-5	24-Nov-92	20	20	1.00	22,800	82,300	41,975.00	18,648.55	0.44
DDD (1,1-bis(chlorophenyl)-2,2-dichloroethane)				11				0.00		
DDT (1,1-bis(chlorophenyl)-2,2,2-trichloroethane)				11				0.00		
Delta BHC (delta hexachlorocyclohexane)				11				0.00		
1,2-Dichlorobenzene				67				0.00		
1,3-Dichlorobenzene				79				0.00		
1,4-Dichlorobenzene				79				0.00		
3,3'-Dichlorobenzidine				31				0.00		
1,1-Dichloroethane				32				0.00		
1,2-Dichloroethane				32				0.00		
1,1-Dichloroethene				32				0.00		
trans-1,2-Dichloroethene				24				0.00		
2,4-Dichlorophenol				31				0.00		

Table D-1
Summary Statistics of Contaminants Analyzed in Soil
Davis Global Communications Site

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Contaminant	Sample Location of Highest Detect	Sample Date	Number of Detects	Number of Samples	Frequency of Detects	Summary of Contaminant Concentrations (ug/kg)				Coefficient of Variation
						Minimum	Maximum	Mean	Standard Deviation	
1,2-Dichloropropane				32				0.00		
cis-1,3-Dichloropropene				32				0.00		
di-N-butyl phthalate	CH-5	24-Nov-92	10	31	0.32	2,400	7,000	1,658.06	2,542.28	1.53
di-N-octyl phthalate (bis-(2-ethylhexyl)phthalate)				31				0.00		
Dibenz(a,h)anthracene				31				0.00		
Dibenzofuran	EM3955	20-May-88	6	31	0.19	59	2,200	217.71	578.45	2.66
Dibromochloromethane				32				0.00		
Dibromomethane				12				0.00		
Dichlorodifluoromethane				12				0.00		
trans-1,3-Dichloropropene				32				0.00		
Dieldrin				11				0.00		
Diesel components				1				0.00		
Diesel hydrocarbons	EM3955	20-May-88	37	104	0.36	44,000	9,120,000	469,961.54	1,303,557.43	2.77
Diethyl phthalate	CH-2	23-Nov-92	2	31	0.06	50	53	3.32	12.87	3.87
Dimethyl phthalate				31				0.00		
2,4-Dimethylphenol				31				0.00		
4,6-Dinitro-2-methylphenol				20				0.00		
2,4-Dinitrophenol				31				0.00		
2,4-Dinitrotoluene				31				0.00		
2,6-Dinitrotoluene				31				0.00		
1,2-Diphenylhydrazine				11				0.00		

Table D-1
Summary Statistics of Contaminants Analyzed in Soil
Davis Global Communications Site

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Contaminant	Sample Location of Highest Detect	Sample Date	Number of Detects	Number of Samples	Frequency of Detects	Summary of Contaminant Concentrations (ug/kg)				Coefficient of Variation
						Minimum	Maximum	Mean	Standard Deviation	
Endosulfan				11				0.00		
Endosulfan sulfate				11				0.00		
Endrin				11				0.00		
Ethylbenzene	EM3955	20-May-88	5	44	0.11	100	550	29.09	97.43	3.35
Fluoranthene				31				0.00		
Fluorene	EM3955	20-May-88	18	31	0.58	130	6,900	1,159.03	1,849.11	1.60
Gamma BHC (lindane)				11				0.00		
Heptachlor				11				0.00		
Heptachlor epoxide				11				0.00		
Hexachlorobenzene				31				0.00		
Hexachlorobutadiene				31				0.00		
Hexachlorocyclopentadiene				31				0.00		
Hexachloroethane				31				0.00		
2-Hexanone				8				0.00		
Indeno(1,2,3-c,d)pyrene				31				0.00		
Iron	CH-5	24-Nov-92	10	10	1.00	24,200,000	50,500,000	35,940,000.00	6,928,876.77	0.19
Isophorone				31				0.00		
Lead	EM3958	20-May-88	20	20	1.00	4,800	13,100	9,140.00	2,893.26	0.32
m,p-Xylene (sum of isomers)	EM3955	20-May-88	6	32	0.19	6	780	72.07	185.41	2.57
Magnesium	CH-5	24-Nov-92	10	10	1.00	12,500,000	32,200,000	22,400,000.00	7,689,242.12	0.34
Manganese	CH-5	24-Nov-92	10	10	1.00	450,000	1,030,000	680,200.00	177,428.42	0.26

Table D-1
Summary Statistics of Contaminants Analyzed in Soil
Devils Global Communications Site

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Contaminant	Sample Location of Highest Detect	Sample Date	Number of Detects	Number of Samples	Frequency of Detects	Summary of Contaminant Concentrations (ug/kg)				
						Minimum	Maximum	Mean	Standard Deviation	Coefficient of Variation
Mercury	EM3958	20-May-88	19	20	0.95	50	13,200	5,856.50	5,884.43	1.00
Methyl ethyl ketone (2-butanone)				8				0.00		
Methyl isobutyl ketone (4-methyl-2-pentanone)				8				0.00		
Methylene chloride	B-3	24-Oct-85	17	32	0.53	15	400	70.63	109.79	1.55
2-Methylnaphthalene	EM3955	20-May-88	14	31	0.45	320	46,500	7,487.74	13,373.74	1.79
2-Methylphenol (o-cresol)				31				0.00		
4-Methylphenol (p-cresol)				31				0.00		
Molybdenum	EM3959	20-May-88	10	10	1.00	890	1,180	1,048.00	96.01	0.09
Naphthalene	EM3955	20-May-88	10	31	0.32	160	21,100	3,079.35	6,142.26	1.99
Nickel	CH-5	24-Nov-92	20	20	1.00	117,000	348,000	188,100.00	62,996.16	0.33
2-Nitroaniline				31				0.00		
3-Nitroaniline				31				0.00		
4-Nitroaniline				31				0.00		
Nitrobenzene				31				0.00		
2-Nitrophenol				31				0.00		
4-Nitrophenol				31				0.00		
n-Nitrosodi-n-propylamine				31				0.00		
n-Nitrosodimethylamine				11				0.00		
n-Nitrosodiphenylamine				20				0.00		
PCB, total				11				0.00		
Pentachlorophenol				31				0.00		

Table D-1
Summary Statistics of Contaminants Analyzed in Soil
Davis Global Communications Site

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Contaminant	Sample Location of Highest Detect	Sample Date	Number of Detects	Number of Samples	Frequency of Detects	Summary of Contaminant Concentrations (ug/kg)				
						Minimum	Maximum	Mean	Standard Deviation	Coefficient of Variation
Petroleum hydrocarbons	B-3	24-Oct-85	20	44	0.45	5,000	17,236,000	766,504.55	2,962,766.23	3.87
Phenanthrene	EM3957	20-May-88	19	30	0.63	92	14,500	2,920.80	4,619.17	1.58
Phenol				30				0.00		
Potassium	CH-2	23-Nov-92	10	10	1.00	779,000	2,560,000	1,708,500.00	629,443.71	0.37
Pyrene	EM3956	20-May-88	5	31	0.16	190	700	56.13	150.97	2.69
Selenium	EM3958	20-May-88	10	20	0.50	6,700	10,200	4,020.00	4,184.51	1.04
Silver	CH-5	24-Nov-92	12	20	0.60	310	810	246.50	233.27	0.95
Sodium	CH-4	23-Nov-92	10	10	1.00	410,000	1,940,000	819,200.00	532,236.75	0.65
Styrene				8				0.00		
Tetrachloroethene (PCE)	SBB-22	13-Dec-89	3	32	0.09	6	19	1.13	3.92	3.49
Thallium	EM3958	20-May-88	19	20	0.95	4,300	169,000	74,430.00	68,441.92	0.92
Toluene	EM3961	20-May-88	9	44	0.20	1	100	5.70	19.14	3.35
Total 1,2-dichloroethene				8				0.00		
Toxaphene				11				0.00		
1,1,1,2-Tetrachloroethane				12				0.00		
1,1,2,2-Tetrachloroethane				32				0.00		
1,2,4-Trichlorobenzene				31				0.00		
1,1,1-Trichloroethane				32				0.00		
1,1,2-Trichloroethane				32				0.00		
Trichloroethene (TCE)	SBB-22	13-Dec-89	2	32	0.06	1	4	0.16	0.72	4.63
Trichlorofluoromethane				12				0.00		

Table D-1
Summary Statistics of Contaminants Analyzed in Soil
Dev's Global Communications Site

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Contaminant	Sample Location of Highest Detect	Sample Date	Number of Defects	Number of Samples	Frequency of Defects	Summary of Contaminant Concentrations (ug/kg)				
						Minimum	Maximum	Mean	Standard Deviation	Coefficient of Variation
2,4,5-Trichlorophenol				31				0.00		
2,4,6-Trichlorophenol				31				0.00		
Vanadium	CH-5	24-Nov-92	20	20	1.00	25,400	100,000	49,660.00	23,050.62	0.46
Vinyl acetate				8				0.00		
Vinyl chloride				32				0.00		
Zinc	CH-5	24-Nov-92	20	20	1.00	43,100	150,000	70,920.00	29,298.39	0.41

Concentrations of metals detected in soil at the Davis Site fell within a defined geochemical baseline level (Severson, et al., 1987), or within the range of observed concentrations in western U.S. soils (Shacklette and Boergnan, 1984) with the exception of antimony, cadmium, and thallium. Metals with concentrations that fell within these background levels were excluded as contaminants of potential concern in the risk assessment. Antimony, cadmium, and thallium are discussed below in further detail. Concentrations of hexavalent chromium reported in soil are likely to have been laboratory artifacts, as discussed in Appendix C, and also were excluded as contaminants of potential concern.

Based on direct comparison of Davis Site data with numerical values published for background concentrations, antimony, cadmium, and thallium could be considered elevated in soil at the Davis Site, and therefore could be included as contaminants of potential concern in the risk assessment. Concentrations of antimony detected in soil are elevated slightly above background. When samples reported as not-detected for antimony are averaged with the detected concentrations, the average concentration falls within the observed range of background concentrations. Elevated concentrations of cadmium in soil are more likely to be associated with agricultural practices, rather than activities at the site. Other known sources of cadmium contamination in soil, such as mining and smelting of metals (Kabata-Pendias and Pendias, 1992) are not likely to have occurred at the site. Concentrations of thallium appear significantly in soil at the Davis Site. However, activities associated with thallium contamination in soil (described in Appendix C) are not likely to have occurred at the site. Also, problems with laboratory analyses have been encountered with thallium in soil during the McClellan IRP, and elevated levels of thallium have been judged to be laboratory artifacts (ATSDR, 1993). Antimony, cadmium, and thallium were excluded as contaminants of potential concern, based on these considerations.

Contaminants of Potential Concern in Soil Gas

Summary statistics of the contaminants detected from all samples at all depths in soil gas at the Davis Site are presented in Table D-2. These results indicate that the contaminants detected in soil are principally chlorinated and aromatic VOCs. Since surface emission fluxes were estimated as area-weighted averages, extent of contamination was an important factor in selecting COPCs in soil gas. VOCs in soil gas that were not included in the risk assessment were 1,2-dichloroethane, trimethylbenzenes, chloroform, and chloromethane. While 1,2-dichloroethane and chloroform are Category B2 carcinogens (probable human carcinogens based on laboratory animal data), emissions of these contaminants to the air are likely to be quite small compared with other carcinogens in soil gas (tetrachloroethene (PCE) and trichloroethene (TCE)), because they are present only in very limited areas of the site. Trimethylbenzenes, noncarcinogenic VOCs possibly originating from releases of petroleum hydrocarbons to soil, also have limited extent in soil gas. Inclusion of other noncarcinogenic aromatic VOCs (ethylbenzene, xylenes, toluene) in the risk assessment is considered adequate to address the risks posed by this class of compounds in soil gas.

Table D-2
Summary Statistics of Contaminants Analyzed in Soil Gas
Davis Global Communications Site

Page 1 of 2

Contaminant	Number of Detects	Number of Samples	Frequency of Detects	Range of Concentrations Detected (µg/l)	
				Minimum	Maximum
Benzene	33	92	0.36	0.00713	1.116
Benzyl chloride		15			
Bromomethane		25			
Carbon dioxide free	7	7	1.00	0.93	10
Carbon tetrachloride		25			
Chlorobenzene		25			
Chloroethane		25			
Chloroform	3	25	0.12	0.01632	0.0336
Chloromethane	1	25	0.04	0.022	0.022
1,2-Dibromoethane (ethylene dibromide)		25			
1,2-Dichlorobenzene		25			
1,3-Dichlorobenzene		25			
1,4-Dichlorobenzene		25			
Dichlorodifluoromethane	3	25	0.12	0.0163177914	0.4944785276
1,1-Dichloroethane	5	25	0.20	0.0124	0.112
1,2-Dichloroethane	1	25	0.04	0.0084	0.0084
1,1-Dichloroethene	25	92	0.27	0.03	10.14
cis-1,2-Dichloroethene	8	25	0.32	0.01794	1.248
cis-1,3-Dichloropropene		25			
trans-1,3-Dichloropropene		25			
Ethylbenzene	21	92	0.23	0.00882	5.8
Freon-114		25			
Hexachlorobutadiene		25			
m,p-Xylene (sum of isomers)	37	92	0.40	0.003906	16.3
Methane (percent)	2	7	0.29	0.11	1.5
Methylene chloride		25			
Nitrogen, nitrite (percent)	7	7	1.00	59	88
o-Xylene (1,2-dimethylbenzene)	22	92	0.24	0.01302	17.5
Oxygen (percent)	6	7	0.86	15	19

Table D-2
Summary Statistics of Contaminants Analyzed in Soil Gas
Davis Global Communications Site

Page 2 of 2

Contaminant	Number of Detects	Number of Samples	Frequency of Detects	Range of Concentrations Detected (µg/l)	
				Minimum	Maximum
Styrene		25			
1,1,2,2-Tetrachloroethane		25			
Tetrachloroethene (PCE)	68	92	0.74	0.02	541.2
Toluene	51	92	0.55	0.0074	25.9
1,2,4-Trichlorobenzene		25			
1,1,1-Trichloroethane	10	25	0.40	0.01113	1.855
1,1,2-Trichloroethane		25			
Trichloroethene (TCE)	42	92	0.46	0.01	50.35
Trichlorofluoromethane		25			
1,1,2-Trichloro-1,2,2-trifluoroethane	10	25	0.40	0.0122633947	107.304703477
1,2,4-Trimethylbenzene	4	25	0.16	0.00864	0.0768
1,3,5-Trimethylbenzene (mesitylene)	3	25	0.12	0.00768	0.01728
Vinyl chloride	1	92	0.01	0.0031875	0.0031875

Contaminants of Potential Concern in Groundwater

In identification of COPCs in groundwater, contaminants detected in groundwater monitoring wells were considered separately from those detected in the site production well. The site production well provides water for non-drinking water uses at the Davis Site, and represents a more plausible pathway of exposure than contaminants detected in groundwater monitoring wells.

Monitoring Well Data

Currently, there are no complete pathways of exposure from contaminants detected in monitoring wells. Because there are no constraints on future use of groundwater, there could be complete pathways of exposure under future land use. However, historical groundwater monitoring data indicate that concentrations of VOCs in groundwater are changing over time, and it is not known what future exposure concentrations might be. Allowable levels of VOC contaminants in groundwater also are driven by regulatory considerations (i.e., aquifer nondegradation policy) rather than considerations of exposures and health risks. Therefore, risk assessment results are

not likely to be significant in determining the need for or extent of remediation of groundwater.

At the request of the regulatory agencies, health risks potentially associated with groundwater contaminants detected in monitoring wells were considered in the risk assessment. These estimates of health risks were based on a future residential land use scenario. Concentrations of PCE and TCE detected in the latest sampling round from Well MW-3 (sampled September 28, 1992) were the exposure concentrations used for this scenario. In this sampling round, PCE was detected at a concentration of 150 $\mu\text{g/l}$; TCE was detected at a concentration of 350 $\mu\text{g/l}$. Table D-3 presents a summary of the concentrations of VOCs detected in groundwater from the monitoring wells at the Davis Site.

Site Production Well Data

The site production well has been sampled by McClellan AFB on a regular basis since 1986. The monitoring results appear in Table D-4. Minimum and maximum concentrations detected in samples from the production well are summarized in Table D-5. Notable contaminants detected in the production well are trihalo-methanes (bromoform, chloroform, chlorodibromomethane, and bromodichloromethane), ethylene dibromide (EDB) and methiocarb. All of the contaminants detected in the production well were evaluated as COPCs in the risk assessment, with the exception of methiocarb. Methiocarb (Mesurol, produced by Mobay Contaminant Corp.) is a moderately toxic carbamate pesticide used principally as a bird repellent in fruit and field crops.

Summary of Contaminants of Potential Concern

The COPCs considered in the risk assessment are summarized in Table D-6. Exposure concentrations for these COPCs are presented in Appendix G, Exposure Assessment for Human Health Risk Assessment.

Table D-3
Summary Statistics of Concentrations in Groundwater - Davis Global Communications Site

Page 1 of 4

Contaminant	Number of Samples Detecting Parameter	Number of Samples	Frequency of Detection	Range of Detected Concentrations (µg/l)	
				Minimum	Maximum
Acetone	6	8	0.75	1	10
Benzene	24	310	0.08		11
Benzyl chloride		75			
Bromobenzene		267			
Bromochloromethane		3			
Bromodichloromethane		344	0.02		
Bromoform		344	0.02		
Bromomethane	1	344	0.02		1
Carbon disulfide	1	8	0.13	11	11
Carbon tetrachloride		343	0.02		
Chlorobenzene		565	0.01		
Chloroethane	8	344	0.02		22
2-Chloroethyl vinyl ether		245			
Chloroform	41	342	0.12		38
1-Chlorohexane		267			
bis(2-Chloroisopropyl) ether		75			
Chloromethane		344	0.02		

Table D-3

Summary Statistics of Concentrations in Groundwater - Davis Global Communications Site

Page 2 of 4

Contaminant	Number of Samples Detecting Parameter	Number of Samples	Frequency of Detection	Range of Detected Concentrations ($\mu\text{g/l}$)	
				Minimum	Maximum
total Chlorotoluene		24			
Dibromochloromethane		336	0.02		
Dibromomethane	1	305			
1,2-Dichlorobenzene		557	0.01		
1,3-Dichlorobenzene	9	557	0.02		1.3
1,4-Dichlorobenzene	9	557	0.02		1
Dichlorodifluoromethane		120	0.06		
1,1-Dichloroethane	40	340	0.12		38
1,2-Dichloroethane	9	343	0.03		0.18
1,1-Dichloroethene	113	330	0.34		390
cis-1,2-Dichloroethene	64	223	0.29	0.41	870
trans-1,2-Dichloroethene	35	336	0.10		3,400
total 1,2-Dichloroethene	1	7	0.14	7	7
1,2-Dichloropropane		344	0.02		
cis-1,3-Dichloropropene		343	0.06		
trans-1,3-Dichloropropene		344	0.05		
Diesel hydrocarbons	24	50	0.48	60	1,100

Table D-3
Summary Statistics of Concentrations in Groundwater - Davis Global Communications Site

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Contaminant	Number of Samples Detecting Parameter	Number of Samples	Frequency of Detection	Range of Detected Concentrations (µg/l)	
				Minimum	Maximum
Ethylbenzene		311	0.02		
2-Hexanone		8			
m,p-Xylene (sum of isomers)	9	98	0.09		3
Methyl ethyl ketone (2-butanone)		8			
Methyl isobutyl ketone (4-methyl-2-pentanone)		8			
Methylene chloride	27	337	0.08		320
o-Xylene (1,2-dimethylbenzene)		1			
p-Xylene (1,4-dimethylbenzene)		1			
Styrene		8			
1,1,1,2-Tetrachloroethane		264			
1,1,2,2-Tetrachloroethane	8	344	0.02		340
Tetrachloroethene (PCE)	151	312	0.48	0.12	1,400
Toluene	19	309	0.06		23
1,1,1-Trichloroethane	26	344	0.08		20.15
1,1,2-Trichloroethane	8	344	0.02		0.5
Trichloroethene (TCE)	214	295	0.72	0.27	3,000
Trichlorofluoromethane	8	336	0.02		150

**Table D-3
Summary Statistics of Concentrations in Groundwater - Davis Global Communications Site**

Page 4 of 4

Contaminant	Number of Samples Detecting Parameter	Number of Samples	Frequency of Detection	Range of Detected Concentrations ($\mu\text{g/l}$)	
				Minimum	Maximum
1,2,3-Trichloropropane		267			
1,1,2-Trichloro-1,2,2-trifluoroethane	3	5	0.60	39	43
Vinyl acetate		8			
Vinyl chloride	30	340	0.09		410
total Xylenes		192			
tert-Butyl methyl ether		7	1.00		

Table D-4
Davis Global Communication Center
Base Production Well
Groundwater Sampling

Sheet 1 of 4

Date	Detected Organics (µg/l)																TOL
	1,1-DCE	1,1,2-TC- 1,2,2-TFM	1,4-DCB	ACT	BDM	BFM	CDM	CFM	EDB	F113	MCB	MEK	MIBK	PCE	TCE	TCFM	
8-Nov-85	3													2.3	3.2		
10-Sep-86														1.4	1.7		
18-Sep-86	0.3													1.9	2.1		
21-Nov-86	0.3					2.7				4				0.9	1.4		
18-Dec-86	0.2				1.3	2.5	2	0.7		5.1				0.5	0.9		
16-Jan-87	0.6					6.4	1.1	1.8		2.5				1	2.5		
28-Jan-87	0.4				0.5	14.3	2.5			1.3				1.1	1.7	0.4	
17-Feb-87					1.5	1.7	3.4	1							0.4		
27-Feb-87															1		
11-Mar-87	0.2														0.9		
26-Mar-87	0.2														0.9		
3-Apr-87					2.6		3.5	2.4									
16-Apr-87	0.2					3.2	1.4			1.7				0.5	0.9		
4-May-87														1.4	1.5		
21-May-87					0.9	5.9	2.9	1		8.4				1.4	1.3		
18-Jun-87							0.6	6.7		14.1				1.3	1.4		
20-Jul-87														1.2	1.4		
30-Jul-87							0.5			5.1				0.9	0.9		
10-Aug-87					1.1		4.9	1.1		5.9				1.3	1		

Table D-4
Davis Global Communication Center
Base Production Well
Groundwater Sampling

Sheet 2 of 4

Date	Detected Organics (µg/l)															TOL
	1,1-DCE	1,1,2-TC- 1,2,2-TFM	1,4-DCB	ACT	BDM	BFM	CDM	CFM	EDB	F113	MCB	MEK	MIBK	PCE	TCE	
27-Aug-87					0.9	25.2	4.8			6.5				1.2	0.9	
11-Sep-87					2.2	25.1	7.6	0.6		6.8				1.3	0.7	
21-Sep-87					1.8	16	6.5	0.8		6.3				1	0.7	
15-Oct-87	0.6				1.4	19	7.6	0.7		5.4				2.1	2.7	
28-Oct-87	1.5				0.7	7.5	4.5	0.5		4.9				3	4.6	
13-Nov-87	2.1					47	1.8			6.1				2.7	5	0.04
20-Nov-87	1.6				1.5	13.4	8.8	0.8		4.3				1.8	3.4	
2-Dec-87	2.2				1.5	14.6	8.7	0.8		6.5				2.7	5.1	
17-Dec-87	2.5				2.3	5.6	8.1	1.1		6.2				2.8	5.4	
5-Jan-88	1.9					2.8	3.7			7.3			1.3	3.2	6	
15-Jan-88	1.3				2.3	5.1	6.2	1.1		6.2				2	4.2	
19-Feb-88	1.2									4.8				2	4.9	
10-Mar-88	1.2													2.1	4	
25-Mar-88	0.9									4.3				1.3	3.1	
15-Apr-88										4.1		0.6		0.8	0.9	
27-Apr-88	1.1									5.1				2.5	3.2	
3-May-88	1.2									7.4			7.2	2.7	4	
25-May-88								0.6		6.3			2.34	1	1.1	
7-Jun-88										9.9			2.16	0.8	0.7	

Table D-4
Davis Global Communication Center
Base Production Well
Groundwater Sampling

Sheet 3 of 4

Date	Detected Organics (µg/l)													TCE	TCFM	TOL
	1,1-DCE	1,1,2-TC- 1,2,2-TFM	1,4-DCB	ACT	BDM	BFM	CDM	CFM	EDB	F113	MCB	MEK	MIBK	PCE		
28-Jun-88										9.7			2.59	1.1	1.1	
14-Jul-88										5.6				2	2.2	
27-Jul-88										6.2				0.8	0.8	
4-Aug-88										6.2				0.9	1	
1-Sep-88			2.95			2.3	1.5			4				1.1	1.1	
1-Sep-88			3.71													
13-Sep-88						1.1	1	0.5		4.6				0.8	1	
20-Sep-88										4.3				1.1	1.4	
6-Oct-88										5.1				0.7	0.9	
25-Oct-88	0.9									6.4				2	3.6	
9-Nov-88	3									8.1				2.1	7	
16-Nov-88	2.9									8				2.3	6.8	
8-Dec-88														0.2	0.2	
4-Jan-89	1.3									5				1.7	4.7	
17-Jan-89	1.5									4.6				2.4	4.9	
1-Feb-89										5				2.6	4.3	
14-Feb-89										3.2				1.6	7.4	
14-Mar-89										2.5				1.7	3.1	
7-Apr-89														1.6	1.6	

Table D-4
Davis Global Communication Center
Base Production Well
Groundwater Sampling

Sheet 4 of 4

Date	Detected Organics (µg/l)																
	1,1-DCE	1,1,2-TC- 1,2,2-TFM	1,4-DCB	ACT	BDM	BFM	CDM	CFM	EDB	F113	MCB	MEK	MIBK	PCE	TCE	TCFM	TOL
9-May-89										3.8				0.7	2	0.6	
6-Jun-89										3.6				0.7	1		
17-Sep-91		2.9							1.407		50			0.5	0.6		
5-Oct-92				41					2.3					0.5	0.6		

Chemical Abbreviations:

1,1-DCE:	1,1-Dichloroethene	1,4-DCB:	1,4-Dichlorobenzene
1,1,2-TC-1,2,2-TFM:	1,1,2-Trichloro-1,2,2-Trifluoromethane	ACT:	Acetone
BDM:	Bromodichloromethane	BFM:	Bromoform
CDM:	Chlorodibromomethane	CFM:	Chloroform
EDB:	Ethylene Dibromide	FR113:	Freon 113
MCB:	Methiocarb	MEK:	Methyl Ethyl Ketone
MIBK:	Methyl Isobutyl Ketone	PCE:	Tetrachloroethene
TCE:	Trichloroethene	TCFM:	Trichlorofluoromethane
TOL:	Toluene		

Table D-5
Groundwater Sample Summary
Site Production Well
Davis Global Communication Site

Contaminant	Number of Detects ^a	Concentration Range (µg/l)	
		Minimum	Maximum
Acetone	1	--	41.0
Bromodichloromethane	15	0.5	2.6
Bromoform	20	1.1	47.0
Chlorodibromomethane	24	0.5	8.8
Chloroform	17	0.5	6.7
1,4-Dichlorobenzene	2	2.95	3.71
1,1-Dichloroethene	27	0.2	3.0
Ethylene dibromide	2	1.407	2.3
Freon 113	45	1.3	14.1
Methiocarb	1	--	50.0
Methyl ethyl ketone	1	--	0.6
Methyl isobutyl ketone	5	1.3	7.2
Tetrachloroethene	55	0.2	3.2
Toluene	2	0.04	0.4
Trichloroethene	59	0.2	7.4
Trichlorofluoromethane	1	--	0.6
1,1,2-Trichloro-1,2,2-trifluoromethane	1	--	2.9
^a Number of detects from a total of 60 sampling rounds.			

Table D-6 Summary of Contaminants of Potential Concern Davis Global Communications Site		
Contaminants of Potential Concern in Soil	Contaminants of Potential Concern in Soil Gas	Contaminants of Potential Concern in Groundwater
Benzyl butyl phthalate bis(2-ethylhexyl) phthalate di-N-butyl phthalate Dibenzofuran Diesel hydrocarbons Fluorene 2-Methylnaphthalene Naphthalene Petroleum hydrocarbons Phenanthrene Pyrene	Benzene 1,1-Dichloroethane 1,1-Dichloroethene cis-1,2-Dichloroethene Ethylbenzene m,p-Xylene (sum of isomers) o-Xylene (1,2-dimethylbenzene) Tetrachloroethene (PCE) Toluene 1,1,1-Trichloroethane Trichloroethene (TCE) Trichlorofluoromethane 1,1,2-Trichloro-1,2,2-trifluoroethane Vinyl chloride	Acetone Bromodichloromethane Bromoform Chlorodibromomethane Chloroform 1,4-Dichlorobenzene 1,1-Dichloroethene Ethylene dibromide Methyl ethyl ketone Methyl isobutyl ketone Tetrachloroethene Toluene Trichloroethene Trichlorofluoromethane 1,1,2-Trichloro-1,2,2-trifluoromethane Vinyl chloride

Works Cited

CH2M HILL. 1992. Draft Final Work Plan, Davis Global Communications Site. McClellan Air Force Base. July.

Radian Corporation. 1992. Draft Final Quality Assurance Project Plan, Installation Restoration Program, Stage 3. McClellan Air Force Base. March.

U.S. EPA. 1989. *Risk Assessment Guidance for Superfund. Volume I. Human Health Evaluation Manual (Part A)*. Interim Final. EPA/540/1-89/002. December.

U.S. EPA. 1992a. *Guidance for Data Usability in Risk Assessment (Part A)*. Final. Publication 9285.7-09A. April.

U.S. EPA. 1992b. Soil Gas Consensus Statement. Final. U.S. Environmental Protection Agency, Region IX. October 30.

Appendix E
TOXICITY ASSESSMENT FOR
THE HUMAN HEALTH RISK ASSESSMENT

PREPARED FOR: Davis Global Communications Site Risk Assessment

PREPARED BY: John Lowe/CH2M HILL

DATE: August 19, 1993

SUBJECT: Toxicity Assessment for the Human Health Risk Assessment

PROJECT: SAC28722.55.15

Introduction

This technical memorandum presents the toxicity assessment for the human health risk assessment for the Davis Global Communications Site. The toxicity assessment determines the relationship between the magnitude of exposure to a contaminant and the potential for adverse health effects. Where possible, a numerical estimate of the increased likelihood and/or severity of adverse effects associated with contaminant exposure is included (U.S. EPA, 1989). This memorandum provides a brief description of the toxicity values used to characterize health risks potentially associated with contaminants of potential concern detected at the Davis Site. Tables summarizing these toxicity criteria are also included.

For purposes of the toxicity assessment, the contaminants of potential concern (COPCs) have been classified into two broad categories: carcinogens and noncarcinogens. This classification has been selected because health risks are calculated quite differently for carcinogenic and noncarcinogenic effects, and separate toxicity values have been developed. These toxicity values represent the potential magnitude of adverse health effects associated with exposure to contaminants, and are developed by the U.S. Environmental Protection Agency (EPA) and the Department of Toxic Substance Control (DTSC). Toxicity studies with laboratory animals or epidemiological studies of human populations provide the data used to develop these toxicity values. These values represent allowable levels of exposure based upon the results of toxicity studies or epidemiological studies. The toxicity values are then combined with the exposure estimates (developed in Appendix G, Exposure Assessment for Human Health Risk Assessment) in the risk characterization process to estimate adverse effects from contaminants potentially originating from the site. Characterization of health risks potentially associated with contaminants detected at the site is also presented in Appendix G.

Sources of Toxicity Values

The following hierarchy of sources was used to obtain toxicity values for the human health risk assessment:

- California Cancer Potency Factors (Cal/EPA, 1992). This list of cancer potency factors was compiled by the Standards and Criteria Work Group, which is composed of staff from the Office of Environmental Health Hazard Assessment, DTSC, and the Department of Pesticide Regulation. These cancer potency factors have been used as a basis for regulatory actions or standards by the State of California.
- The Integrated Risk Information System (IRIS), a database available through EPA's Environmental Criteria and Assessments Office in Cincinnati, Ohio. IRIS, prepared and maintained by EPA, is an electronic database containing health risk and EPA regulatory information on specific contaminants.
- The Health Effects Assessment Summary Tables (HEAST), provided by the EPA Office of Solid Waste and Emergency Response (U.S. EPA, 1991; 1992). HEAST is a compilation of toxicity values published in health effects documents issued by EPA. HEAST is for use in Superfund and RCRA programs.

Toxicity values developed by the California Environmental Protection Agency (Cal/EPA) were used in preference to toxicity values developed by EPA because California regulatory agencies are the lead agencies for the Davis Site.

Toxicity Values for Noncancer Effects

Noncarcinogenic effects were evaluated using either reference doses (RfDs) or reference concentrations (RfCs) developed by EPA. The RfD is a health-based criterion, expressed as contaminant intake rate in units of mg/kg-day, used in evaluating noncarcinogenic effects. The RfD is based on the assumption that thresholds exist for certain toxic effects such as liver or kidney damage, but may not exist for other toxic effects such as carcinogenicity. In general, the RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime of exposure (U.S. EPA, 1989). RfDs are developed for oral routes of exposure. The RfC, expressed as a concentration in air with units of mg/m³, is used to evaluate adverse effects from inhalation exposure.

Potential health risks associated with exposure to noncarcinogenic compounds were evaluated by calculating a hazard quotient (HQ). The potential hazard quotient was calculated as the ratio of the intake to the RfD, as follows:

$$HQ = \frac{\text{Intake}}{RfD} \quad (1)$$

If the estimated daily intake for any single contaminant is greater than its RfD, the HQ will exceed unity. An HQ that exceeds unity indicates that there is a potential for adverse health effects associated with exposure to that contaminant.

A hazard index (HI) is calculated to assess the potential for noncarcinogenic effects posed by more than one contaminant. The hazard index approach assumes that simultaneous subthreshold exposures to several contaminants acting on the same target again or having the same critical toxic effect could result in an adverse health effect. It also assumes that the magnitude of the adverse effect will be proportional to the sum of the ratios of the subthreshold exposures to the acceptable exposure (the RfD). The HI is equal to the sum of the HQs, and is calculated as follows:

$$HI = \frac{E_1}{RfD_1} + \frac{E_2}{RfD_2} + \dots + \frac{E_i}{RfD_i} \quad (2)$$

where E_i is the exposure level (or intake) for the i^{th} contaminant, and RfD_i is the reference dose for the i^{th} contaminant. E and RfD are expressed in the same units (mg/kg-day), and represent the same exposure period (i.e. chronic, subchronic, or short-term).

Exposures to contaminants in air were estimated in units of mg/kg-day (see Appendix G). Therefore, RfCs were converted to inhalation RfDs as follows:

$$RfD_i = RfC(mg/m^3) \times \left(\frac{20m^3/day}{70kg} \right) \quad (3)$$

where RfD_i is the inhalation reference dose, $20 m^3/day$ is the daily inhalation rate, and $70 kg$ is body weight.

Toxicity Values for Carcinogenic Effects

Evidence of carcinogenicity of a contaminant comes from two sources: lifetime studies with laboratory animals and human studies where excess cancer risk is associated with exposure to the contaminant. Unless evidence to the contrary exists, if a carcinogenic response occurs at the exposure levels studied (typically high doses), it is assumed that responses will occur at all lower doses. Exposure to any level of a carcinogen is then considered to have a finite risk of inducing cancer.

Since risks at low levels of exposure cannot be quantified directly by either animal or epidemiological studies, mathematical models are used to extrapolate from high to low doses. The linearized multi-stage model for low dose extrapolation is recommended by regulatory agencies (U.S. EPA, 1986). Use of the linearized multi-stage model leads to a conservative upper bound estimate of risk. The linearized multi-stage model incorporates a procedure for estimating the upper band slope at low doses that is consistent with experimental dose-response data (use of a large slope tends to produce a higher estimate of cancer risk). Generally, the most sensitive species of animal is used for extrapolation to humans (i.e., the assumption is that man is as sensitive as the most sensitive animal species). The true risk is not likely to be higher than the estimate, is most likely lower, and could even be zero.

Numerical estimates of cancer potency are presented as slope factors (SFs). Under an assumption of dose-response linearity at low doses, the SF defines the cancer risk due to continuous constant lifetime exposure to one unit of carcinogen (in units of risk per mg/kg/day). Individual cancer risk was calculated as the product of exposure to a contaminant (in mg/kg/day) and the SF for that contaminant (in mg/kg/day)⁻¹, as follows:

$$\text{Risk} = \text{Intake} \times \text{SF} \quad (4)$$

Cancer risks from exposure to multiple carcinogens and multiple pathways were assumed to be additive, based on the EPA carcinogen risk assessment guidelines (U.S. EPA, 1986).

Each SF is accompanied by a weight-of-evidence classification. This classification considers the available data for a contaminant to evaluate the likelihood that the contaminant is a potential human carcinogen. The evidence is characterized separately for studies in humans and studies in laboratory animals as sufficient, limited, inadequate, no data, or evidence of noncarcinogenicity. EPA recommends that cancer risk estimates always be accompanied by a weight-of-evidence classification to indicate the strength of evidence that a contaminant is a human carcinogen (U.S. EPA, 1986; 1989). A description of the weight-of-evidence classification is presented in Table E-1.

Summary of Toxicity Values

Toxicity values available from both EPA and Cal/EPA appear in Tables E-2, E-3, and E-4. The toxicity values selected for use in characterizing health risk are listed in Table E-5.

Table E-1 EPA Weight-of-Evidence Classification System for Carcinogenicity	
Group	Description
A	Human carcinogen, based on evidence from epidemiological studies
B1 or B2	Probable human carcinogen B1 indicates that limited human data are available B2 indicates sufficient evidence in animals and inadequate or no evidence in humans
C	Possible human carcinogen, based on limited evidence in animals
D	Not classifiable as to human carcinogenicity
E	Evidence of noncarcinogenicity for humans
Source: U.S. EPA, 1986.	

Contaminants Without Available Toxicity Values

Toxicity values are not available for all of the COPCs at the site. RfCs were not available for acetone, benzene, bromodichloromethane, bromoform, chlorodibromomethane, chloroform, cis-1,2-dichloroethene, tetrachloroethene (PCE), trichloroethene (TCE), vinyl chloride, and xylenes. Characterization of health risks for benzene, TCE, and vinyl chloride was based solely on carcinogenic effects. In the other cases, noncancer health risks associated with inhalation exposures were characterized by comparison with the oral RfD.

Another uncertainty in the toxicity assessment is whether to assess cancer risks potentially associated with 1,1-dichloroethene (1,1-DCE). 1,1-DCE is a Group C (possible) human carcinogen. EPA guidelines suggest characterizing cancer risks for Group C carcinogens on a case-by-case basis (U.S. EPA, 1989). Several animal studies with 1,1-DCE have been negative for carcinogenicity. The EPA has judged that these studies are not adequate for detecting a carcinogenic effect (according to the IRIS file for 1,1-DCE, dated January 20, 1992). However, the single positive study judged adequate by EPA did not unequivocally show a carcinogenic dose-response relationship (one important factor in judging whether or not a contaminant does cause cancer). 1,1-DCE is mutagenic and is structurally similar to vinyl chloride, a known human carcinogen. Based on this information, EPA classified 1,1-DCE as a Group C or possible human carcinogen. Since the weight of evidence for carcinogenicity is less for 1,1-DCE, it is less certain that this contaminant is carcinogenic in humans. Including risks from 1,1-DCE may then overestimate total cancer risks associated with contaminants at the site.

Table E-2
U.S. EPA Cancer Potency Factors Available for Contaminants of Potential Concern
Davis Global Communications Site

Page 1 of 2

Contaminant	Carcinogen Weight of Evidence	Oral Slope Factor (mg/kg-day) ⁻¹	Source	Inhalation Slope Factor (mg/kg-day) ⁻¹	Source	Oral Reference Dose (mg/kg-day)
Acetone	D					0.1
Benzene	A	0.029	IRIS	0.029	Calculated from unit risk.	
Bromodichloromethane	B2	0.062	IRIS			0.02
Bromoform	B2	0.0079	IRIS	0.00385	Calculated from unit risk.	0.02
2-Butanone	D					0.05
Butyl benzyl phthalate	C					0.2
Chlorodibromomethane	C	0.084	IRIS			0.02
Chloroform	B2	0.0061	IRIS	0.081	Calculated from unit risk.	0.01
Dibenzofuran	D					0.004
1,2-Dibromoethane	B2	85	IRIS	0.76	Calculated from unit risk.	
1,4-Dichlorobenzene	C	0.024	HEAST 1992			
1,1-Dichloroethane	C					0.1
1,1-Dichloroethene	C	0.6	IRIS	0.175	Calculated from unit risk.	0.009
cis-1,2-Dichloroethene	D					0.01
Diesel, marine	D					0.008
di-N-butyl phthalate	D					0.1
Ethylbenzene	D					0.1
bis(2-Ethylhexyl)phthalate	B2	0.014	IRIS			0.02
Fluorene	D					0.04
4-Methyl-2-pentanone						0.05

Table E-2
U.S. EPA Cancer Potency Factors Available for Contaminants of Potential Concern
Davis Global Communications Site

Page 2 of 2

Contaminant	Carcinogen Weight of Evidence	Oral Slope Factor (mg/kg-day) ⁻¹	Source	Inhalation Slope Factor (mg/kg-day) ⁻¹	Source	Oral Reference Dose (mg/kg-day)
Naphthalene	D					
Phenanthrene	D					
Pyrene	D					0.03
Tetrachloroethene	B2	0.051	Withdrawn from IRIS. Value listed in HEAST 1991 is used.	0.0018	Calculated from unit risk.	0.01
Toluene	D					0.2
1,1,1-Trichloroethane	D					0.09
Trichloroethene	B2	0.011	Withdrawn from IRIS. Value listed in HEAST 1991 is used.	0.006	Calculated from unit risk.	
Trichlorofluoromethane						0.3
1,1,2-Trichloro-1,2,2-trifluoroethane						30
Vinyl chloride	A	1.9	HEAST 1992	0.29	Calculated from unit risk.	
Xylenes (total)	D					2

Notes:

Inhalation Reference Doses calculated from Reference concentrations using 70 kg body weight and 20 m³/day inhalation rate.

