DEPARTMENT OF THE AIR FORCE
27TH CIVIL ENGINEER SQUADRON (ACC)
CANNON AIR FORCE BASE NEW MEXICO

Rec'd 3/24/03

1 6 2003

Mr. Robert S. Pyeatt
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Mr. James Bearzi
Hazardous Waste Bureau Chief
New Mexico Environment Department
2905 Rodeo Park Drive East, Bldg 1
Santa Fe, New Mexico 87505

Dear Mr. Bearzi

Per your request we are enclosing for your records two additional copies of the Corrective Measures Study (CMS) for Site SD-11 (SWMU's 86-90) Final Report dated Jul 99, and two copies of an Addendum to the CMS dated Jul 01. The Addendum addresses the horizontal delineation of the site necessary to determine the western extent of the contamination as previously requested by your office.

This additional information should be sufficient for your office to determine this CMS to be administratively complete and what further action, if any, will need to be taken. If you have any questions, please contact Mr. Peter P. Zamie at (505) 784-1092.

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or person who managed the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Sincerely

ROBERT S. PYEATT, GS-13

Attachments:
CMS, Jul 99
Addendum, Jul 01

cc:
NMED (G. von Gonten)

CAFB03-001

DEPARTMENT OF THE AIR FORCE
27TH CIVIL ENGINEER SQUADRON (ACC)
CANNON AIR FORCE BASE NEW MEXICO

3/10/03

RECEIVED
MAR 2003
NMED Hazardous Waste Bureau

Mr. Robert S. Pyeatt
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Mr. James Bearzi, Chief
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New Mexico Environment Department
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PO Box 26110
Santa Fe NM 87502

Dear Mr. Bearzi

Per your request we are enclosing for your records two additional copies of the Corrective Measures Study (CMS) for Site SD-11 (SWMU's 86-90) Final Report dated July, 1999, and two copies of an Addendum to the CMS dated July 25, 2001. The Addendum addresses the horizontal delineation of the site necessary to determine the western extent of the contamination as previously requested by your office.

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Sincerely

ROBERT S. PYEATT, GS-13

Attachments:
1. Site SD-11 CMS Final Report, Jul 99
2. CMS Addendum, Jul 01

cc:
NMED (G. von Gonten)

CAFB 03-001

FINAL REPORT

LIBRARY COPY

CORRECTIVE MEASURES STUDY SITE SD-11 (SWMUs 86-90)

CANNON AIR FORCE BASE, NEW MEXICO

July 1999

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A-E	Architect-Engineer
AFB	Air Force Base
AOC	Area of Concern
ARARs	Applicable or Relevant and Appropriate Requirements
ARASs	Applicable or Relevant and Appropriate Standards
ASTM	American Society for Testing and Materials
B.P.	Before Present
BGS	Below Ground Surface
BRA	Baseline Risk Assessment
BTEX	Benzene, Toluene, Ethylbenzene, and Xylenes
CEC	Cation Exchange Capacity
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm	Centimeter(s)
cm/sec	Centimeter(s)-per-second
cm/yr	Centimeter(s)-per-year
CMS	Corrective Measure Study
COC	Chemical of Concern
COPC	Chemicals of Potential Concern
COPEC	Contaminant of Potential Ecologic Concern
CRQL	Contract-Required Quantitation Limit
DOT	Department of Transportation
DRO	Diesel Range Organics
DQCR	Daily Quality Control Report
DQO	Data Quality Objective
ECSM	Ecological Conceptual Site Model
EM	Electromagnetic
EPA	Environmental Protection Agency
ERA	Ecological Risk Assessment
ft/yr	Feet-per-year
FSP	Field Sampling Plan
gal/ft	Gallons-per-foot
gpm	Gallons-per-minute
GRO	Gasoline Range Organics
HA	Hand Auger Boring
HI	Hazard Index
HQ	Hazard Quotient
ICP	Inductively Coupled Plasma
ID	Inside Diameter
IDW	Investigation-Derived Waste
IEUBK	Integrated Exposure Uptake Biokinetic Model
IRP	Installation Restoration Program
km/hr	Kilometer(s)-per-hour
L/min	Liters-per-minute
MCLG	Maximum Contaminant Level Goals
MCL	Maximum Contaminant Levels

m^3/m	Cubic meters-per-meter
m/yr	Meter(s)-per-year
mg/kg	Milligrams-per-kilogram
mg/L	Milligrams-per-Liter
MSL	Mean Sea Level
MS/MSD	Matrix Spike/Matrix Spike Duplicate
MSC	Media-Specific Concentration
MSSL	Media-Specific Screening Level
mV	Millivolt
NCP	National Contingency Plan
NMED -	New Mexico Environmental Department
NOAEL	No Observed Adverse Effects Limit
NWR	National Wildlife Refuge
ORNL	Oak Ridge National Laboratory
PAH	Polyaromatic Hydrocarbons
PCB	Polychlorinated Biphenyls
PPE	Personal Protective Equipment
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
QCSR	Quality Control Summary Report
RBCA	Risk-Based Corrective Action
RBSL	Risk-Based Screening Level
RCRA	Resource Conservation and Recovery Act
RDA	Recommended Daily Allowance
RfD	Reference Dose
RFI	RCRA Facility Investigations
RI/FS	Remedial Investigation/Feasibility Study
SARA	Superfund Amendments and Reauthorization Act
SB	Soil Boring
SCEM	Site Conceptual Exposure Model
SCFS	Sample Collection Field Sheet
SDWA	Safe Drinking Water Act
SI	Site Inspection
SMCLs	Secondary Maximum Contaminant Levels
SOP	Standard Operating Procedure
SOS	Scope of Services
SS	Surface Soil Sample
SSHP	Site Safety and Health Plan
SSTL	Site-Specific Target Level
SVOC	Semivolatile Organic Compound
SWMU	Solid Waste Management Unit
TAL	Target Analyte List
TBC	To Be Considered
T/E	Threatened /Endangered
TM	Technical Manager

TPH	Total Petroleum Hydrocarbons
µg/kg	Microgram per kilogram
USACE	United States Army Corps of Engineers
USAF	United States Air Force
USEPA	United States Environmental Protection Agency
UST	Underground Storage Tank
UTL	Upper Tolerance Limit
VOC	Volatile Organic Compound
W-C	Woodward-Clyde

1.1 PURPOSE AND SCOPE

Five Solid Waste Management Units (SWMUs) were identified as areas of potential contamination at Cannon AFB. Subsequent investigations indicated past site activities at these five SWMUs may have resulted in soil contamination. These five SWMUs (86-90) were eventually combined into one site, Site SD-11. A regional map showing the location of Cannon AFB is shown in Figure 1-1. A map of Cannon AFB and the location of SWMUs 86-90 (Site SD-11) are shown in Figure 1-2.

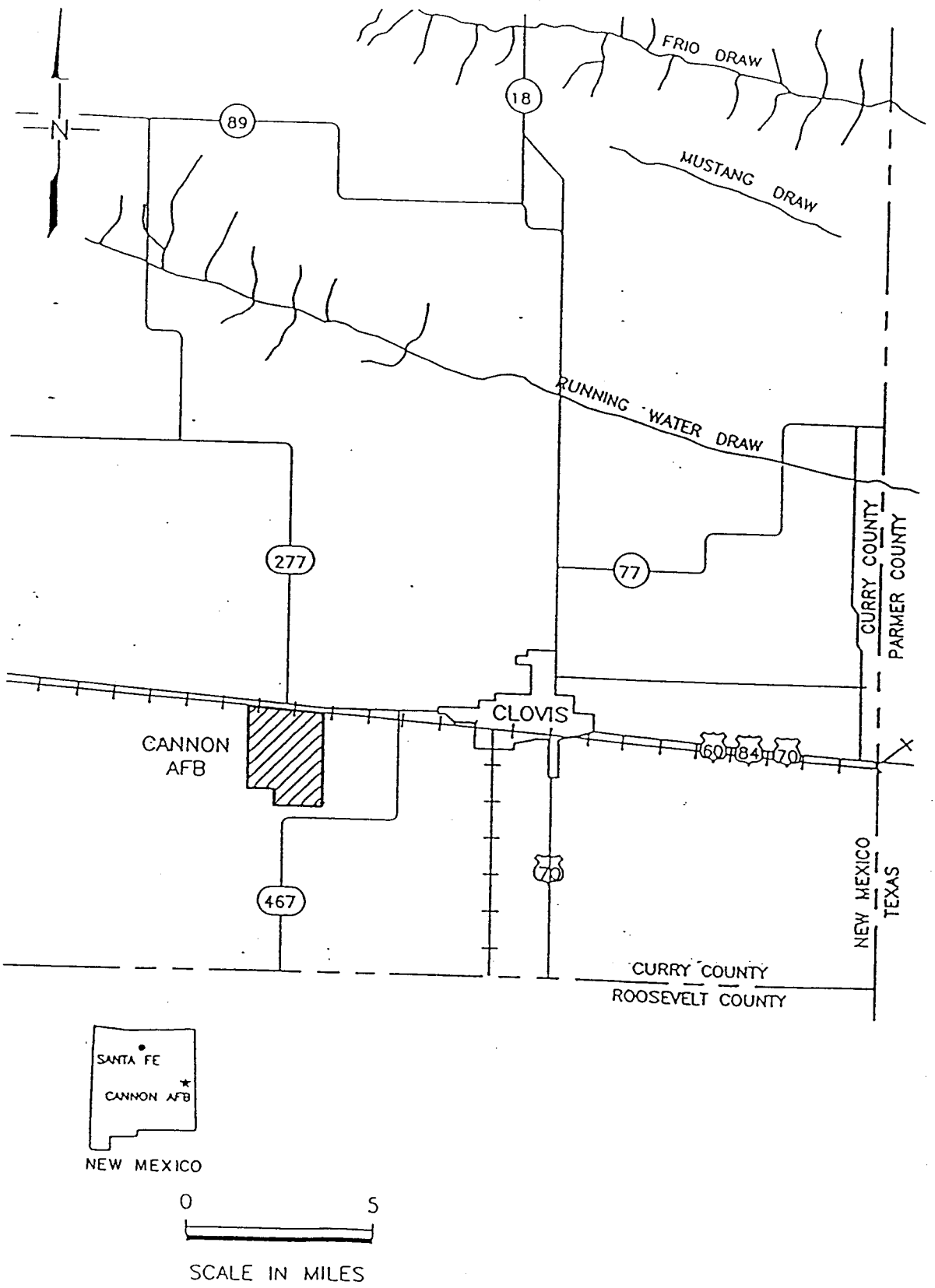
The purpose of this Corrective Measures Study (CMS) is to identify and evaluate corrective measures alternatives and to recommend the selected final corrective measure(s) for Site SD-11. This report is organized as follows:

- Section Two - discusses the objectives and approach for the recommendations presented in the CMS.
- Section Three - provides a facility description, including the physical setting, demographics and land use, climate, geology, hydrogeology, soils, background metals concentrations in soils and water, and biological resources.
- Section Four - presents a site description and history.
- Section Five - discusses results from previous investigations at Site SD-11.
- Section Six - presents the CMS field investigation results.
- Section Seven - discusses the nature and extent of contamination at Site SD-11.
- Section Eight - presents and discusses the results of a screening-level human health risk evaluation.
- Section Nine - presents and discusses the results of the ecological risk evaluation.
- Section Ten - presents the results of the fate and transport modeling.
- Section Eleven – contains a discussion on corrective measure alternatives.
- Section Twelve - contains the summary and recommendations.
- Section Thirteen - contains the references.
- Appendix A - contains the Daily Quality Control Reports (DQCRs), boring logs, survey data, and sample collection field sheets (SCFSs) for the CMS field investigation.
- Appendix B - contains the complete analytical data for the SWMUs 86-90 (Site SD-11) CMS investigation.
- Appendix C - contains the support data used for the Human Health Risk Evaluation.
- Appendix D – contains the support data used for the Ecological Risk Evaluation.
- Appendix E – contains the documentation and output for the HELP and MULTIMED software programs.

1.2 REGULATORY FRAMEWORK

SWMUs 86-90 are identified as Appendix I SWMUs in Cannon's RCRA permit. The five SWMUs were combined into one site under Cannon's Installation Restoration Program (IRP) due to their proximity to each other. The CMS follows the general requirements of Cannon's RCRA permit.

REPORT PHASE: RFI SITE SD-11



March 24, 1999 11:27:21 a.m.
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DRN. BY: TSSM	DATE: 03/25/99	REGIONAL MAP CANNON AIR FORCE BASE NEW MEXICO	PROJECT No.	FIG. No.
CHK'D. BY:	REVISIONS: 0		45F0M9602V.00	1-1

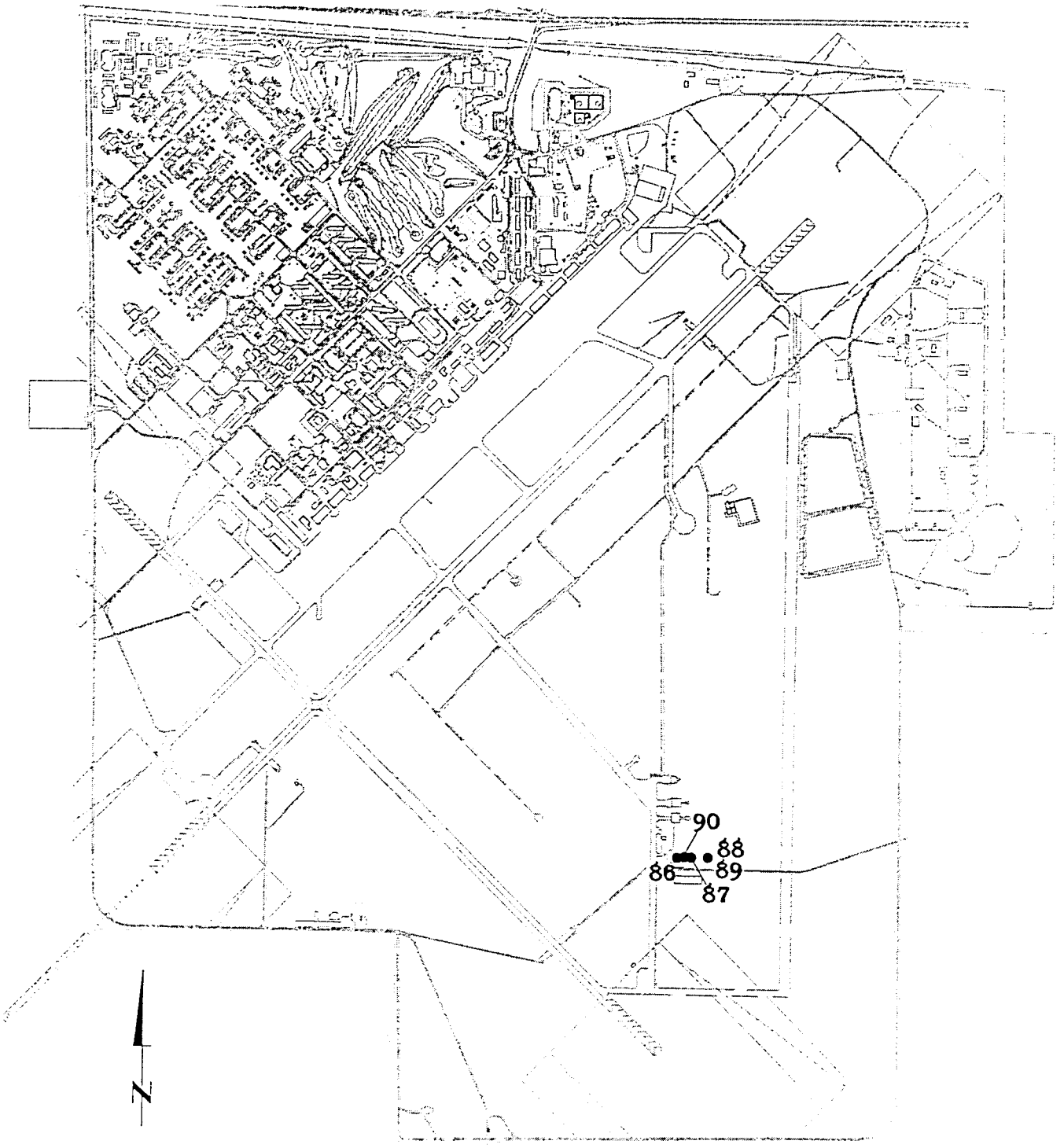
QSR SITE SD-11

REPORT PHASE: PH/

LEGEND

3 ● SOILD WASTE MANAGEMENT UNIT (SWMU) LOCATION AND NUMBER

SWMU No.	DESIGNATED AREA
86	SD-11 ENGINE TEST CELL
87	SD-11 FORMER OVERFLOW PIT
88	SD-11 FORMER LEACHING FIELD
89	SD-11 EVAPORATION POND
90	SD-11 OIL/WATER SEPARATOR No. 5114



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Xrefs: CAN-BASE.DWG

DRN. BY: JWB	DATE: 03/24/99	APPENDIX 1 SWMUs 86-90 (SITE SD-11) LOCATION PLAN CANNON AIR FORCE BASE CLOVIS, NEW MEXICO	PROJECT NO. 45F0M9602V.00	FIG. NO. 1-2
CHK'D. BY:	REVISION: 0			

2.1 CORRECTIVE MEASURES STUDY OBJECTIVES

The overall purpose of this Corrective Measures Study was to develop and evaluate corrective measures alternatives and to recommend the selected final corrective measure(s) that is most cost-effective, most reliable, and easiest to implement.

The preliminary corrective action objective for Site SD-11 was to implement the Risk-Based Corrective Action (RBCA) process to streamline the decision process for corrective action that is protective of human health and the environment. RBCA is the integration of site assessment, remedial action selection, and monitoring with USEPA-recommended risk and exposure assessment practices. RBCA procedures for the assessment and response to a petroleum release are outlined in the American Society for Testing and Materials (ASTM) E1739-95[E1], *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites* (ASTM 1996).

The specific objectives for Site SD-11 were to:

- Further define the extent and degree of contamination levels at this site, specifically at the former evaporation pond (SWMU 89).
- Further assess the potential for contaminant migration in the surrounding environment.
- Further identify public health and environmental risks of contaminants relative to applicable regulatory standards.
- Based on the results of the RBCA process for the assessment and response to a petroleum release, evaluate and justify a "No Further Action" alternative or other appropriate RBCA alternative.

2.2 CORRECTIVE MEASURES STUDY APPROACH

The following decision process was used to assess the data needs and approach for the Corrective Measures Study at Site SD-11. The Data Quality Objective (DQO) evaluation process was designed to provide data of sufficient quality and quantity to evaluate whether a release has occurred that could pose a risk to human health or the environment and to evaluate the need for further action, such as corrective measures implementation, if any.

A general decision diagram (Figure 2-1) was developed for the Cannon AFB CMS at Site SD-11 to present a logical decision process that was used to evaluate the data resulting from field investigations and to assure that objectives are met.

The decision process was designed to identify appropriate actions based on three alternative recommendations: no further action, further evaluation, or corrective measures implementation. The recommendation for the selection of alternative action depended upon whether chemicals of potential concern (COPCs) were detected in soils at levels that could pose an unacceptable risk to human health or the environment. This section provides a summary of the decision-making process that was used.

The decision process was implemented by first evaluating and summarizing existing historical information and analytical data. Historical information was used to identify COPCs and to identify potential sites of chemical release.

Soil was sampled and analyzed for COPCs. The analyte lists from which COPCs were selected are discussed in the QAPP Addendum (W-C 1998). Site-related COPCs were then selected based on the results of the sampling program. Metals that did not exceed background levels, and chemicals which were attributable to field or laboratory contamination, were not included as site-related COPCs. Organic chemicals that do not have EPA-established toxicity factors were not evaluated quantitatively, but their potential contribution to site risks were evaluated qualitatively.

The potential for site-related contaminants to impact groundwater was assessed by evaluating the vertical distribution of contaminants in the soil column. When the concentrations of COPCs decreased significantly with depth, and the concentrations were below levels that are likely to migrate to groundwater (based on fate and transport properties of the contaminant and the vadose zone), the potential for transport to groundwater was considered to be insignificant. When the concentrations were at levels that could potentially migrate to groundwater at concentrations of concern (based on comparison to EPA Region VI soil-screening levels), fate and transport modeling was completed to evaluate the potential for contaminant transport to groundwater.

Once extent and degree of contamination was further defined, then corrective measures alternatives were evaluated (see Section 2.3). The first CMS alternative to be evaluated was "no further action". Concentrations of COPCs detected were evaluated for potential human health and environmental risks by comparing maximum detected concentrations (which are higher than concentrations to which human and ecological receptors would routinely be exposed) to highly conservative (protective) human health risk-based concentrations (i.e., EPA Region VI Human Health Media-Specific Screening Levels [MSSLs]) and screening ecotoxicity values. This conservative approach permits identifying sites that pose no unacceptable risk under highly conservative exposure assumptions and, therefore, warrant no further evaluation or action. The approach also permits identification of sites that may warrant further evaluation based on exceedance of stringent risk-based concentrations. The methods used in the human health and ecological risk evaluations are presented in Sections 2.6 and 2.7, respectively.

After the risk evaluation was completed, recommendations regarding the three alternatives stated above were made on the following basis:

- When the vertical extent and lateral extent of contamination was defined and no threat to human health or the environment existed based on comparison of maximum concentrations (excluding metals/pesticides below background and field/lab contaminants) to EPA Region VI MSSLs or ecotoxicity values, then no further action was recommended.
- If the extent had not been defined and there was a potential significant threat to human health or the environment based on exceedance of EPA Region VI MSSLs or ecotoxicity values, further evaluation would have been recommended for the site.

- If there was an unacceptable threat to human health or the environment and the extent of contamination was defined, additional corrective measures alternatives would have been reviewed and the appropriate measure(s) recommended for implementation.

2.3 APPROACH FOR EVALUATING CORRECTIVE MEASURES ALTERNATIVE(S)

Once extent and degree of contamination was defined, then corrective measures alternative(s) were evaluated. Those alternatives identified in the CMS work plan included:

- No further action
- Excavation and removal
- Bioventing
- Soil vapor extraction

The corrective measure was evaluated and selected based on the following criteria.

1. Technical
   - Performance - corrective measure or measures which are most effective at performing their intended functions and maintaining the performance over extended periods of time were given preference.
   - Reliability - corrective measure or measures which do not require frequent or complex operation and maintenance activities and have proven effective under waste and facility conditions similar to those anticipated were given preference.
   - Implementability - corrective measure or measures which can be constructed and operated to reduce levels of contamination to attain or exceed applicable standards in the shortest period of time were preferred.
   - Safety - corrective measure or measures which pose the least threat to the safety of nearby residents and environments as well as workers during implementation were preferred.
2. Human Health

   The corrective measure(s) must comply with existing U.S. EPA criteria, standards, or regulations for the protection of human health. Corrective measure(s) which provide the minimum level of exposure to contaminants and the maximum reduction in exposure with time are preferred. Human health risk evaluations were completed per the methodology described in Section 2.6.
3. Environmental

   The corrective measure(s) posing the least adverse impact (or greatest improvement) on the environment over the shortest period of time were favored. Ecological risk evaluations were completed per the methodology described in Section 2.7.

4. Cost

The recommended corrective measure alternative was justified using technical, human health, environmental, and cost criteria.

2.4 APPROACH FOR EVALUATING BACKGROUND CONCENTRATIONS

A comparison of Site SD-11 sample concentrations to background concentrations was used to determine whether metals detected in soil samples are site related. The following sections describe the approaches used.

Soils are derived from parent geologic materials as a result of physical, chemical, and biological processes. The soil system is a highly heterogeneous matrix of inorganic and organic components. The relative proportions of these components are dependent upon factors influencing soil formations, such as topography, climate, depositional processes, and time (Sposito and Page 1984). Total concentrations of metals in soils may vary depending upon location; for example, at the surface, soils are influenced by leaching, runoff, atmospheric deposition, and biotic uptake, as well as anthropogenic activity. The ranges of naturally occurring or "background" concentrations of metals in soils is greatly varied due to the composition of parent material and, therefore, care must be taken in the interpretation of metals data generated during an investigation.

Metals concentrations in Site SD-11 soils were compared to background soils concentrations presented in "Naturally Occurring Concentrations of Inorganics and Background Concentrations of Pesticides at Cannon Air Force Base, New Mexico" (W-C 1997). The approach compared the maximum concentrations detected in surface and subsurface soil at Site SD-11 to the 95 percent upper tolerance limit (UTL) of the background concentrations. Using this technique, individual samples at the site with high concentrations relative to background levels (i.e., which could represent a site-related release) were identified.

2.5 HUMAN HEALTH RISK EVALUATION METHODOLOGY

This section provides a description of the approach that was used in the human health risk evaluation for Site SD-11. The Risk-Based Corrective Action (RBCA) process was used to identify human health risks at Site SD-11. RBCA procedures implemented in this report are outlined in the American Society for Testing and Materials (ASTM) E1739-95^{E1}, Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites (ASTM 1996).

2.5.1 RBCA Process

RBCA is the integration of site assessment, evaluation using USEPA-recommended risk and exposure assessment practices, and remedial action selection. The RBCA process was implemented in a tiered approach, involving increasingly sophisticated levels of data collection and analysis. The results and recommendations are reviewed after evaluation of each tier to

decide whether more site-specific analysis is warranted. The RBCA process consisted of the following steps:

1. Initial Site Assessment - Conducted a site investigation and completed a Tier 1 Summary Report to organize available site information regarding primary chemicals of potential concern, extent of affected environmental media, and potential migration pathways, and receptors.

2. Site Classification and Initial Response Action

   - Classified site according to specified scenarios and implement appropriate initial response action.
   - Reclassified the site, when necessary, following initial response actions, interim remedial action, or additional data collection.

3. Tier 1 Evaluation

   - Identified reasonable potential sources, transport pathways, and exposure pathways.
   - Compared detected site soil concentrations (maximum detected concentrations or upper confidence levels if data permits) to risk-based screening levels (RBSLs) in the "look-up" table provided in ASTM E1739-95[E1]. Target levels established in the ASTM guidance have a cancer range of 10^{-6} to 10^{-4} and an HQ = 1. The latest EPA Region VI Residential Media-Specific Screening Levels (MSSLs) were used as the Tier 1 "look-up" table for Site SD-11. Throughout this document, the term MSSL will be used when discussing risk-based screening levels. The MSSLs are discussed in detail in Section 2.6.2 and are presented in Appendix C.
   - If concentrations of chemicals of potential concern exceeded the EPA Region VI Residential MSSLs at the point(s) of compliance, then they became chemicals of concern, and either interim remedial action (e.g., "hot spot" removal), further tier evaluation (i.e., Tier 2 evaluation), or remediation to Tier 1 MSSLs was warranted.
   - If concentrations of chemicals of potential concern did not exceed the EPA Region VI Residential MSSLs, the option recommended was a no further action.

4. Tier 2 Evaluation

   - A Tier 2 evaluation was warranted if Tier 1 MSSLs were exceeded and interim removal action was not appropriate.
   - Additional site data would have been collected, if needed.
   - Indirect exposure scenarios were addressed and the appropriate site-specific points of compliance were identified.
   - Nonsite-specific assumptions and point(s) of exposure used in Tier 1 were replaced with site-specific data and information. Site-specific target levels (SSTLs) based on 10^{-5} risk levels were calculated using the site-specific information and relatively simplistic mathematical models.

- Detected site soil concentrations (maximum detected concentrations or upper confidence levels when data permits) were compared to SSTLs.
- If concentrations of chemicals of concern exceeded the SSTLs at the point(s) of compliance, then interim remedial action (e.g., "hot spot" removal), further tier evaluation (i.e., Tier 3 evaluation), or remediation to Tier 2 SSTLs would have been recommended.
- When concentrations of chemicals of concern did not exceed the SSTLs, the option recommended was no further action.

5. Basic Equation for SSTLs

   - SSTL = Target Risk / (Exposure * Toxicity)

   For Site SD-11, residential MSSLs were used in the Tier 1 evaluation. This is a conservative approach because the SWMUs are industrial sites which are not likely to become residential in the foreseeable future.

   When the calculation of SSTLs was warranted, the exposure component of the equation was modified to account for the industrial exposures that occur at the sites.

The first two steps of the RBCA process listed above were completed during the previous investigations and reports. Therefore, these steps are not included in this CMS. A brief site description and history along with a summary of the previous investigations and reports are provided in Sections 4 and 5. This CMS focuses on the Tier 1 and Tier 2 aspects of the ASTM RBCA process.

2.5.2 Derivation of EPA Region VI MSSLs

The MSSLs were taken from the EPA Region VI table which is provided in Appendix C (EPA 1997b). The latest available version was used. These MSSLs are based on 1×10^{-6} excess cancer risk or a hazard quotient equal to 1, assuming residential ingestion, dermal, and inhalation exposures. A maximum chemical concentration that exceeds a screening-level MSSL does not mean that a health risk exists because the maximum concentration detected is not the concentration to which people would routinely be exposed, and the exposure assumptions used to derive the MSSLs are not site-specific.

For a carcinogen, the soil MSSL is the concentration of a chemical in soil that is estimated to result in an excess cancer risk of 1×10^{-6} (1 in 1,000,000) for Class A and B carcinogens or 1×10^{-5} for Class C carcinogens, assuming long-term (30-year) daily exposures. A range of 1×10^{-6} to 1×10^{-4} (1 in 1,000,000 to 1 in 10,000) is EPA's target excess cancer risk range for cleanup under Superfund and RCRA (EPA 1991). Therefore, MSSLs based on target risks of 1×10^{-6} and 1×10^{-5} are conservative (protective) values, and exceedances of these MSSLs do not necessarily mean that a health risk is present. Exceedance of the MSSLs may mean, however, that further evaluation of chemical concentrations, exposure assumptions, and carcinogenicity may be warranted.

For noncarcinogens, MSSLs are the concentrations in soil that are estimated to result in a "hazard quotient" (HQ) of 1.0. A hazard quotient is the ratio of the estimated daily dose from the assumed exposure to a reference dose (RfD), established by EPA, that is considered safe for a lifetime of daily exposure. A hazard quotient of 1 means that no toxic effects are likely to occur, even to sensitive individuals exposed for a lifetime. A hazard quotient above 1 does not mean that toxic effects will necessarily occur, but that further evaluation of exposures and chemical toxicity is required.

EPA Region VI MSSLs for soil exposures are based on the ingestion, inhalation, and dermal exposure routes. Soil MSSLs are available for industrial and residential scenarios. Site SD-11 are located in industrialized areas of the Base. For the Tier 1 assessment, residential MSSLs were used.

MSSLs for Lead in Soil

EPA withdrew the toxicity factor (i.e., the RfD) for lead in 1989, primarily due to the lack of a discernible threshold dose and because of the numerous sources of lead in the environment. However, EPA guidance (EPA 1994c) recommends an interim soil lead concentration of 400 mg/kg for residential scenarios at CERCLA and RCRA corrective action sites. This level is supported by EPA's Integrated Exposure Uptake Biokinetic (IEUBK) Model (EPA 1994c), which predicts that exposures of children ages 0 to 6 years to soils with approximately these levels will not result in blood lead levels that exceed a level of concern (10 µg/dL) established by the Centers for Disease Control. The interim soil lead concentration is the level above which there is sufficient concern that a site-specific study of risks should be conducted if exposure to children is expected at the site. Based on the residential soil-screening level for lead, EPA Region VI set the residential soil MSSL for lead at 400 mg/kg and the industrial soil MSSL for lead at 2,000 mg/kg. For the Tier 1 assessment, the residential MSSL was used.

2.6 ECOLOGICAL RISK EVALUATION METHODOLOGY

Ecological risk assessment is:

> *... the process that evaluates the likelihood that adverse ecological effects may occur or are occurring as a result of exposure to one or more stressors.* (USEPA 1992, USEPA 1998).

In the context of this CMS, "adverse ecological effects" were understood to be anthropogenic changes considered undesirable because they altered valued structural or functional characteristics of ecological systems (USACE 1996; USEPA 1998). The "stressors" at issue were chemical contaminants.

Certain nondomesticated plants and animals would occur, at least at times, in almost any area that is outdoors, regardless of the absence of "natural" habitat and/or the omnipresence of human activity and artificial structures (buildings, pavement). Thus, strictly speaking, virtually any area outside of a building might include "habitat for ecological receptors." Such essentially artificial habitats were not, however, considered *directly* ecologically relevant because they existed and

were configured to support human (industrial) functions. Understanding the concept of "direct ecological relevance" was very important in assessing ecological risk at this active military site.

Assessment of ecological risk for the unit is based on current and future use and acknowledges that the facility is an active military site with limited potential to support components (populations, communities) that collectively exist and function as an ecosystem or are critical to the structure and function of an adjacent ecosystem. Consideration was limited to resident (those resources that live within the boundaries of the unit) ecological populations and communities that provide an essential attribute (i.e., biomass production, seed dispersal, structural or dynamic control) to the overall ecosystem as well as transient (those ecological resources that pass through and/or utilize the resources within the unit) receptors that may fulfill essential roles in the broader (landscape-scale) system.

2.6.1 Applicable and Relevant Guidance

There is no formally promulgated, official state guidance for performance of ERAs at potentially contaminated sites in New Mexico. USEPA released guidance for the conduct of ecological risk assessments, specifically USEPA (1992, 1996). The latter of these two references is EPA/630/R-95/002B, *Proposed Guidelines for Ecological Risk Assessment*, issued August 21, 1996 under the signature of Secretary Carol M. Browner, published in the Federal Register on September 9, 1996 (61 FR 47552-47631). These guidelines have been finalized, and replace the 1992 EPA *Framework for Ecological Risk Assessment* (EPA/630/R-92-001) by expanding upon and modifying the framework concepts to "reflect Agency [EPA] experience" since 1992 and is "intended as internal guidance for EPA." These guidelines, hereafter referred to as *EPA Guidelines* (or USEPA 1998), "set forth current scientific thinking and approaches for conducting and evaluating ecological risk assessments." However USEPA (1998) does not provide detailed guidance in specific areas and is not intended to be highly prescriptive. One of its stated purposes is to provide a basis or framework for individual EPA programs and regions to develop more specific guidance "suited to their particular needs."

The U.S. Army Corps of Engineers (USACE) released *Environmental Quality Risk Assessment Handbook, Volume II: Environmental Evaluation* in 1996 that applies to ERAs "for all USACE HTRW investigations, studies, and designs under Department of Defense, Defense Environmental Restoration Program (DERP), Base Realignment and Closure (BRAC), U.S. Environmental Protection Agency (EPA) Superfund Program, Civil Works, and Work for Others" (USACE 1996). This is the primary resource for guidance in the ERA presented in the following sections. This guidance manual, like the *EPA Guidelines*, is not intended to be a "how to" document, but rather to provide the concepts for performing an ERA consistent with "good science" and accepted regulatory procedures (USACE 1996).

The EPA Emergency Response Team (ERT, Edison, New Jersey), under the authority of OSWER Directive No. 9285.7-17 of August 12, 1994, has been developing guidance for application at Comprehensive Environmental Response, Compensation and Liability Act (CERCLA, otherwise known as Superfund) sites which is also applicable for the presented ERA. This guidance was initially unveiled to the public in the form of a workshop presented at the

November 1993 meeting of the Society of Environmental Toxicology and Chemistry (SETAC). The external review draft was released in August of 1996 and the interim final was released in June of 1997. The Superfund guidance is widely referred to as "ERAGS" (an acronym based on the title) by risk assessment practitioners outside EPA, although agency personnel (at least in formal discourse) usually refer to it as the *Process Document*. For our purposes of discussion, the document in question will be called ERAGS, and will be considered to be the version dated June 5, 1997 (USEPA 1997a). Supplemental guidance has also been issued from the EPA Emergency Response Team as Intermittent Bulletins (ECO Updates) beginning in 1991 and have been consulted as appropriate and relevant.

Although not specifically labeled "guidance," two other documents were particularly relevant, and were consulted as appropriate. The first was RTI (1995), a technical support document for the proposed hazardous waste identification rule (HWIR; USEPA 1995) which outlines a rationale and approach for estimating exposures and effects of high-volume, low-toxicity wastes and constituents. The second was USEPA (1994a), a compendium of "issue papers" commissioned by EPA's Risk Assessment Forum to highlight important principles and approaches to be considered in developing ERA guidance.

2.6.2 Overview of the Tier I Level Ecological Evaluation Process

The first three steps of the ecological risk evaluation roughly corresponded to a preliminary, or screening-level, assessment (Tier I) wherein: (1) the presence of an ecological component was determined; (2) the contaminated media to which the ecological component(s) could be exposed were identified; and (3) the magnitude of contamination in each applicable medium was compared to a level conservatively assumed to constitute a hazard (ecotoxicological benchmark)[1]. Where an ecological component was lacking, the process concluded that chemicals of interest (COIs) were not of potential ecological concern within the site under consideration. Where an ecological component existed, but COI concentrations in applicable media did not equal or exceed the ecotoxicological benchmarks, the contaminants were not considered chemicals of potential ecological concern (COPECs). But, given the presence of an ecological component *and* at least one COPEC, the site required further evaluation.

2.6.2.1 Site Reconnaissance

For most small sites in developed areas, a walk-through by a qualified biologist, making observations of vegetation, species encountered, terrain and land usage was sufficient to develop conclusions as to the wildlife potential of an area. Vegetation composition, utilization and proximity to other systems are factors that were considered. Visual observations, tracks, dens, scat, and vocals identified wildlife. The terrain and land usage were evaluated in the context of affecting any wildlife in a given area. All of these factors were compiled by a trained biologist and conclusions made as to the potential ecological components within the study area. If no ecological components were identified, it was concluded that the COIs were not of potential

[1] This initial screening tier corresponds to Steps 1 and 2 of the ERAGS process (USEPA 1997) and a screening level ecological risk assessment as defined by USACE (1996).

ecological concern and no further investigation for ecological concerns was warranted. It was not believed that individual organisms that were occasionally present constituted an ecological component because individuals (unless accorded official protection as endangered or threatened) were not appropriate as assessment endpoints for an ecological risk assessment. As stated by USEPA (1997a), "Ecological effects of most concern are those that can impact populations (or higher levels of biological organization)." By definition, an occasional individual did not constitute a population nor were any effects on an occasional individual expected to translate into an effect on a population.

2.6.2.2 Chemicals of Potential Ecological Concern

If an ecological component was identified, chemicals of potential ecological concern (COPECs) were derived from the media-specific analysis of applicable media. A COPEC is a chemical, based on an initial screening of its maximum concentration in applicable media (i.e., surface soil, surface water, and/or surficial sediment[2]), where there is at least a suspicion that the chemical may adversely interact with the environment and have a potential for ecological risk. COPECs were selected based on comparison of maximum contaminant concentrations to ecotoxicological screening benchmarks (e.g., derived from Roberts and Dorough 1984, Efroymson *et al.* 1997a, 1997b, RTI 1995, Alexander 1993, and Verschueren 1983). Generally, the following criteria were used in selecting COPECs:

- If the maximum concentration of a chemical was less than the ecotoxicological benchmark, then the chemical was not selected as a COPEC.
- If the maximum concentration of a chemical exceeded the ecotoxicological screening benchmark, then the chemical was considered a COPEC.
- If a chemical was detected and had the potential to biomagnify within the ecological foodweb, then the chemical was selected as a COPEC, regardless of its ecotoxicological screening benchmark.
- If an inorganic chemical was detected below site-specific background concentrations, then the chemical was not selected as a COPEC.

If no COPECs were identified, it was concluded that the COIs were not of potential ecological concern and no further investigation for ecological concerns were deemed warranted.

2.6.3 Tier II Level Ecological Risk Assessment

Given the presence of an ecological component *and* at least one COPEC, the site required further evaluation;, i.e., a Tier II level risk assessment (or at least aspects thereof, USACE 1996). Based on findings during the first tier of assessment, a formal problem formulation was conducted where:

[2] Subsurface media are not considered here as there is no complete exposure pathway for the subsurface to ecological receptors.

- The ecological component was further characterized in the context of ecological relevance and value that reflected federal, state, or local ecosystem management goals (i.e., identified assessment endpoints - what needed protection).
- Key relationships were described between COPEC(s) and ecological component(s) in the context of appropriate spatial boundaries (administrative and ecological) and temporal scale (i.e., an exposure assessment).
- Identified measures that reflected the appropriate attributes that may be affected by the COPEC(s) (i.e., an effects assessment).

Based on the components identified above, risk(s) and uncertainties were more clearly defined than was possible within the Tier I assessment. All of the assumptions made during the Tier I level assessment resulted in an overestimation of the potential exposure and effects associated with an ecological resource. Such overestimation was purposely performed to ensure that a false-negative conclusion (i.e., suggesting no-risk when in reality a risk existed) did not occur during the screening process. This bias was identified and, to the extent possible, quantified during formal problem formulation to allow for a more realistic evaluation of the potential for ecological harm.

2.6.3.1 Ecological Resource(s) at Risk

Characterization of the habitats, communities, and ecosystem at risk was used to identify assessment and measures for focusing the ecological risk assessment. However, this evaluation had to be performed within the context of the site risk management goals for interpreting the relevance of COPEC exposures. The spatial boundaries (ecological and administrative) needed to be delineated, as well as the temporal scale and ecological component characteristics, to focus the assessment on relevant issues. The term *ecological component* could represent any part of an ecosystem, including populations, communities, and the ecosystem itself. In a sense, at the screening level (Tier I), the "ecological component" was a *community* (assemblage of populations of organisms associated with a particular physical medium). In order to identify potential assessment and measures of effect (relevant issues), the functional roles of the components identified for the site (i.e., habitats, communities and ecosystems) were evaluated in terms of their trophic relationships and ecological relevance (value). *Assessment endpoints* represented ecologically relevant values based on fundamental ecological principles that considered the structure, function, and dynamics of the ecological systems at risk. These assessment endpoints represented the ultimate focus of the ecological risk assessment and linked the "measured" attributes; i.e., *measures of effect*, to the risk management process.

2.6.3.2 Exposure Assessment

Exposure assessment evaluated the potential exposure pathways, identified in a site conceptual exposure model, for the selected COPEC(s) and ecological component(s). The chemical fate and transport properties associated with the COPEC, the physical-chemical setting of the site, the distribution of the COPEC(s) within the site, and the attributes associated with the ecological component, were used to ascertain whether any release and/or transport of a COPEC could be

linked to the ecological component. Simply stated, this process assured that a complete exposure pathway could be demonstrated. All incomplete exposure pathways were eliminated from further investigation, since without exposure there could be no effect.

During the Tier I screening assessment, the maximum detected concentration of a COI was compared to the ecotoxicological screening benchmark. The maximum detection was useful for screening, but was inadequate for characterizing a potential for risk. As such, COPEC concentrations were evaluated in the context of spatial distribution in Tier II. However, analytical data were often from sampling locations that were biased towards the identification of chemical "hot spots" in applicable media. This represented a positive bias, which was consistent with the conservative nature of a screening-level assessment (Tier I). As part of the exposure assessment during formal problem formulation in Tier II, attempts were made in characterizing (statistically) the impact of this bias on the potential for exposure to ecological resources.

2.6.3.3 Effects Assessment

Two tasks were associated with the effects assessment for selected COPECs:

- *Relative sensitivities to potential receptors.* Major phylogenetic categories of organisms; e.g., amphibians, reptiles, birds and mammals, were compared based on information from toxicological references to assess which receptors were at greatest risk to individual COPECs.
- *Mechanism or mode of toxicity.* This represents how a toxic effect was produced within different groups of organisms. This included the target organ or process within a receptor that was pathologically affected by the presence of a poison. This was useful for: (1) differentiating between target organisms; (2) determining whether growth or reproduction were the more important endpoint, and in some cases; (3) determining whether an acute or chronic endpoint was more applicable.

2.6.3.4 Receptors of Concern

To develop a measurement by which risk could be characterized; i.e., a measure of effect, receptors of concern (ROCs) were selected. Populations, communities, or species were selected as ROCs taking the following into consideration:

- general trophic position;
- probable intensity/duration of exposure;
- availability of relevant behavioral and physiological data;
- availability of relevant toxicological data;
- whether there were any federally listed threatened or endangered species; and
- behavioral and physiological attributes such as body weight, area use, diet composition and rates of ingestion of food, soil, and water that might have influenced an animal's susceptibility (and sensitivity) to contaminants.

ROCs were selected based on the characterization of the ecological resources at risk and the results of the exposure assessment, as well as the results of the effects assessment.

2.6.3.5 *Risk Characterization*

Toxicity reference values (TRVs) were selected for both no-observed-adverse-effect levels (NOAELs) and lowest-observed-adverse-effect levels (LOAELs). Risk was then evaluated by calculation of *ecological effects quotients* (EEQs) or *hazard quotients* (HQs). HQs are the ratio between the exposure point concentration and toxicity reference value. These were developed for both NOAEL and LOAEL-based TRVs. If the dose to a ROC did not exceed a level known or predicted to be associated with a significant adverse ecological response (HQ > 1), then the process resulted in a recommendation of no further action. If the environmental dose equaled or exceeded the dose associated with a potentially adverse ecological response by the ROC, an interpretation of the ecological significance of the result was made which resulted in one of the following: (a) a recommendation for no further action or (b) a recommendation for further investigation. Considerations of ecological significance in a no-further-action recommendation would include:

1. The magnitude and uncertainty of the ecological effects quotients.
2. The risk management goals that acknowledged this was an active industrial site (e.g., if only those ecological communities potentially affected were those that were resident and confined to the habitat within the Cannon AFB grounds and if no transport of COPEC effects occurred into the landscape-scale ecosystem surrounding the facility, then a no further action recommendation was appropriate);
3. The potential for a remedial action to result in a detrimental ecological effect.

In the case of (b) above, another iteration of the problem identification, problem formulation, or analysis resulted. A recommendation for further investigation entailed the focused acquisition of new information. Information sought included redefining assessment endpoints and/or site-specific measurements and/or observations designed to corroborate or refute assumptions made during the assessment. These assumptions were related to exposures, effects (responses), or both.

2.7 FATE AND TRANSPORT MODELING APPROACH

Contaminant fate and transport in the vadose zone at Site SD-11 was modeled using the Multimedia Exposure Assessment Model (MULTIMED), Version 2.00 (Salhotra et al. 1995), as distributed by the USEPA Center for Exposure Assessment Modeling (CEAM). MULTIMED uses primarily semi-analytical solution methods to simulate the movement of contaminants leaching from a waste disposal facility or contaminated soils. The use of analytical rather than more complex numerical models is considered to be appropriate for the current level of risk assessment needs at the site. Additionally, the use of an analytical model is consistent with the typical usage of fate and transport models for Tier 2 RBCA evaluations (ASTM 1999).

In addition to MULTIMED, the Hydrologic Evaluation of Landfill Performance (HELP) Model, Version 3.01 (Schroeder et al. 1994), was used to calculate a net infiltration rate at the bottom of the contaminated soil zone (70 feet bgs). HELP uses weather, soil, and design data to account for various processes including runoff, infiltration, evapotranspiration, soil moisture storage, vertical drainage, and leakage through soil, geomembrane, or composite liners. Results are expressed as daily, monthly, annual, and average long-term water budgets. For Site SD-11, soil layers were simulated as vertical percolation layers. The amount of net infiltration or percolation through the bottom layer was then input into MULTIMED as a constant infiltration rate for modeling of contaminant fate and transport from the bottom of the contaminated soil zone to the water table (70 to 265 feet bgs).

A more detailed description of the HELP and MULTIMED models, including inherent model assumptions and limitations, is provided in Appendix E. To compensate for simplifying assumptions, a worst-case scenario for Site SD-11 was constructed, using conservative estimates of input parameters. Model input parameters were based on collected field data, recent literature values, and chemical analytical results. HELP and MULTIMED model results, including input and output, are provided in the following sections.

FIGURE 2-1

CANNON AFB
DECISION DIAGRAM FOR CORRECTIVE MEASURES STUDY AT SWMUs 86-90 (SITE SD-11)

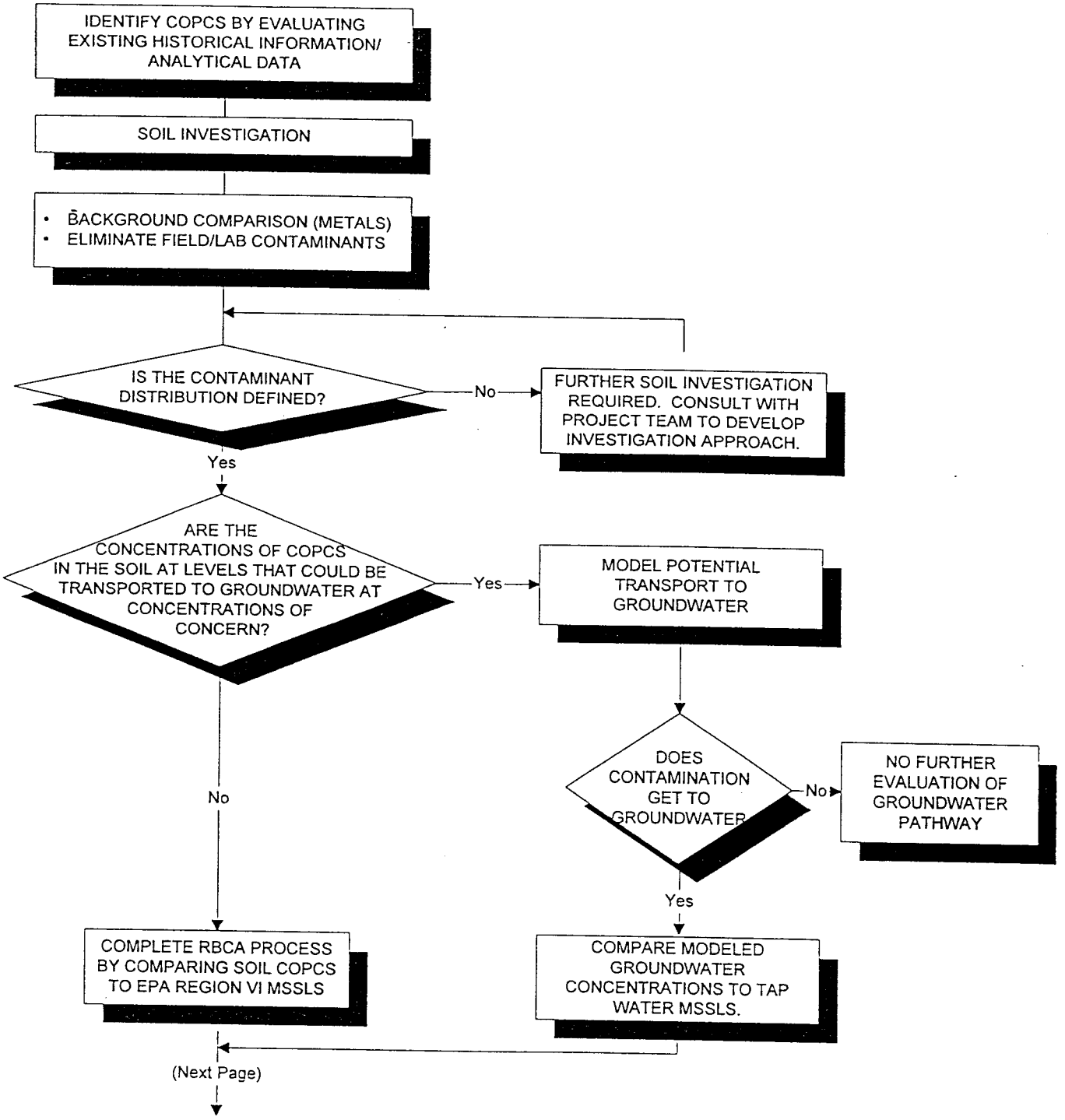
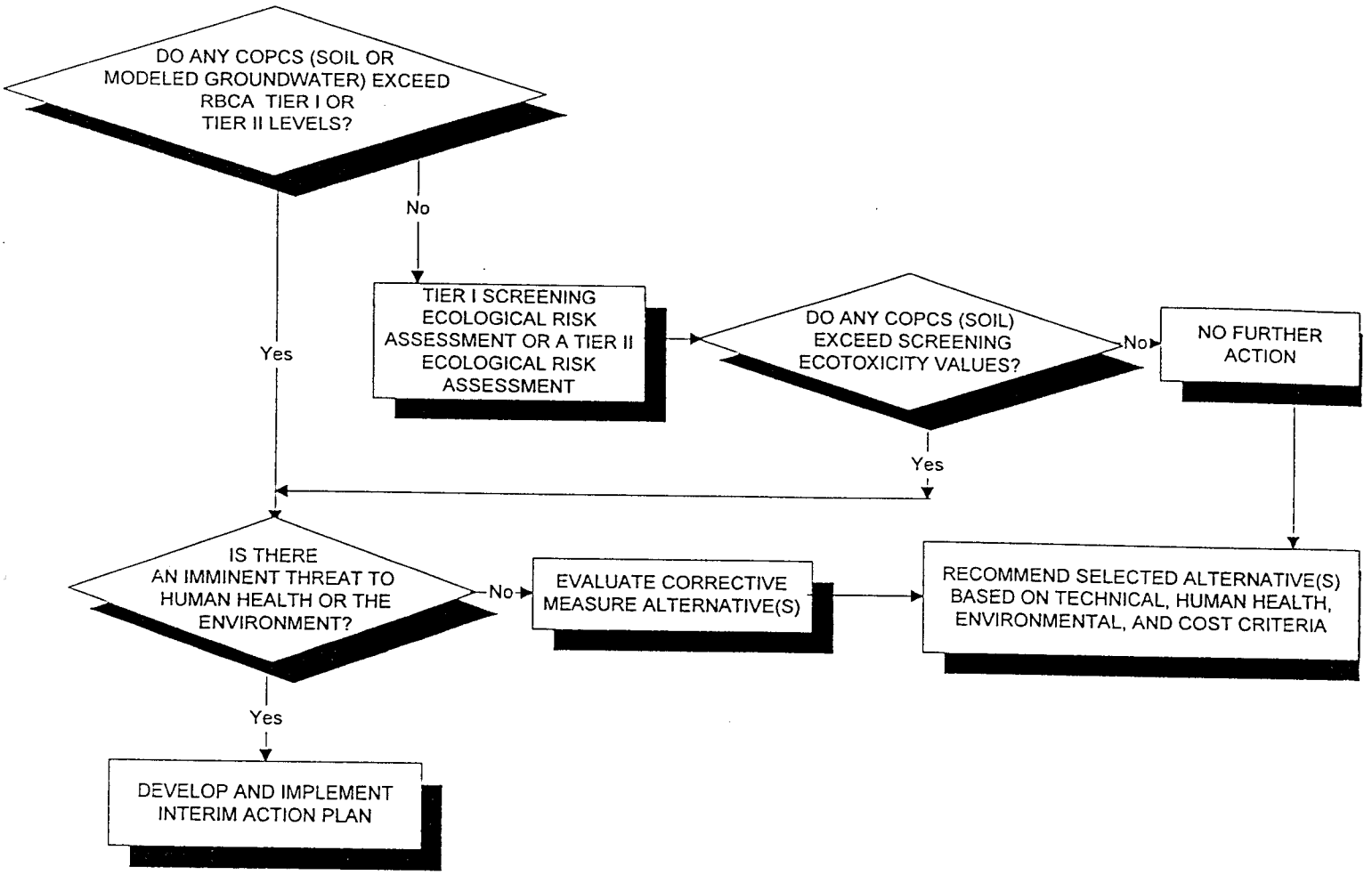


FIGURE 2-1

CANNON AFB
DECISION DIAGRAM FOR CORRECTIVE MEASURES STUDY AT SWMUs 86 - 90 (SITE SD-11)



3.1 SETTING - PHYSICAL GEOGRAPHY

Cannon AFB is situated in the Southern High Plains Physiographic Province in the Llano Estacado subprovince. The Llano Estacado is a nearly flat plain sloping gently (10 to 15 feet per mile) to the east and southeast. Elevations in the eastern New Mexico portion of the Llano Estacado exceed 4,000 feet above mean sea level (msl). In the vicinity of Cannon AFB, elevations range from 4,250 feet to 4,350 feet above msl.

The most prominent geomorphic features in the vicinity of Cannon AFB are blowouts and broad, widely spaced valleys. Less common landforms are relict sand dunes located along the northern side of the Portales Valley south of the Base. Relict dunes are not found on or near Cannon AFB.

Blowouts are broad shallow depressions which form as the result of soil erosion by wind. Blowouts commonly collect surface runoff from small to moderate sized drainage areas. During periods of rainfall, runoff collects in blowouts to form ephemeral playa lakes. Playas have no external surface drainage. Water is lost by infiltration to the soil and evaporation; without recharge, playa lakes persist for only a few days or weeks. Three playas are located within the Base, and several more are found to the north and east of the Base.

Stream valleys tend to be fairly broad and widely spaced. Streams are ephemeral and drainages are poorly developed. No streams exist on or near Cannon AFB. Running Water Draw and Frio Draw, located about 10 and 20 miles, respectively, north of Cannon AFB, are the nearest streams. These are second-order streams. Both streams are very straight, flow southeast, and have rectilinear drainage patterns with short laterals (W-C 1991).

3.2 DEMOGRAPHICS AND LAND USE NEAR CANNON AFB

Cannon AFB is located just south of U.S. Highway 60-84 in a farming and ranching area (Figure 1-1). The majority of the land surrounding Cannon AFB is productive, irrigated farmland or grassland. The major crops are wheat, sorghum, sugar beets, corn, cotton, alfalfa, barley, and peanuts. The land is also used for cattle grazing, both beef and dairy, and Clovis is considered the "Cattle Capital of the Southwest." There were 32,767 people living in Clovis in 1990, while the Cannon AFB population was estimated to be 4,650 in 1990 (W-C 1991).

3.3 CLIMATOLOGY

The climate of east-central New Mexico is classified as tropical semi-arid, with summer temperature and precipitation maxima. Average monthly temperatures range from a January low of 12°C (39°F) to a July high of 26°C (78°F). Extreme daily temperatures range from -24°C (-11°F) to 41°C (106°F) (Lee Wan and Associates 1990). Average monthly precipitation ranges from 1 cm (0.4 inches) in winter to 6.9 cm (2.7 inches) in July. The maximum recorded 24-hour rainfall is 12.2 cm (4.8 inches), which occurred in August. Rainfall occurs on eight or more days per month during the summer precipitation maximum. Mean annual precipitation is approximately 41 cm (16 inches). The mean annual evapotranspiration rate is 181.4 cm/yr

(71.4 inches/yr) (Lee Wan and Associates 1990). Prevailing winds are from the west at an average of 5 km/hr (3.1 mph) during fall, winter, and spring. During the summer, winds are from the south at an average of 3.7 km/hr (2.3 mph).

The atmosphere around the area of Cannon AFB is generally well mixed. The seasonal and annual average mixing heights can vary from 400 meters in the morning to 4,000 meters in the afternoon. The afternoon mixing heights are typically greater during the spring and fall seasons. The morning mixing heights are usually low, due to nighttime heat loss from the ground, producing surface-based temperature inversions. After sunrise, these inversions break up, and solar heating of the earth's surface causes vertical mixing in the atmosphere.

Dust is frequently entrained into the atmosphere in this region of the country because of gusty winds and the semiarid climate. The Texas Panhandle-eastern New Mexico area is considered the worst area in the United States for windblown dust. Occasionally, this windblown dust is of sufficient quantity to restrict visibility. Most of the seasonal dust storms occur in March and April, when the wind speeds are typically high (average 5 km/hr) (W-C 1991).

3.4 GEOLOGY

The near-surface stratigraphic units of interest at Cannon AFB are the Late Miocene-Late Pliocene-age Ogallala Formation and the Early Triassic Dockum Group as shown in Figure 3-1.

The Dockum Group consists of three formations. The stratigraphically lowest unit is the Santa Rosa Sandstone. Overlying the Santa Rosa Sandstone are the Chinle and Redonda Formations. The Chinle and Redonda Formations are composed mainly of red shales with lesser interbedded sands, and are known locally as "redbeds." The top of the Dockum Group is marked by an erosional unconformity having relief of up to several hundred feet (Lee Wan and Associates 1990).

Overlying the Dockum Group redbeds is the Ogallala Formation. The Ogallala Formation extends from eastern New Mexico and Colorado into Texas, Oklahoma, Kansas, Nebraska, and South Dakota. Drillers' logs from Cannon AFB indicate that the Ogallala Formation varies from 360 feet to 415 feet in thickness. The incised upper surface of Triassic redbeds strongly influences Ogallala thickness. Paleo valleys in the post-Triassic unconformity are deep and trend dominantly east-west. Ogallala thickness may thus vary significantly over short north-south distances.

The Ogallala is erosionally truncated to the south along the abandoned Portales Valley, to the west along the Pecos River Valley, and to the north in a series of ephemeral stream valleys. The Ogallala Formation extends more than 125 miles to the east before terminating as an escarpment in Briscoe County, Texas. Springs and seeps are common along the erosional margins of the Ogallala.

The Ogallala dips gently and monoclinally to the southeast in the vicinity of Cannon AFB. As reported in Lee Wan and Associates (1990), data suggest that some Quaternary warping may

have occurred; however, most of the structures are well to the northwest and southwest of Cannon AFB. No faults or buried structural lineaments are known in the vicinity of Cannon AFB.

The Ogallala Formation is composed of unconsolidated poorly sorted gravel, sand, silts, and clays. The base of the Ogallala is generally marked by a gravel, cobble, and boulder deposit. This basal member contains sediments derived from igneous and sedimentary rocks transported from the mountains to the west. The Ogallala Formation was laid down as stream and overbank deposits formed within coalescing alluvial fans. These fans form a broad pediment along the eastern flank of the Rocky Mountains. As is typical of alluvial deposits, Ogallala internal stratigraphy varies vertically and horizontally over short distances.

Except where strongly cemented by calcium carbonate (caliche), the sediments of the Ogallala are loose and friable. Authigenic and allogenic clays are found as a trace to abundant matrix mineral (Lee Wan and Associates 1990). As reported by Lee Wan and Associates (1990), five zones have been distinguished within the Ogallala of east central New Mexico on the basis of clay minerals. Smectites (montmorillonites) and attapulgite (with sepeotite) are the dominant clays throughout the Ogallala. Illite is a lesser, but persistent clay, as is kaolinite. Smectite is a swelling clay, causing deep cracks to form in dry surface soils. Smectite in particular and, to a lesser extent, attapulgite and illite, are clays with moderate to high cation exchange capacities (CEC). The formation as a whole should therefore have a relatively high CEC, which should inhibit the migration of charged contaminants, and especially ionic forms of metals.

Caliche is a major feature of the Ogallala Formation, occurring as nearly continuous to discontinuous layers throughout. A generalized geologic section at Cannon AFB is shown in Figure 3-1. Caliche is hard, white to pale tan on fresh surfaces, weathering to gray, and has a chalky appearance. Caliche forms as calcium carbonate, leached from overlying sediments, and precipitates in the pore space of the host sediments. Precipitation is caused by the evaporation of downward percolating water. The caliche may thus mark the position of ancient vadose zones. As reported in Lee Wan and Associates (1990) radiocarbon dates for the upper "climax" caliche range from 27,000 yr. Before Present (B.P.) to 42,000 yr. B.P.

Caliche is relatively soluble in acidic water ($pH < 7$) or in waters containing dissolved CO_2. The top surface of the upper "climax" caliche in fresh outcrop shows solution etching.

The Ogallala has numerous continuous to discontinuous caliche layers throughout its thickness. The uppermost caliche, termed the "climax" caliche, is pisolitic (consisting of spherical concentrically laminated aggregates 1 to 10 mm in diameter (Lee Wan and Associates 1990). The pisolites are thought to have formed as the caliche was repeatedly chemically weathered and brecciated during Pleistocene pluvials (wet climate episodes) and later recemented during drier intervals. This upper caliche crops out around playas and the bounding escarpments of the Ogallala, and is locally termed "caprock." The "climax" caliche is typically 3 to 5 feet thick. Caliches which occur lower in the Ogallala are platy and harder. Caliche may be thin or absent below playas (W-C 1991).

3.5 HYDROGEOLOGY

The lower portion of the Ogallala Formation is the primary regional aquifer for both potable and irrigation water. No deeper aquifers are utilized in the vicinity of Cannon AFB. The Ogallala aquifer is part of the High Plains Aquifer which extends continuously from Wyoming and South Dakota into New Mexico and Texas. In east central New Mexico, the Ogallala aquifer rests on Dockum Group redbeds, which serve as the basal confining layer. The Ogallala is a water table, or unconfined, aquifer (Lee Wan and Associates 1990). The Ogallala aquifer has a southeasterly regional gradient of about 13 feet/mile. Well yields vary from less than one gallon per minute (gpm) in thin silts and sands, and up to 1,600 gpm in thick sands and gravels (Lee Wan and Associates 1990). Water quality is generally good, with hardness and fluorides being somewhat high (Lee Wan and Associates 1990).

At Cannon AFB, the depth to groundwater is greater than 200 feet, and the Ogallala aquifer has an average saturated thickness of 120 feet based on mid-1960s data. Saturated thickness ranges from 93 to 143 feet, and is influenced by the configuration of the erosional nonconformity surface marking the top of the Dockum Group. The local groundwater gradient is southeasterly at 7.5 feet/mile (Lee Wan and Associates 1990). Figure 3-2 shows water table elevation contours for 1984. Flow within the saturated zone may be influenced by the configuration of the top of the Dockum Group. Yields in tests of Cannon AFB water wells have ranged from 776 L/min (205 gpm) to 4,353 L/min (1150 gpm). Specific capacities range from 0.14 m^3/m (11.4 gal/ft) to 0.35 m^3/m (27.9 gal/ft) (Lee Wan and Associates 1990).

Very rough estimates of hydraulic conductivity were made from well pump tests in water wells 5 and 9 (Figure 3-3) using the Theis equation. An estimate of hydraulic conductivity for water well 8 was based on water level recovery data using the Bouwer and Rice approach (Lee Wan and Associates 1990). The data used in these calculations were obtained to evaluate pump rates, efficiency, and well yield, and were not intended for use in calculating aquifer properties. The results of these calculations should therefore be considered as first approximations.

Hydraulic conductivity values for water wells 5 and 9 were found to be approximately 2.0×10^{-3} cm/sec. Calculations for water well 8 resulted in a hydraulic conductivity of 2.0×10^{-2} cm/sec. In addition, slug testing of two monitoring wells (MW-O and MW-N) was done by Woodward-Clyde in February 1995 (W-C 1995a). The estimated hydraulic conductivities from these slug tests were both 3×10^{-3} cm/sec. These estimates appear to be low when compared to published hydraulic conductivity data for sands and gravels. As reported in Lee Wan and Associates (1990) a groundwater flow velocity of about 45 m/yr (150 ft/yr) has been estimated. This calculates out to a hydraulic conductivity of approximately 1.0×10^{-1} cm/sec. Again, this appears to be low when compared with published data (Freeze and Cherry 1979).

The presence of interstitial clays may account for both the variability and low values of hydraulic conductivities. Boring logs from Cannon AFB IRP projects and published reports (Lee Wan and Associates 1990) indicated that interstitial and interstratified clays are abundant in the Ogallala Formation.

Recharge to the Ogallala is primarily through precipitation. As reported in Lee Wan and Associates (1990), a recharge rate of 0.5 inches/year was calculated using the Theis equation. Lee Wan and Associates (1990) reported that the recharge rate may be as much as 1.0 inches/yr. Due to the high evapotranspiration rate and low precipitation, recharge probably occurs only during heavy rainfall events in which the infiltration capacity of the soil is exceeded and runoff occurs, or during cool months when precipitation exceeds evapotranspiration. Excess runoff flows to playas, and the presence of water in playas may allow deep percolation to the aquifer. The occurrence of this process is evidenced by the presence of clay deposits in, and thin or nonexistent caliche layers directly below, playas. Caliche is soluble in acidic rain waters, and is leached over time to form percolation pathways.

Discharge from the Ogallala occurs through well pumping and springs along the eroded margins of the formation. Spring discharge does not occur on or near Cannon AFB. Domestic and irrigation water wells are common on and around the Base, however. The rate of discharge exceeds the rate of recharge. Water levels in the Ogallala have declined steadily from the 1930s to the present. A decline of 50 to 100 feet has been observed in the area around Clovis, New Mexico for the period from the 1930s to 1980. Lee Wan and Associates (1990), states "the largest area of water level decline exceeding 100 feet occurs south of the Canadian River extending from Curry Co., New Mexico to Crosby Co., Texas."

The dominant uses of groundwater in the Cannon AFB area are for potable and irrigation water. Numerous wells are found in the Cannon AFB area, most of which provide only irrigation water (Figure 3-3).

The Ogallala will continue to be used as the primary source of potable and irrigation water for eastern New Mexico. The New Mexico State Engineer designated Curry County as a Water Basin in 1989. This designation allows for regulation of water rights, usage, and well drilling (W-C 1991).

3.6 SOILS

Soils in the vicinity of Cannon AFB are classified as SM to SC under the Unified Classification Systems, and as aridisols (calciorthids) under the Soil Conservation Service Comprehensive Soil Classification System. The following summary is based on the Soil Conservation Service Curry County Soil Survey as reported in Lee Wan and Associates (1990).

The most common soil type on the Base is the Amarillo fine sandy loam, 0- to 2-percent slope phase (map symbol Ab Figure 3-4). This soil consists of a thin sandy A horizon, well-defined clayey B_{1-3} horizons, with a calcic B_3 horizon at depths below 40 inches. The calcic B_3 horizon lies on a calcic C horizon, or on caliche. The Amarillo fine sandy loam is present on all relatively flat surfaces at the Base, but is also found on slopes associated with playas (map symbol Ac).

Clovis fine sandy loams, 0- to 2-percent slope phase (map symbol Cb) and 2- to 5-percent slope phase (map symbol Cc), are very similar to Amarillo fine sandy loams. In the Clovis soils, the

depth to the calcic C horizon ranges from 28 to 56 inches. The depth to caliche exceeds 56 inches. Clovis and Amarillo fine sandy loams occur in close association.

In a few limited areas, particularly along the steeper slopes around playas, Mausker fine sandy loam, 0- to 2-percent slope phase (map symbol Ma), and 2- to 5-percent phase (map symbol Mb) are found. Mausker fine sandy loams have no B horizons and are very calcareous. The calcic C horizon is within 2 feet of the surface.

The A and B horizons of Amarillo and Clovis fine sandy loams are rapidly to moderately permeable. Mausker fine sandy loam A and Ac horizons are rapidly permeable. Permeabilities in calcic B and C horizons are moderate (Lee Wan and Associates 1990).

3.7 BACKGROUND METALS CONCENTRATIONS IN SOIL AND WATER QUALITY

The natural soils in the vicinity of Cannon AFB are alkaline and rich in metals in general. Typically high concentrations of aluminum, iron, magnesium, manganese, and potassium combine with elevated levels of many other metals in the natural soils. Calcium is naturally present in the soils at levels up to nearly 200,000 mg/kg. Tightly cemented layers of "caliche" are present in several horizons in the natural soils and the Ogallala aquifer below.

The background levels of inorganic compounds in surface and subsurface soil at Cannon AFB are presented in Table 3-1 in the form of a mean value and statistical information on the ranges encountered for each element. Table 3-1 has been adapted from a final report by Woodward-Clyde dated September 1997 entitled "Naturally Occurring Concentrations of Inorganics and Background Concentrations of Pesticides at Cannon Air Force Base, New Mexico." This report summarizes background data for soil from numerous past investigations in the vicinity.

The mean values and upper tolerance limits (UTLs) presented in Table 3-1 are the background levels used in the screening of soil chemical results for this RFI. In addition to comparison to the UTL of the Base-wide background data (which is necessarily from a limited data set), other sources of naturally occurring metals concentrations, such as USGS (1984), were considered when determining whether metals concentrations are within background levels.

3.8 BIOLOGICAL RESOURCES

Land adjacent to Cannon AFB is primarily used for agriculture, and there is little natural vegetation remaining in the area. The wildlife species that are common to agricultural areas throughout the region include bobwhite quail and pheasant. There are a few playa lakes in the area; these are used by upland game for cover, by waterfowl for resting and feeding, and by wildlife in general for drinking. Nearby riverbeds also provide water sources during rainy seasons. During periods of low rainfall, the riverbeds are dry (W-C 1991).

3.8.1 Plant Resources

The climate of the Base area is considered to be semiarid. The thin layer of topsoil in the vicinity of Cannon AFB is sandy loam, which is highly susceptible to wind erosion. The undisturbed natural vegetation is mostly shortgrass prairie, including blue grama grassland and mixed grama grassland vegetation types, which have moderately fast recovery rates (W-C 1991).

Much of the study area has been previously cleared for agricultural crops. The predominant land use of the region is rangeland, primarily for cattle grazing. In general, moderately grazed rangeland areas of the types occurring in the project area are highly productive in terms of both forage quality and quantity. The rangeland in the vicinity may support up to 15 to 20 head of cattle per section, depending on the rainfall. Large trees do not uniformly exist in the vicinity of the range except where planted around buildings and other structures on the Base. Woodlands composed of large shrubs and small trees are confined to riparian areas and playa lakes in the vicinity (W-C 1991).

The following plants are candidate species for the Federal List of Endangered and Threatened Wildlife and Plants (CFR 1990) and are found within a 50-mile radius of Cannon AFB: chatterbox orchid (*Epipactus gigantea*), spiny aster (*Aster harridus*), Whittmans milkvetch (*Astragalus witmanii*), dune unicorn plant (*Proboscidea sabulosa*), and the tall plains spruce (*Eupjorbia strictior*). The dune unicorn plant is also on the state endangered plant species list. No federally protected endangered plants are known to be present on the Base (Lee Wan and Associates 1990).

3.8.2 Wildlife Resources

The eastern New Mexico area contains many nongame wildlife species that are typical of the High Plains. Most of these species are distributed widely throughout the western United States. Species diversity is low in most habitats because of the low vegetation diversity. Most amphibian species are associated with riparian habitats and playa lakes. Reptiles are found in all terrestrial habitat types, but are most abundant in scrub/grasslands. Nocturnal rodents are the most abundant members of the small mammal community.

Grasslands on the High Plains support a variety of seed-eating sparrows and other ground-dwelling birds, both as residents and migrants. Raptors (hawks and owls) are relatively abundant in all habitats in the region. Insectivorous and tree-nesting species are most abundant in riparian areas. Shorebirds and waterbirds and migratory waterfowl in general utilize the rivers, playa lakes, and reservoirs of the region.

Two National Wildlife Refuges (NWRs) are in the region surrounding Cannon AFB. The Grulla and Muleshoe NWRs are within 30 miles of Cannon AFB. These areas provide high-quality habitat for migratory and breeding waterfowl.

Big-game species in the area include mule deer, white-tailed deer, pronghorn, and barbary sheep. Pronghorn are the most abundant game animal in the area. Several species of upland game, such

as quail, ring-necked pheasant, and turkey are common in the area. Reservoirs (Ute Lake, Conchas Lake, and Clayton Lake) and playa lakes are important waterfowl habitats in the region. Numerous species of native and introduced fish inhabit the rivers and perennial streams, and the reservoirs support recreational fishing of warm-water species such as walleye, crappie, channel catfish, largemouth bass, and bluegill.

As determined by the regional office of the U.S. Fish and Wildlife Service, two federally listed endangered animal species, the bald eagle and peregrine falcon, are known to inhabit the area within a 50-mile radius of Cannon AFB. The New Mexico Department of Game and Fish also indicated that the state endangered Mississippi Kite, Baird's Sparrow, and the Black-Footed Ferret may also occur in the vicinity of the Base. The federal- and state-protected species are listed in Table 3-2.

Within Curry County, the only state-protected bird that is expected to occur is the Mississippi Kite. In New Mexico, since the early 1960s, this kite summers regularly and breeds in the Clovis region. The birds frequent the golf course at Cannon AFB. Two other state-protected birds that may occur within Curry County are the McCown's Longspur and Baird's Sparrow. These two species have not been sighted regularly in recent years. No information is available on the McCown's Longspur in New Mexico; however, Baird's Sparrow occurs mainly in autumn during migration in the eastern plains and southern lowlands. Migrants appear as early as the first week of August and move further south by November. The species seems to have declined in abundance throughout its range in the Southwest due to the loss of shrubby shortgrass habitats.

State-protected birds known to occur infrequently are the bald eagle and the peregrine falcon. The bald eagle migrates and winters from the northern border of New Mexico to the Gila, lower Rio Grande, middle Pecos, and Canadian valleys. It is seen occasionally in summer and as a breeding bird, with nests reported in the extreme northern and western parts of the state. Winter and migrant populations appear to have increased with reservoir construction. The peregrine falcon is widely distributed but population numbers are low. The American subspecies breeds statewide in New Mexico, but mainly west of the eastern plains (Source: Draft Environmental Impact Statement - Cannon AFB 1990).

TABLE 3-1

SUMMARY OF BACKGROUND ELEMENTAL CONCENTRATIONS[1] IN SOIL SAMPLES[2] AT CANNON AFB, NEW MEXICO

	Mean (x)		Standard Deviation (s)		95% Upper Tolerance Limit of Background Concentrations (UTLs)	
Element	Surface Soil	Subsurface Soil	Surface Soil	Subsurface Soil	Surface Soil	Subsurface Soil
Aluminum	5,508	5,932	1,964	2,183	8,950	12,214
Antimony	ND (3)	ND (3)	ND (3)	ND (3)	3.15 (3)	16 (3)
Arsenic	2.1	2.1 (4)	0.48	0.96 (4)	3.6	4.3 (4)
Barium	100	210	165	199	670	890
Beryllium	0.35 (4)	0.35 (4)	0.13 (4)	0.17 (4)	0.78 (4)	0.73 (4)
Cadmium	ND (3)	ND (3)	ND (3)	ND (3)	0.435 (3)	1.3 (3)
Calcium	5,645	89,410	11,366	64,611	44,800	237,498
Chromium (total)	7.1	5.6	1.3	2.33	10.5	13.3
Cobalt	2.9	2.6 (4)	1.0	1.4 (4)	6.6	4.7 (4)
Copper	6.8	3.8 (4)	4.6	1.97 (4)	18.3	8.3 (4)
Iron	6,458	5,148	1,349	2,262	10,100	13,148
Lead	6.8	4.7	1.6	1.7	12	8.7
Magnesium	1,066	4,260	390	3,856	1,930	19,300
Manganese	139	83	51	50	307	333
Mercury	0.025 (4)	ND (3)	0.016 (4)	ND (3)	0.056 (4)	0.019 (3)
Nickel	5.5	5.9 (4)	1.6	2.41 (4)	11	14.9 (4)
Potassium	1,345	1,222	413	417	2,691	2,512
Selenium	ND (3)	0.47 (4)	ND (3)	0.31 (4)	0.26 (3)	1.1 (4)
Silver	--- (5)	ND (3)	--- (5)	ND (3)	0.4 (5)	2.65 (3)
Sodium	91	351 (4)	10	253 (4)	102	1,227 (4)
Thallium	ND (3)	ND (3)	ND (3)	ND (3)	0.6 (3)	2.65 (3)
Vanadium	14.9	16	2.8	5.2	23.3	32.8
Zinc	15.4	12.1	5.2	4.8	32.2	30.6

(1) All concentrations are in milligrams per kilogram (mg/kg).

(2) From report entitled "Naturally Occurring Concentrations of Inorganics and Background Concentrations of Pesticides at Cannon Air Force Base, New Mexico" (W-C 1997).

(3) Analytical data were reported as nondetect; therefore, a mean and standard deviation was not calculated. One-half the highest reporting limit is used as the 95% UTL. The actual mean, standard deviation, and UTL may be less than these values.

(4) Values determined from a data set including one-half of the reporting limits for nondetects.

(5) Silver was detected in only one sample; therefore, a mean and standard deviation was not calculated. The single detected concentration is used as the 95% UTL.

TABLE 3-2

FEDERAL- AND STATE-PROTECTED ANIMALS POTENTIALLY OCCURRING IN THE VICINITY OF CANNON AFB (CURRY COUNTY)

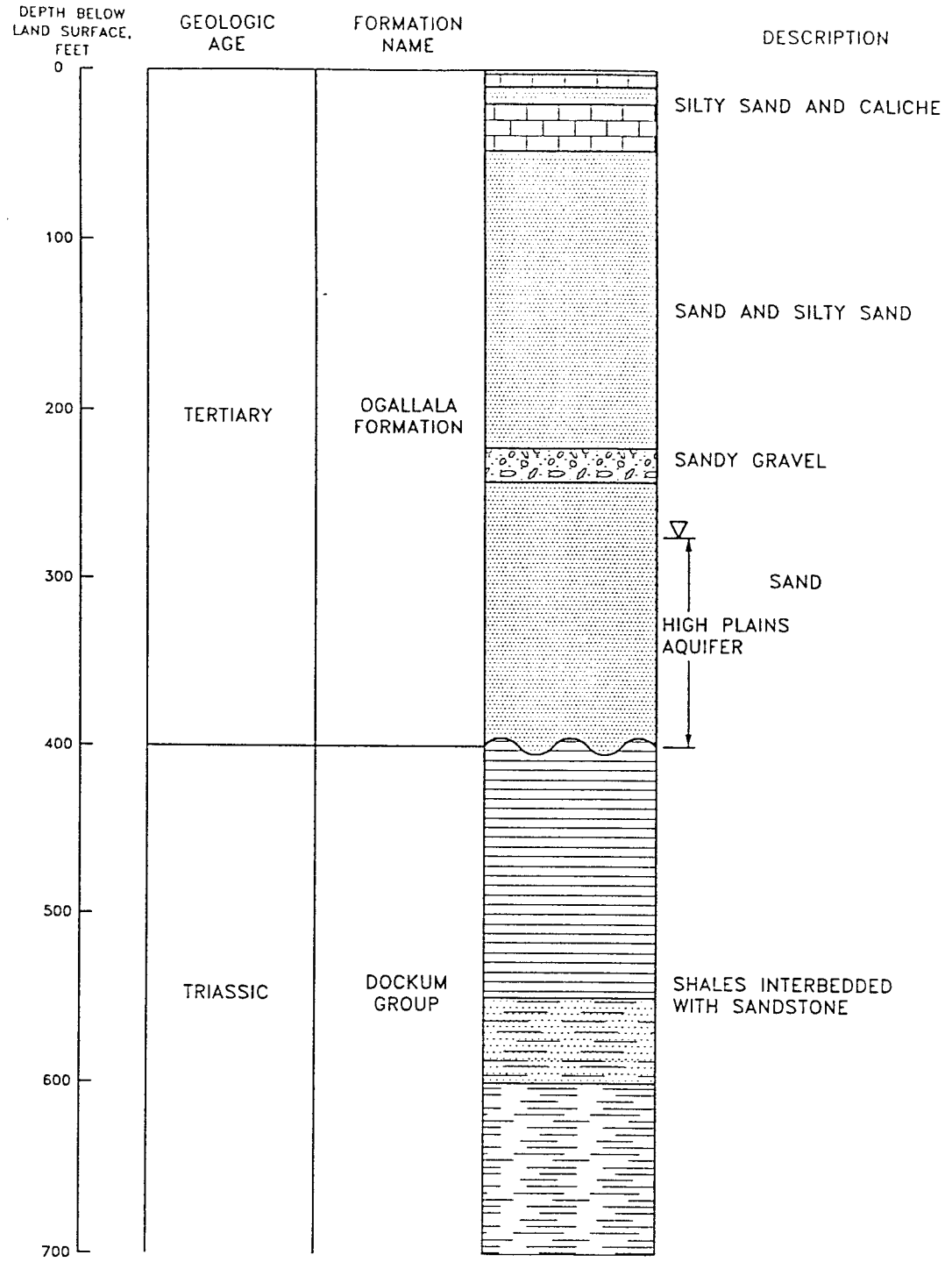
Common Name	Scientific Name	Federal Status	State Status
Birds			
Mississippi kite	*Ictinia mississippiensis*		Endangered (Group 2)
Baird's sparrow	*Ammodramus baridii*		Endangered (Group 2)
Bald eagle	*Haliaeetus leucocephalus*	Endangered	Endangered (Group 2)
Peregrine falcon	*Falco perigrinus*	Endangered	Endangered (Group 1)
Mammals			
Black-footed ferret	*Mustela nigripes*	Endangered	Possibly Extinct

Endangered (Group 1): Species whose prospects of survival or recruitment within the state are in jeopardy

Endangered (Group 2): Species whose prospects of survival or recruitment within the state are likely to become jeopardized in the foreseeable future.

Possibly Extinct: Potentially no longer in existence in the state.

Source: Lee Wan and Associates 1990



LEGEND

LITHOLOGIC CONTACT

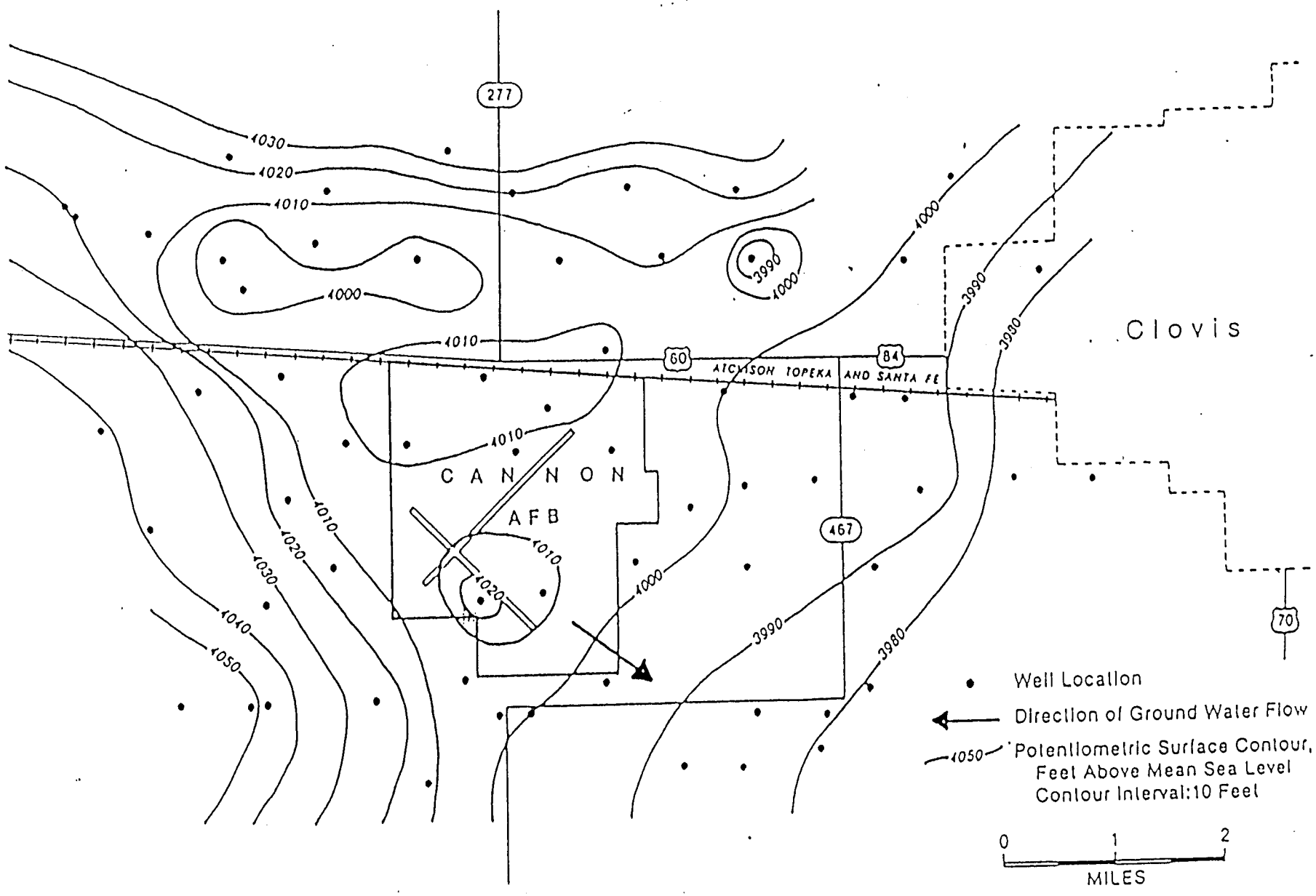
EROSINOAL UNCONFORMITY

WATER LEVEL

SOURCE: NODIFIED FROM GUTENTAG ET.AL., 1984

t:\cannon\m9602v\t5500\fig3-1.dgn

DRN BY TSSM	DATE: 03/24/99	GENERALIZED GEOLOGIC STRATA AT CANNON AIR FORCE BASE NEW MEXICO	PROJECT NO. 45F0M9602V.00	FIG. No. 3-1
CHK'D BY	REVISION 0			

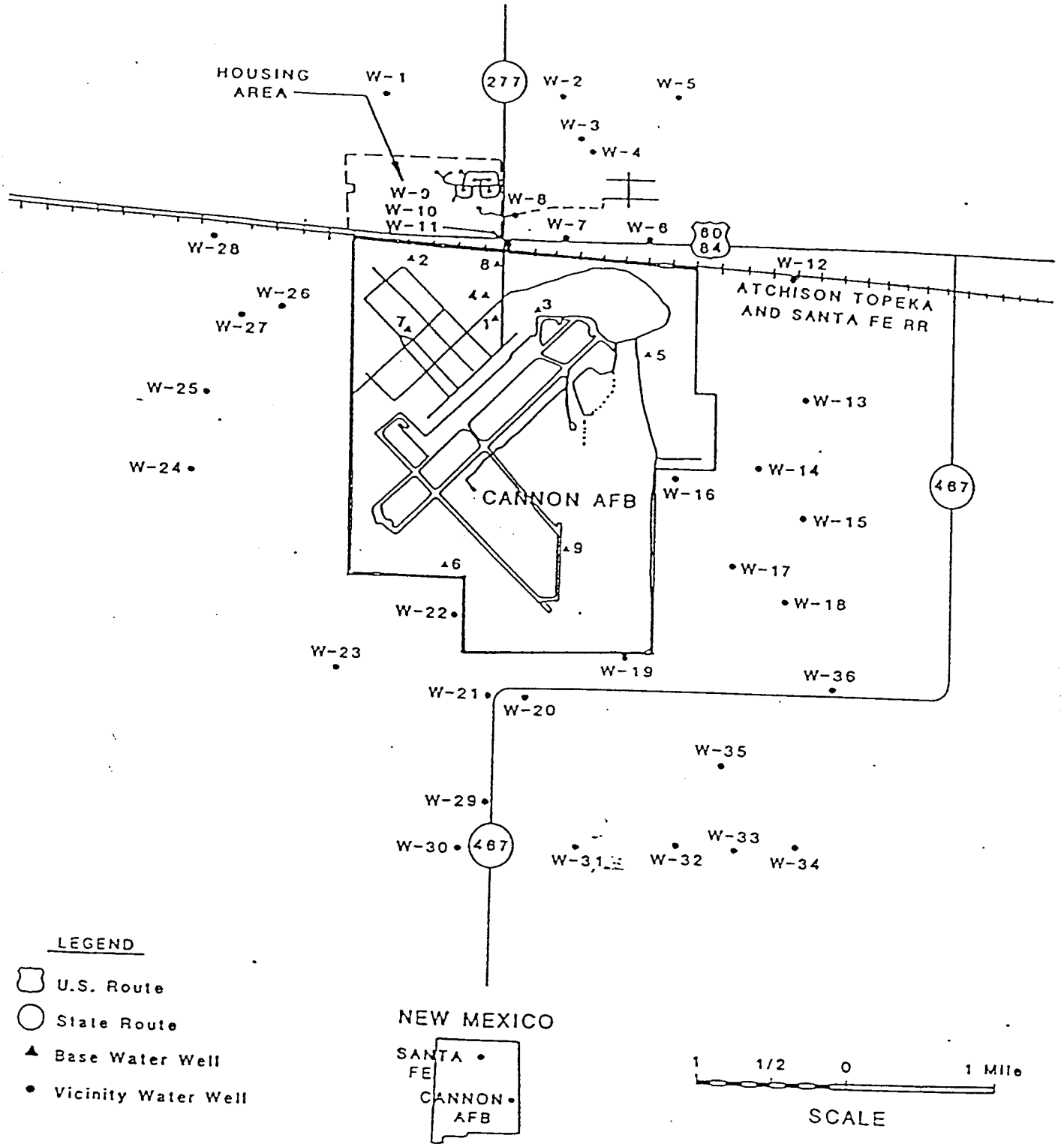


SOURCE: FINAL REPORT, IRP PHASE II

March 24, 1999 11:26:57 a.m.
Drawing: T:\CANNON\M9602V\T6500\FIG3-2.DWG (TSM)

DRN BY TSSM	DATE 07/06/98	POTENTIOMETRIC SURFACE CONTOUR MAP, VICINTY OF CANNON AIR FORCE BASE NEW MEXICO	PROJECT No.	FIG. No.
CHK'D BY	REVISIONS: 0		45F0M9602V.00	3-2

REPORT PHASE: III RFI SITE SD-11

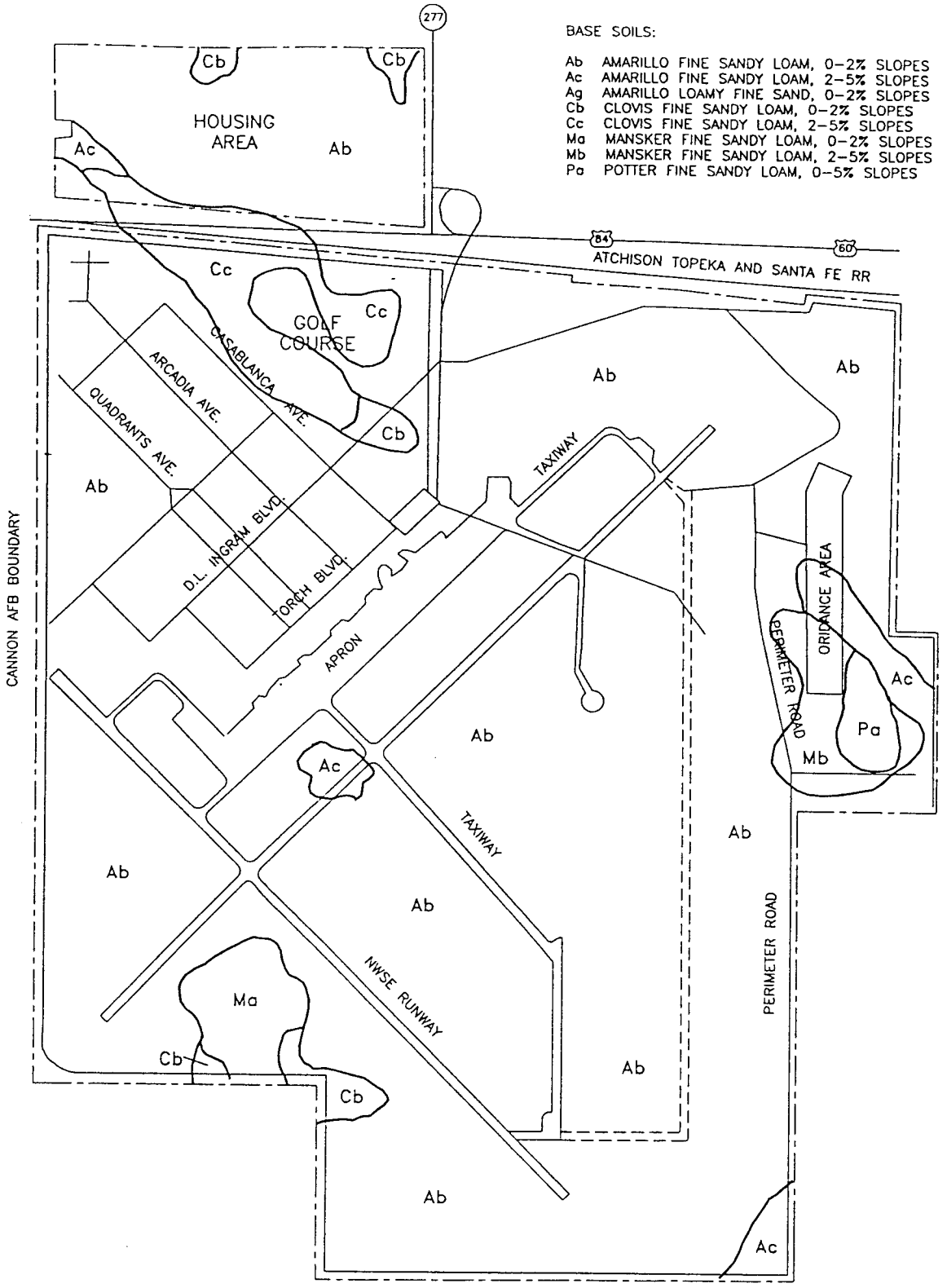


SOURCE: MODIFIED FROM BUTENTAG ET. AL., 1984

March 24, 1999 11:27:21 a.m.
Drawing: T:\CANNON\M9602V\T6500\FIG3-3.DWG (TSM)

DRN. BY: TSSM	DATE: 03/24/99	WATER WELL LOCATIONS ON AND NEAR CANNON AIR FORCE BASE NEW MEXICO	PROJECT No.	FIG. No.
CHK'D. BY:	REVISIONS: 0		45F0M9602V.00	3-3

REPORT PHASE: E III RFI SITE SD-11



BASE SOILS:

Ab	AMARILLO FINE SANDY LOAM, 0–2% SLOPES
Ac	AMARILLO FINE SANDY LOAM, 2–5% SLOPES
Ag	AMARILLO LOAMY FINE SAND, 0–2% SLOPES
Cb	CLOVIS FINE SANDY LOAM, 0–2% SLOPES
Cc	CLOVIS FINE SANDY LOAM, 2–5% SLOPES
Ma	MANSKER FINE SANDY LOAM, 0–2% SLOPES
Mb	MANSKER FINE SANDY LOAM, 2–5% SLOPES
Pa	POTTER FINE SANDY LOAM, 0–5% SLOPES

SOURCE: USDA–S.C.S., SOIL SURVEY OF CURRY COUNTY N.M., 1958

N

2000 1000 0 2000

SCALE IN FEET

March 24, 1999 11:28:12 a.m.
Drawing: T:\CANNON\M9602V\T6500\FIG3-4.DWG (TSM)

DRN. BY: TSSM	DATE: 03/24/99	DISTRIBUTION OF SOILS, BY TYPE CANNON AIR FORCE BASE NEW MEXICO	PROJECT No. 45F0M9602V.00
CHK'D. BY:	REVISIONS: 0		FIG. No. 3-4

4.1 SITE DESCRIPTION

Site SD-11 (SWMUs 86-90) is located in the sparsely populated southeast part of Cannon AFB, about 5,000 feet east and 2,000 feet south of the intersection of the two main runways (see Figure 1-2). The site consists of a former engine test cell (SWMU 86), former overflow pit (SWMU 87), former leach field (SWMU 88) which was later converted to an evaporation pond (SWMU 89), and former oil/water separator with associated 100-gallon collection tank (SWMU 90). A site plan of these SWMUs and surrounding area is shown in Figure 4-1.

The former test cell was enclosed by a 50-foot by 10-foot building resting on a concrete slab. In addition to the test cell structure, a small pumphouse building has been removed, leaving only a bare concrete slab. The oil/water separator system has also been removed. At the time of the Phase III RFI field activities, the concrete slab was being used periodically to conduct outdoor engine tests with portable equipment. Nearby buildings at the site include Building 2330 to the northwest, which is a support building for engine test activities, and a storage building directly south. Other site features include a wellhouse (Base Well No. 9), storage shed, water tank, construction contractor's trailer directly north of the site, and large sound suppressor buildings further to the north.

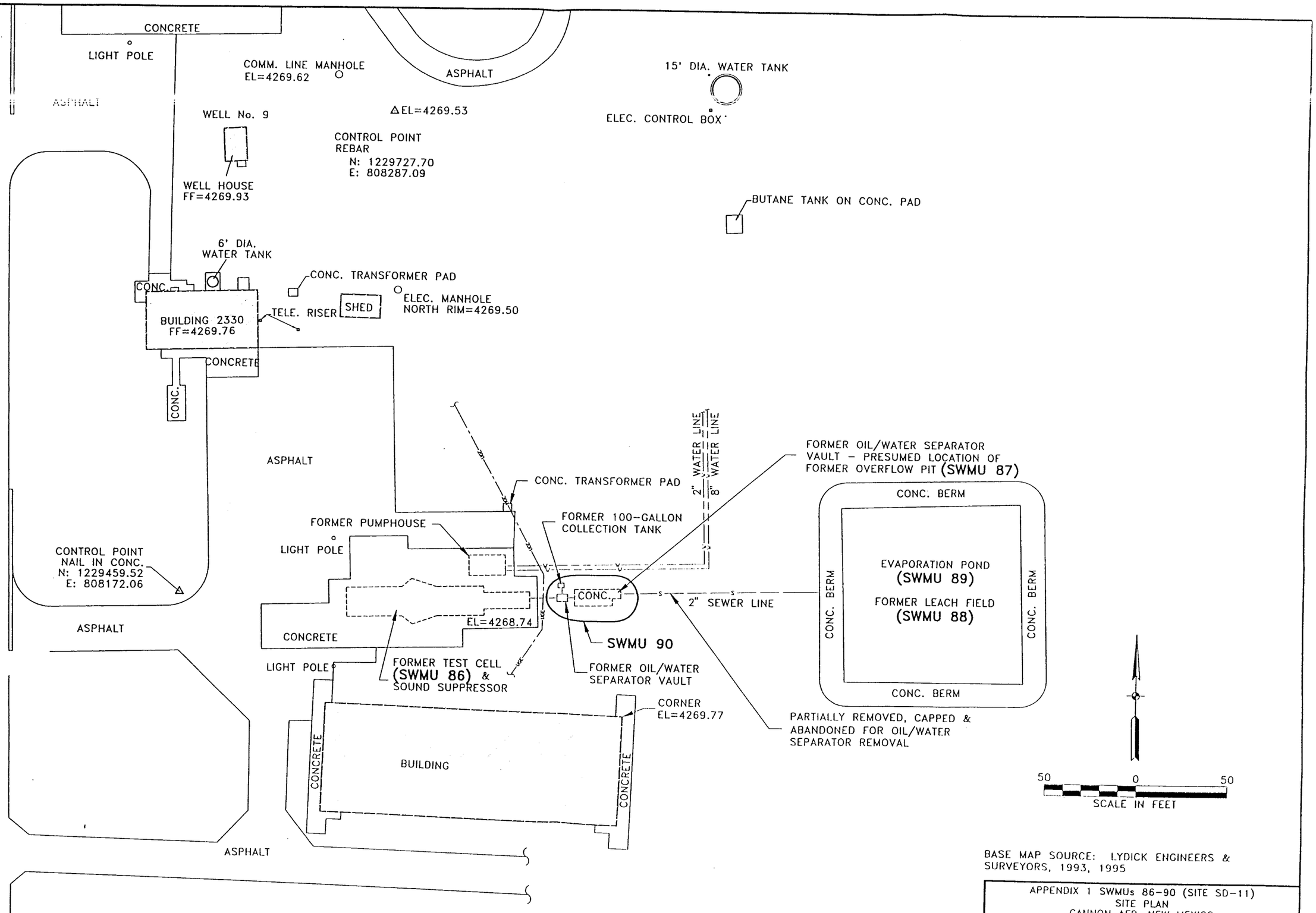
Most of the area around the former test cell is covered by asphalt, gravel, and weeds. Topography is generally flat, near an elevation of 4268 ± 1 feet above mean sea level. Minimal vegetation exists in the area of SWMUs 86-90 (Site SD-11). Exhaust from engine tests currently being conducted at the concrete slab appears to have created a depression, about 1-foot deep, directly east of the slab in the area of the former oil/water separator system. Sheepsfoot compactor marks are visible in the depression where backfill was placed for the removal of the oil/water separator vaults.

4.2 SITE HISTORY

Appendix I SWMUs 86-90 (Site SD-11) were active from 1965 to 1988. The separate areas at the site received potential contaminants from a single operation, the steam cleaning and testing of jet aircraft engines. It has also been reported that jet engines had water injected into the exhaust during testing to help muffle noise. Contaminants that may have been released at the site include lubricating and synthetic oils, residual JP-4 fuel, and possibly solvents.

During the life span of the facility, effluent was handled in several ways. Initially it was discharged only to an overflow pit (SWMU No. 87). Then the oil/water separator system (SWMU No. 90) was installed with discharge to a leach field (SWMU No. 88). Finally, the effluent was routed through the oil/water separator to an evaporation pond (SWMU No. 89). The evaporation pond was constructed in the area of the former leach field (SWMU 88).

REPORT PHASE: PHASE RFI SITE SD-11



BASE MAP SOURCE: LYDICK ENGINEERS & SURVEYORS, 1993, 1995

March 24, 1999 11:33:07 a.m.
Drawing: T:\CANNON\M9602V\T6500\FIG4-1.DWG (TSM)

NOTE: LOCATION OF UNDERGROUND UTILITY LINES SHOWN ARE APPROXIMATE.

APPENDIX 1 SWMUs 86-90 (SITE SD-11) SITE PLAN CANNON AFB, NEW MEXICO			
DRN. BY: TSSM	DATE: 03/24/99	PROJECT NO.	FIG. NO
CHK'D. BY:	REVISION: 0	45FOM9602V.00	4-1

Several investigations have been completed in this area as described below.

1983 - Phase I IRP

A Phase I IRP Records Search was performed in 1983 by CH_2M Hill to identify and fully evaluate suspected problems associated with past hazardous material disposal sites and spill sites at Cannon AFB (CH_2M Hill 1983). During the records search, the existence and potential for migration of hazardous material contaminants was evaluated at the Engine Test Cell Area (SWMUs 86-90) by reviewing the existing information and conducting an analysis of installation records. Results of the Phase I IRP Records Search recommended that potable well 9 be analyzed for priority pollutants to determine if the groundwater had been impacted by activities at the site.

1984-1985 - Phase II IRP

During 1984-1985, a Phase II IRP investigation was conducted by Radian Corporation at the site. Two boreholes were drilled to depths of 35 and 50 feet, respectively (see Figure 5-1). One borehole (11B) was located within the leachfield, and another (11A) was located in a depression which had collected overflow from the oil/water separator. Five soil samples taken from the boreholes were analyzed for purgeable halocarbons and aromatics, oil and grease, and lead. Results of the samples collected during the Radian investigation indicated no soil contamination at the IRP/SWMU site (Radian 1986). Based on the results of the Phase II (Stage I) investigation, additional soil sampling was recommended due to the limited number of borings drilled in the area.

1987 - RFA

In 1987, a Preliminary Review/Visual Site Inspection, RCRA Facility Assessment was conducted for the USEPA at Cannon AFB by A.T. Kearney, Inc. (A.T. Kearney 1987). The purpose of this investigation was to identify and evaluate Solid Waste Management Units to assess the potential for releases to the environment of hazardous wastes or constituents. Results of this investigation identified the site as a potential SWMU. The RCRA Facility Assessment also indicated that the potential for releases to the soil was high due to the past disposal of hazardous wastes and the unlined nature of the IRP/SWMU site. The potential for releases to groundwater was considered to be lower due to the presence of caliche layers possibly inhibiting downward migration of hazardous constituents. Suggested further action was to conduct soil sampling to determine if contaminants had been released from the unit.

1989 - RI

In December 1989, five soil borings (Borings B1 through B5), shown in Figure 5-1, were drilled by Walk, Haydel and Associates and analyzed for volatile organic compounds (VOCs), xylene, base/neutral organics, and total metals (WHA 1990). Borehole 1 was drilled to a depth of 30 feet in the vicinity of the oil/water separator overflow pit. Boreholes 2, 3 and 4 were drilled to depths of 30 feet each immediately adjacent to the west, north, and east, respectively, of the existing

evaporation pond. Borehole 5 was drilled to a depth of 60 feet immediately south. Analytical results indicated very low levels of phenol, 2,2'-methylene bis[6-1,1-(dimethylethyl)-4-ethyl-] (known as antioxidant 425) in boreholes B-1 and B-4. Silver was the only metal detected at levels exceeding background. However, the distribution of silver was considered by Lee Wan and Associates (1990) to be naturally occurring.

1991 - 18 SWMUs RI

In September 1991, Woodward-Clyde (W-C) investigated the site as part of the RI for 18 IRP/SWMU sites at Cannon AFB (W-C 1991, 1992). The objective for sampling at the site during the investigation was to further evaluate the nature and extent of potential hazardous contaminants. Six original soil borings (Borings 0861 through 0866) were drilled and surface and subsurface samples collected for chemical and geotechnical analysis. Some of the borings were redrilled and resampled, due to missed holding times. The soil borings were located near the Engine Test Pad and the old oil/water separator (see Figure 5-1). Surface samples were collected from 0 to 0.5 feet bgs at locations near each of the soil borings. Subsurface soil samples were collected at depths ranging from 2 to 23 feet bgs. All soil samples were analyzed for Target Compound List (TCL) volatile organic compounds (VOCs) and target analyte list (TAL) metals.

None of the target analyte list of volatile organic compounds, except acetone and toluene, were detected above the Contract-Required Quantitation Limit (CRQL) in surface and subsurface soil samples at the SWMUs. Toluene was present in surface sample 0865, at a concentration of 100 µg/kg. Acetone was detected above the CRQL in only one surface sample (i.e., sample 0864 at 17 µg/kg). Acetone was detected in nearly all subsurface samples at all five boring locations with concentrations ranging from 68 µg/kg to 5,700 µg/kg.

A variety of metals were detected in soil borings 0861 through 0865. Vanadium was detected at concentrations of 18-25 mg/kg, slightly higher than background levels. However, the distribution of vanadium was uniform throughout surface and subsurface samples and therefore, could be considered to be naturally occurring. Heavy metals detected at elevated levels were antimony, barium, cadmium, chromium, cobalt, copper, lead, manganese, nickel, and zinc. Other metals, including iron, aluminum, potassium, and mercury were detected infrequently and at concentrations near or below site background or regional levels.

1994 - RA

In August 1994, Remediation Services Incorporated (RSI 1994) removed the oil/water separator system and excavated the petroleum-contaminated soil surrounding the oil/water separator. An area 60 feet long by 30 feet wide by 25 feet deep was excavated (Figure 5-1). Soil samples were taken from the excavated and stockpiled soil periodically and analyzed for TPH, volatiles, semivolatiles, and target analyte metals. Based on this sampling, approximately 186 tons of excavated soil was transported to an off-site facility. Because of concerns about residual contamination in the remaining stockpiled soil, the remaining soil was mixed with clean off-site soil and used to backfill the excavation.

RSI reported that the oil/water separator did not appear to be sealed along the bottom and at the edges and that petroleum contamination in site soils was visible after removing approximately 1 foot of soil.

1995 - Phase III RFI

A Phase III RFI was completed by Woodward-Clyde in October 1995 (W-C 1997b) at Site SD-11. The purpose of this investigation was to assess the vertical and horizontal extent of contamination at the SWMUs and to complete a screening-level risk evaluation.

Field activities included completing and sampling nine soil borings for chemical, microbiological, and geotechnical analysis, and sampling groundwater from one Base production well. Four soil borings (8611, 8612, 8613, and 8614) were completed within the limits of excavation (Figure 5-2) of the oil/water separator system and five borings (8615, 8616, 8617, 8618, and 8619) were completed outside the area of excavation. Both surface and subsurface soil samples were collected and analyzed. Field screening for TRPH using immunoassay techniques was done to determine appropriate sampling intervals.

Soil samples were analyzed for VOCs, SVOCs, TRPH, and TAL metals. Additionally, a groundwater sample was collected from Production Well No. 9 and analyzed for VOCs, SVOCs, herbicides, pesticide/PCBs, Appendix IX metals, and TRPH. Analytical results for the Phase III RFI soil samples and groundwater sample are summarized on Tables 5-1 and 5-2, respectively. The tables provide results for analytes which were detected at least once in the samples.

Low to moderate levels of TRPH (<1,000 mg/kg) were detected in surface soil and/or in backfill soil. Moderate to high concentrations of TRPH (>1,000 mg/kg) were detected in soils below the zone of backfill. Some VOCs and SVOCs were also detected below the zone of backfill. Below the zone of backfill, contaminant concentrations decreased with depth to nondetect levels. Maximum depth of detected contamination was 60 feet. Only low levels of metals, each considered to be within background, were detected in soil.

Bromoform, arsenic, barium, copper, and vanadium were detected in the groundwater sample collected from Base Well No. 9. Each was detected well below its respective published maximum contaminant level (MCL). Bromoform was detected below its EPA Region III Risk-Based Concentration (RBC) for tap water. Vanadium was the only metal detected above its background level, but was below its RBC for tap water.

The results of the microbiological analysis of soil samples are summarized in Table 5-3. Microbial plate count results were within the following ranges:

- Heterotrophic bacteria: $<1 \times 10^3$ CFU/g to 2.0×10^7 CFU/g
- Petroleum hydrocarbon degrading bacteria: $<1 \times 10^3$ CFU/g to 1.3×10^6 CFU/g
- Pseudomonas: $<1 \times 10^2$ CFU/g to 7.7×10^2 CFU/g

TABLE 5-1

SUMMARY OF CHEMICALS DETECTED IN THE SOIL SAMPLES COLLECTED AT SITE SD-11 (PHASE III RFI, 1995) CANNON AFB, NEW MEXICO

LOCATOR	CAN086-8611-0000			CAN086-8611-0004			CAN086-8611-0009			CAN086-8611-0014			CAN086-8611-0039			CAN086-8611-0049			CAN086-8611-0059			CAN086-8611-0069		
LAB SAMPLE NUMBER	0452880010SA			0452880011SA			0452880012SA			0452880013SA			0452880014SA			0452880015SA			0452880016SA			0452880017SA		
COLLECT DATE	10/18/95			10/18/95			10/18/95			10/18/95			10/19/95			10/19/95			10/19/95			10/19/95		
	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
Volatile Organics (µg/kg)																								
Acetone 129,000	<	11	U	<	90	U	<	240	U	<	1100	U	<	1100	U	<	12	U	<	11	U	<	10	U
2-Butanone (MEK)	<	11	U	12	11		33	28		<	1100	U	<	1100	U	<	12	U	<	11	U	<	10	U
Ethylbenzene	<	5.6	U	1.4	5.5	U	<	14	U	18000	570		7200	540		1.5	5.8	U	<	5.5	U	<	5.2	U
Methylene chloride	<	5.6	U	<	5.5	U	<	14	U	<	570	U	<	540	U	<	5.8	U	<	5.5	U	<	5.2	U
Toluene	<	5.6	U	<	5.5	U	<	14	U	<	570	U	300	540	J	<	5.8	U	<	5.5	U	<	5.2	U
Xylenes (total) 82,000	<	5.6	U	1.2	5.5	J	3	14	J	33000	570		22000	540		6.3	5.8		<	5.5	U	<	5.2	U
Semivolatile Organics (µg/kg)																								
Benzo(a)anthracene	41	370	J	44	360	J	<	370	U	<	3800	U	<	350	U	<	380	U	<	360	U	<	340	U
Benzo(a)pyrene	40	370	J	<	360	U	<	370	U	<	3800	U	<	350	U	<	380	U	<	360	U	<	340	U
Benzo(b)fluoranthene	64	370	J	75	360	J	50	370	J	<	3800	U	<	350	U	<	380	U	<	360	U	<	340	U
Benzo(g,h,i)perylene	<	370	U	<	360	U	<	370	U	<	3800	U	<	350	U	<	380	U	<	360	U	<	340	U
bis(2-Ethylhexyl)phthalate	<	370	U	<	360	U	<	370	U	<	3800	U	<	350	U	<	380	U	<	360	U	<	340	U
Chrysene	44	370	J	40	360	J	<	370	U	<	3800	U	<	350	U	<	380	U	<	360	U	<	340	U
Di-n-octyl phthalate	<	370	U	<	360	U	<	370	U	<	3800	U	<	350	U	<	380	U	<	360	U	<	340	U
Dibenzofuran	<	370	U	<	360	U	<	370	U	<	3800	U	<	350	U	<	380	U	<	360	U	<	340	U
Fluoranthene	70	370	J	90	360	J	56	370	J	<	3800	U	<	350	U	<	380	U	<	360	U	<	340	U
Indeno(1,2,3-cd)pyrene	<	370	U	<	360	U	<	370	U	<	3800	U	<	350	U	<	380	U	<	360	U	<	340	U
Isophorone	<	370	U	<	360	U	<	370	U	<	3800	U	<	350	U	<	380	U	<	360	U	<	340	U
2-Methylnaphthalene	<	370	U	190	360	J	110	370	J	18000	3800		3900	350		120	380	J	140	360	J	<	340	U
Naphthalene 79,500	<	370	U	79	360	J	<	370	U	11000	3800		2200	350		85	380	J	83	360	J	<	340	U
Phenanthrene	<	370	U	55	360	J	38	370	J	<	3800	U	<	350	U	<	380	U	<	360	U	<	340	U
Pyrene	61	370	J	69	360	J	48	370	J	<	3800	U	<	350	U	<	380	U	<	360	U	<	340	U

Results presented here are only those chemicals which were detected at least once at this site and have passed data review.
A complete summary of chemical results are presented in Appendix A.