Sources for Cal/EPA slope factors:

ATES: Air Toxicology and Epidemiology Section, Office of Environmental Health Hazard Assessment (OEHHa)

PETS: Pesticide and Environmental Toxicology Section, OEHHa

RCHAS: Reproductive and Cancer Hazard Assessment Section, OEHHa

Table E-3
RfDs and RfCs Available for Contaminants of Potential Concern
Davis Global Communications Site

Page 1 of 2

Contaminant	Source	RfD Uncertainty Factor	RfD Modifying Factor	RfD Confidence	Reference Concentration (mg/m ³)	Source	RfC Uncertainty Factor
Acetone	IRIS	1,000	1	low			
Benzene							
Bromodichloromethane	IRIS	1,000	1	medium			
Bromoform	IRIS	1,000	1	medium			
2-Butanone	HEAST 1992	1,000	1		0.3	IRIS	1,000
Butyl benzyl phthalate	IRIS	1,000	1	low			
Chlorodibromomethane	IRIS	1,000	1	medium			
Chloroform	IRIS	1,000	1	medium			
1,2-Dibromoethane							
1,4-Dichlorobenzene					0.8	HEAST, supplemental 2	100
1,1-Dichloroethane	HEAST 1992	1,000	1		0.5	HEAST 1992	1,000
1,1-Dichloroethene	IRIS	1,000	1	medium			
cis-1,2-Dichloroethene	HEAST 1992	3,000	1				
Dibenzofuran	provisional rfd: memo from joan kenneth poirier, ecao to bill dana, oregon deq, 01/24/92	3,000	1	low			
Diesel, marine	provisional rfd: memo from joan dollarhide epa ecao to carol sweeney, region x epa, 03/23/92	10,000	1	low			
di-N-butyl phthalate	IRIS	1,000	1	low			
Ethylbenzene	IRIS	1,000	1	low	1	IRIS	300

Table E-3
RfDs and RfCs Available for Contaminants of Potential Concern
Davis Global Communications Site

Page 2 of 2

Contaminant	Source	RfD Uncertainty Factor	RfD Modifying Factor	RfD Confidence	Reference Concentration (mg/m ³)	Source	RfC Uncertainty Factor
bis(2-Ethylhexyl)phthalate	IRIS	1,000	1	medium			
Fluorene	IRIS	3,000	1	low			
4-Methyl-2-pentanone	HEAST 1992	1,000	1		0.08	HEAST 1992	1,000
Naphthalene	withdrawn from IRIS and HEAST						
Phenanthrene							
Pyrene	IRIS	3,000	1	low			
Tetrachloroethene	IRIS	1,000	1	medium			
Toluene	IRIS	1,000	1	medium	0.4	IRIS	300
1,1,1-Trichloroethane	HEAST 1992	1,000	1		1	HEAST 1992	1,000
Trichloroethene							
Trichlorofluoromethane	IRIS	1,000	1	medium	0.7	HEAST 1992	10,000
1,1,2-Trichloro-1,2,2-trifluoroethane	IRIS	10	1	low	27	HEAST 1992	100
Vinyl chloride							
Xylenes (total)	IRIS	100	1	medium			

Notes:

Inhalation Reference Doses calculated from Reference concentrations using 70 kg body weight and 20 m³/day inhalation rate.

Sources for Cal/EPA slope factors:

ATES: Air Toxicology and Epidemiology Section, Office of Environmental Health Hazard Assessment (OEHHHA)

PETS: Pesticide and Environmental Toxicology Section, OEHHHA

RCHAS: Reproductive and Cancer Hazard Assessment Section, OEHHHA

Table E-4
Cal/EPA Toxicity Values Available for Contaminants of Potential Concern
Davis Global Communications Site

Sheet 1 of 2

Contaminant	Slope Factors					
	RfC Modifying Factor	RfC Confidence	Inhalation Reference Dose (mg/kg-day)	Inhalation Slope Factor (mg/kg-day) ⁻¹	Source	Oral Slope Factor (mg/kg-day) ⁻¹
Acetone						
Benzene				0.1	ATES	0.1
Bromodichloromethane						
Bromoform						
2-Butanone	3	low	0.1			
Butyl benzyl phthalate						
Chlorodibromomethane						
Chloroform				0.019	ATES	0.031
Dibenzofuran						
1,2-Dibromoethane				0.25	ATES	3.6
1,4-Dichlorobenzene	1	medium	0.2			
1,1-Dichloroethane	1		0.1			
1,1-Dichloroethene						
cis-1,2-Dichloroethene						
Diesel, marine						
di-N-butyl phthalate						
Ethylbenzene	1	low	0.3			
bis(2-Ethylhexyl)phthalate						
Fluorene						

RDD10012A38.WP5-1

Table E-4
Cal/EPA Toxicity Values Available for Contaminants of Potential Concern
Davis Global Communications Site

Sheet 2 of 2

Contaminant	Slope Factors					
	R/C Modifying Factor	R/C Confidence	Inhalation Reference Dose (mg/kg-day)	Inhalation Slope Factor (mg/kg-day) ⁻¹	Source	Oral Slope Factor (mg/kg-day) ⁻¹
4-Methyl-2-pentanone	1		0.02			
Naphthalene						
Phenanthrene						
Pyrene						
Tetrachloroethene				0.051	RCHAS	0.051
Toluene	1	medium	0.1			
1,1,1-Trichloroethane	1		0.3			
Trichloroethene				0.01	ATES	0.015
Trichlorofluoromethane	1		0.2			
1,1,2-Trichloro-1,2,2-trifluoroethane	1		7.7			
Vinyl chloride				0.27	ATES	0.27
Xylenes (total)						

Notes:

Inhalation Reference Doses calculated from Reference concentrations using 70 kg body weight and 20 m³/day inhalation rate.

Sources for Cal/EPA slope factors:

ATES: Air Toxicology and Epidemiology Section, Office of Environmental Health Hazard Assessment (OEHHa)

PETS: Pesticide and Environmental Toxicology Section, OEHHa

RCHAS: Reproductive and Cancer Hazard Assessment Section, OEHHa

Table E-5
Toxicity Values Used to Characterize Health Risks
Davis Global Communications Site

Sheet 1 of 2

Contaminant	Carcinogen Weight of Evidence	Slope Factors (mg/kg-day) ⁻¹			Reference Doses (mg/kg-day) ^a			
		Oral	Source	Inhalation	Source	Oral	Inhalation	Source
Acetone	D						0.1	EPA
Benzene	A			0.1	Cal/EPA			
Bromodichloromethane	B2						0.02	EPA
Bromoform	B2			0.0039	EPA		0.02	EPA
2-Butanone	D						0.1	EPA
Butyl benzyl phthalate	C					0.2	EPA	
Chlorodibromomethane	C						0.02	EPA
Chloroform	B2			0.019	Cal/EPA		0.01	EPA
Dibenzofuran	D					0.004	EPA	
1,2-Dibromoethane	B2			0.25	Cal/EPA			
1,4-Dichlorobenzene	C						0.2	EPA
1,1-Dichloroethane	C						0.1	
1,1-Dichloroethene	C				^b		0.0009	^c
cis-1,2-Dichloroethene	D						0.01	
Diesel, marine	D					0.008	EPA	
di-N-butyl phthalate	D					0.8	EPA	
Ethylbenzene	D							
bis(2-Ethylhexyl)phthalate	B2	0.014	EPA			0.02	EPA	
Fluorene	D					0.04	EPA	
4-Methyl-2-pentanone								

Table E-5
Toxicity Values Used to Characterize Health Risks
Davis Global Communications Site

Sheet 2 of 2

Contaminant	Carcinogen Weight of Evidence	Slope Factors (mg/kg-day) ⁻¹			Reference Doses (mg/kg-day) ^a		
		Oral	Source	Inhalation	Source	Inhalation	Source
Naphthalene	D				0.04	EPA	
Phenanthrene	D						
Pyrene	D				0.03	EPA	
Tetrachloroethene	B2			0.051	Cal/EPA	0.01	
Toluene	D					0.1	EPA
1,1,1-Trichloroethane	D				0.09	EPA	EPA
Trichloroethene	B2			0.01	Cal/EPA		
Trichlorofluoromethane						0.2	EPA
1,1,2-Trichloro-1,2,2-trifluoroethane						7.7	EPA
Vinyl chloride	A			0.27	Cal/EPA		
Xylenes (total)	D					2	

^aThe oral Reference Dose (RfD) was used to characterize noncancer health risks from inhalation in cases where a Reference Concentration (RfC) was not available.

^bHealth risks were assessed based on noncancer effects potentially associated with this contaminant (U.S. EPA, 1990).

^cValue derived by applying an additional tenfold uncertainty factor to the RfD (U.S. EPA, 1990).

EPA Region IX recommends evaluation of the risks associated with 1,1-DCE using a modified RfD approach (as opposed to the SFs for this contaminant). This approach involves including an additional tenfold safety factor to the published RfD for this contaminant to account for potential carcinogenicity. EPA Region IX has stated that the number of negative cancer studies for 1,1-DCE is "notable." Five oral carcinogenicity studies have been conducted on 1,1-DCE, including a lifetime joint study by the National Cancer Institute and National Toxicology Program. All of these oral cancer studies were negative. Eleven studies on 1,1-DCE evaluated carcinogenic potential via inhalation; 10 of these studies were negative. One study, by Maltoni, did produce evidence of carcinogenic potential in mice, although this interpretation is blurred by the lack of a clear dose-response relationship. A similar study by the same group of investigators did not produce cancer in rats, even though doses up to sixfold greater were administered. Thus, the evidence supporting the classification of 1,1-DCE as a "carcinogen" is especially weak (U.S. EPA, 1990).

Works Cited

Cal/EPA. 1992. California Cancer Potency Slopes. Memorandum from the Standards and Criteria Work Group to Cal/EPA Departments, Boards and Offices. June 18.

U.S. EPA. 1986. Guidelines for Carcinogen Risk Assessment. *Federal Register*. 51:33992. September 24.

U.S. EPA. 1989. *Risk Assessment Guidance for Superfund. Volume I. Human Health Evaluation Manual (Part A)*. Interim Final. EPA/540/1-89/002. December.

U.S. EPA. 1991. Health Effects Assessment Summary Tables, FY - 1991. Office of Emergency and Remedial Response and Environmental Criteria and Assessments Office.

U.S. EPA. 1992. Health Effects Assessment Summary Tables, FY - 1992. Office of Emergency and Remedial Response and Environmental Criteria and Assessments Office.

Appendix F
AIR PATHWAY ANALYSIS

PREPARED FOR: Davis Global Communications Site Risk Assessment

PREPARED BY: John Lowe/CH2M HILL

DATE: August 20, 1993

SUBJECT: Air Pathway Analysis

PROJECT: SAC28722.55.15

Introduction

This technical memorandum presents a screening-level evaluation of potential inhalation exposures and health risks associated with emissions to the air from contaminants detected in soil and in samples from the site production well at the Davis Site. This memorandum describes the estimation of emissions based on sampling and analytical data, estimation of concentrations in air associated with those emissions, and potential inhalation exposures and health risks. The principal contaminants of concern for the air exposure pathway are volatile organic compounds (VOCs) detected in soil gas or water at the site. This air pathway analysis was based on methods presented in guidance documents published by the U.S. Environmental Protection Agency (EPA). Guidance was obtained primarily from the Air/Superfund National Technical Guidance Study Series, *Guideline for Predictive Baseline Emissions Estimation Procedures for Superfund Sites*, EPA/450/1-92/002 (U.S. EPA, 1992a), and *Assessing Potential Indoor Air Impacts for Superfund Sites*, EPA/451/R-92/002 (U.S. EPA, 1992b).

Identification of Air Exposure Pathways

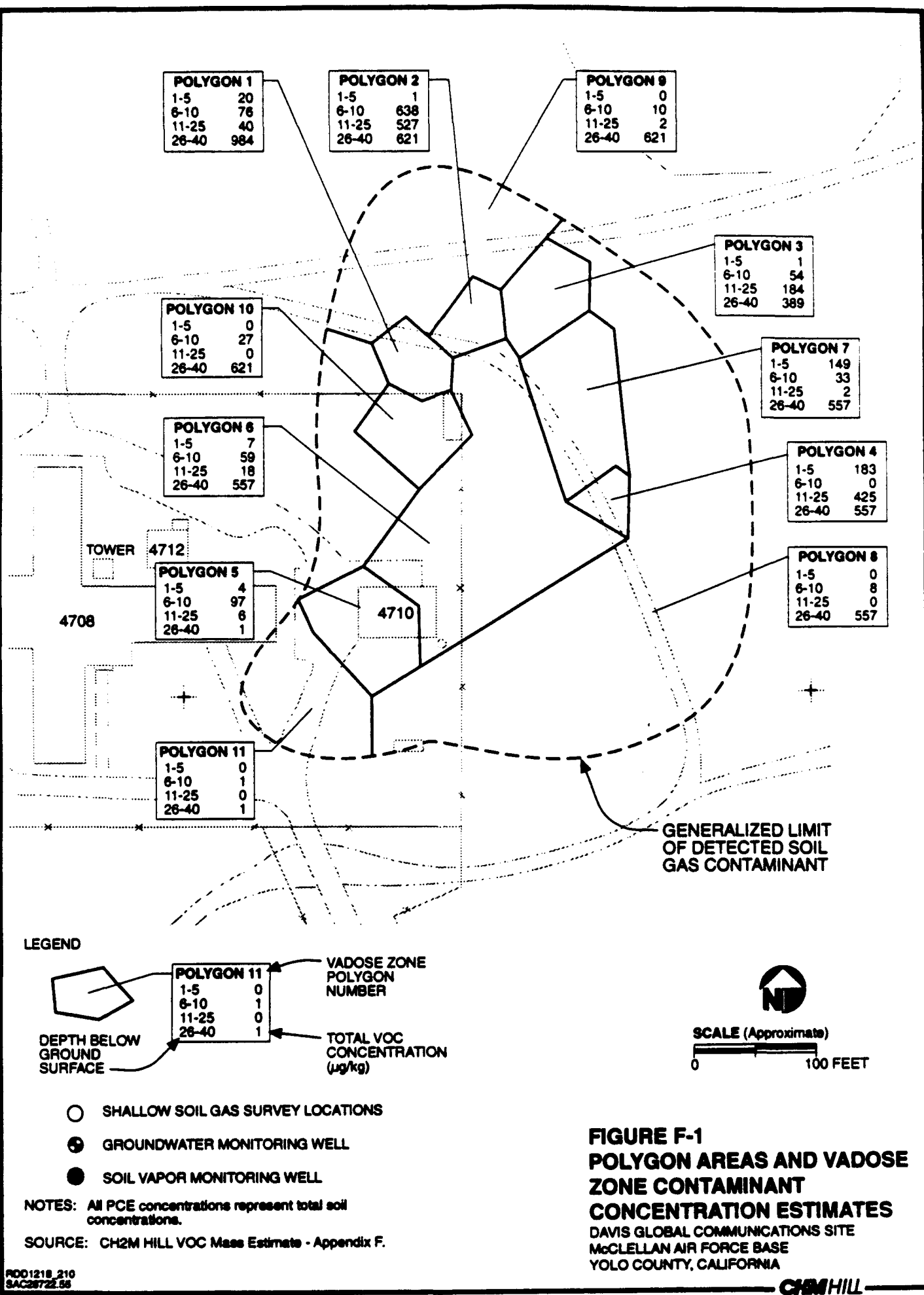
Emissions, concentrations in air, potential inhalation exposures, and health risks were estimated for complete pathways of exposure only. The two possible air exposure pathways are inhalation of contaminants adsorbed to windblown dust and inhalation of contaminants volatilized from soil. Observation of site conditions indicated that there were no complete pathways of exposure to windblown dust. With the exception of the soil piles, there were no contaminants in exposed surface soils. Many of the low-volatile contaminants in soil, such as petroleum hydrocarbons, originated from leaks from underground fuel tanks. Also, much of the site is covered with annual grasses. Given these site conditions, complete exposure pathways from windblown dust emissions are unlikely. Concentrations of VOCs detected in soil gas at the site could diffuse, be emitted from the soil surface, and disperse in either indoor or ambient air. Contaminant intake could potentially occur from inhalation by workers at the

site of the concentrations in air. Therefore, inhalation by workers of VOCs emitted from soil gas was assumed to be a complete exposure pathway.

Shallow soil gas sampling performed in 1992 by CH2M HILL provided the data used to evaluate potential inhalation exposures to VOCs emitted from soil at the site. Soil gas samples were collected from an area of approximately 4 acres. The samples have been collected inside the main compound area and outside the perimeter fence surrounding the facility. Samples were collected from depths ranging from 5 to 40 feet below ground surface (bgs) in areas where soil gas contaminants were detected in previous investigations (ITC, 1992) and near former underground diesel storage tanks. To evaluate potential exposures to onsite workers, four samples from a depth of 5 feet have been collected around Building 4708. All soil gas samples were analyzed in the field using EPA Method 8021. Approximately 15 percent of the field samples were analyzed in a fixed laboratory using Method TO-14. Both the field and fixed laboratory data were used to evaluate potential air exposure pathways.

Soil gas sampling locations and the approximate extent of VOC contamination in soil gas at the site are presented in Figure F-1. A summary of the soil gas sampling and analytical data is presented in Appendix C, Site Conceptual Model. Note that the western edge of the contaminant plume underlies Building 4710. Building 4710 houses a diesel generator used to supply auxiliary power. It is not used continuously as a work space (i.e., workers are not in this building for an entire work shift). Typically, the generator is operated for approximately 1 hour per day. Building 4708 is the main facility for the site. This building houses office space, and could reasonably be inhabited by workers for an entire work shift. Building 4708 is located approximately 100 feet west of Building 4710. Sampling and analytical results from the four samples collected near Building 4708 are presented in Table F-1.

Table F-1 Soil Gas Analytical Results Near Building 4708 Davis Global Communications Site									
Sample	Contaminant (in $\mu\text{g/l}$)								
	Vinyl Chloride	1,1-DCE	TCE	PCE	Benzene	Toluene	Ethylbenzene	m- and p-Xylenes	o-Xylene
RA01-05	<0.01	<0.01	<0.01	2.8	0.05	0.08	<0.01	0.11	<0.01
RA02-05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
RA03-05A	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
RA03-05B	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
RA04-05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
RA05-05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Note: 1,1-DCE = 1,1-dichloroethene; TCE = trichloroethene; PCE = tetrachloroethene									



Emissions Estimation

Emissions from Soil Gas

The soil gas sampling data were area-averaged to obtain an average surface flux emission across the entire area of contamination shown in Figure F-1. The area in which the mass estimate was to be performed was delineated using the available data to outline the known extent of the plume. The area was then subdivided into polygonal areas using either the Thiessen method or grouping by similar contaminant levels. The surface area of each polygon then was determined using a planimeter. The areas around the soil vapor monitoring wells were contained in smaller polygons as these were areas of more intensive sampling. The area that did not fall within the polygons established around the soil vapor monitoring wells was divided based on similar total VOC concentrations. The site and the corresponding polygons are shown in Figure F-1.

Polygons 6 through 11 only had data from the shallow soil gas survey, and no data between 26 through 40 feet bgs were available for those areas. To compensate for the lack of data in these polygons, the VOC concentration found in the nearest soil vapor monitoring well was extrapolated into the adjacent polygon. This procedure is considered to provide a conservatively high estimate of the VOC mass in these polygons. This methodology is consistent with the method used in the RI/FS report to estimate VOC mass in soil for purposes of unsaturated zone transport modeling. Further discussion of this methodology can be obtained from the RI/FS report (CH2M HILL, 1993).

VOCs reported as not detected in samples were not considered in the development of surface flux emissions estimates. Surface flux emissions were estimated as steady-state values from each soil gas sample; the measured soil gas concentrations were not assumed to deplete over time due to volatilization or diffusion to groundwater. This would tend to overestimate surface fluxes averaged over time. The highest surface flux estimated in each source area was used to calculate the area-averaged surface flux:

$$Q = \sum \frac{Q_i A_i}{A_{tot}} \quad (1)$$

Q_i is the highest surface flux in each source area ($\text{g/m}^2\text{-s}$), A_i is the surface area of that source area, A_{tot} is the total surface area of the approximate extent of VOC contamination in soil gas at the site, and Q is the area-averaged surface flux ($\text{g/m}^2\text{-s}$). The value for Q was used to calculate VOC concentrations in air. Summary statistics of the surface flux emissions estimates in each of the source areas are presented in Attachment F-1. The area-averaged surface flux emissions estimates appear in Attachment F-2. The method used to estimate surface flux emissions from soil gas concentrations is described below.

Contaminant diffusion and volatilization is the principal pathway for volatile organic contaminant loss from soils, and is a complex process controlled by soil, contaminant, and atmospheric processes. In general, contaminants with high Henry's Law constants are more volatile, move more readily through soil via vapor diffusion, and tend to move relatively independently of atmospheric conditions.¹ Factors that limit diffusion, such as increased adsorption to soil and increased soil moisture content, can decrease the amount of volatilization that occurs. Factors that increase volatilization include increased soil temperature and increased VOC concentrations in soil (Jury and Valentine, 1986).

VOC emissions from soil gas were estimated using the covered-landfill emission model developed by Farmer et al. (1980). This steady-state model is also cited in the *Superfund Exposure Assessment Manual* (U.S. EPA, 1988). The model is used to predict emissions from a covered landfill based on Fick's First Law of diffusion, and accounts for many of the processes described previously. Diffusion of contaminants to the soil surface is described by diffusion relationships developed by Millington and Quirk (1961). The model is presented as follows:

$$Q_i = D \left(\frac{P_A^{10/3}}{P_T^2} \right) \left(\frac{C_i}{L} \right) \quad (2)$$

The parameters for this equation are presented in Table F-2.

Table F-2 Parameters For Estimating VOC Surface Flux Emissions			
Parameter	Description	Units	Value
Q	Surface emission flux from source area i	g/m ² -s	calculated from Eq. 2
D	Diffusion rate of contaminant in air	cm ² /s	contaminant-specific
P _A	Air-filled porosity of soil	unitless	0.2
P _T	Total porosity of soil	unitless	0.4
C	Concentration in soil gas at depth L	g/cm ³	highest soil gas concentration from source area i
L	Depth of soil cover	cm	sample-specific

Tabulated diffusion coefficients were available for most VOCs in soil gas at the site (U.S. EPA, 1988; Shen, 1981). These values are presented in Table F-3. Contaminants without tabulated diffusion rates were 1,1,2-trichloro-1,2,2-trifluoromethane, and dichlorodifluoromethane. The diffusion rates for these contaminants were estimated with the following equation (U.S. EPA, 1988):

$$D_i = D \sqrt{\frac{MW}{MW_i}} \quad (3)$$

Where:

¹ Henry's Law constant, the ratio of vapor concentration to the aqueous concentration, is an index of the partitioning of a contaminant between dissolved and gaseous phases. The larger the value of Henry's constant, the more likely the contaminant is to move by vapor diffusion as opposed to liquid diffusion.

- D_i = the diffusion coefficient
- MW_i = the molecular weight for the contaminant of interest
- D = the tabulated diffusion coefficient
- MW = the molecular weight for the contaminant with a tabulated diffusion coefficient.

The tabulated diffusion coefficient for trichlorofluoromethane was used to estimate the diffusion coefficients for the other two contaminants.

Table F-3 Diffusion Coefficients		
Contaminant	Molecular Weight	Diffusion Coefficient at 10°C ^a (cm ² /s)
Benzene	78	0.08195
Dichlorodifluoromethane ^c	103	0.08555
Dichloroethane ^b	99	0.08557
Dichloroethene ^c	97	0.07442
Ethylbenzene	116	0.06274
Tetrachloroethene (PCE)	166	0.06968
Toluene	92	0.07367
Trichloroethane	131	0.07638
1,1,1-Trichloroethane	133	0.07496
Trichlorofluoromethane	138	0.07391
1,1,3-Trichloro-1,3,3-trifluoromethane ^c	187	0.06349
Vinyl chloride	63	0.10094
Xylene ^d	106	0.06742
^a Source: EPA, 1988 except where noted as calculated value. ^b Used for both 1,1-dichloroethane and 1,2-dichloroethane. ^c Used for both 1,1-dichloroethene and cis-1,2-dichloroethene. ^d Used for m- and p-xylene and o-xylene. ^e Calculated diffusion coefficient.		

Estimation of VOC Emissions from Sprinkler Irrigation

Water from the site production well is used for irrigating approximately 2.5 acres of landscaping. Total pumping rate from the production well, for both sanitary and irrigation uses, was reported to range from 200,000 to 600,000 gallons per month between 1988 and 1989. Specific amounts used for irrigation are not known, and a use rate of 600,000 gallons per month was assumed for purposes of estimating VOC emissions from water used for sprinkler irrigation.

Based on Henry's Law constants, several of the contaminants detected in production well water would tend to volatilize as the water was used for sprinkler irrigation. A

first approximation of the magnitude of VOC emissions during sprinkler irrigation was estimated using water-to-air transfer coefficients measured with radon (Prichard and Gesell, 1981). This methodology is similar to the one used by EPA to estimate VOC emissions and concentrations in indoor air from residential water use (Andelman, 1990; U.S. EPA, 1991). These data indicate 30 to 90 percent volatilization of radon from water, depending upon water use (Prichard and Gesell, 1981). The transfer efficiencies (percent volatilization) among the different water uses appear in Table F-4.

Table F-4 Transfer Efficiencies for Radon for Various Water Uses in a Typical House		
Water Use	Daily Quantity (l)	Transfer Efficiency (%)
Showers	150	63
Tub baths	150	47
Toilet	365	30
Laundry	130	90
Dishwasher	55	90
Drinking and kitchen	30	30
Cleaning	10	90
Total	890	
Source: Prichard and Gesell, 1981.		

A transfer efficiency for showering (63 percent or 0.63) was considered appropriate for water-to-air transfer of VOCs during sprinkler irrigation. Emissions of VOCs would occur only during periods when sprinklers were operating. According to site personnel, sprinklers generally operate 1 hour a day, 3 days a week (Olgerson, 1993). Emissions at all other times would be zero. Estimating emissions as proportional to water use provides emission rates averaged over all time periods. The steps involved with emissions estimation were:

- Convert water use from gallons per month to l/s
- Convert concentrations in water from $\mu\text{g/l}$ to liquid emission rate, $\mu\text{g/s}$
- Calculate vapor emission rate in $\mu\text{g/s}$ using the transfer coefficient

Sample calculations of the VOC emissions during sprinkler irrigation are presented in Attachment F-3.

Estimation of Concentrations in Air

Concentrations in air associated with VOC emissions from soil gas and sprinkler irrigation were estimated using screening-level models based on conservative assumptions. Estimated inhalation exposures to VOC emissions were based on the assumption that an individual was located over an emissions source for the entire duration of

exposure (in this case, 8 hours per day, 250 days per year for 25 years). Since there are structures located over VOC contamination in soil gas, screening-level estimates of concentrations in both outdoor and indoor air were developed for purposes of estimating inhalation exposures. The following sections describe the methods used to estimate VOC concentrations in outdoor and indoor air.

Estimation of Concentrations in Outdoor Air

Concentrations in air from emissions from an area source (such as surface flux emissions) are expected to be highest at the source and decrease with increasing distance from the source. Therefore, the screening-level approach for evaluating concentrations in outdoor air from VOC emissions from soil gas involves calculating concentrations over the source area. Standard atmospheric dispersion models, such as the Industrial Source Complex - Short Term (ISCST) and SCREEN models, are not designed to calculate concentrations in air over an area source. EPA has recommended use of a "box" model for calculating concentrations in air over an area source (U.S. EPA, 1986; 1991). In the box model, concentration in air within a defined box is proportional to the emission rate and wind speed across the source area:

$$C_o = \frac{Q \times A \times 1,000 \text{ mg/g}}{L \times V \times H} \quad (4)$$

The parameters for this equation are presented in Table F-5.

Table F-5 Parameters for Estimating VOC Concentrations in Outdoor Air			
Parameter	Description	Units	Value
C _o	Concentration in outdoor air	mg/m ³	Calculated in Eq. 5
Q	Surface emissions flux	g/m ² -s	Calculated value
A	Source area surface area	m ²	10,000
L	Width of source area perpendicular to wind direction	m	100
V	Average windspeed within the box	m/s	2.3
H	Box height	m	2

Values for Q were area-averaged surface emission fluxes estimated using the methods described in the previous section. The approximate extent of soil gas contamination was estimated to be 10,000 m², as shown in Attachment F-1. The value for L is assumed to be the square root of A. The value for V was based on an annual average windspeed of 10 miles per hour for Yolo County (see Appendix B, Site Background Information). As recommended by EPA, the average windspeed within the box is assumed to be 0.5, the annual average windspeed. The value for H represents the breathing zone for an individual. Concentrations in outdoor air estimated with the box model are presented in Attachment F-2.

Estimation of Concentrations in Indoor Air

Concentrations in indoor air were estimated for Building 4708. VOCs were detected in shallow soil gas samples collected from the periphery of Building 4708. Estimation of indoor air concentrations are based generally on the following:

$$C_i = \frac{E \times 1,000 \text{ mg/g}}{Q_v} \quad (5)$$

A simplifying assumption used in estimating E is that soil gas enters a structure only by diffusion (differences in air pressure between indoors and soil gas may be a more important process in soil gas infiltration into buildings). Emissions into the building can then be estimated as:

$$E = Q_v \times A \times F \quad (6)$$

The value for Q_v can be estimated as follows:

$$Q_v = \frac{ACH \times V}{3600 \text{ s/hr}} \quad (7)$$

The parameters used in these equations appear in Table F-6.

Table F-6 Parameters for Estimating VOC Concentrations in Indoor Air			
Parameter	Description	Units	Value
C_i	Concentration in indoor air	mg/m ³	Calculated
E	Contaminant infiltration rate	g/s	Calculated
Q_v	Structure ventilation flow rate	m ³ /s	1.26
Q	Surface emission flux	g/m ² -s	Calculated
A	Floor area of the structure	m ²	1,858
F	Fraction of floor area through which soil gas can enter	unitless	1
ACH	Structure air changes per hour	1/hr	1
V	Structure volume	m ³	4,530.5

Values for A were estimated from the building footprints presented on site figures. Values for V were estimated assuming an 8-foot ceiling height. Values for ACH for single-family residences reportedly range from 0.5 to 1.5. These values could range from 0.5 to 0.8 in an energy-efficient structure (U.S. EPA, 1992b; Mueller Associates, 1988). ACH was assumed to be 1.0 for the structures at the site. The highest surface emission fluxes estimated in Source Area No. 5 were used to estimate the contaminant infiltration rate in Building 4710. Surface emissions fluxes estimated from the soil gas concentrations presented in Table F-1 were used to estimate the contaminant infiltration rate in Building 4708.

Another simplifying assumption used to estimate values for E is to set $F = 1$, which corresponds to diffusion of VOCs into a building from a bare dirt floor. Radon measurements indicate that values for F range from 0.7 to 1.0 for single-family homes with ventilated crawl spaces (Nazaroff and Doyle, 1985).

Concrete slabs, which are a common floor surface, are likely to be less permeable to soil gas than bare soil; therefore it appears reasonable to assume that $F < 1$ for estimating emissions into a structure on a concrete slab. One assumption is that $F = 0.001$ (U.S. EPA, 1992). This assumption is based on data indicating that the typical California home has exposed area of 2 to 10 cm^2 per m^2 of floor space (ASHRAE, 1989), and data indicating that the area of cracks in a slab is 0.01 to 0.1 percent of total floor space (Turk et al., 1986). Another assumption used is that soil gas enters a building only through a 0.5-cm-wide crack around the building perimeter at the slab-wall interface (U.S. EPA, 1992b). Note that this approach results in F becoming smaller as floor area increases. The technical literature does not support the use of values of $F < 1$ based on percent cracked area in the concrete slabs for estimating the attenuation of VOC emissions into structures, and their use is not recommended (U.S. EPA, 1992b). Soil gas intrusion into structures through floor cracks probably occurs through a "chimney" effect based on differences in pressure between soil gas and indoors, and it may not be appropriate to estimate VOC emissions through floor cracks using emissions models based on diffusion.

Calculations of the indoor air concentrations in Building 4708 are presented in Attachment F-4.

Works Cited

Andelman, J. B. 1990. "Total Exposure to Volatile Organic Chemicals in Potable Water." *Significance and Treatment of Volatile Organic Compounds in Water*. N.M. Ram, R.F. Christman and K.P. Cantor, eds. Chelsea, MI: Lewis Publishers.

ASHRAE. 1989. Ventilation of Acceptable Indoor Air Quality. ASHRAE Standard 62-1989. American Society of Heating, Refrigerating, and Air Conditioning Engineers. Atlanta, GA.

CH2M HILL. 1992. Draft Final Work Plan, Davis Global Communications Site. McClellan Air Force Base. July.

CH2M HILL. 1993. Remedial Investigation/Feasibility Study Report for the Davis Global Communications Site. Working Copy. McClellan Air Force Base. October.

Farmer, W. J., M. S. Yang, and J. Letey. 1980. *Land Disposal of Hexachlorobenzene Wastes: Controlling Vapor Movement in Soil*. EPA/600/2-80/119.

ITC. 1992. Preliminary Groundwater Remedial Investigation Report. Davis Global Communications Site, McClellan AFB. Volume I. April.

Jury, W. A., and R. L. Valentine. 1986. Transport mechanisms and loss pathways for chemicals in soil, in *Vadose Zone Modeling of Organic Pollutants*. Hern, S.C. and S.M. Melancon, eds. Chelsea, MI: Lewis Publishers, Inc.

Millington, R. J., and J. P. Quirk. 1961. "Permeability of Porous Solids." *Trans. Faraday Soc.* 57:1200-1207.

Mueller Associates, Syscon and Brookhaven National Laboratory. 1988. *Handbook of Radon in Buildings*. New York, NY: Hemisphere Publishing Co.

Nazaroff, W. W., and S. M. Doyle. 1985. "Radon Entry into Homes Having a Crawl Space." *Health Phys.* 48:265-281.

Olgerson, MSgt., Global Communications Center. 1993. Personal communication with John Lowe, CH2M HILL. August 6.

Prichard, H. M., and T. F. Gesell. 1981. "An Estimate of Population Exposures Due to Radon in Public Water Supplies in the Area of Houston, Texas." *Health Phys.* 41:599-606.

Shen, T. 1981. "Estimating Hazardous Air Emissions from Disposal Sites." *Pollution Engineering*. 13:31-34.

Turk, B. H., R. J. Prill, W. J. Fisk, D. T. Grimsrud, B. A. Moed, and R. G. Sextro. 1986. Paper No. 86-43.2. *Proceedings of the 79th Annual Meeting of the Air Pollution Control Association*.

U.S. EPA. 1986. *Development of Advisory Levels for Polychlorinated Biphenyls (PCBs) Cleanup*. EPA/600/6-86/002.

U.S. EPA. 1988. *Superfund Exposure Assessment Manual*. EPA/540/1-88/001.

U.S. EPA. 1991. *Risk Assessment Guidance for Superfund. Volume I. Development of Risk-Based Preliminary Remediation Goals*. Interim. Publication 9285.7-01B. December.

U.S. EPA. 1992a. *Air/Superfund National Technical Guidance Study Series. Guideline for Predictive Baseline Emissions Estimation Procedures for Superfund Sites*. EPA/450/1-92/002. January.

U.S. EPA. 1992b. *Air/Superfund National Technical Guidance Study Series. Assessing Potential Indoor Air Impacts for Superfund Sites*. EPA/451/R-92/002. September.

Attachment F-1
Summary Statistics of Surface Flux Estimates
in Each Source Area

Summary Statistics of Surface Flux Measurements in Each Source Area									
Davis Global Communications Site									
Parameter name	Number of Detects	Number of Samples	Frequency of Detects	Estimated Surface Flux Emissions (g/m ² s)			Coefficient of variation		
				Minimum value of detects	Maximum value of detects	Mean	Standard deviation		
Source Area No. 1									
1,1,1-TRICHLOROETHANE	2	4	0.50	6.67E-13	8.01E-13	3.67E-13	4.27E-13	1.16	
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	2	4	0.50	5.03E-12	1.83E-10	4.70E-11	9.06E-11	1.93	
1,1-DICHLOROETHANE	1	1	1.00	5.78E-13	5.78E-13	5.78E-13			
1,1-DICHLOROETHENE	4	5	0.80	2.50E-12	1.34E-10	3.11E-11	5.76E-11	1.85	
BENZENE	2	5	0.40	5.12E-13	1.56E-12	4.15E-13	6.78E-13	1.64	
DICHLORODIFLUOROMETHANE	1	1	1.00	5.20E-13	5.20E-13	5.20E-13			
M,P-XYLENE (SUM OF ISOMERS)	2	4	0.50	3.40E-13	2.33E-11	5.91E-12	1.16E-11	1.96	
O-XYLENE (1,2-DIMETHYLBENZENE)	1	4	0.25	1.04E-11	1.04E-11	2.59E-12	5.18E-12	2.00	
TETRACHLOROETHYLENE(PCE)	5	5	1.00	8.20E-10	1.45E-08	4.08E-09	5.87E-09	1.44	
TOLUENE	4	5	0.80	2.09E-13	1.31E-09	2.66E-10	5.82E-10	2.19	
TRICHLOROETHYLENE (TCE)	4	5	0.80	3.67E-12	2.33E-10	5.16E-11	1.02E-10	1.97	
VINYL CHLORIDE		1				0.00E+00			
cis-1,2-DICHLOROETHYLENE	1	4	0.25	2.12E-12	2.12E-12	5.29E-13	1.06E-12	2.00	
Source Area No. 2									
1,1,1-TRICHLOROETHANE	2	2	1.00	4.09E-11	4.45E-11	4.27E-11	2.57E-12	0.06	
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	2	2	1.00	7.62E-11	8.49E-11	8.05E-11	6.16E-12	0.08	
1,1-DICHLOROETHANE		1				0.00E+00			
1,1-DICHLOROETHENE	3	5	0.60	2.43E-11	1.67E-10	6.69E-11	8.16E-11	1.22	
BENZENE	2	5	0.40	1.57E-12	3.14E-12	9.42E-13	1.40E-12	1.49	
DICHLORODIFLUOROMETHANE		1				0.00E+00			
M,P-XYLENE (SUM OF ISOMERS)	2	4	0.50	1.62E-12	7.77E-12	2.35E-12	3.69E-12	1.57	
O-XYLENE (1,2-DIMETHYLBENZENE)	1	4	0.25	1.62E-12	1.62E-12	4.04E-13	8.09E-13	2.00	
TETRACHLOROETHYLENE(PCE)	5	5	1.00	4.35E-2	2.27E-08	8.71E-09	9.62E-09	1.10	
TOLUENE	2	5	0.40	1.77E-12	1.38E-10	2.80E-11	6.17E-11	2.20	
TRICHLOROETHYLENE (TCE)	3	5	0.60	2.79E-10	3.89E-10	1.90E-10	1.79E-10	0.94	

Summary Statistics of Surface Flux Measurements in Each Source Area

Davis Global Communications Site

Summary Statistics of Surface Flux Measurements in Each Source Area									
Davis Global Communications Site									
Parameter name	Number of Detects	Number of Samples	Frequency of Detects	Estimated Surface Flux Emissions (g/m ² -s)				Coefficient of variation	
				Surface Flux Emissions					
				Minimum value of detects	Maximum value of detects	Mean	Standard deviation		
Source Area No. 3									
VINYL CHLORIDE		1				0.00E+00			
cis-1,2-DICHLOROETHYLENE	1	2	0.50	9.15E-13	9.15E-13	4.58E-13	6.47E-13		1.41
Source Area No. 3									
1,1,1-TRICHLOROETHANE	2	3	0.67	1.03E-11	3.12E-11	1.38E-11	1.59E-11		1.15
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE		3				0.00E+00			
1,1-DICHLOROETHANE	1	1	1.00	4.63E-13	4.63E-13	4.63E-13			
1,1-DICHLOROETHENE	4	6	0.67	4.46E-12	1.27E-10	4.07E-11	5.00E-11		1.23
BENZENE	4	6	0.67	5.24E-13	4.09E-11	7.49E-12	1.64E-11		2.19
DICHLORODIFLUOROMETHANE		1				0.00E+00			
M,P-XYLENE (SUM OF ISOMERS)	2	5	0.40	1.62E-12	5.05E-11	1.04E-11	2.24E-11		2.15
O-XYLENE (1,2-DIMETHYLBENZENE)	2	5	0.40	1.62E-12	2.20E-11	4.72E-12	9.68E-12		2.05
TETRACHLOROETHYLENE(PCE)	6	6	1.00	2.94E-11	6.42E-09	3.45E-09	2.25E-09		0.65
TOLUENE	5	6	0.83	3.40E-13	8.06E-11	1.47E-11	3.23E-11		2.20
TRICHLOROETHYLENE (TCE)	5	6	0.83	5.21E-11	2.30E-10	1.31E-10	9.13E-11		0.70
VINYL CHLORIDE		1				0.00E+00			
cis-1,2-DICHLOROETHYLENE	1	3	0.33	1.77E-12	1.77E-12	5.91E-13	1.02E-12		1.73
Source Area No. 4									
1,1,1-TRICHLOROETHANE	1	2	0.50	9.46E-12	9.46E-12	4.73E-12	6.69E-12		1.41
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	1	2	0.50	4.40E-12	4.40E-12	2.20E-12	3.11E-12		1.41
1,1-DICHLOROETHANE	1	1	1.00	3.41E-12	3.41E-12	3.41E-12			
1,1-DICHLOROETHENE	3	4	0.75	1.71E-10	3.61E-10	2.00E-10	1.54E-10		0.77
BENZENE	1	4	0.25	2.08E-12	2.08E-12	5.19E-13	1.04E-12		2.00
DICHLORODIFLUOROMETHANE		1				0.00E+00			
M,P-XYLENE (SUM OF ISOMERS)	1	3	0.33	6.47E-12	6.47E-12	2.16E-12	3.74E-12		1.73
O-XYLENE (1,2-DIMETHYLBENZENE)		3				0.00E+00			

Summary Statistics of Surface Flux Measurements in Each Source Area Davis Global Communications Site									
Parameter name	Number of Detects	Number of Samples	Frequency of Detects	Estimated Surface Flux Emissions (g/m ² s)			Coefficient of variation		
				Minimum value of detects	Maximum value of detects	Mean			
TETRACHLOROETHYLENE(PCE)	3	4	0.75	6.70E-09	1.18E-08	6.57E-09	4.89E-09		0.74
TOLUENE	1	4	0.25	7.46E-12	7.46E-12	1.87E-12	3.73E-12		2.00
TRICHLOROETHYLENE (TCE)	3	4	0.75	1.37E-09	1.86E-09	1.23E-09	8.45E-10		0.69
VINYL CHLORIDE		1				0.00E+00			
cis-1,2-DICHLOROETHYLENE	2	2	1.00	3.30E-11	5.24E-11	4.27E-11	1.37E-11		0.32
Source Area No. 5									
1,1,1-TRICHLOROETHANE		3				0.00E+00			
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	1	3	0.33	2.12E-12	2.12E-12	7.07E-13	1.23E-12		1.73
1,1-DICHLOROETHANE	1	1	1.00	1.02E-12	1.02E-12	1.02E-12			
1,1-DICHLOROETHENE		7				0.00E+00			
BENZENE	2	7	0.29	1.57E-12	3.14E-11	4.70E-12	1.18E-11		2.50
DICHLORODIFLUOROMETHANE	1	1	1.00	1.41E-11	1.41E-11	1.41E-11			
M,P-XYLENE (SUM OF ISOMERS)	3	6	0.50	1.29E-12	1.05E-09	1.78E-10	4.30E-10		2.41
O-XYLENE (1,2-DIMETHYLBENZENE)	2	6	0.33	1.04E-11	1.13E-09	1.90E-10	4.62E-10		2.42
TETRACHLOROETHYLENE(PCE)	5	6	0.83	3.34E-12	3.48E-09	6.82E-10	1.38E-09		2.02
TOLUENE	4	7	0.57	2.12E-12	9.01E-10	1.99E-10	3.57E-10		1.80
TRICHLOROETHYLENE (TCE)	2	7	0.29	2.36E-12	6.60E-12	1.28E-12	2.50E-12		1.96
VINYL CHLORIDE	1	1	1.00	4.41E-11	4.41E-11	4.41E-11			
cis-1,2-DICHLOROETHYLENE	1	3	0.33	1.19E-12	1.19E-12	3.98E-13	6.89E-13		1.73
Source Area No. 6									
1,1,1-TRICHLOROETHANE	1	2	0.50	1.83E-12	1.83E-12	9.15E-13	1.29E-12		1.41
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	1	2	0.50	2.93E-12	2.93E-12	1.46E-12	2.07E-12		1.41
1,1-DICHLOROETHENE	1	14	0.07	1.93E-11	1.93E-11	1.38E-12	5.15E-12		3.74
BENZENE	7	14	0.50	1.90E-12	2.12E-11	6.30E-12	8.13E-12		1.29

Summary Statistics of Surface Flux Measurements in Each Source Area									
Davis Global Communications Site									
Parameter name	Number of Detects	Number of Samples	Frequency of Detects	Estimated Surface Flux Emissions (g/m ² -s)			Coefficient of variation		
				Minimum value of detects	Maximum value of detects	Mean			
M,P,XYLENE (SUM OF ISOMERS)	7	14	0.50	4.19E-12	2.72E-11	7.34E-12	9.45E-12		1.29
O-XYLENE (1,2-DIMETHYLBENZENE)	7	14	0.50	1.69E-12	1.88E-11	5.61E-12	7.19E-12		1.28
TETRACHLOROETHYLENE(PCE)	9	14	0.64	6.69E-12	9.36E-10	1.95E-10	3.06E-10		1.57
TOLUENE	8	15	0.53	2.62E-12	4.95E-11	1.24E-11	1.87E-11		1.51
TRICHLOROETHYLENE (TCE)	5	14	0.36	2.82E-12	1.98E-10	1.81E-11	5.24E-11		2.89
cis-1,2-DICHLOROETHYLENE		2				0.00E+00			
Source Area No. 7									
1,1,1-TRICHLOROETHANE		1				0.00E+00			
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE		1				0.00E+00			
1,1-DICHLOROETHENE	1	5	0.20	7.57E-11	7.57E-11	1.51E-11	3.39E-11		2.24
BENZENE	2	5	0.40	1.26E-11	1.57E-11	5.66E-12	7.83E-12		1.38
M,P,XYLENE (SUM OF ISOMERS)	5	5	1.00	1.62E-12	1.68E-11	1.04E-11	6.94E-12		0.67
O-XYLENE (1,2-DIMETHYLBENZENE)	3	5	0.60	7.77E-12	1.55E-11	7.25E-12	7.18E-12		0.99
TETRACHLOROETHYLENE(PCE)	4	5	0.80	5.35E-12	1.03E-08	2.29E-09	4.50E-09		1.96
TOLUENE	5	5	1.00	1.41E-12	1.41E-11	8.63E-12	5.62E-12		0.65
TRICHLOROETHYLENE (TCE)	3	5	0.60	7.77E-12	5.86E-10	1.25E-10	2.58E-10		2.06
cis-1,2-DICHLOROETHYLENE		1				0.00E+00			
Source Area No. 8									

Summary Statistics of Surface Flux Measurements in Each Source Area

Davis Global Communications Site

Parameter name	Number of Detects	Number of Samples	Frequency of Detects	Estimated Surface Flux Emissions (g/m ² s)			Coefficient of variation
				Minimum value of detects	Maximum value of detects	Mean	Standard deviation
1,1,1-TRICHLOROETHANE		2				0.00E+00	
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE		2				0.00E+00	
1,1-DICHLOROETHENE		18				0.00E+00	
BENZENE	2	18	0.11	4.72E-12	5.51E-12	5.68E-13	1.66E-12
M,P-XYLENE (SUM OF ISOMERS)	5	18	0.28	2.53E-13	7.12E-12	9.85E-13	2.09E-12
O-XYLENE (1,2-DIMETHYLBENZENE)	1	18	0.06	4.53E-12	4.53E-12	2.52E-13	1.07E-12
TETRACHLOROETHYLENE(PCE)	12	18	0.67	2.01E-12	1.27E-10	1.42E-11	2.99E-11
TOLUENE	6	18	0.33	2.47E-12	9.90E-12	2.14E-12	3.50E-12
TRICHLOROETHYLENE (TCE)	5	18	0.28	2.93E-12	4.47E-11	3.34E-12	1.05E-11
cis-1,2-DICHLOROETHYLENE		2				0.00E+00	
Source Area No. 9							
1,1-DICHLOROETHENE	2	6	0.33	1.14E-11	6.00E-11	1.19E-11	2.40E-11
BENZENE	1	6	0.17	7.08E-12	7.08E-12	1.18E-12	2.89E-12
M,P-XYLENE (SUM OF ISOMERS)	3	6	0.50	1.29E-12	8.41E-12	2.91E-12	4.05E-12
O-XYLENE (1,2-DIMETHYLBENZENE)	1	6	0.17	1.23E-11	1.23E-11	2.05E-12	5.02E-12
TETRACHLOROETHYLENE(PCE)	3	6	0.50	4.01E-12	3.36E-10	6.20E-11	1.35E-10
TOLUENE	4	6	0.67	1.41E-12	1.56E-11	5.66E-12	6.81E-12
TRICHLOROETHYLENE (TCE)	1	6	0.17	3.67E-12	3.67E-12	6.11E-13	1.50E-12

Summary Statistics of Surface Flux Measurements in Each Source Area									
Davis Global Communications Site									
Parameter name	Number of Detects	Number of Samples	Frequency of Detects	Estimated Surface Flux Emissions (g/m ² s)			Coefficient of variation		
				Minimum value of detects	Maximum value of detects	Mean	Standard deviation		
Source Area No. 10									
TETRACHLOROETHYLENE(PCE)	1	1			9.70E-10				
Source Area No. 11									
TETRACHLOROETHYLENE(PCE)	1	1		1.34E-16	2.34E-15				

VOC Surface Flux Estimates by Soil Gas Sample
Davis Global Communications Site

Sample	Sample Date	Starting Depth (ft)	Ending Depth (ft)	Emission Depth (cm)	Parameter Name	Concentration (ug/L)	Qualifier	Polygon	Diffusion Coefficient (cm ² /s)	Concentration (g/mcm ³)	Emission flux (g/m ² s)
SG41-20	22-SEP-92	0	20	609.6	1,1,1-TRICHLOROETHANE	0	ND		0.07496	0.00E+00	0.00E+00
SG41-20	22-SEP-92	0	20	609.6	1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	0	ND		0.06349	0.00E+00	0.00E+00
SG10-10	17-SEP-92	0	10	304.8	1,1-DICHLOROETHENE	0	ND		0.07442	0.00E+00	0.00E+00
SG28-10	18-SEP-92	0	10	304.8	1,1-DICHLOROETHENE	0	ND		0.07442	0.00E+00	0.00E+00
SG41-20	22-SEP-92	0	20	609.6	1,1-DICHLOROETHENE	0	ND		0.07442	0.00E+00	0.00E+00
SG42-20A	22-SEP-92	0	20	609.6	1,1-DICHLOROETHENE	0	ND		0.07442	0.00E+00	0.00E+00
SG43-10	06-OCT-92	0	10	304.8	1,1-DICHLOROETHENE	0.05	=		0.07442	5.00E-11	3.57E-12
SG44-10	06-OCT-92	0	10	304.8	1,1-DICHLOROETHENE	0.12	=		0.07442	1.20E-10	8.57E-12
SG45-10	06-OCT-92	0	10	304.8	1,1-DICHLOROETHENE	0.09	=		0.07442	9.00E-11	6.43E-12
SG46-10	06-OCT-92	0	10	304.8	1,1-DICHLOROETHENE	0.03	=		0.07442	3.00E-11	2.14E-12
SG10-10	17-SEP-92	0	10	304.8	BENZENE	0	ND		0.08195	0.00E+00	0.00E+00
SG28-10	18-SEP-92	0	10	304.8	BENZENE	0	ND		0.08195	0.00E+00	0.00E+00
SG41-20	22-SEP-92	0	20	609.6	BENZENE	0.00713	=		0.08195	7.13E-12	2.80E-13
SG42-20A	22-SEP-92	0	20	609.6	BENZENE	0.05	=		0.08195	5.00E-11	1.97E-12
SG43-10	06-OCT-92	0	10	304.8	BENZENE	0.01	=		0.08195	1.00E-11	7.87E-13
SG44-10	06-OCT-92	0	10	304.8	BENZENE	0.05	=		0.08195	5.00E-11	3.93E-12
SG45-10	06-OCT-92	0	10	304.8	BENZENE	0.05	=		0.08195	5.00E-11	3.93E-12
SG46-10	06-OCT-92	0	10	304.8	BENZENE	0.05	=		0.08195	5.00E-11	3.93E-12
SG10-10	17-SEP-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	0	ND		0.06742	0.00E+00	0.00E+00
SG28-10	18-SEP-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	0	ND		0.06742	0.00E+00	0.00E+00
SG41-20	22-SEP-92	0	20	609.6	M,P-XYLENE (SUM OF ISOMERS)	0	ND		0.06742	0.00E+00	0.00E+00
SG42-20A	22-SEP-92	0	20	609.6	M,P-XYLENE (SUM OF ISOMERS)	0.07	=		0.06742	7.00E-11	2.26E-12
SG43-10	06-OCT-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	0.03	=		0.06742	3.00E-11	1.94E-12
SG44-10	06-OCT-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	0.21	=		0.06742	2.10E-10	1.36E-11
SG45-10	06-OCT-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	0.28	=		0.06742	2.80E-10	1.81E-11
SG46-10	06-OCT-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	0.27	=		0.06742	2.70E-10	1.75E-11
SG10-10	17-SEP-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND		0.06742	0.00E+00	0.00E+00
SG28-10	18-SEP-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND		0.06742	0.00E+00	0.00E+00
SG41-20	22-SEP-92	0	20	609.6	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND		0.06742	0.00E+00	0.00E+00
SG42-20A	22-SEP-92	0	20	609.6	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND		0.06742	0.00E+00	0.00E+00
SG43-10	06-OCT-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	0.03	=		0.06742	3.00E-11	1.94E-12
SG44-10	06-OCT-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	0.22	=		0.06742	2.20E-10	1.42E-11
SG45-10	06-OCT-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	0.3	=		0.06742	3.00E-10	1.94E-11
SG46-10	06-OCT-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	0.3	=		0.06742	3.00E-10	1.94E-11
SG10-10	17-SEP-92	0	10	304.8	TETRACHLOROETHYLENE(PCE)	0.09	=		0.06968	9.00E-11	6.02E-12
SG28-10	18-SEP-92	0	10	304.8	TETRACHLOROETHYLENE(PCE)	0	ND		0.06968	0.00E+00	0.00E+00
SG41-20	22-SEP-92	0	20	609.6	TETRACHLOROETHYLENE(PCE)	0	ND		0.06968	0.00E+00	0.00E+00
SG42-20A	22-SEP-92	0	20	609.6	TETRACHLOROETHYLENE(PCE)	0	ND		0.06968	0.00E+00	0.00E+00
SG43-10	06-OCT-92	0	10	304.8	TETRACHLOROETHYLENE(PCE)	0.02	=		0.06968	2.00E-11	1.34E-12

VOC Surface Flux Estimates by Soil Gas Sample
Davis Global Communications Site

Sample	Sample Date	Starting Depth (ft)	Ending Depth (ft)	Emission Depth (cm)	Parameter Name	Concentration (ug/L)	Qualther Polygon	Diffusion Coefficient (cm ² /s)	Concentration (g/m ³)		Emission flux (g/m ² s)	
SG44-10	06-OCT-92	0	10	304.8	TETRACHLOROETHYLENE(PCE)	0.04	=	0.06968	4.00E-11	2.68E-16	2.68E-12	
SG45-10	06-OCT-92	0	10	304.8	TETRACHLOROETHYLENE(PCE)	0.07	=	0.06968	7.00E-11	4.68E-16	4.68E-12	
SG46-10	06-OCT-92	0	10	304.8	TETRACHLOROETHYLENE(PCE)	0.05	=	0.06968	5.00E-11	3.34E-16	3.34E-12	
SG10-10	17-SEP-92	0	10	304.8	TOLUENE	0	ND	0.07367	0.00E+00	0.00E+00	0.00E+00	
SG28-10	18-SEP-92	0	10	304.8	TOLUENE	0	ND	0.07367	0.00E+00	0.00E+00	0.00E+00	
SG41-20	22-SEP-92	0	20	609.6	TOLUENE	0.04925	=	0.07367	9.25E-12	3.27E-17	3.27E-13	
SG42-20A	22-SEP-92	0	20	609.6	TOLUENE	0.11	=	0.07367	1.10E-10	3.89E-16	3.89E-12	
SG43-10	06-OCT-92	0	10	304.8	TOLUENE	0.02	=	0.07367	2.00E-11	1.41E-16	1.41E-12	
SG44-10	06-OCT-92	0	10	304.8	TOLUENE	0.11	=	0.07367	1.10E-10	7.78E-16	7.78E-12	
SG45-10	06-OCT-92	0	10	304.8	TOLUENE	0.14	=	0.07367	1.40E-10	9.90E-16	9.90E-12	
SG46-10	06-OCT-92	0	10	304.8	TOLUENE	0.14	=	0.07367	1.40E-10	9.90E-16	9.90E-12	
SG10-10	17-SEP-92	0	10	304.8	TRICHLOROETHYLENE (TCE)	0	ND	0.07638	0.00E+00	0.00E+00	0.00E+00	
SG28-10	18-SEP-92	0	10	304.8	TRICHLOROETHYLENE (TCE)	0	ND	0.07638	0.00E+00	0.00E+00	0.00E+00	
SG41-20	22-SEP-92	0	20	609.6	TRICHLOROETHYLENE (TCE)	0	ND	0.07638	0.00E+00	0.00E+00	0.00E+00	
SG42-20A	22-SEP-92	0	20	609.6	TRICHLOROETHYLENE (TCE)	0	ND	0.07638	0.00E+00	0.00E+00	0.00E+00	
SG43-10	06-OCT-92	0	10	304.8	TRICHLOROETHYLENE (TCE)	0.01	=	0.07638	1.00E-11	7.33E-17	7.33E-13	
SG44-10	06-OCT-92	0	10	304.8	TRICHLOROETHYLENE (TCE)	0.01	=	0.07638	1.00E-11	7.33E-17	7.33E-13	
SG45-10	06-OCT-92	0	10	304.8	TRICHLOROETHYLENE (TCE)	0.02	=	0.07638	2.00E-11	1.47E-16	1.47E-12	
SG46-10	06-OCT-92	0	10	304.8	TRICHLOROETHYLENE (TCE)	0.02	=	0.07638	2.00E-11	1.47E-16	1.47E-12	
SG41-20	22-SEP-92	0	20	609.6	cis-1,2-DICHLOROETHYLENE	0	ND	0.07442	0.00E+00	0.00E+00	0.00E+00	
CH-1	17-DEC-92	25	35	762	1,1,1-TRICHLOROETHANE	0	ND	0.07496	0.00E+00	0.00E+00	0.00E+00	
P-1S	17-DEC-92	14	16	426.72	1,1,1-TRICHLOROETHANE	0	ND	0.07496	0.00E+00	0.00E+00	0.00E+00	
SC09-10	17-SEP-92	0	10	304.8	1,1,1-TRICHLOROETHANE	0.01113	=	0.07496	1.11E-11	8.01E-17	8.01E-13	
SC09-20	17-SEP-92	0	20	609.6	1,1,1-TRICHLOROETHANE	0.01855	=	0.07496	1.86E-11	6.67E-17	6.67E-13	
CH-1	17-DEC-92	25	35	762	1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	7.5	=	0.06349	7.50E-09	1.83E-14	1.83E-10	
P-1S	17-DEC-92	14	16	426.72	1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	0	ND	0.06349	0.00E+00	0.00E+00	0.00E+00	
SC09-10	17-SEP-92	0	10	304.8	1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	0.0825	=	0.06349	8.25E-11	5.03E-16	5.03E-12	
SC09-20	17-SEP-92	0	20	609.6	1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	0	ND	0.06349	0.00E+00	0.00E+00	0.00E+00	
CH-1	17-DEC-92	25	35	762	1,1-DICHLOROETHANE	0.0176	=	0.08557	1.76E-11	5.78E-17	5.78E-13	
CH-1	17-DEC-92	25	35	762	1,1-DICHLOROETHANE	4.68	=	0.07442	4.68E-09	1.34E-14	1.34E-10	
P-1S	17-DEC-92	14	16	426.72	1,1-DICHLOROETHANE	0.1638	=	0.07442	1.64E-10	8.36E-16	8.36E-12	
SC09-05	17-SEP-92	0	5	152.4	1,1-DICHLOROETHANE	0	ND	0.07442	0.00E+00	0.00E+00	0.00E+00	
SC09-10	17-SEP-92	0	10	304.8	1,1-DICHLOROETHANE	0.15	=	0.07442	1.50E-10	1.07E-15	1.07E-11	
SC09-20	17-SEP-92	0	20	609.6	1,1-DICHLOROETHANE	0.07	=	0.07442	7.00E-11	2.50E-16	2.50E-12	
CH-1	17-DEC-92	25	35	762	BENZENE	0.0496	=	0.08195	4.96E-11	1.56E-16	1.56E-12	
P-1S	17-DEC-92	14	16	426.72	BENZENE	0	ND	0.08195	0.00E+00	0.00E+00	0.00E+00	
SC09-05	17-SEP-92	0	5	152.4	BENZENE	0	ND	0.08195	0.00E+00	0.00E+00	0.00E+00	
SC09-10	17-SEP-92	0	10	304.8	BENZENE	0	ND	0.08195	0.00E+00	0.00E+00	0.00E+00	
SC09-20	17-SEP-92	0	20	609.6	BENZENE	0.01302	=	0.08195	1.30E-11	5.12E-17	5.12E-13	

VOC Surface Flux Estimates by Soil Gas Sample
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Sample	Sample Date	Starting Depth (ft)	Ending Depth (ft)	Emission Depth (cm)	Parameter Name	Concentration (ug/L)	Qualifier	Polygon	Diffusion Coefficient (cm ² /s)	Concentration (g/mcm ³)	Emission flux (g/m ² 2 s)
CH-1	17-DEC-92	25	35	762	DICHLORODIFLUOROMETHANE	0.01584	=	1	0.08555	1.58E-11	5.20E-17
P-1S	17-DEC-92	14	16	426.72	M,P-XYLENE (SUM OF ISOMERS)	0	ND	0	0.06742	0.00E+00	0.00E+00
SG09-05	17-SEP-92	0	5	152.4	M,P-XYLENE (SUM OF ISOMERS)	0.18	=	1	0.06742	1.80E-10	2.33E-15
SG09-10	17-SEP-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	0	ND	1	0.06742	0.00E+00	0.00E+00
SG09-20	17-SEP-92	0	20	609.6	M,P-XYLENE (SUM OF ISOMERS)	0.0105	=	1	0.06742	1.05E-11	3.40E-17
P-1S	17-DEC-92	14	16	426.72	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND	1	0.06742	0.00E+00	0.00E+00
SG09-05	17-SEP-92	0	5	152.4	O-XYLENE (1,2-DIMETHYLBENZENE)	0.08	=	1	0.06742	8.00E-11	1.04E-15
SG09-10	17-SEP-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND	1	0.06742	0.00E+00	0.00E+00
SG09-20	17-SEP-92	0	20	609.6	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND	1	0.06742	0.00E+00	0.00E+00
CH-1	17-DEC-92	25	35	762	TETRACHLOROETHYLENE(PCE)	541.2	>	1	0.06968	5.41E-07	1.45E-08
P-1S	17-DEC-92	14	16	426.72	TETRACHLOROETHYLENE(PCE)	17.16	=	1	0.06968	1.72E-08	8.20E-14
SG09-05	17-SEP-92	0	5	152.4	TETRACHLOROETHYLENE(PCE)	11	=	1	0.06968	1.10E-08	1.47E-13
SG09-10	17-SEP-92	0	10	304.8	TETRACHLOROETHYLENE(PCE)	41	=	1	0.06968	4.10E-08	2.74E-13
SG09-20	17-SEP-92	0	20	609.6	TETRACHLOROETHYLENE(PCE)	26	=	1	0.06968	2.60E-08	8.69E-14
CH-1	17-DEC-92	25	35	762	TOLUENE	0.0074	=	1	0.07367	7.40E-12	2.09E-17
P-1S	17-DEC-92	14	16	426.72	TOLUENE	25.9	1	1	0.07367	2.59E-08	1.31E-13
SG09-05	17-SEP-92	0	5	152.4	TOLUENE	0.16	=	1	0.07367	1.60E-10	2.26E-15
SG09-10	17-SEP-92	0	10	304.8	TOLUENE	0	ND	1	0.07367	0.00E+00	0.00E+00
SG09-20	17-SEP-92	0	20	609.6	TOLUENE	0.01813	=	1	0.07367	1.81E-11	6.41E-17
CH-1	17-DEC-92	25	35	762	TRICHLOROETHYLENE (TCE)	7.95	=	1	0.07638	7.95E-09	2.33E-14
P-1S	17-DEC-92	14	16	426.72	TRICHLOROETHYLENE (TCE)	0.3339	=	1	0.07638	3.34E-10	1.75E-15
SG09-05	17-SEP-92	0	5	152.4	TRICHLOROETHYLENE (TCE)	0	ND	1	0.07638	0.00E+00	0.00E+00
SG09-10	17-SEP-92	0	10	304.8	TRICHLOROETHYLENE (TCE)	0.05	=	1	0.07638	5.00E-11	3.67E-16
SG09-20	17-SEP-92	0	20	609.6	TRICHLOROETHYLENE (TCE)	0.1007	=	1	0.07638	1.01E-10	3.69E-16
CH-1	17-DEC-92	25	35	762	VINYL CHLORIDE	0	ND	1	0.10094	0.00E+00	0.00E+00
CH-1	17-DEC-92	25	35	762	cis-1,2-DICHLOROETHYLENE	0.0741	=	1	0.07442	7.41E-11	2.12E-16
P-1S	17-DEC-92	14	16	426.72	cis-1,2-DICHLOROETHYLENE	0	ND	1	0.07442	0.00E+00	0.00E+00
SG09-10	17-SEP-92	0	10	304.8	cis-1,2-DICHLOROETHYLENE	0	ND	1	0.07442	0.00E+00	0.00E+00
SG09-20	17-SEP-92	0	20	609.6	cis-1,2-DICHLOROETHYLENE	0	ND	1	0.07442	0.00E+00	0.00E+00
CH-2	17-DEC-92	14	16	426.72	1,1,1-TRICHLOROETHANE	0.795	=	2	0.07496	7.95E-10	4.09E-15
P-2M	17-DEC-92	30	36	914.4	1,1,1-TRICHLOROETHANE	1.855	=	2	0.07496	1.86E-09	4.45E-15
CH-2	17-DEC-92	14	16	426.72	1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	1.95	=	2	0.06349	1.95E-09	8.49E-15
P-2M	17-DEC-92	30	36	914.4	1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	3.75	=	2	0.06349	3.75E-09	7.62E-15
CH-2	17-DEC-92	14	16	426.72	1,1-DICHLOROETHANE	0	ND	2	0.08557	0.00E+00	0.00E+00
P-2M	17-DEC-92	30	36	914.4	1,1-DICHLOROETHANE	2.808	=	2	0.07442	2.81E-09	1.43E-14
CH-2	17-DEC-92	14	16	426.72	1,1-DICHLOROETHENE	7.02	=	2	0.07442	7.02E-09	1.67E-14
P-2M	17-DEC-92	30	36	914.4	1,1-DICHLOROETHENE	0	ND	2	0.07442	0.00E+00	0.00E+00
SG29-05	18-SEP-92	0	5	152.4	1,1-DICHLOROETHENE	0.34	=	2	0.07442	3.40E-10	2.43E-15
SG29-10	18-SEP-92	0	10	304.8	1,1-DICHLOROETHENE	0	ND	2	0.07442	0.00E+00	0.00E+00
SG29-20B	18-SEP-92	0	20	609.6	1,1-DICHLOROETHENE	0	ND	2	0.07442	0.00E+00	0.00E+00

VOC Surface Flux Estimates by Soil Gas Sample
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Sample	Sample Date	Starting Depth (ft)	Ending Depth (ft)	Emission Depth (cm)	Parameter Name	Concentration (ug/L)	Qualifier	Polygon	Coefficient (cm ² /s)	Diffusion		
										Concentration (g/mcm ³)	Emission flux (g/cm ² s)	flux (g/m ² s)
CH-2	17-DEC-92	14	16	426.72	BENZENE	0.0558	=	2	0.08195	5.58E-11	3.14E-16	3.14E-12
P-2M	17-DEC-92	30	36	914.4	BENZENE	0	ND	2	0.08195	0.00E+00	0.00E+00	0.00E+00
SG29-05	18-SEP-92	0	5	152.4	BENZENE	0	ND	2	0.08195	0.00E+00	0.00E+00	0.00E+00
SG29-10	18-SEP-92	0	10	304.8	BENZENE	0	ND	2	0.08195	0.00E+00	0.00E+00	0.00E+00
SG29-20B	18-SEP-92	0	20	609.6	BENZENE	0.04	=	2	0.08195	4.00E-11	1.57E-16	1.57E-12
P-2M	17-DEC-92	30	36	914.4	DICHLORODIFLUOROMETHANE	0	ND	2	0.08555	0.00E+00	0.00E+00	0.00E+00
CH-2	17-DEC-92	14	16	426.72	M,P-XYLENE (SUM OF ISOMERS)	0	ND	2	0.06742	0.00E+00	0.00E+00	0.00E+00
SG29-05	18-SEP-92	0	5	152.4	M,P-XYLENE (SUM OF ISOMERS)	0.06	=	2	0.06742	6.00E-11	7.77E-16	7.77E-12
SG29-10	18-SEP-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	0.05	=	2	0.06742	5.00E-11	1.62E-16	1.62E-12
SG29-20B	18-SEP-92	0	20	609.6	M,P-XYLENE (SUM OF ISOMERS)	0	ND	2	0.06742	0.00E+00	0.00E+00	0.00E+00
CH-2	17-DEC-92	14	16	426.72	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND	2	0.06742	0.00E+00	0.00E+00	0.00E+00
SG29-05	18-SEP-92	0	5	152.4	O-XYLENE (1,2-DIMETHYLBENZENE)	0.05	=	2	0.06742	5.00E-11	1.62E-16	1.62E-12
SG29-10	18-SEP-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	277.2	=	2	0.06968	2.77E-07	1.32E-12	1.32E-08
SG29-20B	18-SEP-92	0	20	609.6	O-XYLENE (1,2-DIMETHYLBENZENE)	336.6	1	2	0.06968	3.37E-07	7.50E-13	7.50E-09
CH-2	17-DEC-92	14	16	426.72	TETRACHLOROETHYLENE(PCE)	0.26	=	2	0.06968	2.60E-10	3.48E-15	3.48E-11
P-2M	17-DEC-92	30	36	914.4	TETRACHLOROETHYLENE(PCE)	340	=	2	0.06968	3.40E-07	2.27E-12	2.27E-08
SG29-05	18-SEP-92	0	5	152.4	TETRACHLOROETHYLENE(PCE)	0.13	=	2	0.06968	1.30E-10	4.35E-16	4.35E-12
SG29-10	18-SEP-92	0	10	304.8	TETRACHLOROETHYLENE(PCE)	2.738	=	2	0.07367	2.74E-09	1.38E-14	1.38E-10
SG29-20A	18-SEP-92	0	20	609.6	TETRACHLOROETHYLENE(PCE)	0	ND	2	0.07367	0.00E+00	0.00E+00	0.00E+00
CH-2	17-DEC-92	14	16	426.72	TOLUENE	0	ND	2	0.07367	0.00E+00	0.00E+00	0.00E+00
P-2M	17-DEC-92	30	36	914.4	TOLUENE	0	ND	2	0.07367	0.00E+00	0.00E+00	0.00E+00
SG29-05	18-SEP-92	0	5	152.4	TOLUENE	0.05	=	2	0.07367	5.00E-11	1.77E-16	1.77E-12
SG29-10	18-SEP-92	0	10	304.8	TOLUENE	7.42	=	2	0.07638	7.42E-09	3.89E-14	3.89E-10
SG29-20A	18-SEP-92	0	20	609.6	TOLUENE	11.66	=	2	0.07638	1.17E-08	2.85E-14	2.85E-10
CH-2	17-DEC-92	14	16	426.72	TRICHLOROETHYLENE (TCE)	0	ND	2	0.07638	0.00E+00	0.00E+00	0.00E+00
P-2M	17-DEC-92	30	36	914.4	TRICHLOROETHYLENE (TCE)	3.8	=	2	0.07638	3.80E-09	2.79E-14	2.79E-10
SG29-05	18-SEP-92	0	5	152.4	TRICHLOROETHYLENE (TCE)	0	ND	2	0.07638	0.00E+00	0.00E+00	0.00E+00
SG29-10	18-SEP-92	0	10	304.8	TRICHLOROETHYLENE (TCE)	0	ND	2	0.07638	0.00E+00	0.00E+00	0.00E+00
SG29-20B	18-SEP-92	0	20	609.6	TRICHLOROETHYLENE (TCE)	0	ND	2	0.07638	0.00E+00	0.00E+00	0.00E+00
P-2M	17-DEC-92	30	36	914.4	VINYL CHLORIDE	0	ND	2	0.10994	0.00E+00	0.00E+00	0.00E+00
CH-2	17-DEC-92	14	16	426.72	cis-1,2-DICHLOROETHYLENE	0.01794	=	2	0.07442	1.79E-11	9.15E-17	9.15E-13
P-2M	17-DEC-92	30	36	914.4	cis-1,2-DICHLOROETHYLENE	0	ND	2	0.07442	0.00E+00	0.00E+00	0.00E+00
CH-3	17-DEC-92	22	32	670.36	1,1,1-TRICHLOROETHANE	0.954	=	3	0.07496	9.54E-10	3.12E-15	3.12E-11
P-3S	17-DEC-92	15	17	457.2	1,1,1-TRICHLOROETHANE	0	ND	3	0.07496	0.00E+00	0.00E+00	0.00E+00
SG30-20	20-SEP-92	0	20	609.6	1,1,1-TRICHLOROETHANE	0.2862	=	3	0.07496	2.86E-10	1.03E-15	1.03E-11
CH-3	17-DEC-92	22	32	670.36	1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	0	ND	3	0.06349	0.00E+00	0.00E+00	0.00E+00
P-3S	17-DEC-92	15	17	457.2	1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	0	ND	3	0.06349	0.00E+00	0.00E+00	0.00E+00
SG30-20	20-SEP-92	0	20	609.6	1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	0	ND	3	0.06349	0.00E+00	0.00E+00	0.00E+00
CH-3	17-DEC-92	22	32	670.36	1,1-DICHLOROETHANE	0.0124	=	3	0.08557	1.24E-11	4.63E-17	4.63E-13

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Sample	Sample Date	Starting Depth (ft)	Ending Depth (ft)	Emission Depth (cm)	Parameter Name	Concentration (ug/L)	Qualifier	Polygon	Diffusion Coefficient (cm ² /s)	Concentration (g/mcm ³)	Emission flux (g/m ² ·s)	Flux (g/m ² ·s)
CH-3	17-DEC-92	22	32	670.56	1,1-DICHLOROETHENE	3.9	=	3	0.07442	3.90E-09	1.27E-14	1.27E-10
P-3S	17-DEC-92	15	17	457.2	1,1-DICHLOROETHENE	1.17	=	3	0.07442	1.17E-09	5.57E-15	5.57E-11
SG30-05	18-SEP-92	0	5	152.4	1,1-DICHLOROETHENE	0	ND	3	0.07442	0.00E+00	0.00E+00	0.00E+00
SG30-10	18-SEP-92	0	10	304.8	1,1-DICHLOROETHENE	0	ND	3	0.07442	0.00E+00	0.00E+00	0.00E+00
SG30-20	20-SEP-92	0	20	609.6	1,1-DICHLOROETHENE	0.1248	=	3	0.07442	1.25E-10	4.46E-16	4.46E-12
SG30-20A	18-SEP-92	0	20	609.6	1,1-DICHLOROETHENE	1.6	=	3	0.07442	1.60E-09	5.71E-15	5.71E-11
CH-3	17-DEC-92	22	32	670.56	BENZENE	0.0434	=	3	0.08195	4.34E-11	1.55E-16	1.55E-12
P-3S	17-DEC-92	15	17	457.2	BENZENE	0	ND	3	0.08195	0.00E+00	0.00E+00	0.00E+00
SG30-05	18-SEP-92	0	5	152.4	BENZENE	0.26	=	3	0.08195	2.60E-10	4.09E-15	4.09E-11
SG30-10	18-SEP-92	0	10	304.8	BENZENE	0	ND	3	0.08195	0.00E+00	0.00E+00	0.00E+00
SG30-20	20-SEP-92	0	20	609.6	BENZENE	0.01333	=	3	0.08195	1.33E-11	5.24E-17	5.24E-13
SG30-20A	18-SEP-92	0	20	609.6	BENZENE	0.05	=	3	0.08195	5.00E-11	1.97E-16	1.97E-12
CH-3	17-DEC-92	22	32	670.56	DICHLORODIFLUOROMETHANE	0	ND	3	0.08555	0.00E+00	0.00E+00	0.00E+00
P-3S	17-DEC-92	15	17	457.2	M,P-XYLENE (SUM OF ISOMERS)	0	ND	3	0.06742	0.00E+00	0.00E+00	0.00E+00
SG30-05	18-SEP-92	0	5	152.4	M,P-XYLENE (SUM OF ISOMERS)	0.39	=	3	0.06742	3.90E-10	5.05E-15	5.05E-11
SG30-10	18-SEP-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	0	ND	3	0.06742	0.00E+00	0.00E+00	0.00E+00
SG30-20	20-SEP-92	0	20	609.6	M,P-XYLENE (SUM OF ISOMERS)	0	ND	3	0.06742	0.00E+00	0.00E+00	0.00E+00
SG30-20A	18-SEP-92	0	20	609.6	M,P-XYLENE (SUM OF ISOMERS)	0.05	=	3	0.06742	5.00E-11	1.62E-16	1.62E-12
P-3S	17-DEC-92	15	17	457.2	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND	3	0.06742	0.00E+00	0.00E+00	0.00E+00
SG30-05	18-SEP-92	0	5	152.4	O-XYLENE (1,2-DIMETHYLBENZENE)	0.17	=	3	0.06742	1.70E-10	2.20E-15	2.20E-11
SG30-10	18-SEP-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND	3	0.06742	0.00E+00	0.00E+00	0.00E+00
SG30-20	20-SEP-92	0	20	609.6	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND	3	0.06742	0.00E+00	0.00E+00	0.00E+00
SG30-20A	18-SEP-92	0	20	609.6	O-XYLENE (1,2-DIMETHYLBENZENE)	0.05	=	3	0.06742	5.00E-11	1.62E-16	1.62E-12
CH-3	17-DEC-92	22	32	670.56	TETRACHLOROETHYLENE(PCE)	211.2	=	3	0.06968	2.11E-07	6.42E-13	6.42E-09
P-3S	17-DEC-92	15	17	457.2	TETRACHLOROETHYLENE(PCE)	92.4	=	3	0.06968	9.24E-08	4.12E-13	4.12E-09
SG30-05	18-SEP-92	0	5	152.4	TETRACHLOROETHYLENE(PCE)	0.22	=	3	0.06968	2.20E-10	2.94E-15	2.94E-11
SG30-10	18-SEP-92	0	10	304.8	TETRACHLOROETHYLENE(PCE)	29	=	3	0.06968	2.90E-08	1.94E-13	1.94E-09
SG30-20	20-SEP-92	0	20	609.6	TETRACHLOROETHYLENE(PCE)	99	=	3	0.06968	9.90E-08	3.31E-13	3.31E-09
SG30-20A	18-SEP-92	0	20	609.6	TETRACHLOROETHYLENE(PCE)	146	>	3	0.06968	1.46E-07	4.88E-13	4.88E-09
CH-3	17-DEC-92	22	32	670.56	TOLUENE	0.01702	=	3	0.07367	1.70E-11	5.47E-17	5.47E-13
P-3S	17-DEC-92	15	17	457.2	TOLUENE	0	ND	3	0.07367	0.00E+00	0.00E+00	0.00E+00
SG30-05	18-SEP-92	0	5	152.4	TOLUENE	0.57	=	3	0.07367	5.70E-10	8.06E-15	8.06E-11
SG30-10	18-SEP-92	0	10	304.8	TOLUENE	0.07	=	3	0.07367	7.00E-11	4.95E-16	4.95E-12
SG30-20	20-SEP-92	0	20	609.6	TOLUENE	0.00962	=	3	0.07367	9.62E-12	3.40E-17	3.40E-13
SG30-20A	18-SEP-92	0	20	609.6	TOLUENE	0.05	=	3	0.07367	5.00E-11	1.77E-16	1.77E-12
CH-3	17-DEC-92	22	32	670.56	TRICHLOROETHYLENE (TCE)	6.89	=	3	0.07638	6.89E-09	2.40E-14	2.40E-10
P-3S	17-DEC-92	15	17	457.2	TRICHLOROETHYLENE (TCE)	4.081	=	3	0.07638	4.08E-09	1.99E-14	1.99E-10
SG30-05	18-SEP-92	0	5	152.4	TRICHLOROETHYLENE (TCE)	0	ND	3	0.07638	0.00E+00	0.00E+00	0.00E+00
SG30-10	18-SEP-92	0	10	304.8	TRICHLOROETHYLENE (TCE)	0.71	=	3	0.07638	7.10E-10	5.21E-15	5.21E-11