J = Estimated value. Qual = Qualification
R = Rejected value. D = Sample was diluted for analysis.
U = Nondetected value. RL = Reporting Limit.

TABLE 5-1

SUMMARY OF CHEMICALS DETECTED IN THE SOIL SAMPLES COLLECTED AT SITE SD-11 (PHASE III RFI, 1995) CANNON AFB, NEW MEXICO

LOCATOR	CAN086-8611-0000			CAN086-8611-0004			CAN086-8611-0009			CAN086-8611-0014			CAN086-8611-0039			CAN086-8611-0049			CAN086-8611-0059			CAN086-8611-0069		
LAB SAMPLE NUMBER	0452880010SA			0452880011SA			0452880012SA			0452880013SA			0452880014SA			0452880015SA			0452880016SA			0452880017SA		
COLLECT DATE	10/18/95			10/18/95			10/18/95			10/18/95			10/19/95			10/19/95			10/19/95			10/19/95		
	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
Metals (mg/kg)																								
Aluminum	12500	11.2		11600	11		10600	11.1		6640	57		4500	10.7		3450	11.5		3880	10.9		1770	10.4	
Arsenic	2.2	1.1		2.3	1.1		2.8	0.56		1.4	1.1		0.9	0.54		0.54	0.58	J	0.78	0.55		0.56	0.52	
Barium	213	1.1	J	230	1.1	J	273	1.1	J	326	5.7	J	83	1.1	J	26.5	1.2	J	43.4	1.1	J	20.4	1	J
Beryllium	0.62	0.22		0.67	0.22		0.63	0.22		0.71	1.1	J	0.26	0.21		0.22	0.23	J	0.27	0.22		0.14	0.21	J
Calcium	49900	22.5		74200	22.1		64900	22.2		246000	114		82600	21.5		22400	23		73900	21.8		899	20.9	
Chromium	13.6	1.1		13.4	1.1		11.1	1.1		4.7	5.7	J	5.4	1.1		4	1.2		10.5	1.1		2.9	1	
Cobalt	4.1	1.1		4.3	1.1		3.8	1.1		<	5.7	U	1.6	1.1		1.4	1.2		2.1	1.1		<	1	U
Copper	7.5	2.2		7.7	2.2		6.4	2.2		2.3	11.4	J	2.6	2.1		1.5	2.3	J	9.5	2.2		1.3	2.1	J
Iron	10600	11.2		10100	11		9420	11.1		4660	57		3850	10.7		3740	11.5		3980	10.9		2370	10.4	
Lead	7.6	0.56		7.5	0.55		9	1.1		2.6	0.57		2	0.54		2	0.58		5.5	0.55		1.3	0.52	
Magnesium	2880	22.5		2820	22.1		2770	22.2		6050	114		4110	21.5		3730	23		5680	21.8		1430	20.9	
Manganese	173	1.1		204	1.1		143	1.1		105	5.7		37.1	1.1		42.9	1.2		48.7	1.1		18	1	
Mercury	<	0.11	U	<	0.11	U	<	0.11	U	<	0.11	U	<	0.11	U	<	0.12	U	<	0.11	U	<	0.1	U
Nickel	10.5	4.5		10.3	4.4		8.3	4.4		6.2	22.8	J	3.9	4.3	J	3.1	4.6	J	5.3	4.4		2.6	4.2	J
Potassium	2020	562		1900	552		1800	556		1970	2850	J	919	536		669	575		668	545		421	521	J
Sodium	<	562	U	204	552	J	<	556	U	<	2850	U	149	536	J	<	575	U	<	545	U	172	521	J
Thallium	<	0.56	UJ	<	1.1	UJ	<	1.1	UJ	<	1.1	UJ	<	1.1	UJ	<	0.58	UJ	<	1.1	UJ	<	0.52	UJ
Vanadium	24.2	1.1		22.9	1.1		22.2	1.1		12.4	5.7		9.6	1.1		10.8	1.2		13.9	1.1		6.5	1	
Zinc	33.6	2.2		29.5	2.2		27.6	2.2		12.1	11.4		7.7	2.1		7.1	2.3		14.4	2.2		4.2	2.1	
TPH (mg/kg)																								
Total Petroleum Hydrocarbons	523	44.9	J	551	44.2	J	866	44.5	J	5010	456	J	626	42.9	J	166	46	J	533	43.6	J	<	41.7	U

Results presented here are only those chemicals which were detected at least once at this site and have passed data review.
A complete summary of chemical results are presented in Appendix A.

J = Estimated value. Qual = Qualification
R = Rejected value. D = Sample was diluted for analysis.
U = Nondetected value. RL = Reporting Limit.

TABLE 5-1

SUMMARY OF CHEMICALS DETECTED IN THE SOIL SAMPLES COLLECTED AT SITE SD-11
(PHASE III RFI, 1995)
CANNON AFB, NEW MEXICO

LOCATOR	CAN086-8612-0000			CAN086-8612-0009			CAN086-8612-0014			CAN086-8612-0019			CAN086-8612-0029			CAN086-8612-0034			CAN086-8613-0000			CAN086-8613-0014		
LAB SAMPLE NUMBER	0452600005SA			0452880002SA			0452880003SA			0452880004SA			0452880008SA			0452880009SA			0452880007SA			0453180002SA		
COLLECT DATE	10/18/95			10/18/95			10/18/95			10/18/95			10/18/95			10/18/95			10/18/95			10/19/95		
	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
Volatile Organics (µg/kg)																								
Acetone	<	11	U	<	55	U	<	110	U	<	63	U	<	11	U	<	11	U	<	11	U	590	57	J
2-Butanone (MEK)	<	11	U	<	55	U	<	110	U	<	56	U	<	11	U	<	11	U	<	11	U	36	57	J
Ethylbenzene	<	5.7	U	<	28	U	<	56	U	<	28	U	<	5.6	U	<	5.5	U	<	5.5	U	480	29	J
Methylene chloride	<	5.7	U	<	28	U	<	56	U	<	28	U	<	5.6	U	<	5.5	U	<	5.5	U	<	29	U
Toluene	<	5.7	U	<	28	U	<	56	U	<	28	U	<	5.6	U	<	5.5	U	3	5.5	J	<	29	U
Xylenes (total)	<	5.7	U	<	28	U	<	56	U	<	28	U	<	5.6	U	<	5.5	U	<	5.5	U	540	29	J
Semivolatile Organics (µg/kg)																								
Benzo(a)anthracene	<	380	U	<	1500	U	<	370	U	<	370	U	<	370	U	<	360	U	94	360	J	<	3800	U
Benzo(a)pyrene	<	380	U	<	1500	U	<	370	U	<	370	U	<	370	U	<	360	U	98	360	J	<	3800	U
Benzo(b)fluoranthene	<	380	U	<	1500	U	<	370	U	<	370	U	<	370	U	<	360	U	160	360	J	<	3800	U
Benzo(g,h,i)perylene	<	380	U	<	1500	U	<	370	U	<	370	U	<	370	U	<	360	U	49	360	J	<	3800	U
bis(2-Ethylhexyl)phthalate	<	380	U	<	1500	U	<	370	U	<	370	U	<	370	U	<	360	U	<	360	U	<	3800	U
Chrysene	<	380	U	<	1500	U	<	370	U	<	370	U	<	370	U	<	360	U	110	360	J	<	3800	U
Di-n-octyl phthalate	<	380	U	<	1500	U	<	370	U	<	370	U	<	370	U	<	360	U	<	360	U	<	3800	U
Dibenzofuran	<	380	U	<	1500	U	<	370	U	<	370	U	<	370	U	<	360	U	<	360	U	<	3800	U
Fluoranthene	38	380	J	<	1500	U	<	370	U	<	370	U	<	370	U	<	360	U	150	360	J	<	3800	U
Indeno(1,2,3-cd)pyrene	<	380	U	<	1500	U	<	370	U	<	370	U	<	370	U	<	360	U	40	360	J	<	3800	U
Isophorone	<	380	U	<	1500	U	<	370	U	<	370	U	<	370	U	<	360	U	<	360	U	930	3800	J
2-Methylnaphthalene	<	380	U	<	1500	U	<	370	U	<	370	U	<	370	U	<	360	U	<	360	U	940	3800	J
Naphthalene	<	380	U	<	1500	U	<	370	U	<	370	U	<	370	U	<	360	U	<	360	U	760	3800	J
Phenanthrene	<	380	U	<	1500	U	<	370	U	<	370	U	<	370	U	<	360	U	57	360	J	<	3800	U
Pyrene	<	380	U	<	1500	U	<	370	U	<	370	U	<	370	U	<	360	U	110	360	J	<	3800	U

Results presented here are only those chemicals which were detected at least once at this site and have passed data review.
A complete summary of chemical results are presented in Appendix A.

J = Estimated value. Qual = Qualification
R = Rejected value. D = Sample was diluted for analysis.
U = Nondetected value. RL = Reporting Limit.

TABLE 5-1

SUMMARY OF CHEMICALS DETECTED IN THE SOIL SAMPLES COLLECTED AT SITE SD-11
(PHASE III RFI, 1995)
CANNON AFB, NEW MEXICO

LOCATOR	CAN086-8612-0000			CAN086-8612-0009			CAN086-8612-0014			CAN086-8612-0019			CAN086-8612-0029			CAN086-8612-0034			CAN086-8613-0000			CAN086-8613-0014		
LAB SAMPLE NUMBER	0452600005SA			0452880002SA			0452880003SA			0452880004SA			0452880008SA			0452880009SA			0452880007SA			0453180002SA		
COLLECT DATE	10/18/95			10/18/95			10/18/95			10/18/95			10/18/95			10/18/95			10/18/95			10/19/95		
	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
Metals (mg/kg)																								
Aluminum	11300	11.5		7080	22.1		6060	22.5		6540	22.3		5240	22.4		8020	11		10100	10.9		8080	22.8	
Arsenic	3	0.57		1.7	0.55		1.6	0.56		0.89	0.56		0.95	0.56		0.71	0.55		2	0.55		1.5	0.57	
Barium	215	1.1	J	327	2.2	J	189	2.3	J	129	2.2	J	685	2.2	J	40.9	1.1	J	410	1.1	J	297	2.3	J
Beryllium	0.47	0.23		0.59	0.44		0.49	0.45		0.39	0.45	J	0.24	0.45	J	0.31	0.22		0.58	0.22		0.45	0.46	J
Calcium	75100	22.9		126000	44.2		218000	45.1		159000	44.6		147000	44.7		65300	22.1		71400	21.8		199000	45.6	
Chromium	9.5	1.1		5.3	2.2		4.3	2.3		6	2.2		4.9	2.2		6.5	1.1		13.3	1.1		8.1	2.3	
Cobalt	3.6	1.1		2.7	2.2		<	2.3	U	<	2.2	U	<	2.2	U	1.3	1.1		3.7	1.1		2.4	2.3	
Copper	6.6	2.3		2.5	4.4	J	1.6	4.5	J	1.2	4.5	J	1.9	4.5	J	1.7	2.2	J	7.5	2.2		4.3	4.6	J
Iron	9250	11.5		4940	22.1		4330	22.5		4430	22.3		3470	22.4		5260	11		9520	10.9		5800	22.8	
Lead	8.5	2.9		5.1	0.55		3.5	0.56		2.8	0.56		1.9	0.56		2.9	0.55		8	1.1	J	3.7	0.57	
Magnesium	2770	22.9		3580	44.2		4000	45.1		5230	44.6		13200	44.7		8250	22.1		2590	21.8	J	4900	45.6	
Manganese	205	1.1		60.7	2.2		39.2	2.3		32.8	2.2		27.7	2.2		35.6	1.1		175	1.1		160	2.3	
Mercury	<	0.11	U	<	0.11	U	<	0.11	U	<	0.11	U	<	0.11	U	<	0.11	U	<	0.11	U	<	0.11	U
Nickel	9	4.6		5.3	8.8	J	3.8	9	J	3.6	8.9	J	6.1	8.9	J	5.1	4.4		9.8	4.4		8.4	9.1	J
Potassium	1950	573		1450	1100		1400	1130		1390	1120		1000	1120	J	1320	552		1740	545		1810	1140	
Sodium	<	573	U	<	1100	U	<	1130	U	<	1120	U	<	1120	U	<	552	U	<	545	U	<	1140	U
Thallium	0.13	0.57	J	<	1.1	UJ	<	1.1	UJ	<	1.1	UJ	<	1.1	UJ	<	1.1	UJ	<	1.1	UJ	<	1.1	UJ
Vanadium	19.6	1.1		12.2	2.2		12.3	2.3		12.8	2.2		15.9	2.2		15.5	1.1		21.8	1.1		19.1	2.3	
Zinc	26.1	2.3		13.7	4.4		11.8	4.5		10.9	4.5		7.4	4.5		10.7	2.2		38.3	2.2		16.2	4.6	
TPH (mg/kg)																								
Total Petroleum Hydrocarbons	280	45.9		5390	442	J	3230	225	J	889	44.6	J	<	44.7	U	<	44.2	U	553	43.6	J	5270	456	

Results presented here are only those chemicals which were detected at least once at this site and have passed data review.
A complete summary of chemical results are presented in Appendix A.

J = Estimated value. Qual = Qualification
R = Rejected value. D = Sample was diluted for analysis.
U = Nondetected value. RL = Reporting Limit.

TABLE 5-1

SUMMARY OF CHEMICALS DETECTED IN THE SOIL SAMPLES COLLECTED AT SITE SD-11
(PHASE III RFI, 1995)
CANNON AFB, NEW MEXICO

LOCATOR	CAN086-8613-0024			CAN086-8613-0034			CAN086-8613-0049			CAN086-8613-0064			CAN086-8614-0000			CAN086-8614-0009			CAN086-8614-0029			CAN086-8614-0034		
LAB SAMPLE NUMBER	0453180003SA			0453180004SA			0453180005SA			0453180006SA			0452600001SA			0452600002SA			0452600003SA			0452600004SA		
COLLECT DATE	10/19/95			10/19/95			10/20/95			10/20/95			10/17/95			10/17/95			10/17/95			10/17/95		
	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
Volatile Organics (µg/kg)																								
Acetone	130	27		240	58		<	11	U	<	11	U	<	14	U	<	14	U	<	17	U	<	11	U
2-Butanone (MEK)	20	27	J	51	58	J	<	11	U	<	11	U	<	11	U	<	11	U	<	11	U	<	11	U
Ethylbenzene	150	14		180	29		<	5.4	U	<	5.5	U	<	5.5	U	<	5.5	U	<	5.5	U	<	5.5	U
Methylene chloride	3.2	14	J	<	29	U	<	5.4	U	<	5.5	U	<	5.5	U	<	5.5	U	<	5.5	U	<	5.5	U
Toluene	<	14	U	<	29	U	<	5.4	U	<	5.5	U	<	5.5	U	<	5.5	U	<	5.5	U	<	5.5	U
Xylenes (total)	200	14		400	29		<	5.4	U	<	5.5	U	<	5.5	U	<	5.5	U	<	5.5	U	<	5.5	U
Semivolatile Organics (µg/kg)																								
Benzo(a)anthracene	<	720	U	<	760	U	<	360	U	<	360	U	200	360	J	<	360	U	<	360	U	<	360	U
Benzo(a)pyrene	<	720	U	<	760	U	<	360	U	<	360	U	270	360	J	<	360	U	<	360	U	<	360	U
Benzo(b)fluoranthene	<	720	U	<	760	U	<	360	U	<	360	U	440	360		<	360	U	<	360	U	<	360	U
Benzo(g,h,i)perylene	<	720	U	<	760	U	<	360	U	<	360	U	110	360	J	<	360	U	<	360	U	<	360	U
bis(2-Ethylhexyl)phthalate	<	720	U	<	760	U	<	360	U	<	360	U	<	360	U	<	360	U	<	360	U	<	360	U
Chrysene	<	720	U	<	760	U	<	360	U	<	360	U	260	360	J	<	360	U	<	360	U	<	360	U
Di-n-octyl phthalate	<	720	U	<	760	U	<	360	U	<	360	U	<	360	U	<	360	U	<	360	U	<	360	U
Dibenzofuran	<	720	U	150	760	J	<	360	U	<	360	U	<	360	U	<	360	U	<	360	U	<	360	U
Fluoranthene	<	720	U	<	760	U	<	360	U	<	360	U	210	360	J	<	360	U	<	360	U	<	360	U
Indeno(1,2,3-cd)pyrene	<	720	U	<	760	U	<	360	U	<	360	U	89	360	J	<	360	U	<	360	U	<	360	U
Isophorone	<	720	U	<	760	U	<	360	U	<	360	U	<	360	U	<	360	U	<	360	U	<	360	U
2-Methylnaphthalene	2600	720		4800	760		<	360	U	<	360	U	<	360	U	<	360	U	<	360	U	<	360	U
Naphthalene	970	720		1500	760		<	360	U	<	360	U	<	360	U	<	360	U	<	360	U	<	360	U
Phenanthrene	<	720	U	<	760	U	<	360	U	<	360	U	56	360	J	<	360	U	<	360	U	<	360	U
Pyrene	<	720	U	<	760	U	<	360	U	<	360	U	260	360	J	<	360	U	<	360	U	<	360	U

Results presented here are only those chemicals which were detected at least once at this site and have passed data review.

A complete summary of chemical results are presented in Appendix A.

J = Estimated value. Qual = Qualification

R = Rejected value. D = Sample was diluted for and D = Sample was diluted for analysis.

U = Nondetected value. RL = Reporting Limit. RL = Reporting Limit.

TABLE 5-1

SUMMARY OF CHEMICALS DETECTED IN THE SOIL SAMPLES COLLECTED AT SITE SD-11
(PHASE III RFI, 1995)
CANNON AFB, NEW MEXICO

LOCATOR	CAN086-8613-0024			CAN086-8613-0034			CAN086-8613-0049			CAN086-8613-0064			CAN086-8614-0000			CAN086-8614-0009			CAN086-8614-0029			CAN086-8614-0034		
LAB SAMPLE NUMBER	0453180003SA			0453180004SA			0453180005SA			0453180006SA			0452600001SA			0452600002SA			0452600003SA			0452600004SA		
COLLECT DATE	10/19/95			10/19/95			10/20/95			10/20/95			10/17/95			10/17/95			10/17/95			10/17/95		
	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
Metals (mg/kg)																								
Aluminum	6830	11		6880	11.5		3690	10.9		3440	10.9		11700	11		8840	11		3760	22.1		6150	11	
Arsenic	1	0.55		1	0.58		<	3.3	U	<	3.3	U	2.8	0.55	J	2	0.55	J	1.2	0.55	J	1.1	0.55	J
Barium	176	1.1	J	193	1.2	J	58.7	1.1	J	24.5	1.1	J	253	1.1	J	463	1.1	J	67.4	2.2	J	1260	1.1	J
Beryllium	0.26	0.22		0.19	0.23	J	0.14	0.22	J	0.14	0.22	J	0.53	0.22		0.5	0.22		0.22	0.44	J	0.2	0.22	J
Calcium	34400	21.9		115000	23		55600	21.7		7600	21.8		56400	22		103000	22.1		168000	44.2		39100	22	
Chromium	4.9	1.1		6	1.2		3.5	1.1		3.6	1.1				R			R			R			R
Cobalt	1.4	1.1		1.5	1.2		<	1.1	U	1.2	1.1		4.1	1.1		2.6	1.1		<	2.2	U	<	1.1	U
Copper	1.9	2.2	J	2.4	2.3		1.1	2.2	J	1.5	2.2	J	7.3	2.2		4.2	2.2		<	4.4	U	1.9	2.2	J
Iron	5240	11		4020	11.5		3510	10.9		4280	10.9		10200	11		5980	11		2690	22.1		5030	11	
Lead	3.1	0.55		2.5	0.58		2	0.54		2	0.55		4.6	1.1		3.3	0.55		1.4	0.55		2.3	1.1	
Magnesium	3120	21.9		12700	23		5540	21.7		2970	21.8		2680	22		3120	22.1		5930	44.2		3650	22	
Manganese	34.2	1.1		30.5	1.2		44.6	1.1		57.8	1.1		191	1.1	J	95.3	1.1	J	23.8	2.2	J	48	1.1	J
Mercury	<	0.11	U	<	0.12	U	<	0.11	U	<	0.11	U	<	0.11	U	<	0.11	U	<	0.11	U	<	0.11	U
Nickel	4.2	4.4	J	4.3	4.6	J	2.6	4.3	J	2.4	4.4	J	9.3	4.4		6	4.4		2.8	8.8	J	4.5	4.4	
Potassium	1490	548		1390	576		715	543		675	545		2030	550		1600	552		672	1110	J	1550	550	
Sodium	<	548	U	<	576	U	<	543	U	<	545	U	<	550	U	<	552	U	<	1110	U	<	550	U
Thallium	<	0.55	UJ	<	1.2	UJ	<	0.54	UJ	<	0.55	UJ	0.18	1.1	J	0.17	1.1	J	0.12	1.1	J	0.11	1.1	J
Vanadium	12.6	1.1		15	1.2		11	1.1		12.7	1.1		21.1	1.1		14.4	1.1		14.7	2.2		13.1	1.1	
Zinc	10.9	2.2		7	2.3		6.3	2.2		6.7	2.2		29.3	2.2		15.2	2.2		7.7	4.4		10.9	2.2	
TPH (mg/kg)																								
Total Petroleum Hydrocarbons	497	43.8		786	46.1		<	43.4	U	<	43.6	U	363	44		<	44.2	U	<	44.2	U	<	44	U

Results presented here are only those chemicals which were detected at least once at this site and have passed data review.
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J = Estimated value. Qual = Qualification
R = Rejected value. D = Sample was diluted for andD = Sample was diluted for analysis.
U = Nondetected value. RL = Reporting Limit. RL = Reporting Limit.

TABLE 5-1

SUMMARY OF CHEMICALS DETECTED IN THE SOIL SAMPLES COLLECTED AT SITE SD-11 (PHASE III RFI, 1995) CANNON AFB, NEW MEXICO

LOCATOR	CAN086-8615-0001			CAN086-8615-0029			CAN086-8615-0034			CAN086-8616-0000			CAN086-8616-0029			CAN086-8616-0034			CAN086-8617-0000			CAN086-8617-0029		
LAB SAMPLE NUMBER	0453180007SA			0453180008SA			0453180009SA			0453390001SA			0453390002SA			0453390003SA			0453390004SA			0453390005SA		
COLLECT DATE	10/20/95			10/20/95			10/20/95			10/21/95			10/21/95			10/21/95			10/21/95			10/21/95		
	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
Volatile Organics (µg/kg)																								
Acetone	<	11	U	<	11	U	<	11	U	<	11	U	<	11	U	<	11	U	<	11	U	<	11	U
2-Butanone (MEK)	<	11	U	<	11	U	<	11	U	<	11	U	<	11	U	<	11	U	<	11	U	<	11	U
Ethylbenzene	<	5.7	U	<	5.5	U	<	5.4	U	<	5.7	U	<	5.6	U	<	5.7	U	<	5.6	U	<	5.5	U
Methylene chloride	<	5.7	U	<	5.5	U	<	5.4	U	<	5.7	U	<	5.6	U	<	5.7	U	<	5.6	U	<	5.5	U
Toluene	<	5.7	U	4.6	5.5	J	<	5.4	U	<	5.7	U	1.6	5.6	J	<	5.7	U	<	5.6	U	<	5.5	U
Xylenes (total)	<	5.7	U	<	5.5	U	<	5.4	U	<	5.7	U	<	5.6	U	<	5.7	U	<	5.6	U	<	5.5	U
Semivolatile Organics (µg/kg)																								
Benzo(a)anthracene	<	380	U	<	360	U	<	360	U	<	370	U	<	370	U	<	370	U	<	370	U	<	360	U
Benzo(a)pyrene	<	380	U	<	360	U	<	360	U	<	370	U	<	370	U	<	370	U	<	370	U	<	360	U
Benzo(b)fluoranthene	<	380	U	<	360	U	<	360	U	<	370	U	<	370	U	<	370	U	<	370	U	<	360	U
Benzo(g,h,i)perylene	<	380	U	<	360	U	<	360	U	<	370	U	<	370	U	<	370	U	<	370	U	<	360	U
bis(2-Ethylhexyl)phthalate	<	380	U	<	360	U	<	360	U	<	370	U	<	370	U	<	370	U	<	370	U	<	360	U
Chrysene	<	380	U	<	360	U	<	360	U	<	370	U	<	370	U	<	370	U	<	370	U	<	360	U
Di-n-octyl phthalate	<	380	U	<	360	U	<	360	U	<	370	U	<	370	U	<	370	U	<	370	U	<	360	U
Dibenzofuran	<	380	U	<	360	U	<	360	U	<	370	U	<	370	U	<	370	U	<	370	U	<	360	U
Fluoranthene	<	380	U	<	360	U	<	360	U	<	370	U	<	370	U	<	370	U	<	370	U	<	360	U
Indeno(1,2,3-cd)pyrene	<	380	U	<	360	U	<	360	U	<	370	U	<	370	U	<	370	U	<	370	U	<	360	U
Isophorone	<	380	U	<	360	U	<	360	U	<	370	U	<	370	U	<	370	U	<	370	U	<	360	U
2-Methylnaphthalene	<	380	U	<	360	U	<	360	U	<	370	U	<	370	U	<	370	U	<	370	U	<	360	U
Naphthalene	<	380	U	<	360	U	<	360	U	<	370	U	<	370	U	<	370	U	<	370	U	<	360	U
Phenanthrene	<	380	U	<	360	U	<	360	U	<	370	U	<	370	U	<	370	U	<	370	U	<	360	U
Pyrene	<	380	U	<	360	U	<	360	U	<	370	U	<	370	U	<	370	U	<	370	U	<	360	U

Results presented here are only those chemicals which were detected at least once at this site and have passed data review.
A complete summary of chemical results are presented in Appendix A.

J = Estimated value.
R = Rejected value.
U = Nondetected value.
Qual = Qualification
D = Sample was diluted for analysis.
RL = Reporting Limit.

TABLE 5-1

SUMMARY OF CHEMICALS DETECTED IN THE SOIL SAMPLES COLLECTED AT SITE SD-11 (PHASE III RFI, 1995) CANNON AFB, NEW MEXICO

LOCATOR	CAN086-8615-0001			CAN086-8615-0029			CAN086-8615-0034			CAN086-8616-0000			CAN086-8616-0029			CAN086-8616-0034			CAN086-8617-0000			CAN086-8617-0029		
LAB SAMPLE NUMBER	0453180007SA			0453180008SA			0453180009SA			0453390001SA			0453390002SA			0453390003SA			0453390004SA			0453390005SA		
COLLECT DATE	10/20/95			10/20/95			10/20/95			10/21/95			10/21/95			10/21/95			10/21/95			10/21/95		
	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
Metals (mg/kg)																								
Aluminum	12000	11.5		6280	11		5990	10.9		8770	11.3		4430	22.5		5420	11.3		10700	11.1		3730	22	
Arsenic	2.5	0.57		1.4	0.55		1	0.54		2.4	0.57		0.78	0.56		0.69	0.57		2.6	1.1		0.89	0.55	
Barium	78.6	1.1	J	260	1.1	J	110	1.1	J	86.1	1.1	J	931	2.2	J	63.6	1.1	J	145	1.1	J	90.9	2.2	J
Beryllium	0.58	0.23		0.23	0.22		0.19	0.22	J	0.53	0.23		<	0.45	U	0.19	0.23	J	0.55	0.22		<	0.44	U
Calcium	1940	23		80300	22.1		83000	21.7		6370	22.6	J	153000	45	J	108000	22.7	J	20900	22.3		167000	44	
Chromium	11.2	1.1		4.8	1.1		4.3	1.1		8.8	1.1		3.6	2.2		5.7	1.1		9.7	1.1		7.1	2.2	
Cobalt	4.4	1.1		2.4	1.1		<	1.1	U	4.5	1.1		<	2.2	U	1.7	1.1		4.9	1.1		1.8	2.2	J
Copper	8.2	2.3		2	2.2	J	1.4	2.2	J	6.9	2.3		1.6	4.5	J	1.6	2.3	J	9.2	2.2		9.6	4.4	
Iron	11800	11.5		4670	11		4120	10.9		9400	11.3		2800	22.5		3260	11.3		10400	11.1		2620	22	
Lead	8.3	0.57		3	0.55		2.4	0.54		5.7	0.57		1.7	0.56		2	0.57		8.7	0.56		1.8	0.55	
Magnesium	1780	23		5070	22.1		6480	21.7		1650	22.6		9970	45		9670	22.7		2100	22.3		8610	44	
Manganese	183	1.1		47.7	1.1		27.3	1.1		199	1.1		25	2.2		30.3	1.1		214	1.1		37.9	2.2	
Mercury	<	0.11	U	<	0.11	U	<	0.11	U	<	0.11	U	<	0.11	U	<	0.11	U	<	0.11	U	<	0.11	U
Nickel	9.2	4.6		4.7	4.4		3.8	4.3	J	9.5	4.5		4.5	9	J	5.2	4.5		9.4	4.5		6.1	8.8	J
Potassium	1950	575		1520	551		1190	543		1630	566		667	1120	J	959	567		1820	557		629	1100	J
Sodium	<	575	U	<	551	U	<	543	U	<	566	U	<	1120	U	<	567	U	<	557	U	<	1100	U
Thallium	0.18	0.57	J	<	1.1	UJ	<	0.54	UJ	<	0.57	UJ	<	2.2	UJ	<	1.1	UJ	0.14	0.56	J	<	2.2	UJ
Vanadium	24.1	1.1		11.8	1.1		10.1	1.1		21.1	1.1		14.8	2.2		13.5	1.1		21.6	1.1		10.2	2.2	
Zinc	24.8	2.3		10.5	2.2		8	2.2		20.6	2.3		8.3	4.5		6.5	2.3		22.1	2.2		6.3	4.4	
TPH (mg/kg)																								
Total Petroleum Hydrocarbons	<	46	U	<	44.1	U	<	43.4	U	<	45.3	U	<	45	U	<	45.3	U	<	44.6	U	<	44	U

Results presented here are only those chemicals which were detected at least once at this site and have passed data review.

A complete summary of chemical results are presented in Appendix A.

J = Estimated value.
R = Rejected value.
U = Nondetected value.
Qual = Qualification
D = Sample was diluted for analysis.
RL = Reporting Limit.

TABLE 5-1

SUMMARY OF CHEMICALS DETECTED IN THE SOIL SAMPLES COLLECTED AT SITE SD-11 (PHASE III RFI, 1995) CANNON AFB, NEW MEXICO

LOCATOR	CAN086-8617-0034			CAN086-8618-0000			CAN086-8618-0029			CAN086-8618-0034			CAN086-8619-0000			CAN086-8619-0029			CAN086-8619-0034		
LAB SAMPLE NUMBER	0453390006SA			0453690004SA			0453690005SA			0453690006SA			0453690007SA			0453690008SA			0453690009SA		
COLLECT DATE	10/21/95			10/23/95			10/23/95			10/23/95			10/24/95			10/24/95			10/24/95		
	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
Volatile Organics (µg/kg)																					
Acetone	<	11	U	<	11	U	<	11	U	<	11	U	<	11	U	<	12	U	<	11	U
2-Butanone (MEK)	<	11	U	<	11	U	<	11	U	<	11	U	<	11	U	<	12	U	<	11	U
Ethylbenzene	<	5.6	U	<	5.7	U	<	5.6	U	<	5.6	U	<	5.3	U	<	5.8	U	<	5.5	U
Methylene chloride	<	5.6	U	<	5.7	U	<	5.6	U	<	5.6	U	<	5.3	U	<	5.8	U	<	5.5	U
Toluene	<	5.6	U	<	5.7	U	<	5.6	U	<	5.6	U	<	5.3	U	<	5.8	U	<	5.5	U
Xylenes (total)	<	5.6	U	<	5.7	U	<	5.6	U	<	5.6	U	1.1	5.3	J	<	5.8	U	<	5.5	U
Semivolatile Organics (µg/kg)																					
Benzo(a)anthracene	<	370	U	<	370	U	<	370	U	<	370	U	<	350	U	<	380	U	<	360	U
Benzo(a)pyrene	<	370	U	<	370	U	<	370	U	<	370	U	<	350	U	<	380	U	<	360	U
Benzo(b)fluoranthene	<	370	U	<	370	U	<	370	U	<	370	U	<	350	U	<	380	U	<	360	U
Benzo(g,h,i)perylene	<	370	U	<	370	U	<	370	U	<	370	U	<	350	U	<	380	U	<	360	U
bis(2-Ethylhexyl)phthalate	<	370	U	<	370	UJ	<	370	U	<	370	U	<	350	U	<	380	U	<	360	U
Chrysene	<	370	U	<	370	U	<	370	U	<	370	U	<	350	U	<	380	U	<	360	U
Di-n-octyl phthalate	<	370	U	<	370	UJ	<	370	U	<	370	U	<	350	U	<	380	U	<	360	U
Dibenzofuran	<	370	U	<	370	U	<	370	U	<	370	U	<	350	U	<	380	U	<	360	U
Fluoranthene	<	370	U	<	370	U	<	370	U	<	370	U	<	350	U	<	380	U	<	360	U
Indeno(1,2,3-cd)pyrene	<	370	U	<	370	U	<	370	U	<	370	U	<	350	U	<	380	U	<	360	U
Isophorone	<	370	U	<	370	U	<	370	U	<	370	U	<	350	U	<	380	U	<	360	U
2-Methylnaphthalene	<	370	U	<	370	U	<	370	U	<	370	U	<	350	U	<	380	U	<	360	U
Naphthalene	<	370	U	<	370	U	<	370	U	<	370	U	<	350	U	<	380	U	<	360	U
Phenanthrene	<	370	U	<	370	U	<	370	U	<	370	U	<	350	U	<	380	U	<	360	U
Pyrene	<	370	U	<	370	U	<	370	U	<	370	U	<	350	U	<	380	U	<	360	U

Results presented here are only those chemicals which were detected at least once at this site and have passed data review.

A complete summary of chemical results are presented in Appendix A.

J = Estimated value. Qual = Qualification

R = Rejected value. D = Sample was diluted for analysis.

U = Nondetected value. RL = Reporting Limit.

TABLE 5-1

SUMMARY OF CHEMICALS DETECTED IN THE SOIL SAMPLES COLLECTED AT SITE SD-11 (PHASE III RFI, 1995) CANNON AFB, NEW MEXICO

LOCATOR	CAN086-8617-0034			CAN086-8618-0000			CAN086-8618-0029			CAN086-8618-0034			CAN086-8619-0000			CAN086-8619-0029			CAN086-8619-0034		
LAB SAMPLE NUMBER	0453390006SA			0453690004SA			0453690005SA			0453690006SA			0453690007SA			0453690008SA			0453690009SA		
COLLECT DATE	10/21/95			10/23/95			10/23/95			10/23/95			10/24/95			10/24/95			10/24/95		
	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
Metals (mg/kg)																					
Aluminum	5090	11.2		10200	11.3		4100	22.6		5820	11.1		7790	10.6		4090	23.1		5500	22	
Arsenic	0.78	1.1	J	2.5	0.57		0.78	0.56		0.77	0.56		2.2	0.53		0.69	0.58		0.84	1.1	J
Barium	53.7	1.1	J	177	1.1	J	129	2.3	J	131	1.1	J	129	1.1	J	289	2.3	J	124	2.2	J
Beryllium	<	0.22	U	0.56	0.23		<	0.45	U	0.26	0.22		0.42	0.21		<	0.46	U	<	0.44	U
Calcium	103000	22.4		64100	22.6		206000	45.2		68900	22.2		32700	21.3		205000	46.3		140000	44.1	
Chromium	3.7	1.1		8.8	1.1		9.7	2.3		4.1	1.1		8	1.1		3.4	2.3		3.5	2.2	
Cobalt	1.4	1.1		3.6	1.1		<	2.3	U	1.4	1.1		2.9	1.1		1.7	2.3	J	2	2.2	J
Copper	<	2.2	U	6.6	2.3		2.4	4.5	J	1.6	2.2	J	5.4	2.1		2	4.6	J	1.4	4.4	J
Iron	3330	11.2		8960	11.3		3010	22.6		4160	11.1		7500	10.6		2420	23.1		3370	22	
Lead	2.2	0.56		5.5	1.1		1.5	0.56		2.6	0.56		10.1	1.1		1.4	0.58		1.8	0.55	
Magnesium	8140	22.4		2900	22.6		6240	45.2		5040	22.2		1760	21.3		13400	46.3		9000	44.1	
Manganese	30.1	1.1		109	1.1		28.1	2.3		34.2	1.1		130	1.1		22.6	2.3		41.6	2.2	
Mercury	<	0.11	U	<	0.11	U	<	0.11	U	<	0.11	U	<	0.11	U	<	0.12	U	<	0.11	U
Nickel	4.5	4.5		9.9	4.5		4.9	9	J	4.7	4.4		7.3	4.3		4.8	9.3	J	4.6	8.8	J
Potassium	879	559		1700	565		690	1130	J	1290	555		1430	532		634	1160	J	962	1100	J
Sodium	<	559	U	<	565	U	<	1130	U	<	555	U	<	532	U	<	1160	U	<	1100	U
Thallium	<	2.2	UJ	<	1.1	UJ	<	2.3	UJ	<	1.1	UJ	<	0.53	UJ	<	2.3	UJ	<	2.2	UJ
Vanadium	13.7	1.1		19.4	1.1		13.7	2.3		10.4	1.1		16.2	1.1		14.5	2.3		11.7	2.2	
Zinc	6.6	2.2		19.1	2.3		10	4.5		8.1	2.2		23.9	2.1		9.8	4.6		7.5	4.4	
TPH (mg/kg)																					
Total Petroleum Hydrocarbons	<	44.7	U	81.2	45.2		<	45.2	U	<	44.4	U	83.9	42.6		<	46.3	U	<	44.1	U

Results presented here are only those chemicals which were detected at least once at this site and have passed data review.
A complete summary of chemical results are presented in Appendix A.

J = Estimated value.
R = Rejected value.
U = Nondetected value.
Qual = Qualification
D = Sample was diluted for analysis.
RL = Reporting Limit.

TABLE 5-2

SUMMARY OF CHEMICALS DETECTED IN THE GROUNDWATER SAMPLE AT SITE SD-11 (PHASE III RFI, 1995) CANNON AFB, NEW MEXICO

LOCATOR	CAN086-86W9-2001		
LAB SAMPLE NUMBER	0453690001SA		
COLLECT DATE	10/24/95		
	Result	RL	Qual
Volatile Organics (µg/L)			
Bromoform	1.3	5	J
Metals (µg/L)			
Arsenic	5.5	5	
Barium	32	10	
Copper	9.1	20	J
Vanadium	37	5	

Results presented here are only those chemicals which were detected at least once at this site and have passed data review.

A complete summary of chemical results are presented in Appendix A.

J = Estimated value
RL = Reporting Limit
Qual = Qualification

TABLE 5-3

RESULTS OF MICROBIOLOGICAL ANALYSIS AT SITE SD-11
(PHASE III RFI, 1995)
CANNON AFB, NEW MEXICO

Sample Location	Sample Identification	Sample Depth (ft)	Sample Date	Microbial Plate Count: Heterotrophic Bacteria[1] (CFU/g)	Microbial Plate Count: Petroleum Hydrocarbon Degrading Bacteria[2] (CFU/g)	Microbial Plate Count: *Pseudomonas*[3] (CFU/g)	Moisture Content[4] (percent)
8611	CAN086-8611-0007	7-8	10/18/95	2.0×10^7	1.1×10^6 *	7.7×10^2	12
	CAN086-8611-0011	11-12	10/18/95	3.9×10^6	1.2×10^6**	$<1 \times 10^2$	11
	CAN086-8611-0016	15.3-16.3	10/18/95	$<1 \times 10^3$	$<1 \times 10^3$	$<1 \times 10^2$	16
	CAN086-8611-0040	40-41	10/19/95	$<1 \times 10^3$	$<1 \times 10^3$	$<1 \times 10^2$	7
	CAN086-8611-0051	50.5-51.5	10/19/95	3.4×10^6	1.3×10^6	$<1 \times 10^2$	14
	CAN086-8611-0071	70.3-71.3	10/19/95	$<1 \times 10^3$	$<1 \times 10^3$	$<1 \times 10^2$	5

[1] Determined according to "Methods of Soil Analysis" 37-5.2 and 37-8.1.1

[2] Enumerated on mineral medium with gasoline and diesel fuel (2500 mg/L) as the only carbon sources

[3] Determined according to "Methods of Soil Analysis" 37-5.2 and 37-8.3.5 (modified)

[4] Determined gravimetrically using Standard Method 2540B

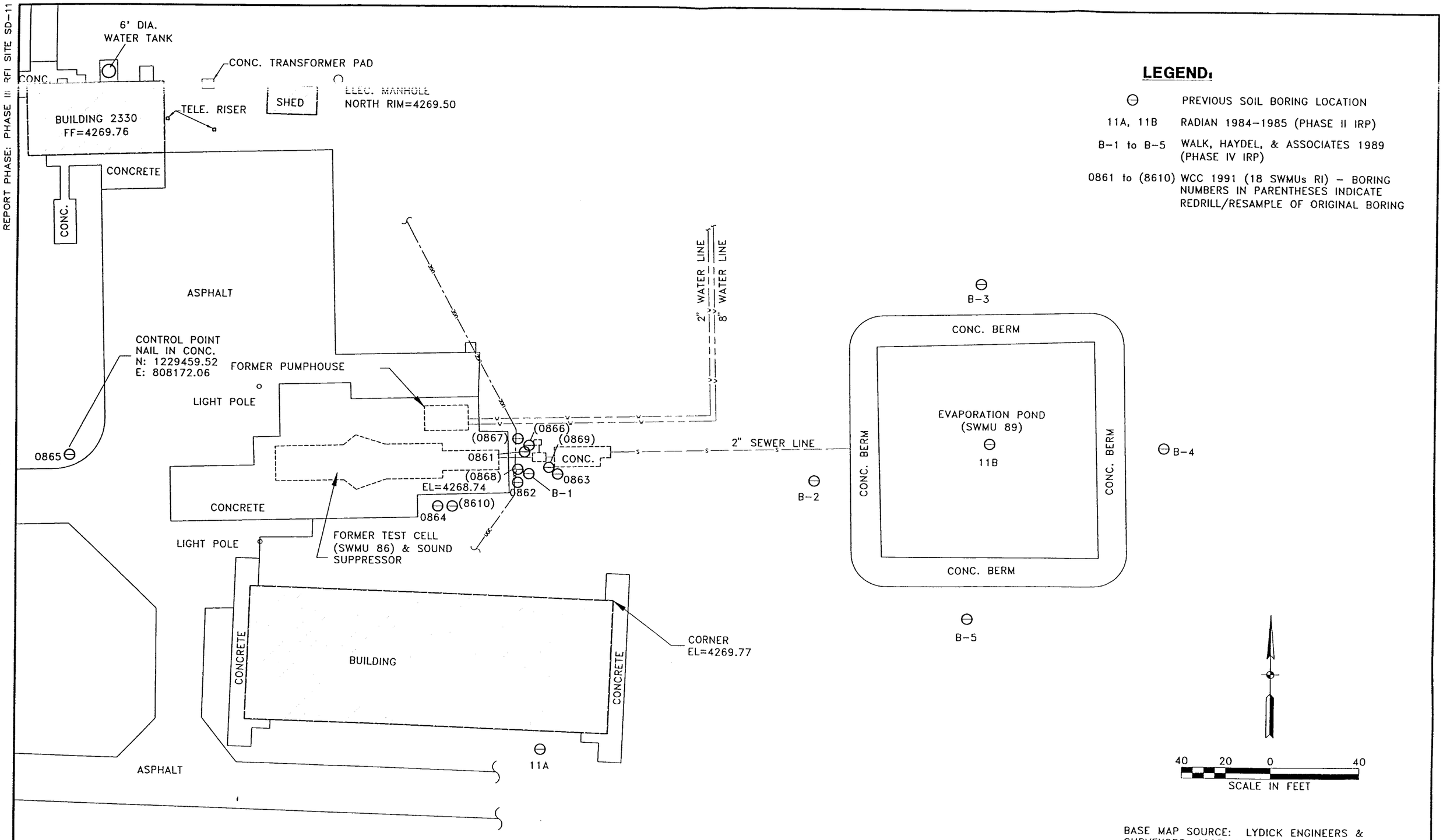
ft = feet

CFU/g = Colony Forming Units per gram of dry weight of soil

* Over 15% were actinomycetes.

** Approximately 10% were actinomycetes.

REPORT PHASE: PHASE III RFI SITE SD-11



LEGEND:

⊖	PREVIOUS SOIL BORING LOCATION
11A, 11B	RADIAN 1984-1985 (PHASE II IRP)
B-1 to B-5	WALK, HAYDEL, & ASSOCIATES 1989 (PHASE IV IRP)
0861 to (8610)	WCC 1991 (18 SWMUs RI) - BORING NUMBERS IN PARENTHESES INDICATE REDRILL/RESAMPLE OF ORIGINAL BORING

BASE MAP SOURCE: LYDICK ENGINEERS & SURVEYORS, 1993, 1995

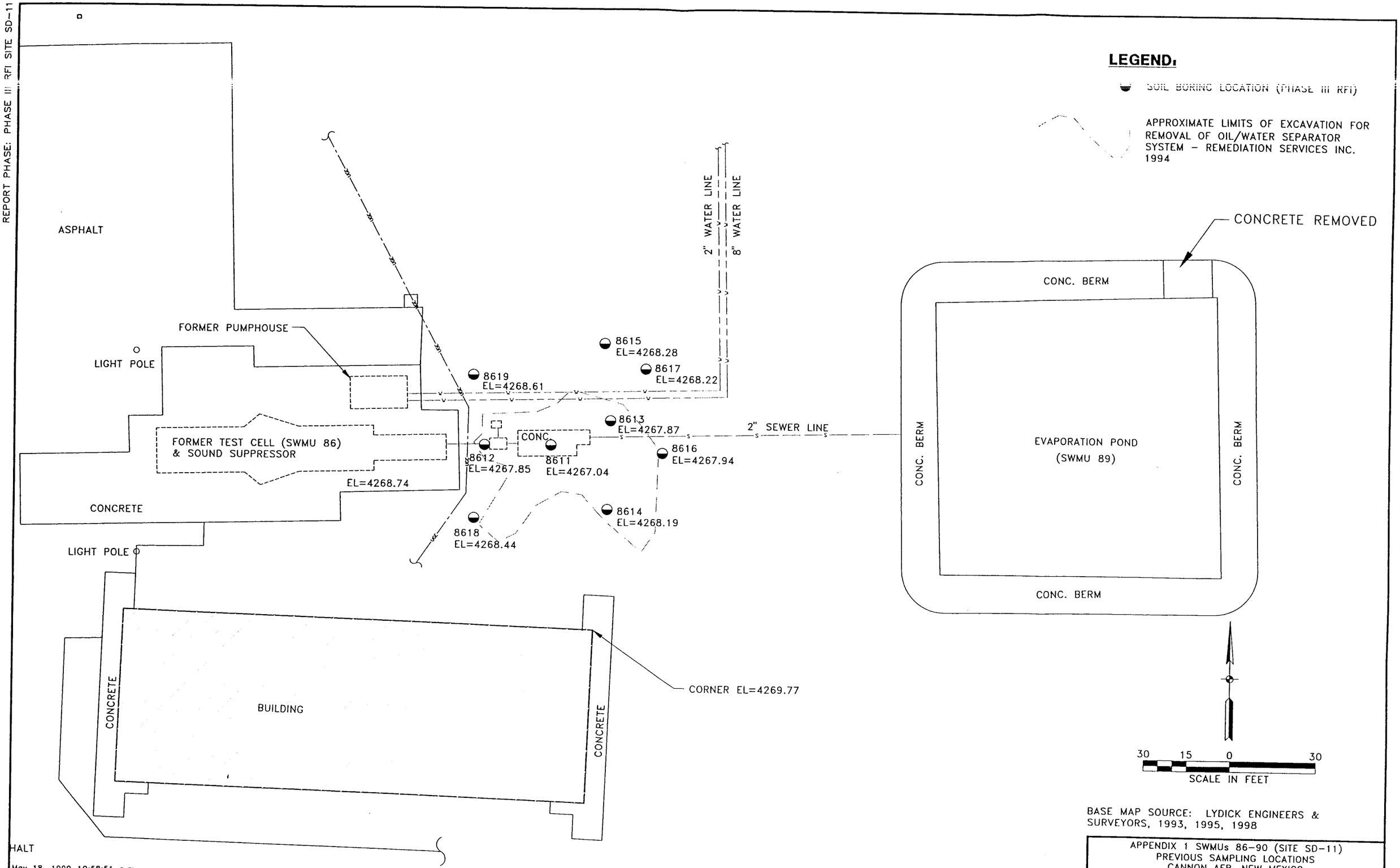
May 18, 1999 10:57:28 a.m.
Drawing: T:\CANNON\M9602V\T6500\FIG5-1.DWG (TSM)

NOTE: LOCATION OF UNDERGROUND UTILITY LINES SHOWN ARE APPROXIMATE.

APPENDIX 1 SWMUs 86-90 (SITE SD-11)
PREVIOUS SAMPLING LOCATIONS
CANNON AFB, NEW MEXICO

DRN. BY: JWB	DATE: 05/18/99	PROJECT NO.	FIG. NO.
CHK'D. BY:	REVISION: 0	45FOM9602V.00	5-1

REPORT PHASE: PHASE III RFI SITE SD-11



BASE MAP SOURCE: LYDICK ENGINEERS & SURVEYORS, 1993, 1995, 1998

May 18, 1999 10:58:51 a.m.
Drawing: T:\CANNON\M9602V\T6500\FIG5-2.DWG (TSM)

APPENDIX 1 SWMUs 86-90 (SITE SD-11)
PREVIOUS SAMPLING LOCATIONS
CANNON AFB, NEW MEXICO

DRN. BY: TSSM	DATE: 05/18/99	PROJECT NO.	FIG. NO.
CHK'D. BY:	REVISION: 0	45FOM9602V.00	5-2

Additional soil sampling was completed at the evaporation pond as part of the CMS for Site SD-11. This section briefly discusses this additional sampling activity.

Field activities included soil borings, surface and subsurface soil sampling, and immunoassay field screening for total petroleum hydrocarbons (TPH). Soil borings were completed in the evaporation pond. The boring locations are shown in Figure 6-1. The evaporation pond is surrounded by a concrete berm. Base personnel excavated a portion of the north side of the berm (Figure 6-1) to facilitate drill rig access.

Soil sampling was completed using a truck-mounted drill rig and stainless-steel split-spoon samplers. Each sample collected was tested for TPH in the field using immunoassay methods.

All samples were field screened for headspace analysis using a 10.2 eV lamp photoionization detector.

Sampling equipment and procedures, sample designation and handling, documentation and analysis were followed as presented in the CMS Field Sampling Plan (FSP).

6.1 SOIL BORINGS

Three soil borings were drilled and sampled at the evaporation pond. The borings were drilled to a depth of 40 feet bgs. Five soil samples were collected from each boring. Soil samples were collected from the following intervals:

- 0 to 1.0 feet bgs
- 8.0 to 10.0 feet bgs
- 18.0 to 20.0 feet bgs
- 28.0 to 30.0 feet bgs
- 38.0 to 40.0 feet bgs

All samples were submitted for the following off-site chemical analyses:

- VOCs by EPA Method 8260B
- SVOCs by EPA Method 3550B/8270C
- TPH (DRO) by EPA Method 8015B
- TRPH by EPA Method 9071/418.1

Surface soil samples were collected from 0 to 0.5 feet bgs for all parameters, except VOCs. Surface soil samples for VOCs were collected from 0.5 to 1.0 feet bgs. A summary of soil samples collected and analyzed is presented in Table 6-1. All samples were field screened for headspace analysis using a Mini-Rae 10.2 eV lamp photoionization detector (PID).

Immunoassay analysis was done for TPH following SW-846 Immunoassay Method 4030 at each of the sample intervals. Three detection levels were used for each test. Typically, a low detection level analysis was analyzed first. If there was a detection exceeding this level, the sample was extracted and diluted, and then analyzed using a higher detection level. If this higher detection level was exceeded, a second dilution was prepared. This second dilution was then tested for yet a higher detection level.

The following table identifies the compounds that can be detected using the Immunoassay kits and their associated reporting limits:

Compound	Low-Level Detection Limit (ppm)	Mid-Level Detection Limit (ppm)	High-Level Detection Limit (ppm)
Gasoline	10	40	160
Diesel	15	60	240
#2 Fuel Oil	15	60	240
Kerosene	15	60	240
Jet Fuel A	15	60	240
Jet Fuel JP-4	15	60	240
#6 Fuel Oil	25	100	400
Mineral Spirits	40	160	640

Each dilution requires several minutes of waiting during sample preparation for analysis. If there was a detection, and subsequent dilutions were necessary, sample preparation and analysis time increased accordingly. Therefore, to save time in case of detections at the minimum detection level test, the first and second dilutions were done concurrent with the minimum detection level tests.

The detection levels used for the immunoassay testing were less than 15 ppm, less than 60 ppm, and less than 240 ppm for diesel through JP-4. Immunoassay is a semi-quantitative method of analysis which identifies a range at which TPH is present in a sample. For example, for a positive result detected using the mid-level standard that was not detected using the high-level standard, the value of TPH present would be between the mid-level and high-level standard concentrations.

Immunoassay analysis for TPH was completed in the field to insure that the bottom two sample intervals from each boring were nondetect. If a detection had occurred, then the USACE Technical Manager would have been contacted.

6.2 DATA REVIEW AND ASSESSMENT

The chemical data from Site SD-11 were assessed to identify quality issues that could potentially affect the use of the data for decision-making purposes. The chemical data generated during this CMS investigation were determined to meet the quality criteria established in the QAPP (W-C 1998).

6.2.1 Data Review Issues

QA/QC objectives for the chemical data were specified in the QAPP and were used as indicators of the quality necessary to support identification and quantitation of chemicals of concern. Some chemicals were qualified as estimated and/or nondetect, but none of the data were rejected.

Chemical results for the soil samples collected at Site SD-11 were qualified on the basis of outlying precision or accuracy parameters. The following bulleted items indicate the rationale for the qualifications and provide a brief explanations of their significance to Site SD-11. A more complete discussion of the data validations and reviews can be found in the Quality Control Summary Report (QCSR).

- The results for methylene chloride for all samples were qualified as nondetect (U) because methylene chloride was detected in the associated method blank. The reporting limits were raised to the concentration of methylene chloride detected in the sample.
- The results for all SVOC compounds were qualified as estimated (J) detects or (UJ) nondetects because of a potential low bias. The qualifications were applied based on poor compound recoveries in the laboratory control sample.

6.3 INVESTIGATION RESULTS

6.3.1 Geology

The shallow subsurface geology at the evaporation pond is illustrated in simplified boring logs (Figure 6-2). The boring logs were constructed with data obtained from the soil borings.

Boring SB01 encountered approximately 1 foot of low plastic clay fill with sand and gravel. Borings SB02 and SB03 had less than one half foot of fill material. The fill material was underlain by fine-grained sand with some silt and clay. This sand layer averaged about three to four feet in thickness.

The sand layer was underlain by silt with caliche. This layer was typically light reddish-brown, dry to moist, with some fine-grained sand and caliche nodules, and moderately to heavily cemented. This silt layer generally extended to about 19 feet bgs. From about 19 feet on, the soil encountered consisted of a fine-grained sand unit. The sand unit was predominantly light red to red, dry to moist, with some silt. The caliche content varied from containing caliche nodules to being heavily cemented, with cementation generally increasing with depth. Total boring depths ranged from 39.2 to 40 feet bgs. Boring SB01 was drilled to 40 feet bgs. Borings SB02 and SB03 were stopped at 39.8 feet bgs and 39.2 feet bgs, respectively, due to refusal.

Copies of the boring logs are presented in Appendix A.

6.3.2 Chemical Results

Fifteen soil samples were collected at the evaporation pond at Site SD-11 and submitted for chemical analysis. The samples were analyzed for VOCs, SVOCs, TRPH and TPH (DRO).

Summaries of the chemical investigation results can be found as follows:

- The samples collected and the types of analyses done are presented in Table 6-1. The chemicals detected, the maximum concentration of each detected chemical and the frequency of detects for surface and subsurface soil samples collected at the evaporation pond at Site SD-11 are summarized in Table 6-2 and 6-3, respectively, and are shown on Figure 6-3.
- Appendix B contains all analytical results.

Samples were analyzed for total petroleum hydrocarbons, diesel range organics (TPH-DRO), by EPA Method 8015 modified, as well as total recoverable petroleum hydrocarbons (TRPH) by EPA Method 418.1. Method 8015 modified uses chromatographic patterns to identify petroleum-related molecules with carbon chains C(n) ranging from C8 through C22. The results are quantified using a diesel fuel standard and are reported as TPH-DRO. Method 418.1 uses infrared to identify petroleum-related molecules with carbon chains ranging from C9 through C40. As a result, TPH and TRPH results are not directly comparable. The nondetect results for TPH-DRO and the positive results for TRPH indicate the presence of heavy petroleum hydrocarbons, C22 to C40.

Three surface soil and 12 subsurface soil samples were collected at the evaporation pond. Immunoassay results for all surface and subsurface soil samples were less than 15 PPM at borings SB01, SB02, and SB03, which was the lowest detection limit used. All headspace field screening results for surface and subsurface soil samples were nondetect. Organic compound results are presented below. Detected metals concentrations are discussed in the risk screening evaluation in Section 8.

6.3.2.1 Organic Results for Surface Soils

VOCs and SVOCs were nondetect for all three surface soil samples. TPH-DRO was detected in one surface soil sample. TPH-DRO was detected at a concentration of 68 mg/kg in sample C11-SB03-002. TRPH were detected in all three surface soil samples at concentrations of 41 mg/kg, 43 mg/kg, and 130 mg/kg at borings SB01, SB02, and SB03, respectively (Figure 6-6).

6.3.2.2 Organic Results for Subsurface Soil Samples

VOCs and TPH-DRO were nondetect in subsurface soil samples at the evaporation pond. Two SVOCs were detected at low concentrations. Di-n-butyl phthalate was once detected at 150 µg/kg in sample C11-SB02-010, and phenol was detected once at 55 µg/kg in sample C11-SB03-010. TRPH were detected in all subsurface soils samples ranging from 24 mg/kg to 62 mg/kg (Figure 6-6).

Generally, the presence of TRPH in samples would result in detections of heavier VOCs and a wide range of SVOCs. However, target VOCs, and essentially all target SVOCs, were reported as nondetect. This was due to the fact that Method 418.1 has the ability to extract, and consequently identify, heavier hydrocarbons than Method 8270. As a result, the heavier compounds which were detected in the TRPH analyses were not detected using Method 8270. This was evident by the spectrum patterns for TRPH which indicated the presence of heavy

hydrocarbons. Review of the SVOC chromatograms indicated the presence of some heavier hydrocarbons at the end of the analytical run. These compounds were not target compounds and were nonquantifiable.

TABLE 6-1

SUMMARY OF ANALYTICAL SAMPLES FROM SITE SD-11 (CMS FIELD INVESTIGATION 1998) CANNON AFB, NEW MEXICO

Sampling Location	Sample Identification		Sample Date	VOCs 8260A	TPH-DRO 8015B	TRPH 418.1	SVOCs 8270C
SB01	C11-SB01-002		12/2/98	X	X	X	X
	C11-SB01-010		12/2/98	X	X	X	X
	C11-SB01-020		12/2/98	X	X	X	X
	C11-SB01-030		12/2/98	X	X	X	X
	C11-SB01-040		12/2/98	X	X	X	X
SB02	C11-SB02-002		12/2/98	X	X	X	X
	C11-SB52-202	Duplicate	12/2/98	X	X	X	X
	C11-SB02-302	QA SPLIT	12/3/98	X	X	X	X
	C11-SB02-010		12/2/98	X	X	X	X
	C11-SB02-110	MS/MSD	12/3/98	X	X	X	X
	C11-SB02-020		12/2/98	X	X	X	X
	C11-SB02-030		12/2/98	X	X	X	X
	C11-SB02-040		12/2/98	X	X	X	X
SB03	C11-SB03-002		12/2/98	X	X	X	X
	C11-SB53-202	Duplicate	12/2/98	X	X	X	X
	C11-SB03-010		12/2/98	X	X	X	X
	C11-SB03-020		12/2/98	X	X	X	X
	C11-SB03-120	MS/MSD	12/2/98	X	X	X	X
	C11-SB03-030		12/2/98	X	X	X	X
	C11-SB03-040		12/2/98	X	X	X	X

VOCs = volatile organic compounds
SVOCs = semivolatile organic compounds
TPH = total petroleum hydrocarbons
TPH-DRO = total petroleum hydrocarbons - diesel-range only
QA = quality assurance
MS/MSD = matrix spike/matrix spike duplicate

TABLE 6-2

SUMMARY OF CHEMICALS DETECTED IN SURFACE SOILS AT SITE SD-11 (CMS FIELD INVESTIGATION 1998) CANNON AFB, NEW MEXICO

FIELD ID			C11-SB01-002			C11-SB02-002			C11-SB03-002		
COLLECT DATE			12/2/98			12/2/98			12/2/98		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
TOTAL PETROLEUM HYDROCARBONS (mg/kg)											
TRPH by Method 418.1	130	3/3	41	20		43	20		130	20	
Diesel Range Organics (DRO)	68	1/3	<	28	U	<	28	U	68	28	

TRPH - Total Recoverable Petroleum Hydrocarbons
DRO - Diesel Range Organics
mg/kg - milligram per killogram
µg/kg - microgram per killogram
J - Estimated
U - Nondetect

TABLE 6-3

SUMMARY OF CHEMICALS DETECTED IN SUBSURFACE SOILS AT SITE SD-11 (CMS FIELD INVESTIGATION 1998) CANNON AFB, NEW MEXICO

FIELD ID			C11-SB01-010			C11-SB01-020			C11-SB01-030			C11-SB01-040			C11-SB02-010			C11-SB02-020		
COLLECT DATE			12/2/98			12/2/98			12/2/98			12/2/98			12/2/98			12/2/98		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
SEMIVOLATILE ORGANICS (METHOD 8270) (µg/kg)																				
Di-N-Butyl Phthalate	150J	1/12	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ	150	380	J	<	380	UJ
Phenol	55	1/12	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ	<	380	UJ	<	380	UJ
TOTAL PETROLEUM HYDROCARBONS (mg/kg)																				
TRPH by Method 418.1	62	12/12	26	20		28	20		34	20		39	20		24	20		62	20	

TRPH - Total Recoverable Petroleum Hydrocarbons
mg/kg - milligram per killogram
µg/kg - microgram per killogram
J - Estimated
U - Nondetect

6000 mg/kg

NMSSL

TABLE 6-3

SUMMARY OF CHEMICALS DETECTED IN SUBSURFACE SOILS AT SITE SD-11 (CMS FIELD INVESTIGATION 1998) CANNON AFB, NEW MEXICO

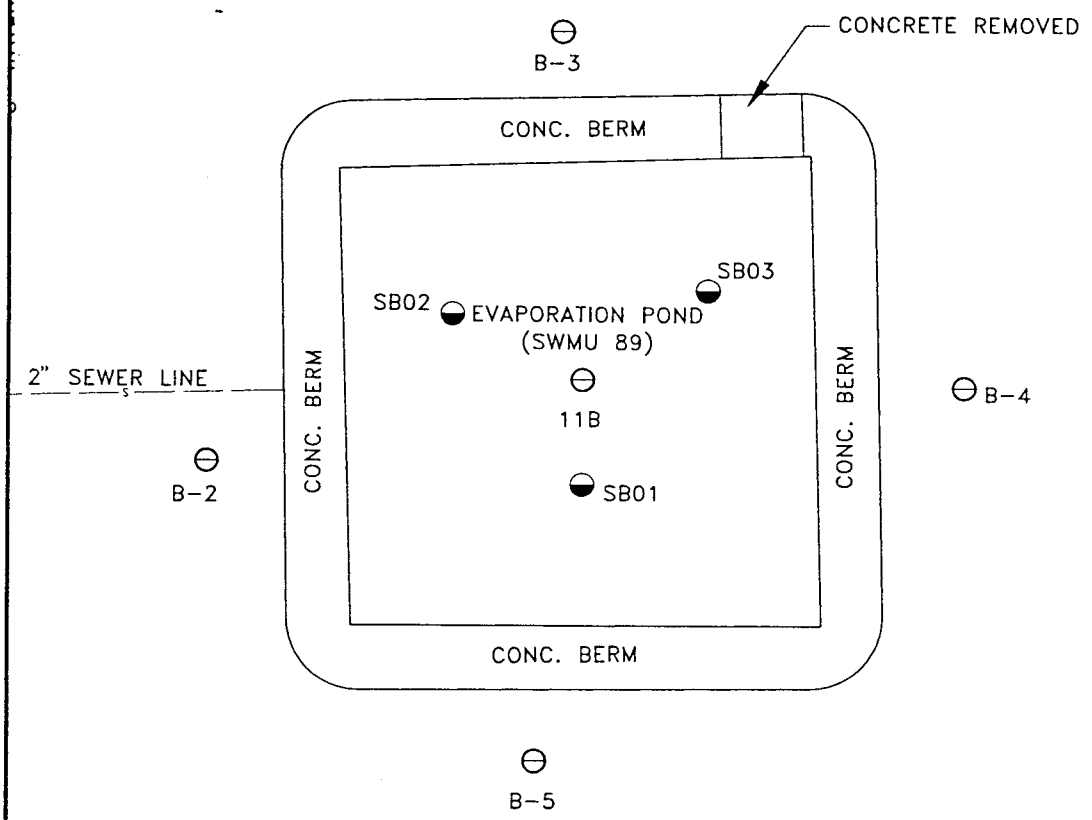
FIELD ID			C11-SB02-030			C11-SB02-040			C11-SB03-010			C11-SB03-020			C11-SB03-030			C11-SB03-040		
COLLECT DATE			12/2/98			12/2/98			12/2/98			12/2/98			12/2/98			12/2/98		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
SEMIVOLATILE ORGANICS (METHOD 8270) (µg/kg)																				
Di-N-Butyl Phthalate	150J	1/12	<	400	UJ	<	360	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
Phenol	55	1/12	<	400	UJ	<	360	UJ	55	360	J	<	370	UJ	<	380	UJ	<	380	UJ
TOTAL PETROLEUM HYDROCARBONS (mg/kg)																				
TRPH by Method 418.1	62	12/12	32	20		25	20		30	20		34	20		36	20		39	20	

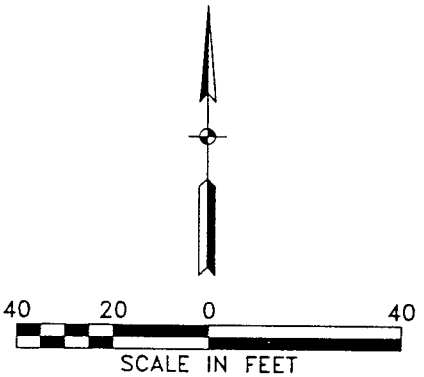
TRPH - Total Recoverable Petroleum Hydrocarbons
mg/kg - milligram per killogram
µg/kg - microgram per killogram
J - Estimated
U - Nondetect

REPORT PHASE: PHASE RFI SITE SD-11

LEGEND:

◒	SOIL BORING LOCATION
⊖	PREVIOUS SOIL BORING LOCATION
11A, 11B	RADIAN 1984–1985 (PHASE II IRP)
B–1 to B–5	WALK, HAYDEL, & ASSOCIATES 1989 (PHASE IV IRP)





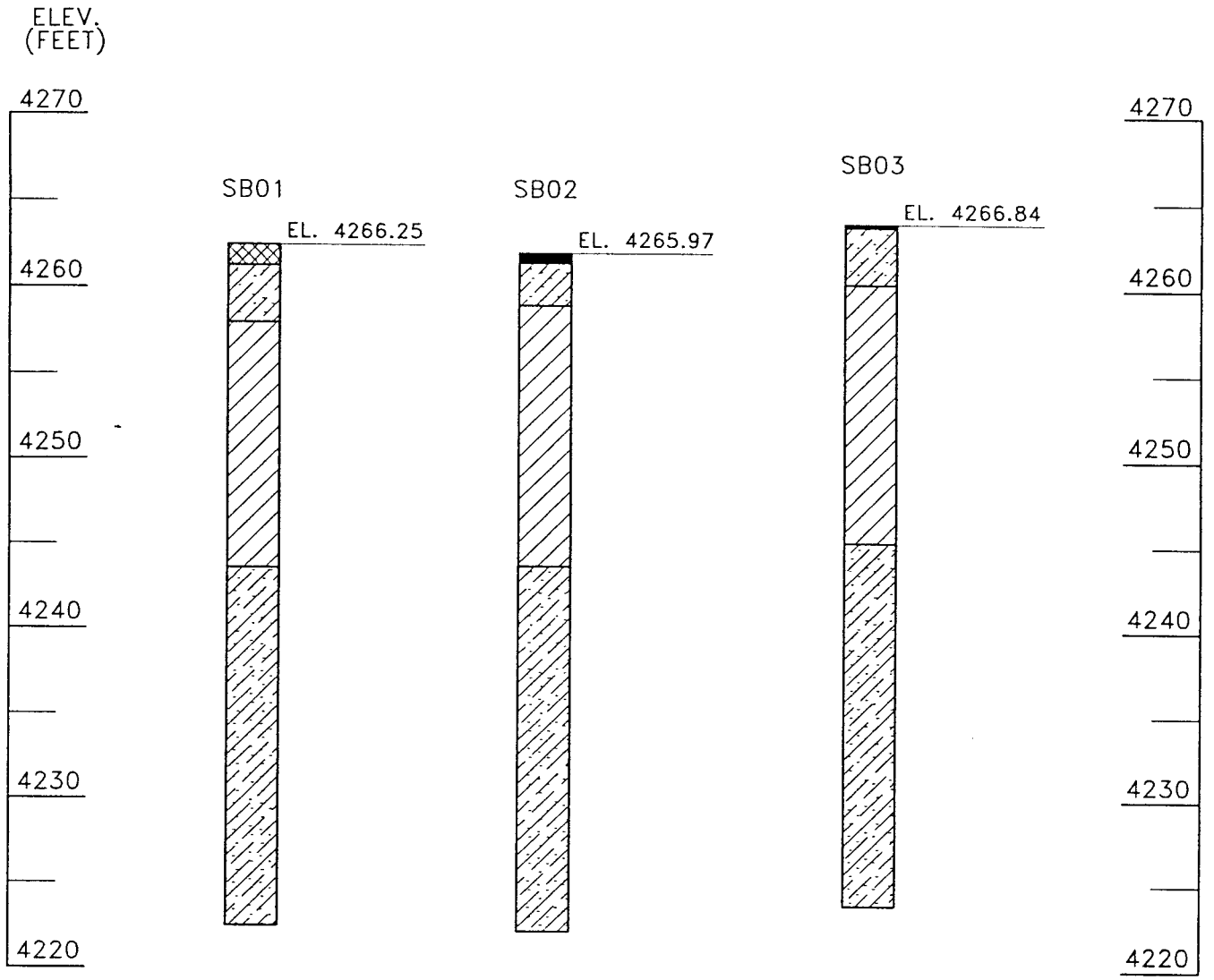
BASE MAP SOURCE: LYDICK ENGINEERS & SURVEYORS, 1993, 1995

NOTE: LOCATION OF UNDERGROUND UTILITY LINES SHOWN ARE APPROXIMATE.

May 18, 1999 10:59:49 a.m.
Drawing: T:\CANNON\M9602V\T6500\FIG6-1.DWG (TSM)

APPENDIX 1 SWMUs 86–90 (SITE SD–11)
CMS SAMPLING LOCATION
CANNON AIR FORCE BASE, NEW MEXICO

DRN. BY: TSSM	DATE: 05/18/99	PROJECT NO. 45F0M9602V.00	FIG. NO. 6–1
CHK'D. BY:	REVISION: 0		



LEGEND

- MEDIUM STIFF, MOIST, BROWN, LOW PLASTIC SILTY CLAY (CL) WITH SOME COARSE SAND AND GRAVEL
- COARSE SAND AND GRAVEL SURFACE COVER
- STIFF TO VERY STIFF, DRY TO MOIST, LIGHT REDDISH-BROWN, LOW PLASTIC SILT (ML)
- LOOSE TO DENSE, SL. MOIST TO MOIST, LIGHT REDDISH-BROWN TO RED, FINE GRAINED SAND (SM) WITH SILT

SCALE: 1" = 5' VERTICAL
NO SCALE HORIZONTAL

APENDIX 1 SWMUs 86-90 (SITE SD-11)
SIMPLIFIED BORING LOGS
CANNON AIR FORCE BASE, NEW MEXICO

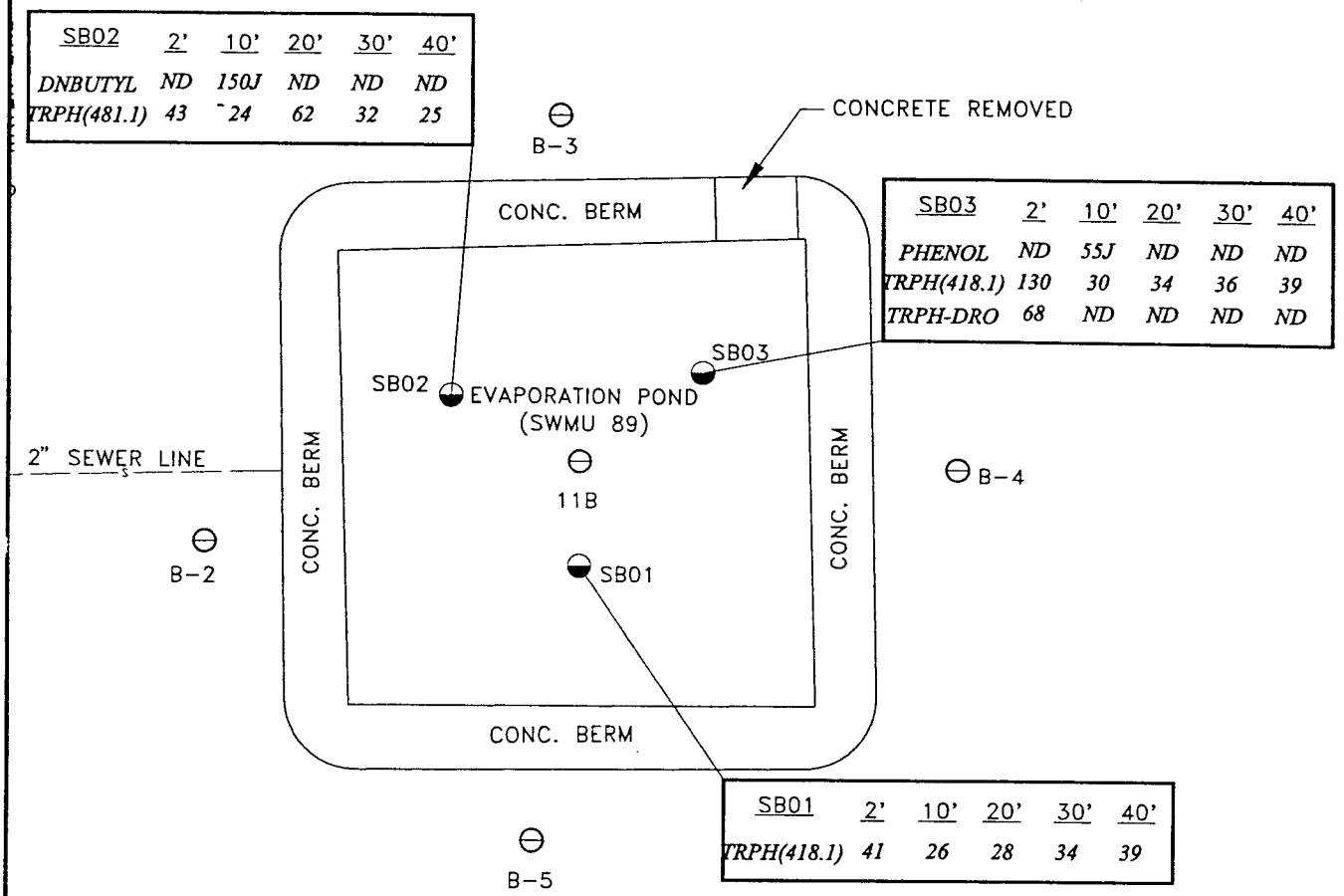
DRN. BY: TSSM	DATE: 03/24/99	PROJECT NO. 45F0M9602V.00	FIG. NO. 6-2
CHK'D. BY:	REVISION: 0		

May 18, 1999 11:01:28 a.m.
Drawing: T:\CANNON\M9602V\T6500\FIG6-2.DWG (TSM)

REPORT PHASE: PHA. RFI SITE SD-11

LEGEND:

◒	SOIL BORING LOCATION
⊖	PREVIOUS SOIL BORING LOCATION
11A, 11B	RADIAN 1984–1985 (PHASE II IRP)
B-1 to B-5	WALK, HAYDEL, & ASSOCIATES 1989 (PHASE IV IRP)



SB02	2'	10'	20'	30'	40'
DNBUTYL	*ND*	*150J*	*ND*	*ND*	*ND*
TRPH(481.1)	*43*	*24*	*62*	*32*	*25*

SB03	2'	10'	20'	30'	40'
PHENOL	*ND*	*55J*	*ND*	*ND*	*ND*
TRPH(418.1)	*130*	*30*	*34*	*36*	*39*
TRPH-DRO	*68*	*ND*	*ND*	*ND*	*ND*

SB01	2'	10'	20'	30'	40'
TRPH(418.1)	*41*	*26*	*28*	*34*	*39*

LEGEND

DNBUTYL	Di-n-butyl phthalate
TRPH-DRO	Total Petroleum Hydrocarbon-Diesel Range Organics
TRPH(418.1)	Total Recoverable Petroleum Hydrocarbons by EPA Method 418.1
ND	Non-detect

40 20 0 40
SCALE IN FEET

NOTE:
1) CONCENTRATIONS OF SVOCs IN $\mu g/kg$
2) CONCENTRATIONS OF TRPH IN mg/kg
3) LOCATION OF UNDERGROUND UTILITY LINES SHOWN ARE APPROXIMATE.

BASE MAP SOURCE: LYDICK ENGINEERS & SURVEYORS, 1993, 1995

CONCENTRATIONS OF SVOCs AND TPH OF THE EVAPORATION POND SWMUS 86-90 (SITE SD-11) CANNON AIR FORCE BASE, NEW MEXICO

DRN. BY: TSSM	DATE: 05/18/99	PROJECT NO. 45F0M9602V.00	FIG. NO. 6-3
CHK'D. BY:	REVISION: 0		

May 18, 1999 11:03:08 a.m.
Drawing: T:\CANNON\M9602V\T6500\FIG6-3.DWG (TSM)

7.1 NATURE AND EXTENT OF CONTAMINATION

7.1.1 General

Soils were sampled for chemical analysis at locations in the area of the former oil/water separator system and evaporation pond at Site SD-11 as part of the Phase III RFI (W-C 1995) and the CMS investigation to determine the vertical and lateral extent of contamination (Figure 7-1). These results were obtained after the 1994 excavation of contaminated soils in the area. Previous investigative results were not used in discussing current nature and extent conditions. Results for soil VOCs, SVOCs, and TRPH are evaluated below. Metals are evaluated in Section 8. Data from the Phase III RFI and CMS investigations were used in the human health and ecological risk evaluations (Sections 8 and 9).

7.1.2 Soils

TRPH serves as an indicator parameter for organic chemical contamination in soil. Generally, where TRPH was not detected, other organic compounds (VOCs and SVOCs) were also not detected. A site map (Figure 7-2) shows the concentrations of TRPH detected in soil samples. Two geologic cross sections (Figure 7-3, Figure 7-4) illustrate vertically and horizontally TRPH concentrations detected in soil at the former oil/water separator. The cross sections were constructed with data obtained from soil boring logs and chemical analytical results for soil samples. Figure 7-5 shows detected TRPH concentrations along with simplified boring logs of the evaporation pond. Figures 7-3 and 7-4 show the general overburden subsurface profile and detected concentrations in an east to west and south to north direction, respectively. Both cross sections bisect the zone of backfill placed for the removal of the oil/water separator system.

VOCs, SVOCs, and/or TRPH were generally detected below the elevation of the former oil/water separator system at borings 8611, 8612, and 8613. Only estimated amounts (J-qualified) of VOCs and SVOCs were detected in samples collected within the zone of backfill at these locations (Table 5-3). TRPH levels were generally an order of magnitude lower in samples collected within the zone of backfill than in samples collected directly below the zone of backfill (Figures 7-3 and 7-4). Below the zone of backfill, TRPH concentrations generally decrease with depth to nondetect levels. TRPH levels at the evaporation pond were much lower than at the OWS (Figure 7-5).

At boring 8611, ethylbenzene, toluene, xylenes, 2-methylnaphthalene, and naphthalene were detected in samples directly below the zone of backfill (Table 5-3). These concentrations decrease with depth to nondetect levels. At boring 8613, acetone, ethylbenzene, xylenes, 2-methylnaphthalene, and naphthalene were detected in samples directly below the zone of backfill at depths of 14, 24, and 34 feet bgs (Table 5-3). Concentrations of these compounds are nondetect below these depths.

Soils were found to be petroleum stained to depths of 9 (boring 8612), 18 (boring 8611), and 32 (boring 8613) feet bgs. Petroleum odors were also evident within, and generally to some depth below, the zone of staining. Petroleum staining within the zone of backfill was generally mottled.

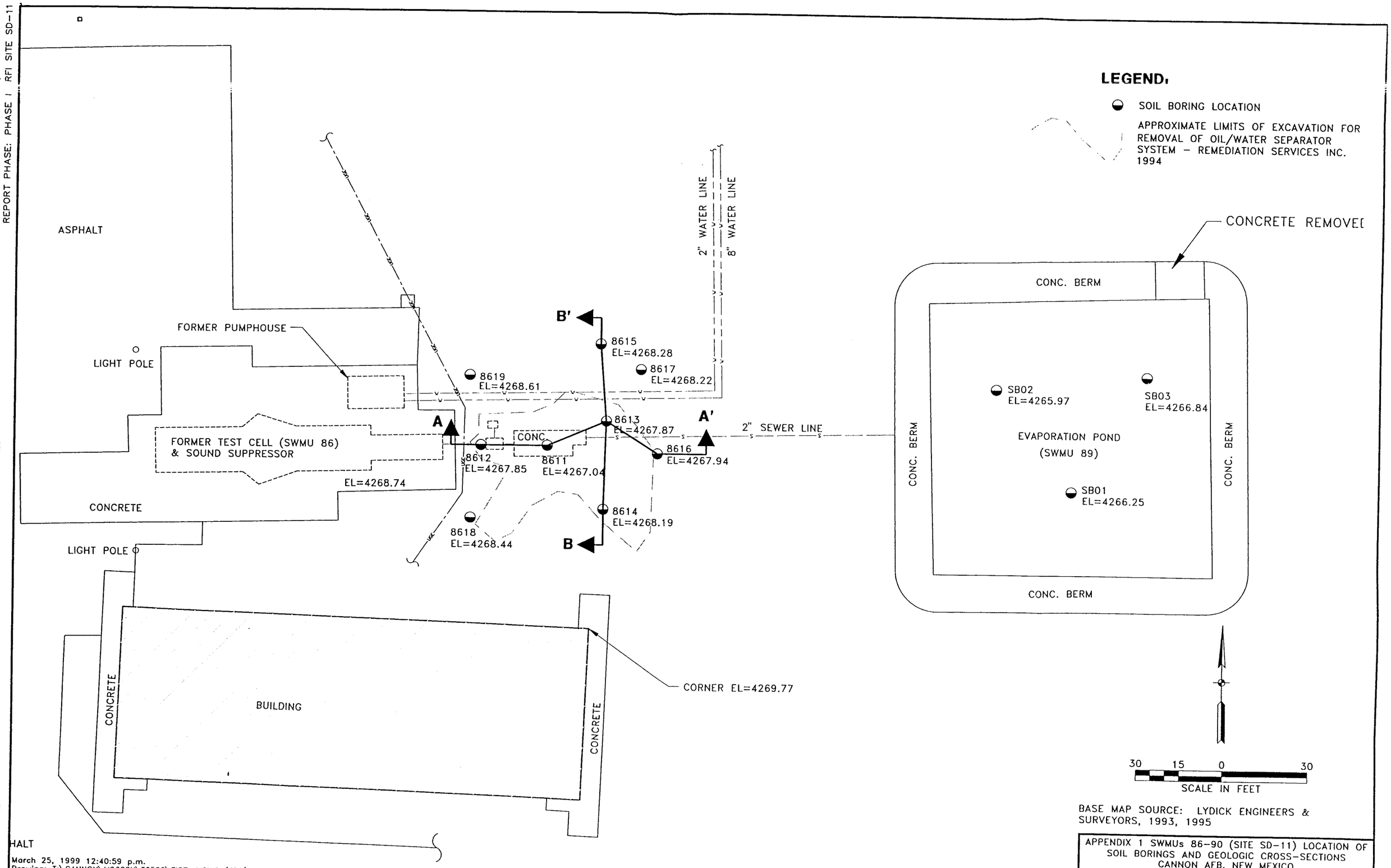
The extent of contamination of soil within the zone of backfill appears to be consistent with how soils were handled for removal of the oil/water separator system, which included excavation, removal, some mixing with uncontaminated soils, and backfilling. Lower or nondetect sample results may be due to volatilization during excavation and/or dilution by mixing.

No VOCs or SVOCs, except for estimated amounts (J-qualified), were detected in soil samples collected form borings 8615, 8616, 8617, 8618, and 8619, located outside the zone of backfill (Table 5-3). No VOCs and only two low-level SVOCs were detected in boring C11-SB01, C11-SB02, and C11-SB03 in the area of the evaporation pond. At boring 8614, located at the edge of the zone of backfill, low levels of polycyclic aromatic hydrocarbons (PAHs) were detected in the surface soil sample. Only benzo(a)pyrene was not an estimated value (Table 5-2).

Low levels of TRPH were detected in surface soil samples at borings 8614, 8618, and 8619 (Figures 7-2 and 7-4). TRPH at boring 8614 is likely due to placement of contaminated backfill. TRPH at borings 8618 and 8619 is likely due to historical cleaning operations at the engine test cell.

Evaluation of metals results for soil samples is presented in Section 8.

REPORT PHASE: PHASE I RFI SITE SD-11



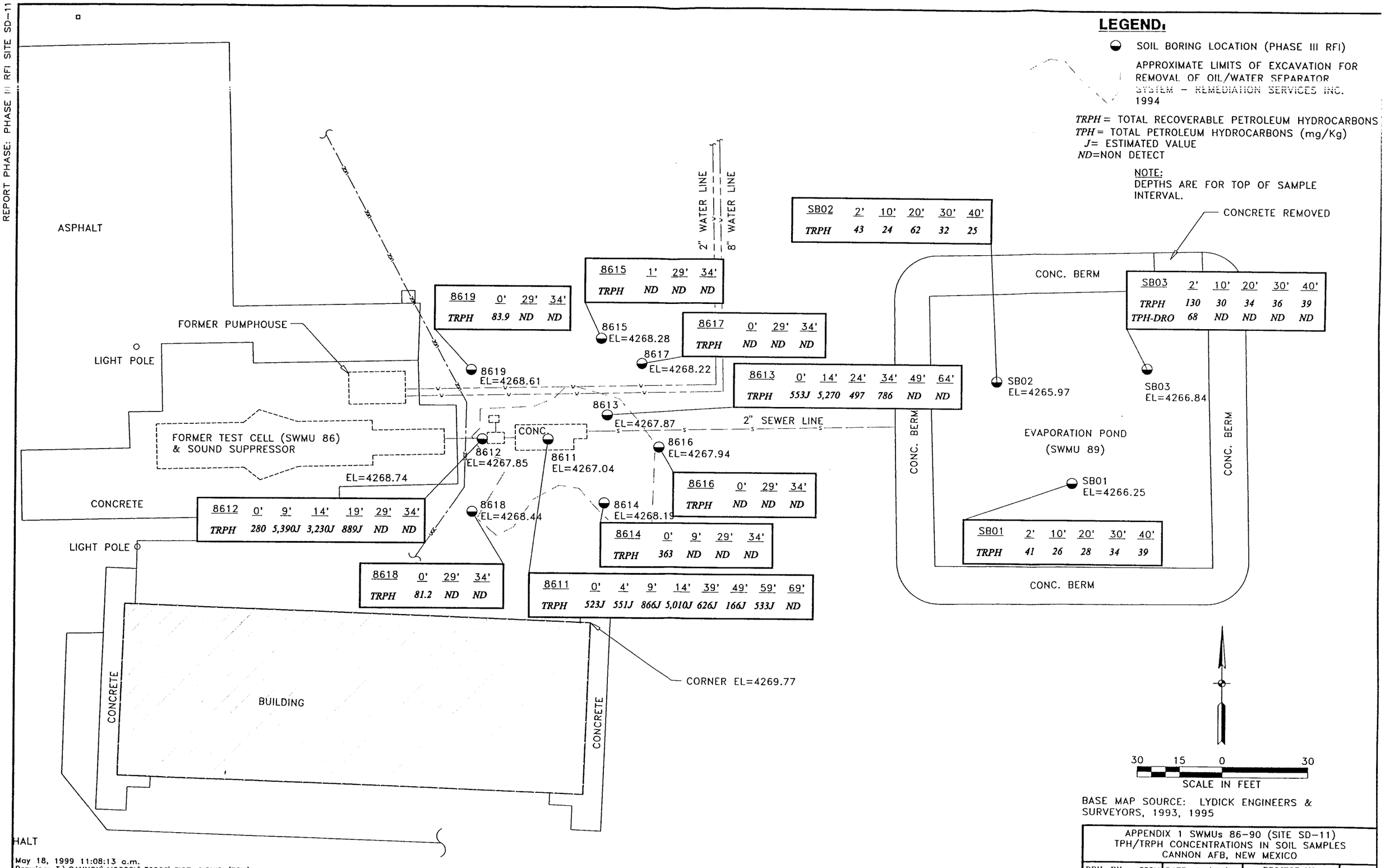
BASE MAP SOURCE: LYDICK ENGINEERS & SURVEYORS, 1993, 1995

March 25, 1999 12:40:59 p.m.
Drawing: T:\CANNON\M9602V\T6500\FIG7-1.DWG (TSM)

APPENDIX 1 SWMUs 86-90 (SITE SD-11) LOCATION OF SOIL BORINGS AND GEOLOGIC CROSS-SECTIONS CANNON AFB, NEW MEXICO

DRN. BY: TSSM	DATE: 03/25/99	PROJECT NO.	FIG. NO.
CHK'D. BY:	REVISION: 0	45FOM9602V.00	7-1

REPORT PHASE: PHASE III RFI SITE SD-11

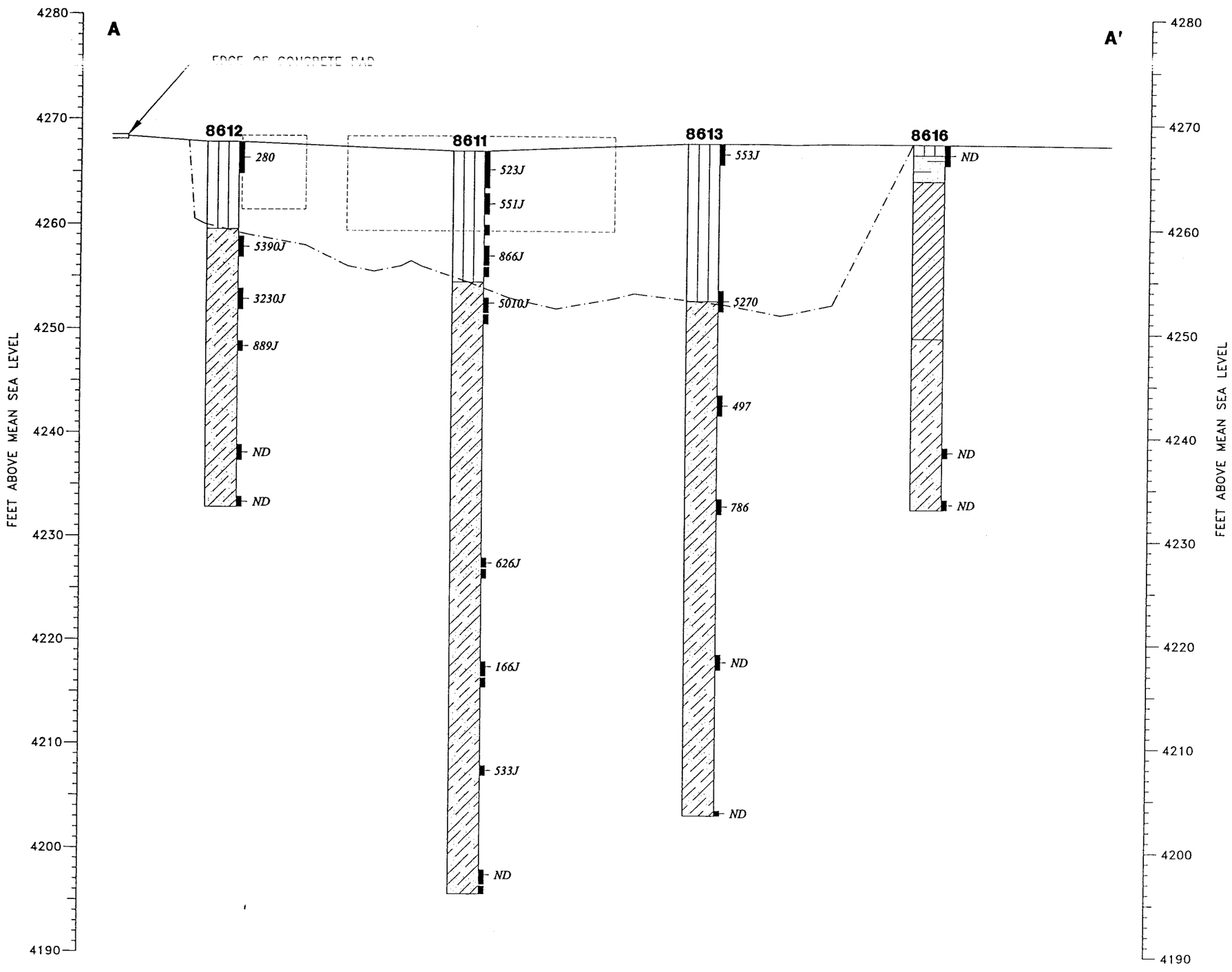


May 18, 1999 11:08:13 a.m.
Drawing: T:\CANNON\M9602V\T6500\FIG7-2.DWG (TSM)

APPENDIX 1 SWMUs 86-90 (SITE SD-11)
TPH/TRPH CONCENTRATIONS IN SOIL SAMPLES
CANNON AFB, NEW MEXICO

DRN. BY: TSSM	DATE: 05/18/99	PROJECT NO.	FIG. NO.
CHK'D. BY:	REVISION: 0	45F0M9602V.00	7-2

REPORT PHASE: PHASE II FI SITE SD-11



LEGEND:

- ASPHALT
- SILTY CLAY FILL WITH FINE SAND AND OCCASIONAL FINE GRAVEL (CL)
- SILTY CLAY WITH FINE SAND (CL)
- CLAYEY SILT WITH FINE SAND, SANDY SILT, OR SILTY SAND (ML, SM)
- FINE SAND WITH SILT (SM, SP-SM)
- APPROXIMATE LOCATION OF FORMER OIL/WATER SEPARATOR
- APPROXIMATE LIMITES OF EXCAVATION FOR REMOVAL OF OIL/WATER SEPARATOR SYSTEM
- *ND* = SOIL SAMPLE INTERVAL SELECTED FOR CHEMICAL OR BIOLOGICAL ANALYSIS

ND=NON DETECT
J=ESTIMATED VALUE
TRPH=TOTAL RECOVERABLE PETROLEUM HYDROCARBONS (mg/Kg)

10 5 0 10 HORIZONTAL IN FEET

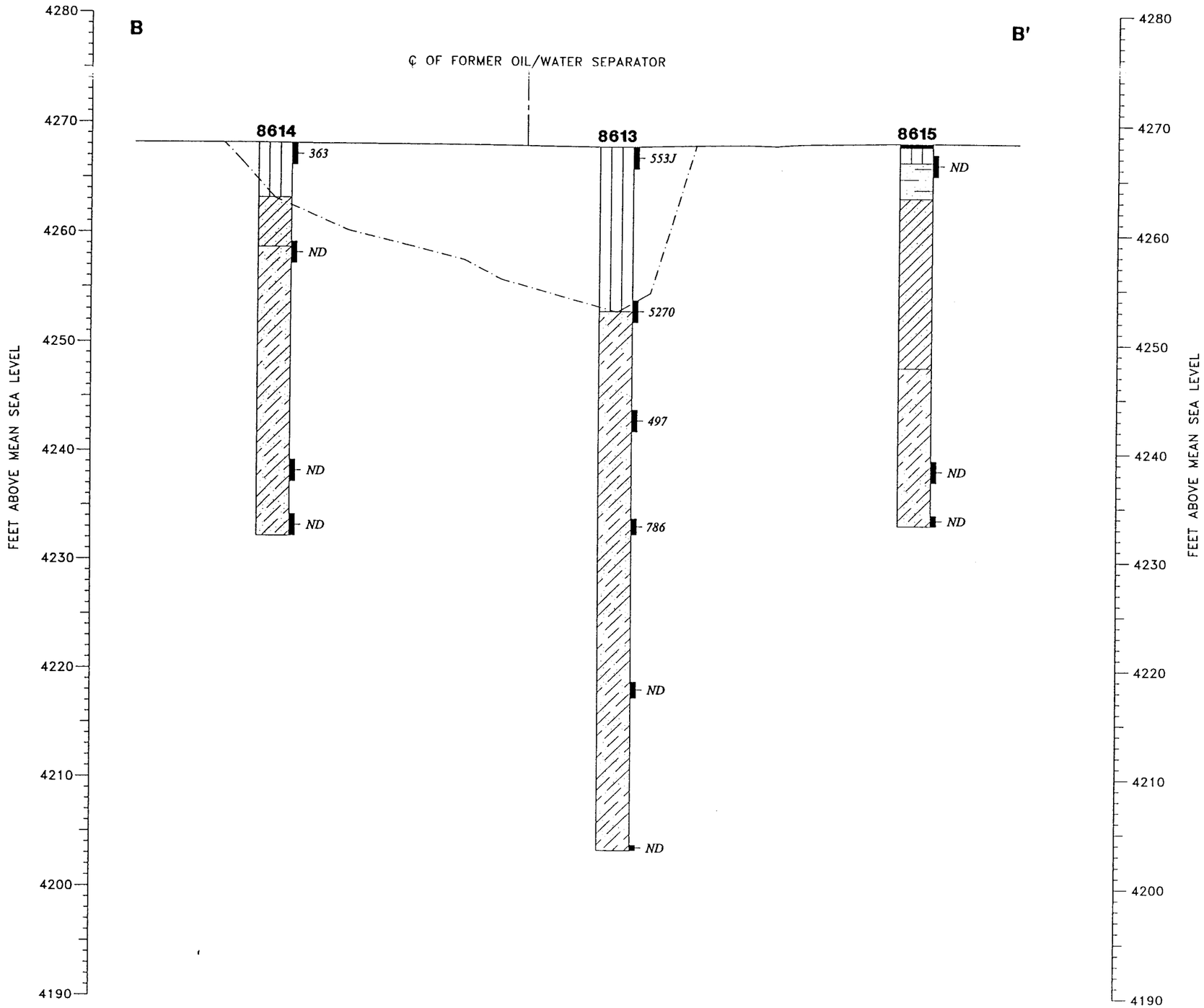
10 5 0 10 VERTICAL IN FEET

May 18, 1999 11:10:33 a.m.
Drawing: T:\CANNON\M9602V\T6500\FIG7-3.DWG (TSM)

APPENDIX 1 SWMUs 86-90 (SITE SD-11)
TRPH CONCENTRATIONS ALONG
GEOLOGIC CROSS-SECTION A -A'
CANNON AFB, NEW MEXICO

DRN. BY: JWB	DATE: 05/18/99	PROJECT NO.	FIG. NO.
CHK'D. BY:	REVISION: 0	45F0M9602V.00	7-3

REPORT PHASE: PHASE III RFI SITE SD-11



LEGEND:

- ASPHALT
- SILTY CLAY FILL WITH FINE SAND AND OCCASIONAL FINE GRAVEL (CL)
- SILTY CLAY WITH FINE SAND (CL)
- CLAYEY SILT WITH FINE SAND, SANDY SILT, OR SILTY SAND (ML, SM)
- FINE SAND WITH SILT (SM, SP-SM)
- APPROXIMATE LIMITES OF EXCAVATION FOR REMOVAL OF OIL/WATER SEPARATOR SYSTEM
- *ND*= SOIL SAMPLE INTERVAL SELECTED FOR CHEMICAL ANALYSIS

ND=NON DETECT
J=ESTIMATED VALUE
TRPH=TOTAL RECOVERABLE PETROLEUM HYDROCARBONS (mg/Kg)

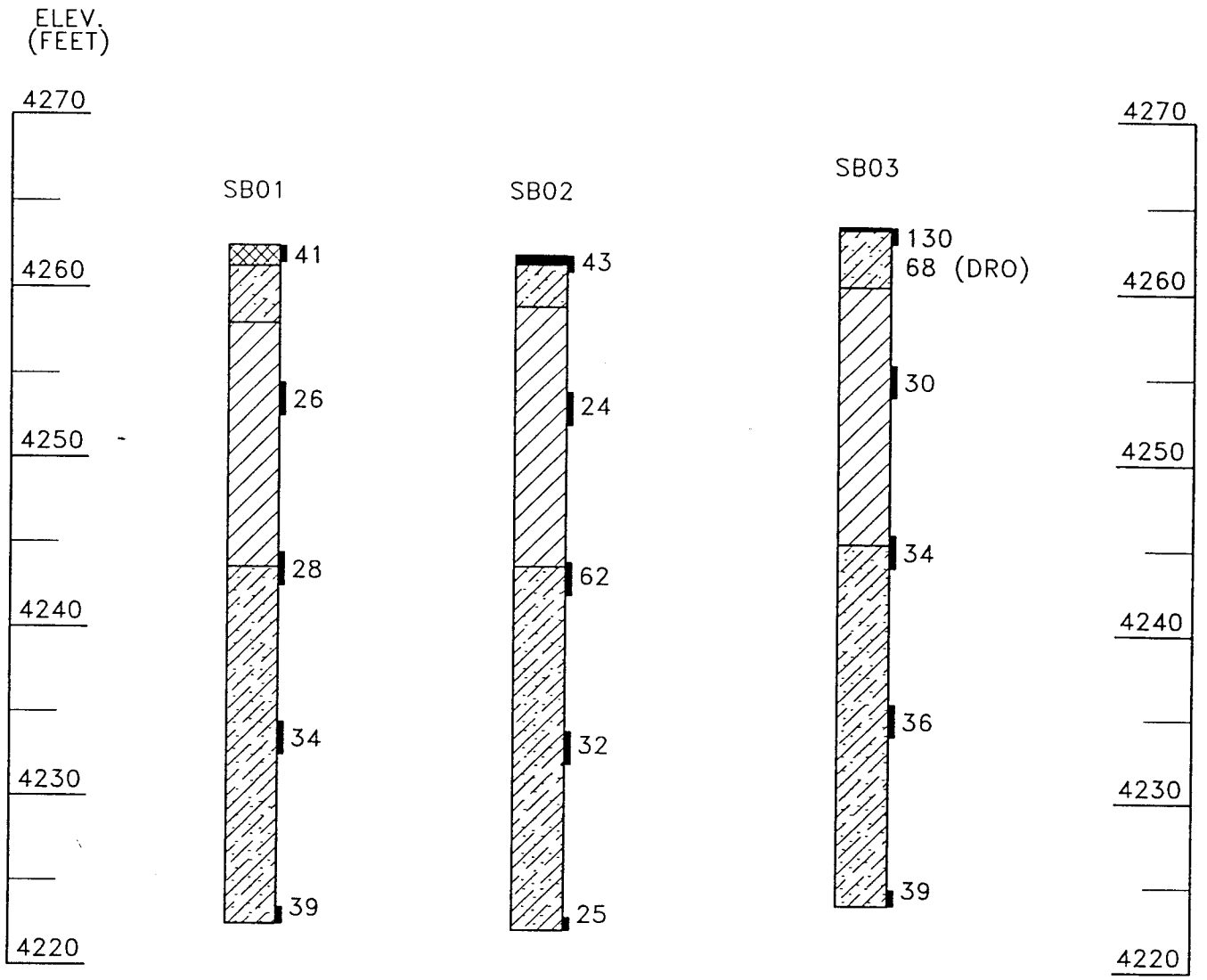
10 5 0 10
HORIZONTAL IN FEET

10 5 0 10
VERTICAL IN FEET

May 18, 1999 11:10:33 a.m.
Drawing: T:\CANNON\M9602V\T6500\FIG7-3.DWG (TSM)

APPENDIX 1 SWMUs 86-90 (SITE SD-11)
TRPH CONCENTRATIONS ALONG
GEOLOGIC CROSS-SECTION B - B'
CANNON AFB, NEW MEXICO

DRN. BY: JWB	DATE: 05/18/99	PROJECT NO.	FIG. NO.
CHK'D. BY:	REVISION: 0	45F0M9602V.00	7-4



LEGEND

- MEDIUM STIFF, MOIST, BROWN, LOW PLASTIC SILTY CLAY (CL) WITH SOME COARSE SAND AND GRAVEL
- COARSE SAND AND GRAVEL SURFACE COVER
- STIFF TO VERY STIFF, DRY TO MOIST, LIGHT REDDISH-BROWN, LOW PLASTIC SILT (ML)
- LOOSE TO DENSE, SL. MOIST TO MOIST, LIGHT REDDISH-BROWN TO RED, FINE GRAINED SAND (SM) WITH SILT

TRPH Total Recoverable Petroleum Hydrocarbons
DRO Diesel Range Organics

NOTE:
1) TRPH CONCENTRATIONS IN mg/kg.

SCALE: 1" = 5' VERTICAL
NO SCALE HORIZONTAL

APENDIX 1 SWMUs 86-90 (SITE SD-11)
CONCENTRATIONS OF TRPH ALONG SIMPLIFIED
BORING LOGS AT EVAPORATION POND
CANNON AIR FORCE BASE, NEW MEXICO

DRN. BY: TSSM	DATE: 05/18/99	PROJECT NO. 45F0M9602V.00	FIG. NO. 7-5
CHK'D. BY:	REVISION: 0		

May 18, 1999 11:14:48 a.m.
Drawing: T:\CANNON\M9602V\T6500\FIG7-5.DWG (TSM)

8.1 SITE CONCEPTUAL EXPOSURE MODEL

The site conceptual exposure model (SCEM) is a schematic representation of the contaminant source areas, chemical release mechanisms, environmental transport media, potential human intake routes, and potential human receptors. A SCEM should identify complete exposure pathways that may result in human health risks and indicate the data needed to evaluate those pathways. An exposure pathway consists of four necessary elements:

- A source and mechanism of chemical release to the environment
- An environmental transport medium for the released chemical (e.g., air, groundwater, or surface water)
- A point of potential human exposure to transported chemicals (e.g., a domestic drinking water well)
- A human intake mechanism (e.g., inhalation or ingestion) at the point of exposure

All four elements must be present for an exposure pathway to be complete and for chemical exposure to occur. In the SCEM, potentially complete exposure pathways are indicated with solid lines; minor (insignificant) pathways are indicated with dashed lines.

This site includes an engine test cell, oil/water separator, and a leach field. The SCEM for Site SD-11 is presented in Figure 8-1. The primary source at Site SD-11 is waste (e.g., fuels, oils, and solvents) that has leaked into subsurface soils or has been discharged or spilled on surface soils. Chemicals from the primary source may be transported away from the primary source areas, affecting other media that may in turn act as secondary sources. Mixing and infiltration of the wastes with soil are shown as the primary chemical release mechanisms. Site-related chemicals in soils may infiltrate/percolate through the soil and be released to groundwater.

Other release mechanisms, such as direct contact (soil ingestion and dermal contact), surface runoff, wind erosion, or volatilization to the atmosphere, are also depicted in the SCEM. Transport by storm runoff is not considered a significant pathway for human exposure at Site SD-11 because the contamination is primarily in the subsurface. Additionally, the site is flat and there are no developed drainageways present.

Potential receptors at Site SD-11 include occupational workers, hypothetical future construction workers, and trespassers. Site SD-11 is located in the industrial area of the Base; therefore, residential development is not a likely future land use. Surface soil and air emissions (volatile and particulate) from surface soil may provide exposures to occupational workers, hypothetical future construction workers, and future trespassers. Subsurface soil and air emissions for subsurface soil (i.e., during excavation) may provide exposures to construction workers.

Groundwater is used for domestic purposes on and off Base. However, potential groundwater exposures were not evaluated because fate and transport modeling indicates that groundwater will not be impacted (see Section 10).

In summary, potential complete human exposure pathways at Site SD-11 are:

Occupational Workers

- Ingestion of surface soil
- Dermal contact with surface soil
- Inhalation of volatile emissions and airborne particulate matter from surface soil

Hypothetical Construction Workers

- Ingestion of subsurface and surface soil
- Dermal contact with subsurface and surface soil
- Inhalation of volatile emissions and airborne particulate matter from subsurface and surface soil

Hypothetical Trespassers

- Ingestion of surface soil
- Dermal contact with surface soil
- Inhalation of volatile emissions and airborne particulate matter from surface soil

8.2 SITE CLASSIFICATION

Site classification is a prioritization step that is used to judge the urgency of the need for initial response actions and maximizes the effectiveness of limited resources. There are four classes of sites (ASTM 1996):

Class 1: Immediate threat to human health and safety or sensitive environmental receptors

Class 2: Short-term threat to human health and safety or sensitive environmental receptors

Class 3: Long-term threat to human health and safety or sensitive environmental receptors

Class 4: No demonstrable threat to human health and safety or sensitive environmental receptors

This site presents no explosive threat and contains no free product, no surface water, and no groundwater discharges. There are no public facilities (i.e., daycares, parks, schools, dwellings) located on or near the site. The nearest potable groundwater aquifer is located approximately 250 feet bgs. Additionally, access to soils is limited primarily to Base personnel. Therefore, Site SD-11 was considered to be a Class 4 site.

8.3 BACKGROUND COMPARISON

Metals are natural constituents of soils and water. Metals that occur in concentrations within background levels are not considered site-related chemicals of concern and are not evaluated

further. To determine if the concentrations of metals detected in surface and subsurface soil at Site SD-11 exceeded background concentrations, the maximum detected concentrations at the site were compared to the calculated background UTLs. The UTLs used in this comparison were calculated as part of the background study for Cannon AFB (W-C 1997). Maximum detected concentrations from surface soils were compared to surface soil UTLs. Maximum detected concentrations from subsurface soils were compared to subsurface UTLs. If the maximum detected concentration exceeded the background UTL, the metal was considered to exceed background and was evaluated in the Tier 1 screen.

8.3.1 Surface Soil

The maximum detected surface soil concentrations of metals were compared to background concentrations (W-C 1997). Aluminum, calcium, chromium, iron, magnesium, vanadium, and zinc were considered to exceed background levels. All other metals were considered to be within background levels. Table 8-1 summarizes the comparison and a discussion is given below.

The maximum detected concentrations of arsenic, barium, beryllium, cobalt, copper, lead, manganese, nickel, potassium, and thallium did not exceed the background UTLs. Therefore, these metals were considered to be within background levels and were not evaluated further.

Seven of nine surface soil samples contained aluminum at concentrations (ranging from 10,100 mg/kg to 12,500 mg/kg) which exceeded the background UTL of 8,950 mg/kg. Therefore, aluminum was considered to exceed background levels and was evaluated further. Five of nine surface soil samples contained calcium at concentrations (ranging from 49,900 mg/kg to 75,100 mg/kg) which exceeded the background UTL of 44,800 mg/kg. Therefore, calcium was considered to exceeded background levels and was evaluated further.

Three of eight surface soil samples contained chromium at concentrations (ranging from 11.2 mg/kg to 13.6 mg/kg) which exceeded the background UTL of 10.5 mg/kg. Therefore, chromium was considered to exceed background levels and was evaluated further.

Four of nine surface soil samples contained iron at concentrations (ranging from 10,200 mg/kg to 11,800 mg/kg) which exceeded the background UTL of 10,100 mg/kg. Therefore, iron was considered to exceed background levels and was evaluated further.

Six of nine surface soil samples contained magnesium at concentrations (ranging from 2,100 mg/kg to 2,900 mg/kg) which exceeded the background UTL of 1,930 mg/kg. Therefore, magnesium was considered to exceed background levels and was evaluated further.

Two of nine surface soil samples contained vanadium at concentrations (ranging from 24.1 mg/kg to 24.2 mg/kg) which exceeded the background UTL of 23.3 mg/kg. Therefore, vanadium was considered to exceed background levels and was evaluated further.

Two of nine surface soil samples contained zinc at concentrations (ranging from 33.6 mg/kg to 38.3 mg/kg) which exceeded the background UTL of 32.2 mg/kg. Therefore, zinc was considered to exceed background levels and was evaluated further.

8.3.2 Subsurface Soil

The maximum detected subsurface soil concentrations of metals were compared to background concentrations (W-C 1997). Barium, calcium, chromium, copper, and lead were considered to exceed background levels. All other metals were considered to be within background levels. Table 8-2 summarizes the comparison and a discussion is given below.

The maximum detected concentrations of Aluminum, arsenic, beryllium, cobalt, iron, magnesium, manganese, nickel, potassium, sodium, thallium, vanadium, and zinc did not exceed the background UTLs. Therefore, these metals were considered to be within background levels and were not evaluated further.

Two of thirty subsurface soil samples contained barium at concentrations (ranging from 931 mg/kg to 1,260 mg/kg) which exceeded the background UTL of 890 mg/kg. Therefore, barium was considered to exceed background levels and was evaluated further.

One of thirty subsurface soil samples contained calcium at a concentration (246,000 mg/kg) which exceeded the background UTL of 237,498 mg/kg. Therefore, calcium was considered to exceeded background levels and was evaluated further.

One of twenty-seven subsurface soil samples contained chromium at a concentration (13.4 mg/kg) which exceeded the background UTL of 13.3 mg/kg. Therefore, chromium was considered to exceed background levels and was evaluated further.

Two of thirty subsurface soil samples contained copper at concentrations (ranging from 9.5 mg/kg to 9.6 mg/kg) which exceeded the background UTL of 8.3 mg/kg. Therefore, copper was considered to exceed background levels and was evaluated further.

One of thirty subsurface soil samples contained lead at a concentration (9 mg/kg) which exceeded the background UTL of 8.7 mg/kg. Therefore, lead was considered to exceed background levels and was evaluated further.

8.3.3 Comparison of Site Essential Nutrient Concentrations to RDAs

The maximum detected concentrations of essential nutrients which exceeded background and which do not have EPA Region VI MSSLs established for them were compared to the recommended daily requirements (RDAs) set by the National Research Council.

At Site SD-11, calcium and magnesium were compared to the RDAs. Table 8-3 shows that the maximum detected concentrations of calcium and magnesium did not cause estimated potential site daily intake to exceed the RDAs. Therefore, these inorganics would not pose a human health risk and were not evaluated further.

8.4 TIER 1 EVALUATION

The Tier 1 evaluation involves the comparison of the maximum detected site concentrations to conservative, nonsite-specific, risk-based screening levels to determine whether site conditions satisfy the criteria for a quick regulatory closure or warrant a more site-specific evaluation.

8.4.1 Chemicals of Potential Concern

COPCs were identified based on the chemical analytical data (both historic and current) presented in Tables 5-2, 5-3, 6-2, and 6-3. Metals which exceeded background levels and all detected organic compounds (except those considered to be laboratory contaminants) were evaluated as COPCs. TPH was not considered to be a COPC because it is a complex chemical mixture with varying constituents. Therefore, individual constituents (e.g. BTEX, PAHs, etc.) were used to evaluate potential impacts from TPH at Site SD-11.

8.4.2 Tier 1 Comparison

Maximum detected concentrations of COPCs were compared to the EPA Region VI Residential MSSLs. The comparison is shown in Table 8-4. The table shows that only benzo(a)pyrene (BaP) exceeded the Tier 1 values. Therefore, BaP is the only chemical of concern (COC) at Site SD-11.

8.5 TIER 2 EVALUATION

The Tier 2 evaluation provides an option to determine the target levels for the COCs identified in the Tier 1 comparison. This step uses site-specific information related to exposure parameters and soil properties to develop site-specific target levels (SSTLs).

At Site SD-11, the SSTL(s) were calculated using the RBCA Tool Kit for Chemical Releases developed by Groundwater Services, Inc. (GSI 1999). The site-specific information used to develop the SSTL included the assumption of a commercial and construction worker exposure scenarios. Tier 1 values assumed residential exposure which is highly conservative for Site SD-11. Site SD-11 is located in an industrial area of the Base and are still used for outdoor engine cell testing. Therefore, industrial exposures are more appropriate for this site. The following exposure assumptions were used to calculate the SSTL for benzo(a)pyrene at Site SD-11.

An exposure frequency of 60 days per year was assumed for the commercial worker scenario. Site SD-11 is located in a remote area of the Base, and no one works routinely (8 hours/day, 250 days/year) at the site. Although testing is still conducted at the site, it is infrequent (less than once a week). Additionally, the site does not require significant ground maintenance/landscaping because ground cover is predominantly asphalt, concrete, and gravel. Therefore, exposure of Base workers to soils at Site SD-11 is unlikely and the assumption of 60 days per year (5 days per month) is conservative and provides protection for Base workers. All other exposure parameters were considered to be the standard default values. Appendix C shows all the input parameters and assumptions used to calculate the benzo(a)pyrene SSTL at Site SD-11.

The SSTL for benzo(a)pyrene at Site SD-11 was 0.43 mg/kg. The maximum detected concentration of BaP (0.27 mg/kg) did not exceed the SSTL.

TABLE 8-1

COMPARISON OF METALS CONCENTRATIONS IN SURFACE SOIL WITH BACKGROUND UTLs AT APPENDIX I SWMUs 86-90 (SITE SD-11) CANNON AFB, NEW MEXICO

Chemical	Frequency Detected	Field Sample ID for Maximum Hit	Maximum Detected Concentration (mg/kg)	Qualifiers for Maximum Hit	Background Surface Soil UTL Concentration[1] (mg/kg)	Exceeds Background UTL	Frequency of Exceedance of UTL	Frequency of Exceedance (%)	Does Metal Exceed Background?
METALS									
Aluminum	9/9	CAN086-8611-0000	12500		8 950	YES	7	78	YES
Arsenic	9/9	CAN086-8612-0000	3		3.6	NO			NO
Barium	9/9	CAN086-8613-0000	410	J	670	NO			NO
Beryllium	9/9	CAN086-8611-0000	0.62		0.78	NO			NO
Calcium	9/9	CAN086-8612-0000	75100		44 800	YES	5	56	YES
Chromium, Total	8/8	CAN086-8611-0000	13.6		10.5	YES	3	38	YES
Cobalt	9/9	CAN086-8617-0000	4.9		6.6	NO			NO
Copper	9/9	CAN086-8617-0000	9.2		18.3	NO			NO
Iron	9/9	CAN086-8615-0001	11800		10100	YES	4	44	YES
Lead	9/9	CAN086-8619-0000	10.1		12	NO			NO
Magnesium	9/9	CAN086-8618-0000	2900		1 930	YES	6	67	YES
Manganese	9/9	CAN086-8617-0000	214		307	NO			NO
Nickel	9/9	CAN086-8611-0000	10.5		11	NO			NO
Potassium	9/9	CAN086-8614-0000	2030		2691	NO			NO
Thallium	4/9	CAN086-8614-0000 CAN086-8615-0001	0.18	J	0.6	NO			NO
Vanadium	9/9	CAN086-8611-0000	24.2		23.3	YES	2	22	YES
Zinc	9/9	CAN086-8613-0000	38.3		32.2	YES	2	22	YES

(1) Upper Tolerance Limit of Background (90% limit of 95th percentile). See Table 6-3 of W-C 1997.
mg/kg = Milligram per Kilogram
J = Estimated

TABLE 8-2

COMPARISON OF METALS CONCENTRATIONS IN SUBSURFACE SOIL WITH BACKGROUND UTLs AT APPENDIX I SWMUs 86-90 (SITE SD-11) CANNON AFB, NEW MEXICO

Chemical	Frequency Detected	Field Sample ID for Maximum Hit	Maximum Detected Concentration (mg/kg)	Qualifiers for Maximum Hit	Background Subsurface Soil UTL Concentration[1] (mg/kg)	Exceeds Background UTL	Frequency of Exceedance of UTL	Frequency of Exceedance (%)	Does Metal Exceed Background?
METALS									
Aluminum	30/30	CAN086-8611-0004	11600		12 214	NO			NO
Arsenic	28/30	CAN086-8611-0009	2.8		4.3	NO			NO
Barium	30/30	CAN086-8614-0034	1260	J	890	YES	2	7	**YES**
Beryllium	24/30	CAN086-8611-0014	0.71	J	0.73	NO			NO
Calcium	30/30	CAN086-8611-0015	246000		237 498	YES	1	3	**YES**
Chromium	27/27	CAN086-8611-0004	13.4		13.3	YES	1	4	**YES**
Cobalt	19/30	CAN086-8611-0004	4.3		4.7	NO			NO
Copper	28/30	CAN086-8617-0029	9.6		8.3	YES	2	7	**YES**
Iron	30/30	CAN086-8611-0004	10100		13 148	NO			NO
Lead	30/30	CAN086-8611-0009	9		8.7	YES	1	3	**YES**
Magnesium	30/30	CAN086-8619-0029	13400		19 300	NO			NO
Manganese	30/30	CAN086-8611-0004	204		333	NO			NO
Nickel	30/30	CAN086-8611-0004	10.3		14.9	NO			NO
Potassium	30/30	CAN086-8611-0014	1970	J	2 512	NO			NO
Sodium	30/30	CAN086-8611-0004	204	J	1 227	NO			NO
Thallium	30/30	CAN086-8614-0009	0.17	J	2.65	NO			NO
Vanadium	30/30	CAN086-8611-0004	22.9		32.8	NO			NO
Zinc	30/30	CAN086-8611-0004	29.5		30.6	NO			NO

(1) Upper Tolerance Limit of Background (90% limit of 95th percentile). See Table 6-3 of W-C 1997.
mg/kg = Milligram per Kilogram
J = Estimated

TABLE 8-3

ESSENTIAL NUTRIENTS EXCLUDED AS POTENTIAL COCs IN THE SURFACE SOIL AT APPENDIX I SWMUs 86-90 (SITE SD-11)

Chemical	Detected Concentration[1] (mg/kg)	Ingestion Rate[2] (mg/d)	Conversion Factor (kg/mg)	Daily Intake from the site[3] (mg/d)	Recommended Daily Allowance (RDA)[4] (mg/d)
Calcium	246 000	100	1.00E-06	24.6	1 200
Magnesium	13 400	100	1.00E-06	1.34	400

[1] Maximum detected concentration at SD-11. See Table 8-2.

[2] Estimation of potential chemical ingestion rate for receptors at SD-11.

[3] Daily Intake = Detected Concentration * Ingestion Rate * Conversion Factor

[4] National Research Council

TABLE 8-4

COMPARISON OF MAXIMUM SOIL CONCENTRATIONS TO MSSLs
APPENDIX I SWMUs 86-90 (SITE SD-11)
CANNON AFB, NEW MEXICO

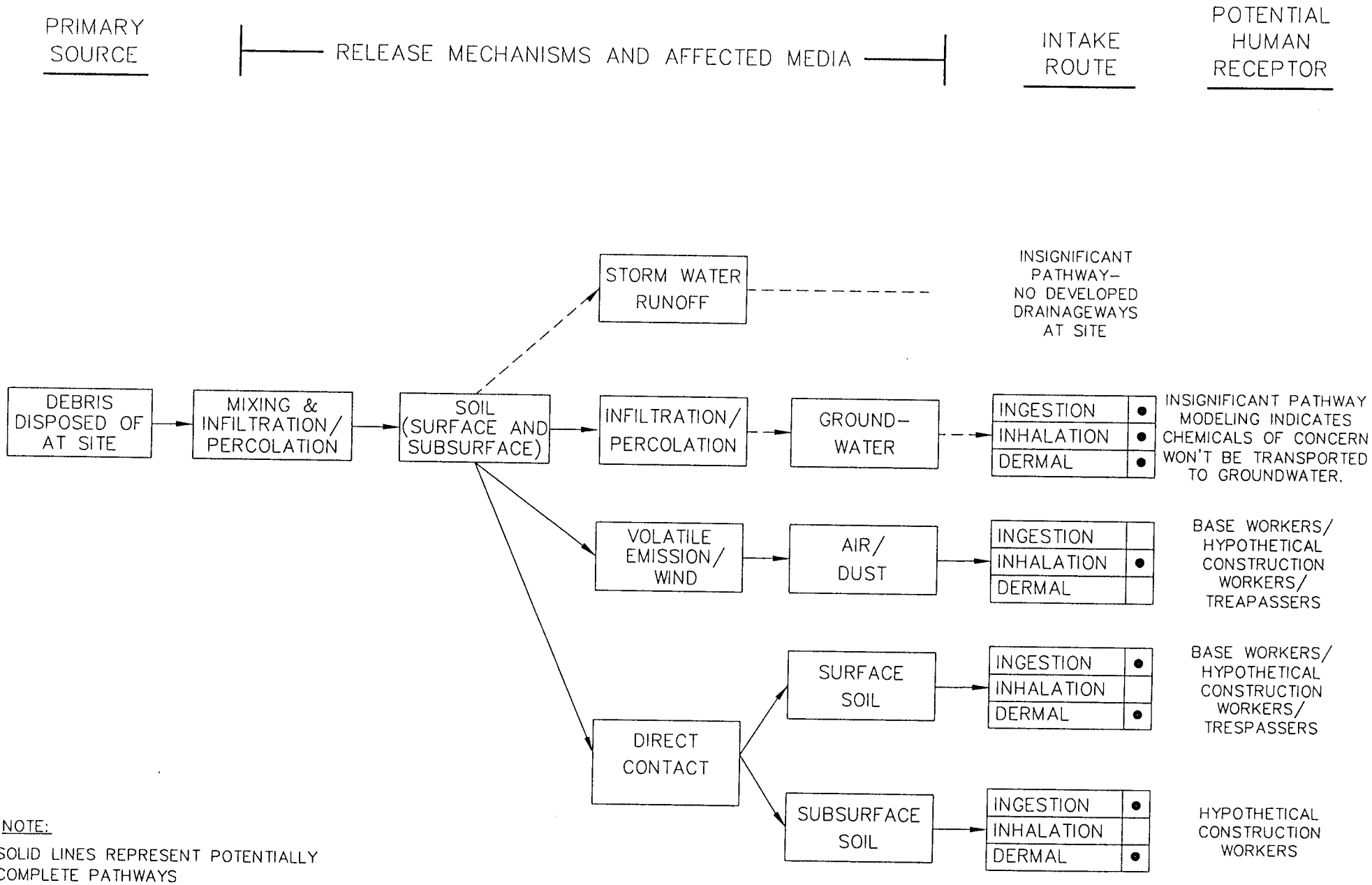
Chemical	Field Sample ID for Maximum Hit	Maximum Detected Concentration (mg/kg)	Qual	Residential Soil MSSL Concentration[1] (mg/kg)	Exceeds MSSL?
VOLATILE ORGANICS					
Acetone	CAN086-8613-0014	0.59	J	1400	NO
2-Butanone	CAN086-8613-0034	0.051	J	6900	NO
Ethylbenzene**	CAN086-8611-0014	18		230	NO
Methylene Chloride	CAN086-8613-0024	0.0032	J	8.5	NO
Toluene**	CAN086-8611-0039	0.3		520	NO
Xylenes**	CAN086-8611-0014	33		210	NO
SEMIVOLATILE ORGANICS					
Benzo(a)anthracene	CAN086-8611-0004	0.2	J	0.56	NO
Benzo(a)pyrene	CAN086-8614-0000	0.27		0.056	**YES**
Benzo(b)fluoranthene	CAN086-8614-0000	0.44	J	0.56	NO
Benzo(g,h,i)perylene*	CAN086-8614-0000	0.11	J	55	NO
Chrysene	CAN086-8611-0004	0.26	J	56	NO
Di-n-Butyl Phthalate	C11-SB02-010	0.15	J	5500	NO
Dibenzofuran	CAN086-8613-0003	0.15	J	210	NO
Fluoranthene	CAN086-8614-0000	0.21	J	2000	NO
Indeno(1,2,3-cd)pyrene	CAN086-8614-0000	0.089	J	0.56	NO
Isophorone	CAN086-8613-0014	0.93	J	4700	NO
2-Methylnaphthalene*	CAN086-8611-0014	18		55	NO
Naphthalene	CAN086-8611-0014	11		55	NO
Phenanthrene*	CAN086-8613-0000	0.057	J	55	NO
Phenol	C11-SB03-010	0.055	J	33000	NO
Pyrene	CAN086-8614-0000	0.26	J	1500	NO
TRPH (418.1)	CAN086-8612-0004	5390	J	NA	NA
TPH-DRO (8015)	C11-SB03-002	68		NA	NA
METALS					
Aluminum	CAN086-8611-0000	12,500		75000	NO
Barium	CAN086-8614-0034	1260		5200	NO
Chromium	CAN086-8611-0000	13.6		30	NO
Copper	CAN086-8617-0029	9.6		2800	NO
Lead	CAN086-8619-0000	10.1		400	NO
Vanadium	CAN086-8611-0000	24.2		520	NO
Zinc	CAN086-8613-0000	38.3		22000	NO

(1) EPA Region Media-Specific Screening Levels for Residential Soil (EPA 1998)

* The MSSL for naphthalene was used as a surrogate for these PAHs. See text.

** The MSSL for ethylbenzene, toluene and xylenes is based on a soil saturation concentration and is not based on risk.

mg/kg = Milligrams per Kilogram



NOTE:

SOLID LINES REPRESENT POTENTIALLY COMPLETE PATHWAYS

DASHED LINES REPRESENT INCOMPLETE OR INSIGNIFICANT PATHWAYS

July 14, 1999 2:25:50 p.m.
Drawing: T:\CANNON\M9602V\T6500\FIG8-1.DWG (TSM)

DRN BY TSSM	DATE 07/14/99	SITE CONCEPTUAL EXPOSURE MODEL SWMUs SD-11 HUMAN EXPOSURES CANNON AIR FORCE BASE NEW MEXICO	PROJECT NO. 45F0M9602V.00
CHK'D BY .	REVISIONS: 0		FIG. NO. 8-1

9.1 INTRODUCTION

As illustrated in Figure 9-1, problem formulation is the first of three phases of an ERA (USEPA 1992, 1998). It is a formal process for developing and evaluating hypotheses about why adverse ecological effects may occur as a result of human activities. During problem formulation, risk management goals are identified to establish the objectives of the ERA, the problem is defined, and the plan for analyzing data (Analysis Phase) and characterizing risk (Risk Characterization Phase) is developed. Problem formulation provides the foundation on which the entire ERA depends (USACE 1996; USEPA 1998).

Successful completion of problem formulation (and, ultimately the ERA) depends upon the quality of three products:

- *Assessment endpoints* that adequately reflect management goals and the ecosystem(s) they represent;
- *Conceptual models* that describe the key relationships between the chemicals of potential ecological concern (COPECs) and assessment endpoints; and
- An analysis plan.

Integration and evaluation of available information (Figure 9-1) develop these products. To begin, there must be an adequate understanding of the ecological resources or ecosystem(s) that could potentially be affected and recognition of the COPECs that might elicit the adverse effect(s).

9.1.1 Overview of the Ecological Evaluation Process

The first three steps of this ecological risk evaluation (Figure 9-2) roughly correspond to a preliminary, or screening level (Tier I) wherein: (1) the presence of an ecological component is determined; (2) the contaminated media to which the ecological component(s) could be exposed are identified; and (3) the magnitude of contamination in each applicable medium is compared to a level conservatively assumed to constitute a hazard (ecotoxicological benchmark). Where an ecological component is lacking, the process concludes that contaminants of interest (COIs) are not of potential ecological concern within the site under consideration. Where an ecological component exists, but COI concentrations in applicable media do not equal or exceed the ecotoxicological benchmarks, the contaminants are not considered chemicals of potential ecological concern (COPECs). But, given the presence of an ecological component *and* at least one COPEC, the site requires further evaluation.

Tier II corresponds to a modified "desktop" ecological risk assessment which retains much of the conservatism of the preliminary screening level but considers site-specific exposure scenarios to augment interpretation of the significance (ecological relevance) of the estimated exposures. A result might be that, even though a screening benchmark was met or exceeded, the *maximal environmental exposure concentration* (MEEC or EEC) to a site-specific Receptor of Concern (ROC) may not equal or exceed a level known or predicted to be associated with a significant adverse ecological response (i.e., an effect that would threaten the structural and functional

integrity of the local ecosystem). For example, a benchmark may be predicted on an adverse effects threshold (AET) in soil where the effect was on directly exposed soil invertebrates, but ingestion of that soil by a mouse (an indirect exposure) may not occur at a rate (dose) associated with a conceivable adverse effect on the mouse. Such a result would lead to a recommendation of no further action based on ecological considerations.

On the other hand, the maximal environmental exposure concentration (i.e., the lower of the maximum detected value or the 95 percent Upper Confidence Limit [UCL] of the mean) may meet or exceed the direct exposure or dose associated with a significant adverse ecological response on the part of the site-specific ROC. This outcome would lead to either: (a) an evaluation of potential corrective measures; or (b) a recommendation for further investigation in the form of a more detailed quantitative ecological risk assessment (i.e., a Tier III ERA -- Expanded Sampling Program, USACE 1996). In essence, the information sought would include site-specific measurements and/or observations designed to corroborate or refute (and hence modify) the assumptions applied in the desktop assessment. Such assumptions could be related to either exposures or effects (responses), or both.

9.1.2 Ecological Relevance and General Assessment Endpoints

The salient difference between human health risk assessment and ecological risk assessment is that the latter "involves multiple endpoints at different levels of biological organization, from single species to communities of organisms to entire ecosystems" (USEPA 1991). Ecological systems are by definition complex, and it is neither feasible (nor necessary) to examine all components in detail (USEPA 1992, 1998). As noted above, USACE (USACE 1996; see also USEPA 1997a, 1998; Suter 1993) emphasizes focusing an ecological risk assessment on ecologically relevant endpoints through a process known as problem formulation. A key element of problem formulation is the identification of general ecologically relevant issues and development of assessment endpoints. *Ecological relevance*, as used here, refers to the properties or values necessary to "sustain the natural structure and function of an ecosystem." In this context, the ecological "values" that are to be protected at a site are called *assessment endpoints* (USEPA 1998, Suter 1993).

There is no current guidance (either in USACE, CERCLA, or in the general ecological literature) on how to systematically evaluate and prioritize those aspects of the environment potentially at risk. Three levels of ecological organization are generally recognized as important: populations, communities, and ecosystems (USACE 1996; USEPA 1989, 1992, 1997a, 1998; Suter 1993). A *population* is "an aggregate of individuals of a species within a specified location in space and time"; a *community* is "an assemblage of populations of different species within a specified location and time"; and an *ecosystem* is "the biotic community and abiotic environment within a specified location and time" (USEPA 1998, 1997a). There is no broadly accepted approach for determining which of the numerous ecological characteristics that fall under these three levels of organization are "values" that are important, either regionally or at specific locations.

Human societal values should also be addressed during development of assessment endpoints (Suter 1993; Harwell *et al.* 1994; USACE 1996), although ERAGS counsels that such

considerations are secondary to ecological relevance. This is because such factors as economics (i.e., recreational or commercial value), esthetics, and policy goals are imbued with subjectivity and are thus largely outside the scope of science.

9.2 ECOLOGICAL RESOURCES POTENTIALLY AT RISK

One of the key elements of problem formulation is defining and characterizing the ecological context, or ecosystem(s), within which adverse effects might occur (USACE 1996; USEPA 1998, 1996, 1997a; Barnthouse and Brown 1994). A series of questions is provided in USEPA (1996) to help identify known and unknown relationships, both of which are important:

- *What are the geographic boundaries? How do they relate to the functional characteristics of the ecosystem?*
- *What are the key abiotic factors influencing the ecosystem (e.g., climatic factors, geology, hydrology, soil type, water quality)?*
- *What are the structural characteristics of the ecosystem (e.g., species number and abundance, trophic relationships)?*
- *What habitat types are present?*
- *Where and how are functional characteristics driving the ecosystem (e.g., energy source and processing, nutrient cycling)?*
- *How do these characteristics influence the susceptibility (sensitivity and likelihood of exposure) of the ecosystem to the stressor(s)?*
- *Are there unique features that are particularly valued (e.g., the last representation of an ecosystem type)?*
- *What is the landscape context within which the ecosystem occurs?*

The area designated as Site SD-11 is represented, for purposes herein, as an area equal to the overall extent of soil sampling, approximately 1 acre. Considering the open areas in close proximity of the actual SWMUs (SWMU 86 through 90) and using the maps produced to depict the unit (e.g., Figure 4-1), there appears to be approximately 6 to 7 acres. This area is continuous with a much larger tract of open area to the north within the Base (e.g., in excess of 100 acres).

9.2.1 Potentially-Affected Habitats

The initial step in ecological evaluation of a site is determining whether the unit has an *ecological component*. This determination is based on the availability, within the subject unit, of *habitat*. Simply defined, the term habitat means the "place where a plant or animal lives" (USACE 1996; USEPA 1997a), but a more functional definition can be paraphrased as the *type of environment* where an organism (or community of similarly adapted organisms) *normally* lives. Gray squirrels, for example, normally spend most of their time in trees, although they can and do "live" on the ground. When the squirrels visit the ground it is usually in proximity to the trees where the animals remain most of the time, seek cover, obtain most of their food, and build nests. Thus,

forests constitute "habitat" for gray squirrels, while open fields do not. Different species exhibit varying degrees of specialization or dependence relative to habitats, some being ubiquitous (e.g., house mouse, house sparrow) and others being more or less confined to very specific types of environment (e.g., gray squirrel). The habitat requirements and relationships of ecological receptors greatly influence their relative vulnerability to contaminant exposures.

9.2.2 Ecological Resources

The usual approach to characterizing the biotic components of an area is to compile an inventory of the kinds (taxa) of organisms known or expected to be present based on zoogeography and available habitat (i.e., Tables 9-1 through 9-3). This provides an indication of the potential biological diversity within a system, but is of limited utility without additional insights on the structure of the communities (e.g., densities or at least relative abundance, details of microhabitat associations, relative mobility, etc.). To interpret the likelihood and significance of potential changes, it is also important to consider the functional roles of the ecological components, especially in terms of their trophic relations. The following subsections characterize the potential biological communities within the site under investigation structurally and functionally, to the extent possible and as necessary for an ecological risk assessment.

9.2.2.1 Vascular Plants

While physical attributes of an area have a significant impact on available habitat for exploitation by biota, these are often most reflected within the primary producers within the system; i.e., green plants (bottom-up ecological control). Thus, most often the initial step in measuring terrestrial habitat is the identification of the vegetative community or communities present (Morrison *et al.* 1992). Site SD-11 from an ecological perspective is best characterized as a disturbed short-grass prairie area. The native dominant species within a shortgrass prairie would be expected to include blue gramma (*Boutelona gracilis*), buffalo grass (*Buchloe dactyloides*), and needle-and-thread (*Stipa comata*) (Brown 1997). Most certainly other weed and grass species are present due to human activity within the unit. Given the continuity and proximity to a relatively undisturbed section of grassland within the Base boundaries, native species would be expected to re-colonize the area and lends support to a conclusion that many native plant species are occurring within the unit proper. The production associated with the actual potentially impacted area (approximately 1-acre) would not be expected to support a large community of organisms. Nevertheless, there may be sufficient quantity and quality of vegetable biomass to present attractive forage for ecological receptors such that, at least at times, relevant ecological receptors would forage within the impacted area.

9.2.2.2 Soil Communities

There is an ecological community that is intimately associated with soil and thus, soil is treated as a specific entity. The biotic community of most soils can be rich and diverse, both in terms of species diversity and its biomass per unit area or volume (Spurr 1964, Owen 1975). The focus of the following discussion is on those components most involved with decomposition, nutrient cycling and, biomass production for utilization at higher trophic levels.

Soil Microorganisms (bacteria, fungi, molds, algae, protozoa)

Under favorable conditions (e.g., temperature, moisture, pH, oxygen, trace minerals) bacteria can be extremely numerous and represent a significant portion of the biomass present in soil (Spurr 1964, Kabata-Pendias and Pendias 1992). There is a suggestion that within native shortgrass prairie that microbial biomass may equal that of the above ground vegetable biomass (Brown 1997). Such populations of soil bacteria may form up to 0.03% of the total topsoil mass (Owen 1975). Soil bacteria do not normally occur as isolated cells within soil, but generally as colonies or films. Most often bacterial films encapsulate the roots and root hairs of plants. These bacterial films, mats, or colonies are generally located within the upper strata of the soil where sufficient oxygen and detritus are available. Fungi and molds present in soil play an instrumental role in the breakdown of cellulose and lignin (Owen 1975). Up to 50% of the decomposed plant debris can be incorporated into fungi and/or molds. Soil algae can also be significant in the upper layers of soils where sunlight can penetrate. Being photosynthetic, all soil algae require direct sunlight for survival and growth. Given direct exposure to sunlight alga cell densities can attain 800,000 cells per gram of dry soil (Owen 1975). Algae (i.e., blue-greens) may serve as a food source in some grassland situations as well as perform significant nitrogen fixation (Owen 1975). This may occur during the short periods of rain at Cannon AFB. Many of the protozoans in soil are capable of photosynthesis as well as utilizing detritus for energy (Brusca and Brusca 1990). There are over 250 species of soil-dwelling protozoans that are generally restricted to the upper layers of soil due to oxygen and food availability (Owen 1975). Protozoan production can result in a total biomass approaching 200 pounds per acre (Owen 1975) but such a condition is not expected for the grassland under consideration here. Commonly, grassland soil like that associated with Site SD-11 and the adjacent area, is dominated by bacteria and perhaps some soil algae. There would be expected a diversity of species resistant to extended periods of dry conditions. It is also expected that these bacteria would play a significant role in nutrient cycling. Here again, however, the size of the potentially impacted area is such that the nutrient cycling associated with the microbial population within Site SD-11 would be insignificant in the context of the overall ecosystem or grassland community within the Base proper.

Soil Invertebrates

Worms, both nonsegmented (i.e., nematodes) and segmented (i.e., annelids) can comprise a significant portion of the soil biomass. Soil nematode populations (e.g., eelworms or horsehair worms) have been estimated to include up to 45 billion individuals within an acre of certain soils (Owen 1975). Many of the nematodes are parasitic (Brusca and Brusca 1990) which can have direct impacts on vegetative communities (especially in agricultural crops; Owen 1975). Annelids, generically termed "earthworms," are highly effective in cultivating and/or turning the soil matrix (Spurr 1964). Earthworm populations in temperate forest soils can attain a population of 650,000 individuals per acre (Spurr 1964). Most lumbriculid worms are intolerant of soils where the pH is less than 4.5 and poorly drained soils (Owen 1975, Kabata-Pendias and Pendias 1992) and are not expected to significantly occur with the short-grass prairie soils here. Soil arthropods (spiders, mites, and ticks [arachnids]; centipedes and millipedes [myriapods]; springtails and larval flies [insects]) constitute another large and diverse group of soil invertebrates. Springtails are often regarded as the most important group of soil insects (Spurr

1964). Millipedes, centipedes, termites, and certain ants can also play a significant role in the decomposition of plant matter (Owen 1975). Many species within these groups are predaceous on other soil invertebrates (e.g., certain arachnids) such that they can be considered secondary consumers. Site SD-11 and the adjacent grassland would be expected to contain a significant diversity of soil invertebrates dominated by insects and their larvae. Many more insects would be associated with the grass above ground. The vegetative biomass associated with the grassland within the potentially impacted area of Site SD-11 is probably sufficient to support a community of soil invertebrates and insects but is unlikely to be sufficient for supporting any significant community of vertebrate consumers. Certainly individuals may exploit the grasses and invertebrate community within Site SD-11 but they are most likely more associated with the community within the adjacent grassland area.

9.2.2.3 Terrestrial Amphibians

All amphibians require water for reproduction but many are terrestrial in their habits, especially considering foraging and trophic relationships. Considering shortgrass prairies (Table 9-1), however, few amphibians are adapted to such a dry environment. These species are dominated by the spadefoots (*Scaphiopus* sp.s), yet two *Bufo* species may also be present, Woodhouse's toad (*Bufo woodhousii*) and perhaps the Great Plains toad (*Bufo cognatus*). Predators of amphibians associated with Site SD-11 would find meager fare as few species and/or numbers of individuals are expected. The fossorial snakes (e.g., the blind snakes [*Leptoyphlops*]) would dominate the most likely predators of any amphibians present. Access to any of the amphibians present by predators is not expected to be restricted.

9.2.2.4 Terrestrial Reptiles

Reptiles utilizing the grassland within Site SD-11 are expected to be dominated by a number of lizards and snakes (Table 9-1). The most likely species (i.e., those most closely associated with the potential habitat) include the racerunner (*Cnemidophorus sixlineatus viridis*), the fence lizard (*Sceloporous undulatus*), and the coachwhip (*Masticophis flagellum*). Several other lizards and snakes have a potential to forage within Site SD-11 (e.g., denoted with a Po within Table 9-1), given the overland connection with the larger habitat patch of grassland adjacent to the unit. A habitat patch is defined here as a "resource patch" which is an area, on a landscape scale that has more or less homogenous environmental conditions (see Morrison et al. 1992). Two other reptiles, the box turtle (*Terrepene ornata*) and the many-lined skink (*Eumeces multivarigatus*) also have a potential to occur on or near Site SD-11. Given a sufficient insect population associated with the grassland within Site SD-11, it would be likely that a reptilian community would be present within the unit and function as part of the larger community within the adjacent grassland. These reptiles would present themselves as desirable forage to many predatory birds, mammals, and other reptiles.

9.2.2.5 Terrestrial Birds

Based on zoogeography and considering only terrestrial birds (excluding aquatic or semi-aquatic species, there is significant number of species potentially resident (including summer or winter

within the area of New Mexico in the vicinity of the Base (Table 9-2). Transient migrants are not considered or listed within Table 9-2. Only those species that have a potential to be permanent residents within the area or those that reside in the area during summer or winter are considered. Of these species, only about one-quarter appear to have a potential to either utilize or occur within the shortgrass prairie habitat associated with Site SD-11. Of these, even fewer species have a significant potential to be associated with shortgrass prairie. Both the longspurs (*Rhychophanes mccownii* and *Calccarius ornatus*), and sparrows (*Ammodramus* spp.s) are listed as winter residents while the meadowlarks (*Sturnella* spp.s), mourning dove (*Zenaidura macroura*), and burrowing owl (*Speotyto cunicularia*) are potentially year-round residents. The remaining birds possibly present (denoted with a "Po" within Table 9-2) would likely, at least at times, forage within or adjacent to Site SD-11. Given this potential diversity of birds, which appears to cross several trophic levels, they would be expected to present an attractive forage base for predators such as, some snakes, mammals, and birds of prey.

9.2.2.6 Terrestrial Mammals

Given the paucity of cover, few, fully terrestrial mammals (those with no fossorial habits) would be expected to occur or even potentially occur as full time residents within the shortgrass prairie within and adjacent to Site SD-11 (Table 9-3). These few species would primarily include the lagamorphs (the jackrabbit [*Lepus californicus*] and cottontails [*Sylvilagus* spp.s]). Terrestrial to fossorial rodent species such as the pocket mice (*Perognathus* spp.s) along with similar species are expected to dominate any small mammalian community associated with Site SD-11. Of the larger mammals, the badger (*Taxidea taxus*) and coyote (*Canis latrans*) are the most likely to frequent the area. It is suspected that other, even more transient, mammals may at times, forage within Site SD-11 or the adjacent grassland. These would include the mule deer (*Odocoileus hemionus*), pronghorn (*Antilocapra americana*), passing skunk (*Spilogale putrorius*), or fox (*Urocyon* or *Vulpes*). Visits by either deer or pronghorn, however, would be considered extremely rare occurrences. Additionally, it is likely that one or more bat species (e.g., *Myotis* or *Tadarida*) would screen the area associated with Site SD-11 for flying insects. It is also likely that the smaller mammals and even medium-sized rabbits occurring or foraging within the unit could be preyed upon by birds of prey, snakes, as well as the foxes and coyotes listed above.

9.2.3 Sensitive Areas/Receptors

Of the candidate species for the Federal listing as endangered or threatened plants (*Epipactus gigantea* [chatterbox orchid], *Aster harridus* [spiny aster], *Asragalus witmanii* [Whittman's milkvetch], *Proposcidea sabulosa* [dune acorn plant], and *Eupjorbia strictior* [tall plains spruce]) none are expected to occur within the Base (Lee Wan and Associates 1990). Although the black-footed ferret (*Mustela nigripes*) has some potential to exploit the potentially present resources within and adjacent to Site SD-11, it is not expected given its status within the State of New Mexico – potentially extinct. The Fish and Wildlife (online service) service lists the swift fox (*Vulpes velox*) as a candidate species for Curry County, New Mexico and has a potential to at least occasionally forage within the vicinity of Site SD-11. Two birds are federally listed as threatened or endangered are believed to have a potential to occur on or near Cannon AFB, the bald eagle (*Haliaeetus leucocephalus*) and the peregrine falcon (*Falco peregrinus tundrius*).

Three New Mexico birds listed by the State for special protection have some potential for occurring within the vicinity of Cannon AFB: the Mississippi kite (*Ictinia missippiensis*), McCown's longspur (*Rhychophanes mccownii*), and Baird's sparrow (*Ammodramus bairdii*). The eagle and kite have been observed on or near Cannon AFB. However, neither species is closely associated with shortgrass prairie habitat. The eagle is generally found foraging near the playa lakes while the kite has been found within the Base golf course. As shown in Table 9-2, the Mississippi kite tends to forage from a perch, where the bird swoops into the air and hawks its prey. Such a foraging behavior is not possible within the grasslands associated with Site SD-11. It is doubtful that the kite would find the area attractive and rarely, if ever, forage there. Both the longspur and the sparrow are closely associated with shortgrass prairie habitat, however, no sightings of these species has been made within the Base or its generally vicinity in many years. The same is true for the swift fox and peregrine falcon. While there are no anecdotal accounts for their presence within the Base, the area within which Site SD-11 resides would present attractive forage to these species and, if present, would likely utilize the area.

The community within which Site SD-11 resides (i.e., the shortgrass prairie habitat patch) appears to have the potential to be fairly diverse (albeit not as diverse as suggested by Tables 9-1 through 9-3). With diversity comes stability. This is a cornerstone postulate within the science of ecology. Site SD-11 is not considered an overly sensitive area. The unit is believed to be fairly similar and in fact part of other, larger, habitat "patches" within the Base such that it does not warrant special consideration as being unique. Four species deserving special recognition have a potential association with the habitat identified for Site SD-11: the swift fox, the peregrine falcon, McCown's longspur, and Baird's sparrow. Their actual presence cannot be determined at this point in time. Nevertheless, the potential for presence of these species constitutes the potential for a presence of sensitive receptors associated with Site SD-11.

9.3 ECOSYSTEM DYNAMICS AND FUNCTION

9.3.1 Ecosystem Dynamics

There is a tendency, once the structure of an ecological system has been characterized, to conceive of the various populations and communities mainly in a planar context, losing mental sight of the temporal dimension. This is less of a problem when dealing with relatively sedentary organisms (e.g., rooted or otherwise attached plants, soil invertebrates) but can be very misleading when dealing with some animal communities. All of the individual organisms mentioned above are members of populations which constantly fluctuate in numbers due to: immigration and emigration; reproduction and recruitment; and mortality. The rates of these processes vary substantially among populations. The assemblages of populations in a given area, or *communities* in the sense adopted herein, are also constantly changing, again at varying rates.

The more "stable" biotic communities are also changing, but on a temporal scale that is so protracted as to generally escape notice (except in retrospect). The process of change in such communities (especially of plants) is often referred to as succession and, in the absence of major natural or anthropogenic disturbances, will inexorably lead to predictable phases. The more

common term usually applied here is "stage" or "state", which misleadingly tends to invoke a sense of stepwise change, whereas, the change is normally continuous and gradual. What resource managers commonly attempt to do, with varying degrees of success, is maintain biological communities in "states" wherein the attributes (e.g., composition, structure) are deemed desirable by humans. In some cases, the mission of the resource managers becomes complicated by changes in cultural/societal "values" (i.e., what is deemed desirable).

The reality and inevitability of change within ecosystems is mentioned here because ecological risk assessment is fundamentally a process of evaluating actual or potential change. USEPA (1992a, 1998) specifies that the ecological *significance* of adverse effects (changes) must ultimately be evaluated. As the ERA *Framework* paradigm has evolved, it has become increasingly apparent that the significance (ecological relevance) of potential changes must be given some consideration during problem formulation (Harwell *et al.* 1994).

Site SD-11 represents an ecologically disturbed area within the Base due to human activities. Directly adjacent and to a certain extent continuous with Site SD-11 lies a relatively significant ecological patch of shortgrass prairie. Neither Site SD-11 nor the adjacent patch of grassland is under any specific natural resource management plan. As such, the value and impact accorded to Site SD-11 and the associated grassland on the overall system cannot be fully characterized at this point but it appears that it does interact significantly with the overall system. The relevancy of the ecological community stability and sustainability is not clear. It presently does represent a part (a patch) within the landscape-scale ecosystem and is therefore relevant in a context of the potential to elicit adverse changes (effects) on this broader, self-sustaining ecosystem within which it resides. The direct influence of the small portion of this grassland designated as Site SD-11, however, is most likely nil.

9.3.2 Ecosystem Function

What an ecosystem basically does is "process" energy and materials (Newman 1998, Morrison *et al.* 1992, Watt 1973, many others). Both energy and materials influence the abundance of organisms, the rates at which the organisms live, and therefore the complexity of the biological communities. Energy and materials flow through the biotic and abiotic compartments of a system together and they are difficult to consider separately. But the flow of energy is always unidirectional, whereas that of materials may be cyclic. An atom of carbon, calcium, or phosphorus may be transferred between living and nonliving "compartments" of the system many times, as indeed it may be exchanged with another ecosystem.

9.3.3 Summary

At this point the questions listed at the beginning of this section are reviewed, to evaluate how well (or poorly) the available information will support problem formulation.

- *What are the geographic boundaries? How do they relate to the functional characteristics of the ecosystem?*

Site SD-11 is geographically extremely small in the context of "ecosystem," and does not represent a self-sustaining ecosystem and barely a true biological community in its own right. It may represent a small fraction of the landscape-scale ecosystem in a context of functioning as potential forage area. There are no apparent barriers regarding a connection between Site SD-11 and the adjacent shortgrass prairie patch such that movements of biota would be restricted.

The adjacent shortgrass prairie represents a limited "patch" of habitat within the landscape-scale ecosystem and appears to have the potential to contain a viable (self-sustaining) ecological community within its boundaries. Its functional role (characteristics) within the ecosystem may include nesting habitat for birds, and a role in the overall biological production of the system. The primary ecological corridor connecting this ecological patch of which Site SD-11 is a part and the overall ecosystem is overland movement which is somewhat restricted by the Base boundary roads, taxiways, and fences. There are, of course, no barriers to movements aerially (i.e., by birds and bats).

- *What are the key abiotic factors influencing the ecosystem (e.g., climatic factors, geology, hydrology, soil type, water quality)?*

Human activities extremely limit and influence the community present within Site SD-11 proper but not to the point where all other factors are inconsequential. Rainfall and soil stability (wind damage – blowouts) appear to be the dominant factors influencing the biological communities within Site SD-11 and adjacent grassland.

- *What are the structural characteristics of the ecosystem (e.g., species number and abundance, trophic relationships)?*

Site-specific details regarding the structural characteristics of the ecological system suggest that while there may be a diverse number of species potentially utilizing Site SD-11 and especially the adjacent grassland, few species and very few numbers of organisms are expected to occur directly within Site SD-11. The community within Site SD-11 is not believed to be capable of exerting any significant control over the overall ecosystem within which it resides. Certain species, especially the terrestrial lower trophic forms, may be of sufficient quantity and quality to represent an attractive forage base for at least a few upper trophic organisms.

- *What habitat types are present?*

A single habitat type is present and best characterized as shortgrass prairie habitat.

- *Where and how are functional characteristics driving the ecosystem (e.g., energy source and processing, nutrient cycling)?*

Human activity and the adjacent patch of grassland directly influence the terrestrial community within Site SD-11. The unmanaged community within which Site SD-11 resides (shortgrass prairie) controls itself primarily through the production of grass during the rainy season (energy input) which is in turn processed by herbivores and detritivores.

- *How do these characteristics influence the susceptibility (sensitivity and likelihood of exposure) of the ecosystem to the stressor(s)?*

Direct exposure to chemical stressors in soils of Site SD-11 are somewhat limited by the presence of the grass superstructure of the soil. The primary pathway for indirect exposure via the foodweb would be associated with root uptake and translocation into shoots for a majority of the grassland herbivorous invertebrates and those that prey upon them. Direct exposure to fossorial animals may also be significant in this grassland situation.

- *Are there unique features that are particularly valued (e.g., the last representation of an ecosystem type)?*

Site SD-11 is in reality, a small part of an unmanaged feral system, which appears presently fairly stable. The overall habitat associated with Site SD-11 and the adjacent grassland are not in any way unique within the Base such that the unit represents a high value unique patch of ecological habitat. Four vertebrate species which have been designated as having a high value, the swift fox, the peregrine falcon, McCown's longspur, and Baird's sparrow, may utilize the habitat associated with Site SD-11.

- *What is the landscape context within which the ecosystem occurs?*

The landscape of the Base in the proximity of the unit under investigation Site SD-11 suggests that the patch of grassland within the section of the Base and directly connected to Site SD-11 may be unique in its general landscape location. The Base is surrounded by cultivated fields and a cow pasture in the general area under investigation. There are natural habitat locations associated with wildlife parks within a 20- to 30-mile radius of the Base, but none directly adjacent. This suggests that the natural shortgrass prairie within the Base may be significant in an overall context of the landscape –i.e., it represents a valued habitat on a landscape scale. Geographically, however, this value is imparted to the entire grassland patch within the Base and not directly attributable to that area designated as Site SD-11.

9.4 GENERAL ECOLOGICALLY RELEVANT ISSUES

In interpreting or establishing ecological relevance it is essential to consider the basic properties that are required for an ecosystem to exist and function (Newman 1998; Morrison *et al.* 1992; Whittaker 1975, Watt 1973, USEPA 1989):

Structure - This property is normally thought of in terms of biological diversity (i.e., structure in the sense of taxonomic composition, or variety/number of different *kinds* of components). Although discussions of biological diversity are usually focused at the species level, the concept can also include genetic diversity (i.e., within populations) and community/habitat diversity.

Function (functional integrity) - This property addresses how the various components, insofar as present, interact according to organizational principles typical of the ecosystem. For example, trophic interactions, primary production, and decomposition should reflect the typical

complexities for ecosystems of the type in question. An ecosystem with integrity has as its primary link a set of living organisms within adapted populations of different taxa (kinds), some of which modify their surroundings primarily by altering the system's abiotic features and secondarily through effects on other organisms.

Dynamics - For an ecosystem to function normally (and retain its integrity), the flow rates of energy and nutrients (including primary production and decomposition) should fall in a range typical of that type of ecosystem.

These three properties are relevant issues at the most general level and are germane to all ecosystems (Newman 1998; Morrison *et al.* 1992; Whittaker 1975; Watt 1973; and many others). The properties can be combined in various ways (e.g., ecosystem structure and function), but it is important to consider overall diversity (both the number of species and their relative abundance; see Subsection 9.2.2), organizational patterns (integrity), and energy and nutrient dynamics separately from function to ensure that these aspects are not overlooked in subsequent steps in the assessment process. All other ecologically relevant issues are subsets of these basic aspects of ecological organization.

9.4.1 Functional Components of Ecosystems

While plants provide energy through primary production, habitat (e.g., cover, substrate), and forage for many animals, the *food web* is a framework used to visualize the interdependent structure of the animal community in an ecosystem. Direct exposure and transport through the food web are important considerations when evaluating contaminant fate and transport and effects in subsequent phases of the ecological risk assessment process. Therefore, food-web organization is the basic framework for identifying ecologically relevant issues that in turn allow for establishing the assessment endpoints to guide the ecological evaluation of the site.

Identification of ecosystem functional components is based on the general ecologically relevant issues of structure, functional integrity, and energy/nutrient dynamics. The three steps in the process are: (1) identify fundamental trophic levels; (2) identify ecosystem-specific functional groups; and (3) identify functional group categories. The functional components are later integrated into habitat-based food webs, where major potential interactions between functional group categories can be illustrated.

From a structural and functional perspective, the dynamics of the grassland community associated with Site SD-11 (and ecosystems in general) are regulated by components that fall into three fundamental *trophic levels*:

- **Producers**, or organisms that use radiant energy (sunlight) to manufacture organic matter (biomass) from inorganic chemicals -- i.e., **green plants**
- **Consumers**, or organisms that feed on other organisms -- i.e., **animals**, which in turn are classified as:
  - primary consumers (plant-eaters or herbivores)
  - secondary consumers (omnivores)

- tertiary/quaternary consumers (carnivores)
- consumers of dead, often partially decomposed biological tissue, and/or biological wastes (detritivores)

- **Decomposers**, or organisms that convert dead biological tissue (detritus) and biological waste materials into simpler organic molecules -- i.e., **bacteria and fungi**

Although each might exist temporarily in isolation (e.g., in a lab culture), these fundamental categories of living organisms must all be represented in some combination to constitute a sustainable (self-perpetuating) ecosystem. The presence and abundance of species belonging to these fundamental levels is a product (under natural conditions) of the food web; the presence and abundance of one species in the food web may be controlled (limited) by the presence and abundance of another species. For example, primary producers (green plants) limit the numbers of herbivorous animals in the sense that the plants are the animals' primary food source. It is also important to recognize that herbivores can (and do) affect the composition and structure of vegetative communities. Since certain carnivores in turn feed predominantly on herbivores, the green plants then also exert a certain degree of control (albeit indirect) on carnivore populations.

The terrestrial vegetative community within which Site SD-11 resides is a shortgrass prairie community. The system is presently self-regulated structurally and dynamically. Terrestrially, there appears to be a small but probably viable ecosystem (community may be a more appropriate term) associated with Site SD-11, in that, Site SD-11 appears to be part of the adjacent patch of shortgrass prairie within the Base.

To ensure that the truly relevant groups can be integrated with the contaminant exposure pathways addressed later in the ecological risk assessment, ecosystem-specific functional groups are defined primarily on the basis of trophic relationships (rather than on habitat relations). This is because food consumption will be the major exposure pathway for some species and the food web(s) provide the linkages needed to evaluate ecologically relevant issues.

The following table summarizes the functional components of the ecosystems that are relevant to evaluation of Site SD-11 and the adjacent grassland:

Fundamental Trophic Level	Ecosystem-Specific Functional Group	Functional Group Category
Producers	unicellular plants	soil - algae
	herbaceous plants	grasses and similar vascular macrophytes.
Consumers	herbivores	invertebrate herbivores vertebrate herbivores
	detritivores	invertebrate detritivores vertebrate detritivores
	omnivores	invertebrate omnivores vertebrate omnivores
	carnivores	first-order carnivores second-order carnivores

Fundamental Trophic Level	Ecosystem-Specific Functional Group	Functional Group Category
Decomposers	microbial decomposers	bacteria, fungi

The producers and decomposers are, for the most part, intimately associated with fixed substrates (e.g., surface soil or parts of plants). The particular species will vary by ecosystem, but tend to be morphologically and physiologically similar within their respective functional group categories across ecosystems. Most consumers (animals) are relatively mobile, and comparatively much more complex organisms (both structurally and physiologically) than plants and microbes. Thus there is greater diversity, in the sense of higher taxonomic levels (especially genera, families, and orders), of animals than of the simpler organisms which function as producers and decomposers. For this reason, the functional group categories for consumers are defined below in broad terms, a brief description of each is provided together with example forms.

Herbivores are those animals that consume only plants. Terrestrial invertebrate herbivores include primarily insects (e.g., grasshoppers), while terrestrial vertebrate herbivores include reptiles (e.g., box turtles), birds (e.g., doves), and mammals (e.g., some mice and rabbits).

Detritivores are animals that primarily consume dead biological tissue (carrion) or excreta. Terrestrial invertebrate detritivores include some insects (e.g., dung beetles), while terrestrial vertebrate detritivores include primarily birds (e.g., vultures), however some mammals will, at least at times, also function as detritivores (e.g., coyote).

Omnivores are animals that consume both plant and animal tissue, generally in a fresh state. Terrestrial invertebrate omnivores include certain insects, while terrestrial vertebrate omnivores include numerous birds (e.g., starlings, orioles) and mammals (e.g., many rodents, skunks, foxes).

First-Order Carnivores consume animals that are primarily herbivorous. Terrestrial invertebrate examples include certain insects and arachnids, while terrestrial vertebrate first-order carnivores include reptiles (e.g., many lizards, some snakes), birds (e.g., kestrel, some owls), and mammals (e.g., bats, badger).

Second-Order Carnivores consume both herbivores and carnivores (and omnivores). Terrestrial invertebrate examples include certain insects and arachnids, while terrestrial second-order carnivores include reptiles (e.g., some snakes, a few lizards), birds (e.g., hawks, some owls), and mammals (e.g., coyote).

Animals mentioned in the above descriptions are provided only as examples and are not meant to indicate specific receptors for risk assessment. It should also be recognized that mention of most of the above examples is not meant to imply that diets consist exclusively of the food types in question.

9.4.2 Ecological Attributes

The functional components of ecosystems possess various attributes that can be used to consider and evaluate the unit for components with ecological relevance:

Food - Is the unit an important source of energy and nutrients for other consumers?

Habitat - Does the unit provide shelter or structural support (substrate) for other components within the community or ecosystem?

Production - Does the unit provide energy and nutrients to the system either through primary production (photosynthesis), secondary production (of biomass through consumption of representatives of lower trophic levels), or through decomposition of detritus (chemical conversion of nonliving organic matter)?

Propagule Dispersal - Does the unit provide a mechanism for distributing propagules (e.g., seeds) from the original source?

Pollination - Does the unit provide a mechanism for cross-fertilization of plants? [For many plant species transfer of pollen by animals such as insects, birds, and/or bats is the sole means of sexual reproduction.]

Decomposition - Does the unit provide a mechanism for the breakdown of non-living organic matter, thus preventing an accumulation that would disrupt energy and nutrient cycling within the system?

Control - Does the unit exert either a "bottom-up" or "top-down" effect on the structure and function of the ecosystem? For example, green plants are the primary source of food in any ecosystem; therefore, they act as a controlling (limiting) mechanism in a food web, where the control is exerted from the bottom of individual food chains (i.e., from the bottom up). Carnivores at the top of the food chain influence other consumers at lower trophic levels, thereby controlling from the top down.

One or more of the foregoing features may be much more important than others, depending upon the functional group. These may be thought of as *critical attributes* (i.e., those upon which the overall structure and function of the ecosystem depends significantly). The identification of any critical ecologically relevant attributes associated with the ecological resources within the unit is key to the derivation of the assessment endpoints for the risk assessment.

9.4.2.1 Primary Producers

As discussed above, Site SD-11 likely contains some native grassland plant species, which are occurring due to the association with an adjacent native shortgrass prairie patch. The level of primary production (biomass for export into the ecosystem) is not expected to provide any significant source of energy or nutrients [Food & Production], shelter or structural support [Habitat], nor do the unit-specific producers exert any structural or functional effect [Control]

over the ecosystem due to the unit's extremely limited spatial expanse (1-acre). Given that there are no ecologically relevant issues regarding the primary producers within Site SD-11, no further ecological evaluation of terrestrial primary producers will be conducted for Site SD-11.

9.4.2.2 Detritivores

The grass and dry-season litter associated with the soil superstructure within Site SD-11 is significantly affected by the presence of microbial and invertebrate detritivores [Control]. These detritivores may be instrumental in the cycling of nutrients and materials necessary for herbaceous plant growth during the wet season. However, given that the grass within Site SD-11 presents no ecologically relevant issues, this functional control imparted to the detritivores is similarly irrelevant. The detritivores themselves do represent biomass for consumption by omnivores and carnivores [Food & Production] but is expected to be of insufficient quantity to assign value.

9.4.2.3 Consumers

The potential herbivores associated with Site SD-11 would include a variety of insects, a few small mammals (mice, pocket gophers, rabbits), and birds (doves, sparrows). The herbivore component within Site SD-11 would not be of significant number or biomass to have any tangible importance as a source of energy [Food and Production], or as a mechanism for Seed Dispersion or Pollination, as well as insufficient to exert any structural or functional effect [Control] over the ecosystem. The few organisms present do however, represent limited forage to transient omnivores and first-order carnivores.

Few, in any, of the potentially occurring omnivores are expected to be resident within Site SD-11 and such would be limited to invertebrates and the smaller insectivores (e.g., grasshopper mouse). No avian omnivores would be expected to reside exclusively within the unit due to the limited expanse associated with the unit. Even more so than for the herbivores, the absolute number and/or biomass of the total resident population of omnivores associated with Site SD-11 would be extremely small. As such, any omnivore component within the unit would not have any significant importance as a source of energy [Food and Production], or as a mechanism for Seed Dispersion or Pollination, as well as insufficient in size or quality to exert any structural or functional effect [Control] over the ecosystem. The limited size of the omnivore component within the unit would however; represent limited forage to transient second-order carnivores.

No first-order or second-order carnivores would be expected to reside or even extensively utilize Site SD-11 due to the lack of a sufficient forage base for support (with the possible exception of certain small lizards or toads). Here again, the absolute number and/or biomass of the total resident population of carnivores associated with Site SD-11 would be extremely small. As such, these carnivores within the unit would not have any significant importance as a source of energy [Food and Production], or as a mechanism for Seed Dispersion or Pollination, as well as insufficient in size or quality to exert any structural or functional effect [Control] over the ecosystem. However, certain transient carnivores, which would be expected to forage within the unit (e.g., some bats, coyote, hawks, and owls), are generally considered to exert a control over the herbivorous and omnivorous communities within the landscape-scale ecosystem.

9.4.3 Summary and Assessment Endpoints

The site-specific components discussed above reveal that the terrestrial ecosystem would not be adversely affected if the resources potentially present within Site SD-11 were unavailable. The terrestrially relevant resources associated with Site SD-11 are of such limited size and quality that they play virtually no role in the function or dynamics of the ecosystem within which they exist. Therefore, there are no ecologically - relevant issues associated with the biota *within* Site SD-11. However, it is possible that at least at times, certain relevant components within the self-sustaining ecosystem (i.e., those with value as seed dispersal [herbivores – omnivores] or as controlling agents within the system [herbivores – omnivores – carnivores]) will utilize the limited ecological resources present. Thus, there is one relevant issue - that of risks associated with transient components of the ecosystem potentially utilizing the unit resources. This relevant issue is then represented by one assessment endpoint for the terrestrial ecosystem of which Site SD-11 is a part.

Protection of -

1. *Transient terrestrial consumers* foraging within Site SD-11 which have special status (threatened or endangered) or provide food, production, and control within the overall landscape-scale ecosystem, as well as a potential recreational resource (e.g., bird-watching).

The foregoing assessment endpoint provides the basis for identification of Receptors of Concern (ROCs) and ecological exposure scenarios to be used in developing the measures of effect for the desktop assessments under Tier II.

9.5 CHEMICALS OF POTENTIAL ECOLOGICAL CONCERN

A Chemical of Potential Ecological Concern (COPEC) is a chemical, based on an initial screening of its maximum concentration in applicable media, where there is at least a suspicion that the chemical may adversely interact with the environment and thus posses a potential for ecological risk. COPECs are derived from the results of the contaminant surveys performed during previous investigations and during this subsequent CMS.

9.5.1 Identification of Applicable Media

A site conceptual model has been developed for Site SD-11 detailing the potential release mechanisms and potential media to which ecological receptors may be exposed. This site conceptual model is presented as Figure 9-3.

Soil, subsurface soil, and groundwater data were used to develop site-specific lists of chemicals of interest (COIs) for evaluation of the unit. Site-specific COIs are identified based on consideration of site-specific analytical data, analytical data from adjacent areas, site-specific waste management activity information, and waste management activity information from adjacent areas. This was performed as part of the initial work plan for the CMS.

Constituents detected *only* in groundwater are not included in the evaluation of ecological risk, as this medium does not provide a complete exposure pathway to ecological receptors, nor are subsurface soil (i.e., below the topsoil [i.e., less than 2 feet below ground surface - bgs]). Subsurface soils are not considered germane to ecological effects due to an incomplete exposure pathway. Even with the presence of fossorial animals, the depths to which they burrow rarely exceeds 2 feet nor do any of the potentially present organisms routinely forage (and thus derive an exposure) from such subsurface depths. Only surface soils are considered relevant in assessing potential ecological risks associated with Site SD-11.

9.5.2 Nature and Extent of Contamination

Analytical data are from sampling locations that were generally biased towards the detection of chemical "hot spots." This represents a positive bias, which is consistent with the conservative nature of a screening-level ecological risk assessment.

For the most part, a total of 12 measurements for each organic COI and 9 measurements for each inorganic COI are available for evaluation and selection of COPECs in surface soils from Site SD-11. Soil measurements prior the excavation activity within the unit in 1994 are considered in the selection process but are not reproduced or summarized in the applicable Tables (Tables 9-4 and 9-5) used for COPEC selection.

9.5.3 Selection of Chemicals of Potential Ecological Concern

The purpose of this Section is to identify and characterize potential chemical stressors that may be present at levels that result in a potential for ecological concern. An additional objective of the evaluation is to preliminarily identify uncertainties that limit interpretation of potential ecological risk(s).

COPECs were selected based on comparison of maximum contaminant concentrations to ecotoxicological screening benchmarks. In general, the following criteria were used in selecting COPECs:

- If the maximum concentration or maximum reporting limit of a chemical was less than the ecotoxicological benchmark, then the chemical was not selected as a COPEC.
- If the maximum concentration of a chemical exceeded the ecotoxicological screening benchmark, then the chemical was considered a COPEC.
- If a chemical was detected and has the potential to biomagnify within the ecological foodweb, then the chemical was selected as a COPEC, regardless of its ecotoxicological screening benchmark.
- If an inorganic chemical was detected below the 95% "Upper Tolerance Limit" for background concentrations, then the inorganic chemical was not selected as a COPEC.

There is a degree of uncertainty associated with this process where: (1) no credible ecotoxicological benchmarks can be obtained or derived; (2) there are insufficient data to evaluate

the results of the chemical analysis (e.g., data rejection or no organic carbon data for soils); and (3) the analytical methodology cannot attain a sensitivity required for comparison to an ecotoxicological benchmark. If the chemical was not detected and its maximum reporting limit exceeded the ecotoxicological screening benchmark, the chemical was defined as an "uncertainty." Where an ecotoxicological benchmark was lacking, chemical concentrations and/or reporting limits were compared to similar chemicals within a chemical class. Where insufficient data were available (e.g., soil organic carbon data), conservative assumptions were applied (e.g., assuming a 1% organic carbon content).

Potential exposure pathways, selection of screening benchmarks, maximum chemical concentrations in surface soil, uncertainties, and ultimate identification of COPECs are discussed in the following subsections. Maximum concentrations in applicable media (i.e., surface soil) in Site SD-11 are compared to ecotoxicological benchmarks (herein referred to as screening concentrations; SCs) in Tables 9-4 and 9-5.

9.5.3.1 Screening Benchmarks for Tetrapod Vertebrates

Potential direct exposure pathways for tetrapod vertebrates (i.e., reptiles, birds and mammals) in the terrestrial ecosystem include inhalation, dermal contact and direct ingestion of contaminated soils. Although some of the chemicals of interest are volatile, the inhalation exposure pathway is not considered. There is presently a lack of understanding (knowledge gap) for estimating the potential ecological exposures to these chemicals via respiration as well as estimating the potential release of these chemicals from the soil. Burrowing or soil foraging animals can have "direct" dermal contact with soil, yet such contact is not directly with the epidermis but rather is associated with fur and/or feathers (additional behavior such as "dusting" results in direct soil contact as well). Most of such soil generally does not reach the epidermis but is discarded (e.g., shaken off) or ingested through preening and grooming behaviors (USEPA 1993). Therefore, for tetrapod vertebrates, ingestion of soil is considered the more important direct exposure pathway.

Screening concentrations for vertebrate consumers (tetrapod vertebrates) were back-calculated from published toxicity reference values (TRVs). TRVs were obtained from the Integrated Risk Information System (IRIS), the Agency for Toxic Substances and Disease Registry's (ATSDR) toxicological profiles, the Hazardous Substance Database (HSDB), synoptic review documents such as the U.S. and Wildlife Service's *Contaminant Hazard Review* series (the "Eisler documents"), the Oak Ridge National Laboratory's technical documents (i.e., Sample *et al.* 1996), the *Supplemental Technical Support Document for the Hazardous Waste Identification Rule* (RTI 1995), and the open scientific literature. Derivation of the screening benchmark was based on a receptor-specific daily dose expressed as a No-Observed-Adverse-Effect-Level (NOAEL) for each chemical, in units of milligrams chemical per kilogram of test organism body weight per day (mg/kg-BW/day). The general strategy for selecting (or deriving) a single NOAEL value among the many values reported in the literature was as follows:

- The highest NOAEL that did not exceed the Lowest-Observed-Adverse-Effect-Level (LOAEL) was selected.

- If NOAEL data were not available, but LOAEL dose data were reported, an uncertainty factor (division) of 10 was applied to the LOAEL to derive a NOAEL.
- If only a subchronic NOAEL was available, an uncertainty factor (division) of 10 was applied to the subchronic NOAEL to derive a chronic NOAEL.
- If only acute toxicity data were available (i.e., LD_{50}s or LD_{LO}s), an uncertainty factor (division) of 100 was applied to derive a NOAEL.

NOAEL values that were selected are summarized in Table 9-6. The test species from which the NOAEL was derived was then used to back-calculate soil screening concentrations (SCs). The SC is based on the NOAEL for the test species and the test species daily food consumption. The species-specific values for food ingestion were obtained from the citation or from either USEPA (1988) or USEPA (1993). SCs were then calculated as follows:

$$SC\ (mg/kg) = mgCOI/kg\text{-}BW/day * BW\ (kg) * 1\ day/(kgs\ consumed)$$

where: SC = the screening concentration or benchmark;
COI = the chemical of interest; and
BW = animal body weight.

This value corresponds to a dietary concentration below which no observable adverse effects would be anticipated to occur. NOAELs were not obtained for all of the COIs. In all cases, however, NOAELs for similar chemicals were obtained and were used as surrogates for those chemicals, which lack a SC. These SCs were used in concert with the presented "Bioconcentration Factors" (BCFs) for plants and soil invertebrates to evaluate the soil concentration in a context of potential toxicological risk (i.e., select chemicals as COPECs). A bioconcentration factor is the ratio between the biological tissue concentration of a chemical and the concentration of the chemical in a specific medium (i.e., soil, sediment, or water). At a BCF of 1, the concentration in biological tissues is equal to the concentration in the medium. If the BCFs are equal to or less than one and the SC is greater than the soil concentration, there is no potential for a primary consuming tetrapod diet to contain a concentration that could elicit a toxic response. Under such a condition, the chemical would not be considered a COPEC. Biomagnification is not considered here – please see Subsection 9.4.3.2. Conversely, if the plant and/or soil invertebrate BCFs are equal to or greater than one, there is a potential for a primary consuming tetrapod diet to contain a concentration higher than the concentration reported in soil. If the soil concentration multiplied by the BCF exceeds the tetrapod SC, the chemical would be declared a COPEC.

The BCFs for plants were obtained primarily from RTI (1995) whereas the soil invertebrate BCFs for the organic COIs (Table 9-4) were estimated using the fugacity concept (e.g., Mackay and Paterson 1981 and many others – See Appendix D). For the inorganic COIs, the presented soil invertebrate BCFs (for earthworms) and small mammals were primarily obtained from Sample *et al.* (1998a and 1998b) as well as from RTI (1995). While it is recognized that there are few, if any, earthworms present within Site SD-11, it is believed that the use of earthworm BCFs is a conservative approach for screening for COPECs. The chemical specific parameters used in these

calculations are also presented in Appendix D and were obtained from the Hazardous Substances Data Bank (HSDB), the USEPA Assessment Tools for the Evaluation of Risk (ASTER on-line Database), and/or RTI (1995).

9.5.3.2 Screening Approach for Biomagnifying Chemicals

Chemicals that may bioaccumulate or biomagnify are retained as COPECs since the screening concentrations for these chemicals may not be protective of higher level consumers. Bioaccumulation is a general term describing a process by which chemicals are taken up by organisms through direct exposure (direct contact) and indirect exposure (e.g., ingestion). Biomagnification is a result of bioconcentration and bioaccumulation by which tissue concentrations of bioaccumulated chemicals increase as the chemical passes up through two or more trophic levels. The term implies an efficient transfer of chemical from food to consumer, so that residue concentrations increase systematically from one trophic level to the next.

To evaluate the chemicals for selection as COPECs, the predicted biomagnification as described by Travis and Arms (1988) is presented as a "Bioaccumulation Factor" (BAF) on the tables used for selecting the COPECs. This BAF represents the ratio between tissue concentration and that concentration in the animal's diet. It does not represent the ratio between soil and the potential tissue concentration (i.e., it is not the same as the BCFs previously described). The BAF relates how well conserved a chemical is once it becomes incorporated into tissues. If the BAF is 1 then the tissue concentration of the consumer is equal to that concentration in its diet. BAFs greater than one suggests that the chemical has a potential to be biomagnified. All detected chemicals with a BAF greater than one are considered COPECs. It is important to note here that these predicted BAFs do account for any metabolism of a chemical by the consumer and as such, should be viewed as indicators of the "propensity" of a chemical for biomagnification.

9.5.3.3 Approach to Uncertainties

There are basically three types of uncertainties associated with the process for selecting COPECs: a lack of knowledge (what we do not know); a lack of data (what we can know but do not presently); and a lack of technology (the limits of our ability to measure or predict). In the context of screening for chemicals that deserve a comprehensive evaluation of potential ecological impact, not all uncertainties are equal. For example, the lack of credible oral toxicity values (TRVs) for amphibians and reptiles is a significant uncertainty in that the potential risks for these receptors (who can be an integral part within an ecosystem) cannot be fully characterized. The lack of organic carbon data for soils is not nearly as significant. While the foregoing example is fairly clear, others are less so.

In the present context, the most often encountered uncertainty is that of a lack of technology -- analytical sensitivity for detection of chemicals in environmental media. The approach used herein to evaluate the significance of such an uncertainty is on a case-by-case basis using a *line-of-evidence* approach. Where a chemical was never detected in surface soil, subsurface soil, or groundwater, the significance of the uncertainty that in one sample, at one time, the analytical sensitivity was such that the reporting limit exceeded the screening concentration, is not believed

to be significant. Conversely, if a chemical was routinely detected in subsurface soil and then not detected in surface soil with a reporting limit that exceeds the screening concentration, the associated uncertainty may be significant. In following subsections the uncertainties are evaluated and identified as warranting or not warranting further, more detailed evaluation (i.e., carried into the Tier II desktop evaluation)

9.5.4 Site SD-11 Chemicals of Potential Ecological Concern (COPECs)

The only applicable media within Site SD-11 is surface soil. Additionally, as discussed and presented in Section 9.3.3 there are no ecologically relevant issues or relevant resources within the boundaries of the unit. The only ecologically relevant issue is the protection of transient consumers foraging within the unit.

9.5.4.1 Site SD-11 Organic COPECs

A total of 13 organic chemicals were detected in the surface soil samples obtained from Site SD-11 (Table 9-4). Nine of these were polynuclear aromatic hydrocarbons (PAHs) of which 8 can be classified as high molecular weight PAHs (molecular weights greater than 200 daltons). The lone detected low molecular weight PAH (phenanthrene) does not exceed the direct ingestion screening concentration (SCs) for tetrapod animals nor is it expected to concentrate or biomagnify within the terrestrial foodweb to a concentration greater than that measured in soil. As such, phenanthrene is not considered a COPEC. While it is recognized that the BAFs presented for the high molecular weight PAHs suggest a potential for biomagnification, it is well known that metabolism of PAHs limits their biomagnification (Newman 1998, Sundlof *et al.* 1996, Rand 1995). Nevertheless, in lower animal forms (invertebrates) a degree of biomagnification may be demonstrated (Irwin *et al.* 1997) such that these PAHs are selected as COPECs. Both pyrene and fluoranthene are considered high molecular weight PAHs, but neither are predicted to be biomagnifiers nor are they predicted to bioconcentrate to a concentration greater than that measured in soil. Given their detection below the SCs, they are not considered COPECs. Neither total petroleum hydrocarbons (TRPH) or hydrocarbons as diesel-range organics (DRO) exceed their respective SCs nor are they expected to bioconcentrate or biomagnify to a concentration greater than in soil and thus not considered COPECs. Xylene and toluene were detected well below their respective SCs and as for TRPH and DRO are not expected to bioconcentrate or biomagnify to concentrations exceeding their SCs. Thus, they are not considered COPECs.

9.5.4.2 Site SD-11 Inorganic COPECs

The maximum detected surface soil concentration for seven inorganics exceed Cannon AFB background concentrations: aluminum, calcium, chromium, iron, magnesium, vanadium, and zinc. No relevant ecotoxicological screening concentrations are available for calcium, iron, or magnesium, as these are essential nutrients. It is well known that some vertebrates deliberately ingest soil to obtain these nutrients, a phenomenon called geophagy. For example, deer commonly lick or nibble soils or rock surfaces to acquire these trace minerals. The daily requirements for these minerals for domesticated animals are presented in Table 9-7. Maximum

recommended values are available for only the common dog. To achieve these values, a dog would have to consume soil at rates of 25%, 33%, and 100% of its normal food consumption for iron, calcium, and magnesium respectively. These rates of soil ingestion do not suggest that these trace minerals are at concentrations that pose a concern for animals *incidentally* ingesting soil. Therefore, none of these essential trace minerals are considered COPECs. The maximum detected concentration for zinc in surface soil did not exceed the SC nor is it expected to bioconcentrate to a concentration that would, therefore zinc is not considered a COPEC. As the soil concentrations of aluminum, chromium, and vanadium exceed their respective SCs, they are considered COPECs. None of the remaining detected inorganic COIs exceed Base background concentrations and are not considered COPECs.

9.5.4.3 Uncertainties within Site SD-11

Seven organic COIs while not detected are presented as "uncertain" on Table 9-4 due to reporting limits exceeding the screening concentration or because they are suspected to be highly bioconcentratable or potential biomagnifiers (i.e., BAFs greater than one). Three of these chemicals have never been detected within subsurface soils or groundwater associated with Site SD-11 nor are they known to be associated with the historical activities for the unit – aniline, benzidine, and hexachlorobenzene. Given that these have never been detected and a lack of anecdotal evidence for their presence within Site SD-11, the uncertainty associated with their reporting limits is not considered sufficient to carry them forward into a Tier II assessment. Two of the remaining three organic chemicals declared uncertain are high molecular weight PAHs, benzo(k)fluoranthene and dibenz(a,h)anthracene. Given that similar PAHs have already been selected as COPECs, these uncertain PAH is carried forward into Tier II. The last uncertainties associated with the organic COIs in surface soils of Site SD-11 are two phthalates which show a propensity for biomagnification, bis(2-ethylhexly)phthalate and di-n-octyl phthalate. As both of these phthalates have been detected in subsurface soils within Site SD-11, the associated uncertainty due to their surface soil reporting limits is believed sufficient to warrant their inclusion in the Tier II evaluation.

Four inorganic COIs are reported as not detected with reporting limit in excess of the reported Cannon AFB background concentrations. In addition, the reporting limits exceed the respective SC or, based on the reporting limit, the COI may concentrate to a level above the respective SC. These inorganics include antimony, cadmium, mercury, and selenium. None of these were detected in subsurface samples taken in 1995 nor in groundwater. Therefore, the uncertainty associated with reporting limits is not considered sufficient to warrant their inclusion within Tier II.

9.5.4.4 COPEC and Uncertainty Summary

Ten COPECs have been identified for Site SD-11. These include 7 PAHs, and 3 inorganics. Additionally, there are two phthalates and one PAH that were never detected but represent uncertainties to be evaluated further.

9.5.5 Environmental Behavior and Relative Toxicity of the COPECs and Uncertainties

An understanding of how a chemical stressor behaves in the environment and how it can elicit stress in an ecosystem are fundamental to the Problem Formulation process. Without exposure there can be no effect. Thus, issues of fate and transport reviewed in the context of the selected COPECs and the uncertainties are discussed in Subsection 9.4.6.1. The identification of those components within an ecosystem at most risk not only requires an understanding of the potential exposures but the relative sensitivities and physiological mechanisms associated with the toxic response. These issues are presented and discussed in Subsection 9.4.6.2.

9.5.5.1 Fate and Transport

The migration and persistence of a COPEC within the environment is controlled by the physical/chemical attributes of the COPEC, the physical attributes of the system, and finally by the biota within the environment. All of these attributes effect the ultimate fate of the chemical. Such interactions are highly site-specific, but certain generalizations can be made. This subsection reviews the following in general terms:

- The importance of the soil matrix and its character;
- The chemical attributes of the COPECs in the context of fate and transport, e.g., lipophilicity, solubility, and sorption phenomena;
- Relative importance of dissolution, volatilization, complexation, photolysis, advection, and biodegradation as transport processes for the COPECs; and
- A review of the processes found most important for the selected COPECs in the context of site-specific attributes.

Soil as a Repository of Contamination

Soil composition is highly variable and is governed by a diverse set of factors dominated by climate and the parent material from which it was formed (Kabata-Pendias and Pendias 1992). The major environmental fate and transport processes that appear most affected by the character of the soil matrix include:

- Dissolution in soil water;
- Partitioning between soil substrates and biota;
- Volatilization;
- Advective transport; and
- Biodegradation.

These same processes are among those of greatest import considering ecological risks of exposure and effects. The dissolution of contaminants into soil water is affected by the structure, organic carbon content, cation exchange capacity (CEC), and Eh/pH of the soil (Kabata-Pendias and Pendias 1992, Donnely *et al.* 1994, Trapp and McFarlene 1995, and others). Many of the soil

biota in direct contact with contaminated soil are realistically exposed, predominantly via the soil water (i.e., plant roots, certain macro-invertebrates) and as such the dissolution of the contaminant into soil water has a profound impact on their exposure and any subsequent partitioning into biological tissue(s). Volatilization of soil-associated contaminants is limited by the structure of the soil matrix (i.e., percent soil air, size of the macropores, vegetative super-structure) as well as by the dissolution into soil water (e.g., Trapp and McFarlene 1995). The physical structure can dictate the vascular plant population capable of utilizing the soil and thus the stability of the soil surface layer affecting advection due to surface water run-off and winds. The chemical composition within the soil can also affect the plant population but the effect on the microorganisms present and their metabolism could have a dramatic impact on any biodegradation processes (Lymann 1995).

Physical/Chemical Properties of the Organic COPECs and Uncertainties in Soil

One of the most illuminating properties of an organic chemical considering fate and transport within the environment is its relative solubility in water and octanol (Table 9-8). The ratio between chemical concentrations in water versus octanol is represented by the octanol-water partitioning coefficient, the K_{ow}. The K_{ow} of a chemical is a useful indication of the chemical's lipophilicity or propensity for sequestering into lipid stores within biota, the chemical's propensity towards adsorption onto organic carbon and, its ability to cross biological membranes. Empirical relationships between a chemical's K_{ow}, water solubility, organic carbon partitioning coefficient (K_{oc}), bioconcentration factor (BCF), and assimilation coefficient for biota have been drawn by numerous authors (e.g., Clark *et al.* 1988, Donnelly *et al.* 1994, Lyman 1995, Mackay *et al.* 1995, Trapp and McFarlane 1995).

Generally speaking, the greater the K_{ow} the lower the water solubility and greater relative adsorption onto organic carbon. All of the organic chemicals selected as COPECs and uncertainties within Site SD-11 show relatively high K_{ow} values and as expected they have relatively low water solubility and low soil mobility while exhibiting high adsorption coefficients for organic carbon.

Soil Mobility Defined by Affinity for Organic Carbon

K_{oc}	*Mobility Class*
> 2000	Immobile
500 - 2000	Low Mobility
150 - 500	Intermediate Mobility
50 - 150	Mobile
< 50	Very Mobile

Reproduced from Donnelly *et al.* (1994)

All of the COPECs selected have K_{oc}s in excess of 2,000 and are considered essentially immobile in soil (unless the soil itself becomes mobile through *advected transport or biological assimilation*).

Certain site-specific features such as soil structure have profound effects on the sorption, volatilization, and/or degradation processes of the COPECs. Certain degradation processes may be significant for the selected COPECs. PAHs can undergo photolysis, oxidation, and biodegradation (ATSDR 1995a, Irwin *et al.* 1997, USEPA 1979). Phthalates do not undergo photolysis, nor are oxidation and volatilization considered significant processes (ASTDR 1993a, USEPA 1979). The significance of these processes is highly dependent on the environmental conditions to which the materials are exposed. The absorbents present in the soil, the type of soil cover, and size of macropores are highly significant site-specific considerations for all of the organic COPECs due to their impact on/interaction with the process of photolysis, volatilization, and oxidation/reduction.

Light-induced oxidation of PAHs follows similar reactions considering either airborne or aqueous (soil water) phases (Neff 1985). There is a strong tendency for greater rates of direct photolysis as the molecular weight of the PAH increases. This relationship however, is not perfect as angular or condensed molecular PAH structures (e.g., indeno(1,2,3-cd)pyrene) are resistant to photolysis.

Example Photolysis Half-lives

COPEC	*Wavelength (nm)*	*Half-Life (t1/2)*
Benzo(a)anthracene	Sunlight	3.3 hr
Benzo(a)pyrene	Sunlight	1 hr
Benzo(b)fluoranthene	Sunlight	8.7 hr
Benzo(g,h,i)perylene	Sunlight	2 hr
Benzo(k)fluoranthene	Sunlight	14.1 hr
Chrysene	313	4.4 hr
Indeno(123-cd)pyrene	Sunlight	nil

(Data obtained from Lymann 1995 and the HSDB)

Volatilization of the organic COPECs from soils has been measured empirically and experimentally but can be considered highly site-specific. None of the high molecular weight PAHs or phthalates are believed to readily volatilize from soils (ATSDR 1993a, 1995a, Irwin *et al.* 1997, USEPA 1979, HSDB reviews). Volatilization is then hampered by sorption to the soil and entrapment by overlying moisture. Lymann (1995) provides a generalization that is useful in qualitatively describing a chemical's propensity towards volatilization using its Henry's constant where:

H (atm m^3/mol)	*Volatilization Potential*
$< 3 \times 10^{-7}$	Chemical is less volatile than water.
3×10^{-7} to 10^{-5}	Chemical volatilizes slowly.
$> 10^{-5}$ to $<10^{-3}$	Volatilization is significant.
$> 10^{-3}$	Volatilization is rapid.

his further suggests little potential for volatilization for the selected COPECs and uncertainties.

Rates of COPEC biodegradation vary widely due to variations in microbial composition, nutrient concentration, COPEC soil concentration (non-toxic levels), and other environmental factors (e.g., temperature, anaerobic or aerobic conditions). The most significant microbial degradation of PAHs and phthalates occurs aerobically in acclimated populations (ATSDR 1995a, Lymann 1995, Irwin *et al.* 1997). While strong evidence exists that significant biodegradation occurs under anaerobic conditions the best evidence is still found for aerobic degradation. Because the grassland soil within Site SD-11 is believed to be fairly aerobic, anaerobic degradation is probably not a significant fate process.

Biodegradation rates for PAHs can be as much as 10 to 40 times less in unacclimated microbial populations. Additionally, the highly ringed, high molecular weight PAHs (e.g., benzo(a)pyrene) are generally more resistant to biodegradation than lower molecular weight forms such as naphthalene (USEPA 1979).

Soil Biodegradation Examples

COPEC	Biodegradation (t1/2)
Benzo(a)anthracene	≈ 1 year
Benzo(a)pyrene	2 days to 2 years
Benzo(b)fluoranthene	> 3 years
Benzo(g,h,i)perylene	600-650 days
Benzo(k)fluoranthene	≈ 2 years
Chrysene	variable
Indeno(1,2,3-cd)pyrene	nil
Bis(2-ethylhexly)phthalate	≈ 4 weeks (optimal)

Data obtained from the HSDB

The presented rates are essentially the ideal rates that do not consider the myriad of site-specific confounding factors. The most significant of these is believed to be the fact that the microbes present may not require these chemicals as carbon sources and preferentially degrade other more *attractive* detritus. This could be especially true in Site SD-11 soils with the presence of a grass detrital layer.

Chemical/Physical Properties of the Inorganic COPECs in Soil

The fate of the inorganic COPECs depends on a myriad of processes best generalized as follows (according to Kabata-Pendias and Pendias 1992);

- Dissolution;
- Sorption;
- Complexation;
- Migration;
- Precipitation;
- Occlusion;
- Diffusion (into minerals);
- Binding by organic substances;
- Absorption/fixation and/or sorption by microbiota; and
- Volatilization.

The most important soil parameters involved with these processes are pH and redox potential. Other factors, such as CEC, iron and manganese hydrous oxides, humics, chlorides, and clay minerals, are all known to impact these processes as well (Kabata-Pendias and Pendias 1992).

Aluminum generally occurs in soil in the +3 valance state and if derived from parent rock generally forms a series of Al hydroxides which in turn become structural components of clay minerals (Kabata-Pendias and Pendias 1992). The solubility of aluminum appears to be highly dependent on soil pH along with the nature of sorbant surfaces and the presence of organics. Solubility and therefore mobility and availability to biota is enhanced at low pH and reduced under alkaline conditions. Dissolved organic carbon (believed to be primarily fulvic acids) enhances the apparent solubility of aluminum, as does the presence of sulfides (Kabata-Pendias and Pendias 1992). The soils within Site SD-11 are believed to be alkaline, based on the general soils in New Mexico, as well as having a fairly high CEC and low organic carbon content (attested by the high calcium concentrations and general geology of the area). This suggests for the most part, that the aluminum is probably fairly immobile and unavailable within the soils of Site SD-11. Only during the rainy season would conditions be more favorable for leaching of aluminum into soil water.

It has been well established that the majority of **chromium** in soil is as Cr^{+3} (Kabata-Pendias and Pendias 1992). Chromium can be in variable oxidation states from Cr^{+2} to Cr^{+6}, although the highly oxidized forms are environmentally unstable (Kabata-Pendias and Pendias 1992). Soil pH and redox-potential primarily govern the behavior of chromium in soil. Under acidic soil conditions, Cr^{+2} predominates (redox of 500 mV), given slightly acidic (redox of 500 mV, pH 5 to 7) conditions, the majority of chromium is as $Cr(OH)^3$ whereas under more alkaline conditions (pH > 7, redox of 500 mV) CrO_4^{-2} predominates (Kabata-Pendias and Pendias 1992). Thus under near-neutral soil pHs, most of the chromium would be expected to be as an insoluble salt.

Chromium will adsorb to clay particles, which is also pH dependent, as well as form organic complexes (Kabata-Pendias and Pendias 1992). Under normal soil conditions, the ready conversion of Cr^{+6} to insoluble Cr^{+3} results in low bioavailability of chromium to plants and animals (Kabata-Pendias and Pendias 1992). This is believed to be the condition within Site SD-11.

Vanadium's geochemical characteristics are strongly dependent on its oxidation state (+2,, +3, +4, and +5) and soil acidity (Kabata-Pendias and Pendias 1992). The behavior of vanadium in soil has not received a great deal of investigation. Vanadium tends to be associated with organic matter, manganese, and potassium. The vanadyl cation (VO^{2+}) and certain anions (VO_4^{3-} VO_3^-) appear to be the significant mobile forms of vanadium in soils (Kabata-Pendias and Pendias 1992). The availability of vanadium for biological uptake and transport within SD-11 soils cannot be fully characterized at this time.

Significant Fate and Transport Attributes of the COPECs in the Context of the Units, Uncertainty, and the Assessment of Ecological Risk

Evaluation of the potential effects of the COPECs on ecological receptors requires consideration of the availability of the contaminants for contact with, or uptake by various organisms. For all of the organic COPECs and the majority of the inorganic COPECs, the previous discussions have shown that the sorption/dissolution process is a dominant feature common to all. This feature has a direct bearing on ecological risk assessment as it impacts exposure pathways and elicits the issue of "bioavailability." Bioavailability is here defined as that fraction of chemical in a form capable of crossing biological barriers (e.g., membranes or integument).

The process and/or degree of sorption with organic carbon has been shown to reduce the apparent bioavailability of organic and inorganic compounds (Kesley and Alexander 1997, Knulst 1992, Dewitt *et al.* 1992, Goodrich *et al.* 1992). The degree of sorption in this context refers to the observed multiphasic nature of the process identified for organic compounds, particularly for sediments (Landrum *et al.* 1992a, Hulscher *et al.* 1999), suspended solids (DiToro 1985), but also for soil particles (Kesley and Alexander 1997).

The vast majority of sorption studies used to estimate or calculate partitioning coefficients for organic chemicals involve short exposure periods, hours to days, followed by desorption periods. These have been performed, for the most part, under the assumption that the sediment sorption process follows first-order thermodynamic kinetics. Certain authors have shown that such an assumption is flawed (DiToro 1985, Landrum *et al.* 1992a, USACE 1985 Hulscher *et al.* 1999). The phenomenon is best illustrated as a two to three-step process where the initial phase involves the chemical sorbing onto the surface of a particle followed by a second phase where the chemical is absorbed *into* the particle. This phenomenon has a greater impact on predictions of desorption than adsorption, in that the contribution of the secondary absorption of a chemical within particles does not have a great impact on the overall mass or concentration of chemical within that particle. The desorption process, however, can be greatly overestimated as contact time and "degree" of adsorption will affect the rate of desorption (Hulscher *et al.* 1999, USACE 1985, Landrum *et al.*

1992a). There is some evidence that given sufficient contact time desorption will not occur (Karrickhoff and Morris 1985, DiToro 1985).

A final uncertainty is in the context of COPEC mass. All of the data available are in the context of media concentrations. As such, the evaluation is limited to concentration-based approaches. Mass-balance cannot be performed as part of the evaluation. While this concentration-based evaluation is a conservative approach, the uncertainty associated with mass requirements for bioconcentration, bioaccumulation or biomagnification to occur should be recognized, in that for forage or prey of the higher trophic-level organisms to achieve a toxic concentration there must be sufficient COPEC mass available in the soil.

9.5.5.2 Most Significant Chronic Exposure Effects and Modes of Action

The "Most Significant Chronic Exposure Effect(s)" are effects which: (1) occur at the lowest exposure levels; and (2) are relevant to population dynamics. That is, growth may be reduced at relatively higher concentrations than those associated with impaired reproduction and the latter is deemed more significant from an ecological perspective (e.g., population-level impacts). Effects considered relevant to population dynamics include survival, reproduction, development, and growth (in that order of diminishing relative significance). If different effects occur at or near the same exposure level, survival was considered most significant, followed by reproduction, development, and growth. This hierarchy was not invoked for selection of the COPECs.

In consideration of ecological receptors, the classical definition of "chronic" effect (e.g., within the ATSDR documents) is not fully applicable. Chronic effects in the context of classical toxicology reflect an effect that occurs either as a consequence of exposure over a significant portion of the subject's lifespan or one that manifests itself over a significant portion of the subject's lifespan. The key attribute in the foregoing definition is the reference to lifespan. Often in ecotoxicological literature chronic is defined by the duration of exposure rather than in connection with the test subject's lifespan. The lifespan of microbes are commonly in the context of population doubling times and generally within the range of hours to days. Many terrestrial invertebrates also have lifespans of only days to months rather than years when considering larger birds and/or mammals. Some mammals have lifespans that encompass decades whereas the lifespan of some reptiles (e.g., turtles) is believed to be in excess of a century. The key consideration within protection of the ecosystem is to consider an organism's *reproductive lifespan*. Once an organism has reproduced, its death (due to being preyed upon or sickness, etc.) has a much lower impact on the *population dynamics* of the species. This is more germane to the lower primary consuming rodents and insectivores than any other group. Thus, although endpoints on longevity and reduced survival well after successful reproduction are used here and elsewhere in typical ERAs, these longevity endpoints may not truly be relevant ecologically.

Additionally, chronic effects are most often defined by the outcome of long-term exposure and not in respect to long-lived effects. This approach has been incorporated more in the study of ecotoxicology than in classical toxicology. For example, lethality has been reported as a chronic effect in the open ecotoxicological literature where classical toxicological literature would report such an effect as a long-term lethal dose (LD_{lo}). LD_{10}s are often reported for lethality even after

90-day or 1-year exposures to experimental animals. Lethality, under the classical definition is not a chronic effect but may be an effect due to chronic exposure. While again this may be an issue of semantics, it bears an impact on the interpretation of the toxicological data.

A "mechanism" or mode of toxicity includes the target organ or process within a receptor that is pathologically affected by the presence of a poison. Often a toxin or poison can affect multiple target organs and/or processes. The understanding of how a poison acts in a sensitive receptor narrows the focus of the overall evaluation by suggesting potential *specific assessment endpoints* within the group of ecologically-relevant assessment endpoints. What follows is a short summary of what is known regarding the modes of toxicity for the COPECs and the most significant chronic toxicological response(s), insofar as discernible, for each COPEC. An attempt was made to consider "most significant chronic response" within the context of the toxicological mechanism whenever possible. That is, if the mechanism is an estrogenic effect the most significant response is expected to be reproduction (fertility, fetotoxicity, etc.), or if the mechanism is an interference with adenosine triphosphate (ATP), the response expected would be in growth and/or development. This can only be done for those chemicals where the level of understanding of the toxic mode and target is high. For some COPECs there is only rudimentary understanding or conflicting theories (e.g., some of the PAHs). In virtually all of those cases where there is a significant level of understanding, the toxicants are best understood/characterized in mammalian models, and the relationship to other ecological receptors is poorly defined, if at all. The information that follows is compiled from toxicological excerpts from the on-line databases HSDB MEDTEC; ASTER; available ATSDR Toxicological Profiles; U.S. Fish and Wildlife Contaminant Hazard Reviews; and several basic texts on environmental toxicology (e.g., Rand 1995; Cockerham and Shane 1994; Sundlof *et al.* 1996, Newman 1998).

Potential Ecotoxicity of the Organic COPECs and Uncertainties

For all of the organic COPECs (polynuclear aromatic hydrocarbons [PAHs]; bis (2-ethylhexyl) phthalate [DEHP] and di-n-octyl phthalate), toxicity is believed to act through polar or nonpolar narcosis. Narcosis is a nonspecific toxicologically-induced, reversible, disruption of neural activity (i.e., anesthesia). There are presently two theories regarding how narcosis occurs within an organism. The "critical volume" theory involves a swelling or volume change due to dissolved toxicant in nerve cells that results in changes in the structure of lipid bilayers within the cell membrane. The "protein binding" theory involves the toxicant binding to specific receptor sites of specific dimensions within the nerve cells, resulting in narcosis (see ATSDRs for the COPECs also Abernethy and Mackay 1988; McCarty 1991; and Landrum *et al.* 1992b).

Many of the high molecular weight **Polynuclear Aromatic Hydrocarbons** (PAHs) (e.g., benzo(a)pyrene) are relatively potent carcinogens. The non-carcinogenic toxicity of polynuclear aromatic hydrocarbons is believed to act through polar narcosis. If carcinogenesis is not considered, the majority of the toxicity of the PAHs exhibit basic metabolic disruption. Non-specific binding to proteins is a probable feature associated with PAH toxicosis. Whichever theory for narcosis is applied (protein binding or membrane effects), the molecular weight of the PAH will determine the effective concentration and/or dose. The available toxicity data bear this hierarchy out. In terrestrial vertebrates, the high molecular weight PAHs appear capable of

eliciting developmental and reproductive effects. This may be associated with increased microsomal activity induced by the PAHs. The most significant chronic exposure endpoints include reproduction and development (Table 9-9).

The phthalates listed as uncertain exhibit toxicity through nonpolar narcosis (see the discussion of nonpolar narcosis above). There is no evidence of any significant developmental effect due to these phthalates, but there is a significant effect on growth and birth weights. Reversible effects on testicular size and weight have been reported in rodents, as well as effects on fetal re-absorption and lowered fertility in males exposed to DEHP. Such effects appear to be associated with high doses. The mechanism for these effects is not clearly understood. Thus, the most significant chronic exposure endpoint, based on the observed effects rather than toxicology, includes reproduction and growth (Tables 9-10 and 9-11).

For both the PAHs and the phthalates there is a paucity of toxicological values for avian species. This makes any differentiation between the relative sensitivities between mammals and birds virtually impossible. Considering the suspected mode of action, nonpolar narcosis, it is likely that there would be little difference in the sensitivities between the two groups. This may be true of the reptiles as well, where given the mode of toxicity (narcosis), similar sensitivities may be expected among variable animal groups.

Potential Ecotoxicity of the Inorganic COPECs

Aluminum is basically a cytotoxin characterized by inhibition of enzyme function. Such interference includes those enzymes associated with adenosine triphosphate (ATP) (e.g., cytochromoxidase, Na-K ATPase, and Mg ATPase). Aluminum also interferes with synaptosomal uptake of gamma-aminobutyric acid (GABA) and acetylcholinesterase (ACHe), as well as enzymatic maintenance of other neurotransmitters. Aluminum can affect bone formation through interaction with osteoblast function and extracellar mineralization. Aluminum-induced anemia can occur due to enzymatic interaction with the synthesis of hemoglobin. In terrestrial vertebrates aluminum is a gastrointestinal irritant which can affect metabolic distribution of enzymes, neurotransmitters and osteoblast function. A primary consideration in aluminum toxicity is the relative doses of calcium and phosphate. Deficiencies in either of these two nutrients can exasperate the apparent toxicity of aluminum due to their interaction – especially considering osteblast function and egg shell development. The most significant chronic exposure endpoint is aluminum's affect on pre- and postnatal development (survival and development – Table 9-12).

Chromium is an essential biological element for glucose, lipid, and protein metabolism. Toxicity due to chromium exposure is related to its oxidative state and membrane permeability. Acute toxicity to Cr VI is characterized by oxidation of tissue. Chronic toxicity may be related to non-specific protein/enzyme binding or perhaps oxidative stress within cells. Reproductive, growth, and/or developmental chronic oral exposure endpoints for chromium as Cr III, the form believed present within Site SD-11 have not been established in mammals. Only no-observed adverse-effects are presented (Table 9-13). This suggests that birds, for which effects have been

documented at doses below the mammalian no-effect doses, are more sensitive to chromium than mammals. The most significant chronic exposure endpoint, for birds, appears to be survival.

Vanadium may be an essential biological element. Several reports suggest this for chickens, rats, plants, and some invertebrates. No specific physiological role, however, has been identified for vanadium and the conditions that produce apparent vanadium deficiencies are unknown. Vanadium exerts disruptive effects on Na+ and K= ATPase enzymatic function as well as monoamine oxidase, tyrosinase, chlolinesterase, and cholesterol synthetase. Such a capacity for enzymatic inhibition is believed to be the specific mechanism of toxicity for vanadium, at least for higher vertebrates. In terrestrial vertebrates chronic oral vanadium toxicity data are limited. There are insufficient data to assess the relative sensitivities between birds and mammals. The most consistently-significant chronic exposure endpoints appear to be survival and growth (Table 9-14).

9.6 SPECIFIC MEASURES OF EFFECT AND RECEPTORS OF CONCERN (ROCS)

Using information regarding COPEC environmental fate and effects coupled with a guild characterization of the potentially effected critical ecological attributes, *specific measures of effect* can be selected along with *receptors of concern* (ROCs) to evaluate the potential ecological risk(s). These are the ultimate focus in an ecological risk assessment and link the attributes "measured" (measures of effect) and assessment endpoints to the risk management process (i.e., remedial decision making). According to the *Framework* and more recent guidance (USEPA 1997a, 1998) as well as USACE (1996), the general considerations for selecting assessment endpoints are ecological relevance, susceptibility to the types of effects associated with the stressors (COPECs), and policy goals and societal values. Under the evolving guidance, these basic considerations have been refined to include:

1. The fate and transport of the contaminant(s) within the ecosystem (communities) at the site;
2. The specific mechanisms by which a toxic effect is produced within the different groups of organisms (not to be confused with the toxic effect itself); and
3. The presence of sensitive receptors, representative of major functional groups, at or near the site.

In ecological risk assessment, conceptual models establish the complete exposure pathways (i.e., based on environmental fate and transport processes) that will be evaluated and the relationships between measures of effect and the assessment endpoints (USACE 1996; USEPA 1994; 1997a; ASTM 1995). In developing the conceptual models the major objective is to trace COPECs through release mechanisms into potential exposure media (see Figure 9-3). These "standardized" conceptual models have a limited utility in evaluating the movement of the COPECs and their potential "effects" within an ecosystem by over-simplifying the site-specific foodweb. A basic or general (conceptual) foodweb is presented as Figure 9-4.

To interpret the likelihood and significance (relevance) of potential risks, it is important to consider the functional roles of the ecological components in terms of their trophic and niche relationships. The inventories of biota known or expected to occur were presented for the most

part as taxonomic assemblages (Tables 9-1 through 9-3). Such an organization however, does not lend itself to a clear understanding of community dynamics and/or interactions. The approach taken to characterize/clarify these dynamics is based on the guild concept (Morrison *et al.* 1992). A guild is defined as:

> "*a group of species that exploit the same class of environmental resources in a similar way. This term groups together species, without regard to taxonomic positions, that overlap significantly in their niche requirements*" (Morrison *et al.* 1992).

A guild, while crossing taxonomic groups, is specific to trophic level which is also defined by the exploitation of resources. Because no empirical data are available for characterizing resource use by species within the grassland under investigation, only "qualitative" guilds can be developed. Qualitative here refers to guild development from historical and literature-based information rather than site-specific empirical knowledge. Additionally, the focus of this investigation is the evaluation of environmental risks rather than wildlife management and as such, assemblage guilds appear to be the most appropriate in attempting to illustrate ecological structure (leading to a better characterization of indirect exposure pathways).

Using the guild concept, a conceptual model of the terrestrial ecosystem (Figures 9-5) can be produced. Such a conceptual model is used in the exposure assessment to: (1) evaluate which guild is most at risk for exposure to a chemical of potential ecological concern (COPEC) given an evaluation of taxonomic sensitivities to the COPEC(s); and (2) select representative receptors of concern.

9.6.1 Specific Measures of Effect

To ensure that the measures of effect are ecologically-relevant, they should be based on attributes associated with the assessment endpoint(s). Thus, the measures of effect are assigned numbers to indicate their foundation in ecological relevance according to the assessment endpoints. Using the toxicological information presented for the COPECs and uncertainties (Tables 9-9 through 9-14) with the guild-based conceptual foodweb model (Figure 9-5), categories of potential receptors of concern can be identified and risk hypotheses (measures of effect [MEs]) can be formulated.

The only assessment endpoint for Site SD-11 is (1) the protection of transient terrestrial consumers (specifically herbivorous, omnivorous and carnivorous vertebrates) foraging within the unit which have special status (i.e., endangered and/or threatened species) or provide food, production, and control, as well as a potential recreational resource (e.g., bird-watching).

Considering the potential fate and toxic effects of the COPECs (and uncertainties), all of these organic chemicals (the PAHs and phthalates) are expected to be immobile in soil and both elicit their toxic effect via narcosis where no particular group of animals (i.e., reptiles, birds, or mammals) would be expected to be more sensitive than the others. There is virtually no toxicological information regarding the organic COPECs in reptiles and very little for birds.

Nonpolar narcosis has been shown to produce adverse effects on survival, reproduction, and growth in experimental animals.

Higher vertebrates readily metabolize both the phthalates and the PAHs (e.g., ATSDR 1993a, 1995a) whereas most invertebrates do not (at least not as quickly such that bioaccumulation is affected). Plants are also well known to metabolize PAHs, although information regarding the phthalates is lacking. Given this, any significant bioconcentration from soil, for at least the PAHs, would be expected to occur in invertebrates. This is probably true for the phthalates as well. It follows then that those animals whose diet relies heavily on invertebrates would be expected to receive the greatest exposure to bioaccumulated PAHs and phthalates. Additionally, as the PAHs and phthalates are closely associated with the soil particles (i.e., relatively immobile), those ecological receptors, who consume soil invertebrates, and which forage in close contact with the soil would be expected to receive the greatest direct exposure. This leads then to the following measure of effect and uncertainty:

(1)MEa Impaired survival and reproduction of ground-gleaning insectivorous birds or mammals exposed to high molecular weight PAHs and phthalates in soil and invertebrates within Site SD-11.

(UN1) Impaired survival and reproduction of ground-gleaning insectivorous reptiles exposed to high molecular weight PAHs in soil and invertebrates within Site SD-11.

Discussed above, aluminum toxicity is highly dependent on the amount of calcium and phosphate in an animals diet (e.g., see Sparling *et al.* 1998). Additionally, it is known that aluminum is not well accumulated across the gastrointestinal tract of most terrestrial vertebrates (e.g., Sparling, ATSDR 1992a). As such, accumulation of aluminum in the vertebrate forage associated with Site SD-11 is not believed to be overly significant. Plants are known to accumulate aluminum. However, not discussed above is the fact that most plants are quite sensitive to aluminum (e.g., Kabata Pendias and Pendias 1992). As primary producers are not considered relevant to the evaluation of ecological risk associated with Site SD-11, their relative sensitivity to aluminum was not reviewed in the previous subsection. Nevertheless, certain tolerant plants can and do accumulate aluminum to a level that may become toxic to vertebrates. Invertebrates are also known to accumulate aluminum, but this has only been well characterized for aquatic species. Most of the aluminum appears to be correlated with the exoskeleton rather than the soft tissues (Sparling *et al.* 1998). It also appears that carnivorous mammals are less sensitive to aluminum than herbivorous or omnivorous mammals (i.e., dog vs. rat vs. lamb values on Table 9-12). This is logical based on the significant difference in their respective gastrointestinal anatomies. Carnivores with short guts would tend to absorb less than long intestined (sometimes multiple stomached) herbivores or omnivores. This has been shown to affect accumulation of xenobiotics, at least in aquatic vertebrates (Klienow and Goodrich 1992). Thus, it follows that, herbivores and omnivores that forage in close proximity to the soil (fossorial or ground gleaning) would not only receive the greatest exposure to aluminum within Site SD-11 but represent the most sensitive groups. This leads to the following measure of effect and uncertainty:

(2)ME Impaired survival and development of ground-gleaning herbivorous and omnivorous birds or mammals exposed to aluminum in soil, plants, and invertebrates within Site SD-11.

(UN2) Impaired survival and reproduction of ground-gleaning omnivorous reptiles (there are no herbivorous reptiles associated with Site SD-11) exposed to aluminum in soil, plants, and invertebrates within Site SD-11.

Chromium, as Cr III which is believed to be the form present within Site SD-11, is basically innocuous in mammals (Table 9-13). No sublethal effects have been established for Cr III in mammals. Effects have been established in birds and as such, birds are believed to be the sensitive (and thus most relevant) group of ecological receptors. Chromium shows little accumulation into plants or small mammals but appears to accumulate in at least earthworms (e.g., see Table 9-5; RTI 1995, Kabata Pendias and Pendias 1992, Sample *et al.* 1998). This suggests that invertivorous or insectivorous birds would receive the greatest bioconcentrated exposure to chromium. Again, as all of the COPECs appear closely associated with the soil matrix (little dissolution, volatilization, etc.), ground gleaning birds (there are no fossorial foraging birds expected) would be expected to receive the greatest direct exposure chromium in Site SD-11. This leads to the following measure of effect and uncertainty:

(3)ME Impaired survival ground-gleaning invertivorous / insectivorous birds exposed to chromium in soil and invertebrates within Site SD-11.

(UN3) Impaired survival and reproduction of ground-gleaning invertivorous / insectivorous reptiles exposed to chromium soil and invertebrates within Site SD-11.

There is insufficient information to fully assess the potential sensitivities to vanadium among the relevant ecological receptors. It is fairly clear, however, that vanadium has a propensity to accumulate in plants to a much greater extent than in invertebrates or small mammals (see Table 9-5; RTI 1995, Sample *et al.* 1998a, 1998b). As with aluminum, vanadium is not readily absorbed across the mammalian gut (ASTDR 1992b). It then follows that herbivorous birds and mammals foraging within Site SD-11 would be at the greatest risk for exposure to bioconcentrated vanadium and foragers closely associated with the soil (fossorial or ground gleaning) would receive the greatest direct exposure compared to other potential receptors. As there are no reptilian representatives within this guild, the following measure of effect is not accompanied by an uncertainty associated with reptiles:

(3)ME Impaired survival and growth of fossorial or ground-gleaning herbivorous birds or mammals exposed to vanadium in soil and plants within SD-11.

9.6.2 Receptors of Concern (ROCs)

The context for testing the aforementioned hypotheses has been established (i.e., the ecosystem at risk, Subsection 9.2) as well as the relevant attributes for testing (i.e., the measures of effect). The receptors to be used for testing these null hypotheses, however, have not been fully

developed. To fully develop a measurement by which these hypotheses may be tested, receptors of concern (ROCs) are identified.

The terms *ecological component* and *receptor of concern (ROC)* can be essentially synonymous. An ecological component/ROC can be any part of an ecosystem, including individuals (i.e., of threatened or endangered species), populations, communities, and the ecosystem itself. The use of the guild concept in evaluating potential exposures has defined those components within the ecosystem with the greatest potential for exposure and has, in fact, identified the ROCs (i.e., ground-gleaning omnivorous mammals, ground-gleaning insectivorous birds, etc.). For higher vertebrates however, the generally accepted approach is to select an indicator species to represent the guild, which is referred to as the ROC (USACE 1996, USEPA 1997a; 1998). This is due to using toxicity reference values (TRVs) and the concept of *hazard quotients* (see Section 9.6). TRVs are expressed as a dose to an individual animal, whereas the effect is interpreted with respect to the guild population. To estimate the environmental dose, organismal parameters are required, thus, the need for selecting a specific species to represent the ROC.

As discussed in Section 9.2 and illustrated above, the potential organisms within the ecological guilds can be high and diverse. Using the conceptual ecosystem model discussed above (Figure 9-5), single species were selected that represent the entire guild. Whenever possible and appropriate, one of those species identified as having special value (species of special concern – the peregrine falcon, swift fox, Baird's sparrow, McCowan's longspur) were selected to both represent themselves as species, as well as the guild as a whole (e.g., McCowns' sparrow was selected to represent itself and all other ground gleaning herbivorous birds). The selection process was based on the following additional selection criteria:

- Probable intensity/duration of exposure. In general, species were selected that are known or anticipated to be relatively common and abundant. For example, given a choice between an infrequent or seasonal immigrant and a year-round resident the latter received preference.
- Availability of relevant behavioral and physiological data. In general, preference was given to relatively well-studied species for which most biological attributes are readily-accessible. When appropriate, for example, ROCs were selected from among those covered in the *Wildlife Exposure Factors Handbook* (USEPA 1993).
- Availability of relevant toxicological data. For ingestion-pathway exposures, virtually no oral toxicity data are available for reptiles for most contaminants. Though there may be adequate knowledge of an animal's behavior and physiology to estimate exposures with reasonable accuracy, it is of limited practical value to do so if there is no basis for evaluating the consequences of the exposures. Reptiles and amphibians are included in the conceptual models, but the hypotheses associated with their selection cannot be properly tested due to the lack of toxicological data.

Another consideration is overall size, which serves as an "index" to behavioral and physiological differences that may influence the animals' susceptibility (and sensitivity) to contaminants. That is, smaller animals *tend* to be shorter-lived, occupy smaller home ranges (and occur in greater densities), and have higher metabolic rates. Other relevant information regarding the behavior and

physiological attributes of potential receptors is required. To this end, the following ingestion-pathway exposure factors (assumptions) have been identified for each of the potential terrestrial receptors:

- Area use (acres)
- Composition of the diet
- Rate of ingestion of food (kilograms/day; IR_{food})
- Rate of ingestion of soil (kilograms/day, IR_{soil})
- Body weight (kilograms; BW)

All of the foregoing are developed in the context of an hypothetical individual of a vertebrate consumer species representing the receptor group or guild. Relatively few empirical measurements of these attributes in wildlife species are available, and those that are available are often based on captive specimens. For these and many other reasons, *assumed* values for these attributes are fraught with uncertainty. Uncertainty can never be totally eliminated, but prudent application of well-documented information about the behavior and physiology of the receptors minimizes uncertainty. For this reason, EPA commissioned the compilation of the *Wildlife Exposure Factors Handbook* (USEPA 1993), which warns its readers that in any given ecological risk assessment it is crucial to apply site- or region-specific knowledge whenever possible. The assumptions used in this analysis are all based on formally-published information for the species, or plausible surrogate species. Generally-accepted principles and qualified-professional judgment are used to derive assumptions from relevant literature (mainly USEPA 1993 and primary sources cited therein) that the Base believes could be representative of conditions at the facility. At the same time, to avoid underestimating exposures, whenever ranges of values are available, the approach consistently incorporates a value at or near the conservative end of the range.

9.6.2.1 Area Use

To account for the fraction of ingested media derived from Site SD-11, behavioral information from the literature (such as home ranges or feeding territories) is considered in light of the relevant dimensions. For example, if a receptor is known to forage over a greater area than is available in a unit, its exposure potential is less than that of an alternate species which forages over a smaller area. Area use, in acres, for representatives of the receptor groups are presented in Table 9-15.

9.6.2.2 Dietary Composition

In nature, the diets of most vertebrates vary considerably (Allee *et al.* 1951; Martin *et al.* 1951). Some have morphological, physiological, and/or behavioral adaptations which limit their ability to use certain broad categories of food. Hence we recognize herbivores, omnivores, and carnivores. Within these types there are some species which are *relatively* more specialized, such as detritivores, granivores, frugivores, and so forth. However, even these more specialized forms seldom subsist on a single species of forage or prey -- except during brief periods when a particular item is readily accessible (Allee *et al.* 1951). There is a wealth of anecdotal information

in the literature regarding the food habits of most common North American birds and mammals. In general, however, there is a paucity of detailed quantitative dietary studies, and these relate primarily to localized populations of only a few species (USEPA 1993). One clear pattern is the tendency for most birds and mammals to be highly opportunistic within the constraints of their respective feeding adaptations. Thus, in the absence of direct observation, it is reasonable to assume that a given bird or mammal will "preferentially" feed upon the more available (i.e., abundant and accessible) items in a given time and place (Allee *et al.* 1951).

For assessment of ingestion-pathway exposures to a given receptor one would ideally have site-specific information upon which to base a representative diet, characterized in terms of percentages by weight of the various major components. Since site-specific studies of the food habits of the selected receptors for the units have not been performed, an appropriate breakdown of the diet for each species must be based on interpretation of the largely-anecdotal literature. This interpretation should be based on professional judgment, common sense, and an awareness of what forage and prey items are most available (or might be most available absent contamination) within Site SD-11.

Major categories to be used in characterizing the diets of selected receptors in the units are:

- *Plants* - Foliage, seeds, and tubers of vascular plants which are growing in surface soil.
- *Invertebrates* - Forms such as crawling, climbing, and flying adult and larval insects, as well as other arthropods such as spiders (Arachnida) and sowbugs (Isopoda).
- *Amphibians and Reptiles* - Members of the vertebrate Classes Amphibia (mainly toads); and Reptilia (mainly lizards and snakes)
- *Birds* - Members of the vertebrate Class Aves (primarily passerines and small fowl-like birds).
- *Mammals* - Members of the vertebrate Class Mammalia (primarily rodents, and lagomorphs).

These categories are based on consideration of the feeding patterns of the potential receptors and the way food habits are commonly described in the literature. For some of the potential receptors, there are proportional breakdowns of the diet which conform to (or can be readily converted to) the above categories. In other cases, it is necessary to infer categorical allocations from qualitative descriptions. Dietary composition breakdowns for the selected representative receptors are presented in Table 9-16.

9.6.2.3 *Food Ingestion Rate (IR_{food})*

There are three general sources of food ingestion rates for wildlife:

- expressions based on a percentage of body weight, derived from collective experience (including some empirical measurements) of researchers familiar with the types of animals in question (e.g., Newell *et al.* 1987);
- empirical measurements, usually obtained from a relatively small "sample" of animals fed *ad libitum* in captivity; and

- allometric equations based on a combination of empirical measurements from a wide variety of representatives of a category of animals and bioenergetic principles and theory (e.g., Nagy 1987; see also USEPA 1993, USEPA 1988).

Most of the food ingestion rates in Table 9-15 are based on allometric relationships developed by Nagy (1987; all reproduced in USEPA 1993). In the absence of empirical measurements specific to the selected receptors, use of the allometric equations is appropriate because these are widely-accepted, empirically-derived relationships. Body weights at the low end of the range reported in the literature were used in the equations to derive the food ingestion rate (see below).