VOC Surface Flux Estimates by Soil Gas Sample
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Sample	Sample Date	Starting Depth (ft)	Ending Depth (ft)	Emission Depth (cm)	Parameter Name	Concentration (ug/L)	Qualifier	Polygon	Diffusion Coefficient (cm ² /s)	Concentration (g/mcm ³)	Emission Flux (g/m ² s)	
SG30-20	20-SEP-92	0	20	609.6	TRICHLOROETHYLENE (TCE)	3.074	1	3	0.07638	3.07E-09	1.13E-14	1.13E-10
SG30-20A	18-SEP-92	0	20	609.6	TRICHLOROETHYLENE (TCE)	5.2	=	3	0.07638	5.20E-09	1.91E-14	1.91E-10
CH-3	17-DEC-92	22	32	670.56	VINYL CHLORIDE	0.0546	ND	3	0.10094	0.00E+00	0.00E+00	0.00E+00
CH-3	17-DEC-92	22	32	670.56	cis-1,2-DICHLOROETHYLENE	0.0546	ND	3	0.07442	5.46E-11	1.77E-16	1.77E-12
P-3S	17-DEC-92	15	17	457.2	cis-1,2-DICHLOROETHYLENE	0	ND	3	0.07442	0.00E+00	0.00E+00	0.00E+00
SG30-20	20-SEP-92	0	20	609.6	cis-1,2-DICHLOROETHYLENE	0	ND	3	0.07442	0.00E+00	0.00E+00	0.00E+00
CH-4	17-DEC-92	27	37	822.96	1,1,1-TRICHLOROETHANE	0.3551	=	4	0.07496	3.55E-10	9.46E-16	9.46E-12
P-4S	17-DEC-92	17	19	518.16	1,1,1-TRICHLOROETHANE	0	ND	4	0.07496	0.00E+00	0.00E+00	0.00E+00
CH-4	17-DEC-92	27	37	822.96	1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	0.195	=	4	0.06349	1.95E-10	4.40E-16	4.40E-12
P-4S	17-DEC-92	17	19	518.16	1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	0	ND	4	0.06349	0.00E+00	0.00E+00	0.00E+00
CH-4	17-DEC-92	27	37	822.96	1,1-DICHLOROETHENE	0.112	=	4	0.08557	1.12E-10	3.41E-16	3.41E-12
CH-4	17-DEC-92	27	37	822.96	1,1-DICHLOROETHENE	10.14	=	4	0.07442	1.01E-08	2.68E-14	2.68E-10
P-4S	17-DEC-92	17	19	518.16	1,1-DICHLOROETHENE	8.58	=	4	0.07442	8.58E-09	3.61E-14	3.61E-10
SG36-05B	21-SEP-92	0	5	152.4	1,1-DICHLOROETHENE	1.2	=	4	0.07442	1.20E-09	1.71E-14	1.71E-10
SG36-20B	21-SEP-92	0	20	609.6	1,1-DICHLOROETHENE	0	ND	4	0.07442	0.00E+00	0.00E+00	0.00E+00
CH-4	17-DEC-92	27	37	822.96	BENZENE	0.0713	=	4	0.08195	7.13E-11	2.08E-16	2.08E-12
P-4S	17-DEC-92	17	19	518.16	BENZENE	0	ND	4	0.08195	0.00E+00	0.00E+00	0.00E+00
SG36-05A	21-SEP-92	0	5	152.4	BENZENE	0	ND	4	0.08195	0.00E+00	0.00E+00	0.00E+00
SG36-20B	21-SEP-92	0	20	609.6	BENZENE	0	ND	4	0.08195	0.00E+00	0.00E+00	0.00E+00
CH-4	17-DEC-92	27	37	822.96	DICHLORODIFLUOROMETHANE	0	ND	4	0.08555	0.00E+00	0.00E+00	0.00E+00
P-4S	17-DEC-92	17	19	518.16	M,P XYLENE (SUM OF ISOMERS)	0	ND	4	0.06742	0.00E+00	0.00E+00	0.00E+00
SG36-05A	21-SEP-92	0	5	152.4	M,P XYLENE (SUM OF ISOMERS)	0.05	=	4	0.06742	5.00E-11	6.47E-16	6.47E-12
SG36-20B	21-SEP-92	0	20	609.6	M,P XYLENE (SUM OF ISOMERS)	0	ND	4	0.06742	0.00E+00	0.00E+00	0.00E+00
P-4S	17-DEC-92	17	19	518.16	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND	4	0.06742	0.00E+00	0.00E+00	0.00E+00
SG36-05A	21-SEP-92	0	5	152.4	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND	4	0.06742	0.00E+00	0.00E+00	0.00E+00
SG36-20B	21-SEP-92	0	20	609.6	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND	4	0.06742	0.00E+00	0.00E+00	0.00E+00
CH-4	17-DEC-92	27	37	822.96	TETRACHLOROETHYLENE(PCE)	270.6	=	4	0.06968	2.71E-07	6.70E-13	6.70E-09
P-4S	17-DEC-92	17	19	518.16	TETRACHLOROETHYLENE(PCE)	198	1	4	0.06968	1.98E-07	7.79E-13	7.79E-09
SG36-05B	21-SEP-92	0	5	152.4	TETRACHLOROETHYLENE(PCE)	88	=	4	0.06968	8.80E-08	1.18E-12	1.18E-08
SG36-20B	21-SEP-92	0	20	609.6	TETRACHLOROETHYLENE(PCE)	0	ND	4	0.06968	0.00E+00	0.00E+00	0.00E+00
CH-4	17-DEC-92	27	37	822.96	TOLUENE	0.2849	=	4	0.07367	2.85E-10	7.46E-16	7.46E-12
P-4S	17-DEC-92	17	19	518.16	TOLUENE	0	ND	4	0.07367	0.00E+00	0.00E+00	0.00E+00
SG36-05A	21-SEP-92	0	5	152.4	TOLUENE	0	ND	4	0.07367	0.00E+00	0.00E+00	0.00E+00
SG36-20B	21-SEP-92	0	20	609.6	TOLUENE	0	ND	4	0.07367	0.00E+00	0.00E+00	0.00E+00
CH-4	17-DEC-92	27	37	822.96	TRICHLOROETHYLENE (TCE)	50.35	=	4	0.07638	5.04E-08	1.37E-13	1.37E-09
P-4S	17-DEC-92	17	19	518.16	TRICHLOROETHYLENE (TCE)	39.22	=	4	0.07638	3.92E-08	1.69E-13	1.69E-09
SG36-05B	21-SEP-92	0	5	152.4	TRICHLOROETHYLENE (TCE)	12.7	=	4	0.07638	1.27E-08	1.86E-13	1.86E-09
SG36-20B	21-SEP-92	0	20	609.6	TRICHLOROETHYLENE (TCE)	0	ND	4	0.07638	0.00E+00	0.00E+00	0.00E+00
CH-4	17-DEC-92	27	37	822.96	VINYL CHLORIDE	0	ND	4	0.10094	0.00E+00	0.00E+00	0.00E+00

VOC Surface Flux Estimates by Soil Gas Sample
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Sample	Sample Date	Starting Depth (ft)	Ending Depth (ft)	Emission Depth (cm)	Parameter Name	Concentration (ug/L)	Qualifier	Polygon	Diffusion Coefficient (cm ² /s)	Concentration		Emission Flux	
										(g/mem 3)	(g/cm 2 s)	(g/m 2 s)	(g/m 2 s)
CH-4	17-DEC-92	27	37	822.96	cis-1,2-DICHLOROETHYLENE	1.248	=	4	0.07442	1.25E+09	3.30E+15	3.30E+11	
P-4S	17-DEC-92	17	19	518.16	cis-1,2-DICHLOROETHYLENE	1.248	=	4	0.07442	1.25E+09	5.24E+15	5.24E+11	
CH-5	17-DEC-92	28	38	853.44	1,1,1-TRICHLOROETHANE	0	ND		5	0.07496	0.00E+00	0.00E+00	0.00E+00
P-5S	17-DEC-92	18	20	548.64	1,1,1-TRICHLOROETHANE	0	ND		5	0.07496	0.00E+00	0.00E+00	0.00E+00
SG22-05	22-SEP-92	0	5	152.4	1,1,1-TRICHLOROETHANE	0	ND		5	0.07496	0.00E+00	0.00E+00	0.00E+00
CH-5	17-DEC-92	28	38	853.44	1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	0.0975	=	5	0.06349	9.75E+11	2.12E+16	2.12E+12	
P-5S	17-DEC-92	18	20	548.64	1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	0	ND		5	0.06349	0.00E+00	0.00E+00	0.00E+00
SG22-05	22-SEP-92	0	5	152.4	1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	0	ND		5	0.06349	0.00E+00	0.00E+00	0.00E+00
CH-5	17-DEC-92	28	38	853.44	1,1-DICHLOROETHANE	0.0348	=	5	0.08557	3.48E+11	1.02E+16	1.02E+12	
CH-5	17-DEC-92	28	38	853.44	1,1-DICHLOROETHANE	0	ND		5	0.07442	0.00E+00	0.00E+00	0.00E+00
P-5S	17-DEC-92	18	20	548.64	1,1-DICHLOROETHANE	0	ND		5	0.07442	0.00E+00	0.00E+00	0.00E+00
SG22-05	18-SEP-92	0	5	152.4	1,1-DICHLOROETHANE	0	ND		5	0.07442	0.00E+00	0.00E+00	0.00E+00
SG22-05	22-SEP-92	0	5	152.4	1,1-DICHLOROETHANE	0	ND		5	0.07442	0.00E+00	0.00E+00	0.00E+00
SG22-10A	18-SEP-92	0	10	304.8	1,1-DICHLOROETHANE	0	ND		5	0.07442	0.00E+00	0.00E+00	0.00E+00
SG22-20B	18-SEP-92	0	20	609.6	1,1-DICHLOROETHANE	0	ND		5	0.07442	0.00E+00	0.00E+00	0.00E+00
SG25-10	18-SEP-92	0	10	304.8	1,1-DICHLOROETHANE	0	ND		5	0.07442	0.00E+00	0.00E+00	0.00E+00
CH-5	17-DEC-92	28	38	853.44	BENZENE	1.116	1		5	0.08195	1.12E+09	3.14E+15	3.14E+11
P-5S	17-DEC-92	18	20	548.64	BENZENE	0	ND		5	0.08195	0.00E+00	0.00E+00	0.00E+00
SG22-05	18-SEP-92	0	5	152.4	BENZENE	0	ND		5	0.08195	0.00E+00	0.00E+00	0.00E+00
SG22-05	22-SEP-92	0	5	152.4	BENZENE	0	ND		5	0.08195	0.00E+00	0.00E+00	0.00E+00
SG22-10A	18-SEP-92	0	10	304.8	BENZENE	0	ND		5	0.08195	0.00E+00	0.00E+00	0.00E+00
SG22-20B	18-SEP-92	0	20	609.6	BENZENE	0	ND		5	0.08195	0.00E+00	0.00E+00	0.00E+00
SG25-10	18-SEP-92	0	10	304.8	BENZENE	0.04	=		5	0.08195	4.00E+11	1.57E+16	1.57E+12
CH-5	17-DEC-92	28	38	853.44	DICHLORODIFLUOROMETHANE	0.48	=		5	0.08555	4.80E+10	1.41E+15	1.41E+11
P-5S	17-DEC-92	18	20	548.64	M,P-XYLENE (SUM OF ISOMERS)	0	ND		5	0.06742	0.00E+00	0.00E+00	0.00E+00
SG22-05	18-SEP-92	0	5	152.4	M,P-XYLENE (SUM OF ISOMERS)	0.09	=		5	0.06742	9.00E+11	1.16E+15	1.16E+11
SG22-05	22-SEP-92	0	5	152.4	M,P-XYLENE (SUM OF ISOMERS)	0	ND		5	0.06742	0.00E+00	0.00E+00	0.00E+00
SG22-10A	18-SEP-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	0	ND		5	0.06742	0.00E+00	0.00E+00	0.00E+00
SG22-20B	18-SEP-92	0	20	609.6	M,P-XYLENE (SUM OF ISOMERS)	0.04	=		5	0.06742	4.00E+11	1.29E+16	1.29E+12
SG25-10	18-SEP-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	16.3	=		5	0.06742	1.63E+08	1.05E+13	1.05E+09
P-5S	17-DEC-92	18	20	548.64	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND		5	0.06742	0.00E+00	0.00E+00	0.00E+00
SG22-05	18-SEP-92	0	5	152.4	O-XYLENE (1,2-DIMETHYLBENZENE)	0.08	=		5	0.06742	8.00E+11	1.04E+15	1.04E+11
SG22-05	22-SEP-92	0	5	152.4	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND		5	0.06742	0.00E+00	0.00E+00	0.00E+00
SG22-10A	18-SEP-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND		5	0.06742	0.00E+00	0.00E+00	0.00E+00
SG22-20B	18-SEP-92	0	20	609.6	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND		5	0.06742	0.00E+00	0.00E+00	0.00E+00
SG25-10	18-SEP-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	17.5	=		5	0.06742	1.75E+08	1.13E+13	1.13E+09
CH-5	17-DEC-92	28	38	853.44	TETRACHLOROETHYLENE(PCE)	0.6006	=		5	0.06968	6.01E+10	1.43E+15	1.43E+11
P-5S	17-DEC-92	18	20	548.64	TETRACHLOROETHYLENE(PCE)	0	ND		5	0.06968	0.00E+00	0.00E+00	0.00E+00
SG22-05	18-SEP-92	0	5	152.4	TETRACHLOROETHYLENE(PCE)	2.04	=		5	0.06968	2.04E+09	2.71E+14	2.71E+10

DIFFUSE.XLS

VOC Surface Flux Estimates by Soil Gas Sample
Davis Global Communications Site

Sample	Sample Date	Starting Depth (ft)	Ending Depth (ft)	Emission		Parameter Name	Concentration (ug/L)	Qualtier	Polygon	Diffusion Coefficient (cm ² /s)	Concentration		Emission flux	
				Depth (cm)	Depth (ft)						(g/mcm ³)	(g/cm ² s)	(g/m ² s)	(g/m ² s)
SG22-10B	18-SEP-92	0	10	304.8		TETRACHLOROETHYLENE(PCE)	52	=	5	0.06968	5.20E-08	1.48E-13	3.48E-09	
SG22-20B	18-SEP-92	0	20	609.6		TETRACHLOROETHYLENE(PCE)	9.7	=	5	0.06968	9.70E-09	3.24E-14	3.24E-10	
SG25-10	18-SEP-92	0	10	304.8		TETRACHLOROETHYLENE(PCE)	0.05	=	5	0.06968	5.00E-11	1.34E-16	3.34E-12	
CH-5	17-DEC-92	28	38	853.44		TOLUENE	0 ND		5	0.07367	0.00E+00	0.00E+00	0.00E+00	
P-5S	17-DEC-92	18	20	548.64		TOLUENE	22.94	1	5	0.07367	2.29E-08	9.01E-14	9.01E-10	
SG22-05	18-SEP-92	0	5	152.4		TOLUENE	0.06	=	5	0.07367	6.00E-11	8.49E-16	8.49E-12	
SG22-05	22-SEP-92	0	5	152.4		TOLUENE	0 ND		5	0.07367	0.00E+00	0.00E+00	0.00E+00	
SG22-10A	18-SEP-92	0	10	304.8		TOLUENE	0 ND		5	0.07367	0.00E+00	0.00E+00	0.00E+00	
SG22-20B	18-SEP-92	0	20	609.6		TOLUENE	0.06	=	5	0.07367	6.00E-11	2.12E-16	2.12E-12	
SG25-10	18-SEP-92	0	10	304.8		TOLUENE	6.8	=	5	0.07367	6.80E-09	4.81E-14	4.81E-10	
CH-5	17-DEC-92	28	38	853.44		TRICHLOROETHYLENE (TCE)	0.0901	=	5	0.07638	9.01E-11	2.36E-16	2.36E-12	
P-5S	17-DEC-92	18	20	548.64		TRICHLOROETHYLENE (TCE)	0 ND		5	0.07638	0.00E+00	0.00E+00	0.00E+00	
SG22-05	18-SEP-92	0	5	152.4		TRICHLOROETHYLENE (TCE)	0 ND		5	0.07638	0.00E+00	0.00E+00	0.00E+00	
SG22-05	22-SEP-92	0	5	152.4		TRICHLOROETHYLENE (TCE)	0 ND		5	0.07638	0.00E+00	0.00E+00	0.00E+00	
SG22-10A	18-SEP-92	0	10	304.8		TRICHLOROETHYLENE (TCE)	0.09	=	5	0.07638	9.00E-11	6.60E-16	6.60E-12	
SG22-20B	18-SEP-92	0	20	609.6		TRICHLOROETHYLENE (TCE)	0 ND		5	0.07638	0.00E+00	0.00E+00	0.00E+00	
SG25-10	18-SEP-92	0	10	304.8		TRICHLOROETHYLENE (TCE)	0 ND		5	0.07638	0.00E+00	0.00E+00	0.00E+00	
CH-5	17-DEC-92	28	38	853.44		VINYL CHLORIDE	1.275	1	5	0.10094	1.28E-09	4.41E-15	4.41E-11	
CH-5	17-DEC-92	28	38	853.44		cis-1,2-DICHLOROETHYLENE	0.0408	=	5	0.07442	4.68E-11	1.19E-16	1.19E-12	
P-5S	17-DEC-92	18	20	548.64		cis-1,2-DICHLOROETHYLENE	0 ND		5	0.07442	0.00E+00	0.00E+00	0.00E+00	
SG22-05	22-SEP-92	0	5	152.4		cis-1,2-DICHLOROETHYLENE	0 ND		5	0.07442	0.00E+00	0.00E+00	0.00E+00	
SG04-10	15-SEP-92	0	10	304.8		1,1,1-TRICHLOROETHANE	0 ND		6	0.07496	0.00E+00	0.00E+00	0.00E+00	
SG08-05	21-SEP-92	0	5	152.4		1,1,1-TRICHLOROETHANE	0.01272	=	6	0.07496	1.27E-11	1.83E-16	1.83E-12	
SG04-10	15-SEP-92	0	10	304.8		1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	0.024	=	6	0.06349	2.40E-11	2.93E-16	2.93E-12	
SG08-05	21-SEP-92	0	5	152.4		1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	0 ND		6	0.07442	0.00E+00	0.00E+00	0.00E+00	
SG01-10A	15-SEP-92	0	10	304.8		1,1-DICHLOROETHENE	0 ND		6	0.07442	0.00E+00	0.00E+00	0.00E+00	
SG02-10	15-SEP-92	0	10	304.8		1,1-DICHLOROETHENE	0 ND		6	0.07442	0.00E+00	0.00E+00	0.00E+00	
SG03-10	15-SEP-92	0	10	304.8		1,1-DICHLOROETHENE	0 ND		6	0.07442	0.00E+00	0.00E+00	0.00E+00	
SG04-10	15-SEP-92	0	10	304.8		1,1-DICHLOROETHENE	0 ND		6	0.07442	0.00E+00	0.00E+00	0.00E+00	
SG05-10A	15-SEP-92	0	10	304.8		1,1-DICHLOROETHENE	0.27	=	6	0.07442	2.70E-10	1.93E-15	1.93E-11	
SG05-13B	15-SEP-92	0	13	396.24		1,1-DICHLOROETHENE	0 ND		6	0.07442	0.00E+00	0.00E+00	0.00E+00	
SG08-05	17-SEP-92	0	5	152.4		1,1-DICHLOROETHENE	0 ND		6	0.07442	0.00E+00	0.00E+00	0.00E+00	
SG08-05	21-SEP-92	0	5	152.4		1,1-DICHLOROETHENE	0 ND		6	0.07442	0.00E+00	0.00E+00	0.00E+00	
SG08-10	17-SEP-92	0	10	304.8		1,1-DICHLOROETHENE	0 ND		6	0.07442	0.00E+00	0.00E+00	0.00E+00	
SG08-20A	17-SEP-92	0	20	609.6		1,1-DICHLOROETHENE	0 ND		6	0.07442	0.00E+00	0.00E+00	0.00E+00	
SG18-05	17-SEP-92	0	5	152.4		1,1-DICHLOROETHENE	0 ND		6	0.07442	0.00E+00	0.00E+00	0.00E+00	
SG18-10	17-SEP-92	0	10	304.8		1,1-DICHLOROETHENE	0 ND		6	0.07442	0.00E+00	0.00E+00	0.00E+00	
SG18-17	17-SEP-92	0	17	518.16		1,1-DICHLOROETHENE	0 ND		6	0.07442	0.00E+00	0.00E+00	0.00E+00	
SG21-10	18-SEP-92	0	10	304.8		1,1-DICHLOROETHENE	0 ND		6	0.07442	0.00E+00	0.00E+00	0.00E+00	

VOC Surface Flux Estimates by Soil Gas Sample
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Sample	Sample Date	Starting Depth (ft)	Ending Depth (ft)	Emission Depth (cm)	Parameter Name	Concentration (ug/L)	Qualtier Polygon	Diffusion Coefficient (cm ² /s)	Concentration (g/mcm ³)	Emission flux (g/m ² ·2 s)	Emission flux (g/m ² ·2 s)
SG01-10A	15-SEP-92	0	10	304.8	BENZENE	0.16	=	6	0.08195	1.60E+10	1.26E+15
SG02-10	15-SEP-92	0	10	304.8	BENZENE	0.25	=	6	0.08195	2.50E+10	1.97E+15
SG03-10	15-SEP-92	0	10	304.8	BENZENE	0.21	=	6	0.08195	2.10E+10	1.65E+15
SG04-10	15-SEP-92	0	10	304.8	BENZENE	0.27	=	6	0.08195	2.70E+10	2.12E+15
SG05-10A	15-SEP-92	0	10	304.8	BENZENE	0.13	=	6	0.08195	1.30E+10	1.02E+15
SG05-13A	15-SEP-92	0	13	396.24	BENZENE	0.1	=	6	0.08195	1.00E+10	6.05E+12
SG08-05	17-SEP-92	0	5	152.4	BENZENE	0	ND	6	0.08195	0.00E+00	0.00E+00
SG08-05	21-SEP-92	0	5	152.4	BENZENE	0.01209	=	6	0.08195	1.21E+11	1.90E+12
SG08-10	17-SEP-92	0	10	304.8	BENZENE	0	ND	6	0.08195	0.00E+00	0.00E+00
SG08-20A	17-SEP-92	0	20	609.6	BENZENE	0	ND	6	0.08195	0.00E+00	0.00E+00
SG18-05	17-SEP-92	0	5	152.4	BENZENE	0	ND	6	0.08195	0.00E+00	0.00E+00
SG18-10	17-SEP-92	0	10	304.8	BENZENE	0	ND	6	0.08195	0.00E+00	0.00E+00
SG18-17	17-SEP-92	0	17	518.16	BENZENE	0	ND	6	0.08195	0.00E+00	0.00E+00
SG21-10	18-SEP-92	0	10	304.8	BENZENE	0	ND	6	0.08195	0.00E+00	0.00E+00
SG01-10A	15-SEP-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	0.16	=	6	0.06742	1.60E+10	1.04E+15
SG02-10	15-SEP-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	0.33	=	6	0.06742	3.30E+10	2.14E+15
SG03-10	15-SEP-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	0.31	=	6	0.06742	3.10E+10	2.01E+15
SG04-10	15-SEP-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	0.42	=	6	0.06742	4.20E+10	2.72E+15
SG05-10A	15-SEP-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	0.15	=	6	0.06742	1.50E+10	9.71E+12
SG05-13A	15-SEP-92	0	13	396.24	M,P-XYLENE (SUM OF ISOMERS)	0.2	=	6	0.06742	2.00E+10	9.96E+12
SG08-05	17-SEP-92	0	5	152.4	M,P-XYLENE (SUM OF ISOMERS)	0	ND	6	0.06742	0.00E+00	0.00E+00
SG08-05	21-SEP-92	0	5	152.4	M,P-XYLENE (SUM OF ISOMERS)	0.03234	=	6	0.06742	3.23E+11	4.19E+12
SG08-10	17-SEP-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	0	ND	6	0.06742	0.00E+00	0.00E+00
SG08-20A	17-SEP-92	0	20	609.6	M,P-XYLENE (SUM OF ISOMERS)	0	ND	6	0.06742	0.00E+00	0.00E+00
SG18-05	17-SEP-92	0	5	152.4	M,P-XYLENE (SUM OF ISOMERS)	0	ND	6	0.06742	0.00E+00	0.00E+00
SG18-10	17-SEP-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	0	ND	6	0.06742	0.00E+00	0.00E+00
SG18-17	17-SEP-92	0	17	518.16	M,P-XYLENE (SUM OF ISOMERS)	0	ND	6	0.06742	0.00E+00	0.00E+00
SG21-10	18-SEP-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	0	ND	6	0.06742	0.00E+00	0.00E+00
SG01-10A	15-SEP-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	0.16	=	6	0.06742	1.60E+10	1.04E+15
SG02-10	15-SEP-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	0.23	=	6	0.06742	2.30E+10	1.49E+15
SG03-10	15-SEP-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	0.26	=	6	0.06742	2.60E+10	1.68E+15
SG04-10	15-SEP-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	0.29	=	6	0.06742	2.90E+10	1.88E+15
SG05-10A	15-SEP-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	0.17	=	6	0.06742	1.70E+10	1.10E+15
SG05-13A	15-SEP-92	0	13	396.24	O-XYLENE (1,2-DIMETHYLBENZENE)	0.1	=	6	0.06742	1.00E+10	4.98E+12
SG08-05	17-SEP-92	0	5	152.4	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND	6	0.06742	0.00E+00	0.00E+00
SG08-05	21-SEP-92	0	5	152.4	O-XYLENE (1,2-DIMETHYLBENZENE)	0.01302	=	6	0.06742	1.30E+11	1.69E+12
SG08-10	17-SEP-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND	6	0.06742	0.00E+00	0.00E+00
SG08-20A	17-SEP-92	0	20	609.6	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND	6	0.06742	0.00E+00	0.00E+00
SG18-05	17-SEP-92	0	5	152.4	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND	6	0.06742	0.00E+00	0.00E+00

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VOC Surface Flux Estimates by Soil Gas Sample
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Sample	Sample Date	Starting Depth (ft)	Ending Depth (ft)	Emission Depth (cm)	Parameter Name	Concentration (ug/L)	Qualifier	Polygon	Diffusion Coefficient (cm ² /s)	Concentration (ug/mcm ³)	Emission flux (g/cm ² s)	Flux (g/m ² s)
SG18-10	17-SEP-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND	6	0.06742	0.00E+00	0.00E+00	0.00E+00
SG18-17	17-SEP-92	0	17	518.16	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND	6	0.06742	0.00E+00	0.00E+00	0.00E+00
SG21-10	18-SEP-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND	6	0.06742	0.00E+00	0.00E+00	0.00E+00
SG01-10B	15-SEP-92	0	10	304.8	TETRACHLOROETHYLENE(PCE)	4	=	6	0.06968	4.00E-09	2.68E-14	2.68E-10
SG02-10	15-SEP-92	0	10	304.8	TETRACHLOROETHYLENE(PCE)	0	ND	6	0.06968	0.00E+00	0.00E+00	0.00E+00
SG03-10	15-SEP-92	0	10	304.8	TETRACHLOROETHYLENE(PCE)	0	ND	6	0.06968	0.00E+00	0.00E+00	0.00E+00
SG04-10	15-SEP-92	0	10	304.8	TETRACHLOROETHYLENE(PCE)	0.858	=	6	0.06968	8.58E-10	5.74E-15	5.74E-11
SG05-10A	15-SEP-92	0	10	304.8	TETRACHLOROETHYLENE(PCE)	14	=	6	0.06968	1.40E-08	9.36E-14	9.36E-10
SG05-13B	15-SEP-92	0	13	396.24	TETRACHLOROETHYLENE(PCE)	0.3	=	6	0.06968	3.00E-10	1.54E-15	1.54E-11
SG08-05	17-SEP-92	0	5	152.4	TETRACHLOROETHYLENE(PCE)	0	ND	6	0.06968	0.00E+00	0.00E+00	0.00E+00
SG08-05	21-SEP-92	0	5	152.4	TETRACHLOROETHYLENE(PCE)	3.498	1	6	0.06968	3.50E-09	4.68E-14	4.68E-10
SG08-10	17-SEP-92	0	10	304.8	TETRACHLOROETHYLENE(PCE)	0	ND	6	0.06968	0.00E+00	0.00E+00	0.00E+00
SG08-20B	17-SEP-92	0	20	609.6	TETRACHLOROETHYLENE(PCE)	1.45	=	6	0.06968	1.45E-09	4.85E-15	4.85E-11
SG18-05	17-SEP-92	0	5	152.4	TETRACHLOROETHYLENE(PCE)	0	ND	6	0.06968	0.00E+00	0.00E+00	0.00E+00
SG18-10	17-SEP-92	0	10	304.8	TETRACHLOROETHYLENE(PCE)	11	=	6	0.06968	1.10E-08	7.36E-14	7.36E-10
SG18-17	17-SEP-92	0	17	518.16	TETRACHLOROETHYLENE(PCE)	4.8	=	6	0.06968	4.80E-09	1.89E-14	1.89E-10
SG21-10	18-SEP-92	0	10	304.8	TETRACHLOROETHYLENE(PCE)	0.1	=	6	0.06968	1.00E-10	6.69E-16	6.69E-12
SG01-10A	15-SEP-92	0	10	304.8	TOLUENE	0.32	=	6	0.07367	3.20E-10	2.26E-15	2.26E-11
SG02-10	15-SEP-92	0	10	304.8	TOLUENE	0.69	=	6	0.07367	6.90E-10	4.88E-15	4.88E-11
SG03-10	15-SEP-92	0	10	304.8	TOLUENE	0.58	=	6	0.07367	5.80E-10	4.10E-15	4.10E-11
SG04-10	15-SEP-92	0	10	304.8	TOLUENE	0.037	=	6	0.07367	3.70E-11	2.62E-16	2.62E-12
SG04-10	15-SEP-92	0	10	304.8	TOLUENE	0.7	=	6	0.07367	7.00E-10	4.95E-15	4.95E-11
SG05-10A	15-SEP-92	0	10	304.8	TOLUENE	0.12	=	6	0.07367	1.20E-10	8.49E-16	8.49E-12
SG05-13A	15-SEP-92	0	13	396.24	TOLUENE	0.15	=	6	0.07367	1.50E-10	8.16E-16	8.16E-12
SG08-05	17-SEP-92	0	5	152.4	TOLUENE	0	ND	6	0.07367	0.00E+00	0.00E+00	0.00E+00
SG08-05	21-SEP-92	0	5	152.4	TOLUENE	0.03478	=	6	0.07367	3.48E-11	4.92E-16	4.92E-12
SG08-10	17-SEP-92	0	10	304.8	TOLUENE	0	ND	6	0.07367	0.00E+00	0.00E+00	0.00E+00
SG08-20A	17-SEP-92	0	20	609.6	TOLUENE	0	ND	6	0.07367	0.00E+00	0.00E+00	0.00E+00
SG18-05	17-SEP-92	0	5	152.4	TOLUENE	0	ND	6	0.07367	0.00E+00	0.00E+00	0.00E+00
SG18-10	17-SEP-92	0	10	304.8	TOLUENE	0	ND	6	0.07367	0.00E+00	0.00E+00	0.00E+00
SG18-17	17-SEP-92	0	17	518.16	TOLUENE	0	ND	6	0.07367	0.00E+00	0.00E+00	0.00E+00
SG21-10	18-SEP-92	0	10	304.8	TOLUENE	0	ND	6	0.07367	0.00E+00	0.00E+00	0.00E+00
SG01-10A	15-SEP-92	0	10	304.8	TRICHLOROETHYLENE (TCE)	0	ND	6	0.07638	0.00E+00	0.00E+00	0.00E+00
SG02-10	15-SEP-92	0	10	304.8	TRICHLOROETHYLENE (TCE)	0	ND	6	0.07638	0.00E+00	0.00E+00	0.00E+00
SG03-10	15-SEP-92	0	10	304.8	TRICHLOROETHYLENE (TCE)	0	ND	6	0.07638	0.00E+00	0.00E+00	0.00E+00
SG04-10	15-SEP-92	0	10	304.8	TRICHLOROETHYLENE (TCE)	0	ND	6	0.07638	0.00E+00	0.00E+00	0.00E+00
SG05-10B	15-SEP-92	0	10	304.8	TRICHLOROETHYLENE (TCE)	2.7	=	6	0.07638	2.70E-09	1.98E-14	1.98E-10
SG05-13A	15-SEP-92	0	13	396.24	TRICHLOROETHYLENE (TCE)	0.05	=	6	0.07638	5.00E-11	2.82E-16	2.82E-12
SG08-05	17-SEP-92	0	5	152.4	TRICHLOROETHYLENE (TCE)	0	ND	6	0.07638	0.00E+00	0.00E+00	0.00E+00

VOC Surface Flux Estimates by Soil Gas Sample
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Sample	Sample Date	Starting Depth (ft)	Ending Depth (ft)	Emission Depth (cm)	Parameter Name	Concentration (ug/L)	Qualifier	Polygon	Diffusion Coefficient (cm ² /s)	Concentration (g/mcm ³)	Emission Flux (g/m ² s)
SG08-05	21-SEP-92	0	5	152.4	TRICHLOROETHYLENE (TCE)	0	ND	6	0.07638	0.00E+00	0.00E+00
SG08-10	17-SEP-92	0	10	304.8	TRICHLOROETHYLENE (TCE)	0	ND	6	0.07638	0.00E+00	0.00E+00
SG08-20A	17-SEP-92	0	20	609.6	TRICHLOROETHYLENE (TCE)	0	ND	6	0.07638	0.00E+00	0.00E+00
SG18-05	17-SEP-92	0	5	152.4	TRICHLOROETHYLENE (TCE)	0	ND	6	0.07638	0.00E+00	0.00E+00
SG18-10	17-SEP-92	0	10	304.8	TRICHLOROETHYLENE (TCE)	0.36	=	6	0.07638	3.60E-10	2.64E-11
SG18-17	17-SEP-92	0	17	518.16	TRICHLOROETHYLENE (TCE)	0.13	=	6	0.07638	1.30E-10	5.61E-12
SG21-10	18-SEP-92	0	10	304.8	TRICHLOROETHYLENE (TCE)	0.29	=	6	0.07638	2.90E-10	2.13E-11
SG04-10	15-SEP-92	0	10	304.8	cis-1,2-DICHLOROETHYLENE	0	ND	6	0.07442	0.00E+00	0.00E+00
SG08-05	21-SEP-92	0	5	152.4	cis-1,2-DICHLOROETHYLENE	0	ND	6	0.07442	0.00E+00	0.00E+00
SG07-10	15-SEP-92	0	10	304.8	1,1,1-TRICHLOROETHANE	0	ND	7	0.07496	0.00E+00	0.00E+00
SG07-10	15-SEP-92	0	10	304.8	1,1,1-TRICHLOROETHANE	0	ND	7	0.07496	0.00E+00	0.00E+00
SG06-10	15-SEP-92	0	10	304.8	1,1-DICHLOROETHENE	0	ND	7	0.07442	0.00E+00	0.00E+00
SG07-10	15-SEP-92	0	10	304.8	1,1-DICHLOROETHENE	0	ND	7	0.07442	0.00E+00	0.00E+00
SG13-05A	17-SEP-92	0	5	152.4	1,1-DICHLOROETHENE	0.53	=	7	0.07442	5.30E-10	7.57E-11
SG13-10	17-SEP-92	0	10	304.8	1,1-DICHLOROETHENE	0	ND	7	0.07442	0.00E+00	0.00E+00
SG13-20A	17-SEP-92	0	20	609.6	1,1-DICHLOROETHENE	0	ND	7	0.07442	0.00E+00	0.00E+00
SG06-10	15-SEP-92	0	10	304.8	BENZENE	0.16	=	7	0.08195	1.60E-10	1.26E-11
SG07-10	15-SEP-92	0	10	304.8	BENZENE	0.2	=	7	0.08195	2.00E-10	1.57E-11
SG13-05A	17-SEP-92	0	5	152.4	BENZENE	0	ND	7	0.08195	0.00E+00	0.00E+00
SG13-10	17-SEP-92	0	10	304.8	BENZENE	0	ND	7	0.08195	0.00E+00	0.00E+00
SG13-20A	17-SEP-92	0	20	609.6	BENZENE	0	ND	7	0.08195	0.00E+00	0.00E+00
SG06-10	15-SEP-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	0.26	=	7	0.06742	2.60E-10	1.68E-11
SG07-10	15-SEP-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	0.25	=	7	0.06742	2.50E-10	1.62E-11
SG13-05A	17-SEP-92	0	5	152.4	M,P-XYLENE (SUM OF ISOMERS)	0.1	=	7	0.06742	1.00E-10	1.29E-11
SG13-10	17-SEP-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	0.07	=	7	0.06742	7.00E-11	4.53E-12
SG13-20A	17-SEP-92	0	20	609.6	M,P-XYLENE (SUM OF ISOMERS)	0.05	=	7	0.06742	5.00E-11	1.62E-12
SG06-10	15-SEP-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	0.24	=	7	0.06742	2.40E-10	1.55E-11
SG07-10	15-SEP-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	0.2	=	7	0.06742	2.00E-10	1.29E-11
SG13-05A	17-SEP-92	0	5	152.4	O-XYLENE (1,2-DIMETHYLBENZENE)	0.06	=	7	0.06742	6.00E-11	7.77E-12
SG13-10	17-SEP-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND	7	0.06742	0.00E+00	0.00E+00
SG13-20A	17-SEP-92	0	20	609.6	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND	7	0.06742	0.00E+00	0.00E+00
SG06-10	15-SEP-92	0	10	304.8	TETRACHLOROETHYLENE(PCE)	14	=	7	0.06968	1.40E-08	9.36E-10
SG07-10	15-SEP-92	0	10	304.8	TETRACHLOROETHYLENE(PCE)	2.97	=	7	0.06968	2.97E-09	1.99E-10
SG13-05B	17-SEP-92	0	5	152.4	TETRACHLOROETHYLENE(PCE)	77	=	7	0.06968	7.70E-08	1.03E-08
SG13-10	17-SEP-92	0	10	304.8	TETRACHLOROETHYLENE(PCE)	0.08	=	7	0.06968	8.00E-11	5.35E-12
SG13-20A	17-SEP-92	0	20	609.6	TETRACHLOROETHYLENE(PCE)	0	ND	7	0.06968	0.00E+00	0.00E+00
SG06-10	15-SEP-92	0	10	304.8	TOLUENE	0.19	=	7	0.07367	1.90E-10	1.34E-11
SG07-10	15-SEP-92	0	10	304.8	TOLUENE	0.2	=	7	0.07367	2.00E-10	1.41E-11
SG13-05A	17-SEP-92	0	5	152.4	TOLUENE	0.07	=	7	0.07367	7.00E-11	9.90E-12

VOC Surface Flux Estimates by Soil Gas Sample
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Sample	Sample Date	Starting Depth (ft)	Ending Depth (ft)	Emission Depth (cm)	Parameter Name	Concentration (ug/L)	Qualifier	Polygon	Diffusion Coefficient (cm ² /s)	Concentration (g/cm ³)	Emission flux (g/m ² s)	Emission flux (g/m ² s)
SG13-10	17-SEP-92	0	10	304.8	TOLUENE	0.06	=	7	0.07367	6.00E-11	4.24E-16	4.24E-12
SG13-20B	17-SEP-92	0	20	609.6	TOLUENE	0.04	=	7	0.07367	4.00E-11	1.41E-16	1.41E-12
SG06-10	15-SEP-92	0	10	304.8	TRICHLOROETHYLENE (TCE)	0.44	=	7	0.07638	4.40E-10	3.23E-15	3.23E-11
SG07-10	15-SEP-92	0	10	304.8	TRICHLOROETHYLENE (TCE)	0.106	=	7	0.07638	1.06E-10	7.77E-16	7.77E-12
SG13-05A	17-SEP-92	0	5	152.4	TRICHLOROETHYLENE (TCE)	4	=	7	0.07638	4.00E-09	5.86E-14	5.86E-10
SG13-10	17-SEP-92	0	10	304.8	TRICHLOROETHYLENE (TCE)	0	ND	7	0.07638	0.00E+00	0.00E+00	0.00E+00
SG13-20A	17-SEP-92	0	20	609.6	TRICHLOROETHYLENE (TCE)	0	ND	7	0.07638	0.00E+00	0.00E+00	0.00E+00
SG07-10	15-SEP-92	0	10	304.8	cis-1,2-DICHLOROETHYLENE	0	ND	7	0.07442	0.00E+00	0.00E+00	0.00E+00
SG19-10	17-SEP-92	0	10	304.8	1,1,1-TRICHLOROETHANE	0	ND	8	0.07496	0.00E+00	0.00E+00	0.00E+00
SG34-10	19-SEP-92	0	10	304.8	1,1,1-TRICHLOROETHANE	0	ND	8	0.07496	0.00E+00	0.00E+00	0.00E+00
SG19-10	17-SEP-92	0	10	304.8	1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	0	ND	8	0.06349	0.00E+00	0.00E+00	0.00E+00
SG34-10	19-SEP-92	0	10	304.8	1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	0	ND	8	0.06349	0.00E+00	0.00E+00	0.00E+00
SG14-10	17-SEP-92	0	10	304.8	1,1-DICHLOROETHENE	0	ND	8	0.07442	0.00E+00	0.00E+00	0.00E+00
SG15-05	17-SEP-92	0	5	152.4	1,1-DICHLOROETHENE	0	ND	8	0.07442	0.00E+00	0.00E+00	0.00E+00
SG15-10	17-SEP-92	0	10	304.8	1,1-DICHLOROETHENE	0	ND	8	0.07442	0.00E+00	0.00E+00	0.00E+00
SG15-20A	17-SEP-92	0	20	609.6	1,1-DICHLOROETHENE	0	ND	8	0.07442	0.00E+00	0.00E+00	0.00E+00
SG16-10A	17-SEP-92	0	10	304.8	1,1-DICHLOROETHENE	0	ND	8	0.07442	0.00E+00	0.00E+00	0.00E+00
SG17-10	17-SEP-92	0	10	304.8	1,1-DICHLOROETHENE	0	ND	8	0.07442	0.00E+00	0.00E+00	0.00E+00
SG19-10	17-SEP-92	0	10	304.8	1,1-DICHLOROETHENE	0	ND	8	0.07442	0.00E+00	0.00E+00	0.00E+00
SG19-10B	17-SEP-92	0	10	304.8	1,1-DICHLOROETHENE	0	ND	8	0.07442	0.00E+00	0.00E+00	0.00E+00
SG23-10	18-SEP-92	0	10	304.8	1,1-DICHLOROETHENE	0	ND	8	0.07442	0.00E+00	0.00E+00	0.00E+00
SG24-10A	18-SEP-92	0	10	304.8	1,1-DICHLOROETHENE	0	ND	8	0.07442	0.00E+00	0.00E+00	0.00E+00
SG32-10	19-SEP-92	0	10	304.8	1,1-DICHLOROETHENE	0	ND	8	0.07442	0.00E+00	0.00E+00	0.00E+00
SG33-10	19-SEP-92	0	10	304.8	1,1-DICHLOROETHENE	0	ND	8	0.07442	0.00E+00	0.00E+00	0.00E+00
SG34-10	19-SEP-92	0	10	304.8	1,1-DICHLOROETHENE	0	ND	8	0.07442	0.00E+00	0.00E+00	0.00E+00
SG35-10A	19-SEP-92	0	10	304.8	1,1-DICHLOROETHENE	0	ND	8	0.07442	0.00E+00	0.00E+00	0.00E+00
SG37-10	22-SEP-92	0	10	304.8	1,1-DICHLOROETHENE	0	ND	8	0.07442	0.00E+00	0.00E+00	0.00E+00
SG38-10	22-SEP-92	0	10	304.8	1,1-DICHLOROETHENE	0	ND	8	0.07442	0.00E+00	0.00E+00	0.00E+00
SG40-10B	22-SEP-92	0	10	304.8	1,1-DICHLOROETHENE	0	ND	8	0.07442	0.00E+00	0.00E+00	0.00E+00
SG41-5	22-SEP-92	0	5	152.4	1,1-DICHLOROETHENE	0	ND	8	0.07442	0.00E+00	0.00E+00	0.00E+00
SG14-10	17-SEP-92	0	10	304.8	BENZENE	0	ND	8	0.08195	0.00E+00	0.00E+00	0.00E+00
SG15-05	17-SEP-92	0	5	152.4	BENZENE	0	ND	8	0.08195	0.00E+00	0.00E+00	0.00E+00
SG15-10	17-SEP-92	0	10	304.8	BENZENE	0	ND	8	0.08195	0.00E+00	0.00E+00	0.00E+00
SG15-20A	17-SEP-92	0	20	609.6	BENZENE	0	ND	8	0.08195	0.00E+00	0.00E+00	0.00E+00
SG16-10A	17-SEP-92	0	10	304.8	BENZENE	0	ND	8	0.08195	0.00E+00	0.00E+00	0.00E+00
SG17-10	17-SEP-92	0	10	304.8	BENZENE	0	ND	8	0.08195	0.00E+00	0.00E+00	0.00E+00
SG19-10	17-SEP-92	0	10	304.8	BENZENE	0	ND	8	0.08195	0.00E+00	0.00E+00	0.00E+00
SG19-10B	17-SEP-92	0	10	304.8	BENZENE	0	ND	8	0.08195	0.00E+00	0.00E+00	0.00E+00
SG23-10	18-SEP-92	0	10	304.8	BENZENE	0	ND	8	0.08195	0.00E+00	0.00E+00	0.00E+00