9.6.2.4 Soil Ingestion Rate (IR_{soil})

Many higher vertebrates are known to ingest soil, usually incidentally to feeding or grooming (USEPA 1993; Beyer *et al.* 1994). The quantities are often a function of the animal's feeding and foraging habits. For some receptors, the literature provides directly-measured rates that reflect conditions that might occur at the Base. Otherwise, professional judgment has been used in interpreting reported rates, or extrapolating from surrogate species. The rate is normally estimated as a percentage of the overall diet, and then converted to mass/day. The assumed soil ingestion rates (IR_{soil}) are included in Table 9-15.

9.6.2.5 Body Weight (BW)

Body weight is an important factor because it is often used in calculating other exposure assumptions when realistic direct measurements are not available (e.g., food ingestion rates). When a range is reported, literature values have been adopted which, based on professional judgment, are representative of the low extreme for wild adults in New Mexico habitats. Assumed body weights for the potential receptors are presented in Table 9-15.

9.7 EXPOSURE AND EFFECTS CHARACTERIZATION

The evaluation or characterization of the measures of effects requires (1) the distribution of the COPEC in soil and food specific to that ROC; and (2) a credible literature-based toxicological effect level. Simply stated, each measure of effect (corresponding to each testable risk hypothesis) is a comparison between the dose the ROC receives (the environmental exposure concentration, EEC) and a toxicity reference value (TRV). Thus to test each hypothesis (measure the effect), the EEC must be estimated and a TRV derived from the literature. The following subsections describe the derivations of the respective (direct and indirect) EECs and TRVs.

9.7.1 Exposure Assessment

To realistically characterize exposures it is necessary to account for the spatial variation in COPEC concentrations as well as distributional attributes of the receptors.

9.7.1.1 Direct-Exposure Concentrations (Bulk Media)

Direct soil-exposure concentrations of the identified COPECs and uncertainties (i.e., phthalates) are used to assess the potential direct (albeit via the ingestion pathway) risk to the ROCs as well as to estimate, via mathematical modeling, indirect exposure concentrations (see Appendix D). The estimated exposure concentration is represented as a *high-end value* (i.e., the upper 95% confidence limit for the mean concentration [UCL] within the dataset or the maximum detected concentration) and as a *low-end value*, represented by the mean or geo-mean of the data. EECs were developed from the raw measured values in soil. The initial determination was whether there were sufficient data to perform a statistical evaluation (i.e., were there 3 or more measurements?). Three values result in 2 degrees of freedom for statistical analysis which is generally recognized as a minimum for most procedures. If a sufficient number of measurements were available from a given sample of abiotic media, the frequency of COPEC detection was evaluated. The following scenarios are possible:

1. If greater than 50% of the measurements were nondetect then a nonparametric statistical method was used to estimate the mean and 95% upper concentration limit of the mean (UCL) to represent the sediment high and low EECs.
2. If greater than 50% of the measurements resulted in detection, *and* if the data were distributed normally, central limit theorem techniques as described by USEPA (1997b) were used to estimate mean and 95% UCL to represent the EECs.
3. If greater than 50% of the measurements resulted in detection, *and* if the data were distributed log-normally, parametric statistics were used to estimate the Minimum Unbiased Estimator of the mean (Gilbert 1987) and the Jackknife procedure was used to estimate the variance of the MVUE (per USEPA 1997c) from which a 95% UCL is derived to represent the high-end EEC.
4. If the data were not normally or log-normally distributed, then a nonparametric (the Jackknife, Sokal and Rohlf 1981) approach was used to estimate the 95% UCL.

The data were evaluated to determine if they were normally distributed or log-normally distributed. This was done using the Shapiro and Wilk W-test (Gilbert 1987). If the data were found to be normally distributed, the central limit theorem (CLT) methods outlined in USEPA (1997b) were used to developed 95% UCLs for the arithmetic mean of the dataset which could then be used as the EEC. If the data were found to be log-normally distributed, the methods of Gilbert (1987) were used to produce the minimum unbiased estimator (MVUE) of the log-mean from which a single-sided (upper) 95% upper confidence interval was derived using the Jackknife procedure (per USEPA 1997b). If the data were found to be neither normally nor log-normally distributed, nonparametric estimates of the EEC were made using the Jackknife method described above. If none of the methods produce 95% UCL EEC estimates less than the maximum concentration detected, the maximum concentration detected was used to represent the high-end EEC.

The results of the statistical analysis of the raw data for the identified COPECs and uncertainties in surficial soils are presented in Tables 9-17 through 9-19.

9.7.1.2 Indirect (Ingestion-Pathway) Exposure-Point Concentrations

Meaningful inferences about the potential hazards of ingesting COPECs requires an understanding of the relationship between exposures, expressed as *doses* or rates (i.e., mass of COPEC/unit of receptor body weight/unit of time), and *responses*. Doses are estimated using:

- The measured and/or predicted concentrations of each COPEC in media known or assumed to be ingested (i.e., food and soil); and
- Estimations of the mass of each COPEC consumed per day, obtained by multiplying the concentration (mg/kg) in a medium by the amount of that medium (kg) assumed to be ingested by an individual in the population of the receptor species and expressed in terms of the mass (body weight) of the receptor.

Ingestion-pathway exposures to the vertebrate ROCs are estimated as *average daily doses* using the approach outlined in USEPA (1993) as follows:

$$ADD = [(IR_{food}*C_{food}) + (IR_{soil}*C_{soil}) * AUF/BW$$

where,

ADD	=	Average Daily Dose (mg/kg/day)
IR_{food}	=	Ingestion rate of food (kg/day)
IR_{soil}	=	Ingestion rate of soil in (kg/day)
C_{food}	=	Concentration of contaminant in food (mg/kg)
C_{food}	=	$[(\text{diet composition}_{food1}*C_{food1})+(\text{diet composition}_{food2}*C_{food2}) \ldots food_n]/100$
C_{soil}	=	Concentration of contaminant in soil (mg/kg)
AUF	=	Area use factor (percent)
BW	=	Body weight (kg)

Diet composition is input as a percentage of the overall diet (i.e., Table 9-16). The sum of all should equal 100. COPEC concentrations in dietary items other than soil, water and sediment are not available -- specifically: terrestrial plants; soil invertebrates; small reptiles; mammals; and birds. Estimation of the COPEC concentrations within these dietary items was based on the direct-exposure point concentration as detailed above and a prioritization scheme as follows:

- If empirically-derived bioconcentration or bioaccumulation factors are reported in the scientific literature or other public-domain documents (e.g., RTI 1995, Sample *et al.* 1998a and 1998b), they were used preferentially.
- If no empirically-based data are available, fugacity-based or equilibrium-partitioning-based modeling was applied to estimate the concentrations (see Appendix D).

- If the modeling approach is inadequate or inappropriate for either the COPEC or the dietary component, the unit-specific soil concentration was used to represent the dietary component of the ROC.

Based on the modeling approach (detailed in Appendix D) EECs for the dietary items for the ROCs were estimated. These results are presented in Table 9-20.

9.7.2 Effects Assessment

In accordance with specific assessment endpoints involving survival, reproduction, development, and/or growth for selected ROCs, appropriate dietary toxicological endpoints were reviewed form those presented in Tables 9-9 through 9-14. These include the lethal dose, the Lowest-Observed-Adverse-Effect Level (LOAEL), and the No-Observed-Adverse-Effect Level (NOAEL). The lethal dose, expressed, for example as the LD_{50}, is the dose lethal to 50% of the test organisms over a specific exposure period. Another example, the LD_{lo}, is a reported dose that is capable of producing lethality. The LOAEL is the lowest dose that results in a statistically significant effect compared to a control. The NOAEL is the highest dose where there is no statistically significant difference from the control response.

The general strategy for selecting (or deriving) a single LOAEL and NOAEL value as a TRV from among the many values reported in the literature was as follows:

- Where literature values are identified for the specific assessment receptor, the lowest LOAEL representing the assessment endpoint (survival, reproduction, development, and/or growth) was selected. For the NOAEL scenario, the highest NOAEL that did not exceed the lowest LOAEL was selected.
- Where values were not available for a specific assessment receptor (which is characteristic of the vast majority of literature values), values from surrogate receptors were used.
- In cases where NOAELs were reported, but LOAELs were not identified, the highest reported NOAEL value was used for deriving TRVs. In such an instance, a LOAEL was be derived based on 10 times the NOAEL.
- If LOAEL and/or NOAEL data were not available, but lethal dose data were reported, an uncertainty factor (division) of 10 was applied to the lowest acute lethal dose to derive a LOAEL, or an uncertainty factor of 100 to derive a NOAEL. LD_{lo}s were selected preferably over LD_{50}s. An uncertainty factor (division) of 10 was also applied to the LOAEL to derive a NOAEL. Note that lethal dose values were only used in the absence of LOAEL and NOAEL information.
- Weight was given to the duration of the study, as well as the toxicological endpoint. Preference was given to studies that were chronic or subchronic exposure versus single event or acute exposures. Where data were available for more than one dosing regime, chronic was selected first, subchronic second, and acute only if no other data were available. Critical life-stage tests also carried significant weight.

- Studies were considered based on the dosing regime. Intraparitoneal or intravenous studies were not used. Studies using gavage or oral intubation were not used when food studies were available.
- Measurement endpoints considered included survival, growth and reproduction. Endpoints specifically related to survival, growth and reproduction such as fetotoxicity or infertility were also considered. Effects such as carcinogenesis, liver damage, kidney function, sperm mobility, enzyme induction, blood pressure, etc., were generally not considered appropriate measures.

Two TRVs for each COPEC were selected, one based on a NOAEL and the second based on a LOAEL. The selected NOAELs and LOAELs are summarized in Table 9-21.

9.7.3 Effects / Risk Characterization

Risk characterization is based on the quotient method (Suter 1993, 1995). A Hazard Quotient (HQ) is calculated as the ratio between the predicted average daily dose (ADD) and a toxicity reference value (TRV). As the assessment relies on highly conservative modeling of a ROC's average daily dose and assumes that the system is in equilibrium, any HQs produced in the ecological risk assessment must be considered conservative or "worst-case." HQs will be interpreted as follows:

- An HQ_{NOAEL} below 1 suggests there is no risk;
- An HQ_{NOAEL} greater than 1 with a HQ_{LOAEL} less than 1 suggests that there is a potential for risk; and
- An HQ_{LOAEL} greater than 1 suggests probable risk.

9.8 RISK CHARACTERIZATION

The average daily doses (ADDs) and resultant hazard quotients (HQs) characterizing the potential exposure and risks to the representative ROCs associated with Site SD-11 are presented in Tables 9-22 for the organic chemicals evaluated and in Table 9-23 for the inorganic chemicals. A total of ten COPECs and three uncertainties were evaluated. None of the organic COPECs or uncertainties were found to produce a HQ in excess of one under the high-end exposure scenario, thus the low-end exposure scenario was not evaluated (Table 9-22). There does not appear to be any relevant ecological concerns regarding organic chemicals within the soils of Site SD-11. Neither chromium nor vanadium produced a HQ greater than one based on the high-end exposure scenario. These chemicals are not believed to pose any relevant ecological risk within Site SD-11. Potential risks to aluminum were identified for Baird's sparrow (omnivorous ground-gleaning birds). This potential appears present under both the high-end and low-end exposure scenarios (Table 9-23).

As discussed previously, aluminum toxicity is highly dependent on calcium and phosphate dietary concentrations. It is uncertain whether or not the sparrow (representing the relevant ecological receptors) is under phosphate deficient diets. Perhaps most importantly, 99% of the dose of

aluminum is predicted to be due to direct ingestion of soil. Aluminum has been shown to produce food-aversion in experimental animals (Sparling *et al.* 1998). In fact, this is believed to be the cause of some of the apparent growth effects – where the animals eat less due to the taste of the aluminum-tainted diet (Sparling *et al.* 1998). Given that the soil ingestion rates were purposely overestimated and the probable aversion of aluminum-tainted soil, it is doubtful that the suggested risks are significant. Whether or not reptiles would avoid aluminum-tainted soil is uncertain. Nevertheless, the aluminum risks are overstated and probably insignificant. As soil ingestion appears to be driving the predicted dose, sampling of biological material to refine the dose estimates is not warranted.

9.8.1 Summary of Potential Risks and Uncertainties

Based on the conservative estimation of exposures and effects in biota and the results presented above, there appears to be only one issue regarding ecological risk within Site SD-11: direct soil ingestion of aluminum to omnivorous birds.

Development of hazard quotients based solely on concentrations in specific media (i.e., soil) using a "desk-top" assessment is subject to the conservatism and uncertainties inherent within the assessment. As the assessment process relies on highly conservative modeling of a ROC's average daily dose, and assumes that the system is in equilibrium rather than dynamic, any HQs produced with the results of the ecological risk assessment must be considered highly conservative.

There are no credible toxicity values for ecologically relevant amphibian or reptilian receptors of concern exposed to soil-associated COPECs. The uncertainty associated with a lack of terrestrial amphibian and reptilian toxicity reference values is difficult to assess. Little information is available regarding the relative sensitivities and toxicology between these organisms and those for which information is available (i.e., mammals). If such information was available at least some inference may be attempted through a comparison with risk estimates for those receptors where estimates were available.

The qualitative surveys made by a URS Greiner Woodward Clyde ecologist suggest that there is a population of reptiles within Site SD-11 and the adjacent grassland. There were no obvious signs of distress within the unit which leads to a qualitative conclusion that there does not appear to be any overt negative impact on these populations due to soil contamination.

9.8.2 Uncertainties Associated with Risk Estimation (Model Uncertainties)

The TRV, ideally, is the daily dose per kilogram of body weight that over chronic exposure results in either (1) no adverse effects or (2) represents the lowest dose (level) at which an adverse effect might occur. These values are selected from laboratory-based test results reported in the literature. This introduces uncertainty in the context that laboratory-derived results may not be directly translatable to population level effects in the natural environment.

TRVs are expressed as the no-observed-adverse-effect level (NOAEL) and the lowest-observed-adverse-effect level (LOAEL). The use, validity, and understanding of laboratory-based NOAELs and LOAELs lies in their experimental definitions. Experimentally, these values are determined statistically, i.e., the NOAEL shows no *statistically significant* adverse effects when compared to control values and the LOAEL is lowest test dose/concentration tested that produces *statistically significant* adverse effects when compared to a control. These parameters by definition are highly biased by the experimental design, specifically the statistical power of the test design. At low statistical power, it is possible that a 20% or 30% reduction in reproduction or growth could occur but be statistically defined as a NOAEL. Conversely, given a high level of statistical power, it is possible for a 1% or 5% reduction to be declared statistically less than a control and result in the test LOAEL. Statistical significance does not automatically relate to biological significance.

In addition to the selection of the TRVs for the ROC and COPEC, the concentrations within the forage items of the ROC were required for calculation of the average daily dose. Modeling was required for the Tier II assessment as COPEC concentrations in biological tissues are unknown. The models used incorporated estimates of bioconcentration and bioaccumulation of COPECs from soil into the forage species within the foodweb. Any model or modeling design has inherent uncertainty. The greatest uncertainty associated with the models used for the assessment of Site SD-11 involves the assumption that the system is at "steady-state" (thermodynamic equilibrium) and in the use of COPEC concentration without consideration of COPEC mass. Steady-state as a model assumption refers to the relationship between media concentrations, in that the concentration relationships are constant and unchanging. This is required to solve the concentration-based equations used within the model. Concentration-based models do not account for mass-balance, where the mass required to produce the predicted concentrations is assumed to be unlimited. This assumption is seldom valid when using the environmental exposure concentrations described in Section 9.6 .1 (the lessor of the maximum concentration or 95% UCL for the mean). There is a certain mass required for each component or environmental phase within the model. The mass required to fill the environmental phases can, at times, exceed the mass available, i.e., be limited.

All of the aforementioned uncertainties lead to an over-estimation of the environmental concentration within biological tissues. This is appropriate for this level of ecological risk evaluation and assures a low probability of Type II errors (suggesting no risk when in reality one exists).

TABLE 9-1

AMPHIBIANS AND REPTILES EXPECTED TO OCCUR WITHIN THE VICINITY OF CANNON AIR FORCE BASE BASED ON ZOOGEOGRAPHY CURRY COUNTY, NEW MEXICO

Scientific Name	*Common Name*	*Typical Substrate - Habitat*	*Foraging Behavior*	*Trophic Level*	*Exploits SD-11?*
Scaphiopus couchi	Couch's spadefoot toad	Tolerant of dry terrain; likes shortgrass prairie as well as mesquite savannah and creosote-bush desert	Grd Amb	Ins	Po to Pr
Scaphiopus bombifrons	Plains spadefoot toad	Shortgrass prairie where soil is loose and dry; occurs in several desert-grassland transitional areas	Grd Amb	Ins	Pr
Scaphiopus hammondi	Western spadefoot toad	Prefers shortgrass plains and sandy, gravelly soils such as alkali flats, washes, and river floodplains	Grd Amb	Ins	Po to Pr
Scaphiopus multiplicatus	New Mexico spadefoot toad	Prefers shortgrass plains, playas and alkali flats of arid and semiarid regions	Grd Amb	Ins	Po to Pr
Bufo woodhousii	Woodhouse's toad	Marshes, swales, river bottoms, mountain canyons, desert streams, and irrigated areas, plus urban and suburban backyards	Grd Amb	Ins	Po
Bufo punctatus	Red-spotted toad	Desert and rocky regions and prairie grasslands, usually near source of permanent water	Grd Amb	Ins	Un
Bufo cognatus	Great Plains toad	Grasslands of the prairie and drier bushy areas	Grd Amb	Ins	Po
Bufo debilis	Green toad	The shelter of rocks in semiarid regions, also found in prairies	Grd Amb	Ins	Un to Po
Bufo blairi	Plains leopard frog	Ponds, small streams, grasslands, and open woods	Wa / Rip Amb	Inv	No
Ambrystoma tigrinum	Tiger salamander	Varied, arid sagebrush plains, pine barrens, mountain forests, damp meadows	Rip Amb	Pre	No
Kinosternon flavescens	Yellow mud turtle	Ponds, small streams, grasslands, and open woods	Ben Gle	Omn	No
Chelydra seroentina	Snapping turtle	Quiet slow moving waters	Wa Gle	Omn	No
Terrapene ornata	Western box turtle	Primarily prairies and grasslands	Grd Gle	Omn	Po to Pr
Pseudemys scipta	Slider	Soft bottom stream, lakes, ponds, marshes, and wetlands	Ben Gle	Pre / Det	No
Eumeces multivarigatus	Many-lined skink	Shortgrass prairies, vacant lots, prairie dog towns	Grd Amb	Ins	Po to Pr
Eumeces obsoletus	Great plains skink	Flat limestone rocks on grassy hillsides, grasslands, and woods – usually near water	Grd Amb	Ins	Un
Cnemidophorus sixlineatus viridis	Prairie racerunner	Prefers dry areas; flat or hilly; sandy or rocky soils; short grass, thin woods, dusty roadsides	Grd Amb	Ins	Pr
Crotaphytus collaris	Collared lizard	Hardwood forests to arid regions with large rocks for basking	Grd Amb	Ins	No

TABLE 9-1

AMPHIBIANS AND REPTILES EXPECTED TO OCCUR WITHIN THE VICINITY OF CANNON AIR FORCE BASE BASED ON ZOOGEOGRAPHY CURRY COUNTY, NEW MEXICO

Scientific Name	*Common Name*	*Typical Substrate - Habitat*	*Foraging Behavior*	*Trophic Level*	*Exploits SD-11?*
Uta stanburiana	Side-blotched lizard	Arid to semiarid regions with coarse gravelly soil and low vegetation	Grd Amb	Ins	Po
Sceloporous undulatus	Fence lizard	Varied; drier woodlands, clearings, brushlands, grasslands, and sandy areas	Grd Amb	Ins	Pr
Phrynosoma cornutum	Texas horned lizard	Dry open country with loose soil; grassland, mesquite, or cactus areas	Grd Amb	Ins	Po
Phrynosoma modestum	Roundtail horned lizard	Sandy, gravelly washes, semiarid regions with scrub vegetation	Grd Amb	Ins	Un
Holbrookia maculata	Lesser earless lizard	Sandy soil areas in grassy prairies, cultivated fields, dry streambeds	Grd Amb	Ins	Po
Leptoyphlops dulcis	Texas blind snake	Semiarid deserts, prairies, hillsides, mountain slopes with sandy or loamy soils	Foss Amb – Pur	Inv	Po
Leptoyphlops myopicus	Mountain blind snake	Arid to semi-arid regions; in sandy to gravelly soils of dry grasslands	Foss Amb – Pur	Inv	Po
Thamnophis marcianus	Checkered garter snake	Arid to semiarid areas near streams, springs, ponds, irrigation sites	Wa Pur – Amb	Pre	No
Diaphopis punctatus	Ringneck snake	Woods, rock covered hillsides, forest paths, field edges; usually near water	Grd / Foss Amb	Pre	No
Rhinocheilus lecontei	Longnose snake	Dry open prairie, desert brushland, and coastal chaparral	Foss Amb – Pur	Pre	Po
Heterdon nasicus	Western hognose snake	Sand and gravelly soil; prairies, scrublands, river flood plains	Grd Amb	Pre	Po
Sonora semiannulata	Western ground snake	Dry open areas with loose sandy soil	Grd / Foss Amb	Pre	Po
Tantilla nigriceps	Plains blackhead snake	Under flat rocks on dry hillsides	Grd Amb – Pur	Inv	Un
Hypsiglena torquata	Night snake	Variable from semiarid and arid sandy or rocky situations to heavy brush chaparral and oak-pine woodland	Grd Amb	Pre	Po to Pr
Lampropeltis getulus	Common kingsnke	Highly variable from desert to swamp situations	Grd Amb	Pre	Po
Lampropeltis triangulum celaenops	Western milk snake	Variable; fields, open woods, river bluffs, rocky hillsides, prairies, pine barren bogs, sandy soils	Grd Amb	Pre	Un to Po
Elaphe guttata emoryi	Great Plains rat snake	Canyons, rocky draws or on hillsides	Grd / Foss Amb	Pre	Un
Arizona elegans	Glossy snake	Dry open sandy areas; chaparral sagebrush flats, oak-hickory woodland	Grd / Foss Amb	Pre	Un

TABLE 9-1

AMPHIBIANS AND REPTILES EXPECTED TO OCCUR WITHIN THE VICINITY OF CANNON AIR FORCE BASE BASED ON ZOOGEOGRAPHY CURRY COUNTY, NEW MEXICO

Scientific Name	*Common Name*	*Typical Substrate - Habitat*	*Foraging Behavior*	*Trophic Level*	*Exploits SD-11?*
Pituophis melanoleucus sayi	Western bullsnake	Sandy pine-oak woodlands, pine flatwoods, cultivated fields, prairies, open brushland, rocky desert	Grd Amb	Pre	Po
Masticophis flagellum	Coachwhip	Dry relatively open areas, grassland prairie, desert scrub, thorn forest, chaparral	Grd Amb	Pre	Pr
Sistrurus catenatus	Massasauga	Rocky hillsides, sagebrush prairies, desert grassland	Grd Amb	Pre	Un to Po
Crotalus atrox	Western diamondback rattlesnake	Variable; arid to semiarid plains to mountains	Grd / Foss Amb – Pur	Pre	Po
Crotalus viridus	Western rattlesnake	Variable, Great Plains grassland to brush covered sand dunes	Grd / Foss Amb – Pur	Pre	Po

Exploitation is determined or predicted based on zoogeographic and behavioral literature (e.g., Smith and Brodie 1982; Coborn 1992; Breen 1994; MacMahon 1997; Conant and Collins 1998; Brown 1997; Collins 1991); as well as limited site-specific observations.

Primary designations relate to degree of certainty or likelihood of exploitation of the resources associated with SD-11 and/or the adjacent grassland: No = assumed absent; Un = exploitation highly unlikely; Po = exploitation is possible, although location-specific confirmation is lacking; Pr = exploitation is probable, although location-specific confirmation is lacking.

Trophic Level Codes: Her = herbivore; Det = detritivore; Omn = omnivore; Pre = predator; Ins = insectivore; Inv = invertivore. Note that "predators," "insectivores," and "invertivores" are all carnivores (consumers of other animals). Note further that the designations refer to the "typical" or predominant composition of the diet, and should not be interpreted as representing the overall diets.

Foraging Behavior Codes: Grd = ground; Wa = water; Ben = benthic; Rip = riparian; Foss = fossorial; Gle = glean; Amb = ambush; Pur = pursuit. Note that these foraging behaviors are "typical" and do not reflect the potential full range of possible foraging behaviors.

TABLE 9-2

NON-AQUATIC OR SEMI-AQUATIC BIRDS EXPECTED TO OCCUR WITHIN THE VICINITY OF CANNON AIR FORCE BASE BASED ON ZOOGEOGRAPHY CURRY COUNTY, NEW MEXICO

Scientific Name	*Common Name*	*Typical Substrate - Habitat*	*Foraging Behavior*	*Trophic Level*	*Exploits SD-11?*
Cathartes aura	Turkey vulture	Open habitat in both lowlands and mountains	S / Grd Gle	Det	Po
Coragyps atratus	Black vulture	Open lowland areas, garbage dumps, avoids forested areas	S / Grd Gle	Det	Po
Ictinia missippiensis	Mississippi kite	Variable; near waterways in forests, open woodland; semiarid rangeland	PSw / Ar Ha	Ins	Un
Accipter cooperii	Cooper's hawk	Forests and woodlands prefers riparian areas	Ar Ha	Pre	Un
Accipter striatus	Sharp-shinned hawk	Woodland and mountains	Ar Ha	Pre	Un
Circus cyaneus	Marsh hawk (WI)	Variable; generally open areas; prairie, savanna, slough, wet meadow, marsh	S / Grd Pou	Pre	Po
Buteo regalis	Ferruginous hawk (WI)	Open country, usually priories, plains, and badlands	Grd Pou	Pre	Po to Pr
Buteo jamaicensis	Red-tailed hawk	Woodland and open country with scattered trees, desert	S / Grd Pou	Pre	Un to Po
Buteo swainsoni	Swainson's hawk (M)	Savanna, prairie, desert, open pine-oak woodland, cultivated fields with trees	S / Grd Pou	Pre	Po to Pr
Aquila chrysaetos	Golden eagle	Open habitat, especially in mountains and hilly areas	S / Grd Pou	Pre	Un to Po
Falco mexicanus	Prairie falcon (WI)	Open habitat in mountainous regions, short-grass prairie, alpine tundra	Ar Ha	Pre	Po to Pr
Falco peregrinus	Peregrine falcon (WI)	Open habitats from tundra, savanna, and seacoasts to high mountains, open forests, and tall building	Ar Ha	Pre	Po
Falco columbarius	Pigeon hawk (WI)	Open habitats, savanna, occasionally in cities	Ar Ha	Pre	Po
Falco sparverius	American kestrel	Open or partly opened habitats with scattered trees, also cultivated and urban areas	H / Grd Pou	Ins	Po
Callipepla squamata	Scaled quail	Semiarid plains, desert grassland, arid scrub	Grd Gle	Omn	Po

TABLE 9-2

NON-AQUATIC OR SEMI-AQUATIC BIRDS EXPECTED TO OCCUR WITHIN THE VICINITY OF CANNON AIR FORCE BASE BASED ON ZOOGEOGRAPHY CURRY COUNTY, NEW MEXICO

Scientific Name	*Common Name*	*Typical Substrate - Habitat*	*Foraging Behavior*	*Trophic Level*	*Exploits SD-11?*
Colinus virginianus	Bobwhite quail	Tall grassland, brushy fields, open woodland, cultivated fields	Grd Gle	Omn	Un to Po
Phasianus colchicus	Ring-necked pheasant	Open county, cultivated areas, marsh, woodland, forest edge	Grd Gle	Omn	Un to Po
Meleagris gallopavo	Wild turkey	Mixed forest and open woodland	Grd Gle	Omn	No
Charadrius vociferus	Killdeer	Variable; fields, meadows, pastures, mud flats, urban and rural areas	Grd Gle	Ins	Un to Po
Columba fasciata	Band-tailed pigeon (SU)	Oak to conifer forests	Lca / Grd Gle	Her	No
Columba livia	Rock dove	Cities, towns, rural areas, always near human habitation	Grd Gle	Her	Po to Pr
Zenaidura macroura	Mourning dove	Variable; generally open areas, common in agricultural areas	Grd Gle	Her	Pr
Coccyzus americanus	Yellow-billed cuckoo (SU)	Open woodland, especially with dense undergrowth, parks, riparian woodland and thickets	Lca / Grd Gle	Ins	No
Geococcyx californianus	Roadrunner	Desert scrub, chaparral, edge of cultivated lands, arid open areas with scattered brush, pine-oak woodland	Grd Gle - Pur	Ins	Po
Otus asio	Screech owl	Woodland, especially oak and riparian, scrub, orchards, woodlots	PSw / Grd Pou	Pre	No
Bubo virginianus	Great horned owl	Dense conifer and mixed forests, wooded swamps, and river valleys	PSw / Grd Pou	Pre	No
Asio otus	Long-eared owl (WI)	Conifer and mixed forests, especially near water, also parks, orchards, and farm woodland	S / Grd Pou	Pre	No
Asio flammeus	Short-eared owl (WI)	Prairie, meadow, tundra, marsh, and savanna	H / Grd Pou	Pre	Po
Tyto alba	Barn owl	Open and partly open habitats, especially grasslands, farmland, often in or near towns	S / Grd Pou	Pre	Po to Pr
Strix occidentalis	Spotted owl	Dense forests, especially shaded, deep	PSw / Grd	Pre	No

TABLE 9-2

NON-AQUATIC OR SEMI-AQUATIC BIRDS EXPECTED TO OCCUR WITHIN THE VICINITY OF CANNON AIR FORCE BASE BASED ON ZOOGEOGRAPHY CURRY COUNTY, NEW MEXICO

Scientific Name	*Common Name*	*Typical Substrate - Habitat*	*Foraging Behavior*	*Trophic Level*	*Exploits SD-11?*
		walled canyon forests	Pou		
Speotyto cunicularia	Burrowing owl	Grassland, prairie, savanna, open areas near human habitation, especially golf courses and airports	Grd Pou	Ins	Pr
Phalaenoptilus nuttalii	Poor-will (SU)	Semiarid and arid habitat, scrub, brush, prairie, rocky canyon, open woodland	Ar Scr	Ins	Po
Chorodeiles minor	Common nighthawk (SU)	Open and semi-open habitats, especially savanna, grassland, fields, cities and towns	Ar Scr	Ins	Po to Pr
Chorodeiles acutipennis	Lessor nighthawk (SU)	Open desert, scrub, savanna, and arid cultivated areas	Ar Scr	Ins	Po to Pr
Aeronautes sexatlis	White-throated swift (SU)	Mountainous country near cliffs and canyons	Ar Scr	Ins	No
Archilochus alexandri	Black-chinned hummingbird (SU)	Open woodland, arid scrub, riparian woodland, chaparral, parks and gardens – most often in arid regions	H / Ar FL	Her	Un
Colaptes cafer	Red-shafted flicker	Groves, river woods, open forests, farms, canyons, semi-open country	Grd Gle	Omn	No
Dendrocopos scalaris	Ladder-backed woodpecker	Deserts, arid scrub, riparian woodland, pinon-juniper woodland, pine savanna, pine-oak woodland, and towns	Ba Gle	Omn	No
Sphyrapicus varius	Yellow-bellied sapsucker	Mixed forests and parks	Ba Gle	Omn	No
Sphyrapicus thyroideus	Willianson's sapsucker (WI)	Montane conifer forests, lodgepole pine, also aspen groves	Ba Gle	Ins	No
Denrocopos villosus	Hairy woodpecker	Conifer forests, occasionally mixed or riparian forests	Ba Gle	Omn	No
Muscivora forfic	Scissor-tailed flycatcher (SU)	Open prairie, scrub, open country with scattered tress	Ar Ha / Grd Gle	Ins	Po
Pyrocephalus rubinus	Vermilion flycatcher (SU)	Riparian woodland, roadsides and deserts	PSw / Grd Pou	Ins	Un
Tyrannus verticalis	Western kingbird (SU)	Savanna, dry open country, agricultural lands, riparian woodlands	PSw / Grd Pou	Ins	Un to Po

TABLE 9-2

NON-AQUATIC OR SEMI-AQUATIC BIRDS EXPECTED TO OCCUR WITHIN THE VICINITY OF CANNON AIR FORCE BASE BASED ON ZOOGEOGRAPHY CURRY COUNTY, NEW MEXICO

Scientific Name	*Common Name*	*Typical Substrate - Habitat*	*Foraging Behavior*	*Trophic Level*	*Exploits SD-11?*
Tyrannus vociferans	Cassin's kingbird (SU)	Oak-pinon and pine-juniper woodlands, dry savanna, scrub	PSw / Grd Pou	Ins	Un
Myiarchus cinerascens	Ash-throated flycatcher (SU)	Scrub, chaparral, open and riparian woods, especially pine-oak, pinon-juniper	Lca Gle	Ins	No
Sayornis nigricans	Black phoebe	Near water in woodlands, canyons, suburbs, farmland with scattered trees	PSw / Ar Ha	Ins	No
Sayornis saya	Say's phoebe	Farmland, savanna, open woodland, usually near water	PSw / Ar Ha	Ins	No
Empidonax difficilis	Western flycatcher (SU)	Mixed forests and woodlands, especially near water	PSw / Ar Ha	Ins	No
Contopus sordidulus	Western wood pewee (SU)	Conifer and mixed forests, forest edge, riparian woodland	PSw / Ar Ha	Ins	No
Eremophila alpestris	Horned lark	Open country, tundras, grassland, agricultural areas	Grd Gle	Omn	Po
Hirundo rustica	Barn swallow (SU)	Open country, savanna, especially near water, agricultural areas	Ar Scr	Ins	Un
Petrochelidon pyrrhonota	Cliff swallow (SU)	Open country, savanna, especially near running water	Ar Scr	Ins	No
Stelgidopteryx ruficollis	Rough-winged swallow (SU)	Open country, savanna, especially near running water	Ar Scr	Ins	No
Aphelocoma coerulescens	Scrub jay	Scrub, especially oak, pinon, and juniper, brush, chaparral, pine-oak woodland	Grd Gle	Omn	No
Corvus corax	Common raven	Variable; often mountainous or hilly areas	Grd Gle	Omn	Un
Corvus cryptolecus	White-necked raven	Arid and semiarid grassland, scrub, and desert	Grd Gle	Omn	Po to Pr
Corvus brachyrhynchos	Common crow (WI)	Woodland, farmland, orchards, and tidal flats; riparian woodland in arid regions	Grd Gle	Omn	Un
Auriparus flaviceps	Verdin	Desert and arid brush, especially mesquite and cresote bush	Lca Gle	Omn	No
Psaltriparus minimus	Common bushtit	Woodland, scrub, chaparral	Lca Gle	Omn	No

TABLE 9-2

NON-AQUATIC OR SEMI-AQUATIC BIRDS EXPECTED TO OCCUR WITHIN THE VICINITY OF CANNON AIR FORCE BASE BASED ON ZOOGEOGRAPHY CURRY COUNTY, NEW MEXICO

Scientific Name	*Common Name*	*Typical Substrate - Habitat*	*Foraging Behavior*	*Trophic Level*	*Exploits SD-11?*
Sitta carolinensis	White-breasted nuthatch	Deciduous forests (especially mature), mixed forests, woodland, forest edge	Ba Gle	Ins	No
Sitta pygmaea	Pygmy nuthatch	Pine forests, especially ponderosa, yellow, Jeffery) also pinon-juniper	Ba Gle	Ins	No
Certhia familiaris	Brown creeper (WI)	Pine forests, especially ponderosa, yellow, and Jeffery	Ba Gle	Ins	No
Thryomanes bewickii	Bewick's wren	Open woodland, scrub land, farms, and suburbs	Grd Gle	Inv	Un
Campylorhynchus brunneicapillus	Catus wren	Deserts with large cacti or other large thorny plants	Grg Gle	Omn	No
Salpinctes obsoletus	Rock wren	Arid and semiarid canyons, valleys with rock outcrops, cliffs	Grd Gle	Ins	No
Catherpes mexicanus	Canyon wren	Arid and semiarid canyons and rock outcrops, occasionally suburban areas	Grd Gle	Ins	Un
Mimus polyglottus	Mockingbird	Habitat generalist – prefers open to semiopen areas, common in suburbs	Grd Gle	Ins	Un to Po
Toxostoma rufum	Brown thrasher (WI)	Brush and scrub lands, forest edges and clearings	Grd Gle	Omn	Un
Oreoscoptes montanus	Sage thrasher	Sagebrush areas	Grd Gle	Ins	Un
Toxostoma curvirostre	Curve-billed thrasher	Scrub areas, semi-desert with cactus and mesquite	Grd Gle	Ins	Un
Toxostoma dorsale	Crissal thrasher	Desert scrub especially stands of mesquite or saltbush, riparian brush	Foss Gle	Ins	No
Turdus migratorius	American robin	Habitat generalist; forests, woodlands, garden, parks	Grd Gle	Inv	Un to Po
Myasestes townsendi	Townsend's solitaire	Open montane coniferous forests or on steep rock slopes	Grd Gle	Ins	No
Hylocicla guttata	Hermit thrush (WI)	Conifer or mixed forests and forest edges	Grd Gle	Ins	No
Sialia mexicana	Western bluebird (WI)	Open, riparian, burned, or cutover woodlands, other open country with scattered trees	PSw / Ar Ha	Ins	No
Sialia currucoides	Mountain bluebird (WI)	Open forests, subalpine meadows, other	PSw / Grd	Ins	No

TABLE 9-2

NON-AQUATIC OR SEMI-AQUATIC BIRDS EXPECTED TO OCCUR WITHIN THE VICINITY OF CANNON AIR FORCE BASE BASED ON ZOOGEOGRAPHY CURRY COUNTY, NEW MEXICO

Scientific Name	*Common Name*	*Typical Substrate - Habitat*	*Foraging Behavior*	*Trophic Level*	*Exploits SD-11?*
		open country generally above 7000 feet	Pou		
Polioptila caerula	Blue-gray gnatcatcher	Variable: forests, woodlands, swamps, scrub, desert	Ca Gle	Ins	No
Polioptila melanura	Black-tailed gnatcatcher	Mesquite and cresote bush, other desert scrub	Ca Gle	Ins	No
Regulus satrapa	Golden-crowned kinglet (WI)	Open conifer forests	Ca Gle	Ins	No
Regulus calendula	Ruby-crowned kinglet (WI)	Conifer and mixed forests	Ca Gle	Ins	No
Bombycilla cedorum	Cedar waxwing (WI)	Woodlands, forest edges, well-planted suburbs	Ca Gle	Her	No
Phainepepla nitens	Phainopepla	Desert scrub, semiarid and riparian woodlots	Ca Gle	Her	No
Lanius ludovicianus	Loggerhead shrike	Open fields with scattered trees, open woodland, scrub	PSw / Grd Pou	Pre	Un
Sturnus vulgaris	Starling	Variable; open fields, woodlots, suburbs and cities	Grd Gle	Omn	Un to Po
Vireo vicinior	Gray vireo (SU)	Arid thorn scrub, chaparral, pinon-juniper and oak-juniper woodlands	Ca Gle	Ins	No
Vireo solitaris	Solitary vireo (WI)	Mixed woodlands	Ca Gle	Ins	No
Vireo gilvus	Warbling vireo (SU)	Open woodlands, riparian forests and thickets	Ca Gle	Ins	No
Dendroica petechia	Yellow warbler (SU)	Second-growth woodlands, gardens, scrub, riparian thickets	Ca Gle	Ins	No
Dendroica coronata	Myrtle warbler (WI)	Conifer and mixed forests	Ca Gle	Ins	No
Dendroica graciae	Grace's warbler (SU)	Montane pine forest and oak-pine forest	Ca Gle	Ins	No
vGeothlypis trichas	Yellowthroat (SU)	Overgrown fields, hedgerows, woodland margins, marshes	Ca Gle	Ins	No
Icteria virens	Yellow-breasted chat (SU)	Dense brush or scrub, especially along streams and swamp margins	Ca Gle	Ins	No
Passer domesticus	House sparrow	Cultivated lands, woodland and edges, generally around human habitation	Grd Gle	Omn	Po
Sturnella magna	Eastern meadowlark	Grassland, savanna, fields	Grd Gle	Omn	Pr

TABLE 9-2

NON-AQUATIC OR SEMI-AQUATIC BIRDS EXPECTED TO OCCUR WITHIN THE VICINITY OF CANNON AIR FORCE BASE BASED ON ZOOGEOGRAPHY CURRY COUNTY, NEW MEXICO

Scientific Name	*Common Name*	*Typical Substrate - Habitat*	*Foraging Behavior*	*Trophic Level*	*Exploits SD-11?*
Sturnella neglecta	Western meadowlark	Grassland, savanna, pasture, cultivated fields	Grd Gle	Omn	Pr
Agelaius phoeniceus	Red-winged blackbird	Marshes, riparian habitats, agricultural fields	Grd Gle	Omn	Un
Euphagus cyanocephalus	Brewer's blackbird (WI)	Shrubby, brushy areas, especially near water, riparian woodland, aspen parks, cultivated lands, marshes	Grd Gle	Omn	No
Cassidix mexicanus	Boat-tailed grackle	Coastal marshes and adjacent open habitats, pastures, cultivated fields	Grd Gle	Omn	Un
Molothrus ater	Brown-headed cowbird	Woodland, forest, forest edge, grassland	Grd / Ca Gle	Her	Un
Icterus parisorum	Scott's oriole (SU)	Dry woods and scrubs, Yucca "forests," oak slopes, and pinons	Ca Gle	Ins	No
Icterus bullockii	Bullock's oriole (SU)	River groves, open oak woods, towns, and farms	Ca Gle	Ins	No
Piranga rubra	Summer tanager (SU)	Deciduous forests, open and riparian woodland, pine-oak woodlots, parks	Ca Gle	Ins	No
Pyrrhuloxia sinuata	Pyrrhuloxia	Arid brush, thorn scrub, and thickets, especially mesquite	Grd Gle	Her	Un
Hesperiphona vespertina	Evening grosbeak (WI)	Conifer and mixed forests, second growth woodlots and parks	Grd Gle	Her	No
Guiraca caerulea	Blue grosbeak (SU)	Riparian thickets, overgrown fields, open woodland, hedgerows, orchards	Grd Gle	Omn	No
Passerina verisicolor	Varied bunting (SU)	Arid thorny brush and thickets, dry washes, arid scrub	Grd Gle	Omn	Un
Passerina ciris	Painted bunting (SU)	Areas of scattered brush and trees, riparian thickets, weedy and shrubby areas	Grd Gle	Her	No
Carpodacus mexicanus	House finch	Arid scrub, open woodland, cultivated land	Grd Gle	Her	Un
Spinus tristis	American goldfinch (WI)	Weedy and cultivated fields, deciduous open forest, riparian woodlots	Ca Gle	Her	No
Spinus psaltria	Lessor goldfinch	Open habitat with scattered trees or brush,	Ca Gle	Her	No

TABLE 9-2

NON-AQUATIC OR SEMI-AQUATIC BIRDS EXPECTED TO OCCUR WITHIN THE VICINITY OF CANNON AIR FORCE BASE BASED ON ZOOGEOGRAPHY CURRY COUNTY, NEW MEXICO

Scientific Name	*Common Name*	*Typical Substrate - Habitat*	*Foraging Behavior*	*Trophic Level*	*Exploits SD-11?*
		forest edges, fields, suburbs			
Chlorura chlorura	Green-tailed towhee(WI)	Thickets, chaparral, scrublands in mountainous areas	Grd Gle	Omn	No
Pipilo erythrophthalmus	Rufous-sided towhee	Forest edges, chaparral, riparian thickets, woodlands	Grd Gle	Omn	No
Pipilo fuscus	Brown towhee	Chaparral, riparian thickets, brushland, arid scrub, often near human habitation	Grd Gle	Her	Un
Passerculus sandwichensis	Savannah sparrow (WI)	Grassland, meadows, marsh, grassy areas	Grd Gle	Omn	Po
Ammodramus savannarum	Grasshopper sparrow (WI)	Grassland, cultivated fields, prairie, old fields, open savanna	Grd Gle	Omn	Pr
Ammodramus bairdii	Baird's sparrow (WI)	Short grass prairie	Grd Gle	Omn	Pr
Calamospiza melanocorys	Lark bunting (WI)	Grassland, prairie, meadows, sagebrush	Grd Gle	Omn	Po to Pr
Pooecetes gramineus	Vesper sparrow (WI)	Grassland, prairie, savanna, old fields, arid scrub, open woodlands	Grd Gle	Her	Po to Pr
Chondestes grammacus	Lark sparrow	Grassland, prairie, savanna, cultivated areas, fields with scattered trees / shrubs	Grd Gle	Her	Po to Pr
Amphispiza bilineata	Black-throated sparrow	Desert shrub, especially rocky uplands	Grd Gle	Omn	Un
Junco oreganus	Oregon junco (WI)	Mixed forests, forest edges, bogs	Grd Gle	Her	No
Junco caniceps	Gray-headed junco (WI)	Mixed forests, forest edges	Grd Gle	Her	No
Aimophila ruficeps	Rufous-crowned sparrow	Dry rocky slopes with scattered shrubs and patches of grass and forbs	Grd Gle	Omn	No
Aimophila cassinii	Cassin's sparrow	Grassland, shortgrass prairie with scattered bushes and mesquite	Grd Gle	Ins	Po
Spizella passering	Chipping sparrow	Open conifer forests, forest edges, oak and pine-oak woodlands, thickets, and parks	Grd Gle	Omn	No
Spizella breweri	Brewer's sparrow (WI)	Arid brushland and low thickets	Grd Gle	Omn	Un to Po
Spizella atroularis	Black-chinned sparrow (SU)	Chaparral, sagebrush, scrub, and brushy slopes	Grd Gle	Omn	No
Zonotrichia leucophrys	White-crowned sparrow (WI)	Stunted woody vegetation, coastal scrub, wet meadows, thickets, chaparral, parks	Grd Gle	Omn	No

TABLE 9-2

NON-AQUATIC OR SEMI-AQUATIC BIRDS EXPECTED TO OCCUR WITHIN THE VICINITY OF CANNON AIR FORCE BASE BASED ON ZOOGEOGRAPHY CURRY COUNTY, NEW MEXICO

Scientific Name	*Common Name*	*Typical Substrate - Habitat*	*Foraging Behavior*	*Trophic Level*	*Exploits SD-11?*
Zonotrichia albicollis	White-throated sparrow (WI)	Mixed forests, edges, thickets, and open woodlands	Grd Gle	Omn	No
Melaspiza lincolnii	Lincoln's sparrow (WI)	Bogs, wet meadows, riparian thickets	Grd Gle	Omn	No
Melospiza melodia	Song sparrow (WI)	Dense vegetation along watercourses, forest edges, clearings, bogs, gardens	Grd Gle	Omn	No
Rhychophanes mccownii	McCown's longspur (WI)	Shortgrass prairies and stubble fields	Grd Gle	Her	Pr
Calccarius ornatus	Chestnut-collared longspur (WI)	Shortgrass prairie	Grd Gle	Omn	Pr

(SU) = summer resident only; (WI) = winter resident only; all others generally year-round residents – Migrants that merely "pass through" the area are not listed

Exploitation is determined or predicted based on zoogeographic literature (e.g., Peterson 1961, Wallace and Mahan 1975, Collins 1981, Robbins *et al.* 1983, Ehrlich *et al.* 1988, Rising 1996, Baicich and Harrison 1997, Brown 1997, MacMahon 1997); and limited site-specific observations.

Primary designations relate to degree of certainty or likelihood of exploitation of the resources associated with SD-11 and/or the adjacent grassland: No = assumed absent; Un = exploitation highly unlikely; Po = exploitation is possible, although location-specific confirmation is lacking; Pr = exploitation is probable, although location-specific confirmation is lacking.

Trophic Level Codes: Her = herbivore; Det = detritivore; Omn = omnivore; Pre = predator; Ins = insectivore; Inv = invertivore. Note that "predators," "insectivores," and "invertivores" are all carnivores (consumers of other animals). Note further that the designations refer to the "typical" or predominant composition of the diet, and should not be interpreted as representing the overall diets.

Foraging Behavior Codes: S = soars; PSw = swoops from a perch H = hovers; Grd = ground; Foss = fossorial; Ar = air; Lca = lower tree canopy; Ba = bark; Ca = tree canopy; Gle = glean; Ha = hawk; Pou = pounce; Pur = pursuit; Scr = screen; FL = floral. Note that these foraging behaviors are "typical" and do not reflect the potential full range of possible foraging behaviors.

TABLE 9-3

MAMMALS EXPECTED TO OCCUR WITHIN THE VICINITY OF CANNON AIR FORCE BASE BASED ON ZOOGEOGRAPHY CURRY COUNTY, NEW MEXICO

Scientific Name	*Common Name*	*Typical Substrate - Habitat*	*Foraging Behavior*	*Trophic Level*	*Exploits SD-11?*
Didelphis marsupialis	Virginia opossum	Variable, but prefers woodlands; Cannon AFB at extreme edge of range	Grd / Lca Gle	Omn & Det	Un
Notiosorex crawfordi	Gray or desert shrew	Dry alluvial fans or chaparral slopes; sagebrush and other low desert shrubs, arid conditions especially semi-desert scrub	Grd / Foss Gle	Omn	Un to Po
Myotis lucifugus	Little brown bat	Fields, forests, wood edges or over water	Ar Scr	Ins	Un
Myotis velifer	Cave myotis	Typically caves and mine tunnels, also buildings	Ar Scr	Ins	Un to Po
Myotis evotis	Long-eared myotis	Thinly forested areas, around buildings and trees, occasionally caves	Ar Scr	Ins	Un
Myotis subulatus	Small footed myotis	Typically caves, mine tunnels, crevices in rocks, also buildings; generally in or near forested areas	Ar Scr	Ins	No
Myotis yumanensis	Yuma myotis	Caves, tunnels, or buildings, arid areas – feeds by screening close to the ground	Ar Scr	Ins	Po to Pr
Myotis volans	Long-legged myotis	Buildings, small pockets and crevices in rock ledges, colonial	Ar Scr	Ins	Un
Pipistrellus hesperus	Western pipistrelle	Generally wooded areas near water	Ar Scr	Ins	No
Lasionycteris noctivagans	Silver-haired bat	Usually feeds over water or among trees	Ar Scr	Ins	No
Eptesicus fuscus	Big brown bat	Varied, common around buildings and woods	Ar Scr	Ins	Un to Po
Lasiurus ega	Hoary bat	Wooded areas	Ar Scr	Ins	Un
Plecotus townsendi	Western big-eared bat	Caves, mine tunnels, and buildings for roosts	Ar Scr	Ins	Un to Po
Antrozous pallidus	Pallid bat	Caves, mine tunnels, and buildings for roosts – prefers desert situations	Ar Scr	Ins	Un to Po
Tadarida molossa	Big freetail bat	Caves, crevices in cliffs, and buildings for roosts	Ar Scr	Ins	Po
Tadarida brasiliensis	Mexican freetail bat	Caves and buildings for roosts – most common southwestern bat	Ar Scr	Ins	Po to Pr
Procyon lotor	Raccoon	Usually feeds in/near water	Rip Gle	Omn	No
Bassariscus astutus	Ringtail cat	Chaparral, rocky ridges, cliffs, near water	Grd Gle	Omn	Un
Mustela frenata	Long-tail weasel	Not restricted, found in all land habitats near water	Grd / Lca Amb – Pur	Pre	No
Mustela nigripes	Black-footed ferret	Prairies, closely associated with prairie dog towns	Grd / Foss Pur	Pre	Un

TABLE 9-3

MAMMALS EXPECTED TO OCCUR WITHIN THE VICINITY OF CANNON AIR FORCE BASE BASED ON ZOOGEOGRAPHY CURRY COUNTY, NEW MEXICO

Scientific Name	*Common Name*	*Typical Substrate - Habitat*	*Foraging Behavior*	*Trophic Level*	*Exploits SD-11?*
Lutra canadensis	River otter	Along streams and lake borders	Wa Amb – Pur	Pre	No
Taxidea taxus	Badger	Open grasslands and deserts	Foss Amb	Pre	Pr
Spilogale putorius	Spotted skunk	Brushy or sparsely wooded areas, prairies, streams, rocky areas	Grd Gle	Omn	Po
Mephitus mephitus	Striped skunk	Varied, woods, open areas and suburbs, within 2 miles of water	Grd Gle	Omn	Un
Mephitus macroura	Hooded skunk	Along streams, rocky ledges	Grd Gle	Omn	No
Conepatus leuconotus	Hognose skunk	Partly wooded, brushy or rocky areas	Grd Gle	Omn	Un to Po
Canis latrans	Coyote	Brush county, grassland, farmlands, prefers open areas	Grd Amb – Pou	Pre	Pr
Urocyon cineroargenteus	Gray fox	Brush, wooded lowlands, chaparral, rimrock country, and swamps	Grd Amb – Pou	Pre	Po to Pr
Vulpes velox	Swift fox	Open desert and plains	Grd Amb – Pou	Pre	Po to Pr
Felis concolor	Mountain lion	Rugged mountains, forests, and swamps – wilderness areas with deer	Grd Amb – Pou	Pre	Un
Lynx rufus	Bobcat	Rimrock and chaparral areas	Grd Pou – Pur	Pre	Un
Cynomys ludovicianus	Black-tailed prairie dog	Dry upland prairies	Foss Bro	Her	Pr
Cittellus varigatus	Rock squirrel	Rocky canyons and boulder-strewn slopes	Grd Gle	Omn	Un
Cittelus tridecemlineatus	Thirteen-lined ground squirrel	Short-grass prairies, golf course, cemeteries	Grd / Foss Gle	Omn	Po
Citellus spilosoma	Spotted ground squirrel	Scattered brush, open forests, grassy parks, dry sandy soil preferred	Grd Gle	Her	Po
Geomys bursarius	Plains pocket gopher	Grasslands, alfalfa fields, pastures, and roadsides – loam soils	Foss Bro	Her	Po to Pr
Pappogeomys castanops	Mexican pocket gopher	Deep, easily worked, sandy soils	Foss Bro	Her	Po to Pr
Perognathus merriami	Merriam pocket mouse	Open plains, sandy or gravelly soil, short or sparse vegetation	Grd Gle	Her	Po to Pr
Perognathus flavus	Silky pocket mouse	Short-grass prairies, sandy, occasionally rocky soils	Grd Bro	Her	Po to Pr
Pergnathus hispidus	Hispid pocket mouse	Short grass prairies with sparse vegetation; fence rows and roadsides in cultivated areas	Grd Gle	Omn	Po

TABLE 9-3

MAMMALS EXPECTED TO OCCUR WITHIN THE VICINITY OF CANNON AIR FORCE BASE BASED ON ZOOGEOGRAPHY CURRY COUNTY, NEW MEXICO

Scientific Name	*Common Name*	*Typical Substrate - Habitat*	*Foraging Behavior*	*Trophic Level*	*Exploits SD-11?*
Dipodomys ordi	Ord kangaroo rat	Sandy soils preferred, but is sometimes found on rather hard soils	Grd Gle	Her	Po to Pr
Castor canadensis	American beaver	Always associated with streams and lakes	Rip Bro	Her	No
Reithrodontomys montanus	Plains harvest Mouse	Chiefly uplands, well drained soils, short grass and other low vegetation	Grd Gle	Her	Po
Reithrodontomys megalotis	Western harvest Mouse	Grassland, open desert, weed patches – usually near water	Grd Gle	Her	Un
Peromyscus leucopus	White-footed mouse	Mixed woods, hardwoods, thickets, and stream-sides	Grd Gle	Her	No
Peromyscus maniculatus	Deer mouse	Highly variable – all habitat types	Grd Gle	Omn	Po to Pr
Peromyscus boyei	Brush mouse	Chaparral areas of arid and semi-arid regions, rocky situations	Grd Gle	Her	Un
Peromyscus truei	Pinon Mouse	Rocky areas with pinon and juniper trees	Grd / Lca Gle	Her	No
Peromyscus difficilus	Rock mouse	Rock outcrops, cliffs, and canyon walls	Grd Gle	Omn	No
Onychomys leucogaster	Northern grasshopper mouse	Low valleys, deserts, and prairies	Grd Gle	Omn	Po to Pr
Neotoma albigula	White throat woodrat	Brush land with shallow caves, forages on cactus and mesquite beans	Grd Bro	Her	Un
Neotoma micropus	Southern plains woodrat	Semi-arid brush land; low valleys and plains	Grd Bro	Her	Un
Sigmodon hispidus	Hispid cotton rat	Tall grasses, sedges, and weeds – primarily moist areas	Grd Bro	Omn	No
Erethizon dorsatum	Porcupine	Chiefly forested areas	Grd / Lca / Uca Bro	Her	No
Lepus californicus	Blacktail jackrabbit	Open prairies and sparsely vegetated deserts	Grd Bro	Her	Po to Pr
Sylvilagus floridanus	Eastern cottontail rabbit	From swampy wood to upland thickets and farmland	Grd Bro	Her	Po
Sylvilagus auduboni	Desert cottontail rabbit	Open plains, foothills, low valleys; grassy areas to pinon/juniper stands	Grd Bro	Her	Po to Pr
Odocoileus virginianus	White-tailed deer	Low mixed woodlands, forest edges, and second growth	Grd / Lca Bro	Her	Un to Po
Odocoileus hemionus	Mule deer	Occupies several types of habitat – forest, chaparral, grassland with shrubs	Grd Bro	Her	Po to Pr

TABLE 9-3

MAMMALS EXPECTED TO OCCUR WITHIN THE VICINITY OF CANNON AIR FORCE BASE BASED ON ZOOGEOGRAPHY CURRY COUNTY, NEW MEXICO

Scientific Name	*Common Name*	*Typical Substrate - Habitat*	*Foraging Behavior*	*Trophic Level*	*Exploits SD-11?*
Antilocapra americana	Pronghorn	Open prairies and sagebrush plains	Grd Bro	Her	Un to Po
Ammotragus lervia	Barbary sheep	Rough or rocky arid areas	Grd Bro	Her	No

Exploitation is determined or predicted based on zoogeographic and behavioral literature (e.g., Nowak 1991; Burt 1980; MacMahon 1997; Brown 1997; Collins 1991); and limited site-specific observations.

Primary designations relate to degree of certainty or likelihood of exploitation of the resources associated with SD-11 and/or the adjacent grassland: No = assumed absent; Un = exploitation highly unlikely; Po = exploitation is possible, although location-specific confirmation is lacking; Pr = exploitation is probable, although location-specific confirmation is lacking.

Trophic Level Codes: Her = herbivore; Det = detritivore; Omn = omnivore; Pre = predator; Ins = insectivore; Inv = invertivore. Note that "predators," "insectivores," and "invertivores" are all carnivores (consumers of other animals). Note further that the designations refer to the "typical" or predominant composition of the diet, and should not be interpreted as representing the overall diets.

Foraging Behavior Codes: Ar = air; Grd = ground; Foss = fossorial; Rip = riparian; Lca = lower canopy; Uca = upper canopy; Amb = ambush; Gle = glean; Bro = browse; Scr = screen; Pou = pounce; Pur = pursuit. Not that these foraging behaviors are "typical" and do not reflect the potential full range of possible foraging behaviors.

TABLE 9-4

SELECTION OF ORGANIC CHEMICALS OF POTENTIAL ECOLOGICAL CONCERN IN SURFACE SOIL SITE SD-11, CANNON AIRFORCE BASE, NEW MEXICO

Soil Data - All Concentrations are in mg/Kg	Maximum Detection	Detection Frequency	Maximum R.L	Minimum R.L.	Median R.L.	Plant BCF	Earthworm BCF	Mammal BAF	Screening Benchmark (Tetrapod Vertebrates)	Tetrapod Vertebrate COPEC? (YES/NO)
Alkanes										
bis (2-Chloroethoxy) methane	ND	0/12	0.38	0.35	0.37	NA	0.046	0.008	8.13	NO - A,C
Bromochloromethane	ND	0/12	0.034	0.0053	0.0057	NA	0.092	0.015	279.5	NO - A,C
Bromodichloromethane	ND	0/12	0.034	0.0053	0.0057	2.4	0.542	0.031	10.0	NO - A,C
Bromoform @	ND	0/12	0.034	0.0053	0.0057	1.7	0.550	0.039	313	NO - A,C
Bromomethane (Methyl Bromide)	ND	0/12	0.034	0.011	0.011	7.9	0.500	0.012	17.5	NO - A,C
Carbon Tetrachloride	ND	0/12	0.034	0.0053	0.0057	1	0.563	0.059	8.88	NO - A,C
Chloroform (Trichloromethane)	ND	0/12	0.034	0.0053	0.0057	3	0.539	0.025	41.5	NO - A,C
Chloromethane (Methyl Chloride) **	ND	0/12	0.034	0.011	0.011	12	0.519	0.009	525	NO - A,C
Dibromochloromethane	ND	0/12	0.034	0.0053	0.0057	NA	0.131	0.030	268	NO - A,C
Dichlorodifluoromethane	ND	0/3	0.034	0.011	0.011	2.2	0.538	0.032	188	NO - A,C
Methylene chloride (Dichloromethane)	ND	0/12	0.046	0.0053	0.0057	7.3	0.529	0.013	73.2	NO - A,C
Trichlorofloromethane	ND	0/3	0.034	0.011	0.011	1.3	0.294	0.043	437	NO - A,C
Halogenated Ethanes										
1,1,2,2-Tetrachloroethane	ND	0/12	0.034	0.0053	0.0057	1.6	0.568	0.042	6.37	NO - A,C
1, 1, 1-Trichloroethane	ND	0/12	0.034	0.0053	0.0057	1.4	0.556	0.045	5,591	NO - A,C
1,1,2-Trichloroethane	ND	0/12	0.034	0.0053	0.0057	2.5	0.550	0.029	21.8	NO - A,C
1, 1-Dichloroethane	ND	0/12	0.034	0.0053	0.0057	3.6	1.121	0.031	478	NO - A,C
1,2-Dichloroethane	ND	0/12	0.034	0.0053	0.0057	5.5	0.536	0.016	250	NO - A,C
Chloroethane	ND	0/12	0.034	0.0053	0.0057	NA	0.094	0.015	17,435	NO - A,C
Hexachloroethane	ND	0/12	0.38	0.35	0.37	0.19	2.944	0.409	12.5	NO - A,C
Halogenated Propanes										
1,2-Dichloropropane	ND	0/12	0.034	0.0053	0.0057	2.8	0.541	0.027	3,128	NO - A,C
Halogenated Alkenes										
1,1-Dichloroethene	ND	0/12	0.034	0.0053	0.0057	2.3	0.542	0.031	11.3	NO - A,C
cis-1,2-Dichloroethylene	ND	0/12	0.034	0.0053	0.0057	3.3	0.537	0.024	400	NO - A,C
cis-1,3-Dichloropropene	ND	0/12	0.034	0.0053	0.0057	2.7	0.538	0.028	375	NO - A,C
Tetrachloroethene	ND	0/12	0.034	0.0053	0.0057	1.1	0.560	0.055	175	NO - A,C
trans-1,2-Dichloroethylene	ND	0/12	0.034	0.0053	0.0057	3.3	0.545	0.030	400	NO - A,C
trans-1,3-Dichloropropene	ND	0/12	0.034	0.0053	0.0057	3.3	0.538	0.028	375	NO - A,C
Trichloroethylene	ND	0/12	0.034	0.0053	0.0057	1.1	0.554	0.057	3.91	NO - A,C
Vinyl chloride	ND	0/12	0.034	0.0053	0.0057	5.3	0.533	0.017	2.13	NO - A,C

@ = detected in ground water; * = detected in 1991
** = detected in subsurface 1995; *** = detected in subsurface 1998

TABLE 9-4

SELECTION OF ORGANIC CHEMICALS OF POTENTIAL ECOLOGICAL CONCERN IN SURFACE SOIL SITE SD-11, CANNON AIRFORCE BASE, NEW MEXICO

Soil Data - All Concentrations are in mg/Kg	Maximum Detection	Detection Frequency	Maximum R.L	Minimum R.L.	Median R.L.	Plant BCF	Earthworm BCF	Mammal BAF	Screening Benchmark (Tetrapod Vertebrates)	Tetrapod Vertebrate COPEC? (YES/NO)
Amines										
2-Nitroaniline	ND	0/12	1.8	0.38	1.8	NA	0.448	0.024	95.5	NO - A,C
3,3'-Dichlorobenzidine	ND	0/12	0.76	0.7	0.75	0.36	0.086	0.056	25.7	NO - A,C
3-Nitroaniline	ND	0/12	1.8	0.38	1.8	NA	0.135	0.014	17.2	NO - A,C
4-Chloroaniline	ND	0/12	0.38	0.35	0.37	3.3	0.538	0.024	15.6	NO - A,C
4-Nitroaniline	ND	0/12	1.8	0.38	1.8	NA	0.229	0.015	10.1	NO - A,C
Aniline (Phenylamine, Aminobenzene)	ND	0/3	0.38	0.38	0.38	11	0.061	0.009	NA	*Uncertain - E*
Benzidine	ND	0/3	1.9	1.9	1.9	11	0.535	0.019	1.01	*Uncertain - D*
n-Nitrosodi-n-propylamine (DNP)	ND	0/12	0.38	0.35	0.37	6	0.087	0.014	6.38	NO - A,C
N-Nitrosodiphenylamine	ND	0/12	0.38	0.35	0.37	0.38	0.538	0.090	62.6	NO - A,C
Benzene and Derivatives										
Benzene	ND	0/12	0.034	0.0053	0.0057	2.3	0.542	0.031	148	NO - A,C
Substituted Benzenes										
1,2-Dichlorobenzene	ND	0/12	0.38	0.35	0.37	0.4	0.563	0.121	1,072	NO - A,C
1,2,4-Trichlorobenzene	ND	0/12	0.38	0.35	0.37	0.19	1.315	0.222	185	NO - A,C
1,3-Dichlorobenzene	ND	0/12	0.38	0.35	0.37	NA	0.975	0.140	313	NO - A,C
1,4-Dichlorobenzene	ND	0/12	0.38	0.35	0.37	0.41	0.565	0.119	375	NO - A,C
Chlorobenzene	ND	0/12	0.034	0.0053	0.0057	0.86	0.554	0.067	611	NO - A,C
Hexachlorobenzene	ND	0/12	0.38	0.35	0.37	0.015	0.629	1.539	1.00	*Uncertain - D*
Methylated Benzenes										
Xylenes (dimethylbenzenes) **	**0.0011**	1/12	0.034	0.0053	0.0057	0.57	0.577	0.093	188	NO - A,C
Toluene **, *	**0.003**	1/12	0.034	0.0053	0.0057	1	0.549	0.060	145	NO - A,C
Other Substituted Benzenes										
Ethylbenzene **	ND	0/12	0.034	0.0053	0.0057	0.59	0.583	0.090	1,215	NO - A,C
Nitrobenzene	ND	0/12	0.034	0.0053	0.0057	3.3	0.539	0.023	37.5	NO - A,C
Styrene (vinylbenzene)	ND	0/12	0.034	0.0053	0.0057	0.77	0.558	0.073	6,437	NO - A,C
Arenes										
2,4-Dinitrotoluene	ND	0/12	0.38	0.35	0.37	2.7	0.526	0.028	6.44	NO - A,C
2,6-Dinitrotoluene	ND	0/12	0.38	0.35	0.37	3.2	0.536	0.024	61.5	NO - A,C
Chlorinated Dienes										
Hexachlorobutadiene	ND	0/12	0.38	0.35	0.37	0.064	0.602	0.505	25.0	NO - A,C
Hexachlorocyclopentadiene	ND	0/12	0.38	0.35	0.37	0.03	0.625	0.924	125	NO - A,C

@ = detected in ground water; * = detected in 1991
** = detected in subsurface 1995; *** = detected in subsurface 1998

TABLE 9-4

SELECTION OF ORGANIC CHEMICALS OF POTENTIAL ECOLOGICAL CONCERN IN SURFACE SOIL SITE SD-11, CANNON AIRFORCE BASE, NEW MEXICO

Soil Data - All Concentrations are in mg/Kg	Maximum Detection	Detection Frequency	Maximum R.L	Minimum R.L.	Median R.L.	Plant BCF	Earthworm BCF	Mammal BAF	Screening Benchmark (Tetrapod Vertebrates)	Tetrapod Vertebrate COPEC? (YES/NO)
Ethers										
4-Bromophenyl phenyl ether	ND	0/12	0.38	0.35	0.37	NA	5.147	0.787	NA	NO - E
4-Chlorophenylphenyl ether	ND	0/12	0.38	0.35	0.37	NA	1.522	0.237	NA	NO - E
bis (2-Chloroethyl) ether	ND	0/12	0.38	0.35	0.37	7.7	0.533	0.012	313	NO - A,C
bis (2-Chloroisopropyl) ether	ND	0/12	0.38	0.35	0.37	1.2	0.559	0.050	200	NO - A.C
Phenols and Substituted Phenols										
Phenol ***	ND	0/12	0.38	0.35	0.37	5.4	0.517	0.016	751	NO - A,C
2,4,5-Trichlorophenol	ND	0/12	1.8	0.38	1.8	0.22	0.581	0.196	1,251	NO - A.C
2,4,6-Trichlorophenol	ND	0/12	0.38	0.35	0.37	0.28	0.581	0.160	52.5	NO - A.C
2,4-Dichlorophenol	ND	0/12	0.38	0.35	0.37	0.64	0.545	0.084	25.0	NO - A.C
2,4-Dimethylphenol	ND	0/12	0.38	0.35	0.37	1.7	0.548	0.040	280	NO - A.C
2,4-Dinitrophenol	ND	0/12	1.8	0.75	1.8	4.9	0.530	0.017	125	NO - A,C
2-Chlorophenol	ND	0/12	0.38	0.35	0.37	2.2	0.538	0.032	62.6	NO - A,C
2-Methylphenol (o-cresol)	ND	0/12	0.38	0.35	0.37	2.7	0.544	0.027	626	NO - A,C
2-Nitrophenol	ND	0/12	0.38	0.35	0.37	NA	0.138	0.022	41.8	NO - A.C
2-Methyl-4,6-dinitrophenol	ND	0/12	1.8	0.75	1.8	NA	0.311	0.049	31.3	NO - A.C
4-Chloro-3-methylphenol	ND	0/12	0.38	0.35	0.37	NA	12.589	0.086	39.7	NO - A.C
4-Methylphenol (p-cresol)	ND	0/12	0.38	0.35	0.37	2.85	0.541	0.027	626	NO - A.C
4-Nitrophenol	ND	0/12	1.8	0.75	1.8	NA	1.935	0.025	313	NO - A.C
Pentachlorophenol	ND	0/12	1.8	0.75	1.8	0.044	0.600	0.664	37.5	NO - A.C
Ketones										
2-Hexanone	ND	0/12	0.057	0.011	0.011	NA	0.097	0.015	145	NO - A.C
Acetone **, *	ND	0/12	0.057	0.011	0.011	53	0.500	0.003	1,251	NO - A,C
Isophorone **	ND	0/12	0.38	0.35	0.37	4	0.532	0.020	4,828	NO - A.C
Methyl Ethyl Ketone (2-Butanone) **	ND	0/12	0.057	0.011	0.011	27	0.500	0.005	22,157	NO - A.C
4-Methyl-2-pentanone (MIBK)	ND	0/12	0.057	0.011	0.011	NA	0.085	0.013	NA	NO - E
Polynuclear Aromatic Hydrocarbons (PAHs)										
Low Molecular Weight PAHs										
2-Chlornaphthalene	ND	0/12	0.38	0.35	0.37	NA	1.581	0.225	1,398	NO - A.C
2-Methylnaphthalene **	ND	0/12	0.38	0.35	0.37	NA	0.426	0.189	NA	NO - E
Acenaphthene	ND	0/12	0.38	0.35	0.37	0.21	0.585	0.200	978	NO - A.C
Acenaphthylene	ND	0/12	0.38	0.35	0.37	NA	1.808	0.234	NA	NO - E
Anthracene	ND	0/12	0.38	0.35	0.37	NA	0.542	0.347	5,591	NO - A.C

@ = detected in ground water; * = detected in 1991
** = detected in subsurface 1995; *** = detected in subsurface 1998

TABLE 9-4

SELECTION OF ORGANIC CHEMICALS OF POTENTIAL ECOLOGICAL CONCERN IN SURFACE SOIL SITE SD-11, CANNON AIRFORCE BASE, NEW MEXICO

Soil Data - All Concentrations are in mg/Kg	Maximum Detection	Detection Frequency	Maximum R.L	Minimum R.L.	Median R.L.	Plant BCF	Earthworm BCF	Mammal BAF	Screening Benchmark (Tetrapod Vertebrates)	Tetrapod Vertebrate COPEC? (YES/NO)
Carbazole	ND	0/12	0.38	0.35	0.37	NA	0.931	0.133	NA	NO - E
Dibenzofuran **	ND	0/12	0.38	0.35	0.37	NA	1.038	0.247	55.9	NO - A,C
Fluorene	ND	0/12	0.38	0.35	0.37	0.14	0.571	0.269	699	NO - A,C
Naphthalene **	ND	0/12	0.38	0.35	0.37	0.44	0.575	0.113	800	NO - A,C
Phenanthrene **	0.057	2/12	0.38	0.35	0.37	NA	0.135	0.316	39.1	NO - A,C
High Molecular Weight PAHs										
Benzo (a) anthracene **	0.200	3/12	0.38	0.35	0.37	0.02	0.625	1.260	NA	YES - D,E
Benzo (a) pyrene **	0.270	3/12	0.38	0.35	0.37	0.011	0.650	1.935	5.59	YES - D
Benzo (b) fluoranthene **	0.440	3/12	0.38	0.35	0.37	0.02	0.667	2.124	NA	YES - D,E
Benzo (g,h,i) perylene **	0.110	3/12	0.38	0.35	0.37	NA	4.752	3.132	NA	YES - D,E
Benzo (k) fluoranthene	ND	0/12	0.38	0.35	0.37	NA	3.459	4.097	NA	*Uncertain - D*
Chrysene **	0.260	3/12	0.38	0.35	0.37	0.02	0.625	1.260	NA	YES - D,E
Dibenz (a,h) anthracene	ND	0/12	0.38	0.35	0.37	0.0053	0.645	3.509	NA	*Uncertain - D*
Fluoranthene **	0.210	4/12	0.38	0.35	0.37	0.043	0.591	0.689	699	NO - A,C
Indeno (1,2,3-cd) pyrene **	0.089	2/12	0.38	0.35	0.37	0.0056	0.668	3.391	NA	YES - D,E
Pyrene **	0.260	3/12	0.38	0.35	0.37	0.043	0.591	0.689	419	NO - A,C
Phthalates										
Butylbenzylphthalate	ND	0/12	0.38	0.35	0.37	0.062	0.526	0.487	1,989	NO - A,C
bis (2-Ethylhexyl) phthalate **	ND	0/12	0.38	0.35	0.37	0.0023	0.667	6.596	102	*Uncertain -D*
Di-n-butylphthalate ***	ND	0/12	0.38	0.35	0.37	0.084	0.603	0.410	1,564	NO - A,C
Di-n-octylphthalate **	ND	0/12	0.38	0.35	0.37	0.00085	0.632	14.171	3,003	*Uncertain - D*
Diethylphthalate	ND	0/12	0.38	0.35	0.37	1.4	0.552	0.047	9,383	NO - A,C
Dimethylphthalate	ND	0/9	0.38	0.35	0.37	4.8	0.529	0.018	NA	NO - A,C
Total Petroleum Hyrdocarbons ***, **	0.553	9/12	0.046	0.0446	0.0453	0.44	0.575	0.113	39.1	NO - A,C
Hydrocarbons as DRO	0.068	1/3	0.028	0.028	0.028	0.44	0.575	0.113	39.1	NO - A,C
Miscellaneous Solvents										
Carbon Disulfide	ND	0/12	0.034	0.0053	0.0057	0.44	0.536	0.028	436	NO - A,C
Benzyl alcohol	ND	0/12	0.38	0.35	0.37	8.8	0.542	0.011	419	NO - A,C

ND = Not detected; NA = Not avialable; R.L. = Reporting limit
BCF = Biota Concentration Factor (uptake factor from soils)
BCF for plants obtained from RTI 1995 and includes aerial uptake
BCF for earthworms based on fugacity model (see text)
BAF = Biota Accumulation Factor (uptake from diet)
taken from Travis and Arms (1988)

A = Maximum detected concentration and/or maximum R.L. less than screening benchmark concentration
B = Maximum detected concentration and/or maximum R.L. greater than screening benchmark concentration
C = Chemical not expected to bioconcentrate or biomagnify within foodweb
D = Chemical may bioconcentration or biomagnify to a concentration greater than the screening benchmark
E = Based on Similar Chemical Screening Value (Chemical Class or Group)

@ = detected in ground water; * = detected in 1991
** = detected in subsurface 1995; *** = detected in subsurface 1998

TABLE 9-5

SELECTION OF INORGANIC CHEMICALS OF POTENTIAL ECOLOGICAL CONCERN IN SURFACE SOIL SITE SD-11, CANNON AIRFORCE BASE, CURRY COUNTY, NEW MEXICO

Soil Data - All Concentrations are in mg/Kg	Maximum Detection	Detection Frequency	Maximum R.L	Minimum R.L.	Median R.L.	Background UTL	Plant BCF	Soil Invert. BCF	Samll Mammal BCF	Screening Benchmark (Tetrapod Vertebrates)	Tetrapod Vertebrate COPEC? (YES/NO)
Aluminum	12500	9/9	AD	AD	AD	8950	0.004c	0.118	0.073	486	YES - B,F
Antimony	ND	9/9	6.9	6.4	6.7	3.150	0.2	NA	NA	4	*Uncertain - B,F*
Arsenic	3	9/9	AD	AD	AD	3.60	0.036	0.523	0.0149	23	NO - A,C,E
Barium	253	9/9	AD	AD	AD	670.0	0.15	NA	0.1121	419	NO - A,C,E
Beryllium	0.62	9/9	AD	AD	AD	0.780	0.01	NA	NA	8	NO - A,C,E
Cadmium	ND	0/9	0.57	0.53	0.56	0.430	0.36	40.69	3.9905	13	*Uncertain - D,F*
Calcium	75100	9/9	AD	AD	AD	44800	NA	NA	NA	NA	NO - G
Chromium, Total[a]	13.6	8/8	AD	AD	AD	10.5	0.0075	3.162	0.333	10	YES - B,F
Cobalt	4.9	9/9	AD	AD	AD	6.600	NA	NA	0.100	5	NO - A,C,E
Copper	9.2	9/9	AD	AD	AD	18.300	0.4	1.531	1.045	85	NO - A,C,E
Iron	11800	9/9	AD	AD	AD	10100	NA	NA	0.017	NA	NO - G
Lead	10.1	9/9	AD	AD	AD	12.0	0.000013	1.522	0.286	10	NO - E
Magnesium	2900	9/9	AD	AD	AD	1930	NA	NA	NA	NA	NO - G
Manganese	214	9/9	AD	AD	AD	307.0	NA	0.124	NA	1,101	NO - AC,E
Mercury	ND	0/9	0.11	0.11	0.11	0.056	0.002	20.625	0.192	4	*Uncertain - D,F*
Nickel	10.5	9/9	AD	AD	AD	11.000	0.11	4.73	0.589	500	NO - E
Potassium	2030	9/9	AD	AD	AD	2691.000	NA	NA	NA	NA	NO - E
Selenium	ND	0/9	2.3	1.1	1.1	0.260	0.016	1.340	1.187	3	*Uncertain - D,F*
Silver	ND	0/9	1.1	1.1	1.1	0.400	0.4	NA	NA	8	NO - E
Sodium	ND	0/9	575	532	562	102.000	NA	NA	NA	NA	NO - G
Thallium	0.18	4/9	1.1	0.53	0.57	0.600	0.004	NA	0.123[b]	1	NO -E
Vanadium	24.2	9/9	AD	AD	AD	23.3	5.3	0.088	0.019	7	YES - B,F
Zinc	38.3	9/9	AD	AD	AD	32.2	0.25	3.201	2.688	228	NO - A, C

ND = Not detected; NA = not available; RL = reporting limit

AD = 100% detections - no reporting limits provided

BCF = Biota Concentration Factor (uptake factor from soil)

UTL = Upper tolerance limit for background concentrations

Plant BCF obtained from RTI 1995

Soil invertebrate BCF obtained from Sample *et al.* 1998a

Small mammal BCF obtained from Sample *et al.* 1998b

a = Data from CANO86-8614-0000 rejected

b = Obtained from RTI 1995

c = Obtained from ATSDR for aluminum (ATSDR 1992)

A = Maximum detected concentration and/or maximum R.L. less than screening benchmark concentration

B = Maximum detected concentration and/or maximum R.L. greater than screening benchmark concentration

C = Chemical not expected to significantly bioconcentrate within foodweb

D = Chemical may bioconcentrate to a concentration greater than the screening benchmark

E = Maximum detected concentration and/or maximum R.L. less than background (UTL)

F = Maximum detected concentration and/or maximum R.L. greater than background (UTL)

G = Chemical is an essential nutrient not at a level of concern (see text)

TABLE 9-6

INGESTION PATHWAY SCREENING CONCENTRATIONS - NO-OBSERVED ADVERSE EFFECTS LEVELS
SITE SD-11, CANNON AIRFORCE BASE, CURRY COUNTY, NEW MEXICO

Constituent	Effect	Species	Dose (mg/kg-BW/day)	Body Weight (kg)	Water Ingestion (L/day)	Food Ingestion (kg/day)	Water Concentration (mg/L)	Screening Concentration (mg/kg)	Reference
Halogenated Methanes									
bis (2-Chloroethoxy) methane	*LD_{50} / 100*	Rat	0.65	0.35	0.046	0.028	5	8	J. Indust. Hy. Toxicol. 30:63, 1948 as cited in RTECS
Bromochloromethane	*No Observable Adverse Effects Subchronic NOAEL/10*	Mouse	50	0.0325	0.008	0.006	204	280	Clayton & Clayton 1982 as cited in HSDB
Bromodichloromethane	*Renal Histopathology LOAEL/10*	Mouse	1.79	0.0325	0.008	0.006	7	10	IRIS
Bromoform	*Hepatic Lesions*	Rat	25	0.35	0.046	0.028	190	313	IRIS
Bromomethane (Methyl Bromide)	*Gastric Lesions and Body Weight*	Rat	1.4	0.35	0.046	0.028	11	18	IRIS
Carbon Tetrachloride	*Liver Histopathology*	Rat	0.71	0.35	0.046	0.028	5	9	IRIS
Chloroform (Trichloromethane)	*Liver Damage LOAEL/10*	Dog	1.29	14	0.550	0.435	33	42	IRIS
Chloromethane (Methyl Chloride)	*Liver Histopathology - Single Dose NOAEL / 10*	Rat	42	0.35	0.046	0.028	319	525	Reynolds & Yee 1967 as cited in ATSDR 1990
Dibromochloromethane	*Hepatic Lesions*	Rat	21.4	0.35	0.046	0.028	162	268	IRIS
Dichlorodifluoromethane	*Body Weight (Growth)*	Rat	15	0.35	0.046	0.028	114	188	IRIS
Methylene chloride (Dichloromethane)	*Liver Toxicity*	Rat	5.85	0.35	0.046	0.028	44	73	IRIS
Trichlorofloromethane	*Survival - Histopathology LOAEL/10*	Rat	34.9	0.35	0.046	0.028	265	437	NCI 1978 as cited in IRIS
Halogenated Ethanes									
1,1,2,2-Tetrachloroethane	*Hepatotoxicity Subchronic-NOAEL/10*	Mouse	1.14	0.0325	0.008	0.006	5	6	Buben & O'Flaherty 1985 as cited in Sample et. al. 1996
1, 1, 1-Trichloroethane	*No Observable Adverse Effects*	Mouse	1000	0.0325	0.008	0.006	4,071	5,591	Lane *et. al*. 192 as cited in Sample *et. al.* 1996
1,1,1,2-Tetrachloroethane	*Kidney / Liver Effects LOAEL/10*	Rat	8.93	0.35	0.046	0.028	68	112	IRIS
1, 1-Dichloroethane	*Survival LOAEL/10*	Rat	38.2	0.35	0.046	0.028	290	478	NCI 1977 as cited in ATSDR 1990
1,2-Dibromoethane	*Reproductive Effects*	Rat	30	0.35	0.046	0.028	228	375	Teramato *et. al*. 1980 as cited in ATSDR 1992
1,2-Dichloroethane	*Egg Production*	Chicken	17.2	1.6	0.185	0.11	148	250	Alumot *et. al.* 1976 as cited in Sample *et. al.* 1996

LD_{50} = lethal dose to 50%; LOAEL = lowest observed adverse effect level;
NOAEL = no observed adverse effect level; NA = not available

TABLE 9-6

INGESTION PATHWAY SCREENING CONCENTRATIONS - NO-OBSERVED ADVERSE EFFECTS LEVELS
SITE SD-11, CANNON AIRFORCE BASE, CURRY COUNTY, NEW MEXICO

Constituent	Effect	Species	Dose (mg/kg-BW/day)	Body Weight (kg)	Water Ingestion (L/day)	Food Ingestion (kg/day)	Water Concentration (mg/L)	Screening Concentration (mg/kg)	Reference
Chloroethane	*Histopathology and Survival*	Rabbit	1000	1.2	0.114	0.069	10,490	17,435	Adams et al. 1939 as cited in ATSDR 1989
Hexachloroethane	*Liver Effects*	Rat	1	0.35	0.046	0.028	8	13	Gorzinski *et. al.* 1985 as cited in IRIS
Halogenated Propanes									
1,2-Dichloropropane	*Liver & Spleen Weights*	Rat	250	0.35	0.046	0.028	1,898	3,128	Fund. Appl. Toxicol. 12:713, 1989 as cited in RTECS
Halogenated Alkenes									
1,1-Dichloroethene	*Hepatic Lesions LOAEL/10*	Rat	0.9	0.35	0.046	0.028	7	11	Quast *et. al.* 1983 as cited in IRIS
cis-1,2-Dichloroethylene	*Body Weights (Growth)*	Rat	32	0.35	0.046	0.028	243	400	McCauley *et. al.* 1990 as cited in ATSDR 1994
cis-1,3-Dichloropropene	*Survival*	Rat	30	0.35	0.046	0.028	228	375	Til *et. al.* 1973 as cited in ATSDR 1992
Tetrachloroethene	*Weight Gain (Growth) and Liver Effects*	Rat	14	0.35	0.046	0.028	106	175	Buben & O'Flaherty 1985 as cited in IRIS
trans-1,2-Dichloroethylene	*Body Weights (Growth)*	Rat	32	0.35	0.046	0.028	243	400	McCauley *et. al.* 1990 as cited in ATSDR 1994
trans-1,3-Dichloropropene	*Survival*	Rat	30	0.35	0.046	0.028	228	375	Til *et. al.* 1973 as cited in ATSDR 1992
Trichloroethylene	*Hepatotoxicity Subchronic - NOAEL/10*	Mouse	0.7	0.0325	0.008	0.006	3	4	Buben & O'Flaherty 1985 as cited in Sample *et. al.* 1996
Vinyl chloride	*Life-time Survival*	Rat	0.17	0.35	0.046	0.028	1	2	Feron *et. al.* 1981 as cited in Sample *et. al.* 1996
Amines									
2-Nitroaniline	*LD_{50} / 100*	Quail	7.5	0.191	0.0195	0.015	74	96	Arch. Environ. Contam. Toxicol. 12:355, 1983 as cited in RTECS
3,3'-Dichlorobenzidine	*Convulsions / Neurological Degeneration LOAEL/10*	Dog	0.8	14	0.550	0.435	20	26	Stula *et. al.* 1978 as cited in ATSDR 1989
3,3'-Dimethylbenzidine	*NA*	NA	NA	NA	NA	NA	NA	NA	NA
3-Nitroaniline	*LD_{50} / 100*	Mouse	3.08	0.0325	0.008	0.006	13	17	Aerospace Med. Res. Lab. Rpt. TR-72-62, 1972 as cited in RTECS
4-Chloroaniline	*Histopathology LOAEL/10*	Rat	1.25	0.35	0.046	0.028	9	16	NCI 1979 as cited in IRIS

LD_{50} = lethal dose to 50%; LOAEL = lowest observed adverse effect level;
NOAEL = no observed adverse effect level; NA = not available

TABLE 9-6

INGESTION PATHWAY SCREENING CONCENTRATIONS - NO-OBSERVED ADVERSE EFFECTS LEVELS
SITE SD-11, CANNON AIRFORCE BASE, CURRY COUNTY, NEW MEXICO

Constituent	Effect	Species	Dose (mg/kg-BW/day)	Body Weight (kg)	Water Ingestion (L/day)	Food Ingestion (kg/day)	Water Concentration (mg/L)	Screening Concentration (mg/kg)	Reference
4-Nitroaniline	*LD_{50} / 100*	Guinea Pig	4.5	0.0875	0.091	0.039	4	10	Problems Communal Hygiene 6:89, 1966 as cited in RTECS
Aniline (Phenylamine, Aminobenzene)	*NA*	NA	NA	NA	NA	NA	NA	NA	NA
Benzidine	*Nuerological LOAEL /10*	Mouse	0.18	0.0325	0.008	0.006	0.73	1.01	Morgan *et al.* 1981 as cited in ATSDR 1995
n-Nitrosodi-n-propylamine (DNP)	*Longevity LOAEL/10*	Rat	0.51	0.35	0.046	0.028	4	6	Lijinsky & Taylor 1978;1979 as cited in ATSDR 1989
N-Nitrosodiphenylamine	*Body Weights (Growth)LOAEL/10*	Rat	5	0.35	0.046	0.028	38	63	Cardy *et. al.* 1979; NCI 1979 as cited in ATSDR 1993
Benzene and Derivatives									
Benzene	*Reproductive Effects LOAEL/10*	Mouse	26.4	0.0325	0.008	0.006	107	148	Nawrot & Staples 1979 as cited in Sample *et. al.* 1996
Chlorinated Benzenes									
1,2-Dichlorobenzene	*No Observable Adverse Effects*	Rat	85.7	0.35	0.046	0.028	651	1,072	NTP 1985 as cited in IRIS
1,2,4-Trichlorobenzene	*Adrenal Weights*	Rat	14.8	0.35	0.046	0.028	112	185	Robinson *et. al.* 1984 as cited in IRIS
1,3-Dichlorobenzene	*Serum Chemistry LOAEL/10*	Rat	25	0.35	0.046	0.028	190	313	Ariyoshi *et. al.* 1975 as cited in HSDB
1,4-Dichlorobenzene	*Survival LOAEL/10*	Rat	30	0.35	0.046	0.028	228	375	NTP 1987 as cited in ATSDR 1993
Chlorobenzene	*Liver Histopathology*	Dog	19	14	0.550	0.435	484	611	Knapp *et. al.* 1971 as cited in IRIS
Hexachlorobenzene	*Liver Effects*	Rat	0.08	0.35	0.046	0.028	1	1	Arnold *et. al.* 1985 as cited in IRIS
Methylated Benzenes									
Xylenes (dimethylbenzenes)	*Nephropathy LOAEL/10*	Rat	15	0.35	0.046	0.028	114	188	Marks *et. al.* 1982 as cited in Sample *et. al.* 1996
Toluene	*Fetal Body Weights LOAEL/10*	Mouse	26	0.0325	0.008	0.006	106	145	Nawrot & Staples 1982 as cited in Sample *et. al.* 1996
Other Substituted Benzenes									

LD_{50} = lethal dose to 50%; LOAEL = lowest observed adverse effect level;
NOAEL = no observed adverse effect level; NA = not available

TABLE 9-6

INGESTION PATHWAY SCREENING CONCENTRATIONS - NO-OBSERVED ADVERSE EFFECTS LEVELS
SITE SD-11, CANNON AIRFORCE BASE, CURRY COUNTY, NEW MEXICO

Constituent	Effect	Species	Dose (mg/kg-BW/day)	Body Weight (kg)	Water Ingestion (L/day)	Food Ingestion (kg/day)	Water Concentration (mg/L)	Screening Concentration (mg/kg)	Reference
Ethylbenzene	*Liver & Kidney Toxicity*	Rat	97.1	0.35	0.046	0.028	737	1,215	Wolf *et. al.* 1956 as cited in IRIS
Nitrobenzene	*Testicular Necrosis Acute LOAEL/10*	Rat	3	0.35	0.046	0.028	23	38	Levin *et. al.* 1988 as cited in ATSDR 1990
Styrene (vinylbenzene)	*Liver Effects & Blood Chemistry*	Dog	200	14	0.550	0.435	5,091	6,437	Quast 1979 as cited in IRIS
Arenes									
2,4-Dinitrotoluene	*Nuerological - Histopathology Effects*	Dog	0.2	14	0.550	0.435	5	6	Ellis *et. al.* 1985 as cited in IRIS
2,6-Dinitrotoluene	*Survival & Reproduction*	Mouse	11	0.0325	0.008	0.006	45	62	Lee *et. al.* 1976 as cited in ATSDR 1989
Chlorinated Dienes									
Hexachlorobutadiene	*Neonatal Weights*	Rat	2	0.35	0.046	0.028	15	25	Schwetz *et. al.* 1977 as cited in ATSDR 1994
Hexachlorocyclopentadiene	*Stomach Lesions*	Rat	10	0.35	0.046	0.028	76	125	Abdo *et. al.* 1984 as cited in IRIS
Ethers									
4-Bromophenyl phenyl ether	*NA*	NA	NA	NA	NA	NA	NA	NA	NA
4-Chlorophenylphenyl ether	*NA*	NA	NA	NA	NA	NA	NA	NA	NA
bis (2-Chloroethyl) ether	*Body Weights (Growth)*	Rat	25	0.35	0.046	0.028	190	313	Weisburger *et. al.* 1981 as cited in ATSDR 1989
bis (2-Chloroisopropyl) ether	*Serum Chemistry*	Mouse	35.8	0.0325	0.008	0.006	146	200	Mitsumori *et. al.* 1979 as cited in IRIS
Phenols and Substituted Phenols									
Phenol	*Fetal Body Weights*	Rat	60	0.35	0.046	0.028	456	751	NTP 1983 as cited in IRIS
2,4,5-Trichlorophenol	*Liver & Kidney Histopathology*	Rat	100	0.35	0.046	0.028	759	1,251	McCollister *et. al.* 1951 as cited in IRIS
2,4,6-Trichlorophenol	*Litter Size*	Rat	4.2	0.35	0.046	0.028	32	53	Exon & Koller 1985 as cited in ATSDR 1990
2,4-Dichlorophenol	*Development LOAEL/10*	Rat	2	0.35	0.046	0.028	15	25	Gigiena i Sanitarya 41(11):102, 1976 as cited in RTECS
2,4-Dimethylphenol	*Clinical Signs*	Mouse	50	0.0325	0.008	0.006	204	280	USEPA 1989 as cited in IRIS
2,4-Dinitrophenol	*Histopathology and Growth*	Rat	10	0.35	0.046	0.028	76	125	NRC 1981 as cited in HSDB

LD_{50} = lethal dose to 50%; LOAEL = lowest observed adverse effect level;
NOAEL = no observed adverse effect level; NA = not available

TABLE 9-6

INGESTION PATHWAY SCREENING CONCENTRATIONS - NO-OBSERVED ADVERSE EFFECTS LEVELS
SITE SD-11, CANNON AIRFORCE BASE, CURRY COUNTY, NEW MEXICO

Constituent	Effect	Species	Dose (mg/kg-BW/day)	Body Weight (kg)	Water Ingestion (L/day)	Food Ingestion (kg/day)	Water Concentration (mg/L)	Screening Concentration (mg/kg)	Reference
2-Chlorophenol	*Reproductive Effects*	Rat	5	0.35	0.046	0.028	38	63	Exon & Koller 1982 as cited in IRIS
2-Methylphenol (o-cresol)	*Body Weight (Growth) & Neurotoxicity*	Rat	50	0.35	0.046	0.028	380	626	USEPA 1986 & 1987 as cited in IRIS
2-Nitrophenol	*$LD_{50}/100$*	Rat	3.34	0.35	0.046	0.028	25	42	Labor Hyg. Occup. Pathol. Estonia SSR 8:145, 1972 as cited in RTECS
2-Methyl-4,6-dinitrophenol	*Serum Chemistry*	Rat	2.5	0.35	0.046	0.028	19	31	Den Tonkelaar *et. al*. 1983 as cited in ATSDR 1995
4-Chloro-3-methylphenol	*LD_{50} / 100*	Mouse	7.1	0.0325	0.008	0.006	29	40	USEPA 1980 as cited in HSDB
4-Methylphenol (p-cresol)	*Body Weight (Growth) & Neurotoxicity*	Rat	50	0.35	0.046	0.028	380	626	USEPA 1986 & 1987 as cited in IRIS
4-Nitrophenol	*Survival*	Rat	25	0.35	0.046	0.028	190	313	Hazleton 1989 as cited in ATSDR 1992
Pentachlorophenol	*Liver & Kidney Histopathology*	Rat	3	0.35	0.046	0.028	23	38	Schwetz *et. al*. 1978 as cited in IRIS
Ketones									
2-Hexanone	*Ataxia LOAEL/10*	Chicken	10	1.60	0.185	0.110	86	145	Abou-Donia *et al.* 192 as cited in ASTDR 1992
Acetone	*Nephrotoxicity / Liver & Kidney Weights*	Rat	100	0.35	0.046	0.028	759	1,251	USEPA 1986 as cited in IRIS
Isophorone	*No Observable Adverse Effects*	Dog	150	14	0.550	0.435	3,818	4,828	Nor. Am. Agric. 1972 as cited in IRIS
Methyl Ethyl Ketone (2-Butanone)	*Fetal Weights*	Rat	1771	0.35	0.046	0.028	13,447	22,157	Cox *et. al*. 1975 as cited in IRIS
4-Methyl-2-pentanone (MIBK)	*NA*	NA	NA	NA	NA	NA	NA	NA	NA
Polynuclear Aromatic Hydrocarbons									
Low Molecular Weight Forms									
2-Chlornaphthalene	*Liver Size*	Mouse	250	0.0325	0.008	0.006	1,018	1,398	USEPA 1989 as cited in IRIS
2-Methylnaphthalene	*NA*	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthene	*Hepatotoxicity*	Mouse	175	0.0325	0.008	0.006	712	978	USEPA 1989 as cited in IRIS
Acenaphthylene	*NA*	NA	NA	NA	NA	NA	NA	NA	NA

LD_{50} = lethal dose to 50%; LOAEL = lowest observed adverse effect level;
NOAEL = no observed adverse effect level; NA = not available

TABLE 9-6

INGESTION PATHWAY SCREENING CONCENTRATIONS - NO-OBSERVED ADVERSE EFFECTS LEVELS
SITE SD-11, CANNON AIRFORCE BASE, CURRY COUNTY, NEW MEXICO

Constituent	Effect	Species	Dose (mg/kg-BW/day)	Body Weight (kg)	Water Ingestion (L/day)	Food Ingestion (kg/day)	Water Concentration (mg/L)	Screening Concentration (mg/kg)	Reference
Anthracene	*No Observable Adverse Effects*	Mouse	1000	0.0325	0.008	0.006	4,071	5,591	USEPA 1989 as cited in IRIS
Carbazole	*NA*	NA	NA	NA	NA	NA	NA	NA	NA
Dibenzofuran	*Growth LOAEL/10*	Mouse	10	0.0325	0.008	0.006	41	56	Shepard's Catalog Tetratogenic Agents 1989 as cited in HSDB
Fluorene	*Blood Chemistry*	Mouse	125	0.0325	0.008	0.006	509	699	USEPA 1989 as cited in IRIS
Naphthalene	*Survival, Growth, & Organ Weights*	Mouse	143	0.0325	0.008	0.006	582	800	USEPA-NTIS PB90-259821 as cited in HSDB
Phenanthrene	*Liver Function LOAEL/10*	Mouse	7	0.0325	0.008	0.006	28	39	Hyg. Sanit. 29:19, 1964 as cited in RTECS
High Molecular Weight Forms									
Benzo (a) anthracene	*NA*	NA	NA	NA	NA	NA	NA	NA	NA
Benzo (a) pyrene	*Fertility and Fetal Body Weights LOAEL/10*	Mouse	1	0.0325	0.008	0.006	4	6	Mackenzie & Angvine 1981 as cited in Sample *et. al*. 1996
Benzo (b) fluoranthene	*NA*	NA	NA	NA	NA	NA	NA	NA	NA
Benzo (g,h,i) perylene	*NA*	NA	NA	NA	NA	NA	NA	NA	NA
Benzo (k) fluoranthene	*NA*	NA	NA	NA	NA	NA	NA	NA	NA
Chrysene	*NA*	NA	NA	NA	NA	NA	NA	NA	NA
Dibenz (a,h) anthracene	*NA*	NA	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	*Clinical Signs & Liver Weights*	Mouse	125	0.0325	0.008	0.006	509	699	USEPA 1989 as cited in IRIS
Indeno (1,2,3-cd) pyrene	*NA*	NA	NA	NA	NA	NA	NA	NA	NA
Pyrene	*Kidney Histopathology*	Mouse	75	0.0325	0.008	0.006	305	419	USEPA 1989 as cited in IRIS
Phthalates									
Butylbenzylphthalate	*Liver & Brain Weights*	Rat	159	0.35	0.046	0.028	1,207	1,989	Carpenter *et. al.* 1953 as cited in IRIS
bis (2-Ethylhexyl) phthalate	*Reproduction*	Mouse	18.3	0.0325	0.008	0.006	74	102	Lamb et al. 1987 as cited in Sample et al. 1996
Di-n-butylphthalate	*Survival*	Rat	125	0.35	0.046	0.028	949	1,564	Smith 1953 as cited in IRIS
Di-n-octylphthalate	*Liver weight LOAEL/10*	Rat	240	0.35	0.046	0.028	1,822	3,003	Mann et al 1985 as cited in RTI 1995
Diethylphthalate	*Growth Rates & Organ Weights*	Rat	750	0.35	0.046	0.028	5,695	9,383	Brown *et. al.* 1978 as cited in IRIS

LD_{50} = lethal dose to 50%; LOAEL = lowest observed adverse effect level;
NOAEL = no observed adverse effect level; NA = not available

INGESTION PATHWAY SCREENING CONCENTRATIONS - NO-OBSERVED ADVERSE EFFECTS LEVELS
SITE SD-11, CANNON AIRFORCE BASE, CURRY COUNTY, NEW MEXICO

Constituent	Effect	Species	Dose (mg/kg-BW/day)	Body Weight (kg)	Water Ingestion (L/day)	Food Ingestion (kg/day)	Water Concentration (mg/L)	Screening Concentration (mg/kg)	Reference
Dimethylphthalate	*NA*	NA	NA	NA	NA	NA	NA	NA	NA
Total Petroleum Hydrocarbons	*Liver Function LOAEL/10 - Phenanthrene as surrogate*	Mouse	7	0.0325	0.008	0.006	28	39	Hyg. Sanit. 29:19, 1964 as cited in RTECS
Hydrocarbons as DRO	*Liver Function LOAEL/10 - Phenanthrene as surrogate*	Mouse	7	0.0325	0.008	0.006	28	39	Hyg. Sanit. 29:19, 1964 as cited in RTECS
Miscellaneous Alcohols, Gycols and Solvents									
Carbon Disulfide	*Fetal Resorptions LOAEL/10*	Rabbit	25	1.2	0.114	0.069	262	436	Jones-Price *et al.* 1984 as cited in ATSDR 1994
Benzyl alcohol	*Birth Weights and Pup Growth LOAEL/10*	Mouse	75	0.0325	0.008	0.006	305	419	Harding *et. al.* 1987 as cited in HSDB
Inorganics									
Aluminum	*Clinical Signs*	Chicken	23.5	1.7	0.194	0.082	206	486	NAS 1980
Antimony	*Growth & Reproduction*	Rat	0.35	0.35	0.046	0.028	3	4	IRIS 1993
Arsenic	*Clinical Signs*	Chicken	1.1	1.7	0.194	0.082	9.63	23	Eisler 1988
Barium	*Growth*	Rat	33.5	0.35	0.046	0.028	254	419	NTP 1994 as cited in IRIS
Beryllium	*Longevity*	Rat	0.66	0.35	0.046	0.028	5	8	Morgareidge et al. 1976 as cited in IRIS
Cadmium	*Reproduction*	Rat	1	0.35	0.046	0.028	8	13	Sutou et al. 1980 as cited in Sample et al. 1996
Calcium	*NA*	NA	NA	NA	NA	NA	NA	NA	NA
Chromium, Total	*Reproduction*	Black duck	1	1.25	0.046	0.138	18	10.0	Haseltine et al. (unpubl.) as cited in Sample et al. 1996
Cobalt	*Survival & Growth*	Chicken	0.24	1.7	0.194	0.082	3.1	3.0	Fisch, Pinc, Minerals Water & Health, Vol1, 1977
Copper	*Reproduction*	Mink	11.7	1	0.099	0.137	118	85	Aulerich et al. 1982 as cited in Sample et al. 1996
Iron	*NA*	NA	NA	NA	NA	NA	NA	NA	NA
Lead	*Reproduction*	Japanese Quail	1.13	0.15	0.017	0.017	10	10.0	Edens et al. 1876 as cited in Sample et al. 1996
Magnesium	*NA*	NA	NA	NA	NA	NA	NA	NA	NA

LD_{50} = lethal dose to 50%, LOAEL = lowest observed adverse effect level,
NOAEL = no observed adverse effect level, NA = not available

TABLE 9-6

INGESTION PATHWAY SCREENING CONCENTRATIONS - NO-OBSERVED ADVERSE EFFECTS LEVELS SITE SD-11, CANNON AIRFORCE BASE, CURRY COUNTY, NEW MEXICO

Constituent	Effect	Species	Dose (mg/kg-BW/day)	Body Weight (kg)	Water Ingestion (L/day)	Food Ingestion (kg/day)	Water Concentration (mg/L)	Screening Concentration (mg/kg)	Reference
Manganese	*Reproduction*	Rat	88	0.35	0.046	0.028	668	1,101	Laskey et al. 1982 as cited in Sample et al. 1996
Mercury (Inorganic)	*Reproduction*	Japanese Quail	0.45	0.15	0.017	0.017	4.1	4.0	Hill & Scaffner 1976 as cited in Sample et al. 1996
Nickel	*Reproduction*	Rat	40	0.35	0.046	0.028	304	500	Ambrose et al. 1976 as cited in Sample et al. 1996
Potassium	*NA*	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	*Reproduction*	Rat	0.2	0.35	0.046	0.028	2	3	Rosenfeld & Beath 1954 as cited in Sample et al. 1996
Silver	*Mortality*	Rat	0.67	0.35	0.046	0.028	5.1	8.4	HSDB, Schroeder, et al., J. Nutrit. 104: 239, 1974
Sodium	*NA*	NA	NA	NA	NA	NA	NA	NA	NA
Thallium	*Mortality*	Rat	0.074	0.35	0.046	0.028	1	1	IRIS 1993
Vanadium	*Survival and Growth*	Mouse	1.22	0.0325	0.008	0.006	5.0	6.8	HSDB, Clayton, et al., Patty's Ind. Hyg. & Tox. Vol. 2A-2C, 1981-2
Zinc	*Reproduction*	Chicken	14.49	1.935	0.214	0.123	131	228	Stahl et al. 1990 as cited in Sample et al. 1996

LD_{50} = lethal dose to 50%; LOAEL = lowest observed adverse effect level;
NOAEL = no observed adverse effect level; NA = not available

TABLE 9-7

NUTRITIONAL REQUIREMENTS OF TRACE MINERALS IN ANIMAL DIETS
CANNON AIRFORCE BASE, CURRY COUNTY, NEW MEXICO

Nutritional Requirements for Selected Minerals in Dietary Concentrations (mg/kg-diet)[1]

	Dog		Cat		Swine	Duck		Chicken		Turkey	Reptile	
	Maintenance	Maximum	Maintenance	Maximum	Maintenance	Chicks	Breeders	Chicks	Breeders	Breeders	Carnivores	Omnivores
Calcium	10000	25000	10000	NA	7470	6500	27500	NA	NA	22500	9500	12500
Phosphorous	8000	16000	8000	NA	6000	4000	3000	NA	NA	3500	7000	7500
Potassium	6000	NA	6000	NA	2000	NA	NA	2500	2500	6000	5000	5000
Sodium	3000	NA	2000	NA	1470	1500	1500	1500	1500	1500	2000	2000
Chloride	4500	NA	3000	NA	1210	1200	1200	1500	1500	1200	NA	NA
Magnesium	400	3000	800	NA	421	500	500	600	500	500	400	2000
Iron	80	3000	80	NA	80	NA	NA	80	60	60	70	200
Copper	7.3	250	5	NA	5	NA	NA	5	4	8	6.5	15
Manganese	5	NA	7.5	NA	10	50	NA	60	20	60	5	150
Zinc	120	1000	75	2000	50	60	NA	40	45	65	50	130
Iodine	1.5	50	0.35	NA	0.158	NA	NA	0.35	0.01	0.4	0.45	0.4
Selenium	0.11	2	0.1	NA	0.158	0.2	NA	0.15	0.06	0.2	0.3	0.3

Nutritional Requirements for Selected Minerals - Dervived Daily Doses (mg/kg-body weight/day)

	Dog		Cat		Swine	Duck		Chicken		Turkey	Reptile	
	Maintenance	Maximum	Maintenance	Maximum	Maintenance	Chicks	Breeders	Chicks	Breeders	Breeders	Carnivores	Omnivores
Calcium	171	429	293	[redacted]	87.3	835	1533	[redacted]	[redacted]	625	190	361
Phosphorous	137	274	234	[redacted]	70.2	514	167	[redacted]	[redacted]	97.2	140	217
Potassium	103	[redacted]	176	[redacted]	23.4	[redacted]	[redacted]	363	121	167	100	145
Sodium	51.4	[redacted]	58.6	[redacted]	17.2	193	83.6	218	72.5	41.6	40.0	57.8
Chloride	77.1	[redacted]	87.9	[redacted]	14.1	154	66.9	218	72.5	33.3	[redacted]	[redacted]
Magnesium	6.86	51.4	23.4	[redacted]	4.92	64.3	27.9	87.1	24.2	13.9	8.00	57.8
Iron	1.37	51.4	2.34	[redacted]	0.935	[redacted]	[redacted]	11.6	2.90	1.67	1.40	5.78
Copper	0.125	4.29	0.146	[redacted]	0.0585	[redacted]	[redacted]	0.726	0.193	0.222	0.130	0.434
Manganese	0.0857	[redacted]	0.220	[redacted]	0.117	6.43	[redacted]	8.71	0.967	1.67	0.100	4.34
Zinc	2.06	17.1	2.20	58.6	0.585	7.71	[redacted]	5.81	2.18	1.80	1.00	3.76
Iodine	0.0257	0.857	0.0103	[redacted]	0.00185	[redacted]	[redacted]	0.0508	0.000484	0.0111	0.00900	0.0116
Selenium	0.00189	0.0343	0.00293	[redacted]	0.00185	0.0257	[redacted]	0.0218	0.00290	0.00555	0.00600	0.00867

Notes: [1] Reproduced from The Merck Veterinary Manual 8th Edition (1998); NA = not available; Mature dog weight = 14 kg, food ingestion = 0.24 kg/day (dry diet; USEPA 1988); Average mature cat weight = 3.55 kg, average food consumption = 0.104 kg/day (dry diet; USEPA 1988); Swine body weight = 162.5 kg, food consumption = 1.9 kg/day (Merck 1998); 10-day old mallard body weight = 92 to 115 g, average = 0.1035 kg (USEPA 1993); Bird food ingestion (based on all birds) = 0.0582 x $BW(kg)^{0.651}$(USEPA 1993); Adult mallard body weight = (average male & female) = 1.134 kg (USEPA 1993); Chick body weight estimated at an age of 7 days = 0.073 kg (USEPA 1988); Chicken body weight (mature) = 1.7 kg (USEPA 1988); Turkey body weight = 13.4 kg, food consumption = 0.372 kg/day (USEPA 1988); Snapping turtle average body weight (Michigan) = 1.66, food consumption (captive) = 0.048 kg/day (USEPA 1993); Racer average (approximate) body weight = 0.175 kg, food consumption = 0.0035 kg/day (USEPA 1993).

TABLE 9-8

CHEMICAL ATTRIBUTES FOR THE CHEMICALS OF POTENTIAL ECOLOGICAL CONCERN AND UNCERTAINTIES SITE SD-11, CANNON AIRFORCE BASE, CURRY COUNTY, NEW MEXICO

COPEC or Uncertainty	CAS #	Molecular Weight (g/mol)	Melting Point (°C)	Water Solubility (mg/L @ 25°C)	Koc	Kow	Henry's Constant	Diffisivity in water (cm2/sec)	Diffisivity in air (cm2/sec)	Soil Degradation Half-Life (hr.s)	Water Degradation Half-Life (hr.s)
Benzo (a) anthracene	56553	228.28	159	0.013	400000	500000	3.60E-06	9.00E-06	6.10E-02	1.60E+04	1.60E+04
Benzo (a) pyrene	50328	252	179	0.0019	1000000	1300000	8.40E-07	9.00E-06	4.30E-02	1.30E+04	1.30E+04
Benzo (b) fluoranthene	205992	252	168	0.0043	1200000	1600000	2.90E-05	8.00E-06	8.00E-02	1.50E+04	1.50E+04
Benzo (g,h,i) perylene	191242	276	277	0.00026	400000	3801894	1.60E-06	NA	NA	NA	NA
Benzo (k) fluoranthene	207089	252	217	0.00055	1000000	6918310	5.59E-08	NA	NA	NA	NA
Chrysene	218019	228.3	250	0.0019	400000	500000	1.20E-06	8.00E-06	8.00E-02	2.40E+04	2.40E+04
Dibenz (a,h) anthracene	53703	278.33	266	0.00067	3800000	4900000	1.10E-08	8.00E-06	8.00E-02	2.30E+04	2.30E+04
Indeno (1,2,3-cd) pyrene	193395	276.34	163	0.000022	3400000	4540000	2.40E-06	8.00E-06	8.00E-02	1.80E+04	1.80E+04
bis (2-Ethylhexyl) phthalate	117817	390.54	-55	0.4	15000000	20000000	8.30E-06	3.70E-06	3.50E-02	5.50E+02	5.50E+02
di-n-octlyphthalate	117840	390.6	-25	0.00098	84000000	110000000	5.70E-05	8.00E-06	8.00E-02	NA	NA

COPEC	CAS #	Atomic Weight g/mol	Atomic Radius (angstroms)	Atomic Volume	Ionic Radius 2+ (angstroms)	Ionic Radius 3+ (angstroms)	Density g/cc	Ionization Potential (eV) 2+	Ionization Potential (eV) 3+
Aluminum (Al)	7429-90-5	26.98	1.25	10.00	---	0.5	2.7	---	28.44
Cadmium (Cd)	7440-43-9	112.4	1.41	13.0	0.97	---	8.6	16.84	---
Chromium (Cr)	7440-47-3	52.0	1.17	7.3	0.64	0.55	7.1	6.76	6.05
Iron (Fe)	7439-89-6	55.8	1.16	7.1	0.83	0.67	7.9	7.9	16.16
Lead (Pb)	7439-92-1	207.19	1.54	18.27	1.32	0.84	11.34	7.41	14.96
Mercury (Hg)	7439-97-6	200.59	1.44	14.0	1.1	---	13.6	10.43	18.65
Vanadium (V)	7440-62-2	50.94	1.22	8.4	0.64	0.56	5.96	6.74	-1.5

NA = Not availble

Data were obtained from USEPA ASTER Database, RTI (1995), Hazardous Substance Database (HSDB), USEPA (1979), Heslop & Robsinson (1963), Merck (1989) and available ATSDRs

TABLE 9-9

POLYCYCLIC AROMATIC HYDROCARBON (PAH) TOXICITY VALUES (HIGH MOLECULAR WEIGHT FORMS) FOR ORAL EXPOSURE SITE SD-11, CANNON ARIFORCE BASE, CURRY COUNTY, NEW MEXICO

PAH	Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
9,10-Anthracenedione	Mouse	LD50	Single Dose	Mortality		>5000	RTECS, Pest. Msnual 9:37, 1991
9,10-Anthracenedione	Quail	LD50	Single Dose	Mortality		>2000	RTECS, Farm Chemicals Handbook,-:c23, 1991
Benzo(a)pyrene	Rodent	LD50	Single Dose	Mortality		50	Eisler, 1987
Pyrene	Rat	LD50	Single Dose	Mortality		2700	RTECS, Labor Hyg. Prof. nye Zabolevaniya, Lab. Hyg. Occ. Die. 15:59, 1971
Pyrene	Mouse	LD50	Single Dose	Mortality		800	RTECS, Labor Hyg. Prof. nye Zabolevaniya, Lab. Hyg. Occ. Die. 15:59, 1971
Benz(a)-anthracene	Hamster	LOAEL	Single Dose	Spermagensis		900	RTECS, Acta Morph. Acad. Scient. Hungaricae 27:199, 1979
Benzo(a)pyrene	Rat	LOAEL	50-day (note A)	Fetotoxicity	2000 mg/kg-total dose	40	RTECS, Experimentia 20:244, 1964
Benzo(a)pyrene	Rat	LOAEL	41-day (Note B)	Live Birth Index	1344 mg/kg-total dose	32.8	RTECS, DOE Symposium Series 54:410, 1981
Benzo(a)pyrene	Rat	LOAEL	Gestation (Note C)	Fetotoxicity	1000 mg/kg-diet	88	HSDB, Shephard, Catal. Teretog. Agents, 4th Ed., 1983
Benzo(a)pyrene	Rat	LOAEL	Gestation	Fetotoxicity	not specified	50	Cervello et al. 1992 as cited in the HSDB
Benzo(a)pyrene	Mouse	LOAEL	10-day (gestation)	Delayed Effects on Newborn	100 mg/kg-total dose	10	RTECS, Internat. J. Abnormal Develop. 19:37a, 1979
Benzo(a)pyrene	Mouse	LOAEL	10-day (gestation)	Fertility and Fetal Body Weights		10	Mackenzie & Angvine 1981 as cited in Sample et al. 1996
Benzo(a)pyrene	Mouse	LOAEL	10-day (gestation)	Newborn Growth	100 mg/kg-total dose	10	RTECS, Biol. Reprod. 24:183, 1981
Benzo(a)pyrene	Mouse	LOAEL	Gestation	Fertility	Oral Intubation	10	Kristensen et al. 1995
Benzo(a)pyrene	Mouse	LOAEL	10-day (gestation)	Sterility of Offspring		40	HSDB, Shephard, Catal. Teretog. Agents, 4th Ed., 1983
Flouranthene	Mouse	LOAEL	13-week	Liver Pathology & Hematology		250	IRIS, Toxicity Res. Lab.s, USEPA, 1988
Pyrene	Mouse	LOAEL	13-week	Kindey Disfuction & Histopathology		125	IRIS, Toxicity Res. Lab.s, USEPA, 1989
Benzo(a)pyrene	Rodent	NOAEL	Single Dose	Testicular Damage		100	Eisler, 1987
Benzo(a)pyrene	Mouse	NOAEL	10-day (gestation)	Offspring Body, Reproduction		10	HSDB, IARC, V32:214, 1983

TABLE 9-9

POLYCYCLIC AROMATIC HYDROCARBON (PAH) TOXICITY VALUES (HIGH MOLECULAR WEIGHT FORMS) FOR ORAL EXPOSURE SITE SD-11, CANNON ARIFORCE BASE, CURRY COUNTY, NEW MEXICO

PAH	Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Benzo(a)pyrene	Chicken	NOAEL	Single Dose	Survival	250 mg-total dose	147	Rigdon, R.H. & J. Neal, Texas Rept. Biol. Med. 21(2):247-556, 1963
Benzo(a)pyrene	Duck	NOAEL	Single Dose	Survival	250 mg-total dose	220	Rigdon, R.H. & J. Neal, Texas Rept. Biol. Med. 21(2):247-556, 1963
Benzo(a)pyrene	Chicken	NOAEL	Not Specified	Fertility & Reproduction	100 mg/kg-diet	4.84	Rigdon, R.H. & J. Neal, Texas Rept. Biol. Med. 21(4):558-566, 1963
Benzo(a)pyrene	Chick	NOAEL	24-days	Growth and Survival	2500 mg/kg-diet	280	Rigdon, R.H. & J. Neal, Texas Rept. Biol. Med. 21(4):558-566, 1963
Flouranthene	Mouse	NOAEL	13-week	Liver Pathology & Hematology		125	IRIS, Toxicity Res. Lab.s, USEPA, 1989
Pyrene	Mouse	NOAEL	13-week	Kindey Disfuction & Histopathology		75	IRIS, Toxicity Res. Lab.s, USEPA, 1989

Note A, dosing began 28 days prior ot mating and continued through 22 days of pregnancy

Note B, dosing began 15 days prior to mating through 5 days after birth, assumed a gestation period of 21 days based on USEPA, 1988 Reference (EPA/600/6-87/008)

Note C, assume normal rat gestation = 21 day, adult female rat body = 0.25 kg, adult female food consumption = 0.022 kg/day EPA 1988; 600/6-89/008

Note D, dosing began 16 days prior to mating through 5 days after birth, assumed a gestation period of 21 days based on USEPA, 1988 (EPA/600/6-87/008)

Chicken Body Weight = 1.7 kg, Reference in USEPA, 1988 EPA/600/6-87/008

Chick Body Weight at 1 day = 0.036 kg, at 21 days = 0.270 kg (average = 0.153 kg) Reference in USEPA, 1988 EPA/600/6-87/008

Bird Food Ingestion (based on all birds) = $0.0582 \times BW(kg)^{0.651}$, Reference is USEPA 93, EPA/600/R-93/187a

TABLE 9-10

BIS(2-ETHYLHEXYL)PHTHALATE (DEHP) TOXICITY VALUES FOR ORAL EXPOSURE SITE SD-11, CANNON AIRFORCE BASE, CURRY COUNTY, NEW MEXICO

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat	LD_{50}	Single Dose	Mortality		30000	OHM/TADS
Rat	LD_{50}	Single Dose	Mortality		30600	RTECS, Environ. Health Perspec. 3:131, 1973
Rat	LD_{50}	Single Dose	Mortality		26000	OHM/TADS
Mouse	LD_{50}	Single Dose	Mortality		14200	OHM/TADS
Mouse	LD_{50}	Single Dose	Mortality		30000	RTECS, Internat. J. Abnormal Develop. 14:259, 1976
Rabbit	LD_{50}	Single Dose	Mortality		34000	OHM/TADS
Guinea Pig	LD_{50}	Single Dose	Mortality		26000	RTECS, IARC, 29:269, 1982
Rabbit	LD_{50}	15-day	Mortality	(gavage)	2000	Parmar et al 1988 as cited in ATSDR 1992
Guinea Pig	LD_{50}	15-day	Mortality	(gavage)	2000	Parmar et al 1988 as cited in ATSDR 1992
Dog	LOAEL	1-year	Cloudy & Enlarged Liver	0.09ml/kg-BW/day	88.7	HSDB, Patty's Indust. Hyg & Toxicol., 1982
Rat	LOAEL	21-day	Fetotoxicity	7.14 g/kg-total dose	340	RTECS, Toxicol. Appll. Pharmacol. 26:253, 1973
Rat	LOAEL	10-day (gestation)	Fetotoxicity	10 g/kg-total dose	1000	RTECS, Indian J. Exper. Biol. 27:885, 1989
Rat	LOAEL	12-day (gestation)	Developmentary Abnormalities	9766 mg/kg-total dose	465	RTECS, Inter. J. Abnormal Develop. 35:41, 1987
Rat	LOAEL	20-day (gestation)	Fetal resorptions	(diet)	1055	Tyl et al. 1988 as cited in ATSDR 1992
Rat	LOAEL	90-day	Growth	1.5 g/kg-diet	130.5	HSDB, IARC, V29, 280, 1982
Rat	LOAEL	3-week	Liver & Kidney Weight	0.1%-diet	8694	HSDB, EPA Document 40-8226118
Rat	LOAEL	7-day	Survival	17.5 g/kg-total dose	2500	RTECS,Toxicol. Appl. Pharm. 61:205, 1981
Rat	LOAEL	6-week	Survival	59388 mg/kg-total dose	1414	RTECS, Food Cosmetics Toxicol. 15:389, 1977
Rat	LOAEL	17-week	Decreased Weight Gain	168 g/kg-total dose	1412	RTECS, Food Cosmetics Toxicol. 15:389, 1977
Rat	LOAEL	21-day	Liver Weight	19796 mg/kg-total dose	943	RTECS, Food Cosmetics Toxicol. 15:389, 1977
Rat	LOAEL	21-day	Liver Weight	25.2 g/kg-total dose	1200	RTECS, Toxicol. Appl. Pharm. 77:116, 1985
Rat	LOAEL	14-day	Liver Weight	14 g/kg-total dose	1000	RTECS, Toxicol. Letters 66:317, 1993
Rat	LOAEL	365-day	Decrease in body weight gain	(diet)	600	Marsmar et al 1988 as cited in ATSDR 1992
Rat	LOAEL	365-day	Decrease in body weight gain	(diet)	200	Carpenter et al as cited in ATSDR 1992

TABLE 9-10

BIS(2-ETHYLHEXYL)PHTHALATE (DEHP) TOXICITY VALUES FOR ORAL EXPOSURE
SITE SD-11, CANNON AIRFORCE BASE, CURRY COUNTY, NEW MEXICO

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat	LOAEL	79-week	Decrease in body weight gain, increased liver weight	(diet)	1000	Tamura et al 1990 as cited in ATSDR 1992
Rat	LOAEL	102-week	Decrease in body weight gain	(diet)	100	Ganning et al 1991 as cited in ATSDR 1992
Rat	LOAEL	108-week	Decrease in body weight gain, increased liver weight	(diet)	1000	Roa et al 1990 as cited in ATSDR 1992
Rat	LOAEL	2-year	Testicular damage	(diet)	2000	Price et al. 1987 as cited in ATSDR 1993
Rat	LOAEL	2-year	Decreased body weight gain, increased liver, kidney weights	(diet)	200	Carpenter et al as cited in ATSDR 1992
Mouse	LOAEL	14-day	Survival	84 g/kg-total dose	6000	RTECS, Toxicol. Letters 66:317, 1993
Mouse	LOAEL	13-week	Survival	33852 mg/kg-total dose	372	RTECS, NTP-TR-217, 82
Mouse	LOAEL	103-week	Kidney & Pituitary Histopathology	6000 mg/kg-diet	1033	HSDB, Kluwe *et al.*, 1982
Mouse	LOAEL	Gestation	Birth Defects, Maternal Weight Gain	0.2%-diet	34857	HSDB, Shiota & Nishimura, 1982
Mouse	LOAEL	8-day (gestation)	Decreased Litter Size	78.88 g/kg-total dose	9860	RTECS, Terat. Carcin. Mutagen. 7:29, 1987
Mouse	LOAEL	7-day (gestation)	Fetotoxicity	1 g/kg-total dose	143	RTECS, Environ. Health Prespect. 45:71, 1982
Mouse	LOAEL	17-day (gestation)	Fetal malformations	(diet)	91	Tyl et al. 1988 as cited in ATSDR 1992
Mouse	LOAEL	105-day	Reproduction	1000 mg/kg-diet	183.3	Lamb et al. 1987 as cited in Sample et al., 1996
Guinea pig	LOAEL	1-year	Liver weight	(diet)	52	Carpenter et al as cited in ATSDR 1992
Dog	NOAEL	1-year	Organ Weight & Liver Function	0.06ml/kg-BW/day	59.2	HSDB, Patty's Indust. Hyg & Toxicol., 1982
Dog	NOAEL	1-year	Renal, hepatic function, growth	(capsule)	59	Carpenter et al as cited in ATSDR 1992
Rat	NOAEL	7-day	Histopathology	2%-diet	17405	HSDB, EPA Document #878210916, ihe# OTS026292, 1982
Rat	NOAEL	20-day (gestation)	Fetal Development	(diet)	357	Tyl et al. 1988 as cited in ATSDR 1992
Rat	NOAEL	90-day	Body Weight & Histopathology	7.5 g/kg-diet	579	HSDB, IARC, V29, 280, 1982
Rat	NOAEL	103-week	Survival	12000 mg/kg-diet	1044	HSDB, IARC, V29, 279, 1982
Rat	NOAEL	108-week	Weight gain, liver weights	(diet)	10	Roa et al 1990 as cited in ATSDR 1992

TABLE 9-10

BIS(2-ETHYLHEXYL)PHTHALATE (DEHP) TOXICITY VALUES FOR ORAL EXPOSURE SITE SD-11, CANNON AIRFORCE BASE, CURRY COUNTY, NEW MEXICO

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat	NOAEL	1-year	Reproduction	(diet)	200	Carpenter et al. As cite in ATSDR 1992
Rat	NOAEL	2-year	Weight gain, liver and kidney weights	(diet)	65	Carpenter et al as cited in ATSDR 1992
Mouse	NOAEL	Gestation	Fetal Development	0.1%-diet	17429	HSDB, Shiota & Nishimura, 1982
Mouse	NOAEL	17-day (gestation)	Fetal malformations	(diet)	44	Tyl et al. 1989 as cited in ATSDR 1992
Mouse	NOAEL	105-day	Reproduction	100 mg/kg-diet	18.3	Lamb et al. 1987 as cited in Sample et al., 1996
Guinea pig	NOAEL	1-year	Liver weight	(diet)	16	Carpenter et al as cited in ATSDR 1992
Marmoset	NOAEL	14-day	Liver & Testes Effects	5mM/kg-BW/day	1953	HSDB, Rhodes, et al., Environ. Health Prespect. 65:299, 1986
Ringed Dove	NOAEL	4-weeks	Reproduction	10 mg/kg-diet	1.11	Peakall 1974 as cited in Sample et al., 1996

DEHP Density = 0.9864 g/ml, Reference is HSDB
DEHP Molecular Weight = 390.6, Reference is ASTER
Rat Average Body Weight (Chronic Exposure) = 0.3045 kg, Reference is USEPA, 1988, EPA 600/6-87/008
Rat Average Food Consumption (Chronic Exposure) = 0.0.0265 kg/day, Reference is USEPA, 1988, EPA 600/6-87/008
Mouse Average Body Weight (Chronic Exposure) = 0.0363 kg, Reference is USEPA, 1988, EPA 600/6-87/008
Mouse Average Food Consumption (Chronic Exposure) = 0.00625 kg/day, Reference is USEPA, 1988, EPA 600/6-87/008
Female Mouse Average Body Weight (Mature) = 0.035 kg, Reference is USEPA, 1988, EPA 600/6-87/008
Female Mouse Average Food Consumption (Mature) = 0.0061 kg/day, Reference is USEPA, 1988, EPA 600/6-87/008

TABLE 9-11

DI-N-OCTYL PHTHALATE TOXICITY VALUES FOR ORAL EXPOSURE
SITE SD-11, CANNON AIRFORCE BASE, CURRY COUNTY, NEW MEXICO

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat	LD_{50}	Not Reported	Mortality		47,000	RTECS (R) Farmakologiya i Toksikologiya 39:635, 1976
Mouse	LD_{50}	Not Reported	Mortality		6,513	RTECS (R) Labor Hygiene & Occupational Diseases 17:51, 1973
Rat	LOAEL	3-week	Increased liver size		2,400	Mann et al. 1985 as cited in RTI 1995
Mouse	LOAEL	8 days	Fertility		9,750	RTECS (R) NTIS PB85-220143
Mouse	LOAEL	8 days	Fertility		9,780	RTECS (R), Teratogenesis, Carcinogenesis, and Mutagenesis 7:29, 1987
Mouse	NOAEL	Through mating period	Reproduction		0.03	Heidndel et al. 1989 as cited in RTI 1995

TABLE 9-12

ALUMINUM TOXICITY VALUES FOR ORAL EXPOSURE
SITE SD-11, CANNON AIRFORCE BASE, CURRY COUNTY, NEW MEXICO

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Mouse (A)	LD_{50}	Single Dose	Mortality		6207	RTECS, Brit. J. Indust. Med. 23:305, 1966
Mouse (A)	LD_{50}	Single Dose	Mortality		4210	HSDB, Venugopal & Luckey, Metal Toxicity on Mammals, 1978
Mouse (A)	LD_{50}	Single Dose	Mortality		770	HSDB, CHRIS Vol2, 1984
Mouse (A)	LD_{50}	Single Dose	Mortality		970	HSDB, NRC, Drinking Water and Health Vol4, 1981
Mouse (A)	LD_{50}	Single Dose	Mortality		6100	HSDB, Gosselin, et al., Clin. Tox. of Comm. Prod., 5th Ed., 1984
Rat (A)	LD_{50}	Single Dose	Mortality		1930	HSDB, Venugopal & Luckey, Metal Toxicity on Mammals, 1978
Rat (B)	LOAEL	21-day (gestation)	Postnatal Mortality		272	HSDB, Shepard, Cat. Teratog. Agents, 4th Ed., 1986
Rat (B)	LOAEL	14-day(gestation)	Postnatal Mortality		155	Bernuszzi et al. 1986
Rat (C)	LOAEL	21-day (gestation)	Postnatal Mortality		378	HSDB, Shepard, Cat. Teratog. Agents, 4th Ed., 1986
Mouse (D)	LOAEL	14-day(gestation)	Fetal Reabsorbtion	200 mg/day	5714	HSDB, Shepard, Cat. Teratog. Agents, 4th Ed., 1986
Rat (D)	LOAEL	14-day(gestation)	Growth of Offspring	1000 mg/kg-diet	88	HSDB, NRC, Drinking Water and Health Vol4, 1981
Rat (E)	LOAEL	4-week (weaning)	Growth Rate	1100 mg/kg-diet	330	Thurston et al. 1972 as cited in NAS 1980
Rat (F)	LOAEL	100-day	Weight gain	(water)	540	Domingo et al. 1984 as cited in ATSDR 1992
Lamb (F)	LOAEL	Not specified	Depressed growth	1450 mg/kg-diet	24.2	Rosa et al 1982 as cited in Sparling et al. 1998
Dairy cow (F)	LOAEL	Not specified	Depressed growth	2000 mg/kg-diet	52.3	Crowe et al. 1990 as cited in Sparling et al. 1998
Chicken (F)	LOAEL	4-week	Depressed egg lying	1500 mg/kg-diet	72.5	Hussein et al. 1988 as cited in Sparling et al. 1998
Chicken (F)	LOAEL	Not specified	Reduced bone strength	2500 mg/kg-diet	121	Hussein et al. 1989 as cited in Sparling et al. 1998
Japanese Quail (F)	LOAEL	3-week	Depressed egg production	3000 mg/kg-diet	233	Hussein et al. 1989 as cited in Sparling et al. 1998

TABLE 9-12

ALUMINUM TOXICITY VALUES FOR ORAL EXPOSURE
SITE SD-11, CANNON AIRFORCE BASE, CURRY COUNTY, NEW MEXICO

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Black and Mallard ducklings (F)	LOAEL	10-week	Depressed growth	1000 mg/kg-diet	85	Sparling 1990 as cited in Sparling et al. 1998
Dog (F)	NOAEL	90-day	No Adverse Effects	2600 mg/kg-diet	80.8	NAS 1980
Dog (G)	NOAEL	6-month	Reproduction	(diet)	60	Katz et al. 1979 as cited in ATSDR 1992
Rat (D)	NOAEL	14-day(gestation)	No Adverse Fetal Effects	0.1% (water)	14400	HSDB, Shepard, Cat. Teratog. Agents, 4th Ed., 1986
Rat (A)	NOAEL	30-day	Neuro-behavioral	0.3% (water)	43200	HSDB, Conner, et al., Pharm. Biochem. Behav. 31:467, 1988
Rat (B)	NOAEL	90-day	Reproduction	(water)	100	Dixon et al. 1979 as cited in ATSDR 1992
Mouse (B)	NOAEL	390-day	Reproduction	(water)	19	Ondreicka et al. 1966 as cited in ATSDR 1992
Ring Dove (A)	NOAEL	63-day	Egg production, fertility, fledging	1000 mg/kg-diet	110	Carriere et al. 1986 as cited in Sample et al. 1996
Chicken (F)	NOAEL	28-day	No Adverse Effects	486 mg/kg-diet	23.5	NAS 1980
Starling (F)	NOAEL	Not specified	Egg shell thickness	5000 mg/kg-diet	696	Miles et al. 1993 as cited in Sparling et al. 1998

Mature Dog Body Weight (average male & female) = 14 kg, Reference is USEPA, 1988 EPA/600/6-87/008
Mature Dog Food Consumption (average male & female) = 0.435 kg/day, Reference is USEPA, 1988 EPA/600/6-87/008
Mature Mouse Body Weight (female) = 0.035 kg, Reference is USEPA, 1988 EPA/600/6-87/008
Mature Rat Body Weight (female) = 0.25 kg, Reference is USEPA, 1988 EPA/600/6-87/008
Mature Rat Food Consumption (female) = 0.022 kg/day, Reference is USEPA, 1988 EPA/600/6-87/008
Mature Rat Water Consumption (female) = 0.036 L/day, Reference is USEPA, 1988 EPA/600/6-87/008
Cattle body weight = 313.6 kg; food ingestion = 8.2 kg/day Reference is Table 7-1;USEPA, 1988 EPA/600/6-87/008
Lamb body weight = 45 kg, food ingestion = 0.75 kg Refrencenis Table 6-1; USEPA, 1988 EPA/600/6-87/008
Chicken Body Weight (mature) = 1.7 kg, Reference in USEPA, 1988 EPA/600/6-87/008
Juvenile Mallard (average from 15 to 30-days of age) Body Weight = 0.333 kg, Reference is USEPA, 1993, EPA/600/R-93/187a
Adult Quail Body Weight = (average over seasons) = 0.191 kg Reference is USEPA, 1993, EPA/600/R-93/187a
Adult Quail Food Consumption = (average over seasons) = 0.07776 g/g-BW Reference is USEPA, 1993, EPA/600/R-93/187a
Starling body weight (average male and female) = 0.082 kg; Reference is Dunning 1993
Bird Food Ingestion (based on all birds) = 0.0582 x BW(kg)$0.^{651}$, Reference is USEPA1993, EPA/600/R-93/187a

A = Aluminum Sulfate
B = Aluminum Chloride
C = Aluminum Lactate
D = Aluminum Trichloride
E = Aluminum Hydroxide
F = not specified
G = Aluminum Phosphate

TABLE 9-13

CHROMIUM TOXICITY VALUES FOR ORAL EXPOSURE
SITE SD-11, CANNON AIRFORCE BASE, CURRY COUNTY, NEW MEXICO

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Mouse (Cr VI)	LD_{50}	Single Dose	Mortality		5	Steven et al. 1976 as cited in Eisler 1986
Mouse (Cr III)	LD_{50}	Single Dose	Mortality		260	Steven et al. 1976 as cited in Eisler 1986
Rat (Cr III)	LD_{50}	Single Dose	Mortality		183 (female) - 200 (male)	Vernot et al. 1977 as cited in ATSDR 1993
Rat (Cr VI)	LD_{50}	Single Dose	Mortality		14 (female) - 21 (male)	Gad et al. 1986 as cited in ATSDR 1993
Rat (Cr VI)	LD_{50}	Single Dose	Mortality		25	Am. Chrome and Chem. 1989 as cited in ATSDR 1993
Rat (Cr VI)	LD_{50}	Single Dose	Mortality		108 (female) - 249 (male)	Vernot et al. 1977 as cited in ATSDR 1993
Rat (Cr VI)	LD_{50}	Single Dose	Mortality		13 (female) - 28 (male)	Gad et al. 1986 as cited in ATSDR 1993
Rat (Cr VI) (female)	LD_{50}	Single Dose	Mortality		811	Shubochkin and Pokhodzei 1980 as cited in ATSDR 1993
Dog (Cr VI)	LD_{LO}	3-month	Mortality	100 mg/kg-diet	3	Steven et al. 1976 as cited in Eisler 1986
Rat (Cr VI)	LD_{LO}	3-month	Mortality	1000 mg/kg-diet	82	Steven et al. 1976 as cited in Eisler 1986
Mouse (CrIV)	LOAEL	19-day (gestation)	Reduced maternal weight gain		120	Trivedi et al. 1989 as cited in ATSDR 1993
Mouse (CrIV)	LOAEL	19-day (gestation)	Increased fetal reabsorptions and gross abnormalities		57	Trivedi et al. 1989 as cited in ATSDR 1993
Black Duck (young)[CrIII]	LOAEL	10-week	Reduced Survival	10 mg/kg-diet	2.7	Haseltine et al. 1985 as cited in Eisler 1986
Black Duck (adult[CrIII]	LOAEL	10-month	Reproduction	50 mg/kg-diet	5	Haseltine et al. (unpubl.) as cited in Sample et al. 1996
Rat (Cr III)	NOAEL	90-day (5x week)	No Effects		1806	Ivankovic and Preussmann 1975 as cited in ATSDR 1993
Rat (Cr III)	NOAEL	600 feedings (840-day)	No Effects	5% -diet, 5x-week	170	IRIS, Jvankovik & Preussman, Food Cosmet. Toxicol. 13:347, 1975
Rat (Cr III)	NOAEL	1-year	Blood serum, renal and liver function		2.7	Mackenzie et al. 1958 as cited in ATSDR 1993

TABLE 9-13

CHROMIUM TOXICITY VALUES FOR ORAL EXPOSURE
SITE SD-11, CANNON AIRFORCE BASE, CURRY COUNTY, NEW MEXICO

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat (Cr III)	NOAEL	2-year	Reproduction and longevity		2737	Ivankovic and Preussmann 1975 as cited in Sample et al. 1996
Guinea Pig (Cr III)	NOAEL	21-week	No Adverse Effects	50 mg/kg-diet	2.1	Preston et al. 1976 as cited in Eisler, 1986
Rat (Cr VI)	NOAEL	3-month	Survival	134 mg/L (water)	18	Steven et al. 1976 as cited in Eisler 1986
Rat (Cr VI)	NOAEL	1-year	No Effects		2.4	IRIS, MacKenzie, et al., Am. Med. Assoc. Ach. Ind. Health, 18:232, 1958
Rat (Cr VI)	NOAEL	1-year	No Effects	25 mg/L (water)	3.3	IRIS, MacKenzie, et al., Am. Med. Assoc. Ach. Ind. Health, 18:232, 1958
Dog (Cr VI)	NOAEL	4-year	No Effects		0.3	IRIS, Anwar, *et al.*, 1961
Dog (Cr VI)	NOAEL	4-year	No observable effects	6 mg/L (water)	0..30	Steven et al. 1976 as cited in Eisler 1986
Chicken (Cr VI)	NOAEL	32-day	No Adverse Effects	100 mg/kg-diet	4.8	Rosomer et al. 1961 as cited in Eisler 1986
Black Duck (adult[CrIII]	NOAEL	10-month	Reproduction	10 mg/kg-diet	1	Haseltine et al. (unpubl.) as cited in Sample et al. 1996
Black Duck (adult[CrIII]	NOAEL	5-month	Survival, Growth, Reproduction	50 mg/kg-diet	2.8	Haseltine et al. 1985 as cited in Eisler 1986
Black Duck (young) [CrIII]	NOAEL	Parental & 7-day	Fright Stimulus Response	100 mg/kg-diet	26.8	Heinz and Haseltine 1980 as cited in Esiler 1986

Mature Dog Body Weight (average male & female) = 14 kg, Reference is USEPA, 1988 EPA/600/6-87/008
Mature Dog Food Consumption (average male & female) = 0.435 kg/day, Reference is USEPA, 1988 EPA/600/6-87/008
Mature Dog Water Consumption (average male & female) = 0.69 L/day, Reference is USEPA, 1988 EPA/600/6-87/008
Mature Rat Body Weight (average male & female) = 0.325 kg, Reference is USEPA, 1988 EPA/600/6-87/008
Mature Rat Food Consumption (average male & female) = 0.0265 kg/day, Reference is USEPA, 1988 EPA/600/6-87/008
Mature Rat Water Consumption (average male & female) = 0.0435 L/day, Reference is USEPA, 1988 EPA/600/6-87/008
Mature Guinea Pig Body Weight (average male & female) = 0.95 kg, Reference is USEPA, 1988 EPA/600/6-87/008
Mature Guinea Pig Food Consumption (average male & female) = 0.0405 kg/day, Reference is USEPA, 1988 EPA/600/6-87/008
Chicken Body Weight (mature) = 1.7 kg, Reference in USEPA, 1988 EPA/600/6-87/008
Black Duck Body Weight (average male & female) = 1.250 kg, (Dunning 1993)
Juvenile Mallard (used for Black Duck)(average from 15 to 30-days of age) Body Weight = 0.333 kg, Reference is USEPA, 1993, EPA/600/R-93/187a
Bird Food Ingestion (based on all birds) = 0.0582 x BW(kg)$0.^{651}$, Reference is USEPA 93, EPA/600/R-93/187a

TABLE 9-14

VANADIUM TOXICITY VALUES FOR ORAL EXPOSURE
SITE SD-11, CANNON AIRFORCE BASE, CURRY COUNTY, NEW MEXICO

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat (A)	LD_{50}	Single Dose	Mortality		100	RTECS, AM. Indust. Hyg. Assoc. J., 30:470, 1969
Rat (B)	LD_{50}	Single Dose	Mortality		160	RTECS, AM. Indust. Hyg. Assoc. J., 30:470, 1969
Rat (C)	LD_{50}	Single Dose	Mortality		540	RTECS, AM. Indust. Hyg. Assoc. J., 30:470, 1969
Rat (D)	LD_{50}	Single Dose	Mortality		350	RTECS, AM. Indust. Hyg. Assoc. J., 30:470, 1969
Rat (F)	LD_{50}	Single Dose	Mortality		10	RTECS, Archive feur Toxicol., 16:182, 1956
Mouse (E)	LD_{50}	Single Dose	Mortality		130	RTECS, Izmerov, etal., Centre Internatl. Proj., GKNT, 1982-:119
Mouse (F)	LD_{50}	Single Dose	Mortality		23	RTECS, Izmerov, etal., Centre Internatl. Proj., GKNT, 1982-:119
Rat (F)	LOAEL	No Duration	Clinical Signs of Toxicity	1000 mg/kg-diet	81.5	HSDB, Clayton, et al., Patty's Ind. Hyg. & Tox. Vol. 2, 1982
Rat (G)	LOAEL	9-day (gestation)	Facial hemorrhage	(gavage)	8.4	Paternain et al. 1987 as cited in ATSDR 1992
Rat (F)	LOAEL	10-day	Fetotoxicity	180 mg/kg-Total Dose	18	RTECS, Chinese J. Prevent. Med., 20:189, 1986
Rat	LOAEL	60-day	Litter Size and Pup Survival		2.1	Domingo et al. 1986 as cited in Sample et. al 1996
Rat (E)	LOAEL	100-day	Decreased maternal weight gain	(diet)	3.9	Franke and Moxon 1937 as cited in ATSDR 1992
Rat (G)	LOAEL	2-generation	Altered lung collagen	(water)	2.8	Kowalska et al 1988 as cited in ATSDR 1992
Chick	LOAEL	3-week	Growth		1.68	Romoser et al. 1961 as cited in RTI 1995
Cattle	NOAEL	Chronic	Maximum Tolerable Level	50 mg/kg-diet	1.31	NAS 1980
Sheep	NOAEL	Chronic	Maximum Tolerable Level	10 mg/kg-diet	0.13	NAS 1980
Mouse	NOAEL	lifetime	Mortality, Growth	5 ppm (water)	1.22	HSDB, Clayton, et al., Patty's Ind. Hyg. & Tox. Vol. 2A-2C, 1981-2

TABLE 9-14

VANADIUM TOXICITY VALUES FOR ORAL EXPOSURE
SITE SD-11, CANNON AIRFORCE BASE, CURRY COUNTY, NEW MEXICO

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Mouse (H)	NOAEL	2-year	Clinical signs, growth	(diet)	4.1	Schroeder and Balassa 1967 as cited in ATSDR 1992
Rat	NOAEL	90-day	Growth	5 ppm (water)	0.67	HSDB, Parker, et al., J. Env. Path. Tox. 2 (2): 235-46, 1978
Rat (E)	NOAEL	100-day	Maternal weight gain	(diet)	2	Franke and Moxon 1937 as cited in ATSDR 1992
Rat, Female Long Evans	NOAEL	lifetime	Mortality, Growth	5 ppm (water)	0.66	IRIS, Ambrose, et al., F. Sci Technol. 13:181, 1976
Rat	NOAEL	2.5-year	Mortality, Growth	179 ppm	24	IRIS, Stokinger, et al., Patty's Ind. Hyg. & Tox.. 3rd ed., 1981
Rat (H)	NOAEL	2.5-year	Clinical signs, growth	(water)	0.7	Schroeder et al. 1970 as cited in ATSDR 1992
Rat	NOAEL	Weaning until death	No observable adverse effects		0.9	Schroeder et al. 1970 as cited in RTI 1995
Rat, Male Wistar	NOAEL	103-day	Clinical signs		7.5	IRIS, Mountain, et al., 1953
Duck	NOAEL	84-day	No adverse effests	1 mg/kg-diet	0.06	NAS, 1980
Poultry	NOAEL	Chronic	Maximum Tolerable Level	10 mg/kg-diet	0.48	NAS, 1980

Mature Rat Body Weight (average male & female) = 0.325 kg, Reference is USEPA, 1988 EPA/600/6-87/008
Mature Rat Food Consumption (average male & female) = 0.0265 kg/day, Reference is USEPA, 1988 EPA/600/6-87/008
Mature Rat Water Consumption (average male & female) = 0.0435 L/day, Reference is USEPA, 1988 EPA/600/6-87/008
Mature Rat (Long Evans) Body Weight (mature female) = 0.35 kg, Reference is USEPA, 1988 EPA/600/6-87/008
Mature Rat (Long Evans) Water Consumption (mature female) = 0.046 L/day, Reference is USEPA, 1988 EPA/600/6-87/008
Mature Mouse Body Weight (average male & female) = 0.0325 kg, Reference is USEPA, 1988 EPA/600/6-87/008
Mature Mouse Water Consumption (average male & female) = 0.00795 L/day, Reference is USEPA, 1988 EPA/600/6-87/008
Cattle body weight = 313.6 kg; food ingestion = 8.2 kg/day Reference is Table 7-1;USEPA, 1988 EPA/600/6-87/008
Sheep body weight = 63 kg, food ingestion = 0.85 kg Refrencenis Table 6-1; USEPA, 1988 EPA/600/6-87/008
Chicken Body Weight (mature) = 1.7 kg, Reference in USEPA, 1988 EPA/600/6-87/008
Mature Mallard Body Weight (average male & female) = 1.134 kg, Reference is USEPA, 1993, EPA/600/R-93/187a
Bird Food Ingestion (based on all birds) = 0.0582 x BW(kg)$0.^{651}$, Reference is USEPA 1993, EPA/600/R-93/187a

(A): Vanadium Chloride
(B): Vanadium Tetrachloride
(C): Vanadium Dichloride
(D): Vanadium Trichloride
(E): Vanadium Trioxide
(F): Vanadium Pentoxide
(G): Sodium Orthovanadate
(H): Vanadyl Sulfate

TABLE 9-15

INGESTION-PATHWAY EXPOSURE ASSUMPTIONS FOR THE ECOLOGICAL RECEPTORS OF CONCERN SITE SD-11, CANNON AIRFORCE BASE, CURRY COUNTY, NEW MEXICO

Common Name	Representing Guild	Area Use (acres)	Body Weight (kg)	Food Ingestion (kg/day)	Soil Ingestion (kg/day)
Mourning Dove[1]	Ground-gleaning herbivorous birds exposed to aluminum and vanadium	8.5a	0.188h	0.0154k	0.000462 (3% of FI)s
Baird's Sparrow	Ground-gleaning omnivorous birds exposed to PAHs, phthalates, and aluminum	2.7b	0.0175h	0.00453m	0.000136 (3% of FI)s
Burrowing Owl[2]	Ground-pouncing insectivorous birds exposed to PAHs, phthalates, and chromium	1.98c	0.155h	0.00713n	0.000356 (5% of FI)t
Silky pocket mouse	Ground-fossorial-gleaning herbivorous mammals exposed to aluminum and vanadium	2.77d	0.008j	0.00201p	0.0000402 (2% of FI)u
Blacktail Jackrabbit	Ground-browsing herbivorous mammals exposed to aluminum and vanadium	40.8e	2.35j	0.163q	0.0102 (6.3% of FI)v
Grasshopper Mouse	Ground-fossorial-gleaning omnivorous mammals exposed to aluminum, PAHs, and phthalates	4.94f	0.0320j	0.00438n	0.000145 (5% of FI)s
Yuma Bat[3]	Air screening insectivorous mammals exposed to PAHs, phthalates, and aluminum	57.8g	0.005j	0.000882r	0 (0% of FI)s

a = Based on pair density as reported by DeGraff and Rudis 1987
b = value for similar species - the grasshopper sparrow (*Ammodramas savannarum*) from Schoener 1966
c = Based on territory size for California (Thomsen 1971 as cited in Sample *et al.* 1997)
d = based on similar species *Perognathus penicillatus* (Blair 1953 as cited in Sample *et al.* 1997)
e = Frech *et al.* 1965 as cited in Sample *et al.* 1997
f = Nowak 1991
g = based on only available area use value for bats (the red bat - DeGraff and Rudis 1987)
h = average of males and females (Dunning 1993)
j = average of males and females (Silva and Downing 1995)
k = based on equation for non-passerine birds; g/day = 0.301 * Wt(g)^0.751 (USEPA 1993)
k = based on equation for passerine birds; g/day = 0.398 * Wt(g)^0.850 (USEPA 1993)
m = based on Coulmbe; Marti 1974; Bell 1990 and Golley 161 as reported in Sample *et al.*1997
n = based on equation for rodents; g/day = 0.621 * Wt(g)^0.564 (USEPA 1993)
p = based on equation for herbivores; g/day = 0.577 * Wt(g)^0.727 (USEPA 1993)
r = based on equation for all mammals; kg/day = 0.0687 * Wt(kg)^0.822 (USEPA 1993)
s = based on best judgement erring towards overestimation and on foraging behavior
t = Themsen 1971 as cited in Sample *et al.* 1997
u = Beyer *et al.* 1994
v = Arthur and Gates 1988 as cited in USEPA 1993

FI = Food ingestion rate
1: McCown's longspur was not selected due to a lack of behavioral information
2: No specifically ground-gleaning / fossorial insectivorous birds are expected
3: No specifically ground-gleaning / fossrial insectivorous mammals are expected

As carnivores are not expected to be at significant risk of exposure neither the peregrine falcon and the swift fox were selected as ROCS

TABLE 9-16

ASSUMED DIETARY COMPOSITION (PERCENT BY WEIGHT) FOR THE ECOLOGICAL RECEPTORS OF CONCERN
SITE SD-11, CANNON AIRFORCE BASE, CURRY COUNTY, NEW MEXICO

Common Name	Plant Foliage	Plant Seeds	Invertebrates	Amphibians	Reptiles	Birds	Mammals	Comments
Mourning Dove		98	2					Almost exclusively seeds, rarely will take soil insects when abundant
Baird's Sparrow		40	60					Primarily grasshoppers, caterpillars, ants, true bugs, spiders, and other invertebrates. Plant food mainly consists of weed and grass seeds.
Burrowing Owl			90		0.5	0.5	9	Diet skewed towards insectivory; based largely on Marti 1974 as cited in Sample *et al.* 1997 - diet can include a significantly greater percentage of small mammals
Silky pocket mouse	5	90	5					Almost exclusively grass seeds, while take significant numbers of insects in spring before seeds ripen
Blacktail Jackrabbit	100							Exclusive herbivore, grasses and forbs but will take prickly pear in summer months
Grasshopper Mouse	5	15	80					As the name implies relies heavily on grasshoppers and other insects. Aslo consumes quantities of grass seeds and some foliage (new shouts)
Yuma Bat			100					Exclusive insectivore, specializes in flying low over open grassland and fields.

Dietary composition developed based on information obtained from Martin *et al*. 1951, Wallace and Mahan 1975, Ehrlich *et al.* 1988, Nowak 1991, Rising 1996, Brown 1997, Sample *et al.* 1997

The presented dietary compositions are derived in consideration of the available forage within SD-11 and the presence of the grassland adjacent to the unit

TABLE 9-17

STATISTICAL ANALYSIS OF HIGH MOLECULAR WEIGHT PAHs IN SOIL
SITE SD-11, CANNON AIRFORCE BASE, CURRY COUNTY, NEW MEXICO

All Concentration are in ug/kg -Dry Weight	Benzo (a) anthracene	Benzo (a) pyrene	Benzo (b) fluoranthene	Benzo (g,h,i) perylene	Benzo (k) fluoranthene	Chrysene	Dibenz (a,h) anthracene	Indeno (1,2,3-cd) pyrene
Number of Samples	12	12	12	12	12	12	12	12
Percent Detection	25.00%	25.00%	25.00%	16.67%	0.00%	25.00%	0.00%	16.67%
Percent of Detects J-Coded	100.00%	100.00%	66.67%	100.00%	0.00%	100.00%	0.00%	100.00%
Maximum Detection	200	270	440	110	No Detects	260	No Detects	89
Maximum Non-Detect	190	190	190	190	190	190	190	190
Minimum Detection	41	40	64	49	No Detects	44	No Detects	40
Minimum Non-Detect	175	175	175	175	175	175	175	175
Normality Test Used	W-Test	W-Test	W-Test	W-Test	W-Test	W-Test	W-Test	W-Test
Critical Value	0.859	0.859	0.859	0.859	0.859	0.859	0.859	0.859
Calculated Value	0.591	0.753	0.615	0.557	0.840	0.747	0.840	0.554
Tested at alpha of	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Pass/Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail
Normal Mean	1.68E+02	1.74E+02	1.95E+02	1.69E+02	1.85E+02	1.75E+02	1.85E+02	1.66E+02
Standard Error	1.40E+01	1.62E+01	2.45E+01	1.27E+01	1.44E+00	1.51E+01	1.44E+00	1.41E+01
90% UCL using CLT	1.86E+02	1.95E+02	2.27E+02	1.85E+02	1.87E+02	1.94E+02	1.87E+02	1.84E+02
95% UCL using CLT	1.91E+02	2.01E+02	2.36E+02	1.89E+02	1.88E+02	1.99E+02	1.88E+02	1.89E+02
Log-Normality Test	W-Test	W-Test	W-Test	W-Test	W-Test	W-Test	W-Test	W-Test
Critical Value	0.859	0.859	0.859	0.859	0.859	0.859	0.859	0.859
Calculated Value	0.531	0.629	0.684	0.507	0.838	0.618	0.838	0.514
Tested at alpha of	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Pass/Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail
Log-Normal MVUE of the Mean	1.73E+02	1.79E+02	1.96E+02	1.72E+02	1.85E+02	1.79E+02	1.85E+02	1.71E+02
Jackknifed Standard Error (MVUE)	1.15E+01	1.38E+01	2.24E+01	1.06E+01	1.44E+00	1.27E+01	1.44E+00	1.15E+01
90% UCL	1.90E+02	1.99E+02	2.27E+02	1.87E+02	1.87E+02	1.97E+02	1.87E+02	1.88E+02
95% UCL	1.94E+02	2.05E+02	2.36E+02	1.92E+02	1.88E+02	2.03E+02	1.88E+02	1.93E+02
NonParametric Results								
Jackknifed Mean	1.68E+02	1.74E+02	1.95E+02	1.69E+02	1.85E+02	1.75E+02	1.85E+02	1.66E+02
Jackknifed Standard Error	1.40E+01	1.62E+01	2.45E+01	1.27E+01	1.44E+00	1.51E+01	1.44E+00	1.41E+01
90% UCL	1.87E+02	1.96E+02	2.29E+02	1.86E+02	1.87E+02	1.95E+02	1.87E+02	1.85E+02
95% UCL	1.93E+02	2.03E+02	2.39E+02	1.91E+02	1.88E+02	2.02E+02	1.88E+02	1.91E+02

UCL = upper confidence limit for the mean; CLT = central limit theorem; MVUE = minimum variance unbiased estimator

Maximum and minimum "nondetect" values reflect 1/2 the reporting limits

TABLE 9-18

STATISTICAL ANALYSIS OF PHTHALATES CONSIDERED UNCERTAIN IN SOIL SITE SD-11, CANNON AIRFORCE BASE, CURRY COUNTY, NEW MEXICO

All Concentration are in ug/kg -Dry Weight	bis (2-Ethylhexyl) phthalate	Di-n-octyl phthalate
Number of Samples	12	12
Percent Detection	0.00%	0.00%
Percent of Detects J-Coded	0.00%	0.00%
Maximum Detection	No Detects	No Detects
Maximum Non-Detect	190	190
Minimum Detection	No Detects	No Detects
Minimum Non-Detect	175	175
Normality Test Used	W-Test	W-Test
Critical Value	0.859	0.859
Calculated Value	0.840	0.840
Tested at alpha of	0.05	0.05
Pass/Fail	Fail	Fail
Normal Mean	1.85E+02	1.85E+02
Standard Error	1.44E+00	1.44E+00
90% UCL using CLT	1.87E+02	1.87E+02
95% UCL using CLT	1.88E+02	1.88E+02
Log-Normality Test	W-Test	W-Test
Critical Value	0.859	0.859
Calculated Value	0.838	0.838
Tested at alpha of	0.05	0.05
Pass/Fail	Fail	Fail
Log-Normal MVUE of the Mean	1.85E+02	1.85E+02
Jackknifed Standard Error (MVUE)	1.44E+00	1.44E+00
90% UCL	1.87E+02	1.87E+02
95% UCL	1.88E+02	1.88E+02
NonParametric Results		
Jackknifed Mean	1.85E+02	1.85E+02
Jackknifed Standard Error	1.44E+00	1.44E+00
90% UCL	1.87E+02	1.87E+02
95% UCL	1.88E+02	1.88E+02

UCL = upper confidence limit for the mean; CLT = central limit theorem;
MVUE = minimum variance unbiased estimator

Maximum and minimum "nondetect" values reflect 1/2 the reporting limits

TABLE 9-19

STATISTICAL ANALYSIS OF INORGANIC CHEMICALS OF POTENTIAL ECOLOGICAL CONCERN IN SOIL SITE SD-11, CANNON AIRFORCE BASE, CURRY COUNTY, NEW MEXICO

All Concentration are in mg/kg -Dry Weight	Aluminum	Vanadium	Chromium
Number of Samples	9	9	8
Percent Detection	100.00%	100.00%	100.00%
Percent of Detects J-Coded	0.00%	0.00%	0.00%
Maximum Detection	12500	24.2	13.6
Maximum Non-Detect	All Detects	All Detects	All Detects
Minimum Detection	7790	16.2	8
Minimum Non-Detect	All Detects	All Detects	All Detects
Normality Test Used	W-Test	W-Test	W-Test
Critical Value	0.829	0.829	0.818
Calculated Value	0.951	0.932	0.874
Tested at alpha of	0.05	0.05	0.05
Pass/Fail	Pass	Pass	Pass
Normal Mean	1.06E+04	2.10E+01	1.04E+01
Standard Error	5.13E+02	8.20E-01	7.50E-01
90% UCL using CLT	1.12E+04	2.21E+01	1.13E+01
95% UCL using CLT	1.14E+04	2.24E+01	1.16E+01
Log-Normality Test	W-Test	W-Test	W-Test
Critical Value	0.829	0.829	0.818
Calculated Value	0.926	0.912	0.901
Tested at alpha of	0.05	0.05	0.05
Pass/Fail	Pass	Pass	Pass
Log-Normal MVUE of the Mean	1.06E+04	2.10E+01	1.04E+01
Jackknifed Standard Error (MVUE)	5.13E+02	8.18E-01	7.53E-01
90% UCL	1.13E+04	2.22E+01	1.14E+01
95% UCL	1.15E+04	2.25E+01	1.18E+01
NonParametric Results			
Jackknifed Mean	1.06E+04	2.10E+01	1.04E+01
Jackknifed Standard Error	5.13E+02	8.20E-01	7.50E-01
90% UCL	1.13E+04	2.22E+01	1.14E+01
95% UCL	1.15E+04	2.25E+01	1.18E+01

UCL = upper confidence limit for the mean; CLT = central limit theorem; MVUE = minimum variance unbiased estimator

Maximum and minimum "nondetect" values reflect 1/2 the reporting limits

TABLE 9-20

MODELED ENVIRONMENTAL EXPOSURE CONCENTRATIONS IN BIOLOGICAL MEDIA USED FOR CALCULATING INDIRECT EXPOSURE HAZARD QUOTIENTS SITE SD-11, CANNON AIRFORCE BASE, CURRY COUNTY, NEW MEXICO

	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Chrysene	Dibenz(a,h)anthracene	Indeno (1,2,3-c,d)pyrene	bis (2-ethylhexyl) Phthalate	di-n-octyl phthala6te	Aluminum	Aluminum -Low End Exposure	Chromium	Vanadium
Soil	0.193	0.203	0.239	0.191	0.188	0.202	0.188	0.191	0.188	0.188	1405	0562	1160	22.40
Plant Foliage	1.54E-01	1.56E-01	1.79E-01	2.01E-02	2.72E-02	1.62E-01	1.46E-01	1.43E-01	1.41E-01	1.44E-01	4.56E+01	4.22E+01	8.70E-02	2.15E+00
Plant Seeds	3.86E-01	3.90E-01	4.48E-01	5.02E-02	6.79E-02	4.04E-01	3.64E-01	3.58E-01	3.53E-01	3.59E-01	7.41E+00	6.87E+00	5.22E-02	6.72E-02
Soil Invertebrates	1.54E-01	1.56E-01	1.79E-01	2.01E-02	2.72E-02	1.62E-01	1.46E-01	1.43E-01	1.41E-01	1.44E-01	1.35E+03	1.25E+03	3.67E+01	1.97E+00
Herbivorous Insects	3.86E-01	3.90E-01	4.48E-01	5.02E-02	6.79E-02	4.04E-01	3.64E-01	3.58E-01	3.52E-01	3.59E-01	4.90E+02	4.54E+02	3.55E+00	9.41E-01
Carnivorous Insects	5.40E-01	5.47E-01	6.27E-01	7.03E-02	9.51E-02	5.66E-01	5.10E-01	5.01E-01	4.93E-01	5.02E-01	4.90E+02	4.54E+02	3.55E+00	9.41E-01
Mourning Dove representing Herbivorous Birds	2.58E-02	2.61E-02	2.99E-02	3.07E-03	4.27E-03	2.70E-02	2.44E-02	2.39E-02	2.36E-02	2.40E-02	8.35E+02	7.73E+02	3.87E+00	4.01E-01
Baird's Sparrow representing Ominovorous Birds	6.42E-02	6.48E-02	7.44E-02	7.57E-03	1.05E-02	6.71E-02	6.06E-02	5.94E-02	5.85E-02	5.96E-02	8.35E+02	7.73E+02	3.87E+00	4.01E-01
Pocket Mouse representing Herbivorous Mammals	7.95E-02	8.03E-02	9.22E-02	9.70E-03	1.34E-02	8.32E-02	7.50E-02	7.36E-02	7.25E-02	7.39E-02	7.98E+01	7.39E+01	3.58E+00	4.26E-01
Grasshopper Mouse representing Omnivorous Mammals	3.05E-02	3.08E-02	3.53E-02	3.57E-03	4.98E-03	3.19E-02	2.88E-02	2.82E-02	2.78E-02	2.83E-02	1.06E+03	9.82E+02	4.05E+00	2.94E-01
Coachwhip representing Reptiles	3.24E-02	3.28E-02	3.77E-02	4.51E-03	5.98E-03	3.40E-02	3.06E-02	3.01E-02	2.96E-02	3.02E-02	1.06E+03	9.82E+02	4.05E+00	2.94E-01

All values for Hig-End Exposure unless noted

TABLE 9-21

DIETARY EXPOSURE TOXICITY REFERENCE VALUES USED IN RISK CHARACTERIZATION SITE SD-11, CANNON AIRFORCE BASE, CURRY COUNTY, NEW MEXICO

COPEC	ROC	Endpoint	Effect	Species	TRV (Dose-mg/kg-BW/day)	Citation
Benzo (a) anthracene	Birds	LOAEL	Benzo (a) pyrene as a surrogate	Chicken	48.4	Rigdon and Neal 1963
		NOAEL	Benzo (a) pyrene as a surrogate	Chicken	4.84	Rigdon and Neal 1963
	Mammals	LOAEL	Benzo (a) pyrene as a surrogate	Mouse	10	Mackenzie and Angvine 1981 as cited in Sample et al. 1996
		NOAEL	Benzo (a) pyrene as a surrogate	Mouse	1	Mackenzie and Angvine 1981 as cited in Sample et al. 1996
Benzo (a) pyrene	Birds	LOAEL	Fertility and Reproduction NOAEL * 10	Chicken	48.4	Rigdon and Neal 1963
		NOAEL	Fertility and Reproduction	Chicken	4.84	Rigdon and Neal 1963
	Mammals	LOAEL	Fertility and Fetal Body Weight	Mouse	10	Mackenzie and Angvine 1981 as cited in Sample et al. 1996
		NOAEL	Fertility and Fetal Body Weight LOAEL/10	Mouse	1	Mackenzie and Angvine 1981 as cited in Sample et al. 1996
Benzo (b) fluoranthene	Birds	LOAEL	Benzo (a) pyrene as a surrogate	Chicken	48.4	Rigdon and Neal 1963
		NOAEL	Benzo (a) pyrene as a surrogate	Chicken	4.84	Rigdon and Neal 1963
	Mammals	LOAEL	Benzo (a) pyrene as a surrogate	Mouse	10	Mackenzie and Angvine 1981 as cited in Sample et al. 1996
		NOAEL	Benzo (a) pyrene as a surrogate	Mouse	1	Mackenzie and Angvine 1981 as cited in Sample et al. 1996
Benzo (g,h,i) perylene	Birds	LOAEL	Benzo (a) pyrene as a surrogate	Chicken	48.4	Rigdon and Neal 1963
		NOAEL	Benzo (a) pyrene as a surrogate	Chicken	4.84	Rigdon and Neal 1963
	Mammals	LOAEL	Benzo (a) pyrene as a surrogate	Mouse	10	Mackenzie and Angvine 1981 as cited in Sample et al. 1996
		NOAEL	Benzo (a) pyrene as a surrogate	Mouse	1	Mackenzie and Angvine 1981 as cited in Sample et al. 1996

TABLE 9-21

DIETARY EXPOSURE TOXICITY REFERENCE VALUES USED IN RISK CHARACTERIZATION SITE SD-11, CANNON AIRFORCE BASE, CURRY COUNTY, NEW MEXICO

COPEC	ROC	Endpoint	Effect	Species	TRV (Dose-mg/kg-BW/day)	Citation
Benzo (k) fluoranthene	Birds	LOAEL	Benzo (a) pyrene as a surrogate	Chicken	48.4	Rigdon and Neal 1963
		NOAEL	Benzo (a) pyrene as a surrogate	Chicken	4.84	Rigdon and Neal 1963
	Mammals	LOAEL	Benzo (a) pyrene as a surrogate	Mouse	10	Mackenzie and Angvine 1981 as cited in Sample et al. 1996
		NOAEL	Benzo (a) pyrene as a surrogate	Mouse	1	Mackenzie and Angvine 1981 as cited in Sample et al. 1996
Chrysene	Birds	LOAEL	Benzo (a) pyrene as a surrogate	Chicken	48.4	Rigdon and Neal 1963
		NOAEL	Benzo (a) pyrene as a surrogate	Chicken	4.84	Rigdon and Neal 1963
	Mammals	LOAEL	Benzo (a) pyrene as a surrogate	Mouse	10	Mackenzie and Angvine 1981 as cited in Sample et al. 1996
		NOAEL	Benzo (a) pyrene as a surrogate	Mouse	1	Mackenzie and Angvine 1981 as cited in Sample et al. 1996
Dibenz (a,h) anthracene	Birds	LOAEL	Benzo (a) pyrene as a surrogate	Chicken	48.4	Rigdon and Neal 1963
		NOAEL	Benzo (a) pyrene as a surrogate	Chicken	4.84	Rigdon and Neal 1963
	Mammals	LOAEL	Benzo (a) pyrene as a surrogate	Mouse	10	Mackenzie and Angvine 1981 as cited in Sample et al. 1996
		NOAEL	Benzo (a) pyrene as a surrogate	Mouse	1	Mackenzie and Angvine 1981 as cited in Sample et al. 1996
Indeno (1,2,3-cd) pyrene	Birds	LOAEL	Benzo (a) pyrene as a surrogate	Chicken	48.4	Rigdon and Neal 1963
		NOAEL	Benzo (a) pyrene as a surrogate	Chicken	4.84	Rigdon and Neal 1963
	Mammals	LOAEL	Benzo (a) pyrene as a surrogate	Mouse	10	Mackenzie and Angvine 1981 as cited in Sample et al. 1996
		NOAEL	Benzo (a) pyrene as a surrogate	Mouse	1	Mackenzie and Angvine 1981 as cited in Sample et al. 1996

TABLE 9-21

DIETARY EXPOSURE TOXICITY REFERENCE VALUES USED IN RISK CHARACTERIZATION SITE SD-11, CANNON AIRFORCE BASE, CURRY COUNTY, NEW MEXICO

COPEC	ROC	Endpoint	Effect	Species	TRV (Dose-mg/kg-BW/day)	Citation
bis (2-Ethylhexyl) phthalate	Birds	LOAEL	Reproduction NOAEL*10	Ringed Dove	11.1	Peakall 1974 as cited in Sample et al. 1996
		NOAEL	Reproduction	Ringed Dove	1.11	Peakall 1974 as cited in Sample et al. 1996
	Mammals	LOAEL	Fertility and Fetotoxicity	Mouse	120	NTIS PB85-105674 as cited in the HSDB
		NOAEL	Organ Weight & Liver Function	Dog	59.2	Patty's Indust. Hyg. Toxicol. 1982 as cited in the HSBD
di-n-octyl phthalate	Birds	LOAEL	bis (2-Ethylhexyl) phthalate as a surrogate	Ringed Dove	11.1	Peakall 1974 as cited in Sample et al. 1996
		NOAEL	bis (2-Ethylhexyl) phthalate as a surrogate	Ringed Dove	1.11	Peakall 1974 as cited in Sample et al. 1996
	Mammals	LOAEL	Liver Size	Rat	2400	Mann et al. 1985 as cited in RTI 1995
		NOAEL	Liver Size LOAEL / 10	Rat	2400	Mann et al. 1985 as cited in RTI 1995
Aluminum (Al)	Birds	LOAEL	Depressed Egg Laying	Chicken	72.5	Hussien et al. 1988 as cited in Sparling et al. 1998
		NOAEL	No Adverse Effects	Chicken	23.5	NAS 1980
	Mammals	LOAEL	Depressed Growth	Lamb	24.2	Rosa et al. 1982 as cited in Sparling et al. 1998
		NOAEL	Reproduction	Mouse	60	Ondreicka et al. 1966 as cited in ATSDR 1992
Chromium (CrIII)	Birds	LOAEL	Reduced Survival	Black Duck	2.7	Haseltine et al. 1985 as cited in Eisler 1986
		NOAEL	Reproduction	Black Duck	1	Haseltine et al. (unpublished) as cited in Sample et al. 1996
	Mammals	LOAEL				
		NOAEL				
Vanadium (V)	Birds	LOAEL	Depressed Growth	Chicken	1.68	Romoser et al. 1961 as cited in RTI 1995
		NOAEL	"Maximum Tolerable Level"	Poultry	0.48	NAS 1980
	Mammals	LOAEL	Litter Size and Pup Survival	Rat	2.1	Domingo et al. 1986 as cited in Sample et al. 1996
		NOAEL	Growth and Survival	Mouse	1.22	Patty's Indust. Hyg. Toxicol. 1982 as cited in the HSBD

TABLE 9-22

HAZARD QUOTIENT (HQ) RESULTS FOR OMNIVOROUS AND INSECTIVOROUS VERTEBRATES EXPOSED TO ORGANIC CHEMICALS OF POTENTIAL ECOLOGICAL CONCERN AND UNCERTAINTIES
SITE SD-11, CANNON AFB, CURRY COUNTY, NEW MEXICO

		Baird's Sparrow	Burrowing Owl	Grasshopper Mouse	Yuma Bat
Benzo (a) anthracene	ADD mg/kg-bw/day =	1.34E-02	4.33E-03	2.17E-03	2.45E-05
	HQ_{NOAEL} =	2.76E-03	8.95E-04	2.17E-03	2.45E-05
	HQ_{LOAEL} =	2.76E-04	8.95E-05	2.17E-04	2.45E-06
Benzo (a) pyrene	ADD mg/kg-bw/day =	1.35E-02	4.39E-03	2.20E-03	2.47E-05
	HQ_{NOAEL} =	2.79E-03	9.06E-04	2.20E-03	2.47E-05
	HQ_{LOAEL} =	2.79E-04	9.06E-05	2.20E-04	2.47E-06
Benzo (b) fluoranthene	ADD mg/kg-bw/day =	1.55E-02	5.04E-03	2.52E-03	2.84E-05
	HQ_{NOAEL} =	3.21E-03	1.04E-03	2.52E-03	2.84E-05
	HQ_{LOAEL} =	3.21E-04	1.04E-04	2.52E-04	2.84E-06
Benzo (g,h,i) perylene	ADD mg/kg-bw/day =	1.92E-03	6.60E-04	3.14E-04	3.18E-06
	HQ_{NOAEL} =	3.96E-04	1.36E-04	3.14E-04	3.18E-06
	HQ_{LOAEL} =	3.96E-05	1.36E-05	3.14E-05	3.18E-07
Benzo (k) fluoranthene	ADD mg/kg-bw/day =	2.52E-03	8.52E-04	4.11E-04	4.30E-06
	HQ_{NOAEL} =	5.20E-04	1.76E-04	4.11E-04	4.30E-06
	HQ_{LOAEL} =	5.20E-05	1.76E-05	4.11E-05	4.30E-07
Chrysene	ADD mg/kg-bw/day =	1.40E-02	4.53E-03	2.27E-03	2.56E-05
	HQ_{NOAEL} =	2.89E-03	9.37E-04	2.27E-03	2.56E-05
	HQ_{LOAEL} =	2.89E-04	9.37E-05	2.27E-04	2.56E-06
Dibenz (a,h) anthracene	ADD mg/kg-bw/day =	1.26E-02	4.09E-03	2.05E-03	2.31E-05
	HQ_{NOAEL} =	2.61E-03	8.46E-04	2.05E-03	2.31E-05
	HQ_{LOAEL} =	2.61E-04	8.46E-05	2.05E-04	2.31E-06
Indeno (1,2,3-c,d) pyrene	ADD mg/kg-bw/day =	1.24E-02	4.02E-03	2.01E-03	2.27E-05
	HQ_{NOAEL} =	2.56E-03	8.31E-04	2.01E-03	2.27E-05
	HQ_{LOAEL} =	2.56E-04	8.31E-05	2.01E-04	2.27E-06
bis(2-ethylhexyl) Phthalate	ADD mg/kg-bw/day =	1.23E-02	4.01E-03	2.01E-03	2.26E-05
	HQ_{NOAEL} =	1.11E-03	3.61E-04	1.10E-04	1.23E-06
	HQ_{LOAEL} =	1.12E-02	3.64E-03	3.86E-05	4.34E-07
di-n-octyl Phthalate	ADD mg/kg-bw/day =	1.26E-02	4.08E-03	2.04E-03	2.30E-05
	HQ_{NOAEL} =	1.13E-03	3.67E-04	8.51E-06	9.58E-08
	HQ_{LOAEL} =	1.14E-02	3.71E-03	8.51E-07	9.58E-09

ADD = Average Daily Dose

HQ_{NOAEL} = Hazard Quotient based on no-observed adverse effect

HQ_{LOAEL} = Hazard Quotient based on lowest-observed adverse effect

TABLE 9-23

HAZARD QUOTIENT (HQ) RESULTS FOR VERTEBRATE TETRAPODS EXPOSED TO INORGANIC CHEMICALS OF POTENTIAL ECOLOGICAL CONCERN
SITE SD-11, CANNON AIR FORCE BASE, CURRY COUNTY, NEW MEXICO

		Baird's Sparrow	Burrowing Owl	Grasshopper Mouse	Yuma Bat	Mourning Dove	Silky Pocket Mouse	Blacktail Jackrabbit
Aluminum	ADD mg/kg-bw/day =	2.88E+01	1.48E+01	5.38E+00	2.59E-02	4.07E-01	8.85E+00	3.16E-02
	HQ_{NOAEL} =	**1.22E+00**	6.32E-01	2.83E-01	1.36E-03	1.73E-02	4.66E-01	1.67E-03
	HQ_{LOAEL} =	3.97E-01	2.05E-01	2.22E-01	1.07E-03	5.62E-03	3.66E-01	1.31E-03
Aluminum - Low End Exposure	ADD mg/kg-bw/day =	2.67E+01						
	HQ_{NOAEL} =	**1.13E+00**						
	HQ_{LOAEL} =	3.68E-01						
Chromium	ADD mg/kg-bw/day =		1.27E-01			5.33E-04		
	HQ_{NOAEL} =		1.27E-01			5.33E-04		
	HQ_{LOAEL} =		4.69E-02			1.97E-04		
Vanadium	ADD mg/kg-bw/day =					8.58E-04	2.20E-02	1.48E-04
	HQ_{NOAEL} =					1.79E-03	1.81E-02	1.21E-04
	HQ_{LOAEL} =					5.11E-04	1.05E-02	7.05E-05

ADD = Average Daily Dose

HQ_{NOAEL} = Hazard Quotient based on no-observed adverse effect

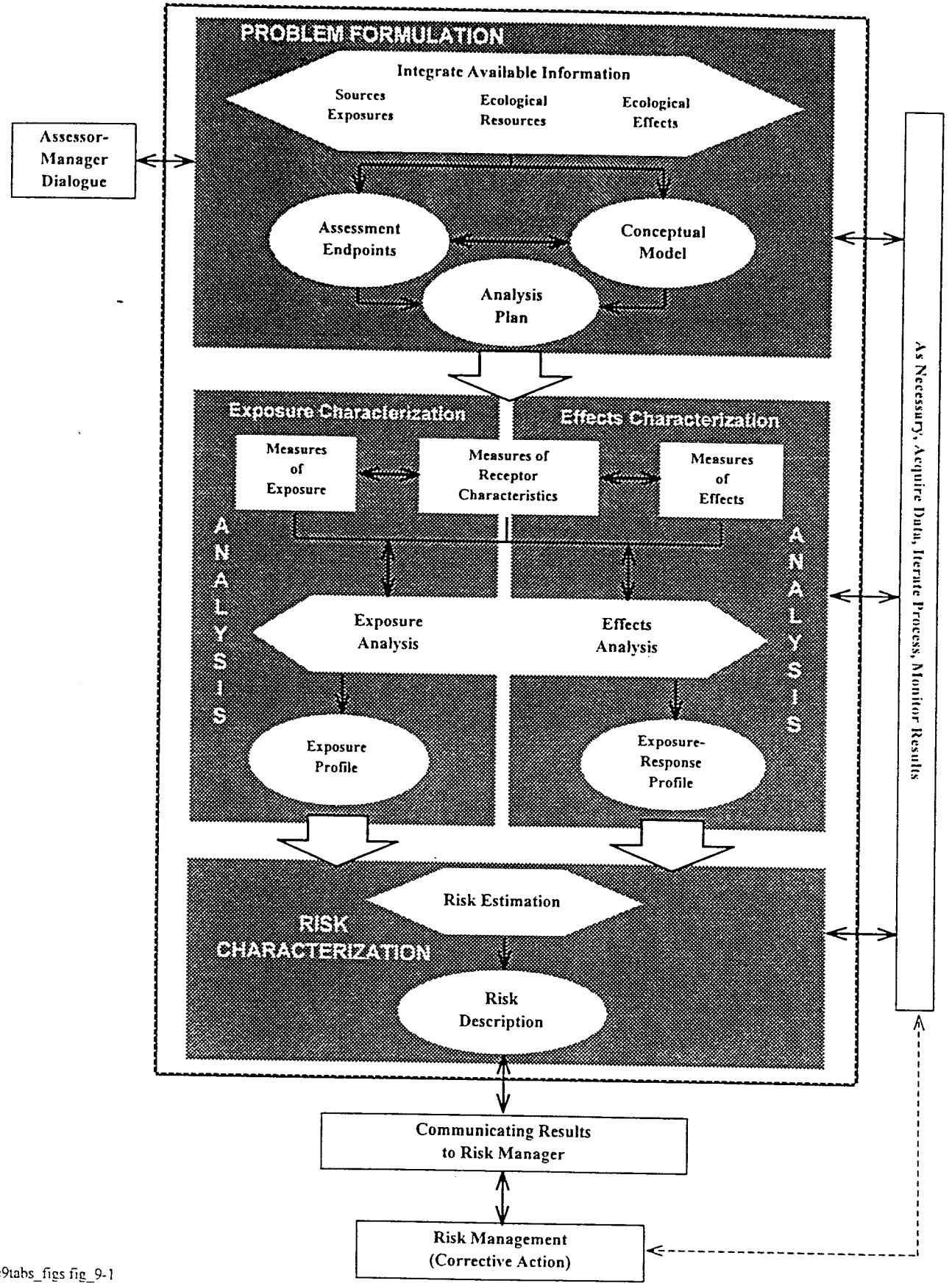
HQ_{LOAEL} = Hazard Quotient based on lowest-observed adverse effect

Values in Bold are HQs in excess of one

Shaded cells reflect no HQ calculation

FIGURE 9-1

FRAMEWORK FOR ECOLOGICAL RISK ASSESSMENT
SITE SD-11, CANNON AIRFORCE BASE, CURRY COUNTY, NEW MEXICO



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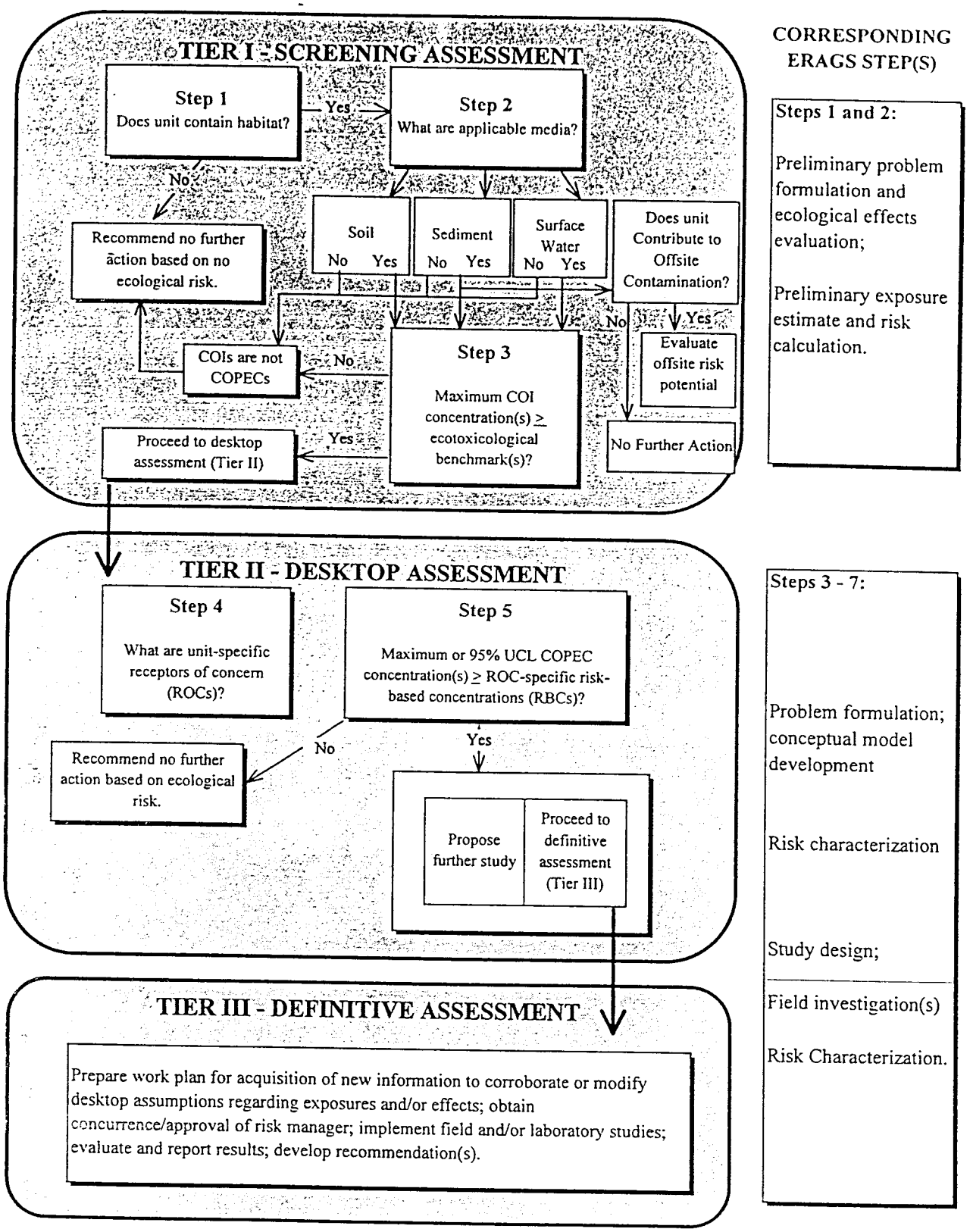
Adapted from USEPA 1998

FIGURE 9-2

ECOLOGICAL EVALUATION PROCESS FOR SITE SD-11, CANNON AIRFORCE BASE, CURRY COUNTY, NEW MEXICO



CORRESPONDING ERAGS STEP(S)

Steps 1 and 2:

Preliminary problem formulation and ecological effects evaluation;

Preliminary exposure estimate and risk calculation.

Steps 3 - 7:

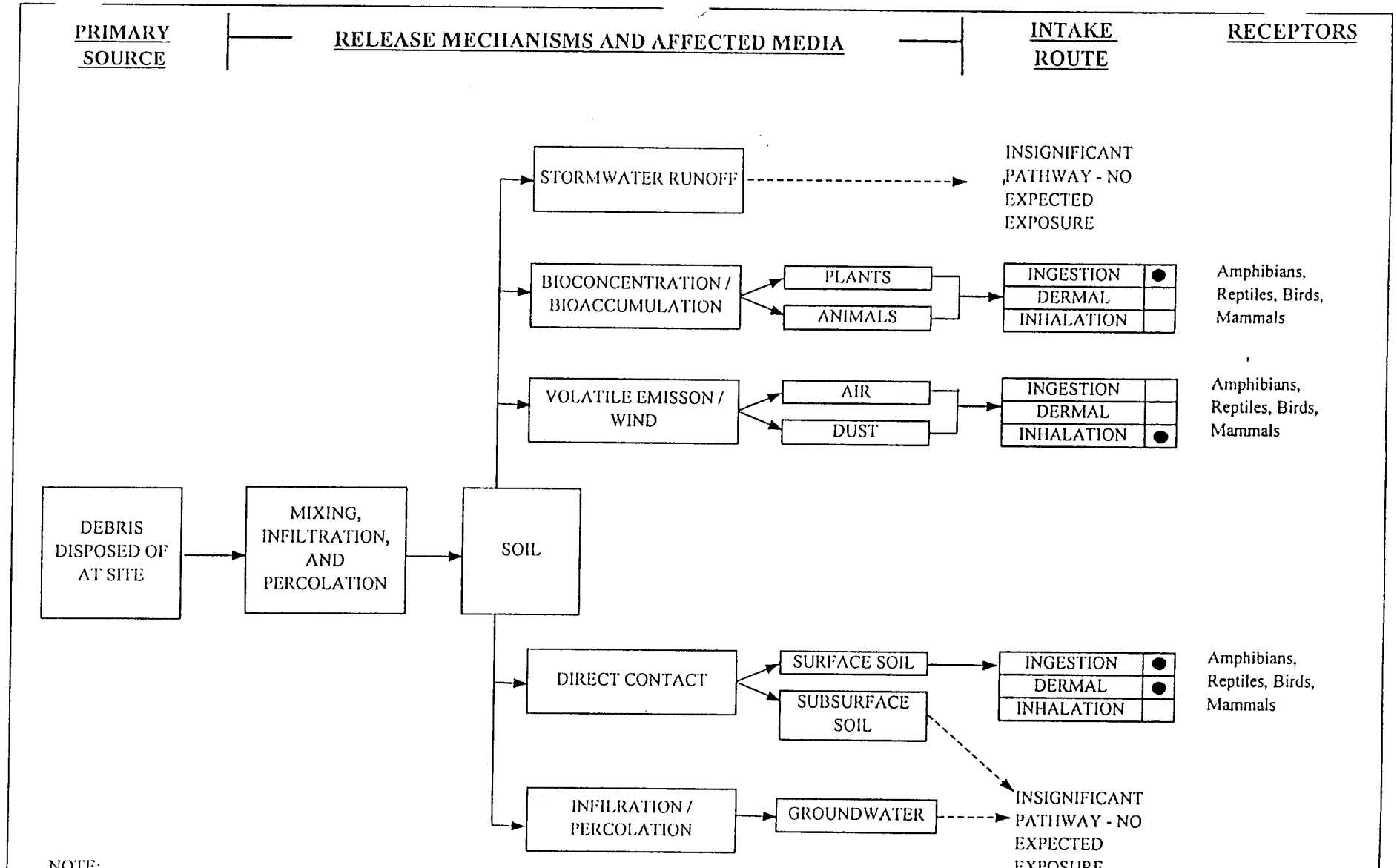
Problem formulation; conceptual model development

Risk characterization

Study design;

Field investigation(s)

Risk Characterization.



NOTE:
SOLID LINES REPRESENT POTENTIALLY COMPLETE PATHWAYS
DASHED LINES REPRESENT INCOMPLETE OR INSIGNIFICANT PATHWAYS

DRN BY MSG	DATE 04/26/99	SITE SD-11 CONCEPTUAL EXPOSURE MODEL ECOLOGICAL EXPOSURES CANNON AIRFORCE BASE NEW MEXICO	PROJECT NO. 45FOM9602V.00.06200	FIG. NO. 9 - 3
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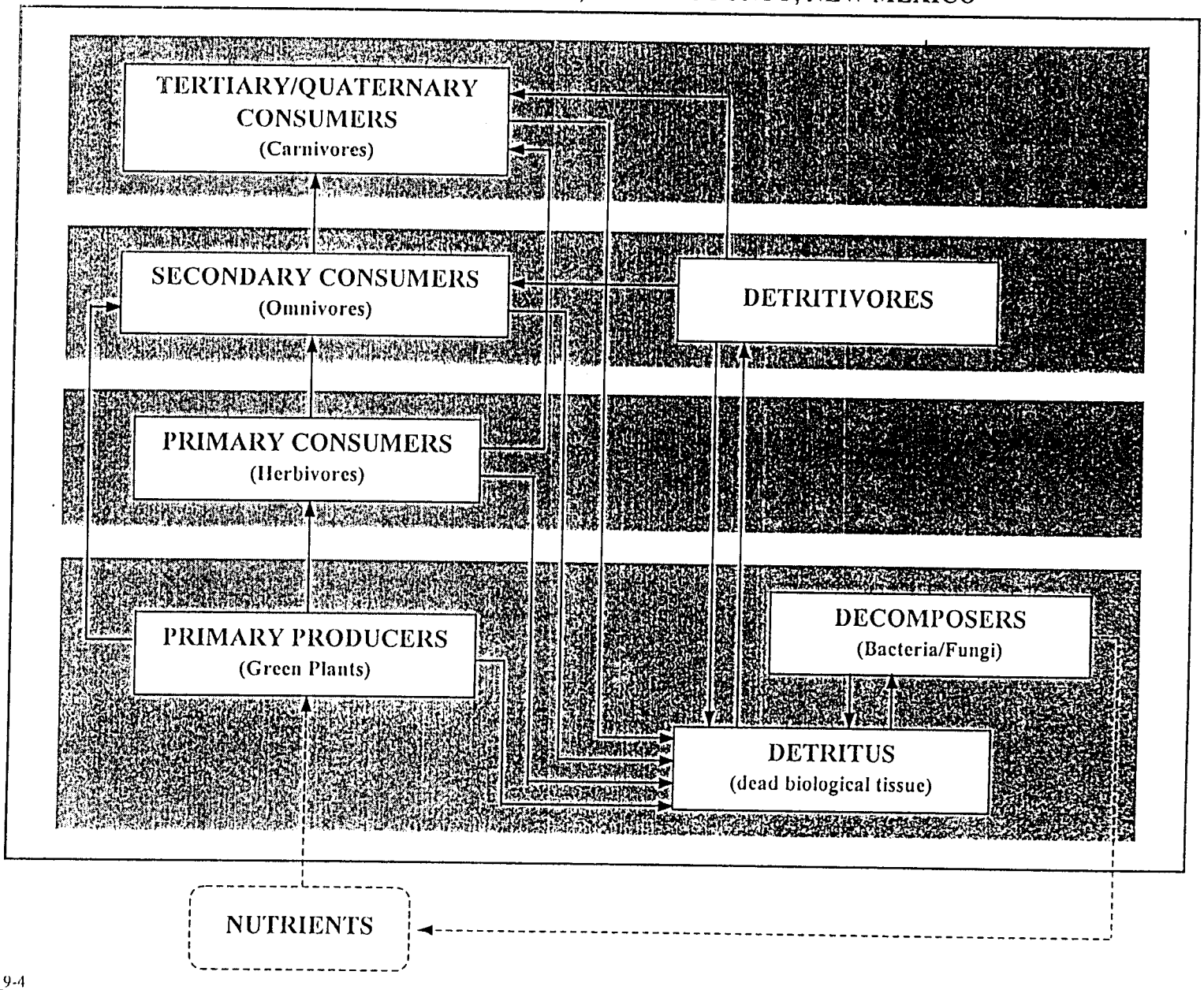
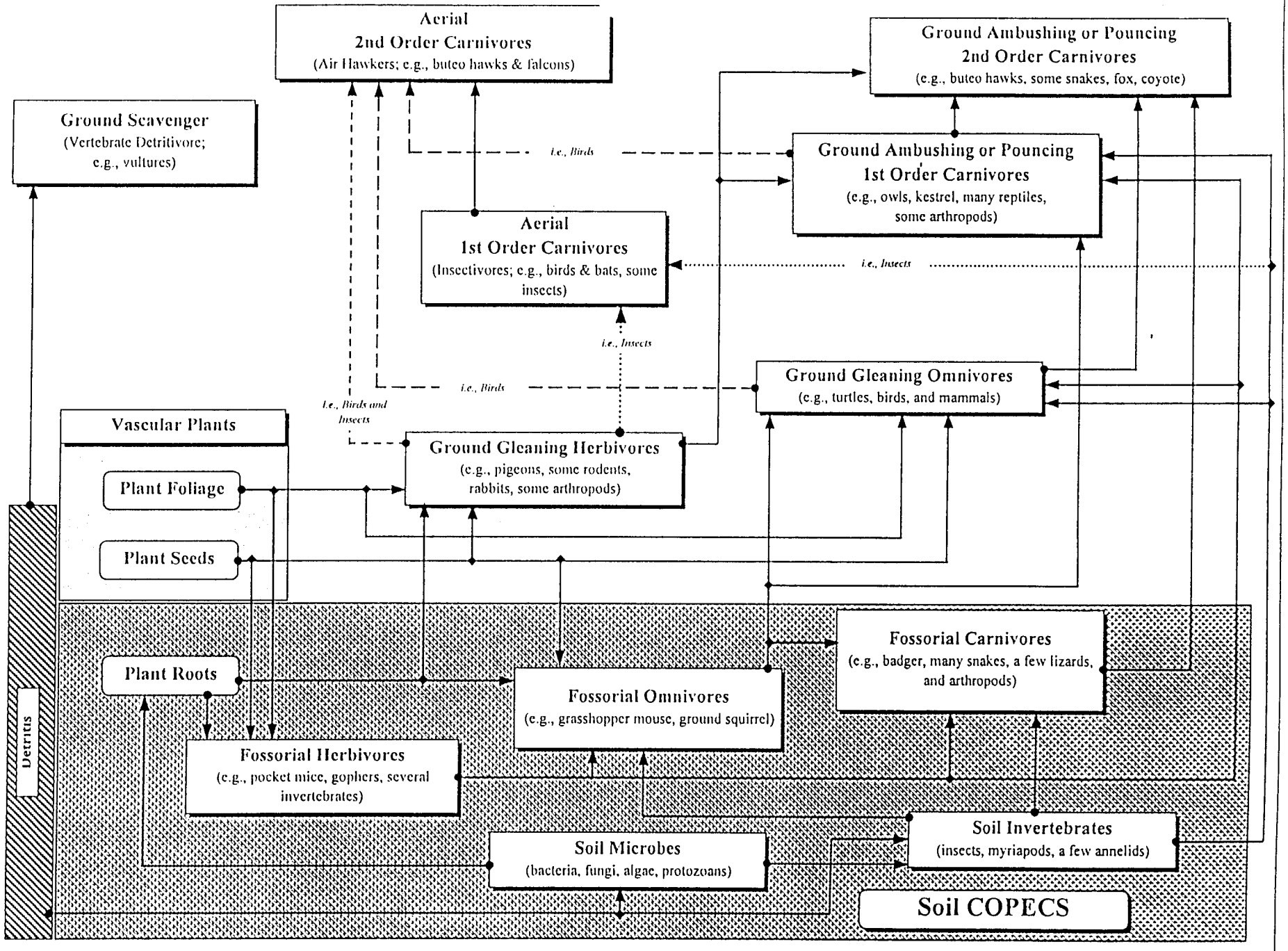
Drawing: sec9tabs_figs fig_9-3

FIGURE 9-4

BASIC FOOD WEB ORGANIZATION (APPLICABLE TO ANY ECOSYSTEM)
CANNON AIR FORCE BASE, CURRY COUNTY, NEW MEXICO



Arrows indicate flow of matter and energy.



DRN BY MSG	DATE 04/26/99	SITE SD-11 CONCEPTUAL FOODWEB MODEL ECOLOGICAL EXPOSURES CANNON AIRFORCE BASE NEW MEXICO	PROJECT NO. 45FOM9602V.00.06200	FIG. NO. 9 - 5
CHK'D BY	REVISIONS: 0			

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Drawing: sec9tabs_figs fig_9-5

Petroleum-related compounds have been detected in soils at Site SD-11 at Cannon AFB. To evaluate the potential for contaminants in soil to be transported to underlying groundwater, the fate and transport of contaminants in the vadose, or unsaturated, zone at Site SD-11 was modeled.

10.1 CONCEPTUAL VADOSE ZONE MODEL

Site operations associated with the release at Site SD-11 occurred from 1965 to 1988. The majority of site contamination has been detected in the area of the former oil/water separator which was removed from the site in 1994. At that time, contaminated soil was removed and taken to an off-site facility and the excavation was backfilled with a mixture of remaining stockpiled soil and clean, imported fill material.

As encountered in borings during the 1995 Phase III RFI, the geologic profile at Site SD-11 generally consists of about 5 feet of silty clay with fine-grained sand and 10 to 15 feet of clayey silt with sand, sandy silt, or silty sand underlain by fine-grained sand with silt and occasional caliche layers. Borings were terminated in the sand layer at depths ranging from 35 to 70 feet below ground surface (bgs). Backfill encountered in borings within the zone of excavation for the former oil/water separator ranged in depth from 5 to 15 feet and consisted primarily of silty clay with fine-grained sand and occasional gravel.

In order to make use of published, statistically based values for various parameters necessary for modeling of the system, the geologic profile as described as above was defined in terms of USDA soil texture classes. Because they can be discontinuous and/or fractured, the presence of caliche layers as a low permeability barrier was neglected for modeling purposes. The vadose zone profile, or schematic, used for modeling is shown in Figure 10-1. Soil descriptions on Figure 10-1 include Unified Soil Classification (USC) symbols.

Per the 1995 Phase III RFI, TPH, as an indicator parameter for organic chemical contamination in soil, was detected at a maximum depth of 60 feet in a boring that extended to 70 feet bgs with a sample interval of about 10 feet. For purposes of modeling, soil contamination was assumed to extend to 70 feet bgs as shown in Figure 10-1. The value of 265 feet as the depth of the bottom of unsaturated zone is based on the reported static water level in well registration records for the nearby Base water supply well (Well No. 9).

The indicator chemical used for modeling was benzo(a)pyrene, since this was the only chemical detected at Site SD-11 that was detected above MSSLs at a maximum concentration of 0.270 mg/kg. For modeling purposes, this concentration is assumed to be constant with depth for the entire zone of soil contamination (Figure 10-1).

10.2 HELP MODEL INPUT AND OUTPUT

The HELP model was used to estimate a net infiltration rate for input into MULTIMED for Site SD-11. HELP input parameters and model output for Site SD-11 are summarized in Tables 10-1 and 10-2, respectively.

10.2.1 Input

Soil and Design Data

The generalized cross-section shown on Figure 10-1 was used to define soil layers for the first 70 feet of depth. HELP default soil values for porosity, field capacity, wilting point, and saturated hydraulic conductivity were used for sandy clay loam (0'-10', HELP texture no. 10), sandy loam (10'-20', HELP texture no. 6), loamy sand (20'-35', HELP texture no. 4), and sand (35'-70', HELP texture no. 2). A HELP-computed runoff curve number was used for runoff calculations using a slope of 1 percent, slope length of 100 feet, soil texture = 10 (sandy clay loam), and vegetation condition = 1 (bare ground). Each layer was modeled as a vertical percolation layer. The soil moisture of each layer was initialized by the program.

Evapotranspiration Data

Amarillo, Texas was selected in the HELP default database as the nearest city to Clovis, New Mexico with similar climate. Evaporative zone depth was conservatively set at 12 inches for bare vegetative conditions. This is also the minimum evaporative zone depth for the area of the U.S. that includes Clovis, based on isocontour maps provided in Schroeder et al. 1994. The minimum leaf area index was set at 0.0 for bare ground. All other evapotranspiration parameters (growing season, wind speed, humidity) are default values for Amarillo.

Precipitation, Temperature, and Solar Radiation Data

The HELP synthetic weather generator was used to generate daily values of precipitation, temperature, and solar radiation using coefficients for Amarillo, Texas, the nearest city in the HELP default database to Clovis, New Mexico with similar climate. Mean monthly values of precipitation and temperature were adjusted using National Oceanic and Atmospheric Administration (NOAA) data from the Clovis, New Mexico weather station for the period of 1910 to 1998. Latitude for solar radiation was set at 34.42 degrees, which is the latitude reported for the Clovis weather station (latitude for Amarillo = 35.23 degrees). Daily values were generated for 100 years, the maximum allowed by the model.

10.2.2 Output

The HELP model for Site SD-11 was run for 100 years of simulation. Soil moisture was initialized by the program at or near the field capacity for each layer. Percolation values for each year of simulation are provided in Table 10-2. Annual percolation through the bottom layer (i.e., at 70 feet bgs) ranged from 0.0011 to 2.05 inches with an average value of 0.79 inches. Values

ranged from 0.0011 to 0.18 inches for the first 30 years of simulation, while soil moisture storage steadily increased, and then ranged from 0.44 to 2.05 inches for the remainder of the 100 year period, while soil moisture storage was relatively constant. Peak daily value of infiltration for the 100-year period was 0.0114 inches. Annual rates compare favorably to the reported estimates of 0.5 to 1.0 inches per year for recharge rates to the Ogallala aquifer at Cannon AFB (Section 3.5).

Based on the results described above, a net infiltration of 2 inches per year for Site SD-11 was selected for input into MULTIMED. This is believed to be a conservative estimate of infiltration rate for the site based on the following:

- In general, the HELP model has been shown to overpredict percolation rates (i.e., vertical moisture flux) in semi-arid and arid climates (Fleenor and King 1995). The HELP model's flow algorithm is primarily based on gravity drainage and field capacity concepts. Under more arid conditions, capillary forces, which have an upward gradient, should also be considered (Mulkey et al. 1989).
- Additional storage in remainder of vadose zone (70 to 265 feet bgs) is neglected by the model. This would lower the amount of percolation through the bottom layer if it were extended to the water table.
- The maximum, rather than the average, annual infiltration from the 100-year simulation period was selected.

10.3 MULTIMED MODEL INPUT AND OUTPUT

MULTIMED was used to model contaminant migration at Site SD-11 from the contaminated soil zone through the vadose zone to the water table. Because the model must balance contaminant mass flux entering and leaving the initial mixing zone in groundwater directly below the facility or contaminated soil area, aquifer parameters were also input. Although not a primary goal of contaminant fate and transport modeling at Site SD-11, the input of aquifer parameters also allows for the evaluation of the dilution effects of initial mixing in groundwater.

To compare results and determine the most appropriate scenario for evaluating transport of contaminants in soil at Site SD-11 to groundwater, MULTIMED was run under steady-state, pulse source, and source decay conditions while considering both sorption and sorption/biodegradation as attenuation mechanisms. The numerical unsaturated transport module of Version 2.00, which allows for consideration of non-linear adsorption, depth-varying initial vadose zone concentrations, time-varying infiltration rates (on an annual basis), and volatilization from the unsaturated zone, was not used for this analysis.

MULTIMED input parameters and model output for Site SD-11 are summarized in Tables 10-3 and 10-4, respectively.

10.3.1 Input

Source-Specific Parameters

The infiltration rate was set at 2.0 inches per year, based on output from the HELP model (Section 10.3). Recharge rate, or the net amount of water that percolates into the aquifer outside of the areal extent of the contaminated soil zone, was set equal to the infiltration rate. Area is assumed to be about 100 feet by 100 feet, based on site characteristics. The initial concentration for benzo(a)pyrene was set at 1.0 mg/L, since model response is linear with this parameter (Sharp-Hansen et al. 1995). This allows for the calculation of an attenuation or dilution-attenuation factor (DAF) that can be divided into a source concentration of any magnitude to calculate a concentration at the bottom of the unsaturated zone or at a chosen receptor point in the aquifer.

A source decay constant of 0.069 year $^{-1}$, based on 10-year half-life, was input for source decay model runs. Degradation half-lives reported in Howard et al. 1991 for benzo(a)pyrene are 1.45 years for soil and 5.8 years for aqueous, anaerobic conditions. Therefore, a constant equivalent to a half-life of 10 years is considered to be conservative. For pulse source model runs, a pulse duration of 100 years was used which provides a greater contaminant source mass than that of a 10-year half-life source decay condition.

Chemical-Specific Parameters

The normalized organic carbon distribution coefficient, K_{oc}, for benzo(a)pyrene is taken from the Soil Screening Guidance Technical Background Document (USEPA 1996), as compiled and evaluated from various sources. The distribution coefficient, K_d, is calculated as the product of K_{oc} and fraction organic carbon content. The biodegradation coefficient for the saturated zone is input as 0.0.

Unsaturated Flow Parameters

Values for saturated hydraulic conductivity and porosity are taken from default values for HELP texture no. 2 (sand) (Schroeder et al. 1994). Values for air entry pressure head and residual water content for sand are taken from Rawls et al. 1992. Van Genuchten coefficients, $\alpha$and β, used to define the relationship between relative permeability and water saturation are taken from Carsel and Parrish 1988. The layer thickness or unsaturated zone depth is calculated by subtracting the depth of the bottom of the contaminated soil zone (70 feet) from the estimated depth of the water table (265 feet).

Unsaturated Transport Parameters

Since calculation using the MULTIMED regression equation provided in Sharp-Hansen et al. 1995 exceeds 1.0 m, the longitudinal dispersivity for the unsaturated zone layer is set at the maximum value of 1.0 m for deep unsaturated zones. Percent organic matter is set at 0.07, based on the median value for sand (hydrologic soil group A) at 0.9-1.2 m from the table of data

provided in Sharp-Hansen et al. 1995 and referenced from other sources. Fraction organic carbon content is calculated by dividing percent organic matter by 172.4. Dry bulk density is calculated using porosity and assumed specific gravity of 2.65. Biological decay coefficient for models runs that consider biodegradation is set at a 1st order decay rate 0.069 year $^{-1}$, based on 10-year half-life for benzo(a)pyrene.

Aquifer-Specific Parameters

Aquifer porosity is assumed to be 0.40 for a typical sand aquifer. Particle diameter is set at 0.2 cm, but is not used by the model since porosity is input directly. Dry bulk density is calculated using aquifer porosity and assumed specific gravity of 2.65. Aquifer thickness is based on an estimated average thickness for the Ogallala aquifer at Cannon AFB of 120 feet (Section 3.5). Mixing zone depth, or aquifer source thickness, is derived by the model. Groundwater seepage velocity is calculated by Darcy's Law using a hydraulic conductivity of 1.0 x 10-2 cm/sec (Section 3.5), hydraulic gradient of 7.5 feet/mile (Section 3.5), and porosity of 0.40. The value for porosity is taken from the general range for sand of 0.25 to 0.40, with a maximum of 0.50, reported in various references (e.g., Freeze and Cherry 1979, Todd 1980). Retardation coefficient is derived by the model using dry bulk density, contaminant distribution coefficient, and porosity. Longitudinal, transverse, and vertical dispersivities are derived by the model using research-based regression equations as described in Sharp-Hansen et al. 1995. Aquifer temperature and pH is set at 12°C and 6.8, respectively. Organic carbon content is calculated using percent organic matter of 0.07. Well distance from site is set at 1.0 m to evaluate initial mixing zone dilution.

10.3.2 Output

MULTIMED output for Site SD-11 under various source conditions and transport processes is summarized in Table 10-4. Active transport processes shown in the table refer only to the unsaturated zone. The calculated DAF represents attenuation in the vadose zone and, because the well distance for the saturated zone is only a short distance (1.0 m) from the source, primarily dilution in the initial groundwater mixing zone.

When using MULTIMED for steady-state analyses, which assume a constant, infinite source, sorption/retardation has no effect on output concentrations unless transport decay is also considered. Under these conditions, the concentration at the bottom of the unsaturated zone is assumed to be equal to the initial leachate concentration (i.e., contaminant is assumed to have achieved breakthrough in vadose zone).

For non-transport decay conditions (dispersion + sorption only), calculated attenuation factors are 1.0 (steady-state), 3,700 (100 year pulse source), and 26,000 (10 year source decay half-life). Calculated DAFs at the water table 1.0 m downgradient of the source are 4.6 (steady-state) and 19,000 (100 year pulse source). The program would not calculate maximum saturated zone concentrations for the source decay condition. However, based on other runs, the DAF would likely be about 26,000 x 5 = 130,000.

For transport decay, or biodegradation, conditions, all runs resulted in a concentration of 0.0 at the bottom of the unsaturated zone. The same results where achieved when the transport decay half-life was increased from 10 to 100 years.

Based on the results described above, the AF for the 100 year pulse source, non-transport decay model run was selected for predicting the concentration of benzo(a)pyrene at the bottom of the vadose zone. This is believed to be a conservative approach based on the following:

- At a minimum, some amount of source decay due to biodegradation and/or volatilization would be expected to occur given the conditions at the site (e.g., low precipitation, high evapotranspiration). However, the source decay constant can be difficult to estimate.
- Conversely, because of the contaminant source mass is expected to decrease over time, the assumption of a constant, infinite source for Site SD-11 is believed to be unrealistic and over-conservative.
- Similar to source decay, the rate of biodegradation can be difficult to estimate, particularly in a deep, unsaturated zone, where microbial activity can be limited.

Therefore, the 100 year pulse, non-transport decay condition is used as the worst case scenario for Site SD-11 with an AF of 3,700 and a DAF of 19,000. When transport decay is considered, the concentration at the bottom of the vadose zone decreases to 0.0.

10.4 MODEL-PREDICTED CONCENTRATIONS

The concentration of benzo(a)pyrene at the bottom of the vadose zone was predicted by calculating an initial leachate concentration using equilibrium partitioning and multiplying by the calculated AF from Section 10.4.2. The initial concentration is calculated using the following equation from the Soil Screening Guidance Technical Background Document (USEPA 1996):

$$Cs = Cw \cdot \left[Kd + \frac{\theta w + \theta a \cdot H'}{\rho b} \right]$$

In the above equation, Cw is the initial leachate concentration and Cs is the soil concentration (0.270 mg/kg). Kd is the distribution coefficient ($K_{oc}*f_{oc}$ = 408 L/kg), θw is water-filled soil porosity (0.24), θa is the air-filled soil porosity (0.16), H' is the dimensionless Henry's law constant (4.63×10^{-5}), and ρb is the dry bulk density (1.60 kg/L). Porosity and bulk density are taken from the HELP layer 1 (sandy clay loam) at field capacity. The value for H' is the value listed for benzo(a)pyrene in USEPA 1996. Other values are the same as used in the MULTIMED model.

Therefore, the calculated value of the initial leachate concentration, Cw, is 0.00066 mg/L. Multiplying this concentration by an AF of 3,700 yields a predicted concentration at the bottom of the vadose zone of 1.8×10^{-7} mg/L. Without even accounting for initial mixing in groundwater, which would lower the value by another order of magnitude, the predicted value is below the

EPA Region VI tap water MSSL of 9.2×10^{-6} mg/L and well below the MCL of 0.0002 mg/L for benzo(a)pyrene. If biodegradation is considered as described in Section 10.4.2, the predicted concentration at the bottom of the vadose zone would be 0.0.

10.5 ASSUMPTIONS AND LIMITATIONS

The results of the vadose zone contaminant fate and transport modeling at Site SD-11 are based on a conservative, analytical approach with many simplifying assumptions. Primary among these is the assumption of constant flow in the unsaturated zone. The steady-state infiltration rate of 2.0 inches per year used for modeling is at least twice the value of reported estimates for recharge rates to the Ogallala aquifer of 0.5 to 1.0 inches per year (Section 3.5). However, due to high evapotranspiration and low precipitation (i.e., semi-arid climate), recharge likely only occurs during heavy rainfall events or during cool months when precipitation exceeds evapotranspiration.

In shallow soil systems, recharge is very dynamic and tends to follow the patterns and quantities of precipitation (Mulkey et al. 1989). Assuming steady-state conditions in a system that exhibits transient behavior may produce inaccurate results and may underestimate contaminant concentrations (Sharp-Hansen et al. 1995). The "spikeness" (i.e., temporal variation) of the recharge, however, decreases with depth, resulting for many studies in the assumption of steady or constant recharge conditions (Mulkey et al. 1989). Therefore, for modeling at Site SD-11, the use of a constant infiltration rate assumes that there is significant depth from the contaminated soil zone to the water table (approximately 200 feet) such that recharge, or infiltration, in the vadose zone approaches a steady-state, or constant, rate.

Although not evaluated by this study, implementation of a more complex, numerical model (e.g., typical for RBCA Tier 3) would most likely produce results that are more representative of actual flow and transport processes that occur at Site SD-11. The use of a numerical model might even result in lower predicted concentrations at the water table for similar assumed source conditions. This is based on the observation that some important unsaturated flow processes that presumably occur at the site, due to its semi-arid climate, are not necessarily accounted for in the models used. These include the effects of capillary forces and hysteresis in the soil system.

Table 10-1

Summary of HELP Input Parameters
Cannon AFB Site SD-11

Parameter	Units	Value	Comments
Soil and Design Data			
Layer 1 - Sandy clay loam			
Thickness	in	120	= 10 feet
Porosity	vol/vol	0.398	HELP texture no. 10
Field Capacity	vol/vol	0.244	HELP texture no. 10
Wilting Point	vol/vol	0.136	HELP texture no. 10
Saturated hydraulic conductivity	cm/sec	1.2E-04	HELP texture no. 10
Layer 2 - Sandy loam			
Thickness	in	120	= 10 feet
Porosity	vol/vol	0.453	HELP texture no. 6
Field Capacity	vol/vol	0.190	HELP texture no. 6
Wilting Point	vol/vol	0.085	HELP texture no. 6
Saturated hydraulic conductivity	cm/sec	7.2E-04	HELP texture no. 6
Layer 3 - Loamy sand			
Thickness	in	180	= 15 feet
Porosity	vol/vol	0.437	HELP texture no. 4
Field Capacity	vol/vol	0.105	HELP texture no. 4
Wilting Point	vol/vol	0.047	HELP texture no. 4
Saturated hydraulic conductivity	cm/sec	1.7E-03	HELP texture no. 4
Layer 4 - Sand			
Thickness	in	420	= 35 feet
Porosity	vol/vol	0.437	HELP texture no. 2
Field Capacity	vol/vol	0.062	HELP texture no. 2
Wilting Point	vol/vol	0.024	HELP texture no. 2
Saturated hydraulic conductivity	cm/sec	5.8E-03	HELP texture no. 2
Evapotranspiration Data			
Evaporative zone depth	in	12	bare vegetation - minimum for area
Maximum leaf area index		0.0	bare ground
Start of growing season	day	95	Amarillo, Texas
End of growing season	day	303	Amarillo, Texas
Average annual wind speed	mph	13.7	Amarillo, Texas
Average 1st quarter relative humidity	%	55.0	Amarillo, Texas
Average 2nd quarter relative humidity	%	52.0	Amarillo, Texas
Average 3rd quarter relative humidity	%	57.0	Amarillo, Texas
Average 4th quarter relative humidity	%	57.0	Amarillo, Texas
Precipitation, Temperature, and Solar Radiation Data			
Station latitude	degrees	34.42	Clovis, NM weather station

Normal Mean Monthly Precipitation (in) - Clovis, NM NOAA data (1910-1998)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0.43	0.43	0.60	1.05	2.09	2.62	2.65	2.95	2.15	1.62	0.57	0.61

Normal Mean Monthly Temperature (F) - Clovis, NM NOAA data (1910-1998)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
37.0	41.2	47.2	56.6	65.5	74.4	77.6	76.1	69.2	58.5	46.3	38.3

Table 10-2

Summary of HELP Output
Cannon AFB Site SD-11

Year	Percolation Through Layer 4 (in)	Year	Percolation Through Layer 4 (in)	Year	Percolation Through Layer 4 (in)
1	0.0037	41	1.41	81	1.72
2	0.0041	42	0.78	82	1.33
3	0.0045	43	1.17	83	1.47
4	0.0041	44	0.98	84	1.34
5	0.0011	45	0.66	85	0.92
6	0.0012	46	0.91	86	1.16
7	0.0018	47	0.47	87	0.98
8	0.0026	48	0.66	88	0.61
9	0.0023	49	0.96	89	1.43
10	0.0038	50	1.27	90	1.24
11	0.005	51	0.99	91	1.14
12	0.0055	52	0.59	92	1.46
13	0.0053	53	1.2	93	1.15
14	0.0046	54	0.81	94	0.66
15	0.005	55	1.02	95	1.18
16	0.005	56	1.65	96	1.1
17	0.0048	57	0.66	97	1.01
18	0.0044	58	1.69	98	0.9
19	0.0042	59	1.69	99	0.81
20	0.0045	60	1.39	100	0.85
21	0.0042	61	1.55		
22	0.0059	62	1.43	Average	0.79
23	0.0055	63	1.46	Minimum	0.0011
24	0.0053	64	1.32	Maximum	2.05
25	0.013	65	0.98		
26	0.022	66	1.32		
27	0.035	67	1.48		
28	0.032	68	1.03		
29	0.019	69	1.01		
30	0.18	70	1.2		
31	0.59	71	1.72		
32	0.46	72	2.05		
33	0.44	73	1.45		
34	0.71	74	1.56		
35	0.6	75	1.95		
36	0.77	76	1.37		
37	0.64	77	1.19		
38	0.99	78	1.39		
39	1.06	79	1.11		
40	1.06	80	1.51		

Table 10-3

Summary of MULTIMED Input Parameters
Cannon AFB Site SD-11

Parameter	Units	Value	Comments
Source-Specific			
Infiltration rate	m/yr	0.051	= 2.0 in/yr
Recharge rate	m/yr	0.051	= 2.0 in/yr
Area	m^2	1,000	≈ 100' x 100'
Length	m	derived	model-calculated (=area$^{1/2}$)
Width	m	derived	model-calculated (=area$^{1/2}$)
Initial concentration	mg/L	1.0	
Source decay constant	1/yr	0.069	half-life = 10 years
Duration of pulse	yr	100	
Spread of contaminant source	m	derived	model-calculated (=width/6)
Chemical-Specific			
Normalized organic carbon distribution	mL/g	1.02E+06	benzo(a)pyrene
Distribution coefficient, K_d	mL/g	derived	model-calculated (=K_{oc}*f_{oc})
Biodegradation coefficient (sat. zone)	1/yr	0.0	
Unsaturated Flow			
Saturated hydraulic conductivity	cm/hr	21.0	HELP texture no. 2 (sand)
Porosity		0.437	HELP texture no. 2 (sand)
Air entry pressure head	m	0.0726	Rawls et al. 1992 (sand)
Number of layers		1	
Thickness of layer	m	59	= 195 feet
Residual water content		0.020	Rawls et al. 1992 (sand)
Van Genuchten alpha coefficient	1/cm	0.145	Carsel and Parrish 1988 (sand)
Van Genuchten beta coefficient		2.68	Carsel and Parrish 1988 (sand)
Unsaturated Transport			
Longitudinal dispersivity	m	1.0	maximum value for deep unsat. zones
Percent organic matter	%	0.07	
Bulk density	g/cm^3	1.49	= specific gravity * (1 - porosity)
Biological decay coefficient	1/yr	0.069	decay - organic
Aquifer-Specific			
Porosity		0.40	
Particle diameter	cm	0.2	
Bulk density	g/cm^3	1.59	= specific gravity * (1 - porosity)
Aquifer thickness	m	37	= 120 feet
Mixing zone depth	m	derived	model-calculated
Hydraulic conductivity	m/yr	3,200	= 1.0 x 10^{-2} cm/sec
Hydraulic gradient		0.0015	= 7.5 feet/mile
Groundwater seepage velocity	m/yr	12	calc. by Darcy's Law
Retardation coefficient		derived	model-calculated
Longitudinal dispersivity	m	derived	model-calculated
Transverse dispersivity	m	derived	model-calculated
Vertical dispersivity	m	derived	model-calculated
Aquifer temperature	C	12	
pH		6.8	
Organic carbon content, f_{oc}		0.0004	calc. using % org. matter = 0.07
Well distance from site	m	1.0	
Angle off center	degrees	0.0	
Well vertical distance	m	0.0	

Table 10-4

Summary of MULTIMED Output
Cannon AFB Site SD-11

Model Run	Source Conditions			Active Transport Processes			C_i (mg/L)	Unsaturated Zone Output		Saturated Zone Output	
	Steady-State	100 Year Pulse	10 Yr Half-Life	Dispersion	Adsorption	Biodegradation		$(C_u)_{max}$ (mg/L)	AF	$(C_s)_{max}$ (mg/L)	DAF
SD11S	✓			✓			1.0	1.0	1.0	0.2176	4.6
SD11SB	✓			✓		✓	1.0	0.0	-	0.0	-
SD11PS		✓		✓	✓		1.0	0.00027	3,700	5.4E-05	19,000
SD11PSB		✓		✓	✓	✓	1.0	0.0	-	0.0	-
SD11DS			✓	✓	✓		1.0	3.9E-05	26,000	-	-
SD11DSB			✓	✓	✓	✓	1.0	0.0	-	0.0	-

C_i = initial concentration at source

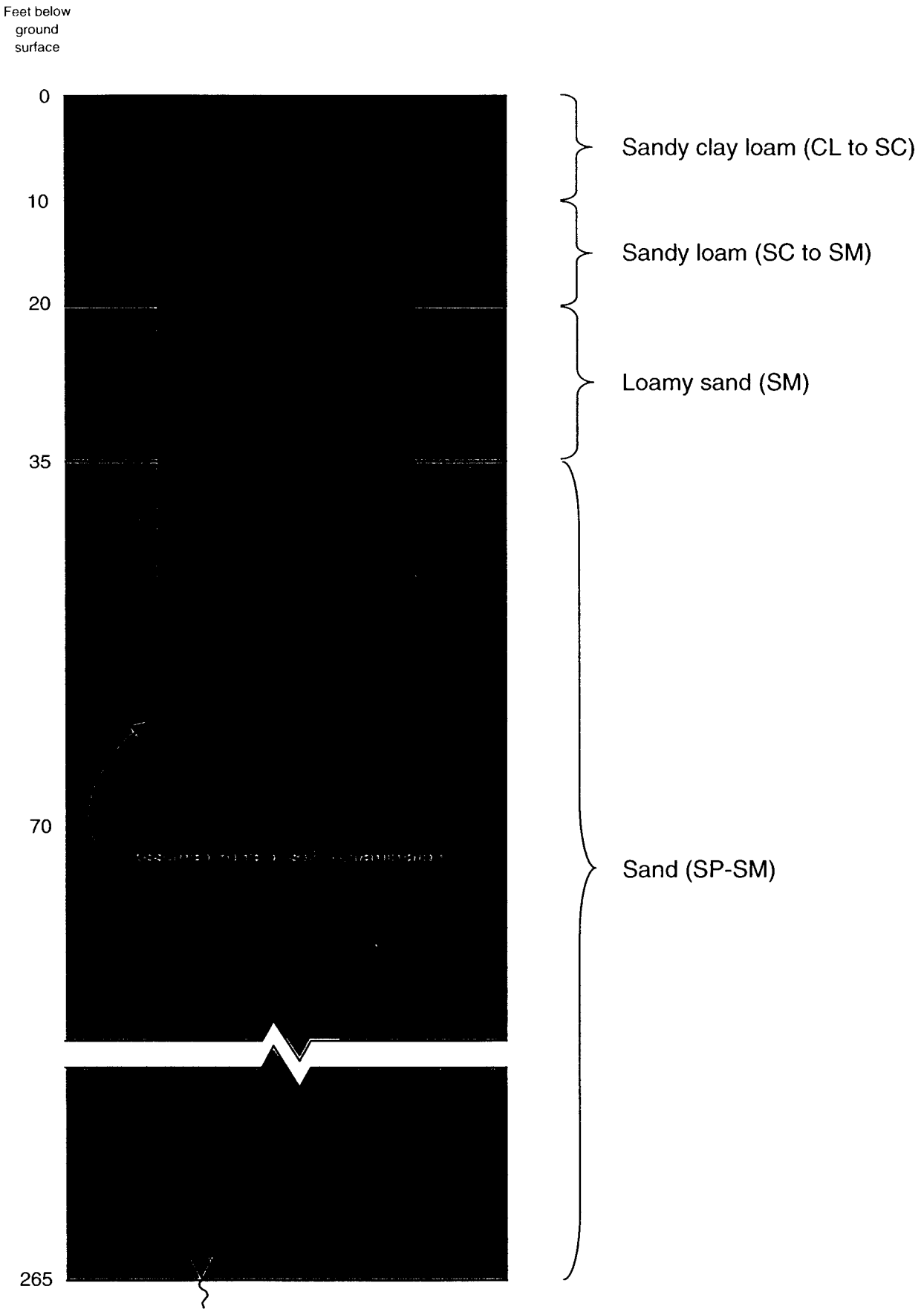
$(C_u)_{max}$ = maximum concentration at bottom of unsaturated zone

AF = attenuation factor for unsaturated zone (= C_i / $(C_u)_{max}$)

$(C_s)_{max}$ = maximum concentration at water table 1.0 m downgradient of source

DAF = dilution-attenuation factor at water table 1.0 m downgradient of source (= C_i / $(C_s)_{max}$)

"-" indicates concentration was not calculated by model or factor is not applicable



DRN. BY: JMR	DATE: 4/28/99	APPENDIX I SWMUs 86-90 (SD-11) VADOSE ZONE MODEL SCHEMATIC	FIG. NO.: 10-1
PROJ. NO.: 45F0M9602V.00	REVISION: 0	CANNON AFB, NEW MEXICO	

Results of the human health and ecological risk evaluations indicate that there is minimal risk to human health and the environment based on the maximum detected concentrations of chemicals of concern in soil at Site SD-11. Furthermore, results of vadose zone fate and transport modeling show that chemicals of concern will not reach groundwater above allowable concentrations for tap water. Therefore, the "No Further Action' alternative was evaluated based on the criteria listed in Section 2.3 and as outlined in the CMS Work Plan (W-C 1998).