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VOC Surface Flux Estimates by Soil Gas Sample
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Sample	Sample Date	Starting Depth (ft)	Ending Depth (ft)	Emission Depth (cm)	Parameter Name	Concentration		Qualifier	Polygon	Diffusion Coefficient (cm ² /s)	Concentration		Emission Flux (g/m ² s)
						(ug/L)	(g/mcm ³)				(g/cm ² s)	(g/m ² s)	
SG24-10A	18-SEP-92	0	10	304.8	BENZENE	0	ND	8	0.08195	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SG32-10	19-SEP-92	0	10	304.8	BENZENE	0	ND	8	0.08195	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SG33-10	19-SEP-92	0	10	304.8	BENZENE	0.06	=	8	0.08195	6.00E-11	4.72E-16	4.72E-12	0.00E+00
SG34-10	19-SEP-92	0	10	304.8	BENZENE	0	ND	8	0.08195	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SG35-10B	19-SEP-92	0	10	304.8	BENZENE	0.07	=	8	0.08195	7.00E-11	5.51E-16	5.51E-12	0.00E+00
SG37-10	22-SEP-92	0	10	304.8	BENZENE	0	ND	8	0.08195	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SG38-10	22-SEP-92	0	10	304.8	BENZENE	0	ND	8	0.08195	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SG40-10B	22-SEP-92	0	10	304.8	BENZENE	0	ND	8	0.08195	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SG41-5	22-SEP-92	0	5	152.4	BENZENE	0	ND	8	0.08195	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SG14-10	17-SEP-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	0	ND	8	0.06742	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SG15-05	17-SEP-92	0	5	152.4	M,P-XYLENE (SUM OF ISOMERS)	0	ND	8	0.06742	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SG15-10	17-SEP-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	0	ND	8	0.06742	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SG15-20A	17-SEP-92	0	20	609.6	M,P-XYLENE (SUM OF ISOMERS)	0.06	=	8	0.06742	6.00E-11	1.94E-16	1.94E-12	0.00E+00
SG16-10A	17-SEP-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	0	ND	8	0.06742	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SG17-10	17-SEP-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	0	ND	8	0.06742	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SG19-10	17-SEP-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	0	ND	8	0.06742	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SG19-10B	17-SEP-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	0	ND	8	0.06742	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SG23-10	18-SEP-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	0.08	=	8	0.06742	8.00E-11	5.18E-16	5.18E-12	0.00E+00
SG24-10A	18-SEP-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	0	ND	8	0.06742	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SG32-10	19-SEP-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	0	ND	8	0.06742	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SG33-10	19-SEP-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	0.11	=	8	0.06742	1.10E-10	7.12E-16	7.12E-12	0.00E+00
SG34-10	19-SEP-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	0.003906	=	8	0.06742	3.91E-12	2.53E-17	2.53E-13	0.00E+00
SG35-10A	19-SEP-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	0.05	=	8	0.06742	5.00E-11	3.24E-16	3.24E-12	0.00E+00
SG37-10	22-SEP-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	0	ND	8	0.06742	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SG38-10	22-SEP-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	0	ND	8	0.06742	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SG40-10B	22-SEP-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	0	ND	8	0.06742	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SG41-5	22-SEP-92	0	5	152.4	M,P-XYLENE (SUM OF ISOMERS)	0	ND	8	0.06742	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SG14-10	17-SEP-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND	8	0.06742	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SG15-05	17-SEP-92	0	5	152.4	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND	8	0.06742	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SG15-10	17-SEP-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND	8	0.06742	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SG15-20A	17-SEP-92	0	20	609.6	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND	8	0.06742	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SG16-10A	17-SEP-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND	8	0.06742	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SG17-10	17-SEP-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND	8	0.06742	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SG19-10	17-SEP-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND	8	0.06742	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SG19-10B	17-SEP-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND	8	0.06742	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SG23-10	18-SEP-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND	8	0.06742	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SG24-10A	18-SEP-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND	8	0.06742	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SG32-10	19-SEP-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND	8	0.06742	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SG33-10	19-SEP-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND	8	0.06742	0.00E+00	0.00E+00	0.00E+00	0.00E+00

VOC Surface Flux Estimates by Soil Gas Sample
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Sample	Sample Date	Starting Depth (ft)	Ending Depth (ft)	Emission Depth (cm)	Parameter Name	Concentration (ug/L)	Qualifier	Polygon	Diffusion Coefficient (cm ² /s)	Concentration (g/mcm ³)	Emission flux (g/cm ² s)	Emission flux (g/m ² s)
SG34-10	19-SEP-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	0.07	=	ND	8	0.06742	0.00E+00	0.00E+00
SG35-10B	19-SEP-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	0.07	=	ND	8	0.06742	0.00E+00	0.00E+00
SG37-10	22-SEP-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	0.07	=	ND	8	0.06742	0.00E+00	0.00E+00
SG38-10	22-SEP-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	0.07	=	ND	8	0.06742	0.00E+00	0.00E+00
SG40-10B	22-SEP-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	0.07	=	ND	8	0.06742	0.00E+00	0.00E+00
SG41-5	22-SEP-92	0	5	152.4	O-XYLENE (1,2-DIMETHYLBENZENE)	0.06	=	ND	8	0.06742	0.00E+00	0.00E+00
SG14-10	17-SEP-92	0	10	304.8	TETRACHLOROETHYLENE(PCE)	0.06	=	ND	8	0.06968	0.00E+00	0.00E+00
SG15-05	17-SEP-92	0	5	152.4	TETRACHLOROETHYLENE(PCE)	0.06	=	ND	8	0.06968	0.00E+00	0.00E+00
SG15-10	17-SEP-92	0	10	304.8	TETRACHLOROETHYLENE(PCE)	1.9	=	ND	8	0.06968	1.90E-09	1.27E-10
SG15-20A	17-SEP-92	0	20	609.6	TETRACHLOROETHYLENE(PCE)	0.06	=	ND	8	0.06968	0.00E+00	0.00E+00
SG16-10A	17-SEP-92	0	10	304.8	TETRACHLOROETHYLENE(PCE)	0.06	=	ND	8	0.06968	0.00E+00	0.00E+00
SG17-10	17-SEP-92	0	10	304.8	TETRACHLOROETHYLENE(PCE)	0.06	=	ND	8	0.06968	0.00E+00	0.00E+00
SG19-10	17-SEP-92	0	10	304.8	TETRACHLOROETHYLENE(PCE)	0.198	=	ND	8	0.06968	1.98E-10	1.32E-11
SG19-10B	17-SEP-92	0	10	304.8	TETRACHLOROETHYLENE(PCE)	0.03	=	ND	8	0.06968	3.00E-11	2.01E-12
SG23-10	18-SEP-92	0	10	304.8	TETRACHLOROETHYLENE(PCE)	0.07	=	ND	8	0.06968	7.00E-11	4.68E-12
SG24-10A	18-SEP-92	0	10	304.8	TETRACHLOROETHYLENE(PCE)	0.04	=	ND	8	0.06968	0.00E+00	0.00E+00
SG32-10	19-SEP-92	0	10	304.8	TETRACHLOROETHYLENE(PCE)	0.04	=	ND	8	0.06968	4.00E-11	2.68E-12
SG33-10	19-SEP-92	0	10	304.8	TETRACHLOROETHYLENE(PCE)	0.04	=	ND	8	0.06968	0.00E+00	0.00E+00
SG34-10	19-SEP-92	0	10	304.8	TETRACHLOROETHYLENE(PCE)	0.04	=	ND	8	0.06968	0.00E+00	0.00E+00
SG35-10B	19-SEP-92	0	10	304.8	TETRACHLOROETHYLENE(PCE)	0.53	=	ND	8	0.06968	5.30E-10	3.54E-11
SG37-10	22-SEP-92	0	10	304.8	TETRACHLOROETHYLENE(PCE)	0.31	=	ND	8	0.06968	3.10E-10	2.07E-11
SG38-10	22-SEP-92	0	10	304.8	TETRACHLOROETHYLENE(PCE)	0.35	=	ND	8	0.06968	3.50E-10	2.34E-11
SG40-10A	22-SEP-92	0	10	304.8	TETRACHLOROETHYLENE(PCE)	0.21	=	ND	8	0.06968	2.10E-10	1.40E-11
SG41-5	22-SEP-92	0	5	152.4	TETRACHLOROETHYLENE(PCE)	0.07	=	ND	8	0.06968	0.00E+00	0.00E+00
SG14-10	17-SEP-92	0	10	304.8	TOLUENE	0.07	=	ND	8	0.07367	0.00E+00	0.00E+00
SG15-05	17-SEP-92	0	5	152.4	TOLUENE	0.07	=	ND	8	0.07367	0.00E+00	0.00E+00
SG15-10	17-SEP-92	0	10	304.8	TOLUENE	0.07	=	ND	8	0.07367	7.00E-11	9.90E-12
SG15-20A	17-SEP-92	0	20	609.6	TOLUENE	0.07	=	ND	8	0.07367	0.00E+00	0.00E+00
SG16-10A	17-SEP-92	0	10	304.8	TOLUENE	0.07	=	ND	8	0.07367	0.00E+00	0.00E+00
SG17-10	17-SEP-92	0	10	304.8	TOLUENE	0.07	=	ND	8	0.07367	0.00E+00	0.00E+00
SG19-10	17-SEP-92	0	10	304.8	TOLUENE	0.07	=	ND	8	0.07367	0.00E+00	0.00E+00
SG19-10B	17-SEP-92	0	10	304.8	TOLUENE	0.07	=	ND	8	0.07367	0.00E+00	0.00E+00
SG23-10	18-SEP-92	0	10	304.8	TOLUENE	0.08	=	ND	8	0.07367	8.00E-11	5.66E-12
SG24-10A	18-SEP-92	0	10	304.8	TOLUENE	0.08	=	ND	8	0.07367	0.00E+00	0.00E+00
SG32-10	19-SEP-92	0	10	304.8	TOLUENE	0.14	=	ND	8	0.07367	0.00E+00	0.00E+00
SG33-10	19-SEP-92	0	10	304.8	TOLUENE	0.07	=	ND	8	0.07367	1.40E-10	9.90E-12
SG34-10	19-SEP-92	0	10	304.8	TOLUENE	0.07	=	ND	8	0.07367	7.00E-11	4.95E-12
SG35-10B	19-SEP-92	0	10	304.8	TOLUENE	0.08	=	ND	8	0.07367	8.00E-11	5.66E-12
SG37-10	22-SEP-92	0	10	304.8	TOLUENE	0.08	=	ND	8	0.07367	0.00E+00	0.00E+00

VOC Surface Flux Estimates by Soil Gas Sample
Davis Global Communications Site

Sample	Sample Date	Starting Depth (ft)	Ending Depth (ft)	Emission Depth (cm)	Parameter Name	Concentration (ug/L)	Qualifier	Polygon	Diffusion Coefficient (cm ² /s)	Concentration (g/m ³)	Emission flux (g/m ² s)	Emission flux (g/m ² s)
SG38-10	22-SEP-92	0	10	304.8	TOLUENE	0	ND	8	0.07367	0.00E+00	0.00E+00	0.00E+00
SG40-10B	22-SEP-92	0	10	304.8	TOLUENE	0	ND	8	0.07367	0.00E+00	0.00E+00	0.00E+00
SG41-5	22-SEP-92	0	5	152.4	TOLUENE	0	ND	8	0.07367	0.00E+00	0.00E+00	0.00E+00
SG14-10	17-SEP-92	0	10	304.8	TRICHLOROETHYLENE (TCE)	0.04	=	8	0.07638	4.00E-11	2.93E-16	2.93E-12
SG15-05	17-SEP-92	0	5	152.4	TRICHLOROETHYLENE (TCE)	0.61	=	8	0.07638	0.00E+00	0.00E+00	0.00E+00
SG15-10	17-SEP-92	0	10	304.8	TRICHLOROETHYLENE (TCE)	0	ND	8	0.07638	6.10E-10	4.47E-15	4.47E-11
SG15-20A	17-SEP-92	0	20	609.6	TRICHLOROETHYLENE (TCE)	0	ND	8	0.07638	0.00E+00	0.00E+00	0.00E+00
SG16-10A	17-SEP-92	0	10	304.8	TRICHLOROETHYLENE (TCE)	0	ND	8	0.07638	0.00E+00	0.00E+00	0.00E+00
SG17-10	17-SEP-92	0	10	304.8	TRICHLOROETHYLENE (TCE)	0.04	=	8	0.07638	4.00E-11	2.93E-16	2.93E-12
SG19-10	17-SEP-92	0	10	304.8	TRICHLOROETHYLENE (TCE)	0	ND	8	0.07638	0.00E+00	0.00E+00	0.00E+00
SG19-10B	17-SEP-92	0	10	304.8	TRICHLOROETHYLENE (TCE)	0	ND	8	0.07638	0.00E+00	0.00E+00	0.00E+00
SG23-10	18-SEP-92	0	10	304.8	TRICHLOROETHYLENE (TCE)	0	ND	8	0.07638	0.00E+00	0.00E+00	0.00E+00
SG24-10A	18-SEP-92	0	10	304.8	TRICHLOROETHYLENE (TCE)	0	ND	8	0.07638	0.00E+00	0.00E+00	0.00E+00
SG32-10	19-SEP-92	0	10	304.8	TRICHLOROETHYLENE (TCE)	0	ND	8	0.07638	0.00E+00	0.00E+00	0.00E+00
SG33-10	19-SEP-92	0	10	304.8	TRICHLOROETHYLENE (TCE)	0	ND	8	0.07638	0.00E+00	0.00E+00	0.00E+00
SG34-10	19-SEP-92	0	10	304.8	TRICHLOROETHYLENE (TCE)	0	ND	8	0.07638	0.00E+00	0.00E+00	0.00E+00
SG35-10B	19-SEP-92	0	10	304.8	TRICHLOROETHYLENE (TCE)	0	ND	8	0.07638	0.00E+00	0.00E+00	0.00E+00
SG37-10	22-SEP-92	0	10	304.8	TRICHLOROETHYLENE (TCE)	0.07	=	8	0.07638	7.00E-11	5.13E-16	5.13E-12
SG38-10	22-SEP-92	0	10	304.8	TRICHLOROETHYLENE (TCE)	0	ND	8	0.07638	0.00E+00	0.00E+00	0.00E+00
SG40-10B	22-SEP-92	0	10	304.8	TRICHLOROETHYLENE (TCE)	0	ND	8	0.07638	0.00E+00	0.00E+00	0.00E+00
SG41-5	22-SEP-92	0	5	152.4	TRICHLOROETHYLENE (TCE)	0.06	=	8	0.07638	6.00E-11	4.40E-16	4.40E-12
SG19-10	17-SEP-92	0	10	304.8	cis-1,2-DICHLOROETHYLENE	0	ND	8	0.07442	0.00E+00	0.00E+00	0.00E+00
SG34-10	19-SEP-92	0	10	304.8	cis-1,2-DICHLOROETHYLENE	0	ND	8	0.07442	0.00E+00	0.00E+00	0.00E+00
SG11-05	17-SEP-92	0	5	152.4	1,1-DICHLOROETHYLENE	0	ND	9	0.07442	0.00E+00	0.00E+00	0.00E+00
SG11-10	17-SEP-92	0	10	304.8	1,1-DICHLOROETHYLENE	0	ND	9	0.07442	0.00E+00	0.00E+00	0.00E+00
SG11-20B	17-SEP-92	0	20	609.6	1,1-DICHLOROETHYLENE	0.32	=	9	0.07442	3.20E-10	1.14E-15	1.14E-11
SG12-10	17-SEP-92	0	10	304.8	1,1-DICHLOROETHYLENE	0	ND	9	0.07442	0.00E+00	0.00E+00	0.00E+00
SG31-10	19-SEP-92	0	10	304.8	1,1-DICHLOROETHYLENE	0	ND	9	0.07442	0.00E+00	0.00E+00	0.00E+00
SG39-10B	22-SEP-92	0	10	304.8	1,1-DICHLOROETHYLENE	0.84	=	9	0.07442	8.40E-10	6.00E-15	6.00E-11
SG11-05	17-SEP-92	0	5	152.4	BENZENE	0	ND	9	0.08195	0.00E+00	0.00E+00	0.00E+00
SG11-10	17-SEP-92	0	10	304.8	BENZENE	0	ND	9	0.08195	0.00E+00	0.00E+00	0.00E+00
SG11-20A	17-SEP-92	0	20	609.6	BENZENE	0	ND	9	0.08195	0.00E+00	0.00E+00	0.00E+00
SG12-10	17-SEP-92	0	10	304.8	BENZENE	0.09	=	9	0.08195	9.00E-11	7.00E-16	7.00E-12
SG31-10	19-SEP-92	0	10	304.8	BENZENE	0	ND	9	0.08195	0.00E+00	0.00E+00	0.00E+00
SG39-10B	22-SEP-92	0	10	304.8	BENZENE	0	ND	9	0.08195	0.00E+00	0.00E+00	0.00E+00
SG11-05	17-SEP-92	0	5	152.4	M,P-XYLENE (SUM OF ISOMERS)	0.06	=	9	0.06742	6.00E-11	7.77E-16	7.77E-12
SG11-10	17-SEP-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	0	ND	9	0.06742	0.00E+00	0.00E+00	0.00E+00
SG11-20A	17-SEP-92	0	20	609.6	M,P-XYLENE (SUM OF ISOMERS)	0.04	=	9	0.06742	4.00E-11	1.29E-16	1.29E-12
SG12-10	17-SEP-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	0.13	=	9	0.06742	1.30E-10	8.41E-16	8.41E-12

VOC Surface Flux Estimates by Soil Gas Sample
Davis Global Communications Site

Sample	Sample Date	Starting Depth (ft)	Ending Depth (ft)	Emission Depth (cm)	Parameter Name	Concentration (ug/L)	Qualifier	Polygon	Diffusion Coefficient (cm ² /s)	Concentration (g/mcm ³)	Emission flux (g/cm ² s)	Flux (g/m ² s)
SG31-10	19-SEP-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	0	ND	9	0.06742	0.00E+00	0.00E+00	0.00E+00
SG39-10B	22-SEP-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	0	ND	9	0.06742	0.00E+00	0.00E+00	0.00E+00
SG11-05	17-SEP-92	0	5	152.4	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND	9	0.06742	0.00E+00	0.00E+00	0.00E+00
SG11-10	17-SEP-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND	9	0.06742	0.00E+00	0.00E+00	0.00E+00
SG11-20A	17-SEP-92	0	20	609.6	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND	9	0.06742	0.00E+00	0.00E+00	0.00E+00
SG12-10	17-SEP-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	0.19	=	9	0.06742	1.90E-10	1.23E-15	1.23E-11
SG31-10	19-SEP-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND	9	0.06742	0.00E+00	0.00E+00	0.00E+00
SG39-10B	22-SEP-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND	9	0.06742	0.00E+00	0.00E+00	0.00E+00
SG11-05	17-SEP-92	0	5	152.4	TETRACHLOROETHYLENE(PCE)	0	ND	9	0.06968	0.00E+00	0.00E+00	0.00E+00
SG11-10	17-SEP-92	0	10	304.8	TETRACHLOROETHYLENE(PCE)	0	ND	9	0.06968	0.00E+00	0.00E+00	0.00E+00
SG11-20B	17-SEP-92	0	20	609.6	TETRACHLOROETHYLENE(PCE)	0.97	=	9	0.06968	9.70E-10	3.24E-15	3.24E-11
SG12-10	17-SEP-92	0	10	304.8	TETRACHLOROETHYLENE(PCE)	0	ND	9	0.06968	0.00E+00	0.00E+00	0.00E+00
SG31-10	19-SEP-92	0	10	304.8	TETRACHLOROETHYLENE(PCE)	0.06	=	9	0.06968	6.00E-11	4.01E-16	4.01E-12
SG39-10B	22-SEP-92	0	10	304.8	TETRACHLOROETHYLENE(PCE)	5.02	=	9	0.06968	5.02E-09	3.36E-14	3.36E-10
SG11-05	17-SEP-92	0	5	152.4	TOLUENE	0.09	=	9	0.07367	9.00E-11	1.27E-15	1.27E-11
SG11-10	17-SEP-92	0	10	304.8	TOLUENE	0.06	=	9	0.07367	6.00E-11	4.24E-16	4.24E-12
SG11-20A	17-SEP-92	0	20	609.6	TOLUENE	0.04	=	9	0.07367	4.00E-11	1.41E-16	1.41E-12
SG12-10	17-SEP-92	0	10	304.8	TOLUENE	0.22	=	9	0.07367	2.20E-10	1.56E-15	1.56E-11
SG31-10	19-SEP-92	0	10	304.8	TOLUENE	0	ND	9	0.07367	0.00E+00	0.00E+00	0.00E+00
SG39-10B	22-SEP-92	0	10	304.8	TOLUENE	0	ND	9	0.07367	0.00E+00	0.00E+00	0.00E+00
SG11-05	17-SEP-92	0	5	152.4	TRICHLOROETHYLENE (TCE)	0	ND	9	0.07638	0.00E+00	0.00E+00	0.00E+00
SG11-10	17-SEP-92	0	10	304.8	TRICHLOROETHYLENE (TCE)	0	ND	9	0.07638	0.00E+00	0.00E+00	0.00E+00
SG11-20A	17-SEP-92	0	20	609.6	TRICHLOROETHYLENE (TCE)	0	ND	9	0.07638	0.00E+00	0.00E+00	0.00E+00
SG12-10	17-SEP-92	0	10	304.8	TRICHLOROETHYLENE (TCE)	0	ND	9	0.07638	0.00E+00	0.00E+00	0.00E+00
SG31-10	19-SEP-92	0	10	304.8	TRICHLOROETHYLENE (TCE)	0	ND	9	0.07638	0.00E+00	0.00E+00	0.00E+00
SG39-10B	22-SEP-92	0	10	304.8	TRICHLOROETHYLENE (TCE)	0.05	=	9	0.07638	5.00E-11	3.67E-16	3.67E-12
SG20-10	18-SEP-92	0	10	304.8	1,1-DICHLOROETHENE	0	ND	10	0.07442	0.00E+00	0.00E+00	0.00E+00
SG20-10	18-SEP-92	0	10	304.8	BENZENE	0	ND	10	0.08195	0.00E+00	0.00E+00	0.00E+00
SG20-10	18-SEP-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	0	ND	10	0.06742	0.00E+00	0.00E+00	0.00E+00
SG20-10	18-SEP-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	0	ND	10	0.06742	0.00E+00	0.00E+00	0.00E+00
SG20-10	18-SEP-92	0	10	304.8	TETRACHLOROETHYLENE(PCE)	14.5	=	10	0.06968	1.45E-08	9.70E-14	9.70E-10
SG20-10	18-SEP-92	0	10	304.8	TOLUENE	0	ND	10	0.07367	0.00E+00	0.00E+00	0.00E+00
SG20-10	18-SEP-92	0	10	304.8	TRICHLOROETHYLENE (TCE)	0	ND	10	0.07638	0.00E+00	0.00E+00	0.00E+00
SG26-10	18-SEP-92	0	10	304.8	1,1-DICHLOROETHENE	0	ND	11	0.07442	0.00E+00	0.00E+00	0.00E+00
SG27-10	18-SEP-92	0	10	304.8	1,1-DICHLOROETHENE	0	ND	11	0.07442	0.00E+00	0.00E+00	0.00E+00
SG26-10	18-SEP-92	0	10	304.8	BENZENE	0	ND	11	0.08195	0.00E+00	0.00E+00	0.00E+00
SG27-10	18-SEP-92	0	10	304.8	BENZENE	0	ND	11	0.08195	0.00E+00	0.00E+00	0.00E+00
SG26-10	18-SEP-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	0	ND	11	0.06742	0.00E+00	0.00E+00	0.00E+00
SG27-10	18-SEP-92	0	10	304.8	M,P-XYLENE (SUM OF ISOMERS)	0	ND	11	0.06742	0.00E+00	0.00E+00	0.00E+00

DIFFUSE.XLS

VOC Surface Flux Estimates by Soil Gas Sample
Davis Global Communications Site

Sample	Sample Date	Starting Depth (ft)	Ending Depth (ft)	Emission Depth (cm)	Parameter Name	Concentration		Qualifier	Diffusion		Emission flux	
						(ug/L)	(g/mcm ³)		Coefficient (cm ² /s)	(g/cm ² s)	(g/m ² s)	(g/m ² s)
SG26-10	18-SEP-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	0	0.06742	ND	11	0.00E+00	0.00E+00	0.00E+00
SG27-10	18-SEP-92	0	10	304.8	O-XYLENE (1,2-DIMETHYLBENZENE)	0	0.06742	ND	11	0.00E+00	0.00E+00	0.00E+00
SG26-10	18-SEP-92	0	10	304.8	TETRACHLOROETHYLENE(PCE)	0.02	0.06968	=	11	2.00E-11	1.34E-16	1.34E-12
SG27-10	18-SEP-92	0	10	304.8	TETRACHLOROETHYLENE(PCE)	0.35	0.06968	=	11	3.50E-10	2.34E-15	2.34E-11
SG26-10	18-SEP-92	0	10	304.8	TOLUENE	0	0.07367	ND	11	0.00E+00	0.00E+00	0.00E+00
SG27-10	18-SEP-92	0	10	304.8	TOLUENE	0	0.07367	ND	11	0.00E+00	0.00E+00	0.00E+00
SG26-10	18-SEP-92	0	10	304.8	TRICHLOROETHYLENE (TCE)	0	0.07638	ND	11	0.00E+00	0.00E+00	0.00E+00
SG27-10	18-SEP-92	0	10	304.8	TRICHLOROETHYLENE (TCE)	0	0.07638	ND	11	0.00E+00	0.00E+00	0.00E+00

Attachment F-2
Emissions Estimation and Box Modeling
(Outdoor Ambient Air) Summary

Emissions Estimation and Box Modeling (Outdoor Ambient Air) Summary												
Davis Global Communications Site												
Maximum Emissions Fluxes in Each Source Area (g/m ² -d)												
Parameter name	Source Area											
	1	2	3	4	5	6	7	8	9	10	11	
1,1,1-TRICHLOROETHANE	8.01E-13	4.45E-11	3.12E-11	9.46E-12		1.83E-12						
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	1.83E-10	8.49E-11		4.40E-12	2.12E-12	2.93E-12						
1,1-DICHLOROETHANE	5.78E-13		4.63E-13	3.41E-12	1.02E-12							
1,1-DICHLOROETHENE	1.34E-10	1.67E-10	1.27E-10	3.61E-10		1.93E-11	7.57E-11		6.00E-11			
BENZENE	1.56E-12	3.14E-12	4.09E-11	2.08E-12	3.14E-11	2.12E-11	1.57E-11	5.51E-12	7.08E-12			
DICHLORODIFLUOROMETHANE	5.20E-13				1.41E-11							
M,P-XYLENE (SUM OF ISOMERS)	2.33E-11	7.77E-12	5.05E-11	6.47E-12	1.05E-09	2.72E-11	1.68E-11	7.12E-12	8.41E-12			
O-XYLENE (1,2-DIMETHYLBENZENE)	1.04E-11	1.62E-12	2.20E-11		1.13E-09	1.88E-11	1.55E-11	4.53E-12	1.23E-11			
TETRACHLOROETHYLENE(PCE)	1.43E-08	2.27E-08	6.42E-09	1.18E-08	3.48E-09	9.36E-10	1.03E-08	1.27E-10	3.36E-10	9.70E-10	2.34E-11	
TOLUENE	1.31E-09	1.38E-10	8.06E-11	7.46E-12	9.01E-10	4.95E-11	1.41E-11	9.90E-12	1.56E-11			
TRICHLOROETHYLENE (TCE)	2.33E-10	3.89E-10	2.30E-10	1.86E-09	6.60E-12	1.98E-10	5.86E-11	4.47E-11	3.67E-12			
VINYL CHLORIDE					4.41E-11							
cis-1,2-DICHLOROETHYLENE	2.12E-12	9.15E-13	1.77E-12	5.24E-11	1.19E-12							
Source Area Surface Area (m ²)	2.44E+02	2.07E+02	3.92E+02	1.43E+02	5.69E+02	2.41E+03	7.37E+02	3.11E+03	1.39E+03	3.95E+02	7.49E+02	Total Area 1.03E+04

Emissions Estimation and Box Modeling (Outdoor Ambient Air) Summary			
Davis Global Communications Site			
Box Model Concentration in Air			
Parameter name	Q	C (g/m ³)	C (mg/m ³)
1,1,1-TRICHLOROETHANE	2.65E-12	5.72E-11	5.72E-08
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	6.88E-12	1.49E-10	1.49E-07
1,1-DICHLOROETHANE	1.34E-13	2.90E-12	2.90E-09
1,1-DICHLOROETHENE	3.42E-11	7.40E-10	7.40E-07
BENZENE	1.21E-11	2.61E-10	2.61E-07
DICHLORODIFLUOROMETHANE	7.87E-13	1.70E-11	1.70E-08
M,P-XYLENE (SUM OF ISOMERS)	7.15E-11	1.55E-09	1.55E-06
O-XYLENE (1,2-DIMETHYLBENZENE)	7.19E-11	1.55E-09	1.55E-06
TETRACHLOROETHYLENE(PCE)	2.47E-09	5.33E-08	5.33E-05
TOLUENE	1.04E-10	2.25E-09	2.25E-06
TRICHLOROETHYLENE (TCE)	1.50E-10	3.24E-09	3.24E-06
VINYL CHLORIDE	2.43E-12	5.24E-11	5.24E-08
cis-1,2-DICHLOROETHYLENE	9.25E-13	2.00E-11	2.00E-08
Length of Side (L) (m) =	1.00E+02		
Annual average windspeed (V) (m) =	2.31E+00		
Box Height (H) (m) =	2.00E+00		
Area (A) (m ²) =	1.00E+04		
Windspeed Calculation			
Windspeed (mph) =	10		
(m/s) =	4.62963		
V =	2.314815		

Emissions Estimation and Box Modeling
(Outdoor Air) Summary
(DAU-BOX.XLS)

Fluxes estimated from soil gas concentrations using
Fryer et al, 1980 model (See Appendix F).

Sample & parameter-specific flux estimates are
shown in DIFFUSE.XLS. Individual flux
estimates are grouped into one of 11
source areas, as shown in FLUX-SUM.XLS
Maximum flux of each parameter is used to
calculate area-weighted flux:

$$Q = \sum \left(\frac{Q_i A_i}{A_{tot}} \right)$$

Q = Area-weighted emission flux used
in box modeling (g/m^2-s)

Q_i = Highest flux in source area i (g/m^2-s)

A_i = Surface Area of source area i (m^2)

A_{tot} = Total extent of soil gas contamination
(m^2) — This is the surface area
used for box modeling

Example for PCE in Source Area 1:

$$\text{Maximum flux } (Q_i) = 1.45 \times 10^{-8} \text{ g/m}^2\text{-s}$$

$$\text{Area } (A_i) = 244.22 \text{ m}^2$$

$$\text{Area, total } (A_{\text{tot}}) = 10,342.79 \text{ m}^2$$

$$Q = \frac{(1.45 \times 10^{-8})(244.22)}{10,342.79}$$
$$= 3.42 \times 10^{-10} \text{ g/m}^2\text{-s}$$

$$\text{Summed across all 11 areas} = 2.47 \times 10^{-9} \text{ g/m}^2\text{-s}$$

Calculation of PCE concentration in air

$$C = \frac{Q \times A \times 1000 \text{ mg/g}}{L \times V \times H}$$

C = Conc. in air - mg/m^3

Q = Area-weighted emissions flux ($\text{g}/\text{m}^2\text{-s}$)

A = Surface Area of extent of soil gas contamination (m^2)

L = Length of side of source area - assumes that A is a square. Estimated as $\sqrt{A}$. (m)

V = Annual average wind speed (m/s) - based on 10 mph (Yolo County, 1983).

H = Box height - corresponds to breathing zone (m).

$$Q = 2.47 \times 10^{-9} \text{ g}/\text{m}^2\text{-s}$$

$$A = 10,000 \text{ m}^2$$

$$L = 100 \text{ m}$$

$$V = 2.31 \text{ m}/\text{s}, \text{ as follows:}$$

$$10 \frac{\text{mi}}{\text{hr}} \times \frac{\text{Km}}{0.6 \text{ mi}} \times \frac{10^3 \text{ m}}{1 \text{ km}} \times \frac{\text{hr}}{3600 \text{ sec}} = 4.63 \text{ m}/\text{s}$$

EPA, 1986 says to use $1/2$ annual average wind speed.

$$\text{so, } V = 2.31 \text{ m}/\text{s}$$

$$H = 2 \text{ m}$$

$$C_2 = \frac{2.47 \times 10^{-9} \text{ g/m}^2\text{-s} \times 10,000 \text{ m}^2 \times 1000 \text{ mg/g}}{100 \text{ m} \times 2.31 \text{ m/s} \times 2 \text{ m}}$$

$$= 5.35 \times 10^{-5} \text{ mg/m}^3$$

Attachment F-3
Estimation of Emissions
from Sprinkler Irrigation

AIRSTRIP.XLS

Concentrations in air associated with sprinkler irrigation with Production Well Water								
Davis Global Communications Site								
Chemical	Concentration in Water (ug/L)	Quantity emitted in water (ug/s)	Quantity emitted to air (ug/s)	Quantity emitted to air (g/s)	Concentration in Air (mg/m^3)			
1,1-Dichloroethene	3	2.63	1.66	1.66E-06	3.56E-06	Water Usage (gal/month) (L/s) =	600000 0.87615741	
1,4-Dichlorobenzene	3.71	3.25	2.05	2.05E-06	4.40E-06			
Acetone	41	35.92	22.63	2.26E-05	4.86E-05	Volatilization factor =	0.63	
Bromodichloromethane	2.6	2.28	1.44	1.44E-06	3.08E-06			
Bromoform	47	41.18	25.94	2.59E-05	5.57E-05	Surface Area (acres) = (m^2)	2.5 10117.5	
Chlorodibromomethane	8.8	7.71	4.86	4.86E-06	1.04E-05			
Chloroform	6.7	5.87	3.70	3.70E-06	7.94E-06	L (m) V (m/s) H (m)	100.585784 2.31481481	
Ethylene dibromide	2.3	2.02	1.27	1.27E-06	2.73E-06			
1,1,2-trichloro-1,2,2-trifluoromethane	14.1	12.35	7.78	7.78E-06	1.67E-05	Windspeed (mph) = (m/s) = V =	2 10 4.62962963 2.31481481	
Methyl ethyl ketone	0.6	0.53	0.33	3.31E-07	7.11E-07			
Methyl isobutyl ketone	7.2	6.31	3.97	3.97E-06	8.53E-06			
Tetrachloroethene	3.2	2.80	1.77	1.77E-06	3.79E-06			
Toluene	0.4	0.35	0.22	2.21E-07	4.74E-07			
Trichloroethene	7.4	6.48	4.08	4.08E-06	8.77E-06			
Trichlorofluoromethane	0.6	0.53	0.33	3.31E-07	7.11E-07			

Davis Global Communications Site Risk Assessment
Concentrations of VOCs in Air Associated with
Sprinkler Irrigation with Production Well Water
(AIRSTRIP.XLS)

Production well pumping rates between 1988-1989
= 200,000 - 600,000 gal/month for
sanitary and irrigation purposes. (ITC, 1992)

Area irrigated = 2.5 Ac (Davis Bajka / MAFB-Em
to Gerald Vogt / CH2M HILL, June 1993)

Example calculation for 1,1-DCE, 3 ug/L
in the production well.

Calculate water use rate in L/s

Assumptions:

- Use rate = 600,000 gal/mo.
- Averaged over 30 d/month, 24 hr/day.

Peak emissions would occur over period when
sprinklers operate (1 hr/day, 3 day/week,
for MSgt. Olgeron, 8/6/93); Emissions
are zero at all other times. Average
emissions are proportional to water use rate
averaged over all hours.

$$\begin{aligned} 600,000 \frac{\text{gal}}{\text{mo}} \times 3.785 \frac{\text{L}}{\text{gal}} \times \frac{\text{mo}}{30 \text{ day}} \times \frac{\text{day}}{24 \text{ hr}} \times \frac{\text{hr}}{3,600 \text{ sec}} \\ = 0.876 \text{ L/s} \end{aligned}$$

Calculate Quantity of VOC emitted in water

$$1,1\text{-DCE} = 3 \text{ ug/L}$$

$$3 \frac{\text{ug}}{\text{L}} \times 0.876 \frac{\text{L}}{\text{s}} = 2.63 \text{ ug/s}$$

Calculate Quantity of VOC emitted into air

A fraction of VOC in water will be emitted into air. Fraction represented by volatilization factor (VF). Approach based on Andelman, 1990. Value for VF selected from following data used by Andelman:

Transfer Efficiencies for Radon for Various Water Uses in a Typical House

Water Use	Daily Quantity (l)	Transfer Efficiency (%)
Showers	150	63
Tub baths	150	47
Toilet	365	30
Laundry	130	90
Dishwasher	55	90
Drinking and kitchen use	30	30
Cleaning	10	90
Total	890	

(Source: Prichard and Gesell, 1981)

Transfer efficiency for showering assumed to be most representative of sprinkler irrigation (63%). $VF = 0.63$

For 1,1-DCE

$$2.63 \text{ ug/s} \times 0.63 = 1.66 \text{ ug/s}$$

$$1.66 \text{ ug/s} \times \text{g}/10^6 \text{ ug} = 1.66 \times 10^{-6} \text{ g/s}$$

Calculate VOC conc. in air

Box model used, assuming 2.5 Ac are is a square.

$$2.5 \text{ Ac} \times \frac{4047 \text{ m}^2}{\text{Ac}} = 10,117.5 \text{ m}^2$$

$$\text{Box Model: } \frac{Q \times 1000 \text{ mg/g}}{L \times V \times H} = C \text{ (mg/m}^3\text{)}$$

$$Q = 1.66 \times 10^{-6} \text{ g/s}$$

$$L = \sqrt{10,117.5 \text{ m}^2} = 100.59 \text{ m}$$

$$V = \text{Annual average windspeed of 10 mph (Yolo County, 1983)}$$

$$10 \frac{\text{mi}}{\text{hr}} \times \frac{\text{km}}{0.6 \text{ mi}} \times \frac{1000 \text{ m}}{\text{km}} \times \frac{\text{hr}}{3,600 \text{ sec}} = 4.6 \text{ m/s}$$

$$\text{EPA, 1986 says to use } 1/2 \text{ Annual Average,}$$
$$\text{so } V = 2.3 \text{ m/s}$$

$$H = 2 \text{ m (EPA, 1986)}$$

$$C = \frac{1.66 \times 10^{-6} \text{ g/s} \times 1,000 \text{ mg/g}}{100.59 \text{ m} \times 2.3 \text{ m/s} \times 2 \text{ m}}$$
$$= 3.59 \times 10^{-6} \text{ mg/m}^3$$

Attachment F-4
Indoor Air Quality "Box Model"
for Contaminants in Soil Gas

Indoor Air Quality "Box Model" for Contaminants in Soil Gas				
Davis Global Communications Site - Building 4708				
Chemical				
	Q	E (calc)	C (calc)	
	(g/m ² -s)	(g/s)	(g/m ³)	(mg/m ³)
1,1,1-TRICHLOROETHANE	0	0.00E+00	0.00E+00	0.00E+00
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	0	0.00E+00	0.00E+00	0.00E+00
1,1-DICHLOROETHANE	0	0.00E+00	0.00E+00	0.00E+00
1,1-DICHLOROETHENE	2.8557E-12	5.31E-09	4.22E-09	4.22E-06
BENZENE	7.8617E-12	1.46E-08	1.16E-08	1.16E-05
DICHLORODIFLUOROMETHANE	0	0.00E+00	0.00E+00	0.00E+00
M,P-XYLENE (SUM OF ISOMERS)	1.4229E-11	2.64E-08	2.10E-08	2.10E-05
O-XYLENE (1,2-DIMETHYLBENZENE)	0	0.00E+00	0.00E+00	0.00E+00
TETRACHLOROETHYLENE(PCE)	3.7434E-10	6.96E-07	5.53E-07	5.53E-04
TOLUENE	1.1308E-11	2.10E-08	1.67E-08	1.67E-05
TRICHLOROETHYLENE (TCE)	0	0.00E+00	0.00E+00	0.00E+00
VINYL CHLORIDE	0	0.00E+00	0.00E+00	0.00E+00
cis-1,2-DICHLOROETHYLENE	0	0.00E+00	0.00E+00	0.00E+00
Parameters				
Symbol	Description	Units	Value	
A	Building Surface Area	m ²	1858	
F	Emission Surface Area Fraction		1	
H	Building Height	m	2.44	
ACH	Air Changes per Hour	1/hr	1	
Calculated Values				
Symbol	Description	Units	Value	
V	Building Volume (A*H)	m ³	4530.5472	
Q	Ventilation rate	m ³ /s	1.26E+00	

Davis Global Communication Site Risk Assessment
Indoor Air Quality "Box model" for
Contaminants in Soil Gas
(IND-BOX2.XLS)

Concentration in indoor air in Bldg 4708 estimated from concentrations in soil gas measured from four samples collected around Bldg 4708. Surface fluxes estimated from the highest detected concentrations

Calculation of Indoor Air Concentration

$$C = \frac{E}{Q}$$

C = Conc. in g/m^3

E = Emission Rate into Bldg, g/s

Q = Bldg ventilation rate, m^3/s

Calculation of E - Example for PCE

$$E = Q_{SG} \times A \times F$$

Q_{SG} = VOC flux from soil gas = $3.74 \times 10^{-10} \text{ g}/\text{m}^2\text{-s}$

A = Floor surface area, measured from scale = $1,858 \text{ m}^2$
figure

F = Fraction of floor surface through which contaminants enter Bldg. = 1.0

Ch. 11 - Davis Site - Indoor
Air Concentration Calculation

2

$$E = 3.74 \times 10^{-10} \text{ g/m}^2\text{-s} \times 1,858 \text{ m}^2 \times 1.0 \\ = 6.95 \times 10^{-7} \text{ g/s}$$

Calculation of Q

$$Q = \frac{V \times \text{ACH}}{3600 \text{ s/hr}}$$

V = Building volume, using a 8' ceiling height
(2.438 m)

$$1,858 \text{ m}^2 \times 2.438 \text{ m} = 4,530 \text{ m}^3$$

$$\text{ACH} = 1 / \text{hr}$$

$$Q = \frac{4,530 \text{ m}^3 \times 1 / \text{hr}}{3,600 \text{ s/hr}} = 1.26 \text{ m}^3/\text{s}$$

$$C = \frac{6.95 \times 10^{-7} \text{ g/s}}{1.26 \text{ m}^3/\text{s}} = 5.52 \times 10^{-7} \text{ g/m}^3 \\ = 5.52 \times 10^{-4} \text{ mg/m}^3$$

Appendix G
EXPOSURE ASSESSMENT FOR
HUMAN HEALTH RISK ASSESSMENT

PREPARED FOR: Davis Global Communications Site Risk Assessment
PREPARED BY: John Lowe/CH2M HILL
DATE: August 20, 1993
SUBJECT: Exposure Assessment for Human Health Risk Assessment
PROJECT: SAC28722.55.15

Introduction

Exposure refers to the potential contact of an individual with a contaminant. Exposure assessment is the estimation of the magnitude, frequency, duration, and routes of exposure to a contaminant. Human exposure to contaminants is typically evaluated by estimating the amount of a contaminant that could come into contact with the lungs, gastrointestinal tract, or skin during a specified period of time. This exposure assessment is based on scenarios that define human populations potentially exposed to contaminants of potential concern (COPCs) originating from the Davis Site. The potential pathways of exposure, frequency and duration of potential exposures, rates of contact with air, water, and soil and the concentrations of contaminants in air, groundwater, or soil are evaluated in the assessment of human intake of COPCs. Contaminant intakes and associated risks have been quantified for all exposure pathways considered potentially complete. This technical memorandum describes the assumptions, data, and methods used to evaluate the potential for human exposure to COPCs originating from the Davis Site and involves the following steps:

- Identification of potentially exposed populations
- Identification of potential exposure pathways and selection of complete exposure pathways
- Evaluation of the environmental fate and transport of contaminants in soil and groundwater
- Development of exposure scenarios
- Estimation of exposure point concentrations used to quantify contaminant intakes
- Quantification of contaminant intakes for each exposure pathway

The information developed through these steps was then used to develop exposure scenarios. An exposure scenario considers the sources of the contaminant substances that could come into contact with the subject population. Exposure prediction models based on the fate and transport of the contaminant substances are then used to evaluate the pathways from the sources to subject population. These can be highly complex models or relatively simple models such as multiplicative factors that predict an individual's exposure as a function of several input variables (such as body weight, inhalation rate and exposure frequency) (U.S. EPA, 1985).