1. Technical

- Performance - the No Further Action alternative is effective at being protective of human health and the environment over extended periods of time. This has been demonstrated through Tier I and Tier II human health and ecological risk evaluations, and fate and transport modeling.
- Reliability - the No Further Action alternative does not require any operation or maintenance activities and has been proven to be effective before for similar sites and conditions.
- Implementability - the No Further Action alternative is easy to implement and will meet or exceed applicable standards.
- Safety - the No Action Alternative poses no threat to the safety of nearby workers.

2. Human Health

- The No Further Action alternative was determined following the Risk-Based Corrective Action (RBCA) process as outlined in ASTM E1739-95, *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites.*
- Maximum concentrations of chemicals of concern left in place are less than conservative Tier I EPA Region VI Media Specific Screening Levels (MSSLs) and calculated Tier II Site-Specific Target Levels (SSTLs).

3. Environmental

- Maximum concentrations of chemicals of concern left in place pose no significant risk to ecological receptors based on Tier I and Tier II evaluations following EPA and USACE guidance.

4. Cost

- The No Further Action alternative is protective of human health and the environment and at the lowest cost.

The following discussion presents a brief summary of the major findings of the CMS Report for Site SD-11, including physical characteristics, nature and extent of contamination, risk evaluations, fate and transport modeling, and corrective measure alternative. These findings are based on the Phase III RFI and CMS investigations.

Physical Characteristics

- Site SD-11 (SWMUs 86-90) is located in the sparsely populated southeast part of Cannon AFB, near Building 2330. The site consists of a former engine test cell (SWMU 86), former overflow pit (SWMU 87), former leach field (SWMU 88) which was later converted to an evaporation pond (SWMU 89), and a former oil/water separator with associated 100-gallon collection tank (SWMU 90). The oil/water separator (OWS) system and much of the petroleum-contaminated soil was removed.
- The topography of the site is relatively flat. Jet engines are periodically tested outdoors on the remaining concrete pad.
- The shallow geology of the site consists of silty clay with fine sand, clayey silt with fine sand, sandy silt, and /or silty sand underlain by fine-grained sand with silt. The fine-grained sand begins at depths of 15 to 20 feet below ground surface and contains cemented zones or layers of caliche. These alluvial sediments are part of the Ogallala Formation. Depth to groundwater is more than 250 feet below ground surface.

Nature and Extent of Contamination

- The extent of contamination at the site is generally defined by TRPH concentrations detected in soil. In the area of the OWS removal low to moderate levels of TRPH (< 1,000mg/kg) were detected within and above the excavation. Moderate to high concentrations (> 1,000 mg/kg) of TRPH were detected in soils directly below the area of the excavation. Concentrations of TRPH decreased with depth to nondetect below the area of the excavation. VOCs and SVOCs generally followed the same trend as TRPH.
- Low levels of TRPH (<150 mg/kg) were detected in the area of the former leach field / evaporation pond to a depth of 40 feet below ground surface. No VOCs were detected and only low levels of two SVOCs were detected in this area.

Human Health Risk Evaluation

- Only benzo(a)pyrene exceeded the Tier I (EPA Region VI MSSL) screening level for residential exposures.
- The calculated acceptable Tier II (SSTL) level for benzo(a)pyrene was 0.43 mg/kg which is above the maximum detected concentration of 0.27 mg/kg; therefore there appears to be minimal risk to human health.

Ecological Risk Evaluation

- The average daily doses and resultant hazard quotients for ten chemicals of potential concern were calculated to characterize the potential exposure and risks to representative ecological

receptors of concern. These hazard quotients were below levels of concern, therefore there appears to be minimal risk to the environment.

Fate and Transport Modeling

- Since benzo(a)pyrene in soil exceeded EPA Region VI MSSLs for residential exposures its potential to be transported to underlying groundwater was evaluated using a fate and transport model.
- Using conservative input parameters the model predicted concentrations of benzo(a)pyrene to range from nondetect to levels significantly below its EPA Region VI tap water MSSL and its MCL.

Corrective Measures Alternative

- The No Further Action alternative was recommended based on the results of the RFI and CMS investigations, human health and ecological risk evaluations, and fate and transport modeling.

A.T. Kearney, Inc. 1987. Preliminary Review/VSI Report, RCRA Facility Assessment. Cannon Air Force Base. U.S. Environmental Protection Agency, Region VI, by A.T. Kearney, Inc. Chicago, Illinois.

Abernethy, S.G., and D. Mackay. 1988. "Volume fraction" correlation for narcosis in aquatic organisms: the key role of partitioning. Environmental Toxicology and Chemistry 7:469-481.

Alexander, M. 1993. *Introduction to Soil Microbiology*. Second Edition. John Wiley & Sons, New York.

Allee, W.C., A.E. Emerson, O. Park, T. Park, and K.P. Schmidt. 1951. *Principles of Animal Ecology*. W.B. Saunders Company. Philadelphia, Pennsylvania.

American Society for Testing and Materials (ASTM). 1995. *Standard Guide for Developing Conceptual Site Models for Contaminated Sites*. Designation E 1689-95. 1995 Annual Book of ASTM Standards. Philadelphia, Pennsylvania.

American Society for Testing and Materials (ASTM). 1996. Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites, Designation: E 1739-95^{E1}. From the Annual Book of ASTM Standards.

American Society for Testing and Materials (ASTM). 1999. RBCA Fate and Transport Models: Compendium and Selection Guidance. Prepared by Foster Wheeler Environmental Corporation, November 1998.

Agency for Toxic Substances and Disease Registry (ATSDR). 1989a. *Toxicological Profile for bis(2-chloroethyl)ether*. U.S. Dept. Health and Human Services, Public Health Service, Washington, DC.

Agency for Toxic Substances and Disease Registry (ATSDR). 1989a. *Toxicological Profile for Chloroethane*. U.S. Dept. Health and Human Services, Public Health Service, Washington, DC.

Agency for Toxic Substances and Disease Registry (ATSDR). 1989b.

Agency for Toxic Substances and Disease Registry (ATSDR). 1989c. *Toxicological Profile for 3,3-Dichlorobenzidine*. U.S. Dept. Health and Human Services, Public Health Service, Washington, DC.

Agency for Toxic Substances and Disease Registry (ATSDR). 1989d. *Toxicological Profile for 2,4-Dinitritoluene, 2,6-Dintrotoluene*. U.S. Dept. Health and Human Services, Public Health Service, Washington, DC.

Agency for Toxic Substances and Disease Registry (ATSDR). 1989e. *Toxicological Profile for n-Nitrosodi-n-propylamine (DNP).* U.S. Dept. Health and Human Services, Public Health Service, Washington, DC.

Agency for Toxic Substances and Disease Registry (ATSDR). 1990a. *Toxicological Profile for Nitrobenzene.* U.S. Dept. Health and Human Services, Public Health Service, Washington, DC.

Agency for Toxic Substances and Disease Registry (ATSDR). 1990b. *Toxicological Profile for 2,4,6-Trichlorophenol.* U.S. Dept. Health and Human Services, Public Health Service, Washington, DC.

Agency for Toxic Substances and Disease Registry (ATSDR). 1992a. *Toxicological Profile for Aluminum.* U.S. Dept. Health and Human Services, Public Health Service, Washington, D.C.

Agency for Toxic Substances and Disease Registry (ATSDR). 1992b. *Toxicological Profile for Vanadium.* U.S. Dept. Health and Human Services, Public Health Service, Washington, DC.

Agency for Toxic Substances and Disease Registry (ATSDR). 1992c. *Toxicological Profile for 2-Nitrophenol, 4-Nitrophenol.* U.S. Dept. Health and Human Services, Public Health Service, Washington, DC.

Agency for Toxic Substances and Disease Registry (ATSDR). 1992c. *Toxicological Profile for 2-Nitrophenol, 4-Nitrophenol.* U.S. Dept. Health and Human Services, Public Health Service, Washington, DC.

Agency for Toxic Substances and Disease Registry (ATSDR). 1992c. *Toxicological Profile for 2-Nitrophenol, 4-Nitrophenol.* U.S. Dept. Health and Human Services, Public Health Service, Washington, DC.

Agency for Toxic Substances and Disease Registry (ATSDR). 1993a. *Toxicological Profile for Di(ethylhexyl)phthalate.* U.S. Dept. Health and Human Services, Public Health Service, Washington, DC.

Agency for Toxic Substances and Disease Registry (ATSDR). 1993b. *Toxicological Profile for Cadmium.* U.S. Dept. Health and Human Services, Public Health Service, Washington, DC.

Agency for Toxic Substances and Disease Registry (ATSDR). 1993c. *Toxicological Profile for Chromium.* U.S. Dept. Health and Human Services, Public Health Service, Washington, DC.

Agency for Toxic Substances and Disease Registry (ATSDR). 1993d. *Toxicological Profile for Lead.* U.S. Dept. Health and Human Services, Public Health Service, Washington, DC.

Agency for Toxic Substances and Disease Registry (ATSDR). 1993e. *Toxicological Profile for Mercury.* U.S. Dept. Health and Human Services, Public Health Service, Washington, DC.

Agency for Toxic Substances and Disease Registry (ATSDR). 1994a. *Toxicological Profile for 1,2-Dichloroethene.* U.S. Dept. Health and Human Services, Public Health Service, Washington, DC.

Agency for Toxic Substances and Disease Registry (ATSDR). 1994b. *Toxicological Profile for Hexachlorobutadiene.* U.S. Dept. Health and Human Services, Public Health Service, Washington, DC.

Agency for Toxic Substances and Disease Registry (ATSDR). 1995a. *Toxicological Profile for Polycyclic Aromatic Hydrocarbons.* U.S. Dept. Health and Human Services, Public Health Service, Washington, DC.

Agency for Toxic Substances and Disease Registry (ATSDR). 1995b. *Toxicological Profile for Dinotrophenols.* U.S. Dept. Health and Human Services, Public Health Service, Washington, DC.

Baicich, P.J. and C.J.O. Harrison. 1997. *A Guide to the Nests, Eggs, and Nestlings of North American Birds: Second Edition.* Academic Press, San Diego CA.

Barnthouse, L.W., and J. Brown. 1994. Issue paper on conceptual model development. Pages 3-1 to 3-70 in *Ecological Risk Assessment Issue Papers.* United States Environmental Protection Agency, Risk Assessment Forum, Washington, D.C. EPA/630/R-94/009.

Beyer, W.N., E.E. Connor, and S. Gerould. 1994. Estimates of soil ingestion by wildlife. Journal of Wildlife Management 58:375-382.

Breen, J.F. 1994. *Encyclopedia of Reptiles and Amphibians: Habits and Care.* T.F.H. Publications, Inc. Neptune, NJ.

Brigadoon, RAH. and J. Neal. 1963. Fluorescence of chickens and eggs following the feeding of benzo(a)pyrene crystals. Texas Ret. Biol. Med. 21(4):558-566.

Brown, L. 1997. *Grasslands.* .Chanticleer Press, Inc., New York, NY.

Brusca, R.C. and G.J. Brusca. 1990. *Invertebrates.* Sinauer Associates, Inc., Sunderland, MA.

Burt, W.H.. 1980. *A Field Guide to the Mammals: North America North of Mexico.* Houghton Mifflin Co., Boston, MA

Calder, W., and E. Braun. 1983. Scaling of osmotic regulation in mammals and birds. American Journal of Physiology 244:R601-R606.

Cannon AFB. 1990. Draft Environmental Impact Statement.

Carsel, R. F., and Parrish, R. S. 1988. Developing Joint Probability Distributions of Soil Water Retention Characteristics. Water Resources Research. Vol. 24, No. 5, p. 755-769, May 1988.

CH2M Hill. 1983. Installation Restoration Program Records Search for Cannon AFB, New Mexico. Prepared for the Air Force Engineering and Service Center and Tactical Air Command. Contract F08637-80-G0010-0018. August.

Clark, T., K. Clark, S. Paterson, D. Mackay, R.J. Norstrom. 1988. Wildlife monitoring, modeling, and fugacity. Environ. Sci. Technol., 22(2): 20.

Cockerham, L.G., and B.S. Shane. 1994. *Basic Environmental Toxicology.* CRC Press, Boca Raton, Florida.

Code of Federal Regulations. 1990. Federal List of Threatened and Endangered Wildlife and Plants.

Collins, H.H. 1981. *Complete Field Guide to North American Wildlife*. Harper and Row Publishers, New York, NY.

Conat, R. and J.T. Collins. 1991. *A Field Guide to the Reptiles and Amphibians* Third Ed., .Houghton Mifftin Co., Boston , MA

DeGraaf, R.M., and D.D. Rudis. 1986. *New England Wildlife: Habitat, Natural History, and Distribution.* U.S. Department of Agriculture, Forest Service, Northeastern Forest Experimental Station. General Technical Report NE-108. 491 pp.

Dewitt, T., R. Ozretich, R. Swartz, J. Lamberson, D. Schults, G. Ditsworth, J. Jones, L. Hoselton, and L. Smith. 1992. The influence of organic matter quality on toxicity and partitioning of sediment-associated fluoranthene. Environmental Toxicology and Chemistry 11:191-208.

DiToro, D.M. 1985. A particle interaction model of reversible organic chemical sorption. Chemosphere 14:1503-1508.

Donnely, K.C., C.S. Anderson, G.C. Barbee, and D.J. Manek. 1994. Soil toxicology. In *Basic Environmental Toxicology*. L.G. Cockerham and B.S. Shane Ed.s, CRC Press, Boca Raton, FL.

Dunning, J.B., Jr. 1993. *CRC Handbook of Avian Body Masses.* CRC Press, Boca Raton, Florida.

Efrroymson, R.A., M.E. Will, and G.W. Suter II. 1997b. *Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision.* Oak Ridge National Laboratory, Oak Ridge, Tennessee. ES/ER/TM-126/R2.

Efrroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten. 1997c. *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision.* Oak Ridge National Laboratory, Oak Ridge, Tennessee. ES/ER/TM-85/R3.

Efrroymson, R.A., G.W. Suter II, B.E. Sample, and D.S. Jones. 1997a. Preliminary Remediation Goals for Ecological Endpoints. Report No. ES/ER/TM-162/R2. Oak Ridge National Laboratory.

Ehrlich, P.R., D.S. Dobkin, and D. Wheye. 1988, *The Birder's Handbook: A Field Guide to the Natural History of North American Birds.* Simon and Schuster, Fireside, New York, NY.

Eisler, R. 1985a. *Cadmium Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review.* United States Department of the Interior, Fish and Wildlife Service, Contaminant Hazard Reviews Report No. 2. Biological Report 85(1.2).

Eisler, R. 1985b. *Selenium Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review.* United States Department of the Interior, Fish and Wildlife Service, Contaminant Hazard Reviews Report No. 5. Biological Report 85(1.5).

Eisler, R. 1986a. *Chromium Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review.* United States Department of the Interior, Contaminant Hazard Reviews Report No. 6. Biological Report 85(1.6).

Eisler, R. 1987a. *Polycyclic Aromatic Hydrocarbon Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review.* United States Department of the Interior, Fish and Wildlife Service, Contaminant Hazard Reviews Report No. 11. Biological Report 85(1.11).

Eisler, R. 1987b. *Mercury Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review.* United States Department of the Interior, Fish and Wildlife Service, Contaminant Hazard Reviews Report No. 10. Biological Report 85(1.10).

Eisler, R. 1988a. *Lead Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review.* United States Department of the Interior, Fish and Wildlife Service, Contaminant Hazard Reviews Report No. 14. Biological Report 85(1.14).

Eisler, R. 1988b. *Arsenic Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review.* United States Department of the Interior, Fish and Wildlife Service, Contaminant Hazard Reviews Report No. 13. Biological Report 85(1.13).

Fish and Wildlife. Online reference – http://ifw2es.fws.gov/EndangeredSpecies/lists/ListSpecies.cfm

Fleenor, W.E. and King, I.P. 1995. Identifying Limitations on Use of the HELP Model. Landfill Closures: Environmental Protection and Land Recovery. Papers presented at the ASCE

Convention in San Diego, CA, October 23-27, 1995. Dunn, R.J. and Singh, U.P., Eds. American Society of Civil Engineers. New York, NY.

Freeze, R.A. and J.A. Cherry. 1979. Groundwater. Prentice-Hall, Inc. Englewood Cliffs, NJ.

Gilbert, R.O. 1987. *Statistical Methods for Environmental Pollution Monitoring.* Van Nostrand Reinhold, New York.

Goodrich, M.S., L. Dulak, M. Friedman, and J. Lech. 1992. Acute and long-term toxicity of water-soluble cationic polymers to rainbow trout (*Oncorhynchus mykiss*) and the modification of toxicity by humic acid. Environmental Toxicology and Chemistry 11:509-515.

Harwell, M.J., B. Norton, W. Cooper, and J. Gentile. 1994. Issue paper on ecological significance. Pages 2-1 to 2-49 in *Ecological Risk Assessment Issue Papers.* United States Environmental Protection Agency, Risk Assessment Forum, Washington, D.C. EPA/630/R-94/009.

Heslop, R., and P. Robinson. 1963. *Inorganic Chemistry: A Guide to Advanced Study.* 2nd Edition. Elsevier Publishing Company, New York.

Howard, P. H., Barthling, R. S., Jarvis, W. F., Meylan, W. M., and Michalenko, E. M. 1991. Handbook of Environmental Degradation Rates. Lewis Publishers, Inc. Chelsea, MI.

Hulscher, T.E.M.T, B.A. Vrind, H. van den Heuvel, P.C.M van Noort, J.E.M. Beurskens, and H.A.J. Govers. 1999. Triphasic desorption of highly resistant chlorobenzenes, polychlorinated biphenyls, and polycyclic aromatic hydrocarbons in field contaminated sediment. Environ. Sci. Technol. 33:126-132.

Irwin, R.J., M. VanMouwerik, L. Stevens, M.D. Seese, and W. Basham. 1997. Environmental Contaminants Encyclopedia. National Park Service, Water Resources Division, Fort Collins, CO.

Jaagumagi, R., D. Persaud, and D. Bedard. 1995. *Ontario's Approach to Sediment Assessment and Remediation.* Presented and distributed at the Second Society of Environmental Toxicology and Chemistry (SETAC) World Congress (16th Annual Meeting), Vancouver, British Columbia. November, 1995.

Kabata-Pendias, A. and H. Pendias. 1992. *Trace Elements in Soils and Plants.* 2nd Edition. CRC Press, Boca Raton, FL.

Karrickoff, S.W., and K.R. Morris. 1985. Sorption dynamics of hydrophobic pollutants in sediment suspensions. Environmental Toxicology and Chemistry 4:469-479.

Kesley, J.W. and M. Alexander. 1997. Declining bioavailability and inappropriate estimation of risk of persistent compounds. Environ. Toxicol. Chem. 16(3):582-585.

Klienow K. and M. Goodrich. 1994. Environmental aquatic toxicology. Chapter 13 In *Basic Environmental Toxicology*. L. Cockerham and B. Shane Ed.s, CRC Press, Boca Raton, FL.

Knulst, J. 1992. Effects of pH and humus on the availability of 2,2',4,4',5,5'-hexachlorobiphenyl-C^{14} in lake water. Environmental Toxicology and Chemistry 11:1209-1216.

Landrum, P.F., B. Eadie, and W. Faust. 1992a. Variation in the bioavailability of polycyclic aromatic hydrocarbons to the amphipod *Diporeia* (ssp.) with sediment aging. Environmental Toxicology and Chemistry 11:1197-1208.

Landrum, P.F., H. Lee II, and M.J. Lydy. 1992b. Toxicokinetics in aquatic systems: Model comparisons and use in hazard assessment. Environ. Toxicol. Chem. 11:1709-1725.

Lee Wan Associates, Inc. 1990. RCRA Facility Investigation Work Plan, Field Sampling Plan, and Program Management Plan. Alexandria, Virginia. June.

Lyman, W. 1995. Transport and transformation processes. Chapter 15 (Pages 449-492) in G.M. Rand (editor). *Fundamentals of Aquatic Toxicology*. Second Edition. Taylor & Francis, Washington, D.C.

Mackay, D., and S. Paterson. 1981. Calculating fugacity. Environmental Science and Technology 15:1006-1014.

Mackay, D., L.A. Burns, and G.M. Rand. 1995. Fate modeling. Chapter 18 (Pages 563-586) in G.M. Rand (editor). *Fundamentals of Aquatic Toxicology*. Second Edition. Taylor & Francis, Washington, D.C.

MacMahon, J.A. 1997. *Deserts*. .Chanticleer Press, Inc., New York, NY.

Martin, A.C., H.S. Zim, and A.L. Nelson. 1951. *American Wildlife Plants: A Guide to Wildlife Food Habits*. McGraw-Hill Book Company, New York.

Merck. 1989. *Merck Index*. 11th Ed. Merck and Co., Inc., Merck Sharp and Dohme Research Laboratories, Rahway, NJ.

Merck. 1998. *Merck Veterinary Manual*. 8th Ed. Merck and Co., Inc., Merck Sharp and Dohme Research Laboratories, Rahway, NJ.

McCarty, L.S. 1991. Toxicant body residues: Implications for aquatic bioassays with some organic chemicals. In *Aquatic Toxicology and Risk Assessment: Fourteenth Volume*. ASTM STP 1124, M.A. Mayes and M.G. Barron, Eds., American Society for Testing and Materials. Philadelphia, PA.

Morrison, M.L., B.G. Marcot, and W.A. Mannan. 1992. *Wildlife - Habitat Relationships*. University of Wisconsin Press, Madison, WI.

Mulkey, L.A., Donigan, A.S. Jr., Allison, T.L., and Raju, C.S. 1989. Evaluation of Source Term Initial Conditions for Modeling Leachate Migration from Landfills. U.S. Environmental Protection Agency. Athens, GA.

Nagy, K.A. 1987. Field metabolic rate and food requirement scaling in mammals and birds. Ecological Monographs 57:111-128.

Neff, J. 1985. Polycyclic aromatic hydrocarbons. Chapter 14 In *Fundamentals of Aquatic Toxicology*. Rand, G.M., and S.R. Petrocelli Ed.s, Hemisphere Publishing Corporation, Washington, D.C.

Newell, A.J., D.W. Johnson, and L.K. Allen. 1987. *Niagara River Biota Contamination Project: Fish Flesh Criteria for Piscivorous Wildlife*. New York State Department of Environmental Conservation, Technical Report 87-3, Division of Fish and Wildlife, Bureau of Environmental Protection. v+182 pp.

Newman, M.C. 1998. *Fundamentals of Ecotoxicology*. Sleeping Bear Press, Chelsa, MI.

Nowak, R.M. 1991. *Walker's Mammals of the World: Fifth Edition*. Volumes I and II. The John Hopkins University Press, Baltimore, MD.

Owen, O.S.. 1975. *Natural Resource Conservation: An Ecological Approach*. 3rd. Ed. Macmillan Publishing Company, New York, NY.

Peterson, R.T. 1961. *Western Birds*. 2nd Ed.. Houghton Mifflin Co., Boston, MA

Radian Corporation. 1986. Installation Restoration Program, Phase II - Confirmation/ Quantification State I, Cannon AFB, N.M. Vols. I (text) and II (Appendixes A-M). Final Report for Period 9/84 - 4/85. September.

Rand, G.M. 1995. *Fundamentals of Aquatic Toxicology, Effects, Environmental Fate, and Risk Assessment*. Second Edition. Taylor & Francis, Bristol, Pennsylvania.

Rawls, W. J., Ahuja, L. R., and Brakensiek, D. L. 1992. Estimation of Soil Hydraulic Properties From Soils Data. In: van Genuchten, M. Th, Leij, F. J., and Lund, L. J. (ed.). Indirect Methods for Estimating the Hydraulic Properties of Unsaturated Soils. Proceedings of the International Workshop on Indirect Methods for Estimating the Hydraulic Properties of Unsaturated Soils. Riverside, California, October 11-13, 1989. University of California, Riverside, CA 92521, USA.

Remediation Services Incorporated. 1994. Closure Report: DACA 45-94-B-0100. September.

Rising, JD and D.D. Beadle. 1996. *A Guide to the Identification and Natural History of: The Sparrows of the United States and Canada.* Acedemic Press. Harcourt Brace and Co., Publ., San Diego, CA.

Robbins, C.S., B. Bruun, and H.S. Zim. 1983. *A Guide to Field Identification Birds of North America.* Golden Press, Western Publ. Co., Racine, WI.

Roberts, B.L., and H.W. Dorough. 1984. Relative toxicities of chemicals to the earthworm *Eisenia foetida*. Environ. Toxicol. Chem. 3:67-78

RTI. 1995. *Supplemental Technical Support Document for the Hazardous Waste Identification Rule: Risk Assessment for Human and Ecological Receptors.* Research Triangle Institute, Center for Environmental Analysis. EPA Contract Number 68-W3-0028.

Salhotra, A. M., Mineart, P., Sharp-Hansen, S., Allison, T., Johns, R., and Mills, W. B. 1995. Multimedia Exposure Assessment Model (MULTIMED 2.0) for Evaluating the Land Disposal of Wastes - Model Theory. U.S. Environmental Protection Agency. Athens, GA. April.

Sample, B.E., and G.W. Suter III. 1994. *Estimating Exposure of Terrestrial Wildlife to Contaminants: Draft.* Oak Ridge National Laboratory, Oak Ridge, Tennessee. ES/ER/TM-125.

Sample, B.E., D.M. Opresko, and G.W. Suter, II. 1996. *Toxicological Benchmarks for Wildlife: 1996 Revision.* Oak Ridge National Laboratory, Oak Ridge, Tennessee. ES/ER/TM-86/R3.

Sample, B.E., M.S. Aplin, R.A. Efroymson, G.W. Suter III, and C.J.E. Walsh. 1997. *Methods and Tools for Estimation of the Exposure of Terrestrial Wildlife to Contaminants.* Oak Ridge National Laboratory, Oak Ridge, Tennessee. ORNL/TM-13391.

Sample, B.E., J.J. Beauchamp, R.A. Efroymson, G.W. Suter, II., and T.L. Ashwood 1998a. *Development and Validation of Bioaccumulation Models for Earthworms.* Oak Ridge National Laboratory, Oak Ridge, Tennessee. ES/ER/TM-220.

Sample, B.E., J.J. Beauchamp, R.A. Efroymson, and G.W. Suter, II. 1998b. *Development and Validation of Bioaccumulation Models for Small Mammals.* Oak Ridge National Laboratory, Oak Ridge, Tennessee. ES/ER/TM-219.

Schoener, T.W. 1968. Sizes of feeding territories among birds. Ecology. 49(1):123-141.

Schroeder, P.R., Dozier, T.S., Zappi, P.A., McEnroe, B.M., Sjostrom, J.W., and Peyton, R.L. 1994. The Hydrologic Evaluation of Landfill Performance (HELP) Model: Engineering Documentation for Version 3. EPA/600/R-94/168b. U.S. Environmental Protection Agency, Risk Reduction Engineering Laboratory, Cincinnati, OH. September.

Sharp-Hansen, S., Travers, C., Hummel, P. Allison, T., Johns, R., and Mills, W. B. 1995. A Subtitle D Landfill Application Manual for the Multimedia Exposure Assessment Model (MULTIMED 2.0). U.S. Environmental Protection Agency. Athens, GA. April.

Silva, M. and J.A. Downing. 1995. *CRC Handbook of Mammalian Body Masses.* CRC Press, Boca Raton, Florida.

Smith, H.M. and E.D. Brodie, Jr. 1982. *A Guide to the Field Identification: Reptiles of North America.* Western Publishing Co., Inc. Golden Press, New York, NY.

Sokal, R.R. and F.J. Rohlf. 1981. *Biometry: The Principles and Practice of Statistics in Biological Research.* 2nd Edition. W.H. Freeman and Company, New York, New York.

Sparling, D.W., T.P Lowe, and P.G.C. Campbell. 1998. Ecotoxicology of aluminum to fish and wildlife. Chapter 3 In *Aluminum in the Environment.* CRC Press, Boca Raton, FL.

Sposito, G. and A.L. Page. 1984. Cycling of Metal Ions in the Soil Environment. Metal Ions in Biological Systems, Volume 18. Circulation of Metals in the Environment. H. Sigel, ed. Marcel Dekker, Inc., New York.

Spurr, S.H. 1964. *Forest Ecology.* The Ronald Press Co., New York, NY.

Sundlof, S.F., J.E. Riviere, and A.L. Criagmill. 1996. *Comparative Veterinary Pharmacokintenis and Residues of Pesticides and Environmental Contaminants.* CRC Press, Boca Raton, FL.

Suter, G.W., II. (editor) 1993. *Ecological Risk Assessment.* Lewis Publishers, Boca Raton, Florida.

Suter, G.W., II. 1995. Introduction to Ecological Risk Assessment for Aquatic Toxic Effects. Pages 803-816 (Chapter 28) in G. Rand (editor). *Aquatic Toxicology, Effects, Environmental Fate, and Risk Assessment.* Second Edition. Taylor & Francis, Bristol, Pennsylvania.

Terres, J.K. 1991. *The Audubon Society Encyclopedia of North American Birds.* Wings Books, New York., NY.

Todd, D.K. 1980. Groundwater Hydrology. John Wiley & Sons, Inc. New York, NY.

Trapp, S., and J.C. McFarlane (editors). *Plant Contamination Modeling and Simulation of Organic Chemical Processes.* Lewis Publishers, Boca Raton, FL.

Travis, C.C. and A.D. Arms. 1988. Bioconcentration of organics in beef, milk, and vegetation. Environ. Sci. Technol. 22(3):271-274.

United States Department of Agriculture - 5. Conservation Service (USDA-5.C.5). 1958. Soil Survey of Curry County, New Mexico.

United States Army Corps of Engineers (USACE). 1985. *Fluoranthene K_{DOC} in Sediment Pore Waters.* Environmental Effects of Dredging Technical Notes EEDP 04-22. U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

United States Army Corps of Engineers (USACE). 1996. *Risk Assessment Handbook, Volume II: Environmental Evaluation.* USACE Engineering and Design, Department of the Army, Washington, D.C. CEMP-RT Manual No. 200-1-4.

United States Environmental Protection Agency (USEPA). 1979. *Water-related Environmental Fate of 129 Priority Pollutants.* EPA/440/4-79-029a&b.

United States Environmental Protection Agency (USEPA). 1988. *Recommendations for and Documentation of Biological Values for Use in Risk Assessment.* USEPA Office of Research and Development, Washington, D.C. EPA/600/6-87/008.

United States Environmental Protection Agency (USEPA). 1989. *Risk Assessment Guidance for Superfund: Volume 2 - Environmental Evaluation Manual, Interim Final.* USEPA Office of Solid Waste and Emergency Response, Washington, D.C. EPA540/1-89/001A.

United States Environmental Protection Agency (USEPA). 1991. *Summary Report on Issues in Ecological Risk Assessment.* USEPA Risk Assessment Forum, Washington, D.C. EPA/625/3-91/018.

United States Environmental Protection Agency (USEPA). 1991. Memorandum from Don R. Clay. Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions. OSWER Directive 9355.0-30. April.

United States Environmental Protection Agency (USEPA). 1991. *Summary Report on Issues in Ecological Risk Assessment.* USEPA Risk Assessment Forum, Washington, D.C. EPA/625/3-91/018.

United States Environmental Protection Agency (USEPA). 1992. *Framework for Ecological Risk Assessment.* USEPA Risk Assessment Forum, Washington, D.C. EPA/630/R-92/001.

United States Environmental Protection Agency (USEPA). 1993. Wild Life Exposure Factors Handbook. Office of Research and Development, EPA/600/R-93/187a & b. (Volumes I and II).

United States Environmental Protection Agency (USEPA). 1994. *Ecological Risk Assessment Issue Papers.* Risk Assessment Forum, Washington, D.C. EPA/630/R-94-009.

United States Environmental Protection Agency (USEPA). 1994. Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities. Office of Solid Waste and Emergency Response. Washington, D.C. July.

United States Environmental Protection Agency (USEPA). 1995. *Hazardous Waste Management System: Identification and Listing of Hazardous Waste: Hazardous Waste Identification Rule.* Proposed Rule. Federal Register, Volume 60, December 21, 1995. Pages 66344 - .

United States Environmental Protection Agency (USEPA). 1996a. *Proposed Guidelines for Ecological Risk Assessment.* Risk Assessment Forum, Washington, D.C. EPA/630/R-95/002B.

United States Environmental Protection Agency (USEPA). 1996b. *Soil Screening Guidance: Technical Background Document.* Office of Solid Waste and Emergency Response. Washington, DC. EPA/540/R-95/128.

United States Environmental Protection Agency (USEPA). 1996a. Soil Screening Guidance: Technical Background Document. Second Edition. EPA/540/R95/128. Office of Solid Waste and Emergency Response. Washington, D.C. May.

United States Environmental Protection Agency (USEPA). 1996b. Drinking Water Regulations and Health Advisories. Office of Water, EPA 822-B-96-002. October.

United States Environmental Protection Agency (USEPA). 1997a. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments. Environmental Response Team, Edison, NJ.

United States Environmental Protection Agency (USEPA). 1997b. EPA Region 6 Human Health Media-Specific Screening Levels. Dallas, Texas.

United States Environmental Protection Agency (USEPA). 1997a. *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments.* Interim Final Version. Environmental Response Team, Edison, New Jersey. June 5, 1997.

United States Environmental Protection Agency (USEPA). 1997b. *The Lognormal Distribution in Environmental Applications.* Office of Research and Development and the Office of Solid Waste and Emergency Response. EPA/600/R-97/006.

United States Environmental Protection Agency (USEPA). 1998. *Guidelines for Ecological Risk Assessment.* Risk Assessment Forum, Washington, D.C. EPA/630/R-95/002F [see also 63FR93:26845-26924]

United States Geological Survey (USGS). 1984. Professional Paper 1270. Element Concentrations in Soil and Other Surficial Materials in the Conterminous United States. By H.T. Shacklette and J.G. Borengen.

Verscheuren, K. 1982. *Handbook of Environmental Data on Organic Chemicals.* 2nd Edition. Van Nostrand Reinhold, New York.

Walk, Haydel & Associates, Inc. (WHA). 1990. Installation Restoration Program. Final Remedial Investigation Report, Cannon Air Force Base, New Mexico. Prepared under contract with Omaha District, Corps of Engineers; Omaha, Nebraska, for Headquarters, Tactical Air Command, HQ, TAC/DEEV; Langley Air Force Base, Virginia.

Wallace, G.J. and H.D. Mahan. 1975. *An Introduction to Ornithology.* Third Ed. Macmillan Publishing Co., Inc., New York, NY

Watt, K.E.F. 1973. *Principles of Environmental Science.* McGraw-Hill Book Co., New York, NY.

Whittaker, R.H. 1975. *Communities and Ecosystems.* 2nd Edition. MacMillan Publishing Inc., New York, NY.

Will, M.E. and G.W. Suter II. 1994. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: Report No. ES/ER/TM-126. Oak Ridge National Laboratory.

Will, M.E. and G.W. Suter II. 1997. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Terrestrial Plants: 1995 Revision. Report No. ES/ER/TM-85-R2. Oak Ridge National Laboratory.

William Matotan and Associates. 1985. Water Well Master Plan Survey. Prepared for Department of the Air Force, Cannon Air Force Base, New Mexico.

Woodward-Clyde (W-C). 1991. Field Sampling Plan. Remedial Investigation. Phase I (18 SWMUs). Cannon AFB, Clovis, New Mexico.

Woodward-Clyde (W-C). 1992. Remedial Investigation Report for 18 Solid Waste Management Units. Cannon AFB, New Mexico. Prepared for U.S. Army Corps of Engineers, Omaha District; Omaha, Nebraska.

Woodward-Clyde (W-C). 1995a. RCRA Facility Investigation. Phase II. Landfill No. 3 and No. 4. SWMUs 105 and 104. March.

Woodward-Clyde (W-C). 1995b. Appendix III SWMUs RCRA Facility Investigation. Final Report.

Woodward-Clyde (W-C). 1997a. "Naturally Occurring Concentrations of Inorganics and Background Concentrations of Pesticides at Cannon Air Force Base, New Mexico." Final Report. September.

Woodward-Clyde (W-C). 1997b. RCRA Facility Investigation Appendix I SWMUs 86-90 (IRP Site SD-11) Phase III.

Woodward-Clyde (W-C). 1998. Corrective Measures Study Work Plans (WP, FSP, QAPP Addendum, SSHP Addendum) at SWMUs 86-90 (Site SD-11), Cannon AFB, New Mexico. August.

W-C DAILY QUALITY CONTROL REPORT

Date 12-01-98

Day	S	M	T	W	TH	F	S
			X				

Weather	Bright Sun	Clear	Overcast	Rain	Snow
		X			

Temp	To 32	32-50	50-70	70-85	85 up
			X		

Wind	Still	Moderate	High	Report No.
	X			

Humidity	Dry	Moderate	Humid	
	X			11-1

COE Project Manager Steve Peterson
Project Cannon AFB, Site SD-11
Project No. 45FOM9602V.00
Contract No. DACA-45-96-D-0017

Subcontractors on Site: None

Equipment on Site: None

Visitors on Site: None

W-C Personnel on Site: Mike Sonderman, Dan Galde

Work Performed (including sampling): Travelled from Omaha to Clovis. Checked in at CE Building at Cannon AFB. Checked on staging area. Purchased supplies.

Project Corrective Measures Study SWMUs 86-90 (Site SD-11) Report No. 11-1
Project No. 45FOM9602V.00 Date 12-01-98

Quality Control Activities (including field calibration): ~~Calibrated PID to 100 ppm~~ ~~Isobutylene.~~

Health and Safety and Activities: PPE = Level D

Problems Encountered/Corrective Actions Taken: None

Downtime/Standby: None

Office Work Performed/ Additional Comments: Picked up packages + coders at hotel. Prepared for tomorrow's work.

By Michael M. Sonderman Title Site Manager

Michael M. Sonderman

Sheet 2 of 2

W-C DAILY QUALITY CONTROL REPORT

Date 12-02-98

Day	S	M	T	W	TH	F	S
				X			

Weather	Bright Sun	Clear	Overcast	Rain	Snow
			X		

Temp	To 32	32-50	50-70	70-85	85 up
			X		

Wind	Still	Moderate	High	Report No.
		X		

Humidity	Dry	Moderate	Humid	
	X			11-2

COE Project Manager Steve Peterson
Project Cannon AFB, Site SD-11
Project No. 45FOM9602V.00
Contract No. DACA-45-96-D-0017

Subcontractors on Site: Southwest Engineering

Equipment on Site: CME 85 Drill rig; PID, Immuno Assay Kit, support vehicle with steam cleaner.

Visitors on Site: None

W-C Personnel on Site: Mike Sonderman, Dan Galde

Work Performed (including sampling): Gave Health + Safety briefings. Drilled and sampled 3 borings at site SD-11. Performed Immuno assay for JP-4 on 15 samples. 15 Samples retained for chemical analysis for 8260A VOCs, 8270C SVOCs, 8015B TPH-DRO, and 418.1 TRPH.

Project Corrective Measures Study SWMUs 86-90 (Site SD-11) Report No. 11-2
Project No. 45FOM9602V.00 Date 12-02-98

Quality Control Activities (including field calibration): Calibrated PID to 100 ppm
Isobutylene. Collected following QA/QC samples:
C11-SB52-202 (Dup); C11-SB02-110 (MS/MSD); ~~C11~~ C11-SB53-202 (Dup); C11-SB03-302 (QA Split); C11-SB03-120 (MS/MSD)
Health and Safety and Activities: PPE = Level D
Problems Encountered/Corrective Actions Taken:
None
Downtime/Standby:
None
Office Work Performed/ Additional Comments:

By Michael M. Sonderman Title Site Manager

Michael M. Sonderman

W-C DAILY QUALITY CONTROL REPORT

Date 12-03-98

Day	S	M	T	W	TH	F	S
					X		

Weather	Bright Sun	Clear	Overcast	Rain	Snow
			X	X	

Temp	To 32	32-50	50-70	70-85	85 up
			X		

Wind	Still	Moderate	High	Report No.
			X	

Humidity	Dry	Moderate	Humid	
			X	11-3

COE Project Manager Steve Peterson
Project Cannon AFB, Site SD-11
Project No. 45FOM9602V.00
Contract No. DACA-45-96-D-0017

Subcontractors on Site: Southwest Engineering - Alex Sanchez, Ralph Luna, Ricardo Romo

Equipment on Site: PID, CME 85 drill rig, ~~Impromo~~ support vehicle with steam cleaner; grout truck

Visitors on Site: Sanford Hutsell

W-C Personnel on Site: Mike Sonderman, Dan Galde

Work Performed (including sampling): Drillers grouted up SD-11 borings and demobilized.

Project Corrective Measures Study SWMUs 86-90 (Site SD-11) Report No. 11-3
Project No. 45FOM9602V.00 Date 12-03-98

Quality Control Activities (including field calibration): Calibrated PID to 100 ppm
Isobutylene.
Health and Safety and Activities: PPE = Level D
Problems Encountered/Corrective Actions Taken: None
Downtime/Standby: None
Office Work Performed/ Additional Comments:

By Michael M. Sonderman Title Site Manager

Michael M. Sonderman

Sheet 2 of 2

HTRW DRILLING LOG

DISTRICT: Omaha District		HOLE NUMBER: SB-02
1.COMPANY NAME: URS Greiner Woodward-Clyde	2.DRILL SUBCONTRACTOR: Southwest Engineering	SHEET 1 OF SHEETS 6
3.PROJECT: Cannon AFB Site SD-11	4.LOCATION: Cannon AFB, NM	
5.NAME OF DRILLER: Alex Sanchez	6.MANUFACTURER'S DESIGNATION OF DRILL: CME 85	
7.SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT: 4 1/4" ID HSA; 3" OD stainless steel split-spoons	8.HOLE LOCATION	
	9.SURFACE ELEVATION	
	10.DATE STARTED: 12-02-98	11.DATE COMPLETED: 12-02-98
12.OVERBURDEN THICKNESS: –	15.DEPTH GROUNDWATER ENCOUNTERED: NA	
13.DEPTH DRILLED INTO ROCK: NA	16.DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED: NA	
14.TOTAL DEPTH OF HOLE: 40' bgs	17.OTHER WATER LEVEL MEASUREMENTS (SPECIFY): NA	

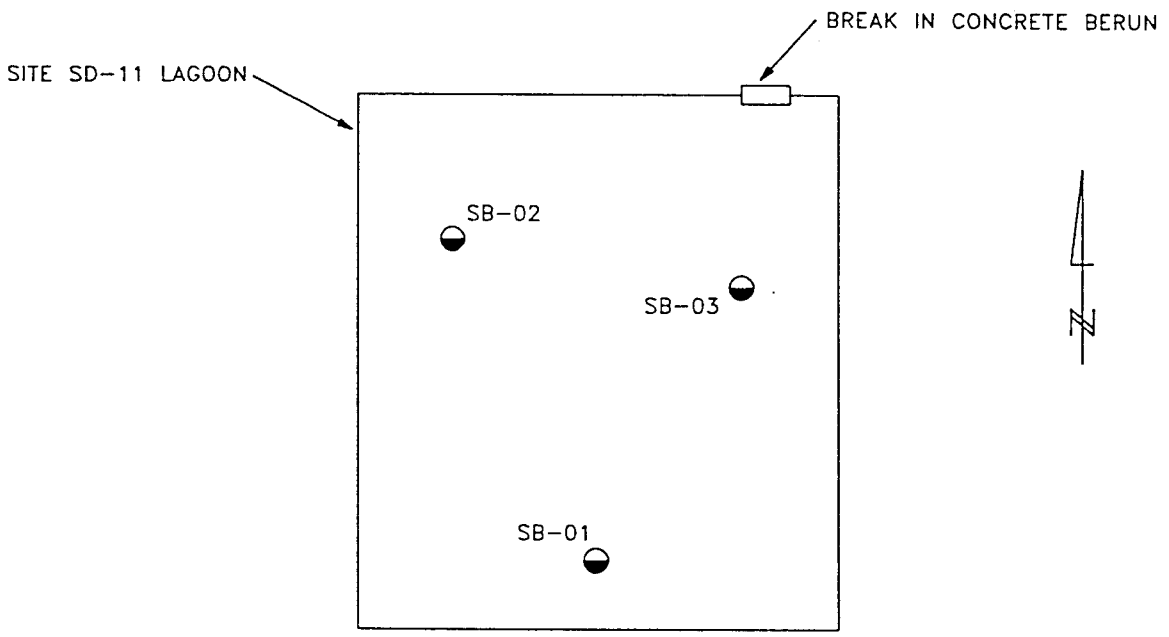
18.GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19.TOTAL NUMBER OF CORE BOXES
0			NA

20.SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21.TOTAL CORE RECOVERY
5	5		5 SVOCs	5 TRPH	5 TPH DRO	NA %

22.DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23.SIGNATURE OF INSPECTOR
	grouted			Michael M. Sonderman

LOCATION SKETCH/COMMENTS

SCALE NOT TO SCALE



PROJECT	HOLE NO.
Cannon AFB Site SD-11	SB-02

ENG FORM 5056A-R, AUG 94

(Proponent: CECW-EG)

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HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: SB-02

PROJECT: Cannon AFB Site SD-11

INSPECTOR: Michael M. Sonderman

SHEET 2 OF 6

ELEV. (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO. (e)	ANALYTICAL SAMPLE NO. (f)	BLOW COUNT (g)	REMARKS (h)
		loose, moist, red, fine grained sand (SM), with some silt and clay, gravel on surface, roots	Background HS=0		CII-SB02 -002 SVOCs, TPH, TRPH	1	Fill on surface
					VOCs	3	N = 6 Rec. = 1.6 T = 1043
	1		HS=0			3	
						3	Duplicate
	2						CAN-SB52-002 2 x 4oz 8260A VOCs 1 x 8oz 8270 SVOCs 1 x 8oz TRPH 1 x 8oz 8015 TPH DRO
	3	stiff, moist, lt. reddish brown, low plastic silt (ML) with clay and fine sand					T = 0800 Alluvium
	4						
	5						
	6						
	7						
	8				CII-SB02 -010	5	N = 14 Rec. = 1.8' T = 1055 2 x 4oz 8260A VOCs 1 x 8oz 8270 SVOCs 1 x 8oz TRPH 2 x 4oz 8015 TPH DRO +MS/MSD CII-SB02-110
			HS=0			8	
	9					6	
	10					7	

PROJECT: Cannon AFB Site SD-11

HOLE NO. SB-02

ENG FORM 5056A-R, AUG 94

(Proponent: CECW-EG)

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HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: SB-02

PROJECT: Cannon AFB Site SD-11

INSPECTOR: Michael M. Sonderman

SHEET 3 OF 6

ELEV. (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO. (e)	ANALYTICAL SAMPLE NO. (f)	BLOW COUNT (g)	REMARKS (h)
		stiff, moist, lt. reddish brown, low plastic silt (ML), with some sand and clay					Alluvium
	11						
	12						
	13						
	14						
	15						
	16						
	17						
	18				CII-SB02 -020	4	N = 22 Rec. = 1.7' T = 1115 2 x 4oz 8260A VOCs 1 x 8oz 8270 SVOCs 1 x 8oz 418.1 TRPH 1 x 8oz 8015 TPH DRO
		med. dense to dense, sl. moist, fine grained sand (SM) with caliche nodules	HS=0			7	
	19					15	
	20					24	

PROJECT: Cannon AFB Site SD-11

HOLE NO. SB-02

ENG FORM 5056A-R, AUG 94

(Proponent: CECW-EG)

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HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: SB-02

PROJECT: Cannon AFB Site SD-11

INSPECTOR: Michael M. Sonderman

SHEET 4 OF 6

ELEV. (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO. (e)	ANALYTICAL SAMPLE NO. (f)	BLOW COUNT (g)	REMARKS (h)
		dense, sl. moist, lt. reddish brown sand (SM) with silt, some cemented nodules					
	21						drilling becoming very hard
	22						
	23						
	24						
	25						
	26						
	27						
	28	heavily cemented caliche	HS=0		CII-SB02 -030	4	N = 37 Rec. = 1.4' T = 1132 2 x 4oz 8260A VOCs 1 x 8oz 8270 SVOCs 1 x 8oz 418.1 TRPH 1 x 8oz 8015B TPH DRO
	29					13	
						24	
	30					31	

PROJECT: Cannon AFB Site SD-11

HOLE NO. SB-02

ENG FORM 5056A-R, AUG 94

(Proponent: CECW-EG)

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HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: SB-02

PROJECT: Cannon AFB Site SD-11

INSPECTOR: Michael M. Sonderman

SHEET 5 OF 6

ELEV. (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO. (e)	ANALYTICAL SAMPLE NO. (f)	BLOW COUNT (g)	REMARKS (h)
		dense, sl. moist, lt. reddish drown, fine grained sand (SM), some silt, caliche nodules					Alluvium
	31						
	32						
	33						
	34						
	35						
	36						drove two spoons
	37						
	38	iron-cemented sand nodules			VOCs	50+	N = 50 Rec. = 0.4' T = 1200
	39				SVOCs, TPH,TRPH	100+	N = 100+ Rec. = 0.3' 2 x 4oz 8260A VOCs 1 x 8oz 8270 SVOCs 1 x 8oz 418.1 TRPH 1 x 8oz 8015B TPH DRO
	40	BOB at 39.8' bgs					

PROJECT: Cannon AFB Site SD-11

HOLE NO. SB-02

ENG FORM 5056A-R, AUG 94

(Proponent: CECW-EG)

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HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: SB-02

PROJECT: Cannon AFB Site SD-11

INSPECTOR: Michael M. Sonderman

SHEET 6 OF 6

ELEV. (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO. (e)	ANALYTICAL SAMPLE NO. (f)	BLOW COUNT (g)	REMARKS (h)
	41						Bkgrnd = Background HS = Headspace N = Number of blows Rec. = Recovery in feet T = Time oz = Ounce sl. = slight lt. = light BOB = Bottom of Boring NA = Not Applicable bgs = Below Ground Surface
	42						

PROJECT: Cannon AFB Site SD-11

HOLE NO. SB-02

ENG FORM 5056A-R, AUG 94

(Proponent: CECW-EG)

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HTRW DRILLING LOG

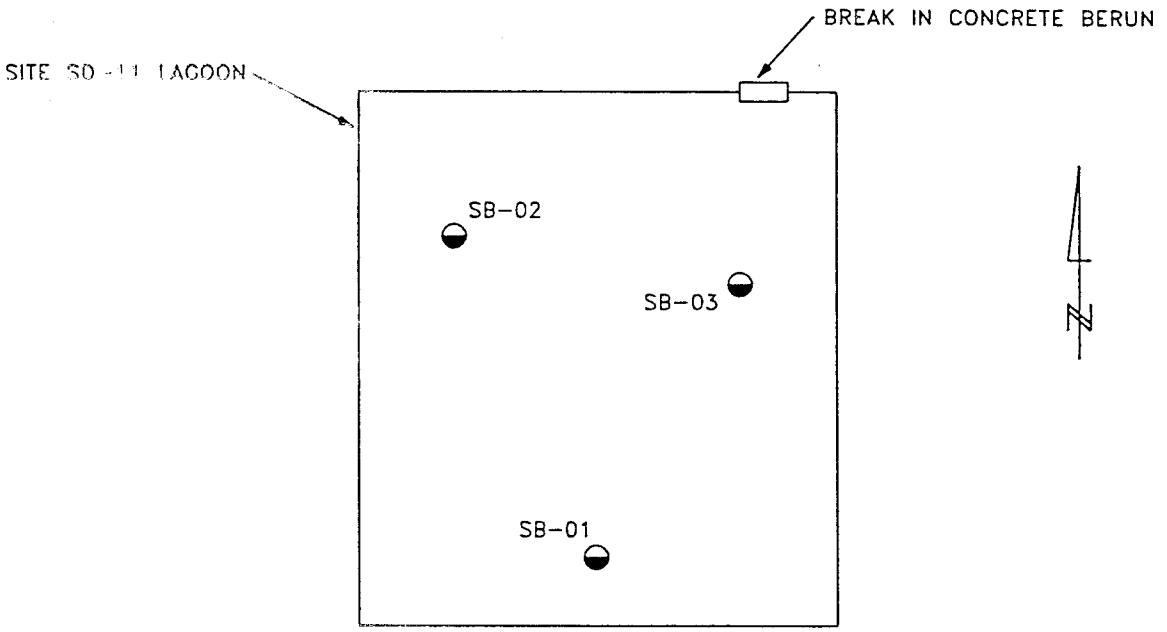
DISTRICT: Omaha District		HOLE NUMBER: SB-03
1.COMPANY NAME: URS Greiner Woodward-Clyde	2.DRILL SUBCONTRACTOR: Southwest Engineering	SHEET 1 OF SHEETS 6
3.PROJECT: Cannon AFB Site SD-11	4.LOCATION: Cannon AFB, NM	
5.NAME OF DRILLER: Alex Sanchez	6.MANUFACTURER'S DESIGNATION OF DRILL: CME 85	
7.SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT: 4¼" ID HSA; 3" OD stainless steel split-spoons	8.HOLE LOCATION	
	9.SURFACE ELEVATION	
	10.DATE STARTED: 12-02-98	11.DATE COMPLETED: 12-02-98
12.OVERBURDEN THICKNESS: –	15.DEPTH GROUNDWATER ENCOUNTERED: NA	
13.DEPTH DRILLED INTO ROCK: NA	16.DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED: NA	
14.TOTAL DEPTH OF HOLE: 39.2' bgs	17.OTHER WATER LEVEL MEASUREMENTS (SPECIFY): NA	

18.GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19.TOTAL NUMBER OF CORE BOXES
0			NA

20.SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21.TOTAL CORE RECOVERY
5	5		5 SVOCs	5 TRPH	5 TPH DRO	NA %

22.DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23.SIGNATURE OF INSPECTOR
	grouted			

LOCATION SKETCH/COMMENTS — SCALE: NOT TO SCALE



PROJECT	HOLE NO.
Cannon AFB Site SD-11	SB-03

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

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HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: SB-03

PROJECT: Cannon AFB Site SD-11

INSPECTOR: Michael M. Sonderman

SHEET 2 OF 6 SHEETS

ELEV. (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO. (e)	ANALYTICAL SAMPLE NO. (f)	BLOW COUNT (g)	REMARKS (h)
		loose, moist, red, fine grained sand (SM), with silt, gravel on surface, roots	Background HS=0		SVOCs, TPH, TRPH	2	Fill on surface CII-SB03-002 Alluvium N = 10 Rec. = 1.7 T = 1354 2 x 4oz 8260A VOCs 1 x 8oz 8270 SVOCs 1 x 8oz TRPH 1 x 8oz 8015 TPH DRO
					VOCs	4	
	1					6	
						6	Duplicate
	2						CII-SB53-002 T = 1500 QA Split
	3						CAN-SB03-002 Lims # T = 1354
		v. stiff, sl. moist to dry, lt. reddish brown, low plastic silt (ML) some fine sand, moderately cemented with caliche nodules present					
	4						
	5						
	6						
	7						
	8				CII-SB03 -010	8	N = 19 Rec. = 1.2' T = 1418 2 x 4oz 8260A VOCs 1 x 8oz 8270 SVOCs 1 x 8oz TRPH 2 x 4oz 8015 TPH DRO
			HS=0			10	
	9					9	
						9	
	10						

PROJECT: Cannon AFB Site SD-11

HOLE NO. SB-03

ENG FORM 5056A-R, AUG 94

(Proponent: CECW-EG)

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HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: SB-03

PROJECT: Cannon AFB Site SD-11

INSPECTOR: Michael M. Sonderman

SHEET 3 OF 6

ELEV. (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO. (e)	ANALYTICAL SAMPLE NO. (f)	BLOW COUNT (g)	REMARKS (h)
		same as above					drilling becomes hard
		v. stiff, sl. moist to dry, lt. reddish brown, low plastic silt (ML), some fine sand, moderately cemented caliche nodules					Alluvium
	11						
	12						(from drilling)
		heavily cemented					
	13						
	14						
	15						
	16						
	17						
	18				CII-SB03 -020	9	N = 43 Rec. = 1.9' T = 1433 2 x 4oz 8260A VOCs 1 x 8oz 8270 SVOCs 1 x 8oz 418.1 TRPH 1 x 8oz 8015 TPH DRO
		dense, sl. moist to dry, red, fine grained sand (SM) with silt, moderately cemented with caliche nodules present	HS=0			23	
	19					20	
	20					28	+MS/MSD CII-SB03-120

PROJECT: Cannon AFB Site SD-11

HOLE NO. SB-03

ENG FORM 5056A-R, AUG 94

(Proponent: CECW-EG)

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HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: SB-03

PROJECT: Cannon AFB Site SD-11

INSPECTOR: Michael M. Sonderman

SHEET 4 OF 6

ELEV. (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO. (e)	ANALYTICAL SAMPLE NO. (f)	BLOW COUNT (g)	REMARKS (h)
		dense, sl. moist to dry, red to lt. reddish brown, fine grained sand (SM), with some silt, heavily cemented					drilling becoming very hard Alluvium
	21						
	22						
	23						
	24						
	25						
	26						
	27						
	28				CII-SB03 -030	12	N = 48 Rec. = 1.8' T = 1453 2 x 4oz 8260A VOCs 1 x 8oz 8270 SVOCs 1 x 8oz 418.1 TRPH 1 x 8oz 8015B TPH DRO
			HS=0			17	
	29					31	
						37	
	30						

PROJECT: Cannon AFB Site SD-11

HOLE NO. SB-03

ENG FORM 5056A-R, AUG 94

(Proponent: CECW-EG)

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HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: SB-03

PROJECT: Cannon AFB Site SD-11

INSPECTOR: Michael M. Sonderman

SHEET 5 OF 6

ELEV. (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO. (e)	ANALYTICAL SAMPLE NO. (f)	BLOW COUNT (g)	REMARKS (h)
		dense, sl. moist to dry, lt. red, fine grained sand (SM), with silt, heavily cemented					drilling very hard
	31						
	32						
	33						
	34						
	35						
	36						
	37						
	38	very dense fine sand (SM), heavily cemented	HS=0		CII-SB03-040	19	N = 89+ Rec. = 1.0' T = 1513 2 x 4oz 8260A VOCs 1 x 8oz 8270 SVOCs 1 x 8oz 418.1 TRPH 1 x 8oz 8015B TPH DRO
						39	
	39					50+	
		BOB at 39.2' bgs					
	40						

PROJECT: Cannon AFB Site SD-11

HOLE NO. SB-03

ENG FORM 5056A-R, AUG 94

(Proponent: CECW-EG)

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HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER	SHEET	SHEETS
SB-03	6	6

PROJECT	INSPECTOR
Cannon AFB Site SD-11	Michael M. Sonderman

ELEV. (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO. (e)	ANALYTICAL SAMPLE NO. (f)	BLOW COUNT (g)	REMARKS (h)
	41						Bkgrnd = Background HS = Headspace N = Number of blows Rec. = Recovery in feet T = Time oz = Ounce sl. = slight lt. = light v. = very BOB = Bottom of Boring NA = Not Applicable bgs = Below Ground Surface
	42						

PROJECT	HOLE NO.
Cannon AFB Site SD-11	SB-03

SOIL SAMPLE COLLECTION FIELD SHEET

GENERAL INFORMATION

SITE NAME: Cannon AFB, NM

PROJECT NO. 45F0M9602V.00

SAMPLE NO. C11-SB01-002

BORING NO. SB01

DATE/TIME COLLECTED: 12-02-98 / 0825

PERSONNEL: M. Sonderman, D. Galde

SAMPLE METHOD / DEPTH: Stainless steel split-spoon / 0-1.0' bgs

SAMPLE MEDIA: SOIL SEDIMENT SLUDGE

SAMPLE QA SPLIT: YES NO

SPLIT SAMPLE NO.

SAMPLE QC DUPLICATE: YES NO

DUPLICATE SAMPLE NO.

MS/MSD REQUESTED: YES NO

SAMPLE CONTAINERS, PRESERVATIVES, ANALYSIS

Sample Container	Preservative	Analysis Requested
2 - 4 oz. glass jar	4° C	8260B VOCs
1 - 8 oz. glass jar	4° C	8270C SVOCs
2-4 ~~1~~ - 8 oz. glass jar	4° C	8015B TPH (DRO)
1 - 8 oz. glass jar	4° C	418.1 TRPH

HNU MEASUREMENTS

Background	0
Breathing zone	0
Boring	0
Headspace	0

SAMPLE DESCRIPTION

DEPTH: 0-1.0

DESCRIPTION: med. stiff, moist, brown, low plastic silty clay (CL), with some coarse sand & gravel (Fill)

GENERAL COMMENTS

SVOCs, TPH, TRPH collected from 0-0.5' bgs
VOCs collected from 0.5-1.0' bgs

SOIL SAMPLE COLLECTION FIELD SHEET

GENERAL INFORMATION

SITE NAME: Cannon AFB, NM

PROJECT NO. 45F0M9602V.00

SAMPLE NO. C11-SB01-010

BORING NO. SB01

DATE/TIME COLLECTED: 12-02-98 / 0830

PERSONNEL: M. Sonderman, D. Galde

SAMPLE METHOD / DEPTH: Stainless steel split-spoon / 8-10' bgs

SAMPLE MEDIA: SOIL SEDIMENT SLUDGE

SAMPLE QA SPLIT: YES NO

SPLIT SAMPLE NO.

SAMPLE QC DUPLICATE: YES NO

DUPLICATE SAMPLE NO.

MS/MSD REQUESTED: YES NO

SAMPLE CONTAINERS, PRESERVATIVES, ANALYSIS

Sample Container	Preservative	Analysis Requested
2 - 4 oz. glass jar	4° C	8260B VOCs
1 - 8 oz. glass jar	4° C	8270C SVOCs
2-4 oz. glass jar	4° C	8015B TPH (DRO)
1 - 8 oz. glass jar	4° C	418.1 TRPH

HNU MEASUREMENTS

Background	0
Breathing zone	0
Boring	0
Headspace	0

SAMPLE DESCRIPTION

DEPTH: 8-10' bgs

DESCRIPTION: med. stiff, moist, light reddish-brown, low plastic. Silt (ML), with caliche nodules

GENERAL COMMENTS

SOIL SAMPLE COLLECTION FIELD SHEET

GENERAL INFORMATION

SITE NAME: Cannon AFB, NM

PROJECT NO. 45F0M9602V.00

SAMPLE NO. C11-SB01-020

BORING NO. SB01

DATE/TIME COLLECTED: 12-02-98/0905

PERSONNEL: M. Sonderman, D. Galde

SAMPLE METHOD / DEPTH: Stainless steel split-spoon / 18-20' bgs

SAMPLE MEDIA: SOIL SEDIMENT SLUDGE

SAMPLE QA SPLIT: YES [NO]

SPLIT SAMPLE NO.

SAMPLE QC DUPLICATE: YES [NO]

DUPLICATE SAMPLE NO.

MS/MSD REQUESTED: YES [NO]

SAMPLE CONTAINERS, PRESERVATIVES, ANALYSIS

Sample Container	Preservative	Analysis Requested
2 - 4 oz. glass jar	4° C	8260B VOCs
1 - 8 oz. glass jar	4° C	8270C SVOCs
1 - 8 oz. glass jar	4° C	8015B TPH (DRO)
1 - 8 oz. glass jar	4° C	418.1 TRPH

HNU MEASUREMENTS

Background	0
Breathing zone	0
Boring	0
Headspace	0

SAMPLE DESCRIPTION

DEPTH:	DESCRIPTION:
18-18.9	med. stiff, moist, lt. reddish-brown, low plastic silt (ML), with caliche nodules
18.9-20'	med. dense, dry, red, fine-grained sand (SM), with some silt

GENERAL COMMENTS

SOIL SAMPLE COLLECTION FIELD SHEET

GENERAL INFORMATION

SITE NAME: Cannon AFB, NM

PROJECT NO. 45F0M9602V.00

SAMPLE NO. C11-SB01-030

BORING NO. SB01

DATE/TIME COLLECTED: 12-02-98 / 0925

PERSONNEL: M. Sonderman, D. Galde

SAMPLE METHOD / DEPTH: Stainless steel split-spoon / 28-30' bgs

SAMPLE MEDIA: SOIL SEDIMENT SLUDGE

SAMPLE QA SPLIT: YES [NO]

SAMPLE QC DUPLICATE: YES [NO]

MS/MSD REQUESTED: YES [NO]

SPLIT SAMPLE NO.

DUPLICATE SAMPLE NO.

SAMPLE CONTAINERS, PRESERVATIVES, ANALYSIS

Sample Container	Preservative	Analysis Requested
2 - 4 oz. glass jar	4° C	8260B VOCs
1 - 8 oz. glass jar	4° C	8270C SVOCs
1 - 8 oz. glass jar	4° C	8015B TPH (DRO)
1 - 8 oz. glass jar	4° C	418.1 TRPH

HNU MEASUREMENTS

Background	0
Breathing zone	0
Boring	0
Headspace	0

SAMPLE DESCRIPTION

DEPTH: 28-30' bgs

DESCRIPTION: med. dense, dry, red, fine-grained, sand (SM) with some silt

GENERAL COMMENTS

SOIL SAMPLE COLLECTION FIELD SHEET

GENERAL INFORMATION

SITE NAME: Cannon AFB, NM

PROJECT NO. 45F0M9602V.00

SAMPLE NO. C11-SB01-040

BORING NO. SB01

DATE/TIME COLLECTED: 12-02-98 / 0947

PERSONNEL: M. Sonderman, D. Galde

SAMPLE METHOD / DEPTH: Stainless steel split-spoon

SAMPLE MEDIA:	SOIL	SEDIMENT	SLUDGE
SAMPLE QA SPLIT:	YES	NO	SPLIT SAMPLE NO.
SAMPLE QC DUPLICATE:	YES	NO	DUPLICATE SAMPLE NO.
MS/MSD REQUESTED:	YES	NO	

SAMPLE CONTAINERS, PRESERVATIVES, ANALYSIS

Sample Container	Preservative	Analysis Requested
2 - 4 oz. glass jar	4° C	8260B VOCs
1 - 8 oz. glass jar	4° C	8270C SVOCs
1 - 8 oz. glass jar	4° C	8015B TPH (DRO)
1 - 8 oz. glass jar	4° C	418.1 TRPH

HNU MEASUREMENTS

Background	0
Breathing zone	0
Boring	0
Headspace	0

SAMPLE DESCRIPTION

DEPTH: 38-40' bgs

DESCRIPTION: med. dense, dry, red, fine-grained sand (SM

GENERAL COMMENTS

SOIL SAMPLE COLLECTION FIELD SHEET

GENERAL INFORMATION

SITE NAME: Cannon AFB, NM

PROJECT NO. 45F0M9602V.00

SAMPLE NO. C11-SB02-002

BORING NO. SB02

DATE/TIME COLLECTED: 12-02-98/1043

PERSONNEL: M. Sonderman, D. Galde

SAMPLE METHOD / DEPTH: Stainless steel split-spoon / 0-1' bgs

SAMPLE MEDIA: SOIL SEDIMENT SLUDGE

SAMPLE QA SPLIT: YES (NO)

SPLIT SAMPLE NO. C11

SAMPLE QC DUPLICATE: (YES) NO

DUPLICATE SAMPLE NO. ~~C11~~ SB52-202 T-0800

MS/MSD REQUESTED: YES (NO)

SAMPLE CONTAINERS, PRESERVATIVES, ANALYSIS

Sample Container	Preservative	Analysis Requested
2 - 4 oz. glass jar	4° C	8260B VOCs
1 - 8 oz. glass jar	4° C	8270C SVOCs
1 - 8 oz. glass jar	4° C	8015B TPH (DRO)
1 - 8 oz. glass jar	4° C	418.1 TRPH

HNU MEASUREMENTS

Background	0
Breathing zone	0
Boring	0
Headspace	0

SAMPLE DESCRIPTION

DEPTH: 0-1' bgs DESCRIPTION: Loose, moist, red, fine-grained sand (SM), with some silt + clay; gravel on surface, roots (fill)

GENERAL COMMENTS

SVOCs, TPH + TRPH from 0-0.5' bgs
VOCs from 0.5 - 1.0' bgs

SOIL SAMPLE COLLECTION FIELD SHEET

GENERAL INFORMATION

SITE NAME: Cannon AFB, NM

PROJECT NO. 45F0M9602V.00

SAMPLE NO. C11-SB02-90

BORING NO. SB02

DATE/TIME COLLECTED: 12-02-98 / 1055

PERSONNEL: M. Sonderman, D. Galde

SAMPLE METHOD / DEPTH: Stainless steel split-spoon / 8-10' bgs

SAMPLE MEDIA: SOIL SEDIMENT SLUDGE

SAMPLE QA SPLIT: YES NO

SAMPLE QC DUPLICATE: YES NO

SPLIT SAMPLE NO.

DUPLICATE SAMPLE NO.

MS/MSD REQUESTED: YES NO

C11-SB02-110

SAMPLE CONTAINERS, PRESERVATIVES, ANALYSIS

Sample Container	Preservative	Analysis Requested
2 - 4 oz. glass jar	4° C	8260B VOCs
1 - 8 oz. glass jar	4° C	8270C SVOCs
1 - 8 oz. glass jar	4° C	8015B TPH (DRO)
1 - 8 oz. glass jar	4° C	418.1 TRPH

HNU MEASUREMENTS

Background	0
Breathing zone	0
Boring	0
Headspace	0

SAMPLE DESCRIPTION

DEPTH: 8-10' bgs

DESCRIPTION: stiff, moist, lt. reddish-brown, low plastic silt (ML), with clay + fine sand

GENERAL COMMENTS

SOIL SAMPLE COLLECTION FIELD SHEET

GENERAL INFORMATION

SITE NAME: Cannon AFB, NM

PROJECT NO. 45F0M9602V.00

SAMPLE NO. C11 - SB02 - 020

BORING NO. SB02

DATE/TIME COLLECTED: 12-02-98 / 1115

PERSONNEL: M. Sonderman, D. Galde

SAMPLE METHOD / DEPTH: Stainless steel split-spoon / 18-20' bgs

SAMPLE MEDIA: SOIL SEDIMENT SLUDGE

SAMPLE QA SPLIT: YES [NO]

SAMPLE QC DUPLICATE: YES [NO]

MS/MSD REQUESTED: YES [NO]

SPLIT SAMPLE NO.

DUPLICATE SAMPLE NO.

SAMPLE CONTAINERS, PRESERVATIVES, ANALYSIS

Sample Container	Preservative	Analysis Requested
2 - 4 oz. glass jar	4° C	8260B VOCs
1 - 8 oz. glass jar	4° C	8270C SVOCs
1 - 8 oz. glass jar	4° C	8015B TPH (DRO)
1 - 8 oz. glass jar	4° C	418.1 TRPH

HNU MEASUREMENTS

Background	0
Breathing zone	0
Boring	0
Headspace	0

SAMPLE DESCRIPTION

DEPTH:	DESCRIPTION:
~~18.0-20.0' bgs~~ 18.0'-18.3'	stiff, moist, lt reddish-brown, low plastic silt (ML), with some sand + clay
18.3-20.0' bgs	med. dense. to dense, sl. moist, fine-grained sand (SP), some caliche nodules

GENERAL COMMENTS

11/30/98

WOODWARD-CLYDE

SOIL SAMPLE COLLECTION FIELD SHEET

GENERAL INFORMATION

SITE NAME: Cannon AFB, NM

PROJECT NO. 45F0M9602V.00

SAMPLE NO. C11-SB02-030

BORING NO. SB02

DATE/TIME COLLECTED: 12-02-98 / 1132

PERSONNEL: M. Sonderman, D. Galde

SAMPLE METHOD / DEPTH: Stainless steel split-spoon / 28-29.5' bgs

SAMPLE MEDIA: SOIL SEDIMENT SLUDGE

SAMPLE QA SPLIT: YES [NO]

SPLIT SAMPLE NO.

SAMPLE QC DUPLICATE: YES [NO]

DUPLICATE SAMPLE NO.

MS/MSD REQUESTED: YES [NO]

SAMPLE CONTAINERS, PRESERVATIVES, ANALYSIS

Sample Container	Preservative	Analysis Requested
2 - 4 oz. glass jar	4° C	8260B VOCs
1 - 8 oz. glass jar	4° C	8270C SVOCs
1 - 8 oz. glass jar	4° C	8015B TPH (DRO)
1 - 8 oz. glass jar	4° C	418.1 TRPH

HNU MEASUREMENTS

Background	0
Breathing zone	0
Boring	0
Headspace	0

SAMPLE DESCRIPTION

DEPTH: 28-29.5' bgs DESCRIPTION: dense, sl. moist, lt. reddish brown sand (SM), with silt, some cemented nodules

GENERAL COMMENTS

SOIL SAMPLE COLLECTION FIELD SHEET

GENERAL INFORMATION

SITE NAME: Cannon AFB, NM

PROJECT NO. 45F0M9602V.00

SAMPLE NO. C11-SB02-040

BORING NO. SB02

DATE/TIME COLLECTED: 12-02-98/ 1200

PERSONNEL: M. Sonderman, D. Galde

SAMPLE METHOD / DEPTH: Stainless steel split-spoon

SAMPLE MEDIA: SOIL SEDIMENT SLUDGE

SAMPLE QA SPLIT: YES [NO]

SAMPLE QC DUPLICATE: YES [NO]

MS/MSD REQUESTED: YES [NO]

SPLIT SAMPLE NO.

DUPLICATE SAMPLE NO.

SAMPLE CONTAINERS, PRESERVATIVES, ANALYSIS

Sample Container	Preservative	Analysis Requested
2 - 4 oz. glass jar	4° C	8260B VOCs
1 - 8 oz. glass jar	4° C	8270C SVOCs
1 - 8 oz. glass jar	4° C	8015B TPH (DRO)
1 - 8 oz. glass jar	4° C	418.1 TRPH

HNU MEASUREMENTS

Background	0
Breathing zone	0
Boring	0
Headspace	0

SAMPLE DESCRIPTION

DEPTH: 38-40' bgs

DESCRIPTION: Dense, sl. moist, lt. reddish-brown, fine-grained sand (SM), some silty caliche nodules, iron cemented sand nodules

GENERAL COMMENTS

VOCs from 38-38.4'; SVOCs, TPH, TRPH from 38-38.4 + 39.5 to 39.8' bgs. Drove 2 spoons.

SOIL SAMPLE COLLECTION FIELD SHEET

GENERAL INFORMATION

SITE NAME: Cannon AFB, NM

PROJECT NO. 45F0M9602V.00

SAMPLE NO. C11-SB03-002

BORING NO. SB03

DATE/TIME COLLECTED: 12-02-98 / 1354

PERSONNEL: M. Sonderman, D. Galde

SAMPLE METHOD / DEPTH: Stainless steel split-spoon / 0-1' bgs

SAMPLE MEDIA: SOIL SEDIMENT SLUDGE

SAMPLE QA SPLIT: [YES] NO

SPLIT SAMPLE NO. C11-SB03-302 LMS 5109

SAMPLE QC DUPLICATE: [YES] NO

DUPLICATE SAMPLE NO. C11-SB53-202

MS/MSD REQUESTED: YES [NO]

SAMPLE CONTAINERS, PRESERVATIVES, ANALYSIS

Sample Container	Preservative	Analysis Requested
2 - 4 oz. glass jar	4° C	8260B VOCs
1 - 8 oz. glass jar	4° C	8270C SVOCs
1 - 8 oz. glass jar	4° C	8015B TPH (DRO)
1 - 8 oz. glass jar	4° C	418.1 TRPH

HNU MEASUREMENTS

Background	0
Breathing zone	0
Boring	0
Headspace	0

SAMPLE DESCRIPTION

DEPTH: 0-1'

DESCRIPTION: Loose, moist, red, fine-grained, sand (SM), with silt, roots, gravel on surface

GENERAL COMMENTS

Fill on surface (0-0.2'); native soil below 0.2' bgs

SOIL SAMPLE COLLECTION FIELD SHEET

GENERAL INFORMATION

SITE NAME: Cannon AFB, NM

PROJECT NO. 45F0M9602V.00

SAMPLE NO. C11-SB03-010

BORING NO. SB03

DATE/TIME COLLECTED: 12-02-98 / 1418

PERSONNEL: M. Sonderman, D. Galde

SAMPLE METHOD / DEPTH: Stainless steel split-spoon / 8-9.2' bgs

SAMPLE MEDIA: SOIL SEDIMENT SLUDGE

SAMPLE QA SPLIT: YES NO

SPLIT SAMPLE NO.

SAMPLE QC DUPLICATE: YES NO

DUPLICATE SAMPLE NO.

MS/MSD REQUESTED: YES NO

SAMPLE CONTAINERS, PRESERVATIVES, ANALYSIS

Sample Container	Preservative	Analysis Requested
2 - 4 oz. glass jar	4° C	8260B VOCs
1 - 8 oz. glass jar	4° C	8270C SVOCs
1 - 8 oz. glass jar	4° C	8015B TPH (DRO)
1 - 8 oz. glass jar	4° C	418.1 TRPH

HNU MEASUREMENTS

Background	0
Breathing zone	0
Boring	0
Headspace	0

SAMPLE DESCRIPTION

DEPTH: 8-9.2' bgs

DESCRIPTION: V. stiff, sl. moist to dry, lt reddish-brown, low plastic silt (ML), some fine sand, moderately cemented with caliche nodules

GENERAL COMMENTS

SOIL SAMPLE COLLECTION FIELD SHEET

GENERAL INFORMATION

SITE NAME: Cannon AFB, NM

PROJECT NO. 45F0M9602V.00

SAMPLE NO. C11-SB03-020

BORING NO. SB03

DATE/TIME COLLECTED: 12-02-98 / 1433

PERSONNEL: M. Sonderman, D. Galde

SAMPLE METHOD / DEPTH: Stainless steel split-spoon 18-19.5' bgs

SAMPLE MEDIA: SOIL SEDIMENT SLUDGE

SAMPLE QA SPLIT: YES [NO]

SPLIT SAMPLE NO.

SAMPLE QC DUPLICATE: YES [NO]

DUPLICATE SAMPLE NO. C11-SB03-120

MS/MSD REQUESTED: (YES) NO

SAMPLE CONTAINERS, PRESERVATIVES, ANALYSIS

Sample Container	Preservative	Analysis Requested
2 - 4 oz. glass jar	4° C	8260B VOCs
1 - 8 oz. glass jar	4° C	8270C SVOCs
1 - 8 oz. glass jar	4° C	8015B TPH (DRO)
1 - 8 oz. glass jar	4° C	418.1 TRPH

HNU MEASUREMENTS

Background	0
Breathing zone	0
Boring	0
Headspace	0

SAMPLE DESCRIPTION

DEPTH: 18-18.6' bgs DESCRIPTION: v. stiff, sl. moist. to dry, lt. reddish-brown, low plastic silty (ML), some fine sand, moderately cemented to heavily cemented

18.6-19.9' bgs Dense, sl. moist. to dry, red fine-grained sand (SM) with silt, moderately cemented with caliche nodules

GENERAL COMMENTS

SOIL SAMPLE COLLECTION FIELD SHEET

GENERAL INFORMATION

SITE NAME: Cannon AFB, NM

PROJECT NO. 45F0M9602V.00

SAMPLE NO. CLL-SB03-030

BORING NO. SB03

DATE/TIME COLLECTED: 12-02-98 / 1453

PERSONNEL: M. Sonderman, D. Galde

SAMPLE METHOD / DEPTH: Stainless steel split-spoon 28-29.8'

SAMPLE MEDIA: SOIL SEDIMENT SLUDGE

SAMPLE QA SPLIT: YES NO

SAMPLE QC DUPLICATE: YES NO

MS/MSD REQUESTED: YES NO

SPLIT SAMPLE NO.

DUPLICATE SAMPLE NO.

SAMPLE CONTAINERS, PRESERVATIVES, ANALYSIS

Sample Container	Preservative	Analysis Requested
2 - 4 oz. glass jar	4° C	8260B VOCs
1 - 8 oz. glass jar	4° C	8270C SVOCs
1 - 8 oz. glass jar	4° C	8015B TPH (DRO)
1 - 8 oz. glass jar	4° C	418.1 TRPH

HNU MEASUREMENTS

Background	0
Breathing zone	0
Boring	0
Headspace	0

SAMPLE DESCRIPTION

DEPTH: 28'-29.8' bgs DESCRIPTION: Dense, sl. moist to dry, red. to lt. reddish-brown, fine grained sand (SM), with some silt, heavily cemented

GENERAL COMMENTS

SOIL SAMPLE COLLECTION FIELD SHEET

GENERAL INFORMATION

SITE NAME: Cannon AFB, NM

PROJECT NO. 45F0M9602V.00

SAMPLE NO. C11-SB03-040

BORING NO. SB03

DATE/TIME COLLECTED: 12-02-98 / 1513

PERSONNEL: M. Sonderman, D. Galde

SAMPLE METHOD / DEPTH: Stainless steel split-spoon / 38.0' - 39.0'

SAMPLE MEDIA: SOIL SEDIMENT SLUDGE

SAMPLE QA SPLIT: YES [NO]

SPLIT SAMPLE NO.

SAMPLE QC DUPLICATE: YES [NO]

DUPLICATE SAMPLE NO.

MS/MSD REQUESTED: YES [NO]

SAMPLE CONTAINERS, PRESERVATIVES, ANALYSIS

Sample Container	Preservative	Analysis Requested
2 - 4 oz. glass jar	4° C	8260B VOCs
1 - 8 oz. glass jar	4° C	8270C SVOCs
1 - 8 oz. glass jar	4° C	8015B TPH (DRO)
1 - 8 oz. glass jar	4° C	418.1 TRPH

HNU MEASUREMENTS

Background	0
Breathing zone	0
Boring	0
Headspace	0

SAMPLE DESCRIPTION

DEPTH: 38-39.0' bgs

DESCRIPTION: very dense, sl. moist to dry, pt red, fine-grained sand (SM) with some silt, heavily cemented

GENERAL COMMENTS

TABLE B-1

SUMMARY OF ANALYTICAL RESULTS FOR SOIL SAMPLES FROM APPENDIX I SWMUs (SITE SD-11) CMS INVESTIGATION' CANNON AFB, NEW MEXICO

FIELD ID			C11-SB01-002			C11-SB01-010			C11-SB01-020			C11-SB01-030			C11-SB01-040		
COLLECT DATE			12/2/98			12/2/98			12/2/98			12/2/98			12/2/98		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
VOLATILE ORGANICS (METHOD 8260) (µg/kg)																	
1,1,1-Trichloroethane		0/15	<	11	U	<	11	U	<	33	U	<	33	U	<	33	U
1,1,2,2-Tetrachloroethane		0/15	<	11	U	<	11	U	<	33	U	<	33	U	<	33	U
1,1,2-Trichloroethane		0/15	<	11	U	<	11	U	<	33	U	<	33	U	<	33	U
1,1-Dichloroethane		0/15	<	11	U	<	11	U	<	33	U	<	33	U	<	33	U
1,1-Dichloroethene		0/15	<	11	U	<	11	U	<	33	U	<	33	U	<	33	U
1,2-Dichloroethane		0/15	<	11	U	<	11	U	<	33	U	<	33	U	<	33	U
1,2-Dichloropropane		0/15	<	11	U	<	11	U	<	33	U	<	33	U	<	33	U
2-Hexanone		0/15	<	19	U	<	19	U	<	55	U	<	55	U	<	55	U
Acetone		0/15	<	19	U	<	19	U	<	55	U	<	55	U	<	55	U
Benzene		0/15	<	11	U	<	11	U	<	33	U	<	33	U	<	33	U
Bromodichloromethane		0/15	<	11	U	<	11	U	<	33	U	<	33	U	<	33	U
Bromoform		0/15	<	11	U	<	11	U	<	33	U	<	33	U	<	33	U
Bromomethane		0/15	<	11	U	<	11	U	<	33	U	<	33	U	<	33	U
Carbon Disulfide		0/15	<	11	U	<	11	U	<	33	U	<	33	U	<	33	U
Carbon Tetrachloride		0/15	<	11	U	<	11	U	<	33	U	<	33	U	<	33	U
Chlorobenzene		0/15	<	11	U	<	11	U	<	33	U	<	33	U	<	33	U
Chloroethane		0/15	<	11	U	<	11	U	<	33	U	<	33	U	<	33	U
Chloroform		0/15	<	11	U	<	11	U	<	33	U	<	33	U	<	33	U
Chloromethane		0/15	<	11	U	<	11	U	<	33	U	<	33	U	<	33	U
cis-1,2-Dichloroethylene		0/15	<	11	U	<	11	U	<	33	U	<	33	U	<	33	U
cis-1,3-Dichloropropene		0/15	<	11	U	<	11	U	<	33	U	<	33	U	<	33	U
Dibromochloromethane		0/15	<	11	U	<	11	U	<	33	U	<	33	U	<	33	U
Dichlorodifluoromethane		0/15	<	11	U	<	11	U	<	33	U	<	33	U	<	33	U
Ethylbenzene		0/15	<	11	U	<	11	U	<	33	U	<	33	U	<	33	U
M,P-Xylene (Sum of Isomers)		0/15	<	11	U	<	11	U	<	33	U	<	33	U	<	33	U
Methyl Ethyl Ketone (2-Butanone)		0/15	<	19	U	<	19	U	<	55	U	<	55	U	<	55	U
Methyl Isobutyl Ketone (4-Methyl-2-Pentanone)		0/15	<	19	U	<	19	U	<	55	U	<	55	U	<	55	U
Methylene Chloride		0/15	<	11	U	<	11	U	<	43	U	<	49	U	<	42	U
O-Xylene (1,2-Dimethylbenzene)		0/15	<	11	U	<	11	U	<	33	U	<	33	U	<	33	U
Styrene		0/15	<	11	U	<	11	U	<	33	U	<	33	U	<	33	U
Tetrachloroethylene(PCE)		0/15	<	11	U	<	11	U	<	33	U	<	33	U	<	33	U
Toluene		0/15	<	11	U	<	11	U	<	33	U	<	33	U	<	33	U
trans-1,2-Dichloroethene		0/15	<	11	U	<	11	U	<	33	U	<	33	U	<	33	U

TABLE B-1

SUMMARY OF ANALYTICAL RESULTS FOR SOIL SAMPLES FROM APPENDIX I SWMUs (SITE SD-11) CMS INVESTIGATION[1] CANNON AFB, NEW MEXICO

FIELD ID			C11-SB01-002			C11-SB01-010			C11-SB01-020			C11-SB01-030			C11-SB01-040		
COLLECT DATE			12/2/98			12/2/98			12/2/98			12/2/98			12/2/98		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
VOLATILE ORGANICS (METHOD 8260) (µg/kg), cont.																	
trans-1,3-Dichloropropene		0/15	<	11	U	<	11	U	<	33	U	<	33	U	<	33	U
Trichloroethylene (TCE)		0/15	<	11	U	<	11	U	<	33	U	<	33	U	<	33	U
Trichlorofluoromethane		0/15	<	11	U	<	11	U	<	33	U	<	33	U	<	33	U
Vinyl Chloride		0/15	<	11	U	<	11	U	<	33	U	<	33	U	<	33	U
SEMIVOLATILE ORGANICS (METHOD 8270) (µg/kg)																	
1,2,4-Trichlorobenzene		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
1,2-Dichlorobenzene		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
1,2-Diphenylhydrazine		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
1,3-Dichlorobenzene		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
1,4-Dichlorobenzene		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
2,2'-Oxybis(1-Chloro)Propane		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
2,4,5-Trichlorophenol		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
2,4,6-Trichlorophenol		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
2,4-Dichlorophenol		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
2,4-Dimethylphenol		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
2,4-Dinitrophenol		0/15	<	750	UJ	<	750	UJ	<	730	UJ	<	730	UJ	<	730	UJ
2,4-Dinitrotoluene		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
2,6-Dinitrotoluene		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
2-Chloronaphthalene		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
2-Chlorophenol		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
2-Methylnaphthalene		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
2-Methylphenol (O-Cresol)		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
2-Nitroaniline		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
2-Nitrophenol		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
3,3'-Dichlorobenzidine		0/15	<	750	UJ	<	750	UJ	<	730	UJ	<	730	UJ	<	730	UJ
3-Nitroaniline		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
4,6-Dinitro-2-Methylphenol		0/15	<	750	UJ	<	750	UJ	<	730	UJ	<	730	UJ	<	730	UJ
4-Bromophenyl Phenyl Ether		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
4-Chloro-3-Methylphenol		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
4-Chloroaniline		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
4-Chlorophenyl Phenyl Ether		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
4-Methylphenol (P-Cresol)		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
4-Nitroaniline		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ

TABLE B-1

SUMMARY OF ANALYTICAL RESULTS FOR SOIL SAMPLES FROM APPENDIX I SWMUs (SITE SD-11) CMS INVESTIGATION' CANNON AFB, NEW MEXICO

FIELD ID			C11-SB01-002			C11-SB01-010			C11-SB01-020			C11-SB01-030			C11-SB01-040		
COLLECT DATE			12/2/98			12/2/98			12/2/98			12/2/98			12/2/98		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
SEMIVOLATILE ORGANICS (METHOD 8270) (µg/kg), cont.																	
4-Nitrophenol		0/15	<	750	UJ	<	750	UJ	<	730	UJ	<	730	UJ	<	730	UJ
Acenaphthene		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
Acenaphthylene		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
Aniline (Phenylamine, Aminobenzene)		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
Anthracene		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
Benzidine		0/15	<	1900	UJ	<	1900	UJ	<	1800	UJ	<	1800	UJ	<	1800	UJ
Benzo(a)anthracene		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
Benzo(a)pyrene		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
Benzo(b)fluoranthene		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
Benzo(g,h,i)perylene		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
Benzo(k)fluoranthene		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
Benzoic Acid		0/15	<	1900	UJ	<	1900	UJ	<	1800	UJ	<	1800	UJ	<	1800	UJ
Benzyl Alcohol		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
Benzyl Butyl Phthalate		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
bis(2-Chloroethoxy) Methane		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
bis(2-Chloroethyl) Ether (2-Chloroethyl Ether)		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
bis(2-Ethylhexyl) Phthalate		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
Carbazole		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
Chrysene		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
Di-N-Butyl Phthalate	150	1/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
Di-N-Octylphthalate		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
Dibenz(a,h)anthracene		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
Dibenzofuran		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
Diethyl Phthalate		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
Dimethyl Propanedioic		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
Fluoranthene		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
Fluorene		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
Hexachlorobenzene		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
Hexachlorobutadiene		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
Hexachlorocyclopentadiene		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
Hexachloroethane		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
Indeno(1,2,3-c,d)pyrene		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
Isophorone		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ

TABLE B-1

SUMMARY OF ANALYTICAL RESULTS FOR SOIL SAMPLES FROM APPENDIX I SWMUs (SITE SD-11) CMS INVESTIGATION' CANNON AFB, NEW MEXICO

FIELD ID			C11-SB01-002			C11-SB01-010			C11-SB01-020			C11-SB01-030			C11-SB01-040		
COLLECT DATE			12/2/98			12/2/98			12/2/98			12/2/98			12/2/98		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
SEMIVOLATILE ORGANICS (METHOD 8270) (µg/kg), cont.																	
N-Nitrosodi-N-Propylamine		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
N-Nitrosodiphenylamine		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
Naphthalene		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
Nitrobenzene		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
Pentachlorophenol		0/15	<	750	UJ	<	750	UJ	<	730	UJ	<	730	UJ	<	730	UJ
Phenanthrene		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
Phenol	55	1/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
Pyrene		0/15	<	380	UJ	<	380	UJ	<	360	UJ	<	360	UJ	<	360	UJ
TOTAL PETROLEUM HYDROCARBONS (TPH) (mg/kg)																	
Petroleum Hydrocarbons, Total Recoverable (TRPH)	130	15/15	41	20		26	20		28	20		34	20		39	20	
TPH - Diesel Range Organics (DRO)	68	1/15	<	28	U	<	28	U	<	27	U	<	27	U	<	27	U

mg/kg - milligram per killogram
µg/kg - microgram per killogram
J - Estimated
U - Nondetect
RL - Reporting Limit
Qual - Qualifier

TABLE B-1

SUMMARY OF ANALYTICAL RESULTS FOR SOIL SAMPLES FROM APPENDIX I SWMUs (SITE SD-11) CMS INVESTIGATION ' CANNON AFB, NEW MEXICO

FIELD ID			C11-SB02-002			C11-SB02-010			C11-SB02-020			C11-SB02-030			C11-SB02-040		
COLLECT DATE			12/2/98			12/2/98			12/2/98			12/2/98			12/2/98		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
VOLATILE ORGANICS (METHOD 8260) (µg/kg)																	
1,1,1-Trichloroethane		0/15	<	34	U	<	11	U	<	34	U	<	36	U	<	33	U
1,1,2,2-Tetrachloroethane		0/15	<	34	U	<	11	U	<	34	U	<	36	U	<	33	U
1,1,2-Trichloroethane		0/15	<	34	U	<	11	U	<	34	U	<	36	U	<	33	U
1,1-Dichloroethane		0/15	<	34	U	<	11	U	<	34	U	<	36	U	<	33	U
1,1-Dichloroethene		0/15	<	34	U	<	11	U	<	34	U	<	36	U	<	33	U
1,2-Dichloroethane		0/15	<	34	U	<	11	U	<	34	U	<	36	U	<	33	U
1,2-Dichloropropane		0/15	<	34	U	<	11	U	<	34	U	<	36	U	<	33	U
2-Hexanone		0/15	<	57	U	<	19	U	<	56	U	<	60	U	<	54	U
Acetone		0/15	<	57	U	<	19	U	<	56	U	<	60	U	<	54	U
Benzene		0/15	<	34	U	<	11	U	<	34	U	<	36	U	<	33	U
Bromodichloromethane		0/15	<	34	U	<	11	U	<	34	U	<	36	U	<	33	U
Bromoform		0/15	<	34	U	<	11	U	<	34	U	<	36	U	<	33	U
Bromomethane		0/15	<	34	U	<	11	U	<	34	U	<	36	U	<	33	U
Carbon Disulfide		0/15	<	34	U	<	11	U	<	34	U	<	36	U	<	33	U
Carbon Tetrachloride		0/15	<	34	U	<	11	U	<	34	U	<	36	U	<	33	U
Chlorobenzene		0/15	<	34	U	<	11	U	<	34	U	<	36	U	<	33	U
Chloroethane		0/15	<	34	U	<	11	U	<	34	U	<	36	U	<	33	U
Chloroform		0/15	<	34	U	<	11	U	<	34	U	<	36	U	<	33	U
Chloromethane		0/15	<	34	U	<	11	U	<	34	U	<	36	U	<	33	U
cis-1,2-Dichloroethylene		0/15	<	34	U	<	11	U	<	34	U	<	36	U	<	33	U
cis-1,3-Dichloropropene		0/15	<	34	U	<	11	U	<	34	U	<	36	U	<	33	U
Dibromochloromethane		0/15	<	34	U	<	11	U	<	34	U	<	36	U	<	33	U
Dichlorodifluoromethane		0/15	<	34	U	<	11	U	<	34	U	<	36	U	<	33	U
Ethylbenzene		0/15	<	34	U	<	11	U	<	34	U	<	36	U	<	33	U
M,P-Xylene (Sum of Isomers)		0/15	<	34	U	<	11	U	<	34	U	<	36	U	<	33	U
Methyl Ethyl Ketone (2-Butanone)		0/15	<	57	U	<	19	U	<	56	U	<	60	U	<	54	U
Methyl Isobutyl Ketone (4-Methyl-2-Pentanone)		0/15	<	57	U	<	19	U	<	56	U	<	60	U	<	54	U
Methylene Chloride		0/15	<	46	U	<	11	U	<	53	U	<	36	U	<	46	U
O-Xylene (1,2-Dimethylbenzene)		0/15	<	34	U	<	11	U	<	34	U	<	36	U	<	33	U
Styrene		0/15	<	34	U	<	11	U	<	34	U	<	36	U	<	33	U
Tetrachloroethylene(PCE)		0/15	<	34	U	<	11	U	<	34	U	<	36	U	<	33	U
Toluene		0/15	<	34	U	<	11	U	<	34	U	<	36	U	<	33	U
trans-1,2-Dichloroethene		0/15	<	34	U	<	11	U	<	34	U	<	36	U	<	33	U

TABLE B-1

SUMMARY OF ANALYTICAL RESULTS FOR SOIL SAMPLES FROM APPENDIX I SWMUs (SITE SD-11) CMS INVESTIGATION' CANNON AFB, NEW MEXICO

FIELD ID			C11-SB02-002			C11-SB02-010			C11-SB02-020			C11-SB02-030			C11-SB02-040		
COLLECT DATE			12/2/98			12/2/98			12/2/98			12/2/98			12/2/98		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
VOLATILE ORGANICS (METHOD 8260) (µg/kg), cont.																	
trans-1,3-Dichloropropene		0/15	<	34	U	<	11	U	<	34	U	<	36	U	<	33	U
Trichloroethylene (TCE)		0/15	<	34	U	<	11	U	<	34	U	<	36	U	<	33	U
Trichlorofluoromethane		0/15	<	34	U	<	11	U	<	34	U	<	36	U	<	33	U
Vinyl Chloride		0/15	<	34	U	<	11	U	<	34	U	<	36	U	<	33	U
SEMIVOLATILE ORGANICS (METHOD 8270) (µg/kg)																	
1,2,4-Trichlorobenzene		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
1,2-Dichlorobenzene		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
1,2-Diphenylhydrazine		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
1,3-Dichlorobenzene		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
1,4-Dichlorobenzene		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
2,2'-Oxybis(1-Chloro)Propane		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
2,4,5-Trichlorophenol		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
2,4,6-Trichlorophenol		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
2,4-Dichlorophenol		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
2,4-Dimethylphenol		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
2,4-Dinitrophenol		0/15	<	760	UJ	<	770	UJ	<	750	UJ	<	800	UJ	<	720	UJ
2,4-Dinitrotoluene		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
2,6-Dinitrotoluene		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
2-Chloronaphthalene		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
2-Chlorophenol		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
2-Methylnaphthalene		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
2-Methylphenol (O-Cresol)		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
2-Nitroaniline		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
2-Nitrophenol		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
3,3'-Dichlorobenzidine		0/15	<	760	UJ	<	770	UJ	<	750	UJ	<	800	UJ	<	720	UJ
3-Nitroaniline		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
4,6-Dinitro-2-Methylphenol		0/15	<	760	UJ	<	770	UJ	<	750	UJ	<	800	UJ	<	720	UJ
4-Bromophenyl Phenyl Ether		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
4-Chloro-3-Methylphenol		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
4-Chloroaniline		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
4-Chlorophenyl Phenyl Ether		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
4-Methylphenol (P-Cresol)		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
4-Nitroaniline		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ

TABLE B-1

SUMMARY OF ANALYTICAL RESULTS FOR SOIL SAMPLES FROM APPENDIX I SWMUs (SITE SD-11) CMS INVESTIGATION' CANNON AFB, NEW MEXICO

FIELD ID			C11-SB02-002			C11-SB02-010			C11-SB02-020			C11-SB02-030			C11-SB02-040		
COLLECT DATE			12/2/98			12/2/98			12/2/98			12/2/98			12/2/98		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
SEMIVOLATILE ORGANICS (METHOD 8270) (µg/kg), cont.																	
4-Nitrophenol		0/15	<	760	UJ	<	770	UJ	<	750	UJ	<	800	UJ	<	720	UJ
Acenaphthene		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
Acenaphthylene		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
Aniline (Phenylamine, Aminobenzene)		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
Anthracene		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
Benzidine		0/15	<	1900	UJ	<	1900	UJ	<	1900	UJ	<	2000	UJ	<	1800	UJ
Benzo(a)anthracene		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
Benzo(a)pyrene		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
Benzo(b)fluoranthene		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
Benzo(g,h,i)perylene		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
Benzo(k)fluoranthene		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
Benzoic Acid		0/15	<	1900	UJ	<	1900	UJ	<	1900	UJ	<	2000	UJ	<	1800	UJ
Benzyl Alcohol		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
Benzyl Butyl Phthalate		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
bis(2-Chloroethoxy) Methane		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
bis(2-Chloroethyl) Ether (2-Chloroethyl Ether)		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
bis(2-Ethylhexyl) Phthalate		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
Carbazole		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
Chrysene		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
Di-N-Butyl Phthalate	150	1/15	<	380	UJ	150	380	J	<	380	UJ	<	400	UJ	<	360	UJ
Di-N-Octylphthalate		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
Dibenz(a,h)anthracene		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
Dibenzofuran		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
Diethyl Phthalate		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
Dimethyl Propanedioic		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
Fluoranthene		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
Fluorene		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
Hexachlorobenzene		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
Hexachlorobutadiene		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
Hexachlorocyclopentadiene		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
Hexachloroethane		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
Indeno(1,2,3-c,d)pyrene		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
Isophorone		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ

TABLE B-1

SUMMARY OF ANALYTICAL RESULTS FOR SOIL SAMPLES FROM APPENDIX I SWMUs (SITE SD-11) CMS INVESTIGATION' CANNON AFB, NEW MEXICO

FIELD ID			C11-SB02-002			C11-SB02-010			C11-SB02-020			C11-SB02-030			C11-SB02-040		
COLLECT DATE			12/2/98			12/2/98			12/2/98			12/2/98			12/2/98		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
SEMIVOLATILE ORGANICS (METHOD 8270) (µg/kg), cont.																	
N-Nitrosodi-N-Propylamine		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
N-Nitrosodiphenylamine		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
Naphthalene		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
Nitrobenzene		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
Pentachlorophenol		0/15	<	760	UJ	<	770	UJ	<	750	UJ	<	800	UJ	<	720	UJ
Phenanthrene		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
Phenol	55	1/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
Pyrene		0/15	<	380	UJ	<	380	UJ	<	380	UJ	<	400	UJ	<	360	UJ
TOTAL PETROLEUM HYDROCARBONS (TPH) (mg/kg)																	
Petroleum Hydrocarbons, Total Recoverable (TRPH)	130	15/15	43	20		24	20		62	20		32	20		25	20	
TPH - Diesel Range Organics (DRO)	68	1/15	<	28	U	<	29	U	<	28	U	<	30	U	<	27	U

mg/kg - milligram per killogram
µg/kg - microgram per killogram
J - Estimated
U - Nondetect
RL - Reporting Limit
Qual - Qualifier

TABLE B-1

SUMMARY OF ANALYTICAL RESULTS FOR SOIL SAMPLES FROM APPENDIX I SWMUs (SITE SD-11) CMS INVESTIGATION' CANNON AFB, NEW MEXICO

FIELD ID			C11-SB03-002			C11-SB03-010			C11-SB03-020			C11-SB03-030			C11-SB03-040		
COLLECT DATE			12/2/98			12/2/98			12/2/98			12/2/98			12/2/98		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
VOLATILE ORGANICS (METHOD 8260) (µg/kg)																	
1,1,1-Trichloroethane		0/15	<	11	U	<	33	U	<	33	U	<	34	U	<	34	U
1,1,2,2-Tetrachloroethane		0/15	<	11	U	<	33	U	<	33	U	<	34	U	<	34	U
1,1,2-Trichloroethane		0/15	<	11	U	<	33	U	<	33	U	<	34	U	<	34	U
1,1-Dichloroethane		0/15	<	11	U	<	33	U	<	33	U	<	34	U	<	34	U
1,1-Dichloroethene		0/15	<	11	U	<	33	U	<	33	U	<	34	U	<	34	U
1,2-Dichloroethane		0/15	<	11	U	<	33	U	<	33	U	<	34	U	<	34	U
1,2-Dichloropropane		0/15	<	11	U	<	33	U	<	33	U	<	34	U	<	34	U
2-Hexanone		0/15	<	19	U	<	54	U	<	56	U	<	56	U	<	57	U
Acetone		0/15	<	19	U	<	54	U	<	56	U	<	56	U	<	57	U
Benzene		0/15	<	11	U	<	33	U	<	33	U	<	34	U	<	34	U
Bromodichloromethane		0/15	<	11	U	<	33	U	<	33	U	<	34	U	<	34	U
Bromoform		0/15	<	11	U	<	33	U	<	33	U	<	34	U	<	34	U
Bromomethane		0/15	<	11	U	<	33	U	<	33	U	<	34	U	<	34	U
Carbon Disulfide		0/15	<	11	U	<	33	U	<	33	U	<	34	U	<	34	U
Carbon Tetrachloride		0/15	<	11	U	<	33	U	<	33	U	<	34	U	<	34	U
Chlorobenzene		0/15	<	11	U	<	33	U	<	33	U	<	34	U	<	34	U
Chloroethane		0/15	<	11	U	<	33	U	<	33	U	<	34	U	<	34	U
Chloroform		0/15	<	11	U	<	33	U	<	33	U	<	34	U	<	34	U
Chloromethane		0/15	<	11	U	<	33	U	<	33	U	<	34	U	<	34	U
cis-1,2-Dichloroethylene		0/15	<	11	U	<	33	U	<	33	U	<	34	U	<	34	U
cis-1,3-Dichloropropene		0/15	<	11	U	<	33	U	<	33	U	<	34	U	<	34	U
Dibromochloromethane		0/15	<	11	U	<	33	U	<	33	U	<	34	U	<	34	U
Dichlorodifluoromethane		0/15	<	11	U	<	33	U	<	33	U	<	34	U	<	34	U
Ethylbenzene		0/15	<	11	U	<	33	U	<	33	U	<	34	U	<	34	U
M,P-Xylene (Sum of Isomers)		0/15	<	11	U	<	33	U	<	33	U	<	34	U	<	34	U
Methyl Ethyl Ketone (2-Butanone)		0/15	<	19	U	<	54	U	<	56	U	<	56	U	<	57	U
Methyl Isobutyl Ketone (4-Methyl-2-Pentanone)		0/15	<	19	U	<	54	U	<	56	U	<	56	U	<	57	U
Methylene Chloride		0/15	<	11	U	<	48	U	<	51	U	<	49	U	<	47	U
O-Xylene (1,2-Dimethylbenzene)		0/15	<	11	U	<	33	U	<	33	U	<	34	U	<	34	U
Styrene		0/15	<	11	U	<	33	U	<	33	U	<	34	U	<	34	U
Tetrachloroethylene(PCE)		0/15	<	11	U	<	33	U	<	33	U	<	34	U	<	34	U
Toluene		0/15	<	11	U	<	33	U	<	33	U	<	34	U	<	34	U
trans-1,2-Dichloroethene		0/15	<	11	U	<	33	U	<	33	U	<	34	U	<	34	U

TABLE B-1

SUMMARY OF ANALYTICAL RESULTS FOR SOIL SAMPLES FROM APPENDIX I SWMUs (SITE SD-11) CMS INVESTIGATION CANNON AFB, NEW MEXICO

FIELD ID			C11-SB03-002			C11-SB03-010			C11-SB03-020			C11-SB03-030			C11-SB03-040		
COLLECT DATE			12/2/98			12/2/98			12/2/98			12/2/98			12/2/98		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
VOLATILE ORGANICS (METHOD 8260) (µg/kg), cont.																	
trans-1,3-Dichloropropene		0/15	<	11	U	<	33	U	<	33	U	<	34	U	<	34	U
Trichloroethylene (TCE)		0/15	<	11	U	<	33	U	<	33	U	<	34	U	<	34	U
Trichlorofluoromethane		0/15	<	11	U	<	33	U	<	33	U	<	34	U	<	34	U
Vinyl Chloride		0/15	<	11	U	<	33	U	<	33	U	<	34	U	<	34	U
SEMIVOLATILE ORGANICS (METHOD 8270) (µg/kg)																	
1,2,4-Trichlorobenzene		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
1,2-Dichlorobenzene		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
1,2-Diphenylhydrazine		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
1,3-Dichlorobenzene		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
1,4-Dichlorobenzene		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
2,2'-Oxybis(1-Chloro)Propane		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
2,4,5-Trichlorophenol		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
2,4,6-Trichlorophenol		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
2,4-Dichlorophenol		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
2,4-Dimethylphenol		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
2,4-Dinitrophenol		0/15	<	750	UJ	<	720	UJ	<	740	UJ	<	750	UJ	<	760	UJ
2,4-Dinitrotoluene		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
2,6-Dinitrotoluene		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
2-Chloronaphthalene		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
2-Chlorophenol		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
2-Methylnaphthalene		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
2-Methylphenol (O-Cresol)		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
2-Nitroaniline		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
2-Nitrophenol		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
3,3'-Dichlorobenzidine		0/15	<	750	UJ	<	720	UJ	<	740	UJ	<	750	UJ	<	760	UJ
3-Nitroaniline		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
4,6-Dinitro-2-Methylphenol		0/15	<	750	UJ	<	720	UJ	<	740	UJ	<	750	UJ	<	760	UJ
4-Bromophenyl Phenyl Ether		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
4-Chloro-3-Methylphenol		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
4-Chloroaniline		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
4-Chlorophenyl Phenyl Ether		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
4-Methylphenol (P-Cresol)		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
4-Nitroaniline		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ

TABLE B-1

SUMMARY OF ANALYTICAL RESULTS FOR SOIL SAMPLES FROM APPENDIX I SWMUs (SITE SD-11) CMS INVESTIGATION CANNON AFB, NEW MEXICO

FIELD ID			C11-SB03-002			C11-SB03-010			C11-SB03-020			C11-SB03-030			C11-SB03-040		
COLLECT DATE			12/2/98			12/2/98			12/2/98			12/2/98			12/2/98		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
SEMIVOLATILE ORGANICS (METHOD 8270) (µg/kg), cont.																	
4-Nitrophenol		0/15	<	750	UJ	<	720	UJ	<	740	UJ	<	750	UJ	<	760	UJ
Acenaphthene		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
Acenaphthylene		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
Aniline (Phenylamine, Aminobenzene)		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
Anthracene		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
Benzidine		0/15	<	1900	UJ	<	1800	UJ	<	1800	UJ	<	1900	UJ	<	1900	UJ
Benzo(a)anthracene		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
Benzo(a)pyrene		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
Benzo(b)fluoranthene		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
Benzo(g,h,i)perylene		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
Benzo(k)fluoranthene		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
Benzoic Acid		0/15	<	1900	UJ	<	1800	UJ	<	1800	UJ	<	1900	UJ	<	1900	UJ
Benzyl Alcohol		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
Benzyl Butyl Phthalate		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
bis(2-Chloroethoxy) Methane		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
bis(2-Chloroethyl) Ether (2-Chloroethyl Ether)		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
bis(2-Ethylhexyl) Phthalate		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
Carbazole		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
Chrysene		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
Di-N-Butyl Phthalate	150	1/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
Di-N-Octylphthalate		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
Dibenz(a,h)anthracene		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
Dibenzofuran		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
Diethyl Phthalate		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
Dimethyl Propanedioic		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
Fluoranthene		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
Fluorene		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
Hexachlorobenzene		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
Hexachlorobutadiene		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
Hexachlorocyclopentadiene		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
Hexachloroethane		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
Indeno(1,2,3-c,d)pyrene		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
Isophorone		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ

TABLE B-1

SUMMARY OF ANALYTICAL RESULTS FOR SOIL SAMPLES FROM APPENDIX I SWMUs (SITE SD-11) CMS INVESTIGATION' CANNON AFB, NEW MEXICO

FIELD ID			C11-SB03-002			C11-SB03-010			C11-SB03-020			C11-SB03-030			C11-SB03-040		
COLLECT DATE			12/2/98			12/2/98			12/2/98			12/2/98			12/2/98		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
SEMIVOLATILE ORGANICS (METHOD 8270) (µg/kg), cont.																	
N-Nitrosodi-N-Propylamine		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
N-Nitrosodiphenylamine		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
Naphthalene		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
Nitrobenzene		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
Pentachlorophenol		0/15	<	750	UJ	<	720	UJ	<	740	UJ	<	750	UJ	<	760	UJ
Phenanthrene		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
Phenol	55	1/15	<	380	UJ	55	360	J	<	370	UJ	<	380	UJ	<	380	UJ
Pyrene		0/15	<	380	UJ	<	360	UJ	<	370	UJ	<	380	UJ	<	380	UJ
TOTAL PETROLEUM HYDROCARBONS (TPH) (mg/kg)																	
Petroleum Hydrocarbons, Total Recoverable (TRPH)	130	15/15	130	20		30	20		34	20		36	20		39	20	
TPH - Diesel Range Organics (DRO)	68	1/15	68	28		<	27	U	<	28	U	<	28	U	<	28	U

mg/kg - milligram per killogram
µg/kg - microgram per killogram
J - Estimated
U - Nondetect
RL - Reporting Limit
Qual - Qualifier

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Region 6 Tap Water Screening Values