The exposure scenarios for this risk assessment (RA) were based on an estimate of the reasonable maximum exposure (RME). The RME is defined as the highest exposure that is reasonably expected to occur at a site. RMEs are estimated for individual exposure pathways. If a population is exposed via more than one pathway, the combination of exposures across pathways must also represent an RME. The intent of the RME is to develop a conservative estimate of exposure (i.e., well above the average case) that is still within the range of possible exposures (U.S. EPA, 1989a). Specific factors in the RME exposure scenario included the 90 or 95 percentile values for input variables such as inhalation rate, exposure frequency and exposure duration, and exposure concentrations based on the upper 95 percent confidence limit (UCL) of mean concentrations, or the highest concentrations, detected at the site (U.S. EPA, 1989b).

Methods used in characterizing health risks are also described in this technical memorandum. Risk characterization involves combining the results of the exposure and toxicity assessments and comparison of these with toxicity criteria established by the regulatory agencies to provide numerical estimates of risks. The toxicity criteria used in characterizing health risks are presented in Appendix E, Toxicity Assessment for the Human Health Risk Assessment.

Summary tables characterizing health risks can be found in Appendix A, Human Health Risk Assessment Summary Tables. Spreadsheet calculations supporting the risk characterization tables are presented in Attachment G-1 to this memorandum.

Identification of Potentially Exposed Populations

Populations potentially exposed to contaminants detected at the site are identified as either onsite or offsite populations that may be present under either current or future land uses. Information developed in Appendix B, Site Background Information, has been used to identify potentially exposed populations.

Current Land Uses

Onsite Populations

The Davis Site is operated 24 hours a day by up to 12 personnel of the 2049th Communications Squadron, which operates out of McClellan AFB. Linked to McClellan AFB by Intersite Microwave Radio, the Davis Site has radio transmitters and antennae that provide long-range radio transmission capabilities. Work activities at the site consist of operation and maintenance of the transmission equipment and associated facilities. Onsite personnel are not involved in work that requires excavation of soils.

Offsite Populations

The closest offsite population is located at the Davis Migrant Center, a migrant farm-worker camp operated by the Yolo County Housing Authority, at the corner of County Roads 105 and 36. This center is approximately one-half mile from areas where contaminants have been detected in soil or groundwater. Reportedly, the migrant center is hydrologically downgradient of the Davis Site.

Future Land Uses

Changes are not anticipated in the mission of the Davis Site; therefore, it is likely that current and future land uses will be identical. Future uses of the site in the event of a mission change are unknown.

Onsite Populations

The area surrounding the site is zoned as agricultural land. Yolo County limits residential development in agricultural land to dwellings for preservation of the family farm or for farm employees. Though the mission and future site uses are unknown, exposures associated with hypothetical future residential land use were considered in the RA to address potential health risks associated with contaminants detected in groundwater monitoring wells.

Offsite Populations

Offsite populations are not likely to change in the future.

Identification of Exposure Pathways

An exposure pathway describes the mechanism through which a contaminant comes into contact with a receptor. There must be a complete exposure pathway from the source of contaminants in the environment (i.e., in soil or groundwater) to human receptors in order for contaminant intake to occur. In this section, the complete exposure pathways are chosen from all potential pathways, and are further evaluated.

A complete contaminant exposure pathway consists of the following four elements:

- A source of contaminant release to the environment
- An environmental transport medium
- A point of contact (known as the exposure point) for receptors with the COPCs
- A route of intake for the contaminant into the receptor

If one of these four elements is missing, the exposure pathway is incomplete and there is no intake (or subsequent health risk) associated with that pathway. The presence or absence of any of these elements depends on the specific conditions found at the site. The potential exposure pathways for each exposure scenario appear in Table G-1. Table G-1 also presents the rationale for identifying and selecting complete exposure pathways that were evaluated in the RA.

Exposure Scenarios

Exposure scenarios describe the conditions under which exposures could potentially occur to contaminants detected at the Davis Site. They identify the receptor populations, the pathways of exposure to those receptors, and the contaminant data used to estimate contaminant intake through each exposure pathway. The exposure scenarios evaluated in the RA are listed in Table G-2. The exposure scenarios are identified by receptor, as follows:

- Onsite worker, outdoors—a worker at the site responsible for work activities located largely outdoors
- Onsite worker, excavation—a construction worker performing work onsite that requires excavation of soil, such as installation of subsurface utilities.
- Onsite worker, indoors (Building 4708)—a worker responsible for work activities located primarily in the main building at the site
- Hypothetical future resident—a mission change at the site, in which it is developed for agricultural use and a farm residence is placed onsite

Note that in most cases, there are multiple exposure pathways associated with a scenario. Health risks for each scenario were aggregated across the exposure scenarios identified in Table G-2.

Table G-1
Initial Screening of Potential Exposure Pathways

Sheet 1 of 2					
Location/Media	Release	Exposure Route	Receptor	Rationale	Exposure Potentially Feasible
Onsite Surface Soil	Direct contact Windblown dust/mechanical disturbance	Dermal/Ingestion Inhalation	Onsite workers/hypothetical residents Onsite workers/offsite individuals	Sources have not released contaminants to surface soil. Site is extensively vegetated with annual grasses.	No No
Onsite Subsurface Soil	Direct contact	Dermal/Ingestion	Onsite workers Onsite workers (excavation) Trespassers Future residents onsite	Workers not likely to have routine contact with contaminants unless soils are excavated and stockpiled onsite. Existing work activities would be unlikely to bring workers into routine contact with excavated soils. Workers could have contact with contaminants if soils are excavated and stockpiled onsite. Contaminants sources are relatively remote from offsite individuals. Offsite individuals not likely to have routine contact with contaminants unless soils are excavated and stockpiled onsite. Site is not likely to be used for residential uses in the future based on zoning restrictions. Potential exposure could occur if contaminants are excavated.	No Yes No Yes
Onsite Soil Gas	Volatilization	Inhalation (outdoors) Inhalation (indoors)	Onsite workers Onsite workers	Volatile organic compounds (VOCs) could diffuse to the soil surface and be emitted into the air. VOCs detected underneath buildings onsite could diffuse through egresses in building foundations and be emitted into indoor air.	Yes Yes

Table G-1 Initial Screening of Potential Exposure Pathways						Sheet 2 of 2
Location/Media	Release	Exposure Route	Receptor	Rationale	Exposure Potentially Feasible	Retained for Risk Assessment
Onsite Groundwater	Direct contact	Ingestion	Onsite workers	Groundwater not used to supply drinking water.	No	No
			Hypothetical future resident	Pathway included at agency request to evaluate aquifer nondegradation.	No	Yes
	Volatilization (indoors)	Dermal	Onsite workers	Groundwater used for other housekeeping and sanitary purposes.	Yes	Yes
			Hypothetical future resident	Pathway included at agency request to evaluate aquifer nondegradation.	No	Yes
			Onsite workers	Workers may use water for showering.	Yes	Yes
			Hypothetical future resident	Pathway included at agency request to evaluate aquifer nondegradation.	No	Yes
	Volatilization (outdoors)	Inhalation (outdoors)	Onsite workers	Groundwater used for irrigating landscaping.	Yes	Yes

Table G-2 Summary of Exposure Scenarios			
Receptor	Location/Media	Exposure Route	Basis for Exposure Concentration
Onsite worker - outdoors	Onsite soil gas Groundwater	Inhalation	Area-averaged, based on maximum VOC concentration in soil gas in each source area. ^a Maximum concentration in water from site production well.
Onsite worker - excavation	Onsite subsurface soil	Soil ingestion Dermal contact with soil ^c	95% UCL of the mean concentration calculated from all soil samples. ^b
Onsite worker - indoors (Building 4708)	Onsite soil gas Groundwater	Inhalation Dermal contact	Maximum VOC concentration in soil gas in samples near Building 4708. Maximum concentration in water from site production well.
Hypothetical future resident	Groundwater, onsite soil gas, onsite soil	Ingestion Inhalation Dermal contact	Maximum concentrations of TCE and PCE detected in MW-3. Maximum concentration of vinyl chloride detected in any monitoring well. 95% UCL of mean concentration calculated from all soil samples. Maximum VOC concentration in soil gas from samples near Building 4708.

^aSee Appendix F, Air Pathway Analysis, for the area-averaging method used to calculate exposure concentration.

^bConcentrations in samples reported as not detected assumed to be present at one-half the detection limit for purposes of calculating the mean.

^cIntake from dermal contact with soil assumed to be equivalent to intake from soil ingestion.

Note: Risks are summed across multiple pathways or media as shown in this table to estimate RME.

Estimation of Exposure Point Concentrations

Exposure point concentrations are the concentrations in groundwater, soil, or air used to estimate the potential intake of contaminants in humans. The concentrations in soil or groundwater have been obtained directly from data collected during the RI. Concentrations in air were estimated using the models from concentrations measured in soil gas samples collected during the RI.

Onsite Worker, Outdoors

Two sources of VOCs contributed to exposure concentrations in air for this scenario: emissions of VOCs in soil gas and emissions of VOCs from production well water used for sprinkler irrigation. Concentrations of VOCs detected in soil gas were converted to surface emission fluxes, then concentrations in air using models as described in Appendix F, Air Pathways Analysis. Similarly, concentrations of VOCs detected in groundwater were converted to emission rates, then concentrations in air (see Appendix F). The exposure concentrations in air from VOC surface emission fluxes appear in Table G-3.

The highest concentrations detected in any sampling round from the site production well were used to estimate the exposure concentrations in air associated with VOC emissions from sprinkler irrigation (see Appendix C, Site Conceptual Model). These exposure concentrations also are presented in Table G-3.

Onsite Worker, Excavation

Exposure concentrations in soil were estimated as 95 percent UCL of the mean concentration calculated across all soil samples from all depths in soil. This provides a conservative estimate of the concentrations in soil that a worker could encounter, should soils be excavated, because excavation would likely blend contaminant hot spots in small volumes of soil with larger volumes of relatively clean soil. Therefore, there is little likelihood of prolonged contact with an UCL concentration in soil. Exposure concentrations in soil are to be found in Table G-4.

Onsite Worker, Indoors

Two sources of VOCs contributed to exposure concentrations for this scenario: emissions of VOCs in soil gas from samples collected near Building 4708 and VOCs detected in samples from the site production well. Concentrations of VOCs detected in soil gas were converted to surface emission fluxes, then concentrations in indoor air using models as described in Appendix F. Concentrations of VOCs detected in groundwater were converted to concentrations in air during showering and intake rates from dermal exposure using the procedures described below.

Table G-3
Exposure Concentrations in Air
Onsite Worker, Outdoors Scenario

Contaminant	Soil Gas		Sprinkler Irrigation	
	Surface Flux (g/m ² -s)	Concentration in Air (mg/m ³)	Concentration in Groundwater (µg/l)	Concentration in Air (mg/m ³)
Acetone	NA ^b	NA ^b	41	0.00005
Benzene	1.2E-11	2.6E-07	NA ^a	NA ^a
Bromodichloromethane	NA ^b	NA ^b	2.6	3.1E-06
Bromoform	NA ^b	NA ^b	47	0.00006
Chlorodibromomethane	NA ^b	NA ^b	8.8	0.00001
Chloroform	NA ^b	NA ^b	6.7	7.9E-06
1,4-Dichlorobenzene	NA ^b	NA ^b	3.71	4.4E-06
Dichlorodifluoromethane	7.9E-13	1.7E-08	NA ^a	NA ^a
1,1-Dichloroethane	1.3E-13	2.9E-09	NA ^a	NA ^a
1,1-Dichloroethene	3.4E-11	7.4E-07	3	3.6E-06
cis-1,2-Dichloroethene	9.3E-13	2.0E-08	NA ^a	NA ^a
Ethylene dibromide	NA ^b	NA ^b	2.3	2.7E-06
m,p-Xylene (sum of isomers)	7.2E-11	1.5E-06	NA ^a	NA ^a
Methyl ethyl ketone	NA ^b	NA ^b	0.6	7.1E-07
Methyl isobutyl ketone	NA ^b	NA ^b	7.2	8.5E-06
o-Xylene (1,2-dimethylbenzene)	7.2E-11	1.6E-06	NA ^a	NA ^a
Tetrachloroethene (PCE)	2.5E-09	0.00005	3.2	3.8E-06
Toluene	1.0E-10	2.2E-06	0.4	4.7E-07
1,1,1-Trichloroethane	2.6E-12	5.7E-08	NA ^a	NA ^a
Trichlorofluoromethane	NA ^b	NA ^b	0.6	7.1E-07
Trichloroethene (TCE)	1.5E-10	3.2E-06	7.4	8.8E-06
1,1,2-Trichloro-1,2,2-trifluoroethane	6.9E-12	1.5E-07	14.1	0.00002
Vinyl chloride	2.4E-12	5.2E-08	NA ^a	NA ^a

^aNA = not applicable, VOC has not been reported in samples from the production well.

^bNA = not applicable, VOC has not been reported in soil gas samples.

Table G-4
Estimation of Exposure Concentrations in Soil
Onsite Worker, Excavation Scenario

Contaminant	Units	No. of Detects	No. of Samples	Maximum Value of Detects	Mean	Standard Deviation	t-value (p<0.05)	95% UCL of the Mean	95% UCL Higher than Max?	Exposure Concentration in Soil (mg/kg)
Benzyl butyl phthalate	µg/kg	5	31	500	32.58	113.08	1.697	67.05	no	0.07
di-N-butyl phthalate	µg/kg	10	31	900	141.94	251.36	1.697	218.55	no	0.22
Dibenzofuran	µg/kg	6	31	2200	216.10	578.98	1.697	392.56	no	0.39
Diethyl phthalate	µg/kg	2	31	3	0.10	0.54	1.697	0.26	no	0.0003
bis(2-Ethylhexyl) phthalate	µg/kg	22	31	2400	488.13	686.74	1.697	697.44	no	0.70
Fluorene	µg/kg	18	31	6900	962.26	1790.17	1.697	1507.89	no	1.51
2-Methylnaphthalene	µg/kg	14	31	46500	6768.39	13261.37	1.697	10810.32	no	10.81
Naphthalene	µg/kg	10	31	21100	2914.84	6138.32	1.697	4785.74	no	4.79
Petroleum hydrocarbons	mg/kg	20	44	17236	517.55	2676.99	1.684	1197.16	no	1197.16
Phenanthrene	µg/kg	19	30	14500	2414.80	4527.54	1.697	3817.56	no	3.82
Pyrene	µg/kg	5	31	700	56.13	150.97	1.697	102.14	no	0.10

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Exposure concentrations in indoor air were estimated from the highest concentrations in soil gas from the four samples collected near Building 4708. Exposure concentrations were not calculated for VOCs not detected in any of these four samples. The exposure concentrations in air used in this scenario appear in Table G-5.

The highest concentrations detected in any sampling round from the site production well were used to estimate the exposure concentrations in air associated with indoor water use (see Appendix C). These exposure concentrations also are presented in Table G-5.

Hypothetical Future Resident

At the request of the regulatory agencies, health risks potentially associated with groundwater contaminants detected in monitoring wells were considered in the RA. These estimates of health risks were based on a future residential land use scenario. Concentrations of tetrachloroethene (PCE) and trichloroethene (TCE) detected in the latest sampling round from Well MW-3 (sampled September 28, 1992) were the exposure concentrations used for this scenario. In this sampling round, PCE was detected at a concentration of 150 $\mu\text{g/l}$; TCE was detected at a concentration of 350 $\mu\text{g/l}$.

Quantification of Contaminant Intakes

This section describes the methods for calculating potential contaminant intakes for the populations and exposure pathways selected for quantitative evaluation. The intakes calculated in this section are expressed as the amount of contaminant at the exchange boundary (i.e., skin,¹ lungs, or gastrointestinal tract) and available for absorption. Estimates of contaminant intakes based on RME scenarios are presented in this section. Contaminant intakes were estimated for populations identified under both current and future land use. Calculations and input parameters used for estimating intake rates through the inhalation, soil ingestion, groundwater ingestion, and dermal contact with soil and groundwater pathways were obtained from EPA (U.S. EPA, 1989; 1990a; 1991a), and are presented below.

Exposures/Risks from Ingestion of Contaminants in Groundwater

Individuals could potentially be exposed to contaminants in groundwater through the ingestion of drinking water. The magnitude of exposure to contaminants through ingestion depends on the amount of water ingested on a daily basis. This assessment assumes that adult residents consume 2 liters of water per day, 350 days per year for 30 years (U.S. EPA, 1991a). The 2 liters per day value is close to the 90th percentile

¹In keeping with EPA guidance, intake for dermal exposure pathways is estimated in terms of absorbed dose and not quantity of chemical at the exchange boundary.

Table G-5
Exposure Concentrations in Air
Onsite Worker, Indoors (Building 4708)

Compound	Exposure Concentrations			
	Soil Gas ($\mu\text{g/l}$)	Exposure Concentration in Air (mg/m^3)	Groundwater ($\mu\text{g/l}$)	Exposure Concentration in Air (mg/m^3)
Acetone	NA ^a	NA	41	2.05E-02
Benzene	0.05	1.16E-05	NA ^b	NA
Bromodichloromethane	NA ^a	NA	2.6	1.30E-03
Bromoform	NA ^a	NA	47	2.35E-02
Chlorodibromomethane	NA ^a	NA	8.8	4.40E-03
Chloroform	NA ^a	NA	6.7	3.35E-03
1,4-Dichlorobenzene	NA ^a	NA	3.71	1.86E-03
1,1-Dichloroethene	0.02	4.22E-06	3	1.50E-03
Ethylene dibromide	NA ^a	NA	2.3	1.15E-03
m,p-Xylene (sum of isomers)	0.11	2.10E-05	NA ^b	NA
Methyl ethyl ketone	NA ^a	NA	0.6	3.00E-04
Methyl isobutyl ketone	NA ^a	NA	7.2	3.60E-03
Tetrachloroethene (PCE)	2.8	5.53E-04	3.2	1.60E-03
Toluene	0.08	1.67E-05	0.4	2.00E-04
Trichloroethene (TCE)	NA ^a	NA	7.4	3.70E-03
Trichlorofluoromethane	NA ^a	NA	0.6	3.00E-04
1,1,2-Trichloro-1,2,2-trifluoroethane	NA ^a	NA	14.1	7.05E-03
^a NA - not applicable. Contaminant not reported in soil gas samples.				
^b NA - not applicable. Contaminant not reported in site production well water samples.				

for drinking water ingestion (U.S. EPA, 1990). The 30-year exposure duration is considered to be a 90th percentile value for time spent at one residence (U.S. EPA, 1990; 1991a). The other parameters used in this intake equation also represent reasonable maximum values.

The following equation is used to calculate the intake associated with the ingestion of contaminants in groundwater:

$$Intake = \frac{C_w \times IR_w \times EF \times ED}{BW \times AT \times 365 \text{ days/year}} \quad (1)$$

Where:

Parameter	Description	Units	Value
Intake	Contaminant intake rate	mg/kg-day	calculated from Eq. 1
C_w	Contaminant concentration in water	mg/l	modeled or measured value
BW	Body weight	kg	70 (70-cancer effects and
AT	Averaging time	years	30-noncancer effects)
EF	Exposure frequency	days/year	350
ED	Exposure duration	years	30
IR_w	Daily water ingestion rate	l/day	2
Source: U.S. EPA, 1991a.			

A lifetime average intake of a contaminant is estimated for carcinogens. This acts to prorate the total cumulative intake over a lifetime. An averaging time of a lifetime of 70 years is used for carcinogens. Contaminant intake rates for noncarcinogens are calculated using an averaging time that is equal to the exposure duration.

The estimated lifetime cancer risk from potential exposure to a carcinogenic VOC through ingestion of groundwater is calculated as follows:

$$Risk = Intake \times SF_o \quad (2)$$

where SF_o is the oral slope factor in units of $(\text{mg/kg-day})^{-1}$. Estimated lifetime cancer risks for all carcinogenic contaminants are then summed to obtain the total risk associated with ingestion of contaminants in groundwater. If risks could exceed 10^{-2} , the exponential form of this equation should be used:

$$Risk = 1 - \exp(-Intake \times SF_o) \quad (3)$$

A hazard quotient (HQ) for potential exposure to a noncarcinogenic contaminant through ingestion of groundwater is calculated as follows:

$$HQ = \frac{Intake}{RfD_o} \quad (4)$$

where RfD_o is the oral reference dose in units of mg/kg-day. The HQs estimated for all noncarcinogenic contaminants are then summed to compute a hazard index (HI) associated with ingestion of contaminants in groundwater.

Exposures/Risks from Inhalation of VOCs in Groundwater

Individuals can be exposed to VOCs transferred from tap water to the air from showers, baths, toilets, dishwashers, washing machines, and cooking. Using a simple predictive equation based on a one-compartment indoor air model, Andelman (1990) predicted the relationship between the concentration of VOCs in water and the concentration in air. This equation is used to estimate the range of average indoor air concentrations that is likely to be encountered from a contaminant volatilizing at an average rate of 50 percent from all water uses. The equation is based on data indicating 30 to 90 percent volatilization of radon from water, depending upon water use (Prichard and Gesell, 1981). The transfer efficiencies (percent volatilization) among the different water uses are presented below:

Transfer Efficiencies for Radon for Various Water Uses in a Typical House		
Water Use	Daily Quantity (l)	Transfer Efficiency (%)
Showers	150	63
Tub baths	150	47
Toilet	365	30
Laundry	130	90
Dishwasher	55	90
Drinking and kitchen	30	30
Cleaning	10	90
Total	890	
Source: Prichard and Gesell, 1981.		

From these data, Andelman concluded that the volume use-weighted mean percent volatilization was about 50 percent.

The relationship of indoor air concentration to water concentration obtained from this model is (Andelman, 1990; Andelman et al., 1987):

$$C_a = 0.1 \times 10^{-4} C_w \quad (5)$$

to

$$C_a = 5 \times 10^{-4} C_w \quad (6)$$

where C_a is the average indoor air concentration (mg/l) generated by the corresponding average water concentration, C_w (mg/l). Thus, a water concentration of 1 mg/l would be expected to generate a concentration between 0.00001 and 0.0005 mg/l in air in the home (Andelman, 1990). A correction factor of 1,000 l/m³ converts the concentration in air to mg/m³. Other studies (McKone, 1987) have predicted similar estimated household air concentrations for different VOCs, with values of C_a ranging from 0.00002 to 0.00012 mg/l for a C_w of 1 mg/l (Andelman, 1990). EPA has selected the highest value to represent the amount of contaminant volatilized into air from water (U.S. EPA, 1991b). This provides a conservative estimate of the amount of VOCs that would volatilize during domestic use of water.

Exposure to VOCs in air in a residential exposure scenario is based on an inhalation rate of 15 m³/day. This inhalation rate considers the potential for exposure during household water uses, such as cooking, laundry, bathing, and showering. Activity-specific inhalation rates were combined with time/activity level data for populations that spend a majority of their time at home to derive daily inhalation values. The inhalation rate of 15 m³/day was found to represent a reasonable upper-bound value for daily, indoor residential activities (U.S. EPA, 1991a).

The following equation is used to calculate the intake associated with the inhalation of contaminants volatilized from groundwater:

$$C_a = C_w(\text{mg/l}) \times 0.0005 \times 1,000(\text{l/m}^3) \quad (7)$$

Equation 7 converts the concentration in groundwater (C_w) to a corresponding concentration in ambient air (C_a). This concentration in air is then used to calculate contaminant intake as follows:

$$\text{Intake} = \frac{C_a \times IR_a \times EF \times ED}{BW \times AT \times 365 \text{ days/year}} \quad (8)$$

Where:

Parameter	Description	Units	Value
Intake	Contaminant intake rate	mg/kg-day	calculated from Eq. 7
C_a	Contaminant concentration in air	mg/m ³	modeled value
BW	Body weight	kg	70
AT	Averaging time	years	70 (cancer effects) 30 (noncancer effects)
EF	Exposure frequency	days/year	350
ED	Exposure duration	years	30
IR_a	Daily inhalation rate	m ³ /day	15
Source: U.S. EPA, 1991a.			

A lifetime average intake of a contaminant is estimated for carcinogens. This acts to prorate the total cumulative intake over a lifetime. An averaging time of a lifetime of 70 years is used for carcinogens. Contaminant intake rates for noncarcinogens are calculated using an averaging time value that is equal to the exposure duration.

Estimated lifetime cancer risk from potential exposure to a carcinogenic VOC in air is calculated as follows:

$$Risk = Intake \times SF_i \quad (9)$$

where SF_i is the inhalation slope factor in units of (mg/kg-day)⁻¹. Estimated lifetime cancer risks for all carcinogenic VOCs are then summed to obtain the total risk associated with inhalation of VOCs in air at the site. If risks could exceed 10⁻², the exponential form of this equation should be used:

$$Risk = 1 - \exp(-Intake \times SF_i) \quad (10)$$

An HQ for potential exposure to a noncarcinogenic VOC in air is calculated as follows:

$$HQ = \frac{Intake}{RfD_i} \quad (11)$$

where RfD_i is the inhalation reference dose in units of mg/kg-day. The HQs estimated for all noncarcinogenic VOCs are then summed to compute an HI associated with inhalation of VOCs in air at the site.

Exposures/Risks from Dermal Contact with Contaminants in Groundwater

Individuals can become exposed through dermal absorption of contaminants in water. The magnitude of potential exposure through this pathway is related to the concentration in water, surface area of exposed skin, the ability of the contaminant to penetrate through the skin, and frequency and duration of exposure. The absorbed dose from

dermal contact with contaminants in groundwater is based on a calculation recommended by Cal-EPA (1992a), and is estimated as follows:

$$I = \frac{C_w \times SA \times K_p \times ET \times EF \times ED \times 0.001 L/cm^3}{BW \times AT \times 365 \text{ days/year}} \quad (12)$$

Where:

Parameter	Description	Units	Value
I	Absorbed dose	mg/kg-day	calculated from Eq. 12
C _w	Concentration in water	mg/l	modeled or measured value
SA	Exposed skin surface area	cm ² /event	23,000
ET	Exposure time during bathing	hour/day	0.25
EF	Exposure frequency	event/year	350
ED	Exposure duration	years	30
BW	Body weight	kg	70
AT	Averaging time	years	70—cancer effects and 30—noncancer effects
K _p	Dermal permeability coefficient	cm/hour	contaminant-specific

Source: Cal-EPA, 1992

Values for K_p can be estimated using an equation provided by EPA (U.S. EPA, 1992):

$$\log K_p = -2.72 + 0.71 \log K_{ow} - 0.0061 MW \quad (13)$$

where MW is the molecular weight of the contaminant, and log K_{ow} is the log octanol/water partition coefficient. These values were obtained from Howard (1989, 1990, 1992, 1993) or U.S. EPA (1979). The values used in the risk calculations are summarized in Table G-6.

Exposures/Risks from Inhalation of Ambient Air (Indoors and Outdoors)

Exposure to contaminants in air in a residential exposure scenario is based on an inhalation rate of 20 m³/day for both indoors and outdoors. EPA combined activity-specific inhalation rates with time/activity level data to derive daily inhalation rates for various occupational activities (U.S. EPA, 1991a). Based on this evaluation, EPA concluded that 20 m³ per 8-hour workday represented a reasonable maximum inhalation rate for the occupational scenario. The occupational scenario is also considered to address a 70-kg adult who is at work 5 days a week for 50 weeks per year (250 days/year). The exposure duration is assumed to be 25 years, which is the 95th percentile value for length of employment at the same location (U.S. EPA, 1991a).

Exposure concentrations of VOCs in air are estimated from VOC concentrations in soil gas using modeling, by the following equation:

Table G-6
Dermal Exposure Assessment Parameters for Selected Chemicals

Chemical	CAS No.	Measured K_p (cm/hr)	Estimated K_p (cm/hr)
Benzene	71432	0.11	0.021
Bromodichloromethane	75274		0.0058
Bromoform	74839		0.0026
Carbon tetrachloride	56235		0.022
Chlorodibromomethane	124481		0.0039
Chloroform	67663	0.13	0.0089
1,2-Dichlorobenzene	95501		0.061
1,3-Dichlorobenzene	541731		0.087
1,4-Dichlorobenzene	106467		0.062
Dichlorodifluoromethane	75718		0.012
1,1-Dichloroethane	75343		0.0089
1,2-Dichloroethane	107062		0.0053
1,1-Dichloroethene	75354		0.016
1,2-Dichloroethene	540590		0.01
1,2-Dichloropropane	542756		0.01
Ethylbenzene	100414	1	0.074
Isophorone	78591		0.0042
Methylene chloride	75092		0.0045
1,1,2,2-Tetrachloroethane	79345		0.009
Tetrachloroethene	127184	0.37	0.048
Toluene	108883	1	0.045
1,1,1-Trichloroethane	71556		0.017
1,1,2-Trichloroethane	79005		0.0084
Trichloroethene	79016	0.23	0.016
Trichlorofluoromethane	75694		0.017
Vinyl chloride	75014		0.0073
Xylene	108383		0.08

Source: U.S. EPA, 1992.

$$Intake = \frac{C_a \times IR_a \times EF \times ED}{BW \times AT \times 365 \text{ days/year}} \quad (14)$$

The intake parameters used in Equation 14 to estimate contaminant intake from inhalation in a worker exposure scenario are:

Parameter	Description	Units	Value
Intake	Contaminant intake rate	mg/kg-day	calculated from Eq. 14
C_a	Contaminant concentration in air	mg/m ³	modeled value
BW	Body weight	kg	70
AT	Averaging time	years	70 (carcinogens) 25 (noncarcinogens)
EF	Exposure frequency	days/year	250
ED	Exposure duration	years	25
IR_a	Daily inhalation rate	m ³ /day	20
Source: U.S. EPA, 1991a			

Estimated lifetime cancer risk from potential exposure to a carcinogenic VOC in air is calculated as follows:

$$Risk = Intake \times SF_i \quad (15)$$

where SF_i is the inhalation slope factor in units of (mg/kg-day)⁻¹. Estimated lifetime cancer risks for all carcinogenic VOCs are then summed to obtain the total risk associated with ingestion exposure to modeled concentrations of VOCs in air at the Davis Site.

An HQ for potential exposure to a noncarcinogenic VOC in air is calculated as follows:

$$HQ = \frac{Intake}{RfD_i} \quad (16)$$

where RfD_i is the inhalation reference dose in units of mg/kg-day. The HQs estimated for all noncarcinogenic VOCs are then summed to compute an HI associated with ingestion exposure to modeled concentrations of VOCs in air at the site.

Exposures/Risks from Soil Ingestion

Under this scenario, workers or hypothetical future residents are assumed to be routinely exposed to contaminants in excavated soils. Workers would most likely to be exposed to contaminants in soil intermittently, and only for limited durations. Risks estimated in this scenarios therefore would significantly overstate the risks of workers exposed to contaminants in soil. Rather than place limits on the frequency

and duration of work activities that could bring workers into contact with contaminated soils, the EPA default assumptions, based on daily contact with soil over a working lifetime, were used to evaluate risks associated with contaminants in soil. Contaminant intake from soil ingestion was estimated using the following equation:

$$Intake = \frac{C_s \times IR \times 0.000001 \text{ kg/mg} \times EF \times ED}{BW \times AT \times 365 \text{ days/year}} \quad (17)$$

Where:

Parameter	Description	Units	Value
Intake	Contaminant intake rate	mg/kg-day	calculated from Eq. 14
C _s	Contaminant concentration in soil	mg/kg	95% UCL of mean
BW	Body weight	kg	70
AT	Averaging time	years	70 (carcinogens) 25 (noncarcinogens)
EF	Exposure frequency	days/year	250
ED	Exposure duration	years	25
IR	Soil ingestion rate	mg/day	50
Source: U.S. EPA, 1991a			

Contaminant intake from dermal exposure was not quantified because regulatory agency guidelines on assessing dermal absorption of contaminants from soil are still evolving. A recent guideline on assessing dermal absorption recommended methods of quantitative assessment for selected compounds (principally dioxin/furans, and PCBs) (U.S. EPA, 1992). For other contaminants, the following approach has been recommended (U.S. EPA, 1991c):

- Volatiles—Assume that dermal contact with these compounds in soil will not significantly increase risks over risks caused by other pathways of exposure to soil
- Other organics and inorganics—Assume that dermal contact with these compounds in soil may cause comparable risks to ingestion of soil

The approach used in this RA for assessing dermal exposure was to assume that intake from dermal contact with contaminants in soil was equivalent to the intake from soil ingestion.

Soil ingestion rates are greater for children than adults. Higher soil ingestion rates in children coupled with lower body weights mean that rates of exposure to contaminants in soil are higher for children than adults (however, this duration of exposure would occur over a shorter duration of time). Therefore, an age-adjusted soil ingestion factor is used in this equation to account for the differences in daily soil ingestion rates, body weights, and exposure durations between children (ages 1 to 6

years) and adults (ages 7 to 31 years). The soil ingestion rates for these two age ranges are time-weighted by the duration of exposure (6 years for children and 24 years for adults) and normalized to body weight to calculate the soil ingestion factor, as shown below:

$$IF_{soil/adj} = \frac{IR_1 \times ED_1}{BW_1} + \frac{IR_2 \times ED_2}{BW_2} \quad (18)$$

Where:

Parameter	Description	Units	Value
$IF_{soil/adj}$	Age-adjusted soil ingestion factor	mg-yr/kg-day	calculated (114)
BW_1	Average body weight from ages 1-6	kg	15
BW_2	Average body weight from ages 7-31	kg	70
ED_1	Exposure duration from ages 1-6	years	6
ED_2	Exposure duration from ages 7-31	years	24
IR_1	Soil ingestion rate from ages 1-6	mg/day	200
IR_2	Soil ingestion rate from ages 7-31	mg/day	100

This factor is then inserted into the intake equation to calculate risk-based contaminant concentrations in soil associated with residential land uses.

Chemical intake from soil ingestion for the hypothetical future residential scenario is calculated as follows:

$$Intake = \frac{C_s \times IF_{soil/adj} \times EF \times 10^{-6} \text{ kg/mg}}{AT \times 365 \text{ days/year}} \quad (19)$$

Where:

Parameter	Description	Units	Value
C_s	Chemical concentration in soil	mg/kg	measured
BW	Body weight	kg	70
AT	Averaging time	years	70 (cancer effects) 30 (noncancer effects)
EF	Exposure frequency	days/year	350
$IF_{soil/adj}$	Age-adjusted soil ingestion factor	mg-yr/kg-day	114

Exposures/Risks from Dermal Contact with Soil

Dermal contact with soil could potentially provide a larger chemical intake for onsite residents than soil ingestion (EPA, 1992). Potential exposures to the hypothetical future resident from dermal contact with soil were estimated using a methodology provided by the California Department of Toxic Substances Control (DTSC, 1993). Chemical intake from dermal contact with soil was estimated using the following calculation:

$$Intake = C_s \times \sum \frac{SA \times AF \times ABS \times EF \times ED \times 10^{-6} \text{ kg/mg}}{BW \times AT \times 365 \text{ days/year}} \quad (20)$$

where intakes for a child and adult are estimated separately, then summed. "Intakes" includes exposed skin surface area (SA), exposure frequency (EF), exposure duration (ED), and body weight (BW). The parameters are presented below:

Parameter	Description	Units	Value
Intake	Chemical intake rate	mg/kg-day	calculated from Eq. 17
C_s	Chemical concentration in soil	mg/kg	95 percent UCL of mean
BW_a	Body weight - adult	kg	70
BW_c	Body weight - child	kg	15
AT	Averaging time	years	70 (cancer effects) 30 (noncancer effects)
EF_a	Exposure frequency - adult	days/year	100
EF_c	Exposure frequency - child	days/year	350
ED_a	Exposure duration - adult	years	24
ED_c	Exposure duration - child	years	6
SA_a	Exposed skin surface area - adult	cm ² /day	5,800
SA_c	Exposed skin surface area - child	cm ² /day	2,000
AF	Soil adherence factor	mg/cm ²	1.0
ABS	Fraction of chemical absorbed from soil to skin	unitless	chemical-specific

Source: DTSC, 1993

The value of ABS was assumed to be 0.15 for all of the COPCs in soil. This value has been estimated for dermal absorption of benzo(a)pyrene from soil, and is considered by DTSC appropriate for petroleum hydrocarbon constituents (DTSC, 1993).

Works Cited

- Andelman, J. B. 1990. *Total Exposure to Volatile Organic Chemicals in Potable Water*. N. M. Ram, R. F. Christman and K. P. Cantor, eds. Chelsea, MI: Lewis Publishers.
- Andelman, J. B., L. C. Wilder, and S. M. Myers. 1987. "Indoor Air Pollution from Volatile Organic Chemicals in Water." *INDOOR AIR '87, Vol. 1*, Proceedings of the 4th

International Conference on Indoor Air Quality and Climate. Institute for Water, Soil and Air Hygiene, Berlin.

Cal-EPA. 1992. Revised Screening Procedure for the Preliminary Endangerment Assessment. Memorandum from Jeffrey J. Wong, Office of the Science Advisor to Bill Ryan, Site Mitigation Program, Department of Toxic Substances Control. Sacramento, CA. December 7.

DTSC. 1993. Preliminary Endangerment Assessment Guidance Manual. Draft, 7/29/93. Cal/EPA, Department of Toxic Substances Control.

Howard, P. H. 1989. *Handbook of Environmental Fate and Exposure Data for Organic Chemicals, Vol. I: Large Production and Priority Pollutants*. Chelsea, MI: Lewis Publishers.

Howard, P. H. 1990. *Handbook of Environmental Fate and Exposure Data for Organic Chemicals, Vol. II: Solvents*. Chelsea, MI: Lewis Publishers.

Howard, P. H. 1992. *Handbook of Environmental Fate and Exposure Data for Organic Chemicals, Vol. III: Pesticides*. Chelsea, MI: Lewis Publishers

Howard, P. H. 1993. *Handbook of Environmental Fate and Exposure Data for Organic Chemicals, Vol. IV: Solvents 2*. Chelsea, MI: Lewis Publishers

McKone, T. E. 1987. "Human Exposure to Volatile Organic Compounds in Household Tap Water: The Indoor Inhalation Pathway." *Environ. Sci. Technol.* 21: 1194-1201.

Prichard, H. M., and T. F. Gesell. 1981. "An Estimate of Population Exposures Due to Radon in Public Water Supplies in the Area of Houston, Texas." *Health Phys.* 41:599-606.

U.S. EPA. 1979. *Water-Related Fate of 129 Priority Pollutants*. Office of Water Planning and Standards. Washington, DC. EPA-440/4-79-029a and b.

U.S. EPA. 1985. *Methodology for Characterization of Uncertainty in Exposure Assessments*. Office of Environmental and Health Assessment, Research Triangle Park, NC. EPA/600/8-85/009. August.

U.S. EPA. 1989a. *Risk Assessment Guidance for Superfund. Human Health Evaluation Manual Part A, Final*. OSWER Directive 9285.701A. Office of Solid Waste and Emergency Response. Washington, DC.

U.S. EPA. 1989b. *Risk Assessment Guidance for Superfund. Human Health Risk Assessment. U.S. EPA Region IX Recommendations*. 15 December 1989 (Interim Final).

U.S. EPA. 1990. *Exposure Factors Handbook*. Office of Research and Development. EPA/600/8-89/043. Washington, DC.

U.S. EPA. 1991a. *Risk Assessment Guidance for Superfund. Vol. 1 Human Health Evaluation Manual. Supplemental Guidance "Standard Exposure Factors."* Draft Final, March 25. OSWER Directive 9285.6-03.

U.S. EPA. 1991b. *Risk Assessment Guidance for Superfund. Volume I. Development of Risk-Based Preliminary Remediation Goals*. Interim. Publication 9285.7-01B. December.

U.S. EPA. 1991c. Review of the Oral Bioavailability Factors, Dermal Permeability Constants and Dermal Bioavailability Factors and Method used to Estimate Health Risks Due to Exposure of Volatile Organic Compounds Associated with Indoor Groundwater Use. Letter from Kenneth A. Porior, Superfund Health Risk Technology Support Center to U.S. EPA Region V.

U.S. EPA. 1992. *Dermal Exposure Assessment: Principles and Applications*. Interim Report. Interim Report. EPA/600/8-91/011B. January.

Attachment G-1
Exposure Assessment
and Risk Characterization Calculation

**Tables -1, -5, and -9 in this series
can be found in Appendix A.**

Table G-2

Calculation of Health Risks Associated with Inhalation of Outdoor Air

Site: Davis Global Communications Site
 Scenario: Reasonable Maximum Exposure
 Receptor: Onsite Worker - VOC emissions from sprinkler irrigation

Contaminant	Inhalation Slope Factor (mg/kg/day) ⁻¹	Inhalation Reference Dose (mg/kg/day)	Concentration in Air (mg/m ³)	Daily Intake - Cancer (mg/kg-day)	Daily Intake - Noncancer (mg/kg-day)	Estimated Lifetime Cancer Risk	Percent of Total Risk	Hazard Quotient
Acetone	0	0.1	4.86E-05	3.40E-06	9.51E-06	0.00E+00	<0.01	9.51E-05
Bromodichloromethane	0	0.02	3.08E-06	2.15E-07	6.03E-07	0.00E+00	<0.01	3.02E-05
Bromoform	0.0039	0.02	5.57E-05	3.8E-06	1.09E-05	1.52E-08	33.46	5.45E-04
Chlorodibromomethane	0	0.02	1.04E-05	7.29E-07	2.04E-06	0.00E+00	<0.01	1.02E-04
Chloroform	0.019	0.01	7.94E-06	5.55E-07	1.55E-06	1.05E-08	23.24	1.55E-04
1,4-Dichlorobenzene	0	0.2	4.40E-06	3.07E-07	8.61E-07	0.00E+00	<0.01	4.30E-06
1,1-Dichloroethene	0	0.0009	3.56E-06	2.49E-07	6.96E-07	0.00E+00	<0.01	7.73E-04
Methyl ethyl ketone	0	0.3	7.11E-07	4.97E-08	1.39E-07	0.00E+00	<0.01	4.64E-07
Methyl isobutyl ketone	0	0	8.53E-06	5.96E-07	1.67E-06	0.00E+00	<0.01	0.00E+00
Tetrachloroethene	0.051	0.01	3.79E-06	2.65E-07	7.42E-07	1.35E-08	29.79	7.42E-05
Toluene	0	0.1	4.74E-07	3.31E-08	9.28E-08	0.00E+00	<0.01	9.28E-07
Trichloroethene	0.01	0	8.77E-06	6.13E-07	1.72E-06	6.13E-09	13.51	0.00E+00
Trichlorofluoromethane	0	0.2	7.11E-07	4.97E-08	1.39E-07	0.00E+00	<0.01	6.96E-07
1,1,2-Trichloro-1,2,2-trifluoromethane	0	7.7	1.67E-05	1.17E-06	3.27E-06	0.00E+00	<0.01	4.25E-07
Total Risk or Hazard Index						4.54E-08		1.78E-03

Parameters	Descriptions	Units	Values
BW	Adult body weight	kg	70
AT_C	Averaging time - Carcinogens	yr	70
AT_N	Averaging time - Noncarcinogens	days/yr	25
EF	Exposure frequency	days/yr	250
ED	Exposure duration	yr	25
IR_A	Daily inhalation rate	m ³ /day	20

Table G-3

Calculation of Health Risks Associated with Inhalation of Outdoor Air

Site: Davis Global Communications Site
 Scenario: Reasonable Maximum Exposure
 Receptor: Onsite Worker - Inhalation of VOC Emissions from Soil Gas

Contaminant	Inhalation Slope Factor (mg/kg/day) ⁻¹	Inhalation Reference Dose (mg/kg/day)	Concentration in Air (mg/m ³)	Daily Intake Cancer (mg/kg-day)	Daily Intake Noncancer (mg/kg-day)	Estimated Lifetime Cancer Risk	Percent of Total Risk	Hazard Quotient
Benzene	0.1	0	2.61E-07	1.82E-08	5.10E-08	1.82E-09	0.93	0.00E+00
1,1-Dichloroethane		0.1	2.90E-09	2.03E-10	5.68E-10	0.00E+00	<0.01	5.68E-09
1,1-Dichloroethene		0.0009	7.40E-07	5.17E-08	1.45E-07	0.00E+00	<0.01	1.61E-04
cis-1,2-Dichloroethene		0.01	2.00E-08	1.40E-09	3.91E-09	0.00E+00	<0.01	3.91E-07
Dichlorodifluoromethane		0.1	1.70E-08	1.19E-09	3.33E-09	0.00E+00	<0.01	3.33E-08
m,p-Xylene (Sum of Isomers)		2	1.55E-06	1.08E-07	3.02E-07	0.00E+00	<0.01	1.51E-07
o-Xylene (1,2-Dimethylbenzene)		2	1.55E-06	1.09E-07	3.04E-07	0.00E+00	<0.01	1.52E-07
Tetrachloroethene (PCE)	0.051	0.01	5.33E-05	3.73E-06	1.04E-05	1.90E-07	97.40	1.04E-03
Toluene		0.1	2.25E-06	1.57E-07	4.40E-07	0.00E+00	<0.01	4.40E-06
Trichloroethene (TCE)	0.01	0	3.24E-06	2.26E-07	6.33E-07	2.26E-09	1.16	0.00E+00
1,1,1-Trichloroethane		0.3	5.72E-08	4.00E-09	1.12E-08	0.00E+00	<0.01	3.73E-08
1,1,2-Trichloro-1,2,2-Trifluoroethane		7.7	1.49E-07	1.04E-08	2.91E-08	0.00E+00	<0.01	3.77E-09
Vinyl Chloride	0.27	0	5.24E-08	3.66E-09	1.03E-08	9.89E-10	0.51	0.00E+00
Total Risk or Hazard Index						1.95E-07		1.21E-03

Parameters	Descriptions	Units	Values
BW	Adult body weight	kg	70
AT_C	Averaging time - Carcinogens	yr	70
AT_N	Averaging time - Noncarcinogens	days/yr	25
EF	Exposure frequency	yr	250
ED	Exposure duration	yr	25
IR_A	Daily inhalation rate	m ³ /day	20

Table G-4

Calculation of Health Risks Associated with Ingestion of Soil

Site: Davis Global Communications Site

Scenario: Reasonable Maximum Exposure

Receptor: Onsite Worker (excavation) - Concentrations in subsurface soil

Contaminant	Oral Slope Factor (mg/kg/day) ⁻¹	Oral Reference Dose (mg/kg/day)	Matrix Bioavailability Site	Toxicity Study	Concentration In Soil (mg/kg)	Daily Intake Cancer (mg/kg-day)	Daily Intake Noncancer (mg/kg-day)	Estimated Lifetime Cancer Risk	Percent of Total Risk	Hazard Quotient
Benzyl Butyl Phthalate	0	0.2	1	1	0.07	1.17E-08	3.28E-08	0.00E+00	<0.01	1.64E-07
Di-n-Butyl Phthalate	0	0.1	1	1	0.22	3.82E-08	1.07E-07	0.00E+00	<0.01	1.07E-06
Dibenzofuran	0	0.004	1	1	0.39	6.86E-08	1.92E-07	0.00E+00	<0.01	4.80E-05
Diethyl Phthalate	0	0.8	1	1	0.0003	4.56E-11	1.28E-10	0.00E+00	<0.01	1.60E-10
bis(2-Ethylhexyl) Phthalate	0.014	0.02	1	1	0.70	1.22E-07	3.41E-07	1.71E-09	100.00	1.71E-05
Fluorene	0	0.04	1	1	1.51	2.63E-07	7.38E-07	0.00E+00	<0.01	1.84E-05
2-Methylnaphthalene	0	0.04	1	1	10.81	1.89E-06	5.29E-06	0.00E+00	<0.01	1.32E-04
Naphthalene	0	0.04	1	1	4.79	8.36E-07	2.34E-06	0.00E+00	<0.01	5.85E-05
Petroleum Hydrocarbons	0	0.008	1	1	1197.16	2.09E-04	5.86E-04	0.00E+00	<0.01	7.32E-02
Phenanthrene	0	0	1	1	3.82	6.67E-07	1.87E-06	0.00E+00	<0.01	0.00E+00
Pyrene	0	0.03	1	1	0.10	1.78E-08	5.00E-08	0.00E+00	<0.01	1.67E-06
Total Risk and Hazard Index									1.71E-09	7.35E-02

Parameters	Descriptions	Units	Values
IR	Soil ingestion rate	mg/day	50
AT_C	Averaging time - carcinogens	yr	70
AT_N	Averaging time - noncarcinogens	yr	25
EF	Exposure frequency	days/yr	250
ED	Exposure Duration	yr	25
BW	Body Weight	kg	70

Table G-6

Calculation of Health Risks Associated with Inhalation of Indoor Air

Site: Davis Global Communications Site

Scenario: Reasonable Maximum Exposure

Receptor: Onsite Worker - Building 4708

Contaminant	Inhalation Slope Factor (mg/kg/day) ⁻¹	Inhalation Reference Dose (mg/kg/day)	Concentration in Air (mg/m ³)	Daily Intake Cancer (mg/kg-day)	Daily Intake Noncancer (mg/kg-day)	Estimated Lifetime Cancer Risk	Percent of Total Risk	Hazard Quotient
Benzene	0.1	0	1.16E-05	8.11E-07	2.27E-06	8.11E-08	3.96	0.00E+00
1,1-Dichloroethene		0.0009	4.22E-06	2.45E-07	8.25E-07	0.00E+00	<0.01	9.17E-04
m,p-Xylene (Sum of Isomers)		2	2.10E-05	1.47E-06	4.11E-06	0.00E+00	<0.01	2.06E-06
Tetrachloroethene (PCE)	0.051	0.01	5.53E-04	3.86E-05	1.08E-04	1.97E-06	96.04	1.08E-02
Toluene		0.1	1.67E-05	1.17E-06	3.27E-06	0.00E+00	<0.01	3.27E-05
Total Risk or Hazard Index						2.05E-06		1.18E-02

Parameters	Descriptions	Units	Values
BW	Adult body weight	kg	70
AT_C	Averaging time - Carcinogens	yr	70
AT_N	Averaging time - Noncarcinogens	days/yr	25
EF	Exposure frequency	yr	250
ED	Exposure duration	yr	25
IR_A	Daily inhalation rate	m ³ /day	20

Table G-7
Calculation of Health Risks Associated with Inhalation of VOCs in Groundwater
Site: Davis Global Communications Site
Scenario: Reasonable Maximum Exposure
Receptor: Current Land Use, Onsite Worker - Production Well Data

Contaminant	Inhalation Slope Factor (mg/kg/day) ⁻¹	Inhalation Reference Dose (mg/kg/day)	Concentration in Water (ug/l)	Estimated Concentration in Air (ug/m ³)	Daily Intake Cancer (mg/kg-day)	Daily Intake Noncancer (mg/kg-day)	Estimated Lifetime Cancer Risk	Percent of Total Risk	Hazard Quotient
Acetone	0	0.1	41	20.5	1.07E-03	3.01E-03	0.00E+00	<0.01	0.03
Bromodichloromethane	0	0.02	2.6	1.3	6.81E-05	1.91E-04	0.00E+00	<0.01	0.01
Bromoform	0.0039	0.02	47	23.5	1.23E-03	3.45E-03	4.80E-06	16.33	0.17
Chlorodibromomethane	0	0.02	8.8	4.4	2.31E-04	6.46E-04	0.00E+00	<0.01	0.03
Chloroform	0.019	0.01	6.7	3.35	1.76E-04	4.92E-04	3.34E-06	11.34	0.05
1,4-Dichlorobenzene	0	0.2	3.71	1.855	9.72E-05	2.72E-04	0.00E+00	<0.01	0.00
1,1-Dichloroethene	0	0.0009	3	1.5	7.86E-05	2.20E-04	0.00E+00	<0.01	0.74
Ethylene dibromide	0.25	0	2.3	1.15	6.03E-05	1.69E-04	1.51E-05	51.21	0.00
Methyl ethyl ketone	0	0.1	0.6	0.3	1.57E-05	4.40E-05	0.00E+00	<0.01	0.00
Methyl isobutyl ketone	0	0	7.2	3.6	1.89E-04	5.28E-04	0.00E+00	<0.01	0.00
Tetrachloroethene	0.051	0.01	3.2	1.6	8.39E-05	2.35E-04	4.28E-06	14.54	0.02
Toluene	0	0.1	0.4	0.2	1.05E-05	2.94E-05	0.00E+00	<0.01	0.00
Trichloroethene	0.01	0	7.4	3.7	1.94E-04	5.43E-04	1.94E-06	6.59	0.00
Trichlorofluoromethane	0	0.2	0.6	0.3	1.57E-05	4.40E-05	0.00E+00	<0.01	0.00
1,1,2-Trichloro-1,2,2-trifluoromethane	0	7.7	14.1	7.05	3.70E-04	1.03E-03	0.00E+00	<0.01	0.00
Total Risk and Hazard Index								2.94E-05	5.64E-01

Parameters	Descriptions	Units	Values
BW	Adult body weight	kg	70
AT_C	Averaging time - carcinogens	yr	70
AT_N	Averaging time - noncarcinogens	days/yr	25
EF	Exposure frequency	yr	250
ED	Exposure duration	m ³ /day	25
IR_A	Daily indoor inhalation rate		15
K	Volatilization factor	(K x 1,000 l/m ³)	0.5

Table G-8

Calculation of Health Risks Associated with Dermal Contact with Groundwater (Cal/EPA Methodology)

Site: Davis Global Communications Site
 Scenario: Reasonable Maximum Exposure
 Receptor: Current Land Use, Onsite Worker - Production Well Data

Contaminant	Oral Slope Factor (mg/kg/day) ⁻¹	Oral Reference Dose (mg/kg/day)	Permeability Coefficient (K _p) (cm/hr)	Concentration In Water (ug/l)	Daily Intake Cancer (mg/kg-day)	Daily Intake Noncancer (mg/kg-day)	Estimated Lifetime Cancer Risk	Percent of Total Risk	Hazard Quotient
Acetone	0	0.1	0.00057	41	4.70E-07	1.31E-06	0.00E+00	<0.01	1.31E-05
Bromodichloromethane	0.13	0.02	0.0058	2.6	3.03E-07	8.48E-07	3.94E-08	4.55	4.24E-05
Bromoform	0.0079	0.02	0.0026	47	2.46E-06	6.88E-06	1.94E-08	2.24	3.44E-04
Chlorodibromomethane	0.084	0.02	0.0039	8.8	6.90E-07	1.93E-06	5.79E-08	6.69	9.65E-05
Chloroform	0.0061	0.01	0.0089	6.7	1.20E-06	3.35E-06	7.31E-09	0.84	3.35E-04
1,4-Dichlorobenzene	0	0.1	0.062	3.71	4.62E-06	1.29E-05	0.00E+00	<0.01	1.29E-04
1,1-Dichloroethene	0	0.0009	0.016	3	9.64E-07	2.70E-06	0.00E+00	<0.01	3.00E-03
Ethylene dibromide	3.6	0	0.0033	2.3	1.53E-07	4.27E-07	5.49E-07	63.39	0.00E+00
Methyl ethyl ketone	0	0.3	0.0011	0.6	1.33E-08	3.71E-08	0.00E+00	<0.01	1.24E-07
Methyl isobutyl ketone	0	0	0.00327	7.2	4.73E-07	1.32E-06	0.00E+00	<0.01	0.00E+00
Tetrachloroethene	0.051	0.01	0.048	3.2	3.09E-06	8.64E-06	1.57E-07	18.17	8.64E-04
Toluene	0	0.2	0.045	0.4	3.62E-07	1.01E-06	0.00E+00	<0.01	5.06E-06
Trichloroethene	0.015	0	0.016	7.4	2.38E-06	6.66E-06	3.57E-08	4.12	0.00E+00
Trichlorofluoromethane	0	0.3	0.017	0.6	2.05E-07	5.74E-07	0.00E+00	<0.01	1.91E-06
1,1,2-Trichloro-1,2,2-trifluoromethane	0	30	0.024	14.1	6.80E-06	1.90E-05	0.00E+00	<0.01	6.35E-07
Total Risk and Hazard Index							8.66E-07		4.83E-03

Parameters	Descriptions	Units	Values
ET	Event duration	hr/event	0.25
SA	Skin surface area	cm ²	23000
BW	Body weight	kg	70
AT_C	Averaging time - carcinogens	yr	70
AT_N	Averaging time - noncarcinogens	days/yr	25
EF	Exposure frequency	days/yr	250
ED	Exposure duration	yr	25

Table G-10

Calculation of Health Risks Associated with Ingestion of Groundwater

Project: McClellan Air Force Base
 Site: Davis Global Communications Center
 Scenario: Reasonable Maximum Exposure
 Receptor: Residential Well, Hypothetical Future Land Use - MW-3, 9/28/92 data
 Associated Summary Table: Table A-10

Chemical	Oral Slope Factor (mg/kg/day) ⁻¹	Oral Reference Dose (mg/kg/day)	Matrix Bioavailability	Concentration in Water (ug/L)	Daily Intake Cancer (mg/kg-day)	Daily Intake Noncancer (mg/kg-day)	Estimated Lifetime Cancer Risk	Percent of Total Risk	Hazard Quotient
Tetrachloroethene	0.051	0.01	1	150	1.76E-03	4.11E-03	8.98E-05	6.19	0.41
Trichloroethene	0.015	0	1	350	4.11E-03	9.59E-03	6.16E-05	4.25	0.00
Vinyl chloride	0.27	0	1	410	4.81E-03	1.12E-02	1.30E-03	89.56	0.00
Total Risk and Hazard Index								1.45E-03	4.11E-01

Parameters	Descriptions	Units	Values
BW	Adult body weight	kg	70
AT_C	Averaging time - carcinogens	yr	70
AT_N	Averaging time - noncarcinogens	days/yr	30
EF	Exposure frequency	yr	350
ED	Exposure duration	yr	30
IR W	Daily water ingestion rate	L/day	2

Table G-11

Calculation of Health Risks Associated with Inhalation of VOCs in Groundwater

Project: McClellan Air Force Base
Site: Davis Global Communications Center
Scenario: Reasonable Maximum Exposure
Receptor: Residential Well, Hypothetical Future Land Use - MW-3, 9/28/92 data
Associated Summary Table: Table A-11

Chemical	Inhalation Slope Factor (mg/kg/day) ⁻¹	Inhalation Reference Dose (mg/kg/day)	Concentration in Water (ug/L)	Estimated Concentration in Air (ug/m ³)	Daily Intake Cancer (mg/kg-day)	Daily Intake Noncancer (mg/kg-day)	Estimated Lifetime Cancer Risk	Percent of Total Risk	Hazard Quotient
	Inhalation Slope Factor (mg/kg/day) ⁻¹	Inhalation Reference Dose (mg/kg/day)	Concentration in Water (ug/L)	Estimated Concentration in Air (ug/m ³)	Daily Intake Cancer (mg/kg-day)	Daily Intake Noncancer (mg/kg-day)	Estimated Lifetime Cancer Risk	Percent of Total Risk	Hazard Quotient
Tetrachloroethene	0.051	0.01	150	75	6.60E-03	1.54E-02	3.37E-04	6.28	1.54
Trichloroethene	0.01	0	350	175	1.54E-02	3.60E-02	1.54E-04	2.87	0.00
Vinyl chloride	0.27	0	410	205	1.81E-02	4.21E-02	4.87E-03	90.85	0.00
Total Risk and Hazard Index							5.37E-03		1.54E+00

Parameters	Descriptions	Units	Values
BW	Adult body weight	kg	70
AT_C	Averaging time - carcinogens	yr	70
AT_N	Averaging time - noncarcinogens	days/yr	30
EF	Exposure frequency	yr	350
ED	Exposure duration	m ³ /day	30
IR_A	Daily indoor inhalation rate		15
K	volatilization factor		0.5
			(K x 1,000 L/m ³)

Table G-12
Calculation of Health Risks Associated with Dermal Contact with Groundwater (Cal/EPA Methodology)

Project: McClellan Air Force Base
Site: Davis Global Communications Center
Scenario: Reasonable Maximum Exposure
Receptor: Residential Well, Hypothetical Future Land Use - Production Well Data
Associated Summary Table : Table A-12

Chemical	Oral Slope Factor (mg/kg/day) ⁻¹	Oral Reference Dose (mg/kg/day)	Permeability Coefficient (K _p) (cm/hr)	Concentration in Water (ug/L)	Daily Intake Cancer (mg/kg-day)	Daily Intake Noncancer (mg/kg-day)	Estimated Lifetime Cancer Risk	Percent of Total Risk	Hazard Quotient
Tetrachloroethene	0.051	0.01	0.048	150	2.43E-04	5.67E-04	1.24E-05	29.16	5.67E-02
Trichloroethene	0.015	0	0.016	350	1.89E-04	4.41E-04	2.84E-06	6.67	0.00E+00
Vinyl chloride	0.27	0	0.0073	410	1.01E-04	2.36E-04	2.73E-05	64.17	0.00E+00
Total Risk and Hazard Index								4.25E-05	5.67E-02

Parameters	Descriptions	Units	Values
ET	Event duration	hr/event	0.25
SA	Skin surface area	cm ²	23000
BW	Body weight	kg	70
AT_C	Averaging time - carcinogens	yr	70
AT_N	Averaging time - noncarcinogens	days/yr	30
EF	Exposure frequency	days/yr	350
ED	Exposure duration	yr	30

Table G-13

Calculation of Health Risks Associated with Ingestion of Soil

Project: McClellan Air Force Base
Site: Davis Global Communications Site
Scenario: Reasonable Maximum Exposure
Receptor: Hypothetical Future Resident
Associated Summary Table: Table A-13

Chemical	Oral Slope Factor (mg/kg/day) ⁻¹	Oral Reference Dose (mg/kg/day)	Matrix Bioavailability Site	Toxicity Study	Concentration in Soil (mg/kg)	Daily Intake Cancer (mg/kg-day)	Daily Intake Noncancer (mg/kg-day)	Estimated Lifetime Cancer Risk	Percent of Total Risk	Hazard Quotient
2-Methylnaphthalene	0	0.04	1	1	10.81	1.69E-05	3.94E-05	0.00E+00	<0.01	9.85E-04
Benzyl butyl phthalate	0	0.2	1	1	0.07	1.05E-07	2.44E-07	0.00E+00	<0.01	1.22E-06
Di-n-butyl phthalate	0	0.1	1	1	0.22	3.41E-07	7.96E-07	0.00E+00	<0.01	7.96E-06
Dibenzofuran	0	0.004	1	1	0.39	6.13E-07	1.43E-06	0.00E+00	<0.01	3.58E-04
Diethylphthalate	0	0.8	1	1	0.0003	4.08E-10	9.51E-10	0.00E+00	<0.01	1.19E-09
Fluorene	0	0.04	1	1	1.51	2.35E-06	5.49E-06	0.00E+00	<0.01	1.37E-04
Naphthalene	0	0.04	1	1	4.79	7.47E-06	1.74E-05	0.00E+00	<0.01	4.36E-04
Petroleum Hydrocarbons	0	0.008	1	1	1197.16	1.87E-03	4.36E-03	0.00E+00	<0.01	5.45E-01
Phenanthrene	0	0	1	1	3.82	5.96E-06	1.39E-05	0.00E+00	<0.01	0.00E+00
Pyrene	0	0.03	1	1	0.10	1.60E-07	3.72E-07	0.00E+00	<0.01	1.24E-05
bis(2-ethylhexyl)phthalate	0.014	0.02	1	1	0.70	1.09E-06	2.54E-06	1.52E-08	100.00	1.27E-04
Total Risk and Hazard Index									1.52E-08	5.47E-01

Parameters	Descriptions	Units	Values
IR_w	Weighted soil ingestion rate	mg-yr/kg-day	114
AT_C	Averaging time - carcinogens	yr	70
AT_N	Averaging time - noncarcinogens	yr	30
EF	Exposure frequency	days/yr	350

Table G-14

Calculation of Health Risks Associated with Inhalation of Outdoor Air

Project: McClellan Air Force Base
Site: Davis Global Communications Site
Scenario: Reasonable Maximum Exposure
Receptor: Hypothetical Future Resident - Inhalation of VOC Emissions from Soil Gas
Associated Summary Table: Table A-14

Chemical	Inhalation Slope Factor (mg/kg/day) ⁻¹	Inhalation Reference Dose (mg/kg/day)	Concentration in Air (mg/m ³)	Daily Intake - Cancer (mg/kg-day)	Daily Intake - Noncancer (mg/kg-day)	Estimated Lifetime Cancer Risk	Percent of Total Risk	Hazard Quotient
1,1,1-Trichloroethane		0.3	5.72E-08	6.72E-09	1.57E-08	0.00E+00	<0.01	5.22E-08
1,1,2-Trichloro-1,2,2-Trifluoroethane		7.7	1.49E-07	1.74E-08	4.07E-08	0.00E+00	<0.01	5.28E-09
1,1-Dichloroethane		0.1	2.90E-09	3.41E-10	7.95E-10	0.00E+00	<0.01	7.95E-09
1,1-Dichloroethene		0.009	7.40E-07	8.68E-08	2.03E-07	0.00E+00	<0.01	2.25E-05
Benzene	0.1	0	2.61E-07	3.06E-08	7.14E-08	3.06E-09	0.93	0.00E+00
Dichlorodifluoromethane		0.1	1.70E-08	2.00E-09	4.66E-09	0.00E+00	<0.01	4.66E-08
m,p-xylenes (sum of isomers)		2	1.55E-06	1.81E-07	4.23E-07	0.00E+00	<0.01	2.12E-07
o-xylene (1,2-Dimethylbenzene)		2	1.55E-06	1.82E-07	4.25E-07	0.00E+00	<0.01	2.13E-07
Tetrachloroethene (PCE)	0.051	0.01	5.33E-05	6.26E-06	1.46E-05	3.19E-07	97.40	1.46E-03
Toluene		0.1	2.25E-06	2.64E-07	6.15E-07	0.00E+00	<0.01	6.15E-06
Trichloroethene (TCE)	0.01	0	3.24E-06	3.80E-07	8.87E-07	3.80E-09	1.16	0.00E+00
Vinyl chloride	0.27	0	5.24E-08	6.16E-09	1.44E-08	1.66E-09	0.51	0.00E+00
cis-1,2-Dichloroethene		0.01	2.00E-08	2.35E-09	5.48E-09	0.00E+00	<0.01	5.48E-07
Total Risk or Hazard Index						3.28E-07		1.49E-03

Parameters	Descriptions	Units	Values
BW	Adult body weight	kg	70
AT_C	Averaging time - Carcinogens	yr	70
AT_N	Averaging time - Noncarcinogens		30
EF	Exposure frequency	days/yr	350

Table G-14

Calculation of Health Risks Associated with Inhalation of Outdoor Air

Project: McClellan Air Force Base
 Site: Davis Global Communications Site
 Scenario: Reasonable Maximum Exposure
 Receptor: Hypothetical Future Resident - Inhalation of VOC Emissions from Soil Gas
 Associated Summary Table: Table A-14

Chemical	Inhalation Slope Factor (mg/kg/day) ⁻¹	Inhalation Reference Dose (mg/kg/day)	Concentration in Air (mg/m ³)	Daily Intake -		Estimated Lifetime Cancer Risk	Percent of Total Risk	Hazard Quotient
				Cancer (mg/kg-day) yr	Noncancer (mg/kg-day) m ³ /day			
ED	Exposure duration				30			
IR A	Daily inhalation rate			m ³ /day	20			

Table G-15
Calculation of Health Risks Associated with Inhalation of Indoor Air

Project: McClellan Air Force Base
Site: Davis Global Communications Site
Scenario: Reasonable Maximum Exposure
Receptor: Hypothetical Future Resident
Associated Summary Table: Table A-15

Chemical	Inhalation Slope Factor (mg/kg/day) ⁻¹	Inhalation Reference Dose (mg/kg/day)	Concentration in Air (mg/m ³)	Daily Intake - Cancer (mg/kg-day)	Daily Intake - Noncancer (mg/kg-day)	Estimated Lifetime Cancer Risk	Percent of Total Risk	Hazard Quotient
1,1-Dichloroethene		0.009	4.22E-06	4.95E-07	1.16E-06	0.00E+00	<0.01	1.28E-04
Benzene	0.1	0	1.16E-05	1.36E-06	3.18E-06	1.36E-07	3.96	0.00E+00
m,p-xylene (sum of isomers)		2	2.10E-05	2.47E-06	5.76E-06	0.00E+00	<0.01	2.88E-06
Tetrachloroethene (PCE)	0.051	0.01	5.53E-04	6.49E-05	1.51E-04	3.31E-06	96.04	1.51E-02
Toluene		0.1	1.67E-05	1.96E-06	4.57E-06	0.00E+00	<0.01	4.57E-05
Total Risk or Hazard Index						3.45E-06		1.53E-02

Parameters	Descriptions	Units	Values
BW	Adult body weight	kg	70
AT_C	Averaging time - Carcinogens	yr	70
AT_N	Averaging time - Noncarcinogens	days/yr	30
EF	Exposure frequency	yr	350
ED	Exposure duration	m ³ /day	30
IR_A	Daily inhalation rate		20

Table G-16

Calculation of Health Risks Associated with Dermal Contact with Soil (Cal/EPA Methodology)

Project: McClellan Air Force Base
Site: Davis Global Communications Site
Scenario: Reasonable Maximum Exposure
Receptor: Hypothetical Future Resident
Associated Summary Table: Table A-16

Chemical	Oral Slope Factor (mg/kg/day) ⁻¹	Oral Reference Dose (mg/kg/day)	Absorption Fraction	Concentration in Soil (mg/kg)	Daily Intake Cancer (mg/kg-day)	Daily Intake Noncancer (mg/kg-day)	Estimated Lifetime Cancer Risk	Percent of Total Risk	Hazard Quotient
2-Methylnaphthalene	0	0.04	0.15	1.00	2.81E-06	4.37E-06	0.00E+00	<0.01	1.09E-04
Benzyl butyl phthalate	0	0.2	0.15	0.07	1.88E-07	2.93E-07	0.00E+00	<0.01	1.46E-06
Di-n-butyl phthalate	0	0.1	0.15	0.22	6.14E-07	9.55E-07	0.00E+00	<0.01	9.55E-06
Dibenzofuran	0	0.004	0.15	0.39	1.10E-06	1.71E-06	0.00E+00	<0.01	4.29E-04
Diethylphthalate	0	0.8	0.15	0.0003	7.34E-10	1.14E-09	0.00E+00	<0.01	1.43E-09
Fluorene	0	0.04	0.15	1.51	4.24E-06	6.59E-06	0.00E+00	<0.01	1.65E-04
Naphthalene	0	0.04	0.15	4.79	1.35E-05	2.09E-05	0.00E+00	<0.01	5.23E-04
Petroleum Hydrocarbons	0	0.008	0.15	1197.16	3.37E-03	5.23E-03	0.00E+00	<0.01	6.54E-01
Phenanthrene	0	0	0.15	3.82	1.07E-05	1.67E-05	0.00E+00	<0.01	0.00E+00
Pyrene	0	0.03	0.15	0.10	2.87E-07	4.46E-07	0.00E+00	<0.01	1.49E-05
bis(2-ethylhexyl)phthalate	0.014	0.02	0.15	0.70	1.96E-06	3.05E-06	2.74E-08	100.00	1.52E-04
Total Risk and Hazard Index							2.74E-08		6.55E-01

Parameters	Descriptions	Units	Values
AT_C	Averaging time - carcinogens	yr	70
AT_N	Averaging time - noncarcinogens	yr	30
EF_c	Exposure frequency - child	days/yr	350
EF_a	Exposure Frequency - adult	days/yr	100
SA_c	Skin Surface Area - child	cm ² /day	2000
SA_a	Skin Surface Area - adult	cm ² /day	5800

Table G-16

Calculation of Health Risks Associated with Dermal Contact with Soil (Cal/EPA Methodology)

Project: McClellan Air Force Base
 Site: Davis Global Communications Site
 Scenario: Reasonable Maximum Exposure
 Receptor: Hypothetical Future Resident
 Associated Summary Table: Table A-16

Chemical	Oral Slope Factor (mg/kg/day) ⁻¹	Oral Reference Dose (mg/kg/day)	Absorption Fraction	Concentration in Soil (mg/kg)	Daily Intake Cancer (mg/kg-day)	Daily Intake Noncancer (mg/kg-day)	Estimated Lifetime Cancer Risk	Percent of Total Risk	Hazard Quotient
AF	Soil adherence factor			mg/cm ²	1				
ED_c	Exposure duration - child			yr	6				
ED_a	Exposure duration - adult			yr	24				
BW_c	Body weight - child			kg	15				
BW_a	Body weight - adult			kg	70				

Appendix H
SITE ECOLOGICAL CHARACTERIZATION

PREPARED FOR: Davis Global Communications Site Risk Assessment

PREPARED BY: Gary Santolo and Jamie Maughan/CH2M HILL

DATE: July 26, 1993

SUBJECT: Site Ecological Characterization

PROJECT: SAC28722.55.15

Introduction

This technical memorandum describes the ecological features of the Davis Site and adjacent area to identify resources potentially at risk. Special attention is given to ecological resources that are sensitive to the type of contamination expected onsite, susceptible to impact from possible remediation activities, or unique or vulnerable on a regional basis (e.g., special-status species and habitats of recreationally important species). The methods used to characterize the ecological resources are given first, followed by a description of botanical resources, wetlands, wildlife, and special-status species.

Methods

The ecological resources (including botanical and wildlife resources) of the Davis Site and adjacent lands were characterized using existing records of the site area, a field-reconnaissance survey conducted in March 1993, and a subsequent site visit in July 1993. The California Natural Diversity Data Base (CNDDB) and the California Wildlife-Habitat Relationships system (WHR) were queried for information on special-status species and general species found in the vicinity of the Davis Site. The CNDDB search was limited to the Davis and Merritt 7.5 minute U.S. Geological Survey (USGS) quadrangles for special-status species and sensitive habitats (CNDDB, 1993). The WHR search was limited to Yolo County annual grassland (California Department of Fish and Game [CDFG], 1989).

The CNDDB is a compilation of locality, habitat, and status information for sensitive species and habitats maintained by the CDFG. It includes records of plant and animal species and sensitive habitats in California from a variety of sources including herbaria, university staff, scientific publications, members of organizations such as the California Native Plant Society and the Audubon Society, agency biologists, and environmental consultants. Data may be accessed by USGS quadrangle, county, or element name (species or habitat). Data included in the CNDDB are compiled by opportunistic rather than systematic means, and may not, therefore, include all species and habitats of concern for all geographic areas.

The WHR is an information system created through multiagency cooperation and maintained by CDFG. It assesses terrestrial vertebrate species occurrence, habitat requirements, life history information, and relative abundance. The information comes from a variety of sources such as university staff, scientific publications, members of organizations such as the Audubon Society, agency biologists, and environmental consultants. Data for a specific location are accessed by selecting such parameters as county, resource agency, region, hydrologic unit, latitude and longitude (Latilong), dominant habitat type, special elements, and others. Nomenclature for plant species follows that of Munz and Keck (1968). Vegetation community descriptions follow Holland (1986) and the WHR classification.

The March 1993 field reconnaissance was conducted over the entire Davis Site study area to identify biological resources and sensitive habitats. The reconnaissance included a general survey of all the potentially affected areas, although none were assessed to the level of detail that will be required for the definitive determination of species occurrence. The purpose of the July 1993 visit was to evaluate potential ecological receptors identified from the initial reconnaissance in light of recent site contaminant data. The field survey and project biologists' experience with California's sensitive plant and animal species helped prevent incorrect omissions and ensured inclusions of species and habitats potentially affected by the project.

Surveys were conducted only during a short period in early March and a single site visit in July. These limited surveys were not detailed enough to verify information from CNDDB or to determine former presence or absence of special-status species; therefore, a conservative approach was adopted in assessing the impact of project activities on species potentially occurring at or around the site. Species for which habitat was known to occur in the site area were assumed to exist or to have been present before changes caused by disturbances at the site.

Botanical Resources

The predominant plant community at the Davis Site and the portion of Wilson Park near the site is annual grassland. No riparian habitat or vernal pools occur within or immediately adjacent to the site. However, riparian habitat, vernal pools, agricultural lands, and urban habitats occur in the general vicinity.

The Sacramento Valley was originally dominated by perennial bunch grasses with a variety of annual plant species also present (Barbour and Major, 1988; Holland and Keil, 1989). Since the mid-1800s, human activities (such as agricultural development) and invasion of introduced plant species have completely altered the species composition of the valley grasslands. Introduced annual grasses, broadleafed weeds, and other ruderal species now dominate the valley grasslands.

Practically all of the unimproved lands of the Davis Site now support the annual grassland typical of the region. Actual species composition varies according to soil type, moisture, nutrients, disturbances, successional stage, and allelopathic interactions. Typical species include various annual grasses, yellow star thistle, Russian

thistle, filaree, prickly lettuce, vetch, and curly dock. There are virtually no shrubs or trees within or near the site.

Wetland vegetation occurs in and around two shallow seasonal wetlands east of the compound. Vegetation supported by these wetlands includes annual grasses, duckweed, rushes, and curly dock.

No riparian habitat occurs on the site but is found nearby along Putah Creek. Plant species typically found in riparian habitat include willows, cottonwood, California black oak, Oregon ash, tree-of-heaven, elderberry, blackberry, white alder, wild grape, red berry, and coffee berry.

Wetlands

Seasonal wetlands were found east of the fenced compound near the center of the Davis Site. These wetlands were probably formed from winter rains and cover less than 1 acre of the site. These areas support some wetland vegetation such as duckweed, rushes, and curly dock, but do not appear to support specific plant species associated with vernal pools. The wetlands do not appear to be subject to §404 regulation because of lack of obligatory wetland vegetation and period of inundation. However, a full characterization based on the three-parameter approach (hydrophytes, hydric soils, and hydrology) was not performed to verify the nonjurisdictional determination. A thorough delineation using the appropriate technique would be necessary, if there is any potential for disturbing the areas during remediation.

The Davis Site may have supported vernal pools in the past, but previous land management practices have altered the unique conditions required for vernal pool development. Vernal pools are small, hardpan-floored depressions in a valley grassland mosaic that fill with water during the winter and dry during the spring (Barbour and Major, 1988). As the pools dry out in the spring, a variety of annual plant species (many unique to vernal pools) flower, often in brightly colored concentric rings. Vernal pools are typically formed in alluvial materials and are heavily weathered with subsoils in clay. Special hydrologic and chemical conditions of vernal pools exclude most Eurasian weeds; such weeds lack the ecological adaptations that allow them to grow in the pools (Holland and Keil, 1989).

Wildlife

Wildlife at the Davis Site consists of common species associated with annual grasslands and agricultural habitats. The riparian areas in the vicinity of the site increase the species diversity. Wildlife species that typically occur in the habitat found at the site and species observed during the reconnaissance survey are listed in Table H-1. Wildlife observed during the March 1993 survey and the July 1993 site visit include northern harriers, turkey vultures, California ground squirrels, burrowing owls, western meadowlarks, loggerhead shrikes, killdeer, mallard, black-tailed hares, and California voles.