Specific Screening Levels

Contaminants	Tap Water																
Acephate	8.7E-03	i	C	4.0E-03	i	8.7E-03	r	4.0E-03	r	30560-19-1	2.2E+02	N	3.4E+03	c	7.7E+00	c	7.7E+01	c	6.0E+01
Acetaldehyde	7.7E-03	r		2.6E-03	r	7.7E-03	i	2.6E-03	i	75-07-0	9.2E+00	c	2.2E+01	c	8.7E-01	c	1.5E+00	c	
Acetochlor				2.0E-02	i			2.0E-02	r	34256-82-1	1.1E+03	N	2.1E+04	N	7.3E+01	N	7.3E+02	N	
Acetone				1.0E-01	i			1.0E-01	r	67-64-1	1.4E+03	N	6.1E+03	N	3.7E+02	N	6.1E+02	N	8.0E-01
Acetone cyanohydrin				8.0E-04	h			2.9E-03	x	75-86-5	4.4E+01	N	8.6E+02	N	1.0E+01	N	2.9E+01	N	
Acetonitrile				6.0E-03	i			1.4E-02	h	75-05-8	2.0E+02	N	1.4E+03	N	5.2E+01	N	7.1E+01	N	
Acetophenone				1.0E-01	i			5.7E-06	x	98-86-2	5.0E-01	N	1.6E+00	N	2.1E-02	N	4.2E-02	N	
Acifluorfen	1.1E-01	o		1.3E-02	i	1.1E-01	r	1.3E-02	r	50594-66-6	4.0E+00	c	2.7E+01	c	6.1E-02	c	6.1E-01	c	
Acrolein				2.0E-02	h			5.7E-06	i	107-02-8	1.0E-01	N	3.4E-01	N	2.1E-02	N	4.2E-02	N	
Acrylamide	4.6E+00	i	B2	2.0E-04	i	4.6E+00	i	2.0E-04	r	79-06-1	9.8E-02	c	6.6E-01	c	1.5E-03	c	1.5E-02	c	
Acrylic acid				5.0E-01	i			2.9E-04	i	79-10-7	2.6E+04	N	1.0E+05	a	1.0E+00	N	1.8E+04	N	
Acrylonitrile	5.4E-01	i	B1	1.0E-03	h	2.4E-01	i	5.7E-04	i	107-13-1	1.9E-01	c	4.9E-01	c	2.8E-02	c	3.9E-02	c	
Alachlor	8.1E-02	h		1.0E-02	i	8.0E-02	r	1.0E-02	r	15972-60-8	5.5E+00	c	3.7E+01	c	8.4E-02	c	8.4E-01	c	
Alar				1.5E-01	i			1.5E-01	r	1596-84-5	8.2E+03	N	1.0E+05	a	5.5E+02	N	5.5E+03	N	
Aldicarb				1.0E-03	i			1.0E-03	r	116-06-3	5.5E+01	N	1.1E+03	N	3.7E+00	N	3.7E+01	N	
Aldicarb sulfone				1.0E-03	i			1.0E-03	r	1646-88-4	5.5E+01	N	1.1E+03	N	3.7E+00	N	3.7E+01	N	
Aldrin	1.7E+01	i	B2	3.0E-05	i	1.7E+01	i	3.0E-05	r	309-00-2	2.6E-02	c	1.8E-01	c	3.9E-04	c	4.0E-03	c	5.9E+02
Ally				2.5E-01	i			2.5E-01	r	5585-64-8	1.4E+04	N	1.0E+05	a	9.1E+02	N	9.1E+03	N	
Allyl alcohol				5.0E-03	x			5.0E-03	r	107-18-6	2.7E+02	N	5.3E+03	N	1.8E+01	N	1.8E+02	N	
Allyl chloride				5.0E-02	h			2.9E-04	i	107-05-1	2.7E+03	N	5.2E+04	N	1.0E+00	N	1.8E+03	N	
Aluminum				1.0E+00	n					7429-90-5	7.5E+04	N	1.0E+05	a			3.7E+04	N	
Aluminum phosphide				4.0E-04	i					20859-73-8	3.0E+01	N	7.5E+02	N			1.5E+01	N	
Amdro				3.0E-04	i			3.0E-04	r	67485-29-4	1.6E+01	N	3.2E+02	N	1.1E+00	N	1.1E+01	N	
Ametryn				9.0E-03	i			9.0E-03	r	834-12-8	4.9E+02	N	9.6E+03	N	3.3E+01	N	3.3E+02	N	
m-Aminophenol				7.0E-02	h			7.0E-02	r	591-27-5	3.8E+03	N	7.5E+04	N	2.6E+02	N	2.6E+03	N	
4-Aminopyridine				2.0E-05	h			2.0E-05	r	504-24-5	1.1E+00	N	2.1E+01	N	7.3E-02	N	7.3E-01	N	
Amitraz				2.5E-03	i			2.5E-03	r	33089-61-1	1.4E+02	N	2.7E+03	N	9.1E+00	N	9.1E+01	N	
Ammonia								2.9E-02	i	7664-41-7					1.0E+02	N			
Ammonium sulfamate				2.0E-01	i					7773-06-0	1.1E+04	N	1.0E+05	a			7.3E+03	N	
Aniline	5.7E-03	i	B2	7.0E-03	n	5.7E-03	r	2.9E-04	i	62-53-3	7.8E+01	c	5.3E+02	c	1.0E+00	N	1.2E+01	c	
Antimony and compounds				4.0E-04	i					7440-36-0	3.0E+01	N	7.5E+02	N			1.5E+01	N	3.0E-01
Antimony pentoxide				5.0E-04	h					1314-60-9	3.7E+01	N	9.4E+02	N			1.8E+01	N	
Antimony potassium tartrate				9.0E-04	h					28300-74-5	6.7E+01	N	1.7E+03	N			3.3E+01	N	
Antimony tetroxide				4.0E-04	h					1332-81-6	3.0E+01	N	7.5E+02	N			1.5E+01	N	
Antimony trioxide				4.0E-04	h					1309-64-4	3.0E+01	N	7.5E+02	N			1.5E+01	N	
Apollo			B2	1.3E-02	i			1.3E-02	r	74115-24-5	7.1E+02	N	1.4E+04	N	4.7E+01	N	4.7E+02	N	
Aramite	2.5E-02	i		5.0E-02	h	2.5E-02	i	5.0E-02	r	140-57-8	1.8E+01	c	1.2E+02	c	2.7E-01	c	2.7E+00	c	
Arsenic (noncancer endpoint)				3.0E-04	i					7440-38-2	2.1E+01	N	4.8E+02	N					
Arsenic (cancer endpoint)	1.5E+00	i	A	3.0E-04	i	1.5E+01	i			7440-38-2	3.8E-01	c	3.0E+00	c	4.5E-04	c	4.5E-02	c	1.0E+00
Arsine								1.4E-05	i	7784-42-1					5.2E-02	N			
Assure				9.0E-03	i			9.0E-03	r	76578-12-6	4.9E+02	N	9.6E+03	N	3.3E+01	N	3.3E+02	N	
Asulam				5.0E-02	i			5.0E-02	r	3337-71-1	2.7E+03	N	5.3E+04	N	1.8E+02	N	1.8E+03	N	
Atrazine	2.2E-01	h		3.5E-02	h	2.2E-01	r	3.5E-02	h	1912-24-9	2.0E+00	c	1.3E+01	c	3.1E-02	c	3.0E-01	c	
Avermectin B1				4.0E-04	i			4.0E-04	r	71751-41-2	2.2E+01	N	4.3E+02	N	1.5E+00	N	1.5E+01	N	
Azobenzene	1.1E-01	i	B2			1.1E-01	i			103-33-3	4.0E+00	c	2.7E+01	c	6.2E-02	c	6.1E-01	c	
Barium and compounds				7.0E-02	i			1.4E-04	h	7440-39-3	5.2E+03	N	1.0E+05	a	5.2E-01	N	2.6E+03	N	8.2E+01
Baygon				4.0E-03	i			4.0E-03	r	114-26-1	2.2E+02	N	4.3E+03	N	1.5E+01	N	1.5E+02	N	
Bayleton				3.0E-02	i			3.0E-02	r	43121-43-3	1.6E+03	N	3.2E+04	N	1.1E+02	N	1.1E+03	N	
Baythroid				2.5E-02	i			2.5E-02	r	68359-37-5	1.4E+03	N	2.7E+04	N	9.1E+01	N	9.1E+02	N	
Benefin				3.0E-01	i			3.0E-01	r	1861-40-1	1.6E+04	N	1.0E+05	a	1.1E+03	N	1.1E+04	N	

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Benomyl			5.0E-02 i		5.0E-02 r	17804-35-2	2.7E+03	N	5.3E+04	N	1.8E+02	N	1.8E+03	N	
Bentazon			3.0E-02 i		3.0E-02 r	25057-89-0	1.6E+03	N	3.2E+04	N	1.1E+02	N	1.1E+03	N	
Benzaldehyde			1.0E-01 i		1.0E-01 r	100-52-7	5.5E+03	N	1.0E+05	a	3.7E+02	N	3.7E+03	N	
Benzene	2.9E-02 i		3.0E-03 n	2.9E-02 i	1.7E-03 n	71-43-2	6.2E-01	C	1.4E+00	C	2.3E-01	C	3.9E-01	C	2.0E-03
Benzidine	2.3E+02 i	A	3.0E-03 i	2.3E+02 i	3.0E-03 r	92-87-5	1.9E-03	C	1.3E-02	C	2.9E-05	C	2.9E-04	C	
Benzoic acid			4.0E+00 i		4.0E+00 i	65-85-0	1.0E+05	a	1.0E+05	a	1.5E+04	N	1.5E+05	N	2.0E+01
Benzotrichloride	1.3E+01 i	B2		1.3E+01 r		98-07-7	3.4E-02	C	2.3E-01	C	5.2E-04	C	5.2E-03	C	
Benzyl alcohol			3.0E-01 h		3.0E-01 r	100-51-6	1.6E+04	N	1.0E+05	a	1.1E+03	N	1.1E+04	N	
Benzyl chloride	1.7E-01 i	B2		1.7E-01 r		100-44-7	8.1E-01	C	2.2E+00	C	4.0E-02	C	6.6E-02	C	
Beryllium and compounds		B2	2.0E-03 i	8.4E+00 i	5.7E-06 i	7440-41-7	1.5E+02	N	2.2E+03	C	8.0E-04	C	7.3E+01	N	3.0E+00
Bidrin			1.0E-04 i		1.0E-04 r	141-66-2	5.5E+00	N	1.1E+02	N	3.7E-01	N	3.7E+00	N	
Biphenthrin (Talstar)			1.5E-02 i		1.5E-02 r	82657-04-3	8.2E+02	N	1.6E+04	N	5.5E+01	N	5.5E+02	N	
1,1-Biphenyl			5.0E-02 i		5.0E-02 r	92-52-4	2.3E+03	N	2.4E+04	N	1.8E+02	N	3.0E+02	N	
Bis(2-chloroethyl)ether	1.1E+00 i	B2		1.2E+00 i		111-44-4	1.8E-01	C	5.6E-01	C	5.8E-03	C	9.8E-03	C	2.0E-05
Bis(2-chloroisopropyl)ether	7.0E-02 h		4.0E-02 i	3.5E-02 h	4.0E-02 r	39638-32-9	2.5E+00	C	7.4E+00	C	1.9E-01	C	2.7E-01	C	
Bis(chloromethyl)ether	2.2E+02 i	A		2.2E+02 i		542-88-1	1.9E-04	C	4.3E-04	C	3.1E-05	C	5.2E-05	C	
Bis(2-chloro-1-methylethyl)ether	7.0E-02 h			3.5E-02 h		108-60-1	6.3E+00	C	4.3E+01	C	1.9E-01	C	9.6E-01	C	
Bis(2-ethylhexyl)phthalate (DEHP)	1.4E-02 i		2.0E-02 i	1.4E-02 r	2.2E-02 r	117-81-7	3.2E+01	C	2.1E+02	C	4.8E-01	C	4.8E+00	C	
Bisphenol A			5.0E-02 i		5.0E-02 r	80-05-7	2.7E+03	N	5.3E+04	N	1.8E+02	N	1.8E+03	N	
Boron			9.0E-02 i		5.7E-03 h	7440-42-8	4.9E+03	N	9.6E+04	N	2.1E+01	N	3.3E+03	N	
Boron trifluoride					2.0E-04 h	7637-07-2	1.0E+05	a	1.0E+05	a	7.3E-01	N			
Bromobenzene			2.0E-02 n		2.9E-03 n	108-86-1	2.8E+01	N	9.2E+01	N	1.0E+01	N	2.0E+01	N	
Bromodichloromethane	6.2E-02 i	D	2.0E-02 i	6.2E-02 r	2.0E-02 r	75-27-4	9.8E-01	C	2.3E+00	C	1.1E-01	C	1.8E-01	C	3.0E-02
Bromoform (tribromomethane)	7.9E-03 i	B2	2.0E-02 i	3.9E-03 i	2.0E-02 r	75-25-2	5.6E+01	C	3.8E+02	C	1.7E+00	C	8.5E+00	C	4.0E-02
Bromomethane			1.4E-03 i		1.4E-03 i	74-83-9	3.8E+00	N	1.3E+01	N	5.2E+00	N	8.7E+00	N	1.0E-02
4-Bromophenyl phenyl ether						101-55-3									
Bromophos			5.0E-03 h		5.0E-03 r	2104-96-3	2.7E+02	N	5.3E+03	N	1.8E+01	N	1.8E+02	N	
Bromoxynil			2.0E-02 i		2.0E-02 r	1689-84-5	1.1E+03	N	2.1E+04	N	7.3E+01	N	7.3E+02	N	

Region 6 Human Health Medium Specific Screening Levels																	
Contaminants																	
Bromoxynil octanoate			2.0E-02	i		2.0E-02	r	1689-99-2	1.1E+03	N	2.1E+04	N	7.3E+01	N	7.3E+02	N	
1,3-Butadiene	9.8E-01	r	B2		9.8E-01	i		106-99-0	6.5E-03	C	1.4E-02	C	6.9E-03	C	1.1E-02	C	
1-Butanol			1.0E-01	i		1.0E-01	r	71-36-3	5.5E+03	N	1.0E+05	a	3.7E+02	N	3.7E+03	N	9.0E-01
Butylate			5.0E-02	i		5.0E-02	r	2008-41-5	2.7E+03	N	5.3E+04	N	1.8E+02	N	1.8E+03	N	
n-Butylbenzene			1.0E-02	n		1.0E-02	r	104-51-8	1.3E+02	N	2.4E+02	sat	3.7E+01	N	6.1E+01	N	
sec-Butylbenzene			1.0E-02	n		1.0E-02	r	135-9-88	1.1E+02	N	2.2E+02	sat	3.7E+01	N	6.1E+01	N	
tert-Butylbenzene			1.0E-02	n		1.0E-02	r	104-5-18	1.2E+02	N	3.9E+02	sat	3.7E+01	N	6.1E+01	N	
Butyl benzyl phthalate			2.0E-01	i		2.0E-01	r	85-68-7	2.4E+02	sat	2.4E+02	sat	7.3E+02	N	7.3E+03	N	8.1E+02
Butylphthalyl butylglycolate			1.0E+00	i		1.0E+00	r	85-70-1	5.5E+04	N	1.0E+05	a	3.7E+03	N	3.7E+04	N	
Cacodylic acid			3.0E-03	h		3.0E-03	r	75-60-5	1.6E+02	N	3.2E+03	N	1.1E+01	N	1.1E+02	N	
Cadmium and compounds			5.0E-04	i	6.3E+00	i	5.7E-05	x	7440-43-9	3.7E+01	N	9.3E+02	N	1.1E-03	C	1.8E+01	N	4.0E-01
Caprolactam			5.0E-01	i			5.0E-01	r	105-60-2	2.7E+04	N	1.0E+05	a	1.8E+03	N	1.8E+04	N	
Captafol	8.6E-03	h	2.0E-03	i	8.6E-03	r	2.0E-03	r	2425-06-1	5.2E+01	C	3.5E+02	C	7.8E-01	C	7.8E+00	C	
Captan	3.5E-03	h	1.3E-01	i	3.5E-03	r	1.3E-01	r	133-06-2	1.3E+02	C	8.6E+02	C	1.9E+00	C	1.9E+01	C	
Carbaryl			1.0E-01	i			1.1E-01	r	63-25-2	5.5E+03	N	1.0E+05	a	4.0E+02	N	3.7E+03	N	
Carbazole	2.0E-02	h			2.0E-02	r			86-74-8	2.2E+01	C	1.5E+02	C	3.4E-01	C	3.4E+00	C	3.0E-02
Carbofuran			5.0E-03	i			5.0E-03	r	1563-66-2	2.7E+02	N	5.3E+03	N	1.8E+01	N	1.8E+02	N	
Carbon disulfide			1.0E-01	i			2.0E-01	i	75-15-0	3.5E+02	N	7.2E+02	sat	7.3E+02	N	1.0E+03	N	2.0E+00
Carbon tetrachloride	1.3E-01	i	7.0E-04	i	5.3E-02	i	5.7E-04	x	56-23-5	2.3E-01	C	5.2E-01	C	1.3E-01	C	1.7E-01	C	3.0E-03
Carbosulfan			1.0E-02	i			1.0E-02	r	55285-14-8	5.5E+02	N	1.1E+04	N	3.7E+01	N	3.7E+02	N	
Carboxin			1.0E-01	i			1.0E-01	r	5234-68-4	5.5E+03	N	1.0E+05	a	3.7E+02	N	3.7E+03	N	
Chloral			2.0E-03	i			2.0E-03	r	302-17-0	1.1E+02	N	2.1E+03	N	7.3E+00	N	7.3E+01	N	
Chloramben			1.5E-02	i			1.5E-02	r	133-90-4	8.2E+02	N	1.6E+04	N	5.5E+01	N	5.5E+02	N	
Chloranil	4.0E-01	h			4.0E-01	r			118-75-2	1.1E+00	C	7.4E+00	C	1.7E-02	C	1.7E-01	C	
Chlordane	3.5E-01	i	5.0E-04	i	3.5E-01	i	2.3E-05	i	57-74-9	1.6E+00	C	1.2E+01	C	1.9E-02	C	1.9E-01	C	5.0E-01
Chlorimuron-ethyl			2.0E-02	i			2.0E-02	r	90982-32-4	1.1E+03	N	2.1E+04	N	7.3E+01	N	7.3E+02	N	
Chlorine			1.0E-01	i					7782-50-5	7.5E+03	N	1.0E+05	a			3.7E+03	N	
Chlorine dioxide							5.7E-05	i	10049-04-4					2.1E-01	N		
Chloroacetaldehyde									107-20-0								
Chloroacetic acid			2.0E-03	h			2.0E-03	r	79-11-8	1.1E+02	N	2.1E+03	N	7.3E+00	N	7.3E+01	N	
2-Chloroacetophenone			8.6E-06	r			8.6E-06	i	532-27-4	3.2E-02	N	1.1E-01	N	3.1E-02	N	5.2E-02	N	
4-Chloroaniline			4.0E-03	i			4.0E-03	r	106-47-8	2.2E+02	N	4.3E+03	N	1.5E+01	N	1.5E+02	N	3.0E-02
Chlorobenzene			2.0E-02	i			5.7E-03	h	108-90-7	5.4E+01	N	1.8E+02	N	2.1E+01	N	3.9E+01	N	7.0E-02
Chlorobenzilate	2.7E-01	h	2.0E-02	i	2.7E-01	h	2.0E-02	r	510-15-6	1.6E+00	C	1.1E+01	C	2.5E-02	C	2.5E-01	C	
p-Chlorobenzoic acid			2.0E-01	h			2.0E-01	r	74-11-3	1.1E+04	N	1.0E+05	a	7.3E+02	N	7.3E+03	N	
4-Chlorobenzotrifluoride			2.0E-02	h			2.0E-02	r	98-56-6	1.1E+03	N	2.1E+04	N	7.3E+01	N	7.3E+02	N	
2-Chloro-1,3-butadiene			2.0E-02	h			2.0E-03	h	126-99-8	3.6E+00	N	1.2E+01	N	7.3E+00	N	1.4E+01	N	
1-Chlorobutane			4.0E-01	h			4.0E-01	r	109-69-3	4.8E+02	sat	4.8E+02	sat	1.5E+03	N	2.4E+03	N	
1-Chloro-1,1-difluoroethane			1.4E+01	r			1.4E+01	i	75-68-3	3.4E+02	sat	3.4E+02	sat	5.2E+04	N	8.7E+04	N	
Chlorodifluoromethane			1.4E+01	r			1.4E+01	i	75-45-6	3.4E+02	sat	3.4E+02	sat	5.1E+04	N	8.5E+04	N	
2-Chloroethyl vinyl ether									110-75-8								
Chloroform	6.1E-03	i	B2	1.0E-02	i	8.1E-02	i	1.0E-02	r	67-66-3	2.4E-01	C	5.2E-01	C	8.4E-02	C	1.6E-01	C	3.0E-02
Chloromethane	1.3E-02	h			6.3E-03	h			74-87-3	1.2E+00	C	2.7E+00	C	1.1E+00	C	1.5E+00	C	
4-Chloro-2-methylaniline	5.8E-01	h			5.8E-01	r			95-69-2	7.7E-01	C	5.2E+00	C	1.2E-02	C	1.2E-01	C	
4-Chloro-2-methylaniline hydrochloride	4.6E-01	h			4.6E-01	r			3165-93-3	9.7E-01	C	6.5E+00	C	1.5E-02	C	1.5E-01	C	
beta-Chloronaphthalene			8.0E-02	i			8.0E-02	r	91-58-7	3.0E+03	N	2.4E+04	N	2.9E+02	N	4.9E+02	N	
o-Chloronitrobenzene	2.5E-02	h			2.5E-02	r		r	88-73-3	1.8E+01	C	1.2E+02	C	2.7E-01	C	2.7E+00	C	
p-Chloronitrobenzene	1.8E-02	h			1.8E-02	r		r	100-00-5	2.5E+01	C	1.7E+02	C	3.7E-01	C	3.7E+00	C	
2-Chlorophenol			5.0E-03	i			5.0E-03	r	95-57-8	5.9E+01	N	2.4E+02	N	1.8E+01	N	3.0E+01	N	2.0E-01
2-Chloropropane			2.9E-02	r			2.9E-02	h	75-29-6	1.7E+02	N	5.9E+02	N	1.0E+02	N	1.7E+02	N	

Chemical	Toxicity Information																	
Chlorothalonil		1.1E-02	h		1.5E-02	i	1.1E-02	r	1.5E-02	r	1897-45-6	4.0E+01	c	2.7E+02	c	6.1E-01	c	6.1E+00	c	
o-Chlorotoluene					2.0E-02	i			2.0E-02	r	95-49-8	1.5E+02	N	5.1E+02	sat	7.3E+01	N	1.2E+02	N	
Chlorpropham					2.0E-01	i			2.0E-01	r	101-21-3	1.1E+04	N	1.0E+05	a	7.3E+02	N	7.3E+03	N	
Chlorpyrifos					3.0E-03	i			3.0E-03	r	2921-88-2	1.6E+02	N	3.2E+03	N	1.1E+01	N	1.1E+02	N	
Chlorpyrifos-methyl					1.0E-02	h			1.0E-02	r	5598-13-0	5.5E+02	N	1.1E+04	N	3.7E+01	N	3.7E+02	N	
Chlorsulfuron					5.0E-02	i			5.0E-02	r	64902-72-3	2.7E+03	N	5.3E+04	N	1.8E+02	N	1.8E+03	N	
Chlorthiophos					8.0E-04	h			8.0E-04	r	60238-56-4	4.4E+01	N	8.6E+02	N	2.9E+00	N	2.9E+01	N	
Total Chromium (1/6 ratio Cr VI/Cr III)							4.2E+01	i			n/a	2.1E+02	c	4.5E+02	c	1.6E-04	c			2.0E+00
Chromium VI				A	5.0E-03	i	2.9E+02	i			7440-47-3	3.0E+01	c	6.4E+01	c	2.3E-05	c	1.8E+02	N	2.0E+00
Cobalt					6.0E-02	x			5.7E-06	x	7440-48-4	3.3E+03	N	2.9E+04	N	2.1E-02	N	2.2E+03	N	
Coke Oven Emissions				A			2.2E+00	i			8007-45-2					3.1E-03	c			
Copper and compounds					3.7E-02	h					7440-50-8	2.8E+03	N	7.0E+04	N			1.4E+03	N	
Crotonaldehyde		1.9E+00	h	C	1.0E-02	x	1.9E+00	x	1.0E-02	r	123-73-9	5.3E-02	c	1.1E-01	c	3.5E-02	c	5.9E-02	c	
Cumene (isopropylbenzene)					1.0E-01	i			1.1E-01	i	98-82-8	1.6E+02	N	5.2E+02	N	4.0E+02	N	6.6E+02	N	
Cyanazine		8.4E-01	h		2.0E-03	h	8.4E-01	r	2.0E-03	r	21725-46-2	5.3E-01	c	3.6E+00	c	8.0E-03	c	8.0E-02	c	
Cyanides											n/a									
Barium cyanide					1.0E-01	h					542-62-1	5.5E+03	N	1.0E+05	a			3.7E+03	N	
Calcium cyanide					4.0E-02	i					592-01-8	2.2E+03	N	4.3E+04	N			1.5E+03	N	
Copper cyanide					5.0E-03	i					544-92-3	2.7E+02	N	5.3E+03	N			1.8E+02	N	
Cyanogen					4.0E-02	i					460-19-5	2.2E+03	N	4.3E+04	N			1.5E+03	N	
Cyanogen bromide					9.0E-02	i					506-68-3	4.9E+03	N	9.6E+04	N			3.3E+03	N	
Cyanogen chloride					5.0E-02	i					506-77-4	2.7E+03	N	5.3E+04	N			1.8E+03	N	
Free cyanide					2.0E-02	i					57-12-5	1.1E+03	N	2.1E+04	N			7.3E+02	N	2.0E+00
Hydrogen cyanide					2.0E-02	i			8.6E-04	i	74-90-8	1.1E+01	N	3.5E+01	N	3.1E+00	N	6.2E+00	N	
Potassium cyanide					5.0E-02	i					151-50-8	2.7E+03	N	5.3E+04	N			1.8E+03	N	
Potassium silver cyanide					2.0E-01	i					506-61-6	1.1E+04	N	1.0E+05	a			7.3E+03	N	
Silver cyanide					1.0E-01	i					506-64-9	5.5E+03	N	1.0E+05	a			3.7E+03	N	
Sodium cyanide					4.0E-02	i					143-33-9	2.2E+03	N	4.3E+04	N			1.5E+03	N	
Zinc cyanide					5.0E-02	i					557-21-1	2.7E+03	N	5.3E+04	N			1.8E+03	N	
Cyclohexanone					5.0E+00	i			5.0E+00	r	108-94-1	1.0E+05	a	1.0E+05	a	1.8E+04	N	1.8E+05	N	
Cyclohexylamine					2.0E-01	i			2.0E-01	r	108-91-8	1.1E+04	N	1.0E+05	a	7.3E+02	N	7.3E+03	N	
Cyhalothrin/Karate					5.0E-03	i			5.0E-03	r	68085-85-8	2.7E+02	N	5.3E+03	N	1.8E+01	N	1.8E+02	N	
Cypermethrin					1.0E-02	i			1.0E-02	r	52315-07-8	5.5E+02	N	1.1E+04	N	3.7E+01	N	3.7E+02	N	
Cyromazine					7.5E-03	i			7.5E-03	r	66215-27-8	4.1E+02	N	8.0E+03	N	2.7E+01	N	2.7E+02	N	
Dacthal					1.0E-02	i			1.0E-02	r	1861-32-1	5.5E+02	N	1.1E+04	N	3.7E+01	N	3.7E+02	N	
Dalapon					3.0E-02	i			3.0E-02	r	75-99-0	1.6E+03	N	3.2E+04	N	1.1E+02	N	1.1E+03	N	
Danitol					2.5E-02	i			2.5E-02	r	39515-41-8	1.4E+03	N	2.7E+04	N	9.1E+01	N	9.1E+02	N	
DDD		2.4E-01	i	B2			2.4E-01	r			72-54-8	2.4E+00	c	1.9E+01	c	2.8E-02	c	2.8E-01	c	8.0E-01
DDE		3.4E-01	i	B2			3.4E-01	r			72-55-9	1.7E+00	c	1.3E+01	c	2.0E-02	c	2.0E-01	c	3.0E+00
DDT		3.4E-01	i	B2	5.0E-04	i	3.4E-01	i	5.0E-04	r	50-29-3	1.7E+00	c	1.3E+01	c	2.0E-02	c	2.0E-01	c	2.0E+00
Decabromodiphenyl ether					1.0E-02	i			1.0E-02	r	1163-19-5	5.5E+02	N	1.1E+04	N	3.7E+01	N	3.7E+02	N	
Demeton					4.0E-05	i			4.0E-05	r	8065-48-3	2.2E+00	N	4.3E+01	N	1.5E-01	N	1.5E+00	N	
Diallate		6.1E-02	h				6.1E-02	r			2303-16-4	7.3E+00	c	4.9E+01	c	1.1E-01	c	1.1E+00	c	
Diazinon					9.0E-04	h			9.0E-04	r	333-41-5	4.9E+01	N	9.6E+02	N	3.3E+00	N	3.3E+01	N	
Dibenzofuran					4.0E-03	x			4.0E-03	r	132-64-9	2.1E+02	N	3.2E+03	N	1.5E+01	N	2.4E+01	N	
1,4-Dibromobenzene					1.0E-02	i			1.0E-02	r	106-37-6	5.5E+02	N	1.1E+04	N	3.7E+01	N	3.7E+02	N	
Dibromochloromethane		8.4E-02	i		2.0E-02	i	8.4E-02	r	2.0E-02	r	124-48-1	5.3E+00	c	3.6E+01	c	8.0E-02	c	8.0E-01	c	2.0E-02
1,2-Dibromo-3-chloropropane		1.4E+00	h		5.7E-05	r	2.4E-03	h	5.7E-05	i	96-12-8	3.2E-01	c	2.1E+00	c	2.1E-01	N	4.8E-02	c	
1,2-Dibromoethane		8.5E+01	i	B2	5.7E-05	r	7.7E-01	i	5.7E-05	h	106-93-4	4.9E-03	c	2.9E-02	c	8.7E-03	c	7.6E-04	c	
Dibutyl phthalate					1.0E-01	i			1.0E-01	r	84-74-2	5.5E+03	N	1.0E+05	a	3.7E+02	N	3.7E+03	N	2.7E+02

Region 6 Human Health Medium Specific Screening Levels	TOXICITY INFORMATION						SCREENING LEVELS										
Contaminants	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Dicamba			3.0E-02 i		3.0E-02 r		1918-00-9	1.6E+03	N	3.2E+04	N	1.1E+02	N	1.1E+03	N		
1,2-Dichlorobenzene			9.0E-02 i		5.7E-02 h		95-50-1	3.7E+02	sat	3.7E+02	sat	2.1E+02	N	3.7E+02	N	9.0E-01	
1,3-Dichlorobenzene			3.0E-02 n		2.3E-03 n		541-73-1	4.1E+01	N	1.4E+02	N	8.4E+00	N	1.7E+01	N		
1,4-Dichlorobenzene	2.4E-01 h		2.0E-01 n	2.4E-02 r	2.3E-01 i		106-46-7	3.0E+00	C	7.3E+00	C	2.8E-01	C	4.7E-01	C	1.0E-01	
3,3-Dichlorobenzidine	4.5E-01 i	B2		4.5E-01 r			91-94-1	9.9E-01	C	6.7E+00	C	1.5E-02	C	1.5E-01	C	3.0E-04	
1,4-Dichloro-2-butene	9.3E+00 r			9.3E+00 h			764-41-0	7.5E-03	C	1.8E-02	C	7.2E-04	C	1.2E-03	C		
Dichlorodifluoromethane			2.0E-01 i		5.7E-02 h		75-71-8	9.4E+01	N	3.1E+02	N	2.1E+02	N	3.9E+02	N		
1,1-Dichloroethane			1.0E-01 h		1.4E-01 h		75-34-3	5.7E+02	N	2.0E+03	N	5.2E+02	N	8.1E+02	N	1.0E+00	
1,2-Dichloroethane (EDC)	9.1E-02 i	B2	2.9E-03 r	9.1E-02 i	2.9E-03 x		107-06-2	3.4E-01	C	7.6E-01	C	7.4E-02	C	1.2E-01	C	1.0E-03	
1,1-Dichloroethylene	6.0E-01 i	C	9.0E-03 i	1.8E-01 i	9.0E-03 r		75-35-4	5.3E-01	C	1.2E+00	C	3.8E-01	C	4.6E-01	C	3.0E-03	
1,2-Dichloroethylene (cis)			1.0E-02 h		1.0E-02 r		156-59-2	4.2E+01	N	1.5E+02	N	3.7E+01	N	6.1E+01	N	2.0E-02	
1,2-Dichloroethylene (trans)			2.0E-02 i		2.0E-02 r		156-60-5	6.2E+01	N	2.1E+02	N	7.3E+01	N	1.2E+02	N	3.0E-02	
2,4-Dichlorophenol			3.0E-03 i		3.0E-03 r		120-83-2	1.6E+02	N	3.2E+03	N	1.1E+01	N	1.1E+02	N	5.0E-02	
4-(2,4-Dichlorophenoxy)butyric Acid (2,4-DB)			8.0E-03 i		8.0E-03 r		94-82-6	4.4E+02	N	8.6E+03	N	2.9E+01	N	2.9E+02	N		
2,4-Dichlorophenoxyacetic Acid (2,4-D)			1.0E-02 i		1.0E-02 r		94-75-7	6.4E+02	N	1.4E+04	N	3.7E+01	N	3.7E+02	N		
1,2-Dichloropropane	6.8E-02 h		1.1E-03 r	6.8E-02 r	1.1E-03 i		78-87-5	3.5E-01	C	7.6E-01	C	9.9E-02	C	1.6E-01	C	1.0E-03	
1,3-Dichloropropene	1.8E-01 h	B2	3.0E-04 i	1.3E-01 h	5.7E-03 i		542-75-6	8.1E-02	C	1.8E-01	C	5.2E-02	C	8.1E-02	C	2.0E-04	
2,3-Dichloropropanol			3.0E-03 i		3.0E-03 r		616-23-9	1.6E+02	N	3.2E+03	N	1.1E+01	N	1.1E+02	N		
Dichlorvos	2.9E-01 i	B2	5.0E-04 i	2.9E-01 r	1.4E-04 i		62-73-7	1.5E+00	C	1.0E+01	C	2.3E-02	C	2.3E-01	C		
Dicofol	4.4E-01 x			4.4E-01 r			115-32-2	1.0E+00	C	6.8E+00	C	1.5E-02	C	1.5E-01	C		
Dicyclopentadiene			3.0E-02 h		5.7E-05 h		77-73-6	5.5E-01	N	1.8E+00	N	2.1E-01	N	4.2E-01	N		
Dieldrin	1.6E+01 i	B2	5.0E-05 i	1.6E+01 i	5.0E-05 r		60-57-1	2.8E-02	C	1.9E-01	C	4.2E-04	C	4.2E-03	C	2.0E-04	
Diethylene glycol, monobutyl ether			5.7E-03 h		5.7E-03 x		112-34-5	3.1E+02	N	6.1E+03	N	2.1E+01	N	2.1E+02	N		
Diethylene glycol, monoethyl ether			2.0E+00 h		2.0E+00 r		111-90-0	1.0E+05	a	1.0E+05	a	7.3E+03	N	7.3E+04	N		
Diethylformamide			1.1E-02 h		1.1E-02 r		617-84-5	6.0E+02	N	1.2E+04	N	4.0E+01	N	4.0E+02	N		
Di(2-ethylhexyl)adipate	1.2E-03 i		6.0E-01 i	1.2E-03 r	6.0E-01 r		103-23-1	3.7E+02	C	2.5E+03	C	5.6E+00	C	5.6E+01	C		
Diethyl phthalate			8.0E-01 i		8.0E-01 r		84-66-2	4.4E+04	N	1.0E+05	a	2.9E+03	N	2.9E+04	N		
Diethylstilbestrol	4.7E+03 h			4.7E+03 r			56-53-1	9.4E-05	C	6.4E-04	C	1.4E-06	C	1.4E-05	C		
Difenzoquat (Avenge)			8.0E-02 i		8.0E-02 r		43222-48-6	4.4E+03	N	8.6E+04	N	2.9E+02	N	2.9E+03	N		
Diflubenzuron			2.0E-02 i		2.0E-02 r		35367-38-5	1.1E+03	N	2.1E+04	N	7.3E+01	N	7.3E+02	N		
1,1-Difluoroethane			1.1E+01 r		1.1E+01 i		75-37-6	1.0E+05	a	1.0E+05	a	4.2E+04	N	6.9E+04	N		
Diisopropyl methylphosphonate			8.0E-02 i		8.0E-02 r		1445-75-6	4.4E+03	N	8.6E+04	N	2.9E+02	N	2.9E+03	N		
Dimethipin			2.0E-02 i		2.0E-02 r		55290-64-7	1.1E+03	N	2.1E+04	N	7.3E+01	N	7.3E+02	N		
Dimethoate			2.0E-04 i		2.0E-04 r		60-51-5	1.1E+01	N	2.1E+02	N	7.3E-01	N	7.3E+00	N		
3,3'-Dimethoxybenzidine	1.4E-02 h			1.4E-02 r			119-90-4	3.2E+01	C	2.1E+02	C	4.8E-01	C	4.8E+00	C		
Dimethylamine			5.7E-06 r		5.7E-06 x		124-40-3	6.3E-02	N	2.5E-01	N	2.1E-02	N	3.5E-02	N		
N-N-Dimethylaniline			2.0E-03 i		2.0E-03 r		121-69-7	1.1E+02	N	2.1E+03	N	7.3E+00	N	7.3E+01	N		
2,4-Dimethylaniline	7.5E-01 h			7.5E-01 r			95-68-1	5.9E-01	C	4.0E+00	C	9.0E-03	C	9.0E-02	C		
2,4-Dimethylaniline hydrochloride	5.8E-01 h			5.8E-01 r			21436-96-4	7.7E-01	C	5.2E+00	C	1.2E-02	C	1.2E-01	C		
3,3'-Dimethylbenzidine	9.2E+00 h			9.2E+00 r			119-93-7	4.8E-02	C	3.3E-01	C	7.3E-04	C	7.3E-03	C		
1,1-Dimethylhydrazine	2.6E+00 x			3.5E+00 x			57-14-7	1.7E-01	C	1.2E+00	C	1.9E-03	C	2.6E-02	C		
1,2-Dimethylhydrazine	3.7E+01 x			3.7E+01 x			540-73-8	1.2E-02	C	8.1E-02	C	1.8E-04	C	1.8E-03	C		
N,N-Dimethylformamide			1.0E-01 h		8.6E-03 i		68-12-2	5.4E+03	N	1.0E+05	a	3.1E+01	N	3.7E+03	N		
Dimethylphenethylamine			1.0E-03 n		1.0E-03 r		122-09-8	5.5E+01	N	1.1E+03	N	3.7E+00	N	3.7E+01	N		
2,4-Dimethylphenol			2.0E-02 i		2.0E-02 r		105-67-9	1.1E+03	N	2.1E+04	N	7.3E+01	N	7.3E+02	N	4.0E-01	
2,6-Dimethylphenol			6.0E-04 i		6.0E-04 r		576-26-1	3.3E+01	N	6.4E+02	N	2.2E+00	N	2.2E+01	N		
3,4-Dimethylphenol			1.0E-03 i		1.0E-03 r		95-65-8	5.5E+01	N	1.1E+03	N	3.7E+00	N	3.7E+01	N		
Dimethyl phthalate			1.0E+01 h		1.0E+01 r		131-11-3	1.0E+05	a	1.0E+05	a	3.7E+04	N	3.7E+05	N		
Dimethyl terephthalate			1.0E-01 i		1.0E-01 r		120-61-6	5.5E+03	N	1.0E+05	a	3.7E+02	N	3.7E+03	N		
4,6-Dinitro-o-cyclohexyl phenol			2.0E-03 i		2.0E-03 r		131-89-5	1.1E+02	N	2.1E+03	N	7.3E+00	N	7.3E+01	N		

Region 6 Tumor Trail Medium Specific Screening Levels	TOXICITY INFORMATION						SCREENING LEVELS									
Contaminant																
1,2-Dinitrobenzene			4.0E-04	h		4.0E-04	r	528-29-0	2.2E+01	N	4.3E+02	N	1.5E+00	N	1.5E+01	N	
1,3-Dinitrobenzene			1.0E-04	i		1.0E-04	r	99-65-0	5.5E+00	N	1.1E+02	N	3.7E-01	N	3.7E+00	N	
1,4-Dinitrobenzene			4.0E-04	h		4.0E-04	r	100-25-4	2.2E+01	N	4.3E+02	N	1.5E+00	N	1.5E+01	N	
2,4-Dinitrophenol			2.0E-03	i		2.0E-03	r	51-28-5	1.1E+02	N	2.1E+03	N	7.3E+00	N	7.3E+01	N	1.0E-02
Dinitrotoluene mixture	6.8E-01	i	B2		6.8E-01	r		25321-14-6	6.5E-01	C	4.4E+00	C	9.9E-03	C	9.9E-02	C	4.0E-05
2,4-Dinitrotoluene			2.0E-03	i		2.0E-03	r	121-14-2	1.1E+02	N	2.1E+03	N	7.3E+00	N	7.3E+01	N	4.0E-05
2,6-Dinitrotoluene			1.0E-03	h		1.0E-03	r	606-20-2	5.5E+01	N	1.1E+03	N	3.7E+00	N	3.7E+01	N	3.0E-05
Dinoseb			1.0E-03	i		1.0E-03	r	88-85-7	5.5E+01	N	1.1E+03	N	3.7E+00	N	3.7E+01	N	
di-n-Octyl phthalate			2.0E-02	h		2.0E-02	r	117-84-0	1.1E+03	N	2.1E+04	N	7.3E+01	N	7.3E+02	N	1.0E+04
1,4-Dioxane	1.1E-02	i	B2		1.1E-02	r		123-91-1	4.0E+01	C	2.7E+02	C	6.1E-01	C	6.1E+00	C	
Dioxin (2,3,7,8-TCDD)	1.5E+05	h			1.5E+05	h		1746-01-6	3.8E-06	C	3.0E-05	C	4.5E-08	C	4.5E-07	C	
Diphenamid			3.0E-02	i		3.0E-02	r	957-51-7	1.6E+03	N	3.2E+04	N	1.1E+02	N	1.1E+03	N	
Diphenylamine			2.5E-02	i		2.5E-02	r	122-39-4	1.4E+03	N	2.7E+04	N	9.1E+01	N	9.1E+02	N	
1,2-Diphenylhydrazine	8.0E-01	i	B2		7.7E-01	i		122-66-7	5.6E-01	C	3.7E+00	C	8.7E-03	C	8.4E-02	C	
Diphenyl sulfone			9.0E-03	n		9.0E-03	r	127-63-9	4.9E+02	N	9.6E+03	N	3.3E+01	N	3.3E+02	N	
Diquat			2.2E-03	i		2.2E-03	r	85-00-7	1.2E+02	N	2.4E+03	N	8.0E+00	N	8.0E+01	N	
Direct black 38	8.6E+00	h			8.6E+00	r		1937-37-7	5.2E-02	C	3.5E-01	C	7.8E-04	C	7.8E-03	C	
Direct blue 6	8.1E+00	h			8.1E+00	r		2602-46-2	5.5E-02	C	3.7E-01	C	8.3E-04	C	8.3E-03	C	
Direct brown 95	9.3E+00	h			9.3E+00	r		16071-86-6	4.8E-02	C	3.2E-01	C	7.2E-04	C	7.2E-03	C	
Disulfoton			4.0E-05	i		4.0E-05	r	298-04-4	2.2E+00	N	4.3E+01	N	1.5E-01	N	1.5E+00	N	
1,4-Dithiane			1.0E-02	i		1.0E-02	r	505-29-3	5.5E+02	N	1.1E+04	N	3.7E+01	N	3.7E+02	N	
Diuron			2.0E-03	i		2.0E-03	r	330-54-1	1.1E+02	N	2.1E+03	N	7.3E+00	N	7.3E+01	N	
Dodine			4.0E-03	i		4.0E-03	r	2439-10-3	2.2E+02	N	4.3E+03	N	1.5E+01	N	1.5E+02	N	
Endosulfan			6.0E-03	i		6.0E-03	r	115-29-7	3.3E+02	N	6.4E+03	N	2.2E+01	N	2.2E+02	N	9.0E-01
Endothall			2.0E-02	i		2.0E-02	r	145-73-3	1.1E+03	N	2.1E+04	N	7.3E+01	N	7.3E+02	N	
Endrin			3.0E-04	i		3.0E-04	r	72-20-8	1.6E+01	N	3.2E+02	N	1.1E+00	N	1.1E+01	N	5.0E-02
Epichlorohydrin	9.9E-03	i	B2	2.0E-03	h	4.2E-03	i	2.9E-04	i	106-89-8	7.4E+00	N	2.6E+01	N	1.0E+00	N	2.0E+00	N	
1,2-Epoxybutane			5.7E-03	r		5.7E-03	i	106-88-7	3.1E+02	N	6.1E+03	N	2.1E+01	N	2.1E+02	N	
EPTC (S-Ethyl dipropylthiocarbamate)			2.5E-02	i		2.5E-02	r	759-94-4	1.4E+03	N	2.7E+04	N	9.1E+01	N	9.1E+02	N	
Ethephon (2-chloroethyl phosphonic acid)			5.0E-03	i		5.0E-03	r	16672-87-0	2.7E+02	N	5.3E+03	N	1.8E+01	N	1.8E+02	N	
Ethion			5.0E-04	i		5.0E-04	r	563-12-2	2.7E+01	N	5.3E+02	N	1.8E+00	N	1.8E+01	N	
2-Ethoxyethanol			4.0E-01	h		5.7E-02	i	110-80-5	2.2E+04	N	1.0E+05	a	2.1E+02	N	1.5E+04	N	
2-Ethoxyethanol acetate			3.0E-01	h		3.0E-01	r	111-15-9	1.6E+04	N	1.0E+05	a	1.1E+03	N	1.1E+04	N	
Ethyl acetate			9.0E-01	i		9.0E-01	r	141-78-6	1.7E+04	N	3.7E+04	sat	3.3E+03	N	5.5E+03	N	
Ethyl acrylate	4.8E-02	h			4.8E-02	r		140-88-5	2.1E-01	C	4.5E-01	C	1.4E-01	C	2.3E-01	C	
Ethylbenzene			1.0E-01	i		2.9E-01	i	100-41-4	2.3E+02	sat	2.3E+02	sat	1.1E+03	N	1.3E+03	N	7.0E-01
Ethyl chloride			4.0E-01	n		2.9E+00	i	75-00-3	1.6E+03	sat	1.6E+03	sat	1.0E+04	N	8.6E+03	N	
Ethylene cyanohydrin			3.0E-01	h		3.0E-01	r	109-78-4	1.6E+04	N	1.0E+05	a	1.1E+03	N	1.1E+04	N	
Ethylene diamine			2.0E-02	h		2.0E-02	r	107-15-3	1.1E+03	N	2.1E+04	N	7.3E+01	N	7.3E+02	N	
Ethylene glycol			2.0E+00	i		2.0E+00	r	107-21-1	1.0E+05	a	1.0E+05	a	7.3E+03	N	7.3E+04	N	
Ethylene glycol, monobutyl ether			5.7E-03	r		5.7E-03	h	111-76-2	3.1E+02	N	6.1E+03	N	2.1E+01	N	2.1E+02	N	
Ethylene oxide	1.0E+00	h			3.5E-01	h		75-21-8	1.3E-01	C	3.4E-01	C	1.9E-02	C	2.4E-02	C	
Ethylene thiourea (ETU)	1.1E-01	h		8.0E-05	i	1.1E-01	r	8.0E-05	r	96-45-7	4.0E+00	C	2.7E+01	C	6.1E-02	C	6.1E-01	C	
Ethyl ether			2.0E-01	i		2.0E-01	r	60-29-7	1.8E+03	sat	1.8E+03	sat	7.3E+02	N	1.2E+03	N	
Ethyl methacrylate			9.0E-02	h		9.0E-02	r	97-63-2	1.4E+02	sat	1.4E+02	sat	3.3E+02	N	5.5E+02	N	
Ethyl p-nitrophenyl phenylphosphorothioate			1.0E-05	i		1.0E-05	r	2104-64-5	5.5E-01	N	1.1E+01	N	3.7E-02	N	3.7E-01	N	
Ethylphthalyl ethyl glycolate			3.0E+00	i		3.0E+00	r	84-72-0	1.0E+05	a	1.0E+05	a	1.1E+04	N	1.1E+05	N	
Express			8.0E-03	i		8.0E-03	r	101200-48-	4.4E+02	N	8.6E+03	N	2.9E+01	N	2.9E+02	N	
Fenamiphos			2.5E-04	i		2.5E-04	r	22224-92-6	1.4E+01	N	2.7E+02	N	9.1E-01	N	9.1E+00	N	
Fluometuron			1.3E-02	i		1.3E-02	r	2164-17-2	7.1E+02	N	1.4E+04	N	4.7E+01	N	4.7E+02	N	

Region 6 Human Health Medium Specific Screening Levels

Contaminants																
Fluoride				6.0E-02	i			16984-48-8	3.3E+03	N	6.4E+04	N			2.2E+03	N	
Fluoridone				8.0E-02	i		8.0E-02	r	59756-60-4	4.4E+03	N	8.6E+04	N	2.9E+02	N	2.9E+03	N	
Flurprimidol				2.0E-02	i		2.0E-02	r	56425-91-3	1.1E+03	N	2.1E+04	N	7.3E+01	N	7.3E+02	N	
Flutolanil				6.0E-02	i		6.0E-02	r	66332-96-5	3.3E+03	N	6.4E+04	N	2.2E+02	N	2.2E+03	N	
Fluvalinate				1.0E-02	i		1.0E-02	r	69409-94-5	5.5E+02	N	1.1E+04	N	3.7E+01	N	3.7E+02	N	
Folpet	3.5E-03	i	B2	1.0E-01	i	3.5E-03	r	1.0E-01	r	133-07-3	1.3E+02	C	8.6E+02	C	1.9E+00	C	1.9E+01	C	
Fomesafen	1.9E-01	i	C			1.9E-01	r			72178-02-0	2.3E+01	C	1.6E+02	C	3.5E-01	C	3.5E+00	C	
Fonofos				2.0E-03	i		2.0E-03	r		944-22-9	1.1E+02	N	2.1E+03	N	7.3E+00	N	7.3E+01	N	
Formaldehyde				1.5E-01	i	4.6E-02	i			50-00-0	8.2E+03	N	1.0E+05	a	1.5E-01	C	5.5E+03	N	
Formic Acid				2.0E+00	h		2.0E+00	r		64-18-6	1.0E+05	a	1.0E+05	a	7.3E+03	N	7.3E+04	N	
Fosetyl-al				3.0E+00	i		3.0E+00	r		39148-24-8	1.0E+05	a	1.0E+05	a	1.1E+04	N	1.1E+05	N	
Furan				1.0E-03	i		1.0E-03	r		110-00-9	2.5E+00	N	8.5E+00	N	3.7E+00	N	6.1E+00	N	
Furazolidone	3.8E+00	h				3.8E+00	r			67-45-8	1.2E-01	C	7.9E-01	C	1.8E-03	C	1.8E-02	C	
Furfural				3.0E-03	i		1.4E-02	h		98-01-1	1.6E+02	N	3.2E+03	N	5.2E+01	N	1.1E+02	N	
Furium	5.0E+01	h				5.0E+01	r			531-82-8	8.9E-03	C	6.0E-02	C	1.3E-04	C	1.3E-03	C	
Furmecyclox	3.0E-02	i	B2			3.0E-02	r			60568-05-0	1.5E+01	C	1.0E+02	C	2.2E-01	C	2.2E+00	C	
Glufosinate-ammonium				4.0E-04	i		4.0E-04	r		77182-82-2	2.2E+01	N	4.3E+02	N	1.5E+00	N	1.5E+01	N	
Glycidaldehyde				4.0E-04	i		2.9E-04	h		765-34-4	2.2E+01	N	4.3E+02	N	1.0E+00	N	1.5E+01	N	
Glyphosate				1.0E-01	i		1.0E-01	r		1071-83-6	5.5E+03	N	1.0E+05	a	3.7E+02	N	3.7E+03	N	
Haloxyfop-methyl				5.0E-05	i		5.0E-05	r		69806-40-2	2.7E+00	N	5.3E+01	N	1.8E-01	N	1.8E+00	N	
Harmony				1.3E-02	i		1.3E-02	r		79277-27-3	7.1E+02	N	1.4E+04	N	4.7E+01	N	4.7E+02	N	
Heptachlor	4.5E+00	i	B2	5.0E-04	i	4.6E+00	i	5.0E-04	r	76-44-8	9.9E-02	C	6.7E-01	C	1.5E-03	C	1.5E-02	C	1.0E+00
Heptachlor epoxide	9.1E+00	i	B2	1.3E-05	i	9.1E+00	i	1.3E-05	r	1024-57-3	4.9E-02	C	3.3E-01	C	7.4E-04	C	7.4E-03	C	3.0E-02
Hexabromobenzene				2.0E-03	i		2.0E-03	r		87-82-1	1.1E+02	N	2.1E+03	N	7.3E+00	N	7.3E+01	N	
Hexachlorobenzene	1.6E+00	i	B2	8.0E-04	i	1.6E+00	i	8.0E-04	r	118-74-1	2.8E-01	C	1.9E+00	C	4.2E-03	C	4.2E-02	C	1.0E-01
Hexachlorobutadiene	7.8E-02	i	C	2.0E-04	h	7.7E-02	i	2.0E-04	r	87-68-3	1.1E+01	N	2.1E+02	N	7.3E-01	N	7.3E+00	N	1.0E-01
HCH (alpha)	6.3E+00	i	B2			6.3E+00	i			319-84-6	8.6E-02	C	6.7E-01	C	1.1E-03	C	1.1E-02	C	3.0E-05
HCH (beta)	1.8E+00	i	C			1.8E+00	i			319-85-7	3.0E+00	C	2.3E+01	C	3.7E-02	C	3.7E-01	C	1.0E-04
HCH (gamma) Lindane	1.3E+00	h		3.0E-04	i	1.3E+00	r	3.0E-04	r	58-89-9	4.2E-01	C	3.2E+00	C	5.2E-03	C	5.2E-02	C	5.0E-04
HCH-technical	1.8E+00	i	B2			1.8E+00	i			608-73-1	3.0E-01	C	2.3E+00	C	3.8E-03	C	3.7E-02	C	1.0E-04
Hexachlorocyclopentadiene				7.0E-03	i		2.0E-05	h		77-47-4	3.8E+02	N	7.1E+03	N	7.3E-02	N	2.6E+02	N	2.0E+01
Hexachlorodibenzo-p-dioxin mixture (Hx	6.2E+03	i	B2			4.6E+03	i			19408-74-3	7.2E-05	C	4.8E-04	C	1.5E-06	C	1.1E-05	C	
Hexachloroethane	1.4E-02	i	C	1.0E-03	i	1.4E-02	i	1.0E-03	r	67-72-1	5.5E+01	N	1.1E+03	N	3.7E+00	N	3.7E+01	N	2.0E-02
Hexachlorophene				3.0E-04	i		3.0E-04	r		70-30-4	1.6E+01	N	3.2E+02	N	1.1E+00	N	1.1E+01	N	
Hexahydro-1,3,5-trinitro-1,3,5-triazine	1.1E-01	i	C	3.0E-03	i	1.1E-01	r	3.0E-03	r	121-82-4	4.0E+01	C	2.7E+02	C	6.1E-01	C	6.1E+00	C	
1,6-Hexamethylene diisocyanate				2.9E-06	r		2.9E-06	i		822-06-0	1.6E-01	N	3.1E+00	N	1.0E-02	N	1.0E-01	N	
n-Hexane				6.0E-02	h		5.7E-02	i		110-54-3	1.1E+02	sat	1.1E+02	sat	2.1E+02	N	3.5E+02	N	
Hexazinone				3.3E-02	i		3.3E-02	r		51235-04-2	1.8E+03	N	3.5E+04	N	1.2E+02	N	1.2E+03	N	
Hydrazine, hydrazine sulfate	3.0E+00	i	B2			1.7E+01	i			302-01-2	1.5E-01	C	1.0E+00	C	3.9E-04	C	2.2E-02	C	
Hydrogen chloride								5.7E-03	i	7647-01-0	1.0E+05	a	1.0E+05	a	2.1E+01	N			
Hydrogen sulfide				3.0E-03	i		2.9E-04	i		7783-06-4	1.6E+02	N	3.2E+03	N	1.0E+00	N	2.0E+00	N	
p-Hydroquinone				4.0E-02	h		4.0E-02	r		123-31-9	2.2E+03	N	4.3E+04	N	1.5E+02	N	1.5E+03	N	
Imazalil				1.3E-02	i		1.3E-02	r		35554-44-0	7.1E+02	N	1.4E+04	N	4.7E+01	N	4.7E+02	N	
Imazaquin				2.5E-01	i		2.5E-01	r		81335-37-7	1.4E+04	N	1.0E+05	a	9.1E+02	N	9.1E+03	N	
Iprodione				4.0E-02	i		4.0E-02	r		36734-19-7	2.2E+03	N	4.3E+04	N	1.5E+02	N	1.5E+03	N	
Iron				3.0E-01	n					7439-89-6	2.2E+04	N	1.0E+05	a			1.1E+04	N	
Isobutanol				3.0E-01	i		3.0E-01	r		78-83-1	1.0E+04	N	4.0E+04	sat	1.1E+03	N	1.8E+03	N	
Isophorone	9.5E-04	i	C	2.0E-01	i	9.5E-04	r	2.0E-01	r	78-59-1	4.7E+03	C	3.2E+04	C	7.1E+01	C	7.1E+02	C	3.0E-02
Isopropalin				1.5E-02	i		1.5E-02	r		33820-53-0	8.2E+02	N	1.6E+04	N	5.5E+01	N	5.5E+02	N	
Isopropyl methyl phosphonic acid				1.0E-01	i		1.1E-01	r		1832-54-8	5.5E+03	N	1.0E+05	a	4.0E+02	N	3.7E+03	N	

Contaminants	Toxicity Information																
	[illegible]		[illegible]		[illegible]		[illegible]		Screening Levels								
	[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]
Isoxaben			5.0E-02	i			5.0E-02	r	82558-50-7	2.7E+03	N	5.3E+04	N	1.8E+02	N	1.8E+03	N	
Kepone	1.8E+01	n			1.8E+01	r			143-50-0	2.5E-02	C	1.7E-01	C	3.7E-04	C	3.7E-03	C	
Lactofen			2.0E-03	i			2.0E-03	r	77501-63-4	1.1E+02	N	2.1E+03	N	7.3E+00	N	7.3E+01	N	
Lead	Screening Levels Based on EPA Models, IEUBK (1994) and TRW (1996								7439-92-1	4.0E+02		2.0E+03				1.5E+01		
Lead (tetraethyl)			1.0E-07	i					78-00-2	5.5E-03	N	1.1E-01	N			3.7E-03	N	
Linuron			2.0E-03	i			2.0E-03	r	330-55-2	1.1E+02	N	2.1E+03	N	7.3E+00	N	7.3E+01	N	
Lithium			2.0E-02	x					7439-93-2	1.5E+03	N	3.7E+04	N			7.3E+02	N	
Londax			2.0E-01	i			2.0E-01	r	83055-99-6	1.1E+04	N	1.0E+05	a	7.3E+02	N	7.3E+03	N	
Malathion			2.0E-02	i			2.0E-02	r	121-75-5	1.1E+03	N	2.1E+04	N	7.3E+01	N	7.3E+02	N	
Maleic anhydride			1.0E-01	i			1.0E-01	r	108-31-6	5.5E+03	N	1.0E+05	a	3.7E+02	N	3.7E+03	N	
Maleic hydrazide			5.0E-01	i			5.0E-01	r	123-33-1	1.6E+03	N	2.4E+03	sat	1.8E+03	N	3.0E+03	N	
Malononitrile			2.0E-05	h			2.0E-05	r	109-77-3	1.1E+00	N	2.1E+01	N	7.3E-02	N	7.3E-01	N	
Mancozeb			3.0E-02	h			3.0E-02	r	8018-01-7	1.6E+03	N	3.2E+04	N	1.1E+02	N	1.1E+03	N	
Maneb	6.0E-02	o	5.0E-03	i	6.0E-02	r	5.0E-03	r	12427-38-2	7.4E+00	C	5.0E+01	C	1.1E-01	C	1.1E+00	C	
Manganese and compounds			4.7E-02	i			1.4E-05	i	7439-96-5	3.1E+03	N	4.5E+04	N	5.1E-02	N	1.7E+03	N	
Mephosfolan			9.0E-05	h			9.0E-05	r	950-10-7	4.9E+00	N	9.6E+01	N	3.3E-01	N	3.3E+00	N	
Mepiquat			3.0E-02	i			3.0E-02	r	24307-26-4	1.6E+03	N	3.2E+04	N	1.1E+02	N	1.1E+03	N	
2-Mercaptobenzothiazole	2.9E-02	n	1.0E-01	n	2.9E-02	r	1.0E-01	r	149-30-4	1.5E+01	C	1.0E+02	C	2.3E-01	C	2.3E+00	C	
Mercury and compounds			3.0E-04	i					7487-94-7	2.2E+01	N	5.6E+02	N			1.1E+01	N	
Mercury (elemental)							8.6E-05	i	7439-97-6					3.1E-01	N			
Mercury (methyl)			1.0E-04	i					22967-92-6	5.5E+00	N	1.1E+02	N			3.7E+00	N	
Merphos			3.0E-05	i			3.0E-05	r	150-50-5	1.6E+00	N	3.2E+01	N	1.1E-01	N	1.1E+00	N	
Merphos oxide			3.0E-05	i			3.0E-05	r	78-48-8	1.6E+00	N	3.2E+01	N	1.1E-01	N	1.1E+00	N	
Metalaxyl			6.0E-02	i			6.0E-02	r	57837-19-1	3.3E+03	N	6.4E+04	N	2.2E+02	N	2.2E+03	N	
Methacrylonitrile			1.0E-04	i			2.0E-04	h	126-98-7	1.9E+00	N	8.4E+00	N	7.3E-01	N	1.0E+00	N	
Methamidophos			5.0E-05	i			5.0E-05	r	10265-92-6	2.7E+00	N	5.3E+01	N	1.8E-01	N	1.8E+00	N	
Methanol			5.0E-01	i			5.0E-01	r	67-56-1	2.7E+04	N	1.0E+05	a	1.8E+03	N	1.8E+04	N	
Methidathion			1.0E-03	i			1.0E-03	r	950-37-8	5.5E+01	N	1.1E+03	N	3.7E+00	N	3.7E+01	N	
Methomyl			2.5E-02	i			2.5E-02	r	16752-77-5	4.4E+01	N	1.5E+02	N	9.1E+01	N	1.5E+02	N	
Methoxychlor			5.0E-03	i			5.0E-03	r	72-43-5	2.7E+02	N	5.3E+03	N	1.8E+01	N	1.8E+02	N	8.0E+00
2-Methoxyethanol			1.0E-03	h			5.7E-03	i	109-86-4	5.5E+01	N	1.1E+03	N	2.1E+01	N	3.7E+01	N	
2-Methoxyethanol acetate			2.0E-03	h			2.0E-03	r	110-49-6	1.1E+02	N	2.1E+03	N	7.3E+00	N	7.3E+01	N	
2-Methoxy-5-nitroaniline	4.6E-02	h			4.6E-02	r			99-59-2	9.7E+00	C	6.5E+01	C	1.5E-01	C	1.5E+00	C	
Methyl acetate			1.0E+00	h			1.0E+00	r	79-20-9	2.0E+04	N	9.2E+04	N	3.7E+03	N	6.1E+03	N	
Methyl acrylate			3.0E-02	h			3.0E-02	r	96-33-3	6.9E+01	N	2.3E+02	N	1.1E+02	N	1.8E+02	N	
2-Methylaniline (o-toluidine)	2.4E-01	h			2.4E-01	r			95-53-4	1.9E+00	C	1.2E+01	C	2.8E-02	C	2.8E-01	C	
2-Methylaniline hydrochloride	1.8E-01	h			1.8E-01	r			636-21-5	2.5E+00	C	1.7E+01	C	3.7E-02	C	3.7E-01	C	
Methyl chlorocarbonate			1.0E+00	x			1.0E+00	r	79-22-1	5.5E+04	N	1.0E+05	a	3.7E+03	N	3.7E+04	N	
2-Methyl-4-chlorophenoxyacetic acid			5.0E-04	i			5.0E-04	r	94-74-6	2.7E+01	N	5.3E+02	N	1.8E+00	N	1.8E+01	N	
4-(2-Methyl-4-chlorophenoxy) butyric acid (MCPB)			1.0E-02	i			1.0E-02	r	94-81-5	5.5E+02	N	1.1E+04	N	3.7E+01	N	3.7E+02	N	
2-(2-Methyl-4-chlorophenoxy) propionic acid			1.0E-03	i			1.0E-03	r	93-65-2	5.5E+01	N	1.1E+03	N	3.7E+00	N	3.7E+01	N	
2-(2-Methyl-1,4-chlorophenoxy) propionic acid (MC			1.0E-03	i			1.0E-03	r	16484-77-8	5.5E+01	N	1.1E+03	N	3.7E+00	N	3.7E+01	N	
Methylcyclohexane			8.6E-01	r			8.6E-01	h	108-87-2	4.7E+04	N	1.0E+05	a	3.1E+03	N	3.1E+04	N	
4,4'-Methylenebisbenzeneamine	2.5E-01	h			2.5E-01	r			101-77-9	1.8E+00	C	1.2E+01	C	2.7E-02	C	2.7E-01	C	
4,4'-Methylene bis(2-chloroaniline)	1.3E-01	h	7.0E-04	h	1.3E-01	h	7.0E-04	r	101-14-4	3.4E+00	C	2.3E+01	C	5.2E-02	C	5.2E-01	C	
4,4'-Methylene bis(N,N'-dimethyl)aniline	4.6E-02	i	B2		4.6E-02	r			101-61-1	9.7E+00	C	6.5E+01	C	1.5E-01	C	1.5E+00	C	
Methylene bromide			1.0E-02	h			1.0E-02	r	74-95-3	5.5E+02	N	1.1E+04	N	3.7E+01	N	3.7E+02	N	
Methylene chloride	7.5E-03	i	6.0E-02	i	1.6E-03	i	8.6E-01	h	75-09-2	8.5E+00	C	2.0E+01	C	4.1E+00	C	4.3E+00	C	1.0E-03
4,4'-Methylenediphenyl isocyanate			1.7E-04	r			1.7E-04	i	101-68-8	9.3E+00	N	1.8E+02	N	6.2E-01	N	6.2E+00	N	
Methyl ethyl ketone			6.0E-01	i			2.9E-01	i	78-93-3	6.9E+03	N	2.7E+04	N	1.0E+03	N	1.9E+03	N	

Region 9 Human Health Medium Specific Screening Levels	Toxicity Information															
Contaminants																
Methyl hydrazine	1.1E+00	h			1.1E+00	r		60-34-4	4.0E-01	c	2.7E+00	c	6.1E-03	c	6.1E-02	c	
Methyl isobutyl ketone			8.0E-02	h			2.3E-02	h	108-10-1	7.5E+02	N	2.8E+03	N	8.3E+01	N	1.6E+02	N	
Methyl mercaptan			5.7E-04	r			5.7E-04	n	74-93-1	3.1E+01	N	6.1E+02	N	2.1E+00	N	2.1E+01	N	
Methyl methacrylate			1.4E+00	i			2.0E-01	i	80-62-6	2.2E+03	N	2.7E+03	sat	7.3E+02	N	1.4E+03	N	
2-Methyl-5-nitroaniline	3.3E-02	h			3.3E-02	r			99-55-8	1.3E+01	c	9.1E+01	c	2.0E-01	c	2.0E+00	c	
Methyl parathion			2.5E-04	i			2.5E-04	r	298-00-0	1.4E+01	N	2.7E+02	N	9.1E-01	N	9.1E+00	N	
2-Methylphenol			5.0E-02	x			5.0E-02	r	95-48-7	2.7E+03	N	5.3E+04	N	1.8E+02	N	1.8E+03	N	8.0E-01
3-Methylphenol			5.0E-02	x			5.0E-02	r	108-39-4	2.7E+03	N	5.3E+04	N	1.8E+02	N	1.8E+03	N	
4-Methylphenol			5.0E-03	h			5.0E-03	r	106-44-5	2.7E+02	N	5.3E+03	N	1.8E+01	N	1.8E+02	N	
Methyl phosphonic acid			2.0E-02	n			2.0E-02	r	993-13-5	1.1E+03	N	2.1E+04	N	7.3E+01	N	7.3E+02	N	
Methyl styrene (mixture)			6.0E-03	h			1.1E-02	h	25013-15-4	1.2E+02	N	5.4E+02	N	4.2E+01	N	6.0E+01	N	
Methyl styrene (alpha)			7.0E-02	h			7.0E-02	r	98-83-9	6.8E+02	sat	6.8E+02	sat	2.6E+02	N	4.3E+02	N	
Methyl tertbutyl ether (MTBE)							8.6E-01	i	1634-04-4					3.1E+03	N	2.0E+01		
Metolaclor (Dual)			1.5E-01	i			1.5E-01	r	51218-45-2	8.2E+03	N	1.0E+05	a	5.5E+02	N	5.5E+03	N	
Metribuzin			2.5E-02	i			2.5E-02	r	21087-64-9	1.4E+03	N	2.7E+04	N	9.1E+01	N	9.1E+02	N	
Mirex	1.8E+00	h	2.0E-04	i	1.8E+00	r	2.0E-04	r	2385-85-5	2.5E-01	c	1.7E+00	c	3.7E-03	c	3.7E-02	c	
Molinate			2.0E-03	i			2.0E-03	r	2212-67-1	1.1E+02	N	2.1E+03	N	7.3E+00	N	7.3E+01	N	
Molybdenum			5.0E-03	h					7439-98-7	3.7E+02	N	9.4E+03	N			1.8E+02	N	
Monochloramine			1.0E-01	h			1.0E-01	h	10599-90-3	5.5E+03	N	1.0E+05	a	3.7E+02	N	3.7E+03	N	
Naled			2.0E-03	i			2.0E-03	r	300-76-5	1.1E+02	N	2.1E+03	N	7.3E+00	N	7.3E+01	N	
Napropamide			1.0E-01	i			1.0E-01	r	15299-99-7	5.5E+03	N	1.0E+05	a	3.7E+02	N	3.7E+03	N	
Nickel and compounds			2.0E-02	i					7440-02-0	1.5E+03	N	3.7E+04	N			7.3E+02	N	7.0E+00
Nickel refinery dust		A			8.4E-01	i			n/a	1.1E+04	c	2.2E+04	c	8.0E-03	c			
Nickel subsulfide		A			1.7E+00	i			12035-72-2	5.2E+03	c	1.1E+04	c	4.0E-03	c			
Nitrapyrin			1.5E-03	x			1.5E-03	r	1929-82-4	8.2E+01	N	1.6E+03	N	5.5E+00	N	5.5E+01	N	
Nitrate	Tap Water Screening Level Based on Infant NOAEL (see IRIS)								14797-55-8							1.0E+04		
Nitric Oxide			1.0E-01	x					10102-43-9	5.5E+03	N	1.0E+05	a			3.7E+03	N	
Nitrite	Tap Water Screening Level Based on Infant NOAEL (see IRIS)								14797-65-0							1.0E+03		
2-Nitroaniline			6.0E-05	r			5.7E-05	h	88-74-4	3.3E+00	N	6.4E+01	N	2.1E-01	N	2.2E+00	N	
3-Nitroaniline									99-09-2									
4-Nitroaniline									100-01-6									
Nitrobenzene			5.0E-04	i			5.7E-04	h	98-95-3	1.6E+01	N	1.0E+02	N	2.1E+00	N	3.4E+00	N	7.0E-03
Nitrofurantoin			7.0E-02	h			7.0E-02	r	67-20-9	3.8E+03	N	7.5E+04	N	2.6E+02	N	2.6E+03	N	
Nitrofurazone	1.5E+00	h			9.4E+00	h			59-87-0	3.0E-01	c	2.0E+00	c	7.2E-04	c	4.5E-02	c	
Nitrogen dioxide			1.0E+00	x					101102-44-	5.5E+04	N	1.0E+05	a			3.7E+04	N	
Nitroguanidine			1.0E-01	i			1.0E-01	r	556-88-7	5.5E+03	N	1.0E+05	a	3.7E+02	N	3.7E+03	N	
4-Nitrophenol			6.2E-02	o			6.2E-02	r	100-02-7	3.4E+03	N	6.6E+04	N	2.3E+02	N	2.3E+03	N	
2-Nitropropane	9.4E+00	r	5.7E-03	r	9.4E+00	h	5.7E-03	i	79-46-9	4.7E-02	c	3.2E-01	c	7.2E-04	c	1.2E-03	c	
N-Nitrosodi-n-butylamine	5.4E+00	i		B2	5.6E+00	i			924-16-3	2.2E-02	c	5.8E-02	c	1.2E-03	c	2.0E-03	c	
N-Nitrosodiethanolamine	2.8E+00	i		B2	2.8E+00	r			1116-54-7	1.6E-01	c	1.1E+00	c	2.4E-03	c	2.4E-02	c	
N-Nitrosodiethylamine	1.5E+02	i		B2	1.5E+02	i			55-18-5	3.0E-03	c	2.0E-02	c	4.5E-05	c	4.5E-04	c	
N-Nitrosodimethylamine	5.1E+01	i		B2	4.9E+01	i			62-75-9	8.7E-03	c	5.9E-02	c	1.4E-04	c	1.3E-03	c	
N-Nitrosodiphenylamine	4.9E-03	i		B2	4.9E-03	r			86-30-6	9.1E+01	c	6.1E+02	c	1.4E+00	c	1.4E+01	c	6.0E-02
N-Nitroso di-n-propylamine	7.0E+00	i			7.0E+00	r			621-64-7	6.3E-02	c	4.3E-01	c	9.6E-04	c	9.6E-03	c	2.0E-06
N-Nitroso-N-methylethylamine	2.2E+01	i		B2	2.2E+01	r			10595-95-6	2.0E-02	c	1.4E-01	c	3.1E-04	c	3.1E-03	c	
N-Nitrosopyrrolidine	2.1E+00	i		B2	2.1E+00	i			930-55-2	2.1E-01	c	1.4E+00	c	3.1E-03	c	3.2E-02	c	
m-Nitrotoluene			1.0E-02	h			1.0E-02	r	99-08-1	5.5E+02	N	1.1E+04	N	3.7E+01	N	3.7E+02	N	
o-Nitrotoluene			1.0E-02	h			1.0E-02	r	99-08-1	5.5E+02	N	1.1E+04	N	3.7E+01	N	3.7E+02	N	
p-Nitrotoluene			1.0E-02	h			1.0E-02	r	99-99-0	5.5E+02	N	1.1E+04	N	3.7E+01	N	3.7E+02	N	
Norflurazon			4.0E-02	i			4.0E-02	r	27314-13-2	2.2E+03	N	4.3E+04	N	1.5E+02	N	1.5E+03	N	

Region 6 Human Health Medium Specific Screening Levels																
Contaminants																
NuStar			7.0E-04	i		7.0E-04	r	85509-19-9	3.8E+01	N	7.5E+02	N	2.6E+00	N	2.6E+01	N	
Octabromodiphenyl ether			3.0E-03	i		3.0E-03	r	32536-52-0	1.6E+02	N	3.2E+03	N	1.1E+01	N	1.1E+02	N	
Octahydro-1357-tetranitro-1357- tetrazocine (HMX)			5.0E-02	i		5.0E-02	r	2691-41-0	2.7E+03	N	5.3E+04	N	1.8E+02	N	1.8E+03	N	
Octamethylpyrophosphoramide			2.0E-03	h		2.0E-03	r	152-16-9	1.1E+02	N	2.1E+03	N	7.3E+00	N	7.3E+01	N	
Oryzalin			5.0E-02	i		5.0E-02	r	19044-88-3	2.7E+03	N	5.3E+04	N	1.8E+02	N	1.8E+03	N	
Oxadiazon			5.0E-03	i		5.0E-03	r	19666-30-9	2.7E+02	N	5.3E+03	N	1.8E+01	N	1.8E+02	N	
Oxamyl			2.5E-02	i		2.5E-02	r	23135-22-0	1.4E+03	N	2.7E+04	N	9.1E+01	N	9.1E+02	N	
Oxyfluorfen			3.0E-03	i		3.0E-03	r	42874-03-3	1.6E+02	N	3.2E+03	N	1.1E+01	N	1.1E+02	N	
Paclobutrazol			1.3E-02	i		1.3E-02	r	76738-62-0	7.1E+02	N	1.4E+04	N	4.7E+01	N	4.7E+02	N	
Paraquat			4.5E-03	i		4.5E-03	r	4685-14-7	2.5E+02	N	4.8E+03	N	1.6E+01	N	1.6E+02	N	
Parathion			6.0E-03	h		6.0E-03	r	56-38-2	3.3E+02	N	6.4E+03	N	2.2E+01	N	2.2E+02	N	
Pebulate			5.0E-02	h		5.0E-02	r	1114-71-2	2.7E+03	N	5.3E+04	N	1.8E+02	N	1.8E+03	N	
Pendimethalin			4.0E-02	i		4.0E-02	r	40487-42-1	2.2E+03	N	4.3E+04	N	1.5E+02	N	1.5E+03	N	
Pentabromo-6-chloro cyclohexane	2.3E-02	h			2.3E-02	r		87-84-3	1.9E+01	C	1.3E+02	C	2.9E-01	C	2.9E+00	C	
Pentabromodiphenyl ether			2.0E-03	i		2.0E-03	r	32534-81-9	1.1E+02	N	2.1E+03	N	7.3E+00	N	7.3E+01	N	
Pentachlorobenzene			8.0E-04	i		8.0E-04	r	608-93-5	4.4E+01	N	8.6E+02	N	2.9E+00	N	2.9E+01	N	
Pentachloronitrobenzene	2.6E-01	h	3.0E-03	i	2.6E-01	r	3.0E-03	r	82-68-8	1.7E+00	C	1.2E+01	C	2.6E-02	C	2.6E-01	C	
Pentachlorophenol	1.2E-01	i	3.0E-02	i	1.2E-01	r	3.0E-02	r	87-86-5	2.5E+00	C	1.5E+01	C	5.6E-02	C	5.6E-01	C	1.0E-03
Perchlorate			5.0E-04	n					7601-90-3	3.7E+01	N	9.4E+02	N			1.8E+01	N	
Permethrin			5.0E-02	i		5.0E-02	r		52645-53-1	2.7E+03	N	5.3E+04	N	1.8E+02	N	1.8E+03	N	
Phenmedipham			2.5E-01	i		2.5E-01	r		13684-63-4	1.4E+04	N	1.0E+05	a	9.1E+02	N	9.1E+03	N	
Phenol			6.0E-01	i		6.0E-01	r		108-95-2	3.3E+04	N	1.0E+05	a	2.2E+03	N	2.2E+04	N	5.0E+00
Phenothiazine			2.0E-03	n		2.0E-03	r		92-84-2	1.1E+02	N	2.1E+03	N	7.3E+00	N	7.3E+01	N	
m-Phenylenediamine			6.0E-03	i		6.0E-03	r		108-45-2	3.3E+02	N	6.4E+03	N	2.2E+01	N	2.2E+02	N	
p-Phenylenediamine			1.9E-01	h		1.9E-01	r		106-50-3	1.0E+04	N	1.0E+05	a	6.9E+02	N	6.9E+03	N	
Phenylmercuric acetate			8.0E-05	i		8.0E-05	r		62-38-4	4.4E+00	N	8.6E+01	N	2.9E-01	N	2.9E+00	N	
2-Phenylphenol	1.9E-03	h			1.9E-03	r			90-43-7	2.3E+02	C	1.5E+03	C	3.5E+00	C	3.5E+01	C	
Phorate			2.0E-04	h		2.0E-04	r		298-02-2	1.1E+01	N	2.1E+02	N	7.3E-01	N	7.3E+00	N	
Phosmet			2.0E-02	i		2.0E-02	r		732-11-6	1.1E+03	N	2.1E+04	N	7.3E+01	N	7.3E+02	N	
Phosphine			3.0E-04	h		8.6E-05	i		7803-51-2	1.6E+01	N	3.2E+02	N	3.1E-01	N	1.1E+01	N	
Phosphoric acid						2.9E-03	i		7664-38-2					1.0E+01	N			
Phosphorus (white)			2.0E-05	i					7723-14-0	1.5E+00	N	3.7E+01	N			7.3E-01	N	
p-Phthalic acid			1.0E+00	h		1.0E+00	r		100-21-0	5.5E+04	N	1.0E+05	a	3.7E+03	N	3.7E+04	N	
Phthalic anhydride			2.0E+00	i		3.4E-02	h		85-44-9	1.0E+05	a	1.0E+05	a	1.2E+02	N	7.3E+04	N	
Picloram			7.0E-02	i		7.0E-02	r		1918-02-1	3.8E+03	N	7.5E+04	N	2.6E+02	N	2.6E+03	N	
Pirimiphos-methyl			1.0E-02	i		1.0E-02	r		23505-41-1	5.5E+02	N	1.1E+04	N	3.7E+01	N	3.7E+02	N	
Polybrominated biphenyls	8.9E+00	h	7.0E-06	h	8.9E+00	r	7.0E-06	r		5.0E-02	C	3.4E-01	C	7.6E-04	C	7.6E-03	C	
Polychlorinated biphenyls (PCBs)	2.0E+00	i	B2		2.0E+00	r			1336-36-3	2.0E-01	C	1.3E+00	C	3.4E-03	C	3.4E-02	C	
Aroclor 1016			7.0E-05	i		7.0E-05	r		12674-11-2	3.4E+00	N	6.3E+01	N	2.6E-01	N	2.6E+00	N	
Aroclor 1254			2.0E-05	i		2.0E-05	r		11097-69-1	9.7E-01	N	1.8E+01	N	7.3E-02	N	7.3E-01	N	
Polynuclear aromatic hydrocarbons																		
Acenaphthene			6.0E-02	i		6.0E-02	r		83-32-9	2.6E+03	N	2.8E+04	N	2.2E+02	N	3.7E+02	N	2.9E+01
Anthracene			3.0E-01	i		3.0E-01	r		120-12-7	1.4E+04	N	1.0E+05	a	1.1E+03	N	1.8E+03	N	5.9E+02
Benz[a]anthracene	7.3E-01	n			3.1E-01	n			56-55-3	5.6E-01	C	3.6E+00	C	2.2E-02	C	9.2E-02	C	8.0E-02
Benzo[b]fluoranthene	7.3E-01	n	B2		3.1E-01	n			205-99-2	5.6E-01	C	3.6E+00	C	2.2E-02	C	9.2E-02	C	2.0E-01
Benzo[k]fluoranthene	7.3E-02	n	B2		3.1E-02	n			207-08-9	5.6E+00	C	3.6E+01	C	2.2E-01	C	9.2E-01	C	2.0E+00
Benzo[a]pyrene	7.3E+00	i	B2		3.1E+00	n			50-32-8	5.6E-02	C	3.6E-01	C	2.2E-03	C	9.2E-03	C	4.0E-01
Chrysene	7.3E-03	n			3.1E-03	n			218-01-9	5.6E+01	C	3.6E+02	C	2.2E+00	C	9.2E+00	C	8.0E+00
Dibenz[ah]anthracene	7.3E+00	n			3.1E+00	n			53-70-3	5.6E-02	C	3.6E-01	C	2.2E-03	C	9.2E-03	C	8.0E-02
Fluoranthene			4.0E-02	i		4.0E-02	r		206-44-0	2.0E+03	N	3.7E+04	N	1.5E+02	N	1.5E+03	N	2.1E+02

Contaminants	TOXICITY INFORMATION							SCREENING LEVELS									
	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fluorene				4.0E-02	i		4.0E-02	r	86-73-7	1.8E+03	N	2.2E+04	N	1.5E+02	N	2.4E+02	N	2.8E+01
Indeno[1,2,3-cd]pyrene	7.3E-01	n				3.1E-01	n		193-39-5	5.6E-01	C	3.6E+00	C	2.2E-02	C	9.2E-02	C	7.0E-01
Naphthalene			B2	2.0E-02	i		8.6E-04	i	91-20-3	5.5E+01	N	1.9E+02	N	3.1E+00	N	6.2E+00	N	4.0E+00
Pyrene				3.0E-02	i		3.0E-02	r	129-00-0	1.5E+03	N	2.6E+04	N	1.1E+02	N	1.8E+02	N	2.1E+02
Prochloraz	1.5E-01	i	C	9.0E-03	i	1.5E-01	r	9.0E-03	r	67747-09-5	3.0E+01	C	2.0E+02	C	4.5E-01	C	4.5E+00	C	
Profluralin				6.0E-03	h		6.0E-03	r	26399-36-0	3.3E+02	N	6.4E+03	N	2.2E+01	N	2.2E+02	N	
Prometon				1.5E-02	i		1.5E-02	r	1610-18-0	8.2E+02	N	1.6E+04	N	5.5E+01	N	5.5E+02	N	
Prometryn				4.0E-03	i		4.0E-03	r	7287-19-6	2.2E+02	N	4.3E+03	N	1.5E+01	N	1.5E+02	N	
Pronamide				7.5E-02	i		7.5E-02	r	23950-58-5	4.1E+03	N	8.0E+04	N	2.7E+02	N	2.7E+03	N	
Propachlor				1.3E-02	i		1.3E-02	r	1918-16-7	7.1E+02	N	1.4E+04	N	4.7E+01	N	4.7E+02	N	
Propanil				5.0E-03	i		5.0E-03	r	709-98-8	2.7E+02	N	5.3E+03	N	1.8E+01	N	1.8E+02	N	
Propargite				2.0E-02	i		2.0E-02	r	2312-35-8	1.1E+03	N	2.1E+04	N	7.3E+01	N	7.3E+02	N	
Propargyl alcohol				2.0E-03	i		2.0E-03	r	107-19-7	1.1E+02	N	2.1E+03	N	7.3E+00	N	7.3E+01	N	
Propazine				2.0E-02	i		2.0E-02	r	139-40-2	1.1E+03	N	2.1E+04	N	7.3E+01	N	7.3E+02	N	
Propham				2.0E-02	i		2.0E-02	r	122-42-9	1.1E+03	N	2.1E+04	N	7.3E+01	N	7.3E+02	N	
Propiconazole				1.3E-02	i		1.3E-02	r	60207-90-1	7.1E+02	N	1.4E+04	N	4.7E+01	N	4.7E+02	N	
iso-Propylbenzene				1.0E-02	n		1.0E-02	r	104-5-18	1.2E+02	N	3.9E+02	sat	3.7E+01	N	6.1E+01	N	
n-Propylbenzene				1.0E-02	n		1.0E-02	r	104-51-8	1.3E+02	N	2.4E+02	sat	3.7E+01	N	6.1E+01	N	
Propylene glycol				2.0E+01	h		2.0E+01	r	57-55-6	1.0E+05	a	1.0E+05	a	7.3E+04	N	7.3E+05	N	
Propylene glycol, monoethyl ether				7.0E-01	h		7.0E-01	r	111-35-3	3.8E+04	N	1.0E+05	a	2.6E+03	N	2.6E+04	N	
Propylene glycol, monomethyl ether				7.0E-01	h		5.7E-01	i	107-98-2	3.8E+04	N	1.0E+05	a	2.1E+03	N	2.6E+04	N	
Propylene oxide	2.4E-01	i	B2	8.6E-03	r	1.3E-02	i	8.6E-03	i	75-56-9	1.5E+00	C	6.8E+00	C	5.2E-01	C	2.2E-01	C	
Pursuit				2.5E-01	i		2.5E-01	r	81335-77-5	1.4E+04	N	1.0E+05	a	9.1E+02	N	9.1E+03	N	
Pydrin				2.5E-02	i		2.5E-02	r	51630-58-1	1.4E+03	N	2.7E+04	N	9.1E+01	N	9.1E+02	N	
Pyridine				1.0E-03	i		1.0E-03	r	110-86-1	5.5E+01	N	1.1E+03	N	3.7E+00	N	3.7E+01	N	
Quinalphos				5.0E-04	i		5.0E-04	r	13593-03-8	2.7E+01	N	5.3E+02	N	1.8E+00	N	1.8E+01	N	
Quinoline	1.2E+01	h				1.2E+01	r		91-22-5	3.7E-02	C	2.5E-01	C	5.6E-04	C	5.6E-03	C	
RDX (Cyclonite)	1.1E-01	i	C	3.0E-03	i	1.1E-01	r	3.0E-03	r	121-82-4	4.0E+01	C	2.7E+02	C	6.1E-01	C	6.1E+00	C	
Resmethrin				3.0E-02	i		3.0E-02	r	10453-86-8	1.6E+03	N	3.2E+04	N	1.1E+02	N	1.1E+03	N	
Ronnel				5.0E-02	h		5.0E-02	r	299-84-3	2.7E+03	N	5.3E+04	N	1.8E+02	N	1.8E+03	N	
Rotenone				4.0E-03	i		4.0E-03	r	83-79-4	2.2E+02	N	4.3E+03	N	1.5E+01	N	1.5E+02	N	
Savey				2.5E-02	i		2.5E-02	r	78587-05-0	1.4E+03	N	2.7E+04	N	9.1E+01	N	9.1E+02	N	
Selenious Acid				5.0E-03	i				7783-00-8	2.7E+02	N	5.3E+03	N			1.8E+02	N	
Selenium				5.0E-03	i				7782-49-2	3.7E+02	N	9.4E+03	N			1.8E+02	N	3.0E-01
Selenourea				5.0E-03	h				630-10-4	2.7E+02	N	5.3E+03	N			1.8E+02	N	
Sethoxydim				9.0E-02	i		9.0E-02	r	74051-80-2	4.9E+03	N	9.6E+04	N	3.3E+02	N	3.3E+03	N	
Silver and compounds				5.0E-03	i				7440-22-4	3.7E+02	N	9.4E+03	N			1.8E+02	N	2.0E+00
Simazine	1.2E-01	h		5.0E-03	i	1.2E-01	r	2.0E-03	r	122-34-9	3.7E+00	C	2.5E+01	C	5.6E-02	C	5.6E-01	C	
Sodium azide				4.0E-03	i		4.0E-03	r	26628-22-8	2.2E+02	N	4.3E+03	N	1.5E+01	N	1.5E+02	N	
Sodium diethyldithiocarbamate	2.7E-01	h		3.0E-02	i	2.7E-01	r	3.0E-02	r	148-18-5	1.6E+00	C	1.1E+01	C	2.5E-02	C	2.5E-01	C	
Sodium fluoroacetate				2.0E-05	i		2.0E-05	r	62-74-8	1.1E+00	N	2.1E+01	N	7.3E-02	N	7.3E-01	N	
Sodium metavanadate				1.0E-03	h		1.0E-03	r	13718-26-8	5.5E+01	N	1.1E+03	N	3.7E+00	N	3.7E+01	N	
Strontium, stable				6.0E-01	i				7440-24-6	4.5E+04	N	1.0E+05	a			2.2E+04	N	
Strychnine				3.0E-04	i		3.0E-04	r	57-24-9	1.6E+01	N	3.2E+02	N	1.1E+00	N	1.1E+01	N	
Styrene				2.0E-01	i		2.9E-01	i	100-42-5	1.7E+03	sat	1.7E+03	sat	1.1E+03	N	1.6E+03	N	2.0E-01
Systhane				2.5E-02	i		2.5E-02	r	88671-89-0	1.4E+03	N	2.7E+04	N	9.1E+01	N	9.1E+02	N	
2,3,7,8-TCDD (dioxin)	1.5E+05	h				1.5E+05	h		1746-01-6	3.8E-06	C	3.0E-05	C	4.5E-08	C	4.5E-07	C	
Tebuthiuron				7.0E-02	i		7.0E-02	r	34014-18-1	3.8E+03	N	7.5E+04	N	2.6E+02	N	2.6E+03	N	
Temephos				2.0E-02	h		2.0E-02	r	3383-96-8	1.1E+03	N	2.1E+04	N	7.3E+01	N	7.3E+02	N	
Terbacil				1.3E-02	i		1.3E-02	r	5902-51-2	7.1E+02	N	1.4E+04	N	4.7E+01	N	4.7E+02	N	

Contaminant																
Terbufos				2.5E-05	h			2.5E-05	r	13071-79-9	1.4E+00	N	2.7E+01	N	9.1E-02	N	9.1E-01	N	
Terbutryn				1.0E-03	i			1.0E-03	r	886-50-0	5.5E+01	N	1.1E+03	N	3.7E+00	N	3.7E+01	N	
1,2,4,5-Tetrachlorobenzene				3.0E-04	i			3.0E-04	r	95-94-3	1.6E+01	N	3.2E+02	N	1.1E+00	N	1.1E+01	N	
1,1,1,2-Tetrachloroethane	2.6E-02	i	C	3.0E-02	i	2.6E-02	i	3.0E-02	r	630-20-6	2.9E+01	C	6.9E+01	C	2.6E+00	C	4.3E+00	C	
1,1,2,2-Tetrachloroethane	2.0E-01	i	C			2.0E-01	i			79-34-5	3.6E+00	C	8.7E+00	C	3.3E-01	C	5.5E-01	C	2.0E-04
Tetrachloroethylene (PCE)	5.2E-02	n		1.0E-02	i	2.0E-03	n	1.1E-01	n	127-18-4	4.7E+00	C	1.6E+01	C	3.3E+00	C	1.1E+00	C	3.0E-03
2,3,4,6-Tetrachlorophenol				3.0E-02	i			3.0E-02	r	58-90-2	1.6E+03	N	3.2E+04	N	1.1E+02	N	1.1E+03	N	
p,a,a,a-Tetrachlorotoluene	2.0E+01	h				2.0E+01	r			5216-25-1	2.2E-02	C	1.5E-01	C	3.4E-04	C	3.4E-03	C	
Tetrachlorovinphos	2.4E-02	h		3.0E-02	i	2.4E-02	r	3.0E-02	r	961-11-5	1.9E+01	C	1.2E+02	C	2.8E-01	C	2.8E+00	C	
Tetraethyldithiopyrophosphate				5.0E-04	i			5.0E-04	r	3689-24-5	2.7E+01	N	5.3E+02	N	1.8E+00	N	1.8E+01	N	
Tetrahydrofuran				8.6E-02	r			8.6E-02	n	109-99-9	4.7E+03	N	9.2E+04	N	3.1E+02	N	3.1E+03	N	
Thallic oxide				7.0E-05	h					1314-32-5	5.2E+00	N	1.3E+02	N			2.6E+00	N	
Thallium acetate				9.0E-05	i					563-68-8	6.7E+00	N	1.7E+02	N			3.3E+00	N	4.0E-01
Thallium carbonate				8.0E-05	i					6533-73-9	6.0E+00	N	1.5E+02	N			2.9E+00	N	4.0E-01
Thallium chloride				8.0E-05	i					7791-12-0	6.0E+00	N	1.5E+02	N			2.9E+00	N	4.0E-01
Thallium nitrate				9.0E-05	i					10102-45-1	6.7E+00	N	1.7E+02	N			3.3E+00	N	4.0E-01
Thallium selenite				9.0E-05	x					12039-52-0	6.7E+00	N	1.7E+02	N			3.3E+00	N	4.0E-01
Thallium sulfate				8.0E-05	i					7446-18-6	6.0E+00	N	1.5E+02	N			2.9E+00	N	4.0E-01
Thiobencarb				1.0E-02	i			1.0E-02	r	28249-77-6	5.5E+02	N	1.1E+04	N	3.7E+01	N	3.7E+02	N	
Thiocyanate				1.0E-01	n			1.0E-01	r	N/A	5.5E+03	N	1.0E+05	a	3.7E+02	N	3.7E+03	N	
2-(Thiocyanomethylthio)- benzothiazole (TCMTB)				3.0E-02	x			3.0E-02	r	21564-17-0	1.6E+03	N	3.2E+04	N	1.1E+02	N	1.1E+03	N	
Thiofanox				3.0E-04	h			3.0E-04	r	39196-18-4	1.6E+01	N	3.2E+02	N	1.1E+00	N	1.1E+01	N	
Thiophanate-methyl				8.0E-02	i			8.0E-02	r	23564-05-8	4.4E+03	N	8.6E+04	N	2.9E+02	N	2.9E+03	N	
Thiram				5.0E-03	i			5.0E-03	r	137-26-8	2.7E+02	N	5.3E+03	N	1.8E+01	N	1.8E+02	N	
Tin and compounds				6.0E-01	h					n/a	4.5E+04	N	1.0E+05	a			2.2E+04	N	
Toluene				2.0E-01	i			1.1E-01	h	108-88-3	5.2E+02	sat	5.2E+02	sat	4.0E+02	N	7.2E+02	N	6.0E-01
Toluene-2,4-diamine	3.2E+00	h				3.2E+00	r			95-80-7	1.4E-01	C	9.4E-01	C	2.1E-03	C	2.1E-02	C	
Toluene-2,5-diamine				6.0E-01	h			6.0E-01	r	95-70-5	3.3E+04	N	1.0E+05	a	2.2E+03	N	2.2E+04	N	
Toluene-2,6-diamine				2.0E-01	h			2.0E-01	r	823-40-5	1.1E+04	N	1.0E+05	a	7.3E+02	N	7.3E+03	N	
p-Toluidine	1.9E-01	i				1.9E-01	r			106-49-0	2.3E+00	C	1.6E+01	C	3.5E-02	C	3.5E-01	C	
Toxaphene	1.1E+00	i	B2			1.1E+00	i			8001-35-2	4.0E-01	C	2.7E+00	C	6.0E-03	C	6.1E-02	C	2.0E+00
Tralomethrin				7.5E-03	i			7.5E-03	r	66841-25-6	4.1E+02	N	8.0E+03	N	2.7E+01	N	2.7E+02	N	
Triallate				1.3E-02	i			1.3E-02	r	2303-17-5	7.1E+02	N	1.4E+04	N	4.7E+01	N	4.7E+02	N	
Triasulfuron				1.0E-02	i			1.0E-02	r	82097-50-5	5.5E+02	N	1.1E+04	N	3.7E+01	N	3.7E+02	N	
1,2,4-Tribromobenzene				5.0E-03	i			5.0E-03	r	615-54-3	2.7E+02	N	5.3E+03	N	1.8E+01	N	1.8E+02	N	
Tributyltin oxide (TBTO)				3.0E-04	i					56-35-9	1.6E+01	N	3.2E+02	N			1.1E+01	N	
2,4,6-Trichloroaniline	3.4E-02	h				3.4E-02	r			634-93-5	1.3E+01	C	8.8E+01	C	2.0E-01	C	2.0E+00	C	
2,4,6-Trichloroaniline hydrochloride	2.9E-02	h				2.9E-02	r			33663-50-2	1.5E+01	C	1.0E+02	C	2.3E-01	C	2.3E+00	C	
1,2,4-Trichlorobenzene				1.0E-02	i			5.7E-02	h	120-82-1	4.8E+02	N	3.0E+03	sat	2.1E+02	N	1.9E+02	N	3.0E-01
1,1,1-Trichloroethane				3.5E-02	n			2.9E-01	n	71-55-6	6.9E+02	N	1.4E+03	sat	1.0E+03	N	7.9E+02	N	1.0E-01
1,1,2-Trichloroethane	5.7E-02	i		4.0E-03	i	5.6E-02	i	4.0E-03	r	79-00-5	8.2E-01	C	1.9E+00	C	1.2E-01	C	2.0E-01	C	9.0E-04
Trichloroethylene (TCE)	1.1E-02	n		6.0E-03	x	6.0E-03	n	6.0E-03	r	79-01-6	2.7E+00	C	6.1E+00	C	1.1E+00	C	1.6E+00	C	3.0E-03
Trichlorofluoromethane				3.0E-01	i			2.0E-01	h	75-69-4	3.8E+02	N	1.3E+03	N	7.3E+02	N	1.3E+03	N	
2,4,5-Trichlorophenol				1.0E-01	i			1.0E-01	r	95-95-4	5.5E+03	N	1.0E+05	a	3.7E+02	N	3.7E+03	N	1.4E+01
2,4,6-Trichlorophenol	1.1E-02	i	B2			1.1E-02	i			88-06-2	4.0E+01	C	2.7E+02	C	6.2E-01	C	6.1E+00	C	8.0E-03
2,4,5-Trichlorophenoxyacetic Acid				1.0E-02	i			1.0E-02	r	93-76-5	5.5E+02	N	1.1E+04	N	3.7E+01	N	3.7E+02	N	
2-(2,4,5-Trichlorophenoxy) propionic acid				8.0E-03	i			8.0E-03	r	93-72-1	4.4E+02	N	8.6E+03	N	2.9E+01	N	2.9E+02	N	
1,1,2-Trichloropropane				5.0E-03	i			5.0E-03	r	598-77-6	1.5E+01	N	5.1E+01	N	1.8E+01	N	3.0E+01	N	
1,2,3-Trichloropropane	7.0E+00	h		6.0E-03	i	7.0E+00	r	5.0E-03	r	96-18-4	1.4E-03	C	3.1E-03	C	9.6E-04	C	1.6E-03	C	
1,2,3-Trichloropropene				5.0E-03	h			5.0E-03	r	96-19-5	1.1E+01	N	3.9E+01	N	1.8E+01	N	3.0E+01	N	

Region 6 Screening Levels	Toxicity Information															
Specific Screening Levels																
Contaminants																
1,1,2-Trichloro-1,2,2-trifluoroethane				3.0E+01	i			8.6E+00	h	76-13-1	5.6E+03	sat	5.6E+03	sat	3.1E+04	N	5.9E+04	N	
Tridiphane				3.0E-03	i			3.0E-03	r	58138-08-2	1.6E+02	N	3.2E+03	N	1.1E+01	N	1.1E+02	N	
Triethylamine				2.0E-03	r			2.0E-03	i	121-44-8	2.2E+01	N	8.6E+01	N	7.3E+00	N	1.2E+01	N	
Trifluralin	7.7E-03	i	C	7.5E-03	i	7.7E-03	r	7.5E-03	r	1582-09-8	4.1E+02	N	3.9E+03	C	8.7E+00	C	8.7E+01	C	
1,2,4-Trimethylbenzene				5.0E-02	n			1.7E-03	n	95-63-6	5.1E+01	N	1.7E+02	N	6.2E+00	N	1.2E+01	N	
1,3,5-Trimethylbenzene				5.0E-02	n			1.7E-03	n	108-67-8	2.1E+01	N	7.0E+01	N	6.2E+00	N	1.2E+01	N	
Trimethyl phosphate	3.7E-02	h				3.7E-02	r			512-56-1	1.2E+01	C	8.1E+01	C	1.8E-01	C	1.8E+00	C	
1,3,5-Trinitrobenzene				3.0E-02	i			3.0E-02	r	99-35-4	1.6E+03	N	3.2E+04	N	1.1E+02	N	1.1E+03	N	
Trinitrophenylmethylnitramine				1.0E-02	h			1.0E-02	r	479-45-8	5.5E+02	N	1.1E+04	N	3.7E+01	N	3.7E+02	N	
2,4,6-Trinitrotoluene	3.0E-02	i	C	5.0E-04	i	3.0E-02	r	5.0E-04	r	118-96-7	2.7E+01	N	5.3E+02	N	1.8E+00	N	1.8E+01	N	
Vanadium				7.0E-03	h					7440-62-2	5.2E+02	N	1.3E+04	N			2.6E+02	N	3.0E+02
Vanadium pentoxide				9.0E-03	i					1314-62-1	6.7E+02	N	1.7E+04	N			3.3E+02	N	3.0E+02
Vanadium sulfate				2.0E-02	h					13701-70-7	1.5E+03	N	3.7E+04	N			7.3E+02	N	3.0E+02
Vernam				1.0E-03	i			1.0E-03	r	1929-77-7	5.5E+01	N	1.1E+03	N	3.7E+00	N	3.7E+01	N	
Vinclozolin				2.5E-02	i			2.5E-02	r	50471-44-8	1.4E+03	N	2.7E+04	N	9.1E+01	N	9.1E+02	N	
Vinyl acetate				1.0E+00	h			5.7E-02	i	108-05-4	4.3E+02	N	1.4E+03	N	2.1E+02	N	4.1E+02	N	8.0E+00
Vinyl bromide	1.1E-01	r		8.6E-04	r	1.1E-01	h	8.6E-04	i	593-60-2	1.9E-01	C	4.2E-01	C	6.1E-02	C	1.0E-01	C	
Vinyl chloride	1.9E+00	h				3.0E-01	h			75-01-4	2.1E-02	C	4.8E-02	C	2.2E-02	C	2.0E-02	C	7.0E-04
Warfarin				3.0E-04	i			3.0E-04	r	81-81-2	1.6E+01	N	3.2E+02	N	1.1E+00	N	1.1E+01	N	
m-Xylene				2.0E+00	i			2.0E-01	x	108-38-3	2.1E+02	sat	2.1E+02	sat	7.3E+02	N	1.4E+03	N	1.0E+01
o-Xylene				2.0E+00	i			2.0E-01	x	95-47-6	2.8E+02	sat	2.8E+02	sat	7.3E+02	N	1.4E+03	N	9.0E+00
p-Xylene										106-42-3	3.7E+02	sat	3.7E+02	sat					1.0E+01
Zinc				3.0E-01	i					7440-66-6	2.2E+04	N	1.0E+05	a			1.1E+04	N	6.2E+02
Zinc phosphide				3.0E-04	i					1314-84-7	2.2E+01	N	5.6E+02	N			1.1E+01	N	
Zineb				5.0E-02	i			5.0E-02	r	12122-67-7	2.7E+03	N	5.3E+04	N	1.8E+02	N	1.8E+03	N	

Main Screen

RBCA Tool Kit for Chemical Releases
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1. Project Information

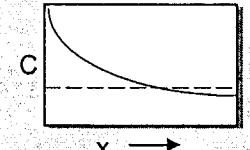
Site Name:	SD-11		
Location:	Cannon AFB		
Compl. By:	S. Volkmer		
Date:	16-Mar-99	Job ID:	45FOM9602V00

2. Which Type of RBCA Analysis?

○ Tier 1

Generic Values
On-Site
Exposure

◉ Tier 2



Site-Specific Values
On- or Off-Site Exposure

3. Calculation Options

Affects which input data are required

- ☐ ***Baseline Risks (Forward mode)***
- ☑ ***RBCA Cleanup Standards (Backward mode)***

4. RBCA Evaluation Process

Prepare Input Data

Data Complete? (■= yes, ■= no)

- ■□ Exposure Pathways
- ■□ Constituents of Concern (COCs)
- ■□ Transport Models
- ■□ Soil Parameters
- GW Parameters
- ■□ Air Parameters

Review Output

- Exposure Flowchart
- COC Chem. Parameters
- Input Data Summary
- User-Spec. COC Data...
- Transient Domenico Analysis...
- Baseline Risks...
- Cleanup Standards...

5. Commands and Options

New Site	Load Data...	Save Data As...	Quit
Print Sheet	Set Units	Custom Chem. Data...	*Help*

Exposure Pathway Identification

Site Name: SD-11
Location: Cannon AFB
Compl. By: S. Volkmer
Job ID: 45FOM9602V00 Date: 16-Mar-99

1. Groundwater Exposure

?

Groundwater Ingestion/ Surface Water Impact

Receptor Type:	None / On-site	None / Off-site1	None / Off-site2

Distance to GW receptors

	0	0	0 (ft)
	On-site	Off-site1	Off-site2
	0	0	0 (ft)

☐ Affected Groundwater

☐ Affected Soils Leaching to Groundwater

Surface Discharge to Surface Water Exposure

☐ Groundwater

☐ Surface Water

☐ Sediment

Enter ALP Criteria

2. Surface Soil Exposure

Direct Ingestion and Dermal Contact

?

Receptor Type:	Com. / On-site	No off-site receptors

Construction Worker ☑

3. Air Exposure

Volatilization and Particulates to Outdoor Air Inhalation

?

Receptor Type:	Com. / On-site	None / Off-site1	None / Off-site2
	0		0 (ft)

Construction worker ☑

☑ Affected Soils--Volatilization to Ambient Outdoor Air

☐ Affected Groundwater--Volatilization to Ambient Outdoor Air

☑ Affected Surface Soils--Particulates to Ambient Outdoor Air

Volatilization to Indoor Air Inhalation

Receptor Type:	None / On-site	No off-site receptors

☐ Affected Soils--Volatilization to Indoor Air

☐ Affected Groundwater--Volatilization to Indoor Air

4. Commands and Options

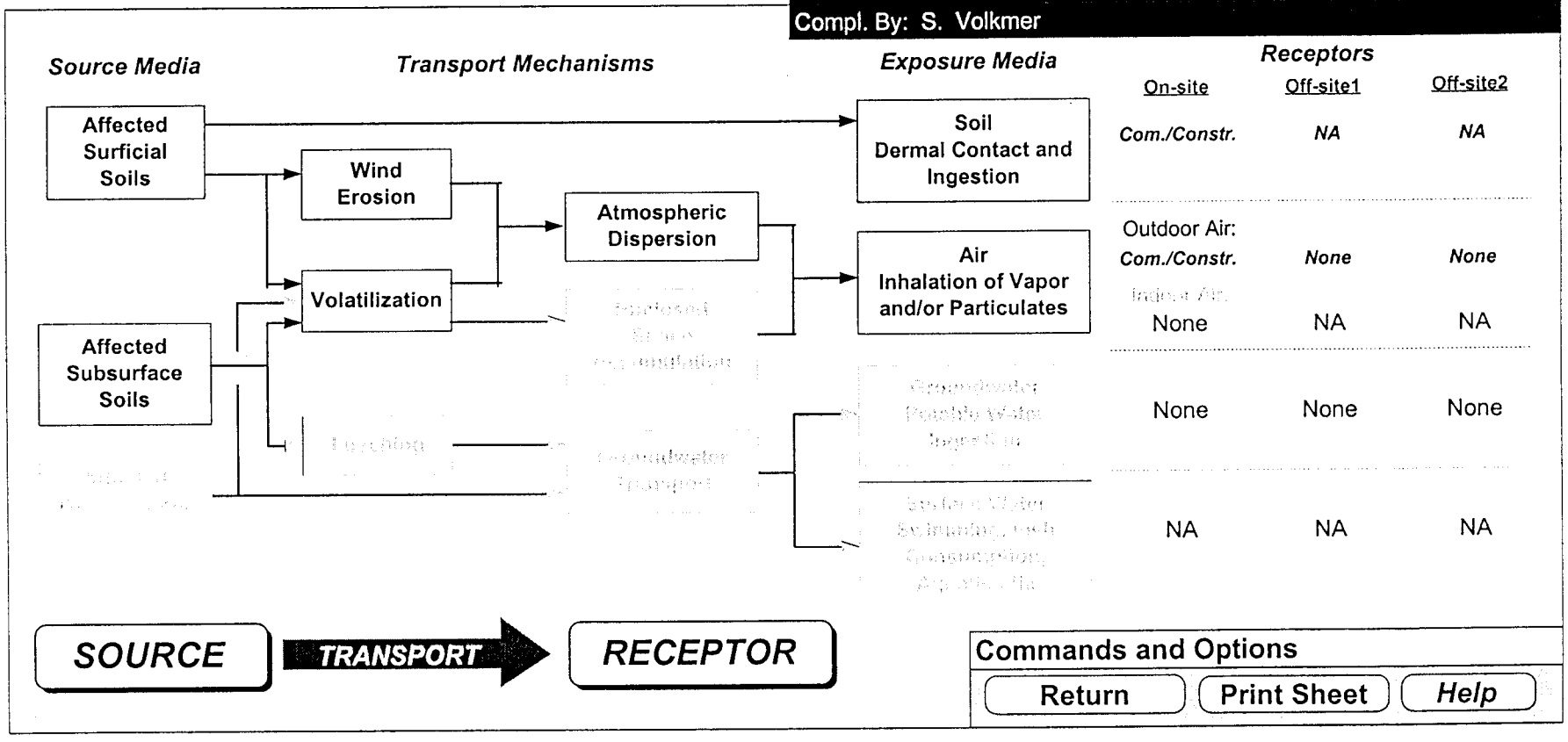
Main Screen | Print Sheet | Set Units | *Help*

■ ☐ Exposure Factors & Target Risks | Exposure Flowchart

Exposure Pathway Flowchart

Site Name: SD-11
Location: Cannon AFB
Compl. By: S. Volkmer

Job ID: 45FOM9602V00
Date: 16-Mar-99



Receptors	On-site	Off-site1	Off-site2
Soil Dermal Contact and Ingestion	Com./Constr.	NA	NA
Air Inhalation of Vapor and/or Particulates: Outdoor Air	Com./Constr.	None	None
Air Inhalation of Vapor and/or Particulates: Indoor Air	None	NA	NA
Groundwater Potable Water Ingestion	None	None	None
Surface Water Swimming, Fish Consumption, Agricultural Use	NA	NA	NA

SOURCE → TRANSPORT → RECEPTOR

Commands and Options

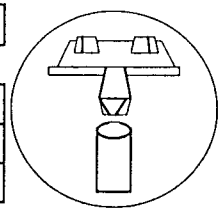
Return | Print Sheet | Help

Exposure Factors and Target Risk Limits

Site Name: SD-11
Location: Cannon AFB
Compl. By: S. Volkmer
Job ID: 45FOM9602V00 Date: 16-Mar-99

1. Exposure Parameters

Age Adjustment?	Residential Adult	Residential (Age 0-6)	Residential (Age 0-16)	Commercial Chronic	Commercial Construc.
Averaging time, carcinogens (yr)	70				
Averaging time, non-carcinogens (yr)	30			25	1
Body weight (kg)	70	15	35	70	
Exposure duration (yr)	30	6	16	25	1
Exposure frequency (days/yr)	350			60	180
Dermal exposure frequency (days/yr)	350			60	
☐ Skin surface area, soil contact (cm^2)	5800		2023	5800	5800
Soil dermal adherence factor ($mg/cm^2/day$)	1				
Water ingestion rate (L/day)	2			1	
☐ Soil ingestion rate (mg/day)	100	200		50	100
Indoor air inhalation rate (m^3/day)	15			20	
Outdoor air inhalation rate (m^3/day)	20			20	10
Swimming exposure time (hr/event)	3				
Swimming event frequency (events/yr)	12	12	12		
☐ Swimming water ingestion rate (L/hr)	0.05	0.5			
☐ Skin surface area, swimming (cm^2)	23000		8100		
Fish consumption rate (kg/day)	0.025				
Contaminated fish fraction (unitless)	1				



2. Risk Goal Calculation Options

- ○ Individual Constitiuent Risk Goals Only
- ○ Cumulative Constituent Risk Goals Only
- ◉ Individual and Cumulative Risk Goals

3. Target Health Risk Limits

	Individual	Cumulative
Target Risk (Class A/B carcins.)	1.0E-6	1.0E-5
Target Risk (Class C carcinogens)	1.0E-5	
Target Hazard Quotient	1.0E+0	
Target Hazard Index		1.0E+0

4. Commands and Options

Return to Exposure Pathways

Use Default Values

Print Sheet

Help

RBCA SITE ASSESSMENT

Site Name: SD-11
Site Location: Cannon AFB

Completed By: S. Vc
Date Completed: 16-M

Exposure Parameters		Residential			Commercial/Industrial	
		Adult	(1-6yrs)	(1-16 yrs)	Chronic	Construc.
AT_c	Averaging time for carcinogens (yr)	70				
AT_n	Averaging time for non-carcinogens (yr)	30			25	1
BW	Body weight (kg)	70	15	35	70	
ED	Exposure duration (yr)	30	6	16	25	1
τ	Averaging time for vapor flux (yr)	30			25	1
EF	Exposure frequency (days/yr)	350			60	180
EF_D	Exposure frequency for dermal exposure	350			60	
IR_w	Ingestion rate of water (L/day)	2			1	
IR_s	Ingestion rate of soil (mg/day)	100	200		50	100
IR_{air-In}	Inhalation rate indoor (m^3/day)	15			20	
$IR_{air-Out}$	Inhalation rate outdoor (m^3/day)	20			20	10
SA	Skin surface area (dermal) (cm^2)	5800		2023	5800	5800
M	Soil to skin adherence factor	1				
ET_{swim}	Swimming exposure time (hr/event)	3				
EV_{swim}	Swimming event frequency (events/yr)	12	12	12		
IR_{swim}	Water ingestion while swimming (L/hr)	0.05	0.5			
SA_{swim}	Skin surface area for swimming (cm^2)	23000		8100		
IR_{fish}	Ingestion rate of fish (kg/yr)	0.025				
FI_{fish}	Contaminated fish fraction (unitless)	1				

Complete Exposure Pathways and Receptors	On-site	Off-site 1	Off-site 2
Groundwater:			
Groundwater Ingestion	None	None	None
Soil Leaching to Groundwater Ingestion	None	None	None
Applicable Surface Water Exposure Routes:			
Swimming			NA
Fish Consumption			NA
Aquatic Life Protection			NA
Soil:			

Direct Ingestion and Dermal Contact	Com./Constr.		
Outdoor Air:			
Particulates from Surface Soils	Com./Constr.	None	None
Volatilization from Soils	Com./Constr.	None	None
Volatilization from Groundwater	None	None	None
Indoor Air:			
Volatilization from Subsurface Soils	None	NA	NA
Volatilization from Groundwater	None	NA	NA

Receptor Distance from Source Media	On-site	Off-site 1	Off-site 2	(Units)
Groundwater receptor	NA	NA	NA	(ft)
Soil leaching to groundwater receptor	NA	NA	NA	(ft)
Outdoor air inhalation receptor	0	NA	NA	(ft)

Target Health Risk Values		Individual	Cumulative
TR_{ab}	Target Risk (class A&B carcinogens)	1.0E-6	1.0E-5
TR_c	Target Risk (class C carcinogens)	1.0E-5	
THQ	Target Hazard Quotient (non-carcinogenic risk)	1.0E+0	1.0E+0

Modeling Options	
RBCA tier	Tier 2
RBCA calculation mode	Backward Only
Risk goal calculation option	Individual & Cumulative Constituent Risks
Soil volatilization model option	Surface & subsurface models
Use soil attenuation model (SAM) for leachate?	NA
Air dilution factor	NA
Groundwater dilution-attenuation factor	NA

NOTE: NA = Not applicable

Input Parameter Summary

olkmer
Mar-99

Job ID: 45FOM9602V00

Surface Parameters		General	Construction	(Units)
A	Source zone area	9.0E+4	9.0E+4	(ft^2)
W	Length of source-zone area parallel to wind	4.5E+2	4.5E+2	(ft)
W_{gw}	Length of source-zone area parallel to GW flow	NA		(ft)
U_{air}	Ambient air velocity in mixing zone	7.4E+0		(ft/s)
δ_{air}	Air mixing zone height	6.6E+0		(ft)
P_a	Areal particulate emission rate	6.9E-14		(g/cm^2/s)
L_{ss}	Thickness of affected surface soils	2.0E+0		(ft)

Surface Soil Column Parameters		Value			(Units)
h_{cap}	Capillary zone thickness	NA			(ft)
h_v	Vadose zone thickness	NA			(ft)
ρ_s	Soil bulk density	1.7E+0			(g/cm^3)
f_{oc}	Fraction organic carbon	1.0E-2			(-)
θ_T	Soil total porosity	4.1E-1			(-)
K_{vs}	Vertical hydraulic conductivity	1.0E+3			(ft/yr)
k_v	Vapor permeability	1.1E-12			(ft^2)
L_{gw}	Depth to groundwater	NA			(ft)
L_s	Depth to top of affected soils	0.0E+0			(ft)
L_{base}	Depth to base of affected soils	5.0E+1			(ft)
L_{subs}	Thickness of affected soils	5.0E+1			(ft)
pH	Soil/groundwater pH	6.8E+0			(-)
		capillary	vadose	foundation	
θ_w	Volumetric water content	0.369	0.12	0.12	(-)
θ_a	Volumetric air content	0.041	0.29	0.26	(-)

Building Parameters		Residential	Commercial	(Units)
L_b	Building volume/area ratio	NA	NA	(ft)
A_b	Foundation area	NA	NA	(cm^2)
X_{crk}	Foundation perimeter	NA	NA	(ft)
ER	Building air exchange rate	NA	NA	(1/s)
L_{crk}	Foundation thickness	NA	NA	(ft)
Z_{crk}	Depth to bottom of foundation slab	NA	NA	(ft)

η	Foundation crack fraction	NA	NA	(-)
dP	Indoor/outdoor differential pressure	NA	NA	(g/cm/s^2)
Q_s	Convective air flow through slab	NA	NA	(ft^3/s)

Groundwater Parameters		Value	(Units)
δ_{gw}	Groundwater mixing zone depth	NA	(ft)
I_f	Net groundwater infiltration rate	NA	(cm/yr)
U_{gw}	Groundwater Darcy velocity	NA	(ft/yr)
V_{gw}	Groundwater seepage velocity	NA	(ft/yr)
K_s	Saturated hydraulic conductivity	NA	(ft/yr)
i	Groundwater gradient	NA	(-)
S_w	Width of groundwater source zone	NA	(ft)
S_d	Depth of groundwater source zone	NA	(ft)
θ_{eff}	Effective porosity in water-bearing unit	NA	(-)
$f_{oc\text{-}sat}$	Fraction organic carbon in water-bearing unit	NA	(-)
pH_{sat}	Groundwater pH	NA	(-)
	Biodegradation considered?	NA	

Transport Parameters		Off-site 1	Off-site 2	Off-site 1	Off-site 2	(Units)
Lateral Groundwater Transport		Groundwater Ingestion		Soil Leaching to GW		
α_x	Longitudinal dispersivity	NA	NA	NA	NA	(ft)
α_y	Transverse dispersivity	NA	NA	NA	NA	(ft)
α_z	Vertical dispersivity	NA	NA	NA	NA	(ft)
Lateral Outdoor Air Transport		Outdoor Air Inhalation				
σ_y	Transverse dispersion coefficient	NA	NA			(ft)
σ_z	Vertical dispersion coefficient	NA	NA			(ft)
ADF	Air dispersion factor	NA	NA			(-)

Surface Water Parameters		Off-site 2	(Units)
Q_{sw}	Surface water flowrate	NA	(ft^3/s)
W_{pi}	Width of GW plume at SW discharge	NA	(ft)
δ_{pi}	Thickness of GW plume at SW discharge	NA	(ft)
DF_{sw}	Groundwater-to-surface water dilution factor	NA	(-)

Transport Modeling Options

Site Name: SD-11
Location: Cannon AFB
Compl. By: S. Volkmer

Job ID: 45FOM9602V00
Date: 16-Mar-99

1. Vertical Transport, Surface Soil Column

Outdoor Air Volatilization Factors ?