Table H-1
Wildlife Species Potentially Occurring and Known to Occur
at the Davis Global Communications Site

Sheet 1 of 5

Species Name	Scientific Name	Known to Occur Onsite	Status					
			F E	C E	C T	C P	H	CA SC
Amphibians								
Tiger Salamander	<i>Ambystoma tigrinum</i>							
Western Spadefoot	<i>Scaphiopus hammondi</i>							
Western Toad	<i>Bufo boreas</i>							
Pacific Treefrog	<i>Hyla regilla</i>	X						
Reptiles								
Western Pond Turtle	<i>Clemmys marmorata</i>							
Western Fence Lizard	<i>Sceloporus occidentalis</i>							
Coast Horned Lizard	<i>Phrynosoma coronatum</i>							
Racer	<i>Coluber constrictor</i>							
Coachwhip	<i>Masticophis flagellum</i>							
Gopher Snake	<i>Pituophis melanoleucus</i>							
Common Kingsnake	<i>Lampropeltis getulus</i>							
Common Garter Snake	<i>Thamnophis sirtalis</i>							
Western Terrestrial Garter Snake	<i>Thamnophis elegans</i>							
Western Aquatic Garter Snake	<i>Thamnophis couchi</i>							
Western Rattlesnake	<i>Crotalus viridis</i>							
Birds								
Great Blue Heron	<i>Ardea herodias</i>							
Great Egret	<i>Casmerodius albus</i>	X						
Cattle Egret	<i>Bubulcus ibis</i>							
Greater White-fronted Goose	<i>Anser albifrons</i>						X	
Snow Goose	<i>Chen caerulescens</i>						X	
Ross' Goose	<i>Chen rossii</i>						X	
Canada Goose	<i>Branta canadensis</i>						X	
Green-winged Teal	<i>Anas crecca</i>						X	
Mallard	<i>Anas platyrhynchos</i>	X					X	
Northern Pintail	<i>Anas acuta</i>						X	
Blue-winged Teal	<i>Anas discors</i>						X	
Cinnamon Teal	<i>Anas cyanoptera</i>						X	
Northern Shoveler	<i>Anas clypeata</i>						X	
Gadwall	<i>Anas strepera</i>						X	
American Wigeon	<i>Anas americana</i>						X	
Turkey Vulture	<i>Cathartes aura</i>	X						
Black-shouldered Kite	<i>Elanus caeruleus</i>	X				X		

Table H-1
Wildlife Species Potentially Occurring and Known to Occur
at the Davis Global Communications Site

Sheet 2 of 5

Species Name	Scientific Name	Known to Occur Onsite	Status					
			F E	C E	C T	C P	H	CA SC
Birds (Continued)								
Northern Harrier	<i>Circus cyaneus</i>	X						X
Sharp-shinned Hawk	<i>Accipiter striatus</i>							
Cooper's Hawk	<i>Accipiter cooperii</i>							
Red-shouldered Hawk	<i>Buteo lineatus</i>							
Swainson's Hawk	<i>Buteo swainsoni</i>				X			X
Red-tailed Hawk	<i>Buteo jamaicensis</i>	X						
Ferruginous Hawk	<i>Buteo regalis</i>							
Rough-legged Hawk	<i>Buteo lagopus</i>							
Golden Eagle	<i>Aquila chrysaetos</i>					X		
American Kestrel	<i>Falco sparverius</i>	X						
Merlin	<i>Falco columbarius</i>							X
Peregrine Falcon	<i>Falco peregrinus</i>		X	X		X		
Prairie Falcon	<i>Falco mexicanus</i>							
Ring-necked Pheasant	<i>Phasianus colchicus</i>						X	
California Quail	<i>Callipepla californica</i>						X	
American Coot	<i>Fulica americana</i>						X	
Sandhill Crane	<i>Grus canadensis</i>					X		
Black-bellied Plover	<i>Pluvialis squatarola</i>							
Killdeer	<i>Charadrius vociferus</i>	X						
Mountain Plover	<i>Charadrius montanus</i>							
Black-necked Stilt	<i>Himantopus mexicanus</i>	X						
Spotted Sandpiper	<i>Actitis macularia</i>							
Long-billed Curlew	<i>Numenius americanus</i>							
Ring-billed Gull	<i>Larus delawarensis</i>							
California Gull	<i>Larus californicus</i>							
Rock Dove	<i>Columba livia</i>	X					X	
Mourning Dove	<i>Zenaida macroura</i>	X					X	
Common Barn Owl	<i>Tyto alba</i>							
Western Screech-owl	<i>Otus kennicottii</i>							
Great Horned Owl	<i>Bubo virginianus</i>							
Burrowing Owl	<i>Athene cunicularia</i>	X						X
Long-eared Owl	<i>Asio otus</i>							X
Short-eared Owl	<i>Asio flammeus</i>							X
Lesser Nighthawk	<i>Chordeiles acutipennis</i>							

Table H-1
Wildlife Species Potentially Occurring and Known to Occur
at the Davis Global Communications Site

Sheet 3 of 5

Species Name	Scientific Name	Known to Occur Onsite	Status					
			F E	C E	C T	C P	H	CA SC
Birds (Continued)								
Common Poorwill	<i>Phalaenoptilus nuttallii</i>							
White-throated Swift	<i>Aeronautes saxatalis</i>							
Northern Flicker	<i>Colaptes auratus</i>							
Black Phoebe	<i>Sayornis nigricans</i>							
Say's Phoebe	<i>Sayornis saya</i>							
Western Kingbird	<i>Tyrannus verticalis</i>							
Horned Lark	<i>Eremophila alpestris</i>							
Purple Martin	<i>Progne subis</i>							2
Tree Swallow	<i>Tachycineta bicolor</i>							
Violet-green Swallow	<i>Tachycineta thalassina</i>							
Northern Rough-winged Swallow	<i>Stelgidopteryx serripennis</i>							
Bank Swallow	<i>Riparia riparia</i>				X			
Cliff Swallow	<i>Hirundo pyrrhonota</i>							
Barn Swallow	<i>Hirundo rustica</i>							
Yellow-billed Magpie	<i>Pica nuttalli</i>	X						
American Crow	<i>Corvus brachyrhynchos</i>						X	
Western Bluebird	<i>Sialia mexicana</i>							
American Robin	<i>Turdus migratorius</i>							
Northern Mockingbird	<i>Mimus polyglottos</i>	X						
American Pipit	<i>Anthus spinoletta</i>							
Loggerhead Shrike	<i>Lanius ludovicianus</i>	X						
European Starling	<i>Sturnus vulgaris</i>	X						
Yellow-rumped Warbler	<i>Dendroica coronata</i>							
Common Yellowthroat	<i>Geothlypis trichas</i>							
Blue Grosbeak	<i>Guiraca caerulea</i>							
Chipping Sparrow	<i>Spizella passerina</i>							
Lark Sparrow	<i>Chondestes grammacus</i>							
Savannah Sparrow	<i>Passerculus sandwichensis</i>	X						
Grasshopper Sparrow	<i>Ammodramus savannarum</i>							
Song Sparrow	<i>Melospiza melodia</i>							
Lincoln's Sparrow	<i>Melospiza lincolni</i>							
Golden-crowned Sparrow	<i>Zonotrichia atricapilla</i>							
White-crowned Sparrow	<i>Zonotrichia leucophrys</i>							
Red-winged Blackbird	<i>Agelaius phoeniceus</i>	X						

Table H-1
Wildlife Species Potentially Occurring and Known to Occur
at the Davis Global Communications Site

Sheet 4 of 5

Species Name	Scientific Name	Known to Occur Onsite	Status					
			F E	C E	C T	C P	H	CA SC
Birds (Continued)								
Tricolored Blackbird	<i>Agelaius tricolor</i>							
Western Meadowlark	<i>Sturnella neglecta</i>	X						
Yellow-headed Blackbird	<i>Xanthocephalus xanthocephalus</i>							
Brewer's Blackbird	<i>Euphagus cyanocephalus</i>	X						
Brown-headed Cowbird	<i>Molothrus ater</i>							
House Finch	<i>Carpodacus mexicanus</i>							
Lesser Goldfinch	<i>Carduelis psaltria</i>							
Lawrence's Goldfinch	<i>Carduelis lawrencei</i>							
American Goldfinch	<i>Carduelis tristis</i>							
Mammals								
Virginia Opossum	<i>Didelphis virginiana</i>							
Ornate Shrew	<i>Sorex ornatus</i>							
Broad-footed Mole	<i>Scapanus latimanus</i>							
Yuma Myotis	<i>Myotis yumanensis</i>							
Long-legged Myotis	<i>Myotis volans</i>							
California Myotis	<i>Myotis californicus</i>							
Western Pipistrelle	<i>Pipistrellus hesperus</i>							
Big Brown Bat	<i>Eptesicus fuscus</i>							
Red Bat	<i>Lasiurus borealis</i>							
Hoary Bat	<i>Lasiurus cinereus</i>							
Townsend's Big-eared Bat	<i>Plecotus townsendii</i>							
Pallid Bat	<i>Antrozous pallidus</i>							
Brazilian Free-tailed Bat	<i>Tadarida brasiliensis</i>							
Desert Cottontail	<i>Sylvilagus audubonii</i>						X	
Black-tailed Hare	<i>Lepus californicus</i>	X					X	
California Ground Squirrel	<i>Spermophilus beecheyi</i>	X						
Botta's Pocket Gopher	<i>Thomomys bottae</i>	X						
San Joaquin Pocket Mouse	<i>Perognathus inornatus</i>							
California Kangaroo Rat	<i>Dipodomys californicus</i>							
Western Harvest Mouse	<i>Reithrodontomys megalotis</i>							
Deer Mouse	<i>Peromyscus maniculatus</i>							
California Vole	<i>Microtus californicus</i>	X						
House Mouse	<i>Mus musculus</i>							
Coyote	<i>Canis latrans</i>						X	

Table H-1
Wildlife Species Potentially Occurring and Known to Occur
at the Davis Global Communications Site

Sheet 1 of 5

Species Name	Scientific Name	Known to Occur Onsite	Status					
			F E	C E	C T	C P	H	CA SC
Mammals (Continued)								
Red Fox	<i>Vulpes vulpes</i>							
Gray Fox	<i>Urocyon cinereoargenteus</i>						X	
Raccoon	<i>Procyon lotor</i>						X	
Long-tailed Weasel	<i>Mustela frenata</i>						X	
Badger	<i>Taxidea taxus</i>						X	
Western Spotted Skunk	<i>Spilogale gracilis</i>						X	
Striped Skunk	<i>Mephitis mephitis</i>	X					X	
Bobcat	<i>Felis rufus</i>						X	
FE: Federal Endangered		CT: California Threatened		CASC: California Special Concern				
CE: California Endangered		CP: California Protected		H : Harvest				

Special-Status Species

No special-status plant species were identified by the CNDDDB query or observed during the reconnaissance survey.

Almost all species of birds in the U.S. are protected by the 1972 Migratory Bird Treaty Act. This act protects birds from unregulated "take," which can include poisoning at hazardous waste sites. Special-status wildlife species include those listed by the U.S. Fish and Wildlife Service or CDFG in the following categories:

- Species listed or proposed for listing as threatened or endangered under the Federal Endangered Species Act of 1973 as amended (50 CFR 17.11).
- Species that are Category 1 or 2 candidates for listing as threatened or endangered under the Federal Endangered Species Act of 1973 (54 Federal Register 554, January 6, 1989). Category 1 candidates are those for which the U.S. Fish and Wildlife Service has sufficient information to support listing as threatened or endangered, and Category 2 candidates are those for which further information is required to determine appropriate status.
- Species listed or proposed for listing under the California Endangered Species Act (14 CCR 670, et seq.).

- Animals fully protected in California (California Fish and Game Code, §§ 3511 (birds), 4700 (mammals), and 5050 (amphibians and reptiles), prohibiting taking or possessing at any time protected animals or parts thereof.
- Species that meet the definitions of rare or endangered under State California Environmental Quality Act guidelines (an unlisted species shall be considered rare, threatened, or endangered if it meets the criteria outlined in Section 15380).
- Animal Species of Special Concern to the California Department of Fish and Game (birds [Remsen, 1978], mammals [Williams, 1986] not included in CDFG code).

Special-status species identified by the CNDDDB as occurring in the vicinity of the Davis site are listed in Table H-2, and information on habitat, status, and the occurrence or potential occurrence is described below.

Table H-2 Special-Status Species and Habitats Identified in the California Natural Diversity Data Base			
Common Name	Scientific Name	Status (State/Federal)	Potential Occurrence
Reptiles			
Giant Garter Snake	<i>Thamnophis gigas</i>	T/PE	Marshes and sloughs
Birds			
Swainson's Hawk	<i>Buteo Swainsoni</i>	T/C3	Agricultural fields and annual grassland
Western Snowy Plover	<i>Charadrius alexandrius nivosus</i>	CSC/T	Open areas and alkali flats
Burrowing Owl	<i>Athene cunicularia</i>	CSC/	Annual grasslands
Notes: T = Threatened PE = Proposed Federal Endangered C3 = Candidate for Federal Listing CSC = California Special Concern Source: CNDDDB, 1993.			

Giant Garter Snake. The giant garter snake is a Proposed Federal Endangered species (Federal Register, December 27, 1991) and a California Threatened species. It is primarily associated with riparian marsh or slough habitats that are periodically inundated. Periodic flooding provides moisture and forage fish and helps remove terrestrial competitors. Loss of habitat (because of urbanization and agricultural practices) and the introduction of competitors and predators are stated as reasons for the

decline of giant garter snake populations (CDFG, 1987; 1988b). It is unlikely that giant garter snakes inhabit the Davis Site because of the lack of suitable habitat.

Swainson's Hawk. Swainson's hawks are a California Threatened species that nest mostly in riparian areas, but they may also nest in lone trees or groves in agricultural fields, pastures, and roadsides. They forage in open grasslands, lightly grazed pastures, alfalfa, and other hay crops with abundant prey (small mammals, birds, reptiles, and insects). The decline in the Swainson's hawk population is possibly due to loss of nesting and foraging habitat as a result of agriculture and urbanization. Pesticides may also have contributed to the decline of the Swainson's hawk population (CDFG, 1988a; 1990). The Davis Site lacks suitable nesting habitat but may provide some foraging habitat. A number of known Swainson's hawk nests were identified within a 10-mile radius of the site (CNDDDB, 1993).

Western Snowy Plover. The coastal population of the western snowy plover is listed as a Federal Threatened species and a CDFG Species of Special Concern. Interior populations are generally stable (Page, 1993). They require a sandy, gravelly, or friable soil substrate for nesting and frequently nest near or under objects such as driftwood, rocks, or defoliated bushes. Nests may also occur on open barren ground in alkali sinks with no nearby cover. Nesting occurs from April through August. The major inland nesting habitat of these birds appears to be on salt pond levees, alkali sinks, and at Salton Sea and Mono Lake (CDFG, 1990). Snowy plover chicks were observed at the Davis sewage treatment ponds in 1963 (CNDDDB, 1993). This location is about 6 miles north of the site. However, snowy plovers would not be expected to occur at the Davis Site because it lacks suitable nesting habitat.

Burrowing Owl. The burrowing owl is a CDFG Species of Special Concern. The species is rare or absent in much of Northern California and is generally uncommon where it does occur. The decline of this species is attributed to loss of habitat caused by agricultural and urban development. The burrowing owl is found in open, dry grassland areas; it eats mostly insects but also feeds on small mammals, reptiles, birds, and carrion. Burrowing owls use existing burrows (especially ground squirrel burrows) for shelter and nesting cover (CDFG, 1990). Burrowing owls were observed in the fields along the entrance road south of the compound, and on communication towers and the wires supporting the towers north and south of the fenced compound. Potential habitat exists for the owl over much of the site. Ground squirrel burrows were found in gravel stockpiled for road maintenance and soil piles left from removal of underground diesel fuel storage tanks east and north of the compound. Burrows in these piles could be used by burrowing owls, although none were observed during the reconnaissance survey.

Works Cited

Barbour, M. G., and J. Major. 1988. *Terrestrial Vegetation of California*. California Native Plant Society. Special Publication No. 9.

California Department of Fish and Game. 1987. Five Year Status Report: Giant Garter Snake. Prepared by S. R. Ellis, CDFG, Inland Fisheries Division, Endangered Species Project. July 1.

California Department of Fish and Game. 1988a. Five Year Status Report: Swainson's Hawk. Prepared by Nongame Bird and Mammal Section, Wildlife Management Division, CDFG. July 31.

California Department of Fish and Game. 1988b. David C. Zeiner, et al., EA-10 eds. *California Wildlife, Volume I, Amphibians and Reptiles*. May 2.

California Department of Fish and Game. 1989. Wildlife Habitats Relationships Data Base. Sacramento, California.

California Department of Fish and Game. 1990. David C. Zeiner, et al., eds. *California Wildlife, Volume II, Birds*. November.

CNDDDB (California Natural Diversity Data Base). 1993. Unpublished report generated from the CNDDDB by the CDFG. Sacramento, CA.

Holland, R. F. 1986. Preliminary Descriptions of the Terrestrial Natural Communities of California. CDFG Nongame Heritage Program.

Holland, V. L., and D. J. Keil. 1989. *California Vegetation*. El Corral Publications, Biological Sciences Department. California Polytechnic State University.

Munz, P. A., and D. D. Keck. 1968. *A California Flora*. Berkeley, CA: University of California Press.

Page, Gary, Point Reyes Bird Observatory, CA. 1993. Telephone conversation with Gary Santolo, CH2M HILL. March 16.

Remsen, J. V. 1978. Bird Species of Special Concern in California. CDFG, Nongame Wildlife Investigations, Wildlife Management Branch Administrative Report No. 78-1. June.

Williams, D. F. 1986. Mammalian Species of Special Concern in California. CDFG, Wildlife Management Division Administrative Report 86-1. June.

Appendix I
ECOLOGICAL CONTAMINANTS OF POTENTIAL CONCERN

PREPARED FOR: Davis Global Communications Site Risk Assessment

PREPARED BY: Jamie Maughan/CH2M HILL

DATE: July 26, 1993

SUBJECT: Ecological Contaminants of Potential Concern

PROJECT: SAC28722.55.15

Introduction

This technical memorandum identifies contaminants associated with the Davis Site that could pose an ecological risk. The identification process involves first evaluating ecological exposure pathways from the potentially contaminated media to ecological receptors. If a pathway is identified, contaminants in the media are examined to determine which contaminants in which media warrant further evaluation of potential ecological effects.

Contaminants are evaluated by comparing them to background concentrations, determining the frequency of occurrence, and comparing them to toxicity values reported in the literature to establish ecological benchmarks. Inorganic contaminants were never used onsite so there is no reason to expect their presence; therefore, only organic compounds (petroleum hydrocarbons and synthetic organic compounds) were measured and are thus the only contaminants addressed in the risk assessment. Because these compounds do not occur naturally (i.e., no measurable background concentration), any detectable levels are considered above background concentrations. For this ecological evaluation of contaminants of potential concern (COPCs), if a compound was detected in 5 percent or more of the samples, it was evaluated further.

The process of developing ecological benchmarks and comparing them to onsite concentrations varies by media and compound. For some media, criteria and standards have been established. For example, EPA has developed water quality criteria for most inorganic and many organic compounds (U.S. EPA, 1986 and 1992a). For soils, bioassay tests and onsite measurements of ecological effects often can be used in developing site-specific ecological benchmarks. For inhalation pathways, little or no ecological research has been done, and most ecological benchmarks must be based on research and calculations done for human health considerations.

The COPCs are evaluated below for each of the potentially contaminated media.

Soils

Ecological pathways in soils are generally confined to the surface (top 5 feet or less). Most plants and animals do not obtain food, shelter, or nutrients below this depth so there is no opportunity for exposure by contact or ingestion. Under normal conditions, contamination from deeper soils is not likely to be mixed with the top 5 feet; thus, soils below 5 feet do not support an exposure pathway.

All soil contamination at the Davis Site resulted from leaks of underground tanks or other sources placing contaminants well below 5 feet (see Appendix C, Site Conceptual Model). Surface soils were considered clean and were not tested. Therefore, with the exception noted below, soils are not considered a medium of concern.

The only soil-related concern is soil presumably excavated during tank removal and stockpiled onsite. These soils represent potential pathways via ingestion, inhalation, and dermal contact, particularly for animals burrowing into the soil piles. Testing of these soils identified diesel concentrations based on the modified Method 8015 analysis (see Appendix C):

- Number of samples – 14
- Frequency of detection – 50 percent
- Maximum concentration – 180 mg/kg
- Mean $\pm$ standard deviation – 55 ± 67 mg/kg (using half detection limits for nondetectable values)

Based on toxicity data from EPA (1992b) and estimated ingestion rates and size for small mammals, a soils ecological benchmark for ingestion of diesel-contaminated soil was calculated as follows:

$$\text{Soil criterion (mg/kg)} = \frac{TV \times BW}{RI \times CF} \quad (1)$$

Where:

TV	=	Toxicity value as lowest observed adverse effect level
BW	=	Body weight (kg)
IR	=	Ingestion rate (mg/day)
CF	=	Conversion factor (1×10^{-6} kg/mg)

An ingestion benchmark for soil of 2,033 mg/kg was estimated using this method.

Stating with an inhalation exposure criterion, an inhalation pathway benchmark in soils was calculated as follows:

$$H = \frac{C_{gas}}{C_{water}} \quad (2)$$

$$K_d = \frac{C_{soil}}{C_{water}} \quad (3)$$

$$K_d = K_{oc} \times f_{oc} \quad (4)$$

Where:

H is adjusted for temperature and made unitless by:

$H = H'/RT$ where:

H' = Henry's Constant for diesel in atm-m³/mol = 2.9E-4 (USAF, 1989)

R = 8.26E-5 atm-m³/mol/K°

T = temperature in K° (assumed to be 305K° for the Davis Site)

C_{gas} = concentration in gas (mg/m³)

C_{water} = concentration in water (μg/l)

C_{soil} = concentration in soil (μg/kg)

K_d = partitioning coefficient corrected for carbon content

K_{oc} = organic carbon partitioning coefficient (962 ml/g) (USAF, 1989)

f_{oc} = fraction organic carbon in soil (assumed to be 0.005 for the Davis Site)

Using 150 mg/m³ as the concentration in gas (which is the inhalation lowest observed effect level for small mammals given by U.S. EPA [1992b]) a soil concentration of 62,678 μg/kg or 63 mg/kg was calculated for the Davis Site.

No dermal contact toxicity information was available to determine a benchmark. Inhalation was judged to be the critical pathway and was judged not to be a concern if levels did not pose a risk for inhalation dermal contact.

Comparison of onsite concentrations to these benchmarks indicates that diesel is not a concern for ingestion. However, at the maximum concentrations, it could potentially be of concern for inhalation. Therefore, it is retained as a COPC.

Groundwater

Under natural conditions, groundwater from the Davis Site does not reach the surface; in fact it is at least 10 feet below the surface at all times. Consequently, there is no potential for contact or consumption of groundwater by ecological receptors. Without a completed pathway, the contaminants in groundwater are not considered a concern for the ecological risk assessment.

Surface Water

Because there is no surface water on the site, there is no ecological exposure pathway via this medium. However, one remediation scenario involves treating groundwater for organic contaminants followed by spray irrigation of the effluent for disposal. The spray irrigation system would require an effluent holding pond, which would be a possible surface-water ecological exposure route. The effluent would be treated for organics and therefore free from organic contaminants, but inorganic compounds that naturally occur in the groundwater might be present in the effluent. Predicted concentrations of several inorganics in the holding pond exceed applicable ecological benchmarks (Table I-1). For purposes of the following comparison, the benchmarks are considered as 100 percent. The following contaminants exceed benchmarks and therefore are considered COPCs:

- Antimony—273 percent of benchmark
- Iron—555 percent of benchmark
- Lead—714 percent of benchmark
- Nickel—123 percent of benchmark
- Selenium—550 percent of benchmark
- Thallium—208 percent of benchmark

Soil Gas

Animals that live close to the ground can be exposed to gases in the soil. Soil burrowing animals are particularly susceptible to inhaling soil gases because they can live in a closed space where no dilution of soil gases occurs. Several gases were detected at frequencies ranging from 20 percent to 69 percent of the samples (Table I-2).

Ecological benchmarks for inhalation pathways are not readily available (Maughan, 1993; Suter, 1993). Consequently, potential for ecological risk was determined by comparing measured soil concentrations to standards and research developed for

Table I-1 Human Health Protection Criteria Compared to Expected Pond Influent Concentrations ($\mu\text{g/l}$)		
Contaminant	Pond Average Concentration	EPA Freshwater^a Chronic Criteria
Aluminum	1,858	N/A
Antimony	81.8	30
Barium	170.0	2,000
Calcium	32,714	N/A
Chromium (III)	127.4	365 ^c
Cobalt	9.4	N/A
Copper	14.0	21 ^c
Iron	5,549	1,000
Lead	55.0	7.7 ^c
Magnesium	101,571	N/A
Manganese	152.4	N/A
Molybdenum	9.1	N/A
Nickel	346.8	283 ^c
Selenium	27.5	5
Sodium	115,571	N/A
Thallium	83.0	40
Vanadium	19.9	N/A
Zinc	62.9	191 ^c
^a U.S. EPA (1986, 1992a). ^b Pond values as average concentrations from six monitoring wells at the project site. Fall and winter, 1992. ^c Calculated based on a hardness of 200 ppm as CaCO_3 . Note: N/A = Not Applicable		

human exposure (Table I-2). If maximum measured concentrations are significantly below the standards, no ecological risk is expected. If the onsite levels approach or exceed the human health criteria, additional toxicity evaluation such as partitioning and modeling can be performed (Kappleman; 1993; Suter, 1993).

At the Davis Site, all detected soil gas concentrations were significantly below the values developed for human exposure (Table I-2). In addition, site specific evaluations for inhalation exposure of burrowing animals have been conducted for several compounds detected at the Davis Site; comparison of these levels supports the conclusion of no ecological risk from soil gases. A level of 160 $\mu\text{g/l}$ (compared to 0.27 $\mu\text{g/l}$ at the Davis Site) was calculated for benzene (Kappleman, 1993). For toluene, Kappleman (1993) calculated an ecological effects level for burrowing mammals of 320 $\mu\text{g/l}$ (maximum Davis Site concentration of 6.8 $\mu\text{g/l}$). On the basis of these comparisons, contaminants in soil gas are not considered a concern.

Table I-2
Summary of Davis Global Communications Site
Soil Gas Concentrations

	Detection Frequency	Unit	Maximum Concentration	Benchmark	Percent Benchmark ^a
Benzene	0.26	mg/m ³	0.27	30 ^c	0.90
1,1-Dichlorethene	0.22	mg/m ³	1.6	100 ^b	1.60
Ethylbenzene	0.2	mg/m ³	5.8	435 ^c	1.33
M,P-Xylene (sum of Isomers)	0.43	mg/m ³	16.3	435 ^c	3.75
O-Xylene (1,2=Dimethylbenzene)	0.26	mg/m ³	17.5	435 ^c	4.02
Tetrachloroethene (PCE)	0.69	mg/m ³	146	670 ^c	21.79
Toluene	0.48	mg/m ³	6.8	750 ^c	0.91
Trichloroethene (TCE)	0.36	mg/m ³	12.7	535 ^c	2.37

^aFor purposes of this comparison, 100 = standard.

^bMaltoni, et al., 1985.

^cSittig, 1985.

Summary

Listed below are ecological compounds of concern for each media at the Davis Global Communication Site:

- Soils—Diesel (soil piles only)
- Groundwater—None
- Surface Water (effluent storage pond only)
 - Antimony
 - Iron
 - Lead
 - Nickel
 - Selenium
 - Thallium
- Soil Gas—None

Works Cited

Kappleman, William B. 1993. "Pine Street Canal Ecological Assessment: A Case Study." *Ecological Assessment of Hazardous Waste Sites*. J. T. Maughan, ed. New York, NY: Van Nostrand Reinhold.

Maltoni, C., et al. 1985. "Experimental Research on Vinylidene Chloride Carcinogenesis." *Archives of Research on Industrial Carcinogenesis*. Vol. 3. C. Maltoni and M. H. Mehlman, eds. Princeton, N.J.: Princeton Scientific Publishers

Maughan, J. T. 1993. *Ecological Assessment of Hazardous Waste Sites*. New York, NY: Van Nostrand Reinhold.

Sittig, Marshall. 1985. *Handbook of Toxic and Hazardous Chemicals and Carcinogens*. 2nd edition. Park Ridge, NJ: Noyles Publications.

Suter, G. W. 1993. *Ecological Risk Assessment*. Boca Raton, FL: Lewis Publishers.

USAF. 1989. Installation Restoration Program Toxicology Guide. Prepared for the Henry G. Armstrong Aerospace Medical Research Laboratory, Air Force Systems Command, Wright-Patterson AFB, by Oak Ridge National Laboratory.

U.S. EPA. 1986. Quality Criteria for Water. Office of Water Regulation and Standards. EPA/440/5-86/001.

U.S. EPA. 1992a. Quality Criteria for Water 1992. Poster. Office of Water Regulations and Standards. Washington, D.C.

U.S. EPA. 1992b. Oral Reference Doses and Oral Slope Factors of JP-4, JP-5, Diesel Fuel and Gasoline. Memorandum from Office of Environmental Criteria and Assessment. Cincinnati, OH. March 24.

Appendix J
ECOLOGICAL EFFECTS OF REMEDIATION

PREPARED FOR: Davis Global Communication Site Risk Assessment

PREPARED BY: Jamie Maughan/CH2M HILL

DATE: July 27, 1993

SUBJECT: Ecological Effects of Remediation

PROJECT: SAC28722.55.15

Introduction

This technical memorandum identifies and evaluates the potential effects of remediation on ecological resources and the effects of contaminants left onsite. Measures to avoid or minimize those impacts are also identified and evaluated. The discussion is presented under the headings of the significant resources on or adjacent to the site.

Surface Water

Ecological Effects

Neither the Proposed Action using the reinjection end-use option nor the No-Action Alternative would adversely affect the site's surface-water features. The temporary winter rainwater pools are not located in the immediate vicinity of the project, and no permanent surface-water features would be affected. Runoff hydrology would not be affected by the project because extensive grading and new impervious surfaces are not planned.

With the Proposed Action irrigation end-use option, a storage reservoir (pond) would be constructed to allow for irrigation management and irrigation system downtime. The proposed design provides for a 5- to 10-foot-deep pond of 0.5-acre in surface area. Estimates of pond water quality are presented in Table J-1. Because the treated water (effluent from the groundwater treatment system) would meet drinking water criteria, aquatic life protection standards for VOCs also would be met for water in the reservoir.

Table J-1 Expected Groundwater Treatment Effluent Holding Pond Water Quality Characteristics		
Parameter – Cations^a	Pond Average Concentration (µg/l)	EPA Freshwater Chronic Criteria (µg/l)
Aluminum	1,858	N/A
Antimony	81.8	30
Barium	170.0	2,000
Calcium	32,714	N/A
Chromium (III)	127.4	365 ^b
Cobalt	9.4	N/A
Copper	14.0	21 ^b
Iron	5,549	1,000
Lead	55.0	7.7 ^b
Magnesium	101,571	N/A
Manganese	152.4	N/A
Molybdenum	9.1	N/A
Nickel	346.8	283 ^b
Selenium	27.5	5
Sodium	115,571	N/A
Thallium	83.0	40
Vanadium	19.9	N/A
Zinc	62.9	191 ^b
^a Pond values as average concentrations from six monitoring wells at the project site. Fall, winter 1992. ^b Calculated based on a hardness of 200 ppm as CaCO ₃ . Note: N/A = Not Applicable		

Cation concentrations are not expected to be changed by the VOC remediation process. Some average cation concentrations may fail to meet state and federal aquatic life protection standards. Antimony, iron, lead, nickel, selenium, and thallium concentrations in the pumped groundwater may exceed chronic water quality criteria. Selenium is of particular concern because of known toxicity to waterfowl at these concentrations.

The most significant surface-water quality concerns relate to the management of the pond because it may be used by waterfowl or other semiaquatic birds. VOCs would be essentially eliminated from the pond inlet water. Any remaining VOCs would degrade and volatilize naturally in the pond, further reducing average in-pond concentrations below those of the inlet water. The greatest water quality concerns for the

pond are excessive biological enrichment and selenium concentrations. The treated groundwater stored in the pond is expected to be relatively nutrient-rich (from nitrogen and phosphorus compounds) and to stimulate the growth of algae, aquatic plants, and populations of aquatic insects such as midges and mosquitos. These insects might attract waterfowl. During late summer and fall, dieoff of aquatic plants and bacterial blooms might create water quality problems for waterfowl and shorebirds if the pond were drawn down or if water levels were to fluctuate as part of irrigation management. Botulism outbreaks in waterfowl are known in the Yolo County area under these conditions. Botulism production and aquatic bird deaths in ponds are favored by decaying organic matter, shallow and fluctuating water depth, and high ambient temperatures (Locke and Friend, 1987). These conditions can be expected in Yolo County shallow ponds in late summer.

Neither the Proposed Action nor the No-Action Alternative would have significant impacts on absorption rates, drainage patterns, or the amount of surface runoff. The Proposed Action would not involve major grading of the site and/or construction of impervious surfaces that would promote surface runoff. If the irrigation alternative is chosen, 1.0 acre of the site would be used for construction of a water storage reservoir. This reservoir would retain treated water near the northwest portion of the site for irrigation reuse and would only affect absorption rates beneath the pond.

Mitigation

For the Proposed Action irrigation end-use option, the pond should be managed to maintain the maximum possible water depth. Management for botulism prevention should consist of maintaining high water levels in the pond during late summer and quickly removing any bird carcasses found on the edge of the pond (Locke and Friend, 1987). Proper management would reduce this potential impact to less-than-significant levels. In addition, water levels in the pond should be kept high to reduce mosquito breeding and to discourage waterfowl and shorebird use during the breeding season (spring, early summer) to avoid problems with selenium toxicity. Deeper water is less attractive to these species than shallow water (<3 feet deep). Proper pond management should reduce surface-water problems for waterfowl to insignificant levels.

Biological Resources

Ecological Effects

Botanical Resources

The Proposed Action using the irrigation end-use option would change botanical resources in portions of the Davis Site because about 1 acre would be excavated to create a holding reservoir, and 55 acres of annual grassland vegetation would be converted to irrigated cropland to grow alfalfa. The impact on plant populations at the

site would be less than significant because no special-status species are known to occur there.

With the implementation of either the Proposed Action reinjection end-use option or the No-Action Alternative, land use would not change, and there would be no significant impact on botanical resources.

Wetlands

There are no vernal pools at the Davis Site. A seasonal wetland at the site is used as resting and foraging area by some ducks and shorebirds, but it is too small an area and too sparsely vegetated to be an important wetland area for wildlife populations in the vicinity. Furthermore, no major disturbances of the wetland are anticipated as a result of construction activities in the project area.

Wildlife Resources

The Proposed Action irrigation end-use option would cause a loss of some wildlife habitat in portions of the Davis Site. The Proposed Action calls for excavating about 1 acre to create a holding reservoir and converting an additional 55 acres from annual grassland vegetation to irrigated cropland to grow alfalfa. Direct impacts to wildlife habitat would vary during construction. The areas used for the reservoir would be permanently lost to terrestrial wildlife but would provide habitat for aquatic species such as waterfowl and possibly shorebirds. The portions of the site converted to alfalfa would continue to provide habitat for terrestrial wildlife species. During construction, the more mobile wildlife species would be temporarily displaced into nearby similar habitats but would be expected to return to adjacent, undisturbed habitats soon after completion of construction. The Proposed Action would have a less-than-significant impact on wildlife populations at the site; the No-Action Alternative would have no effect on wildlife populations at the site. For both the Proposed Action and the No-Action Alternative, areas disturbed for the pipelines and injection wells would be affected in the short-term but would revegetate with annual grassland species.

Soil piles north and east of the compound in the middle of the site were presumably created when underground storage tanks were removed. These piles have maximum residual concentrations of 180 mg/kg diesel (see Appendix I, Ecological Contaminants of Potential Concern) and provide opportunities, which are realized, for California ground squirrels to construct burrows. Within the burrows, the air could reach equilibrium with the contaminated soil and pose an inhalation threat to animals using the burrows.

The Proposed Action includes grading the soil piles. The grading should dilute the areas of diesel contamination to at least the average concentration (55 mg/kg), which is below the ecological benchmark of 63 mg/kg. Also, much of the diesel would be volatilized during the spreading, thus significantly reducing the amount available to contaminate air in burrows. Most significantly, grading the piles would make construction of a burrow surrounded by contaminated soil impossible, so the pathway

would be eliminated. Consequently, the burrowing owl and other animals would not be affected by contaminated soil.

Under the No-Action Alternative, the piles and diesel-contaminated soil would remain in place. The contamination is not expected to affect mammal populations on the site because only a few of the piles (25 percent) are sufficiently contaminated to have effects, and the remaining area is sufficient for burrow construction. However, burrowing owl populations use the ground squirrel burrows in the piles as shelter or breeding habitat; inhalation of volatilized petroleum hydrocarbons could have an effect.

Aquatic Resources

Neither the No-Action Alternative nor the reinjection end-use option of the Proposed Action would have an effect on aquatic resources. For the Proposed Action using the irrigation end-use option, the effluent holding pond would not support establishment of an unaffected, self-sustaining aquatic community because chronic water quality criteria are significantly exceeded for six metals (Table J-1). However, because the pond water would generally meet acute water quality criteria (Table J-2), the pond could support some tolerant forms for short periods. The lack of a permanent aquatic community is not considered a significant impact because no existing resource is lost or impaired. Establishment of a temporary community would not be considered a positive effect because, as noted above, it could attract waterfowl and have potentially significant wildlife impacts.

Table J-2 Comparison of Effluent Pond Water Quality to Acute Water Quality Criteria		
Contaminant of Potential Concern	Acute Criteria	Estimated Pond Level ($\mu\text{g/l}$)
Antimony	88 ^a	82
Iron	N/A	5,549
Lead	197 ^b	55
Nickel	2,549 ^b	347
Selenium	20	28
Thallium	1,400 ^c	83
^a Proposed		
^b Hardness dependent, calculated at 200 ppm total hardness		
^c No criteria developed, number is lowest observed effect level		
Source: U.S. EPA (1986, 1992)		

Special-Status Species

Plant Species. No special-status plants are found at the Davis Site so no special-status plant species will be affected by either the Proposed Action or the No-Action Alternative.

Swainson's Hawk. The California Department of Fish and Game (CDFG) has established a mitigation goal of no net loss of Swainson's hawk breeding or foraging habitat and has developed strategies and mitigation criteria to reverse the population decline of this species in the Central Valley (CDFG, 1992). In these guidelines CDFG has established the destruction of nesting and/or foraging habitat as "take" under the California Endangered Species Act. California considers all lands with suitable cover crop within a 10-mile radius of an active nest site to be potential foraging areas. Adverse modification of foraging areas may require mitigation for loss of foraging habitat. The need to mitigate impacts depends on the following criteria (CDFG, 1992):

- Territory must have been used at least once historically (as determined by CDFG Swainson's hawk nesting records).
- Mitigation is required for all lands within the defined foraging area (10 miles), excluding lands currently in urban use or lands that have no existing potential value for foraging Swainson's hawks as determined by site-specific surveys by a CDFG-qualified raptor biologist.
- Mitigation for foraging areas shall be a minimum of 1 acre actually managed for Swainson's hawk habitat for every acre lost. Increased mitigation ratios may be necessary in certain instances to maintain adequate foraging habitat to support Swainson's hawk populations or if a project site provides breeding or forage habitat for more than one pair. Habitat conservation plans currently being prepared for several areas may identify new information regarding habitat requirements for nesting pairs. Therefore, these criteria are to be considered interim guidelines. Mitigation ratios may increase for future projects based on additional information from research on this species.

Swainson's hawks are known to nest and forage within 10 miles of the Davis Site. Any project, public or private, that adversely affects Swainson's hawk habitat requires a mitigation plan following the guidelines developed by CDFG (1992). The annual grassland habitat on the Davis Site may provide some foraging opportunities for Swainson's hawks.

Implementing the option of the Proposed Action would have a less-than-significant effect on Swainson's hawks. About 1 acre of annual grassland habitat would be lost because of construction of the reservoir. However, about 55 acres would be converted to irrigated agriculture to grow alfalfa. Alfalfa is considered optimal foraging habitat and would improve the foraging opportunities for Swainson's hawks in the

Davis Site vicinity. The alfalfa habitat would be considered of greater value to Swainson's hawks than grassland. Construction of the pipeline and injection wells would cause temporary disturbance to 1 to 2 acres of annual grassland habitat. This disturbance would be temporary, and no significant adverse effect would be expected. No construction disturbance would be expected within one-half mile of any known nests (an evaluation criterion that has been used by CDFG), so there would be no significant impact to Swainson's hawk nesting or foraging habitat.

If there is no change in land use, there would be no impact to Swainson's hawks with the No-Action Alternative.

Burrowing Owls. The Proposed Action irrigation end-use option would have less-than-significant impacts on burrowing owl populations at the Davis Site. About 1 acre of annual grassland habitat would be lost because of construction of the reservoir. Few ground squirrel burrows were observed on the north side of the site where this action would be taken. Because of the lack of burrows and the tall, dense vegetation found in this area, it is only marginally suitable for burrowing owls. However, the levees to be constructed for the reservoir probably would be colonized by ground squirrels, creating additional habitat suitable for burrowing owl use. About 55 acres would be converted to irrigated agriculture to grow alfalfa. The irrigated fields would not provide habitat for burrowing owls, but the edges of the alfalfa fields might provide suitable habitat. Construction of the pipeline and injection wells would temporarily disturb 1 to 2 acres of annual grassland habitat. Because this disturbance would be temporary, no significant impact to owls would be expected.

Implementation of the Proposed Action reinjection end-use option would have no impact on burrowing owls.

The Proposed Action includes redistributing the soil piles. This would dilute high concentrations of petroleum hydrocarbons, eliminate the potential for burrows in contaminated soil, and significantly accelerate concentration reduction resulting from vaporization. Consequently, there would be no impact to burrowing owls under the Proposed Action.

As discussed previously under the No-Action Alternative, diesel-contaminated soil in piles north and east of the site could potentially limit owl shelter and breeding habitat. Inhalation of diesel vapors for long periods by animals in the burrows could affect those animals. It is unclear if there is an existing impact; if there is, it is marginal and should diminish with time as the diesel vaporizes. Therefore, even with no action, the impact on owls would be minimal over time.

Western Snowy Plover and Giant Garter Snake. According to information from the California Natural Diversity Data Base (CNDDB), the California Wildlife Habitat Relationships System (WHR), and the reconnaissance survey, it is unlikely that western snowy plovers or giant garter snakes occur at the Davis Site. Therefore, there would be no impact to these species from either the Proposed Action or the No-Action Alternative.

Mitigation

No significant adverse effects on botanical resources, including threatened or endangered species of plants, have been identified, and no major disturbances of the site or construction activities are anticipated in the project area that would have an adverse impact on any botanical resources. Consequently, no mitigation is required. The only potential impact to wetland or wildlife resources would be the possible loss of Swainson's hawk foraging habitat if spray irrigation is used. This impact would be mitigated to nonsignificance by the cultivation of 55 acres of alfalfa associated with spray irrigation.

Works Cited

California Department of Fish and Game. 1992. Draft Mitigation Guidelines for Swainson's Hawks (*Buteo swainsoni*) in the Central Valley of California. CDFG, Region 2, Environmental Services. Revised January 1.

Locke, L. N. and M. Friend. 1987. Chapter 7: "Avian Botulism." *Field Guide to Wildlife Diseases*, M. Friend, ed. U.S. Department of the Interior. Fish and Wildlife Service. Res. Pub. 167.

U.S. EPA. 1986. Quality Criteria for Water. Office of Water Regulation and Standards. EPA/440/5-86/001.

U.S. EPA. 1992. Quality Criteria for Water 1992. Poster. Office of Water Regulations and Standards. Washington, D.C.