- ○ Surface soil volatilization model only
- ◉ Combination surface soil/Johnson & Ettinger models
  - Thickness of surface soil zone [2] *(ft)*
- ○ User-specified VF from other model — Enter VF Values

?

- ○
- ○ — Enter VF Values

?

- ○
- ☐
- ☐ — Enter Decay Rates
- ○ — Enter LF Values

?

- ○
- ○

Off-site 1	Off-site 2	
1.00E+0	1.00E+0	(-)

4. Commands and Options

Main Screen | Print Sheet | *Help*

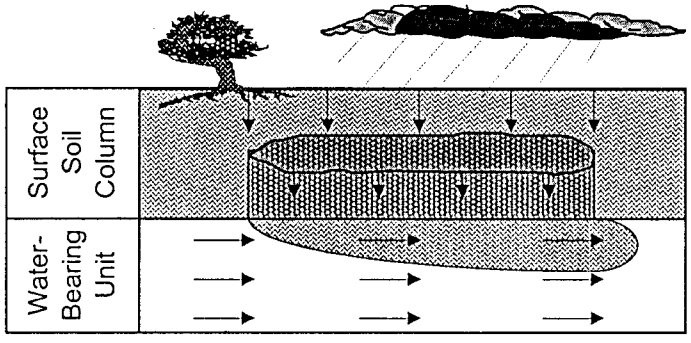
Site-Specific Soil Parameters

Site Name: SD-11 | Job ID: 45FOM9602V00
Location: Cannon AFB | Date: 16-Mar-99
Compl. By: S. Volkmer

1. Soil Source Zone Characteristics

Affected Soil Zone

Depth to top of affected soils	0		(ft)
Depth to base of affected soils	50		(ft)
Affected soil area	90000	90000	(ft)
Length of affected soil parallel to assumed wind direction	450	450	(ft)



2. Surface Soil Column

Vadose Zone | Capillary Fringe

Predominant USCS Soil Type

SM: Silty Sand

or Enter Directly

	Vadose Zone	Capillary Fringe	
Total porosity	0.41		(-)
Volumetric water content	0.12	0.369	(-)
Volumetric air content	0.29	0.041	(-)
Dry bulk density	1.7		(kg/L)
Vertical hydraulic conductivity	1.0E+3		(ft/yr)
Vapor permeability	1.1E-12		(ft^2)
Capillary zone thickness	1.6E-1		(ft)

or NA

Partitioning Parameters

Fraction organic carbon	0.01	(-)
Soil/water pH	6.8	(-)

3. Commands and Options

Main Screen | Use Default Values | Print Sheet
Set Units | Help

CHEMICAL DATA FOR SELECTED COCs

Physical Property Data

Constituent	CAS Number	type	Molecular Weight (g/mole) MW	ref	Diffusion Coefficients in air (cm2/s) Dair	ref	Diffusion Coefficients in water (cm2/s) Dwat	ref	log (Koc) or log(Kd) (@ 20 - 25 C) log(L/kg) partition		ref	Henry's Law Constant (@ 20 - 25 C) (atm-m3) mol	(unitless)	ref	Vapor Pressure (@ 20 - 25 C) (mm Hg)	ref	Solubility (@ 20 - 25 C) (mg/L)	ref	acid pKa	base pKb	ref
Benzo(a)Pyrene	50-32-8	PAH	252.3	PS	4.30E-02	PS	9.00E-06	PS	6.01	Koc	PS	1.13E-06	4.66E-05	PS	5.68E-04	PS	1.62E-03	PS	-	-	-

Site Name: SD-11
Site Location: Cannon AFB

Completed By: S. Volkmer
Date Completed: 16-Mar-99

Job ID: 45FOM9602V00

CHEMICAL DATA FOR SELECTED COCs

Toxicity Data

Constituent	Reference Dose (mg/kg/day) Oral RfD_oral	ref	Reference Dose (mg/kg/day) Dermal RfD_dermal	ref	Reference Conc. (mg/m3) Inhalation RfC_inhal	ref	Slope Factors 1/(mg/kg/day) Oral SF_oral	ref	Slope Factors 1/(mg/kg/day) Dermal SF_dermal	ref	Unit Risk Factor 1/(µg/m3) Inhalation URF_inhal	ref	EPA Weight of Evidence	Is Constituent Carcinogenic ?
Benzo(a)Pyrene	-	-	-	-	1.10E+01	31	7.30E+00	PS	8.20E+00	TX	2.09E-03	PS	B2	TRUE

Site Name: SD-11

Site Location: Cannon AFB

Miscellaneous Chemical Data

Constituent	Maximum Contaminant Level MCL (mg/L)	ref	Time-Weighted Average Workplace Criteria TWA (mg/m3)	ref	Aquatic Life Prot. Criteria AQL (mg/L)	ref	Biocon-centration Factor (L-wat/kg-fish)
Benzo(a)Pyrene	2.00E-04	57 31776 (17 Jul 92)	2.00E-01	PS	-	-	1

Site Name: SD-11

Site Location: Cannon AFB

CHEMICAL DATA FOR SELECTED COCs

Miscellaneous Chemical Data

Constituent	Dermal Relative Absorp. Factor (unitless)	Water Dermal Permeability Data: Dermal Permeability Coeff. (cm/hr)	Lag time for Dermal Exposure (hr)	Critical Exposure Time (hr)	Relative Contr of Derm Perm Coeff (unitless)	Water/Skin Derm Adsorp Factor (cm/event)	ref	Detection Limits: Groundwater (mg/L)	ref	Soil (mg/kg)	ref	Half Life (First-Order Decay) (days): Saturated	Unsaturated	ref
Benzo(a)Pyrene	0.05	-	-	-	-	-	-	0.01	32	0.66	32	1060	1060	H

Site Name: SD-11

Site Location: Cannon AFB

RBCA SITE ASSESSMENT

Site Name: SD-11
Site Location: Cannon AFB

Completed By: S. Volkmer
Date Completed: 16-Mar-99

Job ID: 45FOM9602V00

SOIL (0 - 50 ft) SSTL VALUES

Target Risk (Class A & B) 1.0E-6
Target Risk (Class C) 1.0E-5
Target Hazard Quotient 1.0E+0

Groundwater DAF Option:

SSTL Results For Complete Exposure Pathways ("X" if Complete)

CONSTITUENTS OF CONCERN		Representative Concentration		Soil Leaching to Groundwater Ingestion / Discharge to Surface Water				Soil Vol. to Indoor Air	X	Soil Volatilization and Surface Soil Particulates to Outdoor Air				X	Surface Soil Inhalation, Ingestion,Dermal Contact		Applicable SSTL	SSTL Exceeded ?	Required CRF
				On-site (0 ft)	Off-site 1 (0 ft)	Off-site 2 (0 ft)	On-site (0 ft)	On-site (0 ft)				Off-site 1 (0 ft)	Off-site 2 (0 ft)	On-site (0 ft)					Only if "yes" left
CAS No.	Name		(mg/kg)	None	None	None	None	Commercial		Construction Worker		None	None	Commercial		Construction Worker	(mg/kg)	"■" if yes	
50-32-8	Benzo(a)Pyrene			NA	NA	NA	NA	1.8E+0		>1.7E+1		NA	NA	4.3E-1		3.2E+0	4.3E-1	☐	NA

">" indicates risk-based target concentration greater than constituent residual saturation value. NA = Not applicable. NC = Not calculated.

D.1 INDIRECT (INGESTION PATHWAY) EXPOSURE POINT CONCENTRATIONS

Concentrations of the chemicals of potential ecological concern (COPECs) in dietary items other than soil are not available -- specifically: plants; soil invertebrates; insects; reptiles or amphibians; mammals; and birds. Estimation of the COPEC concentrations within these dietary items are made using a spreadsheet model (sd-11MOD.xls) using the calculations outlined in the following sections. Uptake of organic COPECs into plants from soil is modeled following the fugacity methods presented in Trapp and McFarlane (1995) and Mackay and Paterson (1995). Uptake of organic COPECs into invertebrates, secondary and tertiary consumers are also modeled following fugacity methods (Mackay and Paterson 1981; Clark et al. 1988; Clark et al. 1990; Mackay and Paterson 1991; Thomann et al. 1992; Mackay, et al. 1995a and b; Spacie et al. 1995) as well as guidance obtained from Belfroid et al. (1994) and Belfroid et al. (1995). Estimation of inorganic COPEC concentrations in lower trophic-level organisms within the diet of the receptors of concern are based on literature-derived Biota Concentration Factors (BCFs) for plants, invertebrates, and mammals (Sample et al 1998a and 1998b – mammalian BCFs were used to estimated concentrations in birds and reptiles – see sd-11MOD.xls). Overall guidance for the modeling approach was obtained from Jones et al. (1991), Rand (1995), Newman 1998, and RTI (1995).

D.2 FUGACITY AND FUGACITY CAPACITIES (ORGANIC CHEMICALS)

The fugacity approach enables considerations of both chemical-specific and organism-specific attributes (e.g., Clark et al. 1988). Fugacity (*F*) is regarded as the "escaping tendency" of a chemical from a particular phase (Mackay and Paterson 1981) with units of pressure (pascals, Pa), and can be related to phase concentrations. For any particular environmental phase (e.g., water, soil, air, or biota) there is a corresponding "fugacity capacity" with units of mol/m^3-Pa which is denoted by a Z value. The relationship between fugacity, fugacity capacity and chemical concentration (C) is defined by:

(1) $C = ZF$

Fugacity capacities for a given chemical are calculated (equations 2 through 5) for the phases of interest in order for the exposure point concentration estimation methodology (Mackay and Paterson 1981; Mackay et al. 1995b). The following calculations require chemical-specific parameters and an assumption of the system temperature, 25°C.

(2) $Z_{water} = 1 \div H$

(3) $Z_{soil} = K_d \times \rho_{soil} \div H$

(4) $Z_{air} = 1 \div (R \times T)$

(5) $Z_{biota} = lipid \times K_{ow} \times \rho_{biota} \div H$

where:

H	=	Henry's Constant
K_d	=	soil or sediment partitioning coefficient = fraction organic carbon × K_{oc} (partitioning coefficient between water and organic carbon)
ρ_{soil}	=	bulk density of the soil (g/cm^3)
R	=	Universal Gas Constant (8.31 Joules-m3/mol-°K)
T	=	temperature in degrees Kelvin
lipid	=	fraction of lipid in the organism
K_{ow}	=	octanol to water partitioning coefficient
ρ_{biota}	=	the density of the organism (g/cm^3)

The resultant fugacity capacities (Z values) can be used in concert with phase volumes and transport mechanisms (e.g., advection, biotransformation, photolysis, etc) to calculate chemical flux, distributions, mass balance, and persistence (e.g., Mackay and Paterson 1981, 1991). In the risk assessment application here, Z values are used to estimate partitioning between the phases under steady-state conditions assuming no degradation, biotransformation, and unlimited chemical mass (i.e., concentration-based).

Concentration-based modeling departs from the strict fugacity approach due to the assumption that mass is unlimited. The application here uses the relationship between fugacity capacities and partitioning coefficients (i.e., Biota-Transfer Factors, BTFs or Bioconcentration Factors, BCFs) to predict COPEC concentrations in the diet of the receptors of concern. In order for the relationship between fugacity and partitioning to be functional, in this context, the system is assumed to be at steady-state (Mackay et al. 1995b). This is an implicit assumption for this modeling approach[1].

By definition (Mackay, et al. 1995b), the ratio between Z values of different phases equals the steady-state partitioning coefficient (e.g., the bioconcentration factor; BCF).

For example: $Z_{octanol} \div Z_{water} = K_{ow}$

$Z_{fish} \div Z_{water} = BCF$

This approach allows estimation of the partitioning between abiotic media, biological tissue, and ingested materials.

[1] Unlimited mass assumes that there is sufficient chemical mass to result in steady-state concentrations within all components within the model -- abiotic and biotic. This often results in severe over-estimation as kilograms of chemical can be required to produce the predicted concentrations in secondary and tertiary consumers within an ecosystem.

D.2.1 Terrestrial Plants

A soil concentration does not solely determine the direct exposure concentration considering uptake of organic contaminants into plants (Bacci et al. 1990). For plants there are two pertinent uptake pathways: (1) water taken into the root and transported via the transpiration stream; and (2) uptake from soil-air where soil contaminants have volatilized[2].

A soil pore-water concentration must be estimated to use this approach in terrestrial plants. This was accomplished following the equations of Trapp (1995) given soil moisture, total volumetric porosity, and organic carbon content within soil:

(6) $C_{soil\text{-}water} = C_b \div K_{bw}$

(7) $K_{bw} = \rho_b \times K_d + \theta + (\varepsilon - \theta) \times K_{aw}$

where:

$C_{soil\text{-}water}$	=	the soil water concentration
C_b	=	the bulk soil concentration
K_{bw}	=	the bulk soil-to-soil water partitioning coefficient
K_d	=	the soil-to-water partitioning coefficient ($K_d = K_{oc} \times OC$) (K_{oc} = the organic carbon-to-water partitioning coefficient and OC = the fraction organic carbon in the soil)
ρb	=	soil bulk density (gm/cm3)
θ	=	the volumetric water fraction of the soil
ε	=	the volumetric total porosity of the soil
K_{aw}	=	the air-to-water partitioning coefficient ($Kaw = H \div (R \times T)$)

Given the soil pore-water concentration of the COPEC, the partitioning between the water and plant root is defined by the root water (W_r) lipid content (L_r), and the K_{ow} of the COPEC adjusted by a correction exponent, b, using a default value of 0.75 (Trapp 1995). This is to account for the differences between plant lipid and octanol. Finally, the partitioning is adjusted by the root density compared to water:

(8) $K_{rw} = (W_r + L_r \times K_{ow}{}^b) \times \rho_r \div \rho_w$

[2] Volatilization of chemicals into surface air is not considered in this model. Proper estimations would require wind velocities, consideration of spatial volumes (e.g., 1 foot above the ground), and a more complete characterization of the soil surface (i.e., bare ground, vegetated, littered, etc.) such that estimates are not practical.

Combining these equations 6, 7, and 8 results in a solution for the root concentration based on the soil-water and soil-air uptake routes:

(9) $C_{root} = [(W_r + L_r \times K_{ow}^{b}) \times \rho_r \div \rho_w)] \times [C_b \div (\rho_b \times K_d + \theta + (\varepsilon - \theta) \times K_{aw})]$

Once within the root tissue the contaminant can be transported via the xylem transpiration stream (Trapp 1995). This translocation, represented below as the transpiration stream concentration factor (TSCF) is defined by the K_{ow} and the soil-water concentration (it is not dependent on the root concentration):

(10) $TSCF = 0.784 \times \exp[-(\log K_{ow} - 1.78)^2 \div 2.44]$

and thus the concentration within the xylem is calculated as:

(11) $C_{Xy} = TSCF \times C_{soil\text{-}water}$

The relationship between the concentration in the foliage, fruits, seeds or nuts and the concentration in the xylem is related to the fugacity capacities of the respective phases. The partitioning coefficients are calculated based on the fugacity capacities (Z's):

(12) $Z_{xylem} = TSCF \div H$

(13) $Z_{foliage} = fZ_{air} + fZ_{water} + fZ_{lipid}$

(14) $Z_{fruits} = fZ_{air} + fZ_{water} + fZ_{lipid}$

(15) $Z_{seeds\ or\ nuts} = fZ_{air} + fZ_{water} + fZ_{lipid}$

The fugacity capacities of the different plant parts are weighted by the fractions of its constituents: air, water, and lipids (i.e., *f*'s of 18, 80, and 2% respectively for foliage). The partitioning between these plant parts and xylem is then:

(16) $C_{plant\ part} = (Z_{plant\ part} \div Z_{xylem}) \times C_{xylem}$

D.2.2 Terrestrial Invertebrates and Insects

Invertebrate detritivores dwelling within the soil are exposed to both soil-water and via the ingestion of soil (Belfroid, et al. 1994). Insects, in the context of the model presented, are exposed primarily via the ingestion of plant material and other insects. Given the chitinous exoskeleton, uptake from soil-water is considered insignificant for most insects (Crommentaijn et al. 1994). Development of bioconcentration factors for these organisms is based on their fugacity capacities and those of the respective media to which they are exposed.

The concentration in invertebrates is calculated as a combination of uptake from soil pore-water and ingested soil across the gastrointestinal tract:

(17) $C_{invertebrate} = [C_b \times (Z_{invertebrate} \div Z_{soil})] + [C_{soil\ water} \times (Z_{invertebrate} \div Z_{soil\ water})]$

Z values are calculated as specified in equations 2, 3, and 5. For insects only exposure to soil via ingestion of plants or other insects are considered; therefore:

(18) $C_{herbivorous\ insects} = C_{plant\ foliage} \times (Z_{insect} \div Z_{foliage})$

(19) $C_{carnivorous\ insects} = C_{herbivorous\ insect} \times (Z_{insect} \div Z_{herbivorous\ insects})$

D.3 EXPOSURE POINT CONCENTRATIONS (INORGANIC CHEMICALS)

BCF values for individual inorganic COPEC in soil are used to estimate the concentration in dietary items (plants, worms, insects, and small herbivorous vertebrates). There is little evidence for inorganics regarding "biomagnification," i.e., the process by which progressively higher concentrations are associated with higher trophic levels (USACE 1995, Laskowski, 1991) and the model presented herein assumes that biomagnification of inorganics does not occur. Thus, for dietary items associated with soil their respective concentrations are estimated as follows:

(20) $C_{dietary\ item} = BCF_{dietary\ item} \times C_{soil}$

The specific inorganic BCFs are listed within the file sd-11MOD.xls.

D.4 SECONDARY AND TERTIARY CONSUMER EXPOSURE POINT CONCENTRATIONS

Modeling of organic COPEC concentrations in the secondary and tertiary consumers begins with the calculation of total ingested mass of COPEC based on ingestion rates and COPEC concentrations within the ingested materials.

(21) $M_{abiotic} = (C_{soil} \times IR_{soil}) + (C_{water} \times IR_{water})$

(22) $M_{biotic} = (C_{dietary\ item\ 1} \times IR \times P_{dietary\ item\ 1}) + (C_{dietary\ item\ 2} \times IR \times P_{dietary\ item\ 2}) + (C_{dietary\ item\ n} \times IR \times P_{dietary\ item\ n})$

(23) $M_{total} = M_{abiotic} + M_{biotic}$

where:

$M_{abiotic}$ = mass of COPEC ingested from abiotic items (soil, sediment and water)
M_{biotic} = mass of COPEC ingested from biological tissues
M_{total} = total mass of COPEC ingested
$C_{dietary\ item\ i}$ = COPEC concentration in dietary item
IR = food ingestion rate
$P_{dietary\ item\ i}$ = percentage of diet comprised by dietary item

The COPEC concentration within the diet or more specifically within the gastrointestinal tract (GIT) of the animal is calculated as:

(24) $C_{diet} = M_{total} \div$ [Water Consumed (kg/day) + Soil Consumed (kg/day) + Food Consumed (kg/day)]

Partitioning between the gut contents of an organism and the organism itself can be estimated via fugacity considering organic COPECs. The fugacity capacity of the receptor (Z_{biota}) is calculated based on the percent lipid in the animal, the K_{ow} of the COPEC, the density of the animal, assumed to be 1, and the COPEC Henry's constant using equation 5. The Z_{diet} is calculated by weighting the individual Z values for each component by its percentage (*f*) of the total material ingested (food + water + soil or sediment). Thus for the terrestrial foodweb:

(25) $Z_{diet} = [(f_{soil\ in\ diet}) \times Z_{soil}] + [(f_{water\ in\ diet}) \times Z_{water}] + [(f_{plants\ in\ diet}) \times Z_{plants}] + [(f_{insects\ in\ diet}) \times Z_{insects}] + [(f_{soil\ invertebrates\ in\ diet}) \times Z_{soil\ invertebrates}] + [(f_{small\ mammals\ in\ diet}) \times Z_{small\ mammals}] + [(f_{birds\ in\ diet}) \times Z_{birds}]$

As previously stated, the ratio of Z values between environmental phases is equal to the partitioning coefficient, thus:

(26) $C_{animal} = C_{diet} \times (Z_{animal} \div Z_{diet})$

The resultant concentrations are then used within the model as dietary concentrations for other organisms that may prey upon the ecological receptors within the foodweb. The spreadsheet model developed for Site SD-11 within Cannon AFB (Curry County, New Mexico) is included for review. A sample output of the model is also provided as a PDF viewable file.

D.5 REFERENCES

Bacci, E., D. Calamari, C. Gaggi, and M. Vighi. 1990. Bioconcentration of organic chemical vapors in plant leaves: Experimental measurements and correlation. Environ. Sci. Technol., 24(6): 885-889.

Belfroid, A., M. Sikkenk, W. Seinen, K.V. Gestel, J. Hermens. 1994. The toxicokinetic behavior of chlorobenzenes in earthworm (*Eisenia andrei*) experiments in soil. Environ. Toxicol. Chem., 13(1): 93-99.

Belfroid, A., M. Van den Berg, W. Seinen, J. Hermens, and K.V. Gestel. 1995. Uptake, bioavailability and elimination of hydrophobic compounds in earthworms (*Eisenia andrei*) in field-contaminated soil. Environ. Toxicol. Chem., 14(4): 605-612.

Clark, T., K. Clark, S. Paterson, D. Mackay, R.J. Norstrom. 1988. Wildlife monitoring, modeling, and fugacity. Environ. Sci. Technol., 22(2): 20.

Clark, K.E., F.A.P.C. Gobas, and D. Mackay. 1990. Model of organic chemical uptake and clearance by fish from and water. Environ. Sci. Technol. 24:1203-1213.

Cobb, G.P., E.H. Hol, P.W. Allen, J.A. Gagne, and R.J. Kendall. 1995. Uptake, metabolism and toxicity of terbufos in the earthworm (*Lumbricus terrestris*) exposed to COUNTER®-15G in artificial soils. Environ. Toxicol. Chem. 14(2): 279-285.

Crommentuijn, T., C.J.A.M. Doodeman, A. Doorekamp, J.J.C. van der Pol, J.J.M. Bedaux, and C.A.M. van Gestle. 1994. Lethal body concentrations and accumulation patterns determine time-dependent toxicity of cadmium in soil arthropods. Environ. Toxicol. Chem. 13:1781-1789.

Gobas, F.A.P.C., J.R. McCorquodale, and G.D. Haffner. 1993. Intestinal absorption and biomagnification of organochlorines. Environ. Toxicol. Chem. 12:567-576.

Jones, K.C., T. Keating, P. Diage, and A.C. Chang. 1991. Transport and food chain modeling and its role in assessing human exposure to organic chemicals. J. Environ. Qual. 20(2): 317-329.

Laskowski, R. 1991. Are top carnivores endangered by heavy metal biomagnification? OIKOS 60:387-390.

Mackay, D., and S. Paterson. 1981. Calculating fugacity. Environ. Sci. Technol., 15(9): 1006-1014.

Mackay, D., and S. Paterson. 1991. Evaluating the multimedia fate of organic chemicals: A level III fugacity model. Environ. Sci. Technol., 25(3): 427-436.

Mackay, D., and S. Paterson. 1995 Interpreting chemical partitioning in soil-plant-air systems with a fugacity model. Chapter 7. In *Plant Contamination Modeling and Simulation of Organic Chemical Processes.* S. Trapp & J. McFarlane, Eds. Lewis Publishers, Boca Raton, Florida. pp. 191-214.

Mackay, D., L.A. Burns, and G.M. Rand. 1995. Fate Modeling. Chapter 18. In *Fundamentals of Aquatic Toxicology.* G. Rand, Ed. Taylor & Francis Publishers, Washington, D.C. pp. 563-588.

Newman, M.C. 1998. *Fundamentals of Ecotoxicology.* Sleeping Bear Press, Chelsa, MI.

Rand. G.M. 1995 *Fundamentals of Aquatic Toxicology.* Taylor & Francis Publishers, Washington, D.C. 1125p.

RTI. 1995. *Supplemental Technical Support Document for the Hazardous Waste Rule: Risk Assessment for Human and Ecological Receptors.* Research Triangle Institute, Center for Environmental Analysis. EPA Contract Number 68-W3-0028. November, 1995.

Sample, B.E., J.J. Beauchamp, R.A. Efroymson, G.W. Suter, II., and T.L. Ashwood 1998a. *Development and Validation of Bioaccumulation Models for Earthworms.* Oak Ridge National Laboratory, Oak Ridge, Tennessee. ES/ER/TM-220.

Sample, B.E., J.J. Beauchamp, R.A. Efroymson, and G.W. Suter, II. 1998b. *Development and Validation of Bioaccumulation Models for Small Mammals.* Oak Ridge National Laboratory, Oak Ridge, Tennessee. ES/ER/TM-219.

Spacie, A., L.S. McCarty, and G.M. Rand. 1995. Bioaccumulation and bioavailability in multiphase systems. Chapter 16. In *Fundamentals of Aquatic Toxicology.* G. Rand, Ed. Taylor & Francis Publishers, Washington, D.C. pp. 493-521.

Suter, G.W., II. (editor) 1993. *Ecological Risk Assessment.* Lewis Publishers, Boca Raton, Florida.

Suter, G.W., II. 1995. Introduction to Ecological Risk Assessment for Aquatic Toxic Effects. Pages 803-816 (Chapter 28) in G. Rand (editor). *Aquatic Toxicology, Effects, Environmental Fate, and Risk Assessment.* Second Edition. Taylor & Francis, Bristol, Pennsylvania.

Thomann, R.V., J.P. Connolly, and T.F. Parkerton. 1992. An equilibrium model of organic chemical accumulation in aquatic food webs with sediment interaction. Environ. Toxicol. Chem. 11: 615-629.

Trapp, S. 1995. Model for uptake of xenobiotics into plants. Chapter 5. In *Plant Contamination Modeling and Simulation of Organic Chemical Processes.* S. Trapp & J. McFarlane, Eds. Lewis Publishers, Boca Raton, Florida. pp. 107-151.

Trapp, S., and J.C. McFarlane (editors). 1995. *Plant Contamination Modeling and Simulation of Organic Chemical Processes.* Lewis Publishers, Boca Raton, Florida.

United States Army Corps of Engineers (USACE). 1995. Trophic transfer and biomagnification potential of contaminants in aquatic ecosystems. Environmental Effects of Dredging: Technical Notes. EEDP-01-33. Waterways Experiment Station, Vicksburg, MS.

United States Environmental Protection Agency (USEPA) 1993. Wildlife Exposure Factors Handbook. Volumes I and II. EPA/630/R-92/001.

United States Environmental Protection Agency (USEPA) 1995. Final Water Quality Guidance for the Great Lakes System. Federal Register, Volume 60, Number 56, pp. 66344-66469.

TABLE D-1

ORGANIC CHEMICAL PARAMETERS USED IN SELECTION OF POTENTIAL ECOLOGICAL CONCERN IN SOIL AT SITE SD-11 CANNON AIR FORCE BASE, NEW MEXICO

	CAS Number	Koc	Kow	Henry's Constant	Plant BCF	Earth-worm BCF	Mammal BAF
Alkanes							
bis (2-Chloroethoxy) methane	111911	61	5.6	1.70E-07	NA	0.046	0.008
Bromochloromethane	74975	139	26	1.50E-03	NA	0.092	0.015
Bromodichloromethane	75274	120	130	3.20E-03	2.4	0.542	0.031
Bromoform	75252	200	220	6.10E-04	1.7	0.550	0.039
Bromomethane (Methyl Bromide)	74839	15	15	1.40E-02	7.9	0.500	0.012
Carbon Tetrachloride	56235	480	540	2.90E-02	1	0.563	0.059
Chloroform (Trichloromethane)	67663	77	83	4.00E-03	3	0.539	0.025
Chloromethane (Methyl Chloride)	74873	7.8	8.1	4.50E-02	12	0.519	0.009
Dibromochloromethane	124481	468	123	8.50E-04	NA	0.131	0.030
Dichlorodifluoromethane	75718	130	140	2.60E+00	2.2	0.538	0.032
Methylene chloride (Dichloromethane)	75092	17	18	2.40E-03	7.3	0.529	0.013
Trichlorofloromethane	75694	457	269	1.38E-01	1.3	0.294	0.043
Halogenated Ethanes							
1,1,2,2-Tetrachloroethane	79345	220	250	3.70E-04	1.6	0.568	0.042
1, 1, 1-Trichloroethane	71556	270	300	1.90E-02	1.4	0.556	0.045
1,1,2-Trichloroethane	79005	100	110	1.00E-03	2.5	0.550	0.029
1, 1-Dichloroethane	75434	58	130	5.80E-03	3.6	1.121	0.031
1,2-Dichloroethane	107062	28	30	1.30E-03	5.5	0.536	0.016
Chloroethane	75003	143	27	8.48E-03	NA	0.094	0.015
Hexachloroethane	67721	6918	40738	-1.2E+00		2.944	0.409
Halogenated Propanes							
1,2-Dichloropropane	78875	86	93	2.80E-03	2.8	0.541	0.027
Halogenated Alkenes							
1,1-Dichloroethene	75354	120	130	2.50E-02	2.3	0.542	0.031
cis-1,2-Dichloroethylene	156592	67	72	4.50E-03	3.3	0.537	0.024
cis-1,3-Dichloropropene	10060115	93	100	2.00E-03			0.028
Tetrachloroethene	127184	420	470	1.70E-02	1.1	0.560	0.055
trans-1,2-Dichloroethylene	156605	110	120	5.60E-03	3.3	0.545	0.030
trans-1,3-Dichloropropene	10061026	93	100	1.60E-03	3.3	0.538	0.028
Trichloroethylene	79016	460	510	1.10E-02	1.1	0.554	0.057
Vinyl chloride	75014	30	32	8.40E-02	5.3	0.533	0.017
Amines							
2-Nitroaniline	88744	79	71	1.00E-07	NA	0.448	0.024
3,3'-Dichlorobenzidine	91941	2800	480	2.10E-08	0.36	0.086	0.056
3-Nitroaniline	99092	87	23	7.20E-09	NA	0.135	0.014
4-Chloroaniline	106478	66.0	71	1.10E-04	3.3	0.538	0.024
4-Nitroaniline	100016	53.7	25	7.20E-10	NA	0.229	0.015
Aniline (Phenylamine, Aminobenzene)	62533	68	8	2.01E-06	11	0.061	0.009
Benzidine	92875	43	46	3.90E-11	11	0.535	0.019
n-Nitrosodi-n-propylamine (DNP)	621647	131	23	1.40E-06	6	0.087	0.014
N-Nitrosodiphenylamine	86306	1300	1400	7.00E-04	0.38	0.538	0.090

TABLE D-1

ORGANIC CHEMICAL PARAMETERS USED IN SELECTION OF POTENTIAL ECOLOGICAL CONCERN IN SOIL AT SITE SD-11 CANNON AIR FORCE BASE, NEW MEXICO

	CAS Number	Koc	Kow	Henry's Constant	Plant BCF	Earth-worm BCF	Mammal BAF
Benzene and Derivatives							
Benzene	71432	120	130	5.50E-03	2.3	0.542	0.031
Substituted Benzenes							
1,2-Dichlorobenzene	95501	2400	2700	2.10E-03	0.4	0.563	0.121
1,2,4-Trichlorobenzene	120821	3981	10471	1.53E-03	0.19	1.315	0.222
1,3-Dichlorobenzene	54173	1905	3715	2.92E-03	NA	0.975	0.140
1,4-Dichlorobenzene	106467	2300	2600	2.80E-03	0.41	0.565	0.119
Chlorobenzene	108907	650	720	4.40E-03	0.86	0.554	0.067
Hexachlorobenzene	118741	620000	780000	7.50E-04	0.015	0.629	1.539
Methylated Benzenes							
m & p-Xylene (dimethylbenzenes)	08383,p=106	1300	1500	6.00E-03	0.57	0.577	0.093
o-Xylene (dimethylbenzene)	95476	1300	1500	6.00E-03	0.57	0.577	0.093
Toluene	108883	510	560	6.10E-03	1	0.549	0.060
Other Substituted Benzenes							
Ethylbenzene	100414	1200	1400	7.70E-03	0.59	0.583	0.090
Nitrobenzene	98953	64.0	69	2.10E-05	3.3	0.539	0.023
Styrene (vinylbenzene)	100425	780	870	3.30E-03	0.77	0.558	0.073
Arenes							
2,4-Dinitrotoluene	121142	95.0	100	1.50E-07	2.7	0.526	0.028
2,6-Dinitrotoluene	606202	69.0	74	1.30E-07	3.2	0.536	0.024
Chlorinated Dienes							
Hexachlorobutadiene	87683	54000	65000	2.40E-02	0.064	0.602	0.505
Hexachlorocyclopentadiene	77474	200000	250000	1.70E-02	0.03	0.625	0.924
Ethers							
4-Bromophenyl phenyl ether	101553	17000	174985	1.17E-04	NA	5.147	0.787
4-Chlorophenylphenyl ether	7005723	3950	12023	8.40E-04	NA	1.522	0.237
bis (2-Chloroethyl) ether	111444	15	16	2.10E-05	7.7	0.533	0.012
bis (2-Chloroisopropyl) ether	39638329	340	380	1.00E-04	1.2	0.559	0.050
Phenols and Substituted Phenols							
Phenol	108952	29	30	6.00E-07			0.016
2,4,5-Trichlorophenol	95954	6800	7900	4.40E-06	0.22	0.581	0.196
2,4,6-Trichlorophenol	88062	4300	5000	4.10E-06	0.28	0.581	0.160
2,4-Dichlorophenol	120832	1100	1200	2.40E-07	0.64	0.545	0.084
2,4-Dimethylphenol	105679	210	230	3.30E-06	1.7	0.548	0.040
2,4-Dinitrophenol	51285	33.0	35	4.80E-09	4.9	0.530	0.017
2-Chlorophenol	95578	130	140	1.70E-05	2.2	0.538	0.032
2-Methylphenol (o-cresol)	95487	90.0	98	1.60E-06	2.7	0.544	0.027
2-Nitrophenol	88755	224	62	3.50E-06	NA	0.138	0.022
2-Methyl-4,6-dinitrophenol	534521	590	366	4.80E-11	NA	0.311	0.049
4-Chloro-3-methylphenol	59507	50.0	1259	6.70E-07	NA	12.589	0.086
4-Methylphenol (p-cresol)	106445	86.0	93	8.80E-07	2.85	0.541	0.027
4-Nitrophenol	100027	21.0	81	9.78E-08	NA	1.935	0.025
Pentachlorophenol	87865	100000	120000	1.40E-05	0.044	0.600	0.664

TABLE D-1

ORGANIC CHEMICAL PARAMETERS USED IN SELECTION OF POTENTIAL ECOLOGICAL CONCERN IN SOIL AT SITE SD-11 CANNON AIR FORCE BASE, NEW MEXICO

	CAS Number	Koc	Kow	Henry's Constant	Plant BCF	Earth-worm BCF	Mammal BAF
Ketones							
2-Hexanone	591786	123.03	23.99	1.13E-04		0.097	0.015
Acetone	67641	0.58	0.58	2.90E-05		0.500	0.003
Isophorone	78591	47.0	50	6.20E-06	4	0.532	0.020
Methyl Ethyl Ketone (2-Butanone)	78933	1.9	1.9	3.60E-05		0.500	0.005
4-Methyl-2-pentanone (MIBK)	108101	104.7	17.78	5.35E-05		0.085	0.013
Polynuclear Aromatic Hydrocarbons (PAHs)							
Low Molecular Weight PAHs							
2-Chlornaphthalene	91587	3388	10715	5.96E-05	NA	1.581	0.225
2-Methylnaphthalene	91576	8500	7244	2.60E-04	NA	0.426	0.189
Acenaphthene	83329	7100	8300	1.10E-04	0.21	0.585	0.200
Acenaphthylene	208968	3250	11749	1.13E-05	NA	1.808	0.234
Anthracene	120127	26000	28184	5.75E-04	NA	0.542	0.347
Carbazole	86758	1778	3311	7.91E-05		0.931	0.133
Dibenzofuran	132649	6350	13183	9.73E-05	NA	1.038	0.247
Fluorene	86737	14000	16000	7.30E-05	0.14	0.571	0.269
Naphthalene	91203	2000	2300	4.80E-04	0.44	0.575	0.113
Phenanthrene	85018	85018	22909	37154	NA	0.135	0.316
High Molecular Weight PAHs							
Benzo (a) anthracene	56553	400000	500000	3.60E-06	0.02	0.625	1.260
Benzo (a) pyrene	50328	1000000	1300000	8.40E-07	0.011	0.650	1.935
Benzo (b) fluoranthene	205992	1200000	1600000	2.90E-05	0.02	0.667	2.124
Benzo (g,h,i) perylene	191242	400000	3801893.96	1.60E-06	NA	4.752	3.132
Benzo (k) fluoranthene	207089	1000000	6918310	5.59E-08	NA	3.459	4.097
Chrysene	218019	400000	500000	1.20E-06	0.02	0.625	1.260
Dibenz (a,h) anthracene	53703	3800000	4900000	1.10E-08	0.0053	0.645	3.509
Fluoranthene	206440	110000	130000	9.30E-06	0.043	0.591	0.689
Indeno (1,2,3-cd) pyrene	193395	3400000	4540000	2.40E-06	0.0056	0.668	3.391
Pyrene	129000	110000	130000	8.30E-06	0.043	0.591	0.689
Phthalates							
Butylbenzylphthalate	85687	57000	60000	1.90E-06	0.062	0.526	0.487
bis (2-Ethylhexyl) phthalate	117817	1.5E+07	2.0E+07	8.30E-06	0.0023	0.667	6.596
Di-n-butylphthalate	84742	34000	41000	1.40E-06	0.084	0.603	0.410
Di-n-octylphthalate	117840	8.7E+07	1.1E+08	5.70E-05	0.00085	0.632	14.171
Diethylphthalate	84662	290	320	5.50E-07	1.4	0.552	0.047
Dimethylphthalate	131113	35.0	37	5.80E-07	4.8	0.529	0.018
Hydrocarbons as DRO	NA	2000	2300	4.80E-04	0.44	0.575	0.113
Hydrocarbons as GRO	NA	2000	2300	4.80E-04	0.44	0.575	0.113
Miscellaneous Solvents							
Carbon Disulfide	75150	93.3254301	100	1.22E-02	0.44	0.536	0.028
Benzyl alcohol	100516	12	13	3.90E-07	8.8	0.542	0.011

To evaluate the potential for contaminants in the vadose, or unsaturated, zone to be transported to underlying groundwater at Site SD-11, two models were used: Hydrologic Evaluation of Landfill Performance (HELP) and Multimedia Exposure Assessment Model (MULTIMED). The HELP model, Version 3.01 was used to estimate a net infiltration rate at the bottom of the contaminated soil zone for input into MULTIMED. MULTIMED, Version 2.00, was then used to model contaminant migration from the contaminated soil zone through the vadose zone to the water table. This appendix provides documentation for each model, as applicable for modeling completed at Site SD-11, as well as model output.

E.1 DOCUMENTATION

The information provided below has been taken primarily from Schroeder et al. 1994 for the HELP model and Salhotra et al. 1995 for MULTIMED.

E.1.1 HELP Model

The HELP model is a quasi-two-dimensional, deterministic, water-routing model for determining water balances (Schroeder et al. 1994). The general water balance equation is:

$$PERC = P - RO - \Delta ST - ET$$

Where:

PERC = Percolation (inches)
P = Precipitation (inches)
RO = Surface runoff (inches)
Δ ST = Change in soil moisture storage (inches)
ET = Evapotranspiration (inches)

The HELP model was developed to help hazardous waste landfill designers and regulators evaluate the hydrologic performance of proposed landfill designs. The model accepts weather, soil and design data and uses solution techniques that account for the effects of surface storage, snowmelt, runoff, infiltration, evapotranspiration, vegetative growth, soil moisture storage, lateral subsurface drainage, leachate recirculation, unsaturated vertical drainage, and leakage through soil, geomembrane or composite liners. Landfill systems including various combinations of vegetation, cover soils, waste cells, lateral drain layers, low permeability barrier soils, and synthetic geomembrane liners may be modeled. Results are expressed as daily, monthly, annual and long-term average water budgets (Schroeder et al. 1994).

The HELP model requires daily climatologic data, soil characteristics, and design specifications to perform the analysis. Daily rainfall data may be input by the user, generated stochastically, or taken from the model's historical database. The model contains parameters for generating synthetic precipitation for 139 U.S. cities. The historical database contains five years of daily precipitation data for 102 U.S. cities. Daily temperature and solar radiation data are generated

stochastically or may be input by the user. Necessary soil data include porosity, field capacity, wilting point, saturated hydraulic conductivity, and Soil Conservation Service (SCS) runoff curve number for antecedent moisture condition II. The model contains default soil characteristics for 42 material types for use when measurements or site-specific estimates are not available (Schroeder et al. 1994).

Figure D-1 is a definition sketch for a somewhat typical closed hazardous waste landfill profile. The layers in the landfill are typed by the hydraulic function that they perform. Four types are of layers are available: vertical percolation layers, lateral drainage layers, barrier soil liners and geomembrane liners. The topsoil and waste layers are generally vertical percolation layers. Sand layers above liners are typically lateral drainage layers; compacted clay layers are typically barrier soil liners. Geomembranes are typed as geomembrane liners. Composite liners are modeled as two layers. Geotextiles are not considered as layers unless they perform a unique hydraulic function (Schroeder et al. 1994).

In a vertical percolation layer (e.g., layers 1 and 5 in Figure D-1), flow is either downward due to gravity drainage or extracted by evapotranspiration. Unsaturated vertical drainage is assumed to occur by gravity drainage whenever the soil moisture is greater than the field capacity (greater than the wilting point for soils in the evaporative zone) or when the soil suction of the layer below the vertical percolation layer is greater than the soil suction in the vertical percolation layer. The rate of gravity drainage (percolation) in a vertical percolation layer is assumed to be a function of the soil moisture storage and largely independent of conditions in adjacent layers. The rate can be restricted when the layer below is saturated and drains slower than the vertical percolation layer (Schroeder et al. 1994).

More detailed information on the HELP model, including data generation, default values, methods of solution, and assumptions/limitations, can be found in Schroeder et al. 1994.

E.1.2 MULTIMED Model

MULTIMED uses analytical, semi-analytical, and numerical solution techniques to solve the mathematical equations describing flow and transport. The model consists of modules that estimate contaminant releases to air, soil, groundwater, and surface water from a waste disposal facility or contaminated soils. Modules include the landfill, unsaturated zone flow, unsaturated zone transport, saturated zone transport, surface water, air emissions, air dispersion, and statistical analysis (i.e., Monte Carlo) modules. Releases to air are estimated independently of releases to the subsurface or surface water. The program uses a pre-processor (PREMED) for input and a post-processor (POSTMED) for output (Salhotra et al. 1995, Sharp-Hansen et al. 1995).

Figure D-2 presents a schematic of waste facility and leachate migration as simulated by MULTIMED. For simulation of leachate flux, the steady-state infiltration rate can be either input directly or estimated using the landfill module. The landfill module is one-dimensional and steady-state, and simulates the effect of precipitation, runoff, infiltration, evapotranspiration, barrier layers, and lateral drainage. A one-dimensional, semi-analytical module simulates flow

in the unsaturated zone. The output from this module, degree of water saturation versus depth, is used as input to the unsaturated zone transport module. This module simulates transient, one-dimensional (vertical) transport in the unsaturated zone, including longitudinal (vertical direction) dispersion, linear or non-linear adsorption, and first-order decay. Steady-state or time series concentrations at the water table estimated by this module are used to couple the unsaturated zone transport module with the steady-state or transient, semi-analytical saturated zone module. The saturated zone module includes one-dimensional uniform flow, three-dimensional dispersion, linear adsorption, first-order decay, and dilution due to direct infiltration into the groundwater plume. The surface water module simulates contamination of a surface stream due to complete interception of a steady-state saturated zone plume. Air emissions and atmospheric dispersion modules simulate the movements of contaminants into the atmosphere. The uncertainty of input parameters can be quantified using built-in Monte Carlo uncertainty analysis (Salhotra et al. 1995).

Version 2.0 of MULTIMED includes a numerical unsaturated zone transport option, which was not included in Version 1.0, to allow the user to simulate (1) non-linear adsorption, (2) initial contamination conditions, (3) time-varying infiltration rates, and (4) volatilization of chemicals in the unsaturated zone. The numerical unsaturated zone transport model in MULTIMED Version 2.0 is based on the VADOFT code (Salhotra et al. 1995). These four model enhancements are briefly summarized as follows (Salhotra et al. 1995):

(1) Non-linear Adsorption. The numerical model allows the user to simulate chemicals, such as metals, which have a non-linear relationship between the dissolved and adsorbed phase concentration. Two non-linear adsorption models are considered: the Freundlich adsorption isotherm and an empirical adsorption model defined by the user. The dissolved and adsorbed phases are considered to be in equilibrium in both the linear or non-linear adsorption models.

(2) Initial Contamination Conditions. The numerical model allows for simulation of the transport of chemicals that have already migrated out of the waste source and are present as soil contamination in the unsaturated zone. For example, the user can directly enter the profile of soil chemical concentrations versus depth, eliminating the need to simulate pre-existing contamination as a waste source.

(3) Time-Varying Infiltration Rates. The numerical model allows for simulation of the leaching of chemicals from a waste source whose water infiltration rates vary with time, allowing the user to simulate the effects of changes in waste management alternatives, such as caps, on chemical migration. The user may enter an arbitrary time series of infiltration rates, on an annual basis, that allows infiltration to increase or decrease for different time periods.

(4) Volatilization of Chemicals from the Unsaturated Zone. The numerical model allows for simulation of the vertical transport of chemicals in the unsaturated zone by both infiltration within the water phase and diffusion within the vapor phase. The leaching

and volatilization processes are simulated simultaneously such that the air and ground water pathways can compete for the chemical; a mass balance is maintained between the initial chemical mass and the chemical mass ultimately released to the air or ground water.

The four enhancements to MULTIMED have been verified through testing and have found to be correctly implemented in the unsaturated zone transport module. Recommendations for improving Version 2.0, which is currently in beta (i.e., test) form, include revision of the convolution integral scheme to avoid spurious saturated zone results when the initial mass-in-place and variable infiltration rate options are invoked (Tetra Tech/GeoTrans 1995).

Because MULTIMED relies on primarily analytical solutions, the complexity of the systems that can be represented by the model is limited. The MULTIMED model does not account for site-specific spatial variability, shape of the land disposal facility, site-specific boundary conditions, multiple aquifers, or pumping wells. Also, MULTIMED cannot simulate multi-phase flow, fracture flow, or chemical reactions between contaminants. Site-specific use of MULTIMED requires the assumption of spatially uniform, or homogeneous, hydrogeologic properties. For complex systems, it may be more appropriate to use MULTIMED as a "screening level" model to gain a better understanding of the system. A numerical model could then be applied if it is needed and if there are sufficient data for its use (Salhotra et al. 1995, Sharp-Hansen et al. 1995).

More detailed information on the MULTIMED model, including governing equations, boundary and initial conditions, and limitations associated with the unsaturated zone flow, unsaturated zone transport, and saturated zone transport modules, can be found in Salhotra et al. 1995. Information on model application and input parameter selection can be found in Sharp-Hansen et al. 1995.

E.2 OUTPUT

Output generated by HELP and MULTIMED for vadose zone contaminant fate and transport modeling at Site SD-11 are provided, respectively, in Attachments D-1 and D-2. Attachment D-1 includes a graph of annual percolation through the bottom of the contaminated soil zone for each year of simulation in addition to summary output generated by HELP. Attachment D-2 includes a summary table of output for each model run in addition to output generated by MULTIMED. MULTIMED output files shown in the attachment for each model run include the main output file which summarizes input parameters and shows results in the saturated zone; vtrnspt.out, which shows concentrations versus time at the bottom of the unsaturated zone; and vflow.out, which shows steady-state velocity, degree of water saturation, and pressure head at each node of the unsaturated zone.

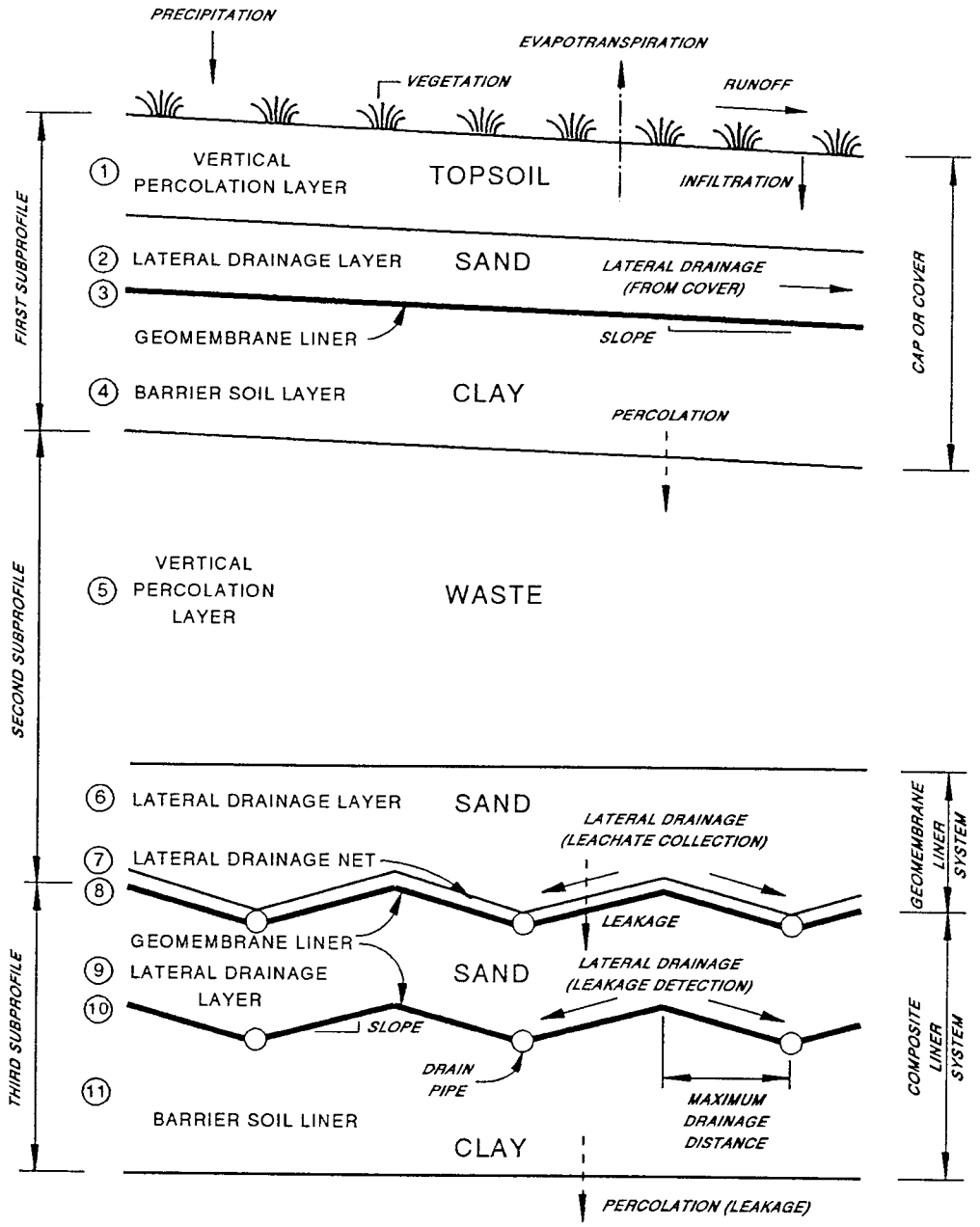
E.3 REFERENCES

Salhotra, A. M., Mineart, P., Sharp-Hansen, S., Allison, T., Johns, R., and Mills, W. B. 1995. Multimedia Exposure Assessment Model (MULTIMED 2.0) for Evaluating the Land Disposal of Wastes - Model Theory. U.S. Environmental Protection Agency. Athens, GA. April.

Schroeder, P.R., Dozier, T.S., Zappi, P.A., McEnroe, B.M., Sjostrom, J.W., and Peyton, R.L. 1994. The Hydrologic Evaluation of Landfill Performance (HELP) Model: Engineering Documentation for Version 3. EPA/600/R-94/168b. U.S. Environmental Protection Agency, Risk Reduction Engineering Laboratory, Cincinnati, OH. September.

Sharp-Hansen, S., Travers, C., Hummel, P. Allison, T., Johns, R., and Mills, W. B. 1995. A Subtitle D Landfill Application Manual for the Multimedia Exposure Assessment Model (MULTIMED 2.0). U.S. Environmental Protection Agency. Athens, GA. April.

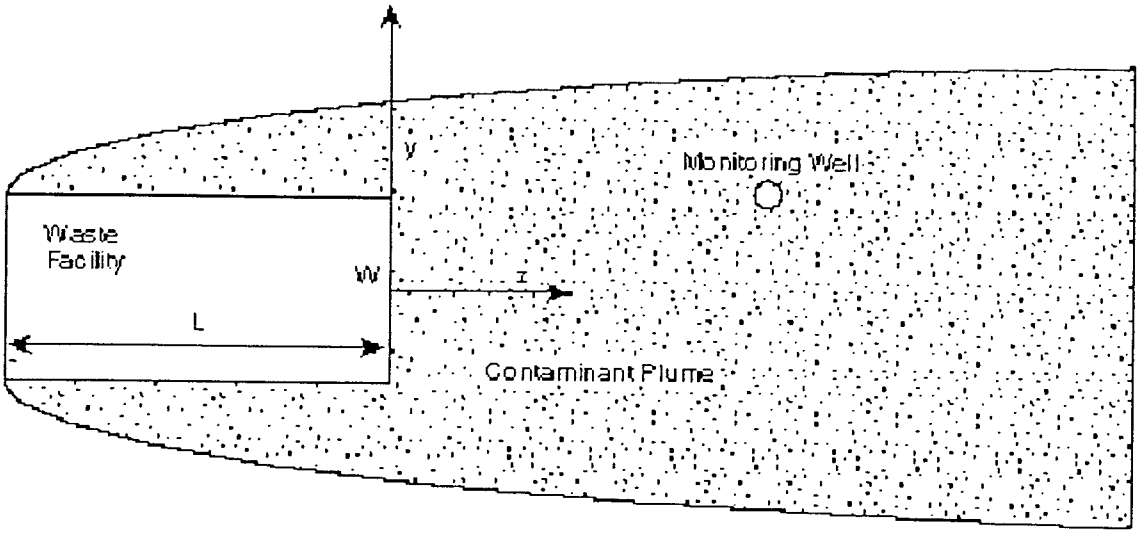
Tetra Tech, Inc., and GeoTrans, Inc. 1995. Revised Verification Testing of the Enhancements MULTIMED Model(2.0). Final Report. U.S. Environmental Protection Agency. Athens, GA. April.



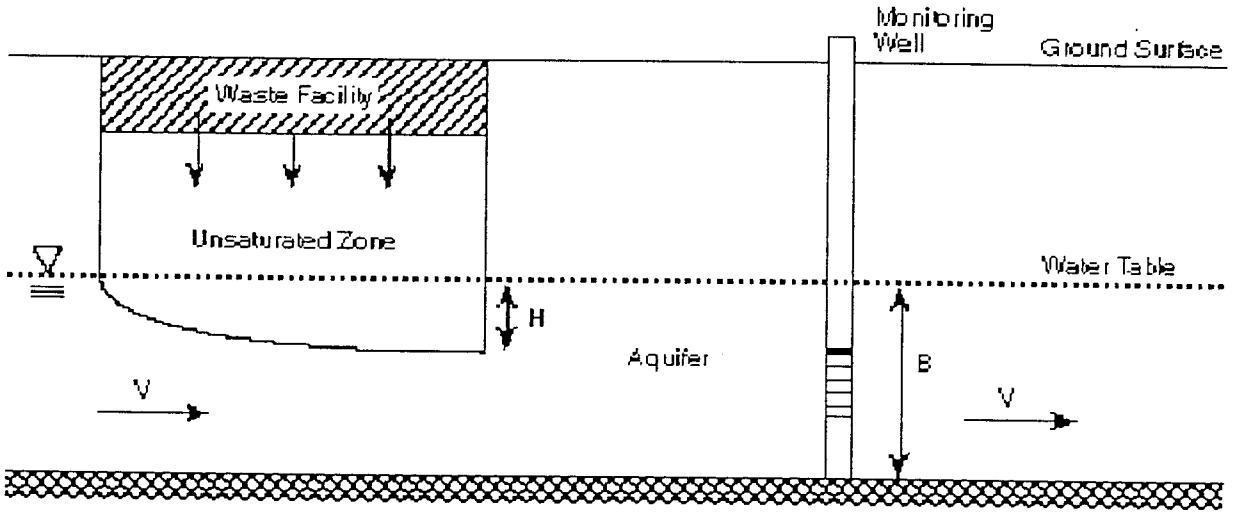
Source: Schroeder et al. 1994

DRN. BY: JMR	DATE: 5/3/99	TYPICAL LANDFILL PROFILE FOR USE WITH HELP MODEL	FIG. NO.: E-1
PROJ. NO.: 45F0M9602V.00	REVISION: 0		

PLAN VIEW



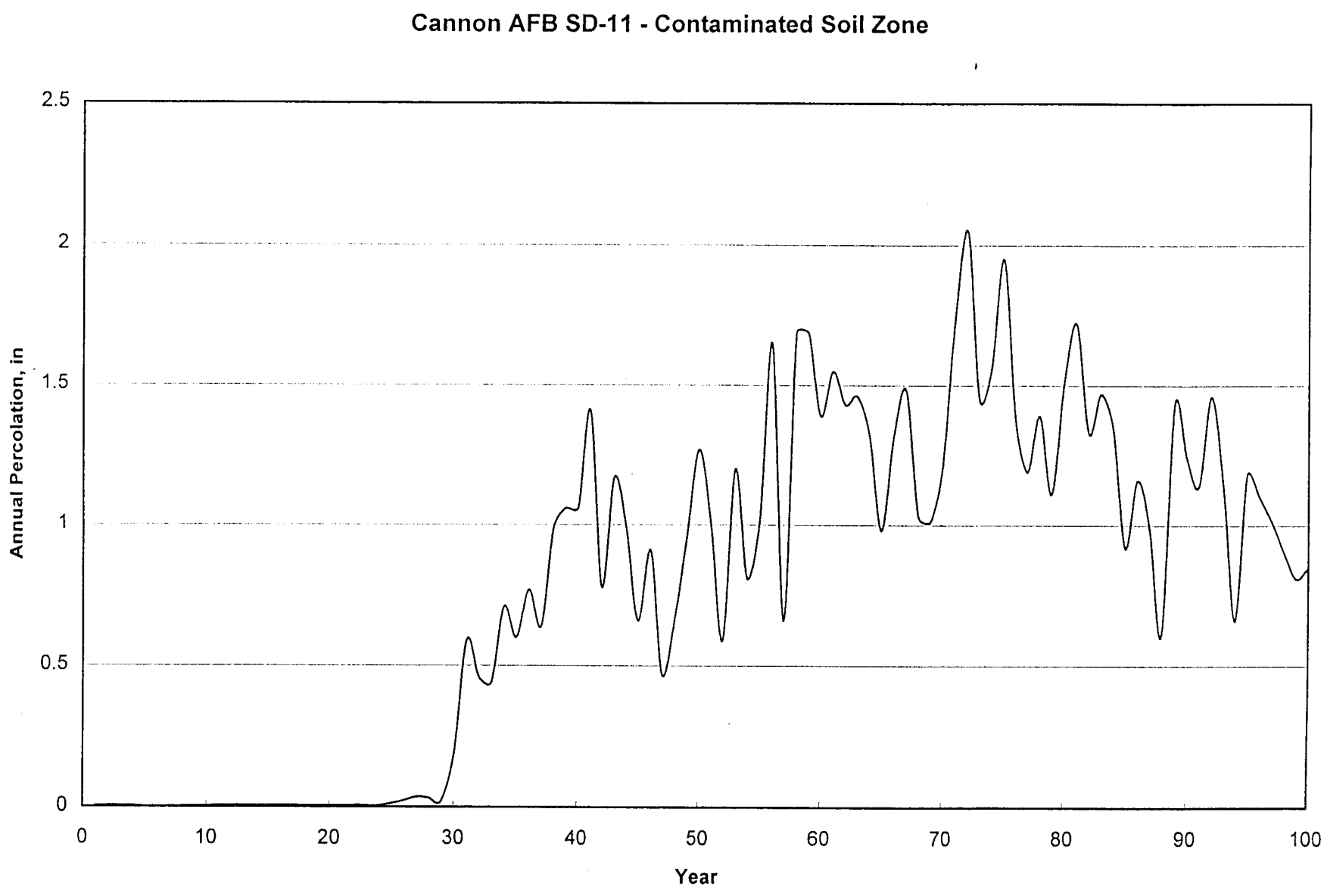
SECTION VIEW



Source: Salhotra et al. 1995

DRN. BY: JMR	DATE: 5/3/99	SCHEMATIC OF WASTE FACILITY AND LEACHATE MIGRATION FOR MULTIMED SIMULATION	FIG. NO.: E-2
PROJ. NO.: 45F0M9602V.00	REVISION: 0		

ATTACHMENT D-1
HELP OUTPUT


Cannon AFB SD-11 - Contaminated Soil Zone
Annual Percolation, in
2.5
2
1.5
1
0.5
0
0
10
20
30
40
50
60
70
80
90
100
Year

Summary Output

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**               HELP MODEL VERSION 3.01    (14 OCTOBER 1994)               **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************

PRECIPITATION DATA FILE:     C:\HELP3\CLOVIS.D4
TEMPERATURE DATA FILE:       C:\HELP3\CLOVIS.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\CLOVIS.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3\SD11.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3\SD11.D10
OUTPUT DATA FILE:            C:\HELP3\sd11sum.OUT


TIME:  16:44     DATE:   4/25/1999


******************************************************************************

     TITLE:  Cannon AFB SD-11 CMS - Contaminated Soil Zone

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  10
          THICKNESS                    =    120.00   INCHES
          POROSITY                     =      0.3980 VOL/VOL
          FIELD CAPACITY               =      0.2440 VOL/VOL
          WILTING POINT                =      0.1360 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.2402 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC
```

LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 6

THICKNESS	=	120.00	INCHES
POROSITY	=	0.4530	VOL/VOL
FIELD CAPACITY	=	0.1900	VOL/VOL
WILTING POINT	=	0.0850	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1914	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.720000011000E-03	CM/SEC

LAYER 3

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 4

THICKNESS	=	180.00	INCHES
POROSITY	=	0.4370	VOL/VOL
FIELD CAPACITY	=	0.1050	VOL/VOL
WILTING POINT	=	0.0470	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1062	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.170000002000E-02	CM/SEC

LAYER 4

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 2

THICKNESS	=	420.00	INCHES
POROSITY	=	0.4370	VOL/VOL
FIELD CAPACITY	=	0.0620	VOL/VOL
WILTING POINT	=	0.0240	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0620	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.579999993000E-02	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #10 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 1.% AND A SLOPE LENGTH OF 100. FEET.

SCS RUNOFF CURVE NUMBER	=	94.10	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	0.500	ACRES

EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	2.474	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	4.776	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.632	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	96.950	INCHES
TOTAL INITIAL WATER	=	96.950	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
AMARILLO TEXAS

MAXIMUM LEAF AREA INDEX	=	0.00
START OF GROWING SEASON (JULIAN DATE)	=	95
END OF GROWING SEASON (JULIAN DATE)	=	303
AVERAGE ANNUAL WIND SPEED	=	13.70 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	55.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	52.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	57.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	57.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AMARILLO TEXAS

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.43	0.43	0.60	1.05	2.09	2.62
2.65	2.95	2.15	1.62	0.57	0.61

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AMARILLO TEXAS

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
37.00	41.20	47.20	56.60	65.50	74.40
77.60	76.10	69.20	58.50	46.30	38.30

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AMARILLO TEXAS

STATION LATITUDE = 34.42 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.42	0.45	0.59	1.01	2.17	2.52
	2.62	2.90	2.13	1.88	0.59	0.60
STD. DEVIATIONS	0.36	0.34	0.43	0.76	1.20	1.23
	1.34	1.79	1.43	1.61	0.60	0.58
RUNOFF						
TOTALS	0.006	0.006	0.017	0.097	0.312	0.475
	0.405	0.662	0.501	0.434	0.034	0.031
STD. DEVIATIONS	0.022	0.020	0.044	0.187	0.374	0.512
	0.406	0.759	0.570	0.652	0.077	0.085
EVAPOTRANSPIRATION						
TOTALS	0.446	0.327	0.406	0.696	1.544	2.061
	2.130	2.060	1.618	1.340	0.692	0.469
STD. DEVIATIONS	0.349	0.221	0.361	0.658	0.952	0.856
	1.049	1.135	0.984	0.972	0.590	0.355
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0819	0.0781	0.0806	0.0672	0.0629	0.0587
	0.0518	0.0461	0.0532	0.0614	0.0710	0.0793
STD. DEVIATIONS	0.0687	0.0634	0.0649	0.0563	0.0550	0.0519
	0.0501	0.0433	0.0554	0.0644	0.0659	0.0713

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

	INCHES		CU. FEET	PERCENT
PRECIPITATION	17.88	(3.604)	32444.9	100.00
RUNOFF	2.980	(1.3472)	5408.68	16.670
EVAPOTRANSPIRATION	13.788	(2.6129)	25024.70	77.130
PERCOLATION/LEAKAGE THROUGH FROM LAYER 4	0.79211	(0.59928)	1437.674	4.43112
CHANGE IN WATER STORAGE	0.316	(0.8758)	573.88	1.769

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 100

	(INCHES)	(CU. FT.)
PRECIPITATION	3.24	5880.600
RUNOFF	2.370	4301.7373
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.011383	20.66062
SNOW WATER	1.32	2396.3718

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3025

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1021

****

****

FINAL WATER STORAGE AT END OF YEAR 100

LAYER	(INCHES)	(VOL/VOL)
1	28.3940	0.2366
2	24.0451	0.2004
3	28.4023	0.1578
4	47.7269	0.1136
SNOW WATER	0.000	

****
****

ATTACHMENT D-2
MULTIMED OUTPUT

Summary of MULTIMED Model Results
Cannon AFB SD-11 Vadose Zone

Model Run	Source Input: Pulse Duration	Source Input: Decay Half-Life	Active Transport Processes	Model Output: $(C_u)_{max}$[1] (mg/L)	Model Output: $(T_p)_u$[2] (yr)	Model Output: DAF_u[3]	Model Output: $(C_s)_{max}$[4] (mg/L)	Model Output: $(T_p)_s$[5] (yr)	Model Output: DAF_s[6]
SD11S	-	-	Dilution/dispersion + sorption	1.0	-	1.0	0.2176	-	4.6
SD11SB	-	-	Dilution/dispersion + sorption + decay	0.0	-	-	0.0	-	-
SD11PS	100 yr	-	Dilution/dispersion + sorption	0.00027	714,000	3,700	5.4E-05	-	19,000
SD11PSB	100 yr	-	Dilution/dispersion + sorption + decay	0.0	-	-	0.0	-	-
SD11DS	-	10 yr	Dilution/dispersion + sorption	3.9E-05	714,000	26,000	-	-	-
SD11DSB	-	10 yr	Dilution/dispersion + sorption + decay	0.0	-	-	0.0	-	-

[1] $(C_u)_{max}$ = maximum concentration at bottom of unsaturated zone

[2] $(T_{p)u}$ = time of peak concentration at bottom of unsaturated zone (time of C_{max})

[3] DAF_u = dilution-attenuation factor for unsaturated zone = $1.0 / (C_u)_{max}$

[4] $(C_s)_{max}$ = maximum concentration in saturated zone at water table 1.0 m downgradient of source zone

[5] $(T_{p)u}$ = time of peak concentration in saturated zone (time of C_{max})

[6] DAF_s = dilution-attenuation factor for unsaturated/saturated zone system = $1.0 / (C_s)_{max}$

1

U. S. ENVIRONMENTAL PROTECTION AGENCY

EXPOSURE ASSESSMENT

MULTIMEDIA MODEL

MULTIMED - (Version 2.00 Beta - October 1996)

1
Run options
--- -------

Cannon AFB SD-11 - Vadose Zone

Benzo(a)pyrene - Steady State - Sorption
Chemical simulated is Benzo(a)pyrene

Option Chosen	Saturated and unsaturated zone models
Run was	DETERMIN

Infiltration input by user
Run was steady-state
Reject runs if Y coordinate outside plume
Do not reject runs if Z coordinate outside plume
Gaussian source used in saturated zone model
1
1
UNSATURATED ZONE FLOW MODEL PARAMETERS
(input parameter description and value)

NP	- Total number of nodal points	240
NMAT	- Number of different porous materials	1
KPROP	- Van Genuchten or Brooks and Corey	1
IMSHGN	- Spatial discretization option	1
NVFLAYR	- Number of layers in flow model	1

OPTIONS CHOSEN
------- ------
Van Genuchten functional coefficients
User defined coordinate system
1

Layer information

LAYER NO.	LAYER THICKNESS	MATERIAL PROPERTY
1	59.00	1

DATA FOR MATERIAL 1

VADOSE ZONE MATERIAL VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Saturated hydraulic conductivity	cm/hr	CONSTANT	21.0	-999.	0.100E-10	0.100E+05
Unsaturated zone porosity	--	CONSTANT	0.437	-999.	0.100E-08	0.990
Air entry pressure head	m	CONSTANT	0.726E-01	-999.	0.000	-999.
Depth of the unsaturated zone	m	CONSTANT	59.0	-999.	0.100E-08	-999.

DATA FOR MATERIAL 1

VADOSE ZONE FUNCTION VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Residual water content	--	CONSTANT	0.200E-01	-999.	0.100E-08	1.00
Brook and Corey exponent,EN	--	CONSTANT	0.000	-999.	0.000	10.0
ALFA coefficient	1/cm	CONSTANT	0.145	-999.	0.000	1.00
Van Genuchten exponent, ENN	--	CONSTANT	2.68	-999.	1.00	5.00

1

UNSATURATED ZONE TRANSPORT MODEL PARAMETERS

Currently Not Used in Multimed Version 2.0	1
NTSTPS - Number of time values concentration calc	20
DUMMY - Not presently used	1
ISOL - Type of scheme used in unsaturated zone	1
N - Stehfest terms or number of increments	18
NTEL - Points in Lagrangian interpolation	3
NGPTS - Number of Gauss points	104
NIT - Convolution integral segments	2

IBOUND - Type of boundary condition		1
ITSGEN - Time values generated or input		1
TMAX - Max simulation time	--	0.0
WTFUN - Weighting factor	--	1.2
Used only for Numerical Model	--	0.0
Used only for Numerical Model	--	0.0
Used only for Numerical Model	--	0.0
Used only for Numerical Model	--	0.0
Used only for Numerical Model	--	0.0

OPTIONS CHOSEN
--- ---

Analytical unsaturated zone model
Stehfest numerical inversion algorithm
Nondecaying continuous source
Computer generated times for computing concentrations

1

DATA FOR MATERIAL 1
--- --- ---
VADOSE TRANSPORT VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Longitudinal dispersivity of material	m	CONSTANT	1.00	-999.	0.100E-02	0.100E+05
Percent organic matter	--	CONSTANT	0.700E-01	-999.	0.000	100.
Bulk density of soil for material	g/cc	CONSTANT	1.49	-999.	0.100E-01	5.00
Biological decay coefficient	1/yr	CONSTANT	0.000	-999.	0.000	-999.
Parameter not used by the Analytical Model		CONSTANT	0.000	0.000	0.000	0.000
Parameter not used by the Analytical Model		CONSTANT	0.000	0.000	0.000	0.000

1

CHEMICAL SPECIFIC VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Solid phase decay coefficient	1/yr	DERIVED	-999.	-999.	0.000	0.100E+11
Dissolved phase decay coefficient	1/yr	DERIVED	-999.	-999.	0.000	0.100E+11
Overall chemical decay coefficient	1/yr	DERIVED	-999.	-999.	0.000	0.100E+11
Acid catalyzed hydrolysis rate	1/M-yr	CONSTANT	0.000	-999.	0.000	-999.
Neutral hydrolysis rate constant	1/yr	CONSTANT	0.000	-999.	0.000	-999.
Base catalyzed hydrolysis rate	1/M-yr	CONSTANT	0.000	-999.	0.000	-999.
Reference temperature	C	CONSTANT	25.0	-999.	0.000	100.
Normalized distribution coefficient	ml/g	CONSTANT	0.102E+07	-999.	0.000	-999.
Distribution coefficient	--	DERIVED	420.	-999.	0.000	0.100E+11
Biodegradation coefficient (sat. zone)	1/yr	CONSTANT	0.000	-999.	0.000	-999.
Air diffusion coefficient	cm2/s	CONSTANT	0.000	-999.	0.000	10.0
Reference temperature for air diffusion	C	CONSTANT	25.0	-999.	0.000	100.
Molecular weight	g/M	CONSTANT	0.000	-999.	0.000	-999.
Mole fraction of solute	--	CONSTANT	0.000	-999.	0.100E-08	1.00
Vapor pressure of solute	mm Hg	CONSTANT	0.000	-999.	0.000	100.
Henry`s law constant	atm-m^3/M	CONSTANT	0.000	-999.	0.100E-09	1.00
Overall 1st order decay sat. zone	1/yr	DERIVED	0.000	0.000	0.000	1.00
Soil/Air Boundary Layer Thickness	cm	CONSTANT	-999.	-999.	0.000	-999.
Not currently used		CONSTANT	-999.	-999.	0.000	1.00

1

SOURCE SPECIFIC VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Infiltration rate	m/yr	CONSTANT	0.510E-01	-999.	0.100E-09	0.100E+11
Area of waste disposal unit	m^2	CONSTANT	0.100E+04	-999.	0.100E-01	-999.
Duration of pulse	yr	CONSTANT	100.	-999.	0.100E-08	-999.
Spread of contaminant source	m	DERIVED	-999.	-999.	0.100E-08	0.100E+11
Recharge rate	m/yr	CONSTANT	0.510E-01	-999.	0.000	0.100E+11
Source decay constant	1/yr	CONSTANT	0.000	-999.	0.000	-999.
Initial concentration at landfill	mg/l	CONSTANT	1.00	-999.	0.000	-999.
Length scale of facility	m	DERIVED	-999.	-999.	0.100E-08	0.100E+11
Width scale of facility	m	DERIVED	-999.	-999.	0.100E-08	0.100E+11
Near field dilution		DERIVED	1.00	0.000	0.000	1.00

1

AQUIFER SPECIFIC VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Particle diameter	cm	CONSTANT	0.200	-999.	0.100E-08	100.
Aquifer porosity	--	CONSTANT	0.400	-999.	0.100E-08	0.990
Bulk density	g/cc	CONSTANT	1.59	-999.	0.100E-01	5.00
Aquifer thickness	m	CONSTANT	37.0	-999.	0.100E-08	0.100E+06
Source thickness (mixing zone depth)	m	DERIVED	-999.	-999.	0.100E-08	0.100E+06
Conductivity (hydraulic)	m/yr	CONSTANT	0.320E+04	-999.	0.100E-06	0.100E+09
Gradient (hydraulic)		CONSTANT	0.150E-02	-999.	0.100E-07	-999.
Groundwater seepage velocity	m/yr	DERIVED	12.0	-999.	0.100E-09	0.100E+09
Retardation coefficient	--	DERIVED	0.167E+04	-999.	1.00	0.100E+09
Longitudinal dispersivity	m	CONSTANT	0.100	-999.	0.100E-02	0.100E+05
Transverse dispersivity	m	CONSTANT	0.333E-01	-999.	0.100E-02	0.100E+05
Vertical dispersivity	m	CONSTANT	0.560E-02	-999.	0.100E-02	0.100E+05
Temperature of aquifer	C	CONSTANT	12.0	-999.	0.000	100.
pH	--	CONSTANT	6.80	-999.	0.300	14.0
Organic carbon content (fraction)		CONSTANT	0.400E-03	-999.	0.100E-05	1.00
Well distance from site	m	CONSTANT	1.00	-999.	1.00	-999.
Angle off center	degree	CONSTANT	0.000	-999.	0.000	360.
Well vertical distance	m	CONSTANT	0.000	-999.	0.000	1.00

CONCENTRATION AFTER SATURATED ZONE MODEL 0.2176

5D115

VTRNSPT.OUT

CONCENTRATION AT BOTTOM OF VADOSE ZONE
RUN NO. 1 STEADY-STATE CONC 0.1000E+01

1

DEPTH	CONCENTRATION	NORMALIZED CONCENTRATION

Cannon AFB SD-11 - Vadose Zone

Benzo(a)pyrene - Steady State - Sorption

VADOSE FLOW MODEL: INPUT PARAMETERS AND OUTPUT

SIMULATION RUN FOR Benzo(a)pyrene

CONSTANT PARMS FOR MATERIAL 1		
Saturated hydraulic conductivity	cm/hr	21.0
Unsaturated zone porosity	--	0.437
Air entry pressure head	m	0.726E-01
Depth of the unsaturated zone	m	59.0
Residual water content	--	0.200E-01
Brook and Corey exponent,EN	--	0.000
ALFA coefficient	1/cm	0.145
Van Genuchten exponent, ENN	--	2.68

MONTE CARLO AND MODEL DERIVED PARMS ARE LISTED BELOW,
ONE LINE FOR EACH MATERIAL, FOR EXAMPLE:

RUN NO.	NLAYER
1	1

THESE ARE THE MONTE CARLO AND DERIVED VALUES USED
FOR THE FIRST ITERATION, LAYER 1
VALUES FOR OTHER ITERATIONS FOLLOW THE LAST CONSTANT PARM LISTING

VADOSE FLOW MODEL RESULTS FOR RUN NO. 1

STEADY-STATE UNSATURATED FLOW MODEL RESULTS

	NODE DEPTH	DARCY VELOCITY	WATER SATURATION	HEAD
1	0.000E+00	0.510E-01	0.155E+00	-0.248E+00
2	0.100E+01	0.510E-01	0.155E+00	-0.248E+00
3	0.200E+01	0.510E-01	0.155E+00	-0.248E+00
4	0.300E+01	0.510E-01	0.155E+00	-0.248E+00
5	0.400E+01	0.510E-01	0.155E+00	-0.248E+00
6	0.500E+01	0.510E-01	0.155E+00	-0.248E+00
7	0.600E+01	0.510E-01	0.155E+00	-0.248E+00
8	0.700E+01	0.510E-01	0.155E+00	-0.248E+00
9	0.800E+01	0.510E-01	0.155E+00	-0.248E+00
10	0.900E+01	0.510E-01	0.155E+00	-0.248E+00
11	0.100E+02	0.510E-01	0.155E+00	-0.248E+00
12	0.110E+02	0.510E-01	0.155E+00	-0.248E+00
13	0.120E+02	0.510E-01	0.155E+00	-0.248E+00
14	0.130E+02	0.510E-01	0.155E+00	-0.248E+00
15	0.140E+02	0.510E-01	0.155E+00	-0.248E+00

16	0.150E+02	0.510E-01	0.155E+00	-0.248E+00
17	0.160E+02	0.510E-01	0.155E+00	-0.248E+00
18	0.170E+02	0.510E-01	0.155E+00	-0.248E+00
19	0.180E+02	0.510E-01	0.155E+00	-0.248E+00
20	0.190E+02	0.510E-01	0.155E+00	-0.248E+00
21	0.200E+02	0.510E-01	0.155E+00	-0.248E+00
22	0.210E+02	0.510E-01	0.155E+00	-0.248E+00
23	0.220E+02	0.510E-01	0.155E+00	-0.248E+00
24	0.230E+02	0.510E-01	0.155E+00	-0.248E+00
25	0.240E+02	0.510E-01	0.155E+00	-0.248E+00
26	0.250E+02	0.510E-01	0.155E+00	-0.248E+00
27	0.260E+02	0.510E-01	0.155E+00	-0.248E+00
28	0.270E+02	0.510E-01	0.155E+00	-0.248E+00
29	0.280E+02	0.510E-01	0.155E+00	-0.248E+00
30	0.290E+02	0.510E-01	0.155E+00	-0.248E+00
31	0.300E+02	0.510E-01	0.155E+00	-0.248E+00
32	0.310E+02	0.510E-01	0.155E+00	-0.248E+00
33	0.320E+02	0.510E-01	0.155E+00	-0.248E+00
34	0.330E+02	0.510E-01	0.155E+00	-0.248E+00
35	0.340E+02	0.510E-01	0.155E+00	-0.248E+00
36	0.350E+02	0.510E-01	0.155E+00	-0.248E+00
37	0.360E+02	0.510E-01	0.155E+00	-0.248E+00
38	0.370E+02	0.510E-01	0.155E+00	-0.248E+00
39	0.380E+02	0.510E-01	0.155E+00	-0.248E+00
40	0.390E+02	0.510E-01	0.155E+00	-0.248E+00
41	0.400E+02	0.510E-01	0.155E+00	-0.248E+00
42	0.410E+02	0.510E-01	0.155E+00	-0.248E+00
43	0.420E+02	0.510E-01	0.155E+00	-0.248E+00
44	0.430E+02	0.510E-01	0.155E+00	-0.248E+00
45	0.440E+02	0.510E-01	0.155E+00	-0.248E+00
46	0.450E+02	0.510E-01	0.155E+00	-0.248E+00
47	0.460E+02	0.510E-01	0.155E+00	-0.248E+00
48	0.470E+02	0.510E-01	0.155E+00	-0.248E+00
49	0.480E+02	0.510E-01	0.155E+00	-0.248E+00
50	0.490E+02	0.510E-01	0.155E+00	-0.248E+00
51	0.500E+02	0.510E-01	0.155E+00	-0.248E+00
52	0.510E+02	0.510E-01	0.155E+00	-0.248E+00
53	0.520E+02	0.510E-01	0.155E+00	-0.248E+00
54	0.530E+02	0.510E-01	0.155E+00	-0.248E+00
55	0.540E+02	0.510E-01	0.155E+00	-0.248E+00
56	0.550E+02	0.510E-01	0.155E+00	-0.248E+00
57	0.560E+02	0.510E-01	0.155E+00	-0.248E+00
58	0.570E+02	0.510E-01	0.160E+00	-0.247E+00
59	0.580E+02	0.510E-01	0.388E+00	-0.234E+00
60	0.590E+02	0.510E-01	0.100E+01	0.000E+00

1

U. S. ENVIRONMENTAL PROTECTION AGENCY

EXPOSURE ASSESSMENT

MULTIMEDIA MODEL

MULTIMED - (Version 2.00 Beta - October 1996)

1

Run options
--- -------

Cannon AFB SD-11 - Vadose Zone

Benzo(a)pyrene - Steady State - Sorption/Biodegradation
Chemical simulated is Benzo(a)pyrene

Option Chosen	Saturated and unsaturated zone models
Run was	DETERMIN

Infiltration input by user
Run was steady-state
Reject runs if Y coordinate outside plume
Do not reject runs if Z coordinate outside plume
Gaussian source used in saturated zone model

1
1

UNSATURATED ZONE FLOW MODEL PARAMETERS
(input parameter description and value)

NP	- Total number of nodal points	240
NMAT	- Number of different porous materials	1
KPROP	- Van Genuchten or Brooks and Corey	1
IMSHGN	- Spatial discretization option	1
NVFLAYR	- Number of layers in flow model	1

OPTIONS CHOSEN
------- ------

Van Genuchten functional coefficients
User defined coordinate system

1

Layer information

LAYER NO.	LAYER THICKNESS	MATERIAL PROPERTY
1	59.00	1

DATA FOR MATERIAL 1

VADOSE ZONE MATERIAL VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Saturated hydraulic conductivity	cm/hr	CONSTANT	21.0	-999.	0.100E-10	0.100E+05
Unsaturated zone porosity	--	CONSTANT	0.437	-999.	0.100E-08	0.990
Air entry pressure head	m	CONSTANT	0.726E-01	-999.	0.000	-999.
Depth of the unsaturated zone	m	CONSTANT	59.0	-999.	0.100E-08	-999.

DATA FOR MATERIAL 1

VADOSE ZONE FUNCTION VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Residual water content	--	CONSTANT	0.200E-01	-999.	0.100E-08	1.00
Brook and Corey exponent,EN	--	CONSTANT	0.000	-999.	0.000	10.0
ALFA coefficient	1/cm	CONSTANT	0.145	-999.	0.000	1.00
Van Genuchten exponent, ENN	--	CONSTANT	2.68	-999.	1.00	5.00

1

UNSATURATED ZONE TRANSPORT MODEL PARAMETERS

Currently Not Used in Multimed Version 2.0		1
NTSTPS	- Number of time values concentration calc	20
DUMMY	- Not presently used	1
ISOL	- Type of scheme used in unsaturated zone	1
N	- Stehfest terms or number of increments	18
NTEL	- Points in Lagrangian interpolation	3
NGPTS	- Number of Gauss points	104
NIT	- Convolution integral segments	2

IBOUND	- Type of boundary condition		1
ITSGEN	- Time values generated or input		1
TMAX	- Max simulation time	--	0.0
WTFUN	- Weighting factor	--	1.2
Used only for Numerical Model		--	0.0
Used only for Numerical Model		--	0.0
Used only for Numerical Model		--	0.0
Used only for Numerical Model		--	0.0
Used only for Numerical Model		--	0.0

OPTIONS CHOSEN
------- ------
Analytical unsaturated zone model
Stehfest numerical inversion algorithm
Nondecaying continuous source
Computer generated times for computing concentrations
1

DATA FOR MATERIAL 1
---- --- --------
VADOSE TRANSPORT VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Longitudinal dispersivity of material	m	CONSTANT	1.00	-999.	0.100E-02	0.100E+05
Percent organic matter	--	CONSTANT	0.700E-01	-999.	0.000	100.
Bulk density of soil for material	g/cc	CONSTANT	1.49	-999.	0.100E-01	5.00
Biological decay coefficient	1/yr	CONSTANT	0.690E-01	-999.	0.000	-999.
Parameter not used by the Analytical Model		CONSTANT	0.000	0.000	0.000	0.000
Parameter not used by the Analytical Model		CONSTANT	0.000	0.000	0.000	0.000

1

CHEMICAL SPECIFIC VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Solid phase decay coefficient	1/yr	DERIVED	-999.	-999.	0.000	0.100E+11
Dissolved phase decay coefficient	1/yr	DERIVED	-999.	-999.	0.000	0.100E+11
Overall chemical decay coefficient	1/yr	DERIVED	-999.	-999.	0.000	0.100E+11
Acid catalyzed hydrolysis rate	1/M-yr	CONSTANT	0.000	-999.	0.000	-999.
Neutral hydrolysis rate constant	1/yr	CONSTANT	0.000	-999.	0.000	-999.
Base catalyzed hydrolysis rate	1/M-yr	CONSTANT	0.000	-999.	0.000	-999.
Reference temperature	C	CONSTANT	25.0	-999.	0.000	100.
Normalized distribution coefficient	ml/g	CONSTANT	0.102E+07	-999.	0.000	-999.
Distribution coefficient	--	DERIVED	420.	-999.	0.000	0.100E+11
Biodegradation coefficient (sat. zone)	1/yr	CONSTANT	0.000	-999.	0.000	-999.
Air diffusion coefficient	cm2/s	CONSTANT	0.000	-999.	0.000	10.0
Reference temperature for air diffusion	C	CONSTANT	25.0	-999.	0.000	100.
Molecular weight	g/M	CONSTANT	0.000	-999.	0.000	-999.
Mole fraction of solute	--	CONSTANT	0.000	-999.	0.100E-08	1.00
Vapor pressure of solute	mm Hg	CONSTANT	0.000	-999.	0.000	100.
Henry`s law constant	atm-m^3/M	CONSTANT	0.000	-999.	0.100E-09	1.00
Overall 1st order decay sat. zone	1/yr	DERIVED	0.000	0.000	0.000	1.00
Soil/Air Boundary Layer Thickness	cm	CONSTANT	-999.	-999.	0.000	-999.
Not currently used		CONSTANT	-999.	-999.	0.000	1.00

1

SOURCE SPECIFIC VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Infiltration rate	m/yr	CONSTANT	0.510E-01	-999.	0.100E-09	0.100E+11
Area of waste disposal unit	m^2	CONSTANT	0.100E+04	-999.	0.100E-01	-999.
Duration of pulse	yr	CONSTANT	100.	-999.	0.100E-08	-999.
Spread of contaminant source	m	DERIVED	-999.	-999.	0.100E-08	0.100E+11
Recharge rate	m/yr	CONSTANT	0.510E-01	-999.	0.000	0.100E+11
Source decay constant	1/yr	CONSTANT	0.000	-999.	0.000	-999.
Initial concentration at landfill	mg/l	CONSTANT	1.00	-999.	0.000	-999.
Length scale of facility	m	DERIVED	-999.	-999.	0.100E-08	0.100E+11
Width scale of facility	m	DERIVED	-999.	-999.	0.100E-08	0.100E+11
Near field dilution		DERIVED	1.00	0.000	0.000	1.00

1

AQUIFER SPECIFIC VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Particle diameter	cm	CONSTANT	0.200	-999.	0.100E-08	100.
Aquifer porosity	--	CONSTANT	0.400	-999.	0.100E-08	0.990
Bulk density	g/cc	CONSTANT	1.59	-999.	0.100E-01	5.00
Aquifer thickness	m	CONSTANT	37.0	-999.	0.100E-08	0.100E+06
Source thickness (mixing zone depth)	m	DERIVED	-999.	-999.	0.100E-08	0.100E+06
Conductivity (hydraulic)	m/yr	CONSTANT	0.320E+04	-999.	0.100E-06	0.100E+09
Gradient (hydraulic)		CONSTANT	0.150E-02	-999.	0.100E-07	-999.
Groundwater seepage velocity	m/yr	DERIVED	12.0	-999.	0.100E-09	0.100E+09
Retardation coefficient	--	DERIVED	0.167E+04	-999.	1.00	0.100E+09
Longitudinal dispersivity	m	CONSTANT	0.100	-999.	0.100E-02	0.100E+05
Transverse dispersivity	m	CONSTANT	0.333E-01	-999.	0.100E-02	0.100E+05
Vertical dispersivity	m	CONSTANT	0.560E-02	-999.	0.100E-02	0.100E+05
Temperature of aquifer	C	CONSTANT	12.0	-999.	0.000	100.
pH	--	CONSTANT	6.80	-999.	0.300	14.0
Organic carbon content (fraction)		CONSTANT	0.400E-03	-999.	0.100E-05	1.00
Well distance from site	m	CONSTANT	1.00	-999.	1.00	-999.
Angle off center	degree	CONSTANT	0.000	-999.	0.000	360.
Well vertical distance	m	CONSTANT	0.000	-999.	0.000	1.00

CONCENTRATION AFTER SATURATED ZONE MODEL 0.0000

SD115B

CONCENTRATION AT BOTTOM OF VADOSE ZONE
RUN NO. 1 STEADY-STATE CONC 0.0000E+00

1

DEPTH	CONCENTRATION	NORMALIZED CONCENTRATION

Cannon AFB SD-11 - Vadose Zone

Benzo(a)pyrene - Steady State - Sorption/Biodegradation

VADOSE FLOW MODEL: INPUT PARAMETERS AND OUTPUT

SIMULATION RUN FOR Benzo(a)pyrene

	CONSTANT PARMS FOR MATERIAL 1	
Saturated hydraulic conductivity	cm/hr	21.0
Unsaturated zone porosity	--	0.437
Air entry pressure head	m	0.726E-01
Depth of the unsaturated zone	m	59.0
Residual water content	--	0.200E-01
Brook and Corey exponent,EN	--	0.000
ALFA coefficient	1/cm	0.145
Van Genuchten exponent, ENN	--	2.68

MONTE CARLO AND MODEL DERIVED PARMS ARE LISTED BELOW,
ONE LINE FOR EACH MATERIAL, FOR EXAMPLE:

RUN NO.	NLAYER
1	1

THESE ARE THE MONTE CARLO AND DERIVED VALUES USED
FOR THE FIRST ITERATION, LAYER 1
VALUES FOR OTHER ITERATIONS FOLLOW THE LAST CONSTANT PARM LISTING

VADOSE FLOW MODEL RESULTS FOR RUN NO. 1

STEADY-STATE UNSATURATED FLOW MODEL RESULTS

	NODE DEPTH	DARCY VELOCITY	WATER SATURATION	HEAD
1	0.000E+00	0.510E-01	0.155E+00	-0.248E+00
2	0.100E+01	0.510E-01	0.155E+00	-0.248E+00
3	0.200E+01	0.510E-01	0.155E+00	-0.248E+00
4	0.300E+01	0.510E-01	0.155E+00	-0.248E+00
5	0.400E+01	0.510E-01	0.155E+00	-0.248E+00
6	0.500E+01	0.510E-01	0.155E+00	-0.248E+00
7	0.600E+01	0.510E-01	0.155E+00	-0.248E+00
8	0.700E+01	0.510E-01	0.155E+00	-0.248E+00
9	0.800E+01	0.510E-01	0.155E+00	-0.248E+00
10	0.900E+01	0.510E-01	0.155E+00	-0.248E+00
11	0.100E+02	0.510E-01	0.155E+00	-0.248E+00
12	0.110E+02	0.510E-01	0.155E+00	-0.248E+00
13	0.120E+02	0.510E-01	0.155E+00	-0.248E+00
14	0.130E+02	0.510E-01	0.155E+00	-0.248E+00
15	0.140E+02	0.510E-01	0.155E+00	-0.248E+00

16	0.150E+02	0.510E-01	0.155E+00	-0.248E+00
17	0.160E+02	0.510E-01	0.155E+00	-0.248E+00
18	0.170E+02	0.510E-01	0.155E+00	-0.248E+00
19	0.180E+02	0.510E-01	0.155E+00	-0.248E+00
20	0.190E+02	0.510E-01	0.155E+00	-0.248E+00
21	0.200E+02	0.510E-01	0.155E+00	-0.248E+00
22	0.210E+02	0.510E-01	0.155E+00	-0.248E+00
23	0.220E+02	0.510E-01	0.155E+00	-0.248E+00
24	0.230E+02	0.510E-01	0.155E+00	-0.248E+00
25	0.240E+02	0.510E-01	0.155E+00	-0.248E+00
26	0.250E+02	0.510E-01	0.155E+00	-0.248E+00
27	0.260E+02	0.510E-01	0.155E+00	-0.248E+00
28	0.270E+02	0.510E-01	0.155E+00	-0.248E+00
29	0.280E+02	0.510E-01	0.155E+00	-0.248E+00
30	0.290E+02	0.510E-01	0.155E+00	-0.248E+00
31	0.300E+02	0.510E-01	0.155E+00	-0.248E+00
32	0.310E+02	0.510E-01	0.155E+00	-0.248E+00
33	0.320E+02	0.510E-01	0.155E+00	-0.248E+00
34	0.330E+02	0.510E-01	0.155E+00	-0.248E+00
35	0.340E+02	0.510E-01	0.155E+00	-0.248E+00
36	0.350E+02	0.510E-01	0.155E+00	-0.248E+00
37	0.360E+02	0.510E-01	0.155E+00	-0.248E+00
38	0.370E+02	0.510E-01	0.155E+00	-0.248E+00
39	0.380E+02	0.510E-01	0.155E+00	-0.248E+00
40	0.390E+02	0.510E-01	0.155E+00	-0.248E+00
41	0.400E+02	0.510E-01	0.155E+00	-0.248E+00
42	0.410E+02	0.510E-01	0.155E+00	-0.248E+00
43	0.420E+02	0.510E-01	0.155E+00	-0.248E+00
44	0.430E+02	0.510E-01	0.155E+00	-0.248E+00
45	0.440E+02	0.510E-01	0.155E+00	-0.248E+00
46	0.450E+02	0.510E-01	0.155E+00	-0.248E+00
47	0.460E+02	0.510E-01	0.155E+00	-0.248E+00
48	0.470E+02	0.510E-01	0.155E+00	-0.248E+00
49	0.480E+02	0.510E-01	0.155E+00	-0.248E+00
50	0.490E+02	0.510E-01	0.155E+00	-0.248E+00
51	0.500E+02	0.510E-01	0.155E+00	-0.248E+00
52	0.510E+02	0.510E-01	0.155E+00	-0.248E+00
53	0.520E+02	0.510E-01	0.155E+00	-0.248E+00
54	0.530E+02	0.510E-01	0.155E+00	-0.248E+00
55	0.540E+02	0.510E-01	0.155E+00	-0.248E+00
56	0.550E+02	0.510E-01	0.155E+00	-0.248E+00
57	0.560E+02	0.510E-01	0.155E+00	-0.248E+00
58	0.570E+02	0.510E-01	0.160E+00	-0.247E+00
59	0.580E+02	0.510E-01	0.388E+00	-0.234E+00
60	0.590E+02	0.510E-01	0.100E+01	0.000E+00

1

U. S. ENVIRONMENTAL PROTECTION AGENCY

EXPOSURE ASSESSMENT

MULTIMEDIA MODEL

MULTIMED - (Version 2.00 Beta - October 1996)

1

Run options
--- -------

Cannon AFB SD-11 - Vadose Zone

Benzo(a)pyrene - Pulse Source - Sorption
Chemical simulated is Benzo(a)pyrene

Option Chosen Saturated and unsaturated zone models
Run was DETERMIN
Infiltration input by user
Run was transient
Reject runs if Y coordinate outside plume
Do not reject runs if Z coordinate outside plume
Gaussian source used in saturated zone model
1
1

UNSATURATED ZONE FLOW MODEL PARAMETERS
(input parameter description and value)

NP	- Total number of nodal points	240
NMAT	- Number of different porous materials	1
KPROP	- Van Genuchten or Brooks and Corey	1
IMSHGN	- Spatial discretization option	1
NVFLAYR	- Number of layers in flow model	1

OPTIONS CHOSEN
------- ------
Van Genuchten functional coefficients
User defined coordinate system
1

Layer information

LAYER NO.	LAYER THICKNESS	MATERIAL PROPERTY
1	59.00	1

DATA FOR MATERIAL 1

VADOSE ZONE MATERIAL VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Saturated hydraulic conductivity	cm/hr	CONSTANT	21.0	-999.	0.100E-10	0.100E+05
Unsaturated zone porosity	--	CONSTANT	0.437	-999.	0.100E-08	0.990
Air entry pressure head	m	CONSTANT	0.726E-01	-999.	0.000	-999.
Depth of the unsaturated zone	m	CONSTANT	59.0	-999.	0.100E-08	-999.

DATA FOR MATERIAL 1

VADOSE ZONE FUNCTION VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Residual water content	--	CONSTANT	0.200E-01	-999.	0.100E-08	1.00
Brook and Corey exponent,EN	--	CONSTANT	0.000	-999.	0.000	10.0
ALFA coefficient	1/cm	CONSTANT	0.145	-999.	0.000	1.00
Van Genuchten exponent, ENN	--	CONSTANT	2.68	-999.	1.00	5.00

1

UNSATURATED ZONE TRANSPORT MODEL PARAMETERS

Currently Not Used in Multimed Version 2.0		1
NTSTPS	- Number of time values concentration calc	20
DUMMY	- Not presently used	1
ISOL	- Type of scheme used in unsaturated zone	1
N	- Stehfest terms or number of increments	18
NTEL	- Points in Lagrangian interpolation	3
NGPTS	- Number of Gauss points	104
NIT	- Convolution integral segments	2

IBOUND - Type of boundary condition		2
ITSGEN - Time values generated or input		1
TMAX - Max simulation time	--	0.0
WTFUN - Weighting factor	--	1.2
Used only for Numerical Model	--	0.0
Used only for Numerical Model	--	0.0
Used only for Numerical Model	--	0.0
Used only for Numerical Model	--	0.0
Used only for Numerical Model	--	0.0

OPTIONS CHOSEN
--- ---

Analytical unsaturated zone model
Stehfest numerical inversion algorithm
Nondecaying pulse source
Computer generated times for computing concentrations
1

DATA FOR MATERIAL 1
--- --- ---
VADOSE TRANSPORT VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Longitudinal dispersivity of material	m	CONSTANT	1.00	-999.	0.100E-02	0.100E+05
Percent organic matter	--	CONSTANT	0.700E-01	-999.	0.000	100.
Bulk density of soil for material	g/cc	CONSTANT	1.49	-999.	0.100E-01	5.00
Biological decay coefficient	1/yr	CONSTANT	0.000	-999.	0.000	-999.
Parameter not used by the Analytical Model		CONSTANT	0.000	0.000	0.000	0.000
Parameter not used by the Analytical Model		CONSTANT	0.000	0.000	0.000	0.000

1

CHEMICAL SPECIFIC VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Solid phase decay coefficient	1/yr	DERIVED	-999.	-999.	0.000	0.100E+11
Dissolved phase decay coefficient	1/yr	DERIVED	-999.	-999.	0.000	0.100E+11
Overall chemical decay coefficient	1/yr	DERIVED	-999.	-999.	0.000	0.100E+11
Acid catalyzed hydrolysis rate	l/M-yr	CONSTANT	0.000	-999.	0.000	-999.
Neutral hydrolysis rate constant	1/yr	CONSTANT	0.000	-999.	0.000	-999.
Base catalyzed hydrolysis rate	l/M-yr	CONSTANT	0.000	-999.	0.000	-999.
Reference temperature	C	CONSTANT	25.0	-999.	0.000	100.
Normalized distribution coefficient	ml/g	CONSTANT	0.102E+07	-999.	0.000	-999.
Distribution coefficient	--	DERIVED	420.	-999.	0.000	0.100E+11
Biodegradation coefficient (sat. zone)	1/yr	CONSTANT	0.000	-999.	0.000	-999.
Air diffusion coefficient	cm2/s	CONSTANT	0.000	-999.	0.000	10.0
Reference temperature for air diffusion	C	CONSTANT	25.0	-999.	0.000	100.
Molecular weight	g/M	CONSTANT	0.000	-999.	0.000	-999.
Mole fraction of solute	--	CONSTANT	0.000	-999.	0.100E-08	1.00
Vapor pressure of solute	mm Hg	CONSTANT	0.000	-999.	0.000	100.
Henry`s law constant	atm-m^3/M	CONSTANT	0.000	-999.	0.100E-09	1.00
Overall 1st order decay sat. zone	1/yr	DERIVED	0.000	0.000	0.000	1.00
Soil/Air Boundary Layer Thickness	cm	CONSTANT	-999.	-999.	0.000	-999.
Not currently used		CONSTANT	-999.	-999.	0.000	1.00

SOURCE SPECIFIC VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Infiltration rate	m/yr	CONSTANT	0.510E-01	-999.	0.100E-09	0.100E+11
Area of waste disposal unit	m^2	CONSTANT	0.100E+04	-999.	0.100E-01	-999.
Duration of pulse	yr	CONSTANT	100.	-999.	0.100E-08	-999.
Spread of contaminant source	m	DERIVED	-999.	-999.	0.100E-08	0.100E+11
Recharge rate	m/yr	CONSTANT	0.510E-01	-999.	0.000	0.100E+11
Source decay constant	1/yr	CONSTANT	0.000	-999.	0.000	-999.
Initial concentration at landfill	mg/l	CONSTANT	1.00	-999.	0.000	-999.
Length scale of facility	m	DERIVED	-999.	-999.	0.100E-08	0.100E+11
Width scale of facility	m	DERIVED	-999.	-999.	0.100E-08	0.100E+11
Near field dilution		DERIVED	1.00	0.000	0.000	1.00

AQUIFER SPECIFIC VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Particle diameter	cm	CONSTANT	0.200	-999.	0.100E-08	100.
Aquifer porosity	--	CONSTANT	0.400	-999.	0.100E-08	0.990
Bulk density	g/cc	CONSTANT	1.59	-999.	0.100E-01	5.00
Aquifer thickness	m	CONSTANT	37.0	-999.	0.100E-08	0.100E+06
Source thickness (mixing zone depth)	m	DERIVED	-999.	-999.	0.100E-08	0.100E+06
Conductivity (hydraulic)	m/yr	CONSTANT	0.320E+04	-999.	0.100E-06	0.100E+09
Gradient (hydraulic)		CONSTANT	0.150E-02	-999.	0.100E-07	-999.
Groundwater seepage velocity	m/yr	DERIVED	12.0	-999.	0.100E-09	0.100E+09
Retardation coefficient	--	DERIVED	0.167E+04	-999.	1.00	0.100E+09
Longitudinal dispersivity	m	CONSTANT	0.100	-999.	0.100E-02	0.100E+05
Transverse dispersivity	m	CONSTANT	0.333E-01	-999.	0.100E-02	0.100E+05
Vertical dispersivity	m	CONSTANT	0.560E-02	-999.	0.100E-02	0.100E+05
Temperature of aquifer	C	CONSTANT	12.0	-999.	0.000	100.
pH	--	CONSTANT	6.80	-999.	0.300	14.0
Organic carbon content (fraction)		CONSTANT	0.400E-03	-999.	0.100E-05	1.00
Well distance from site	m	CONSTANT	1.00	-999.	1.00	-999.
Angle off center	degree	CONSTANT	0.000	-999.	0.000	360.
Well vertical distance	m	CONSTANT	0.000	-999.	0.000	1.00

CONCENTRATION AFTER SATURATED ZONE MODEL 0.5388E-04

SD11 PS


```
CONCENTRATION AT BOTTOM OF VADOSE ZONE
 RUN NO.    1
     AT TIME = 0.3422E+06  CONC = -.4509E-05
     AT TIME = 0.4619E+06  CONC = 0.3873E-04
     AT TIME = 0.5616E+06  CONC = 0.2146E-03
     AT TIME = 0.6447E+06  CONC = 0.2857E-03
     AT TIME = 0.7140E+06  CONC = 0.2702E-03
     AT TIME = 0.7140E+06  CONC = 0.2703E-03
     AT TIME = 0.7140E+06  CONC = 0.2703E-03
     AT TIME = 0.7140E+06  CONC = 0.2702E-03
     AT TIME = 0.7140E+06  CONC = 0.2702E-03
     AT TIME = 0.7140E+06  CONC = 0.2702E-03
     AT TIME = 0.7140E+06  CONC = 0.2702E-03
     AT TIME = 0.7141E+06  CONC = 0.2702E-03
     AT TIME = 0.7141E+06  CONC = 0.2702E-03
     AT TIME = 0.7141E+06  CONC = 0.2702E-03
     AT TIME = 0.7833E+06  CONC = 0.2161E-03
     AT TIME = 0.8664E+06  CONC = 0.1402E-03
     AT TIME = 0.9662E+06  CONC = 0.6753E-04
     AT TIME = 0.1086E+07  CONC = 0.1875E-04
     AT TIME = 0.1553E+07  CONC = -.4176E-05

1                          UNSATURATED ZONE TRANSPORT RESULTS


 SERIAL NUMBER          TIME              DEPTH        CONCENTRATION        NORMALIZED
                                                                            CONCENTRATION
```

Cannon AFB SD-11 - Vadose Zone

Benzo(a)pyrene - Pulse Source - Sorption

VADOSE FLOW MODEL: INPUT PARAMETERS AND OUTPUT

SIMULATION RUN FOR Benzo(a)pyrene

	CONSTANT PARMS	FOR MATERIAL 1
Saturated hydraulic conductivity	cm/hr	21.0
Unsaturated zone porosity	--	0.437
Air entry pressure head	m	0.726E-01
Depth of the unsaturated zone	m	59.0
Residual water content	--	0.200E-01
Brook and Corey exponent,EN	--	0.000
ALFA coefficient	1/cm	0.145
Van Genuchten exponent, ENN	--	2.68

MONTE CARLO AND MODEL DERIVED PARMS ARE LISTED BELOW,
ONE LINE FOR EACH MATERIAL, FOR EXAMPLE:

RUN NO.	NLAYER
1	1

THESE ARE THE MONTE CARLO AND DERIVED VALUES USED
FOR THE FIRST ITERATION, LAYER 1
VALUES FOR OTHER ITERATIONS FOLLOW THE LAST CONSTANT PARM LISTING

VADOSE FLOW MODEL RESULTS FOR RUN NO. 1

STEADY-STATE UNSATURATED FLOW MODEL RESULTS

	NODE DEPTH	DARCY VELOCITY	WATER SATURATION	HEAD
1	0.000E+00	0.510E-01	0.155E+00	-0.248E+00
2	0.100E+01	0.510E-01	0.155E+00	-0.248E+00
3	0.200E+01	0.510E-01	0.155E+00	-0.248E+00
4	0.300E+01	0.510E-01	0.155E+00	-0.248E+00
5	0.400E+01	0.510E-01	0.155E+00	-0.248E+00
6	0.500E+01	0.510E-01	0.155E+00	-0.248E+00
7	0.600E+01	0.510E-01	0.155E+00	-0.248E+00
8	0.700E+01	0.510E-01	0.155E+00	-0.248E+00
9	0.800E+01	0.510E-01	0.155E+00	-0.248E+00
10	0.900E+01	0.510E-01	0.155E+00	-0.248E+00
11	0.100E+02	0.510E-01	0.155E+00	-0.248E+00
12	0.110E+02	0.510E-01	0.155E+00	-0.248E+00
13	0.120E+02	0.510E-01	0.155E+00	-0.248E+00
14	0.130E+02	0.510E-01	0.155E+00	-0.248E+00

15	0.140E+02	0.510E-01	0.155E+00	-0.248E+00
16	0.150E+02	0.510E-01	0.155E+00	-0.248E+00
17	0.160E+02	0.510E-01	0.155E+00	-0.248E+00
18	0.170E+02	0.510E-01	0.155E+00	-0.248E+00
19	0.180E+02	0.510E-01	0.155E+00	-0.248E+00
20	0.190E+02	0.510E-01	0.155E+00	-0.248E+00
21	0.200E+02	0.510E-01	0.155E+00	-0.248E+00
22	0.210E+02	0.510E-01	0.155E+00	-0.248E+00
23	0.220E+02	0.510E-01	0.155E+00	-0.248E+00
24	0.230E+02	0.510E-01	0.155E+00	-0.248E+00
25	0.240E+02	0.510E-01	0.155E+00	-0.248E+00
26	0.250E+02	0.510E-01	0.155E+00	-0.248E+00
27	0.260E+02	0.510E-01	0.155E+00	-0.248E+00
28	0.270E+02	0.510E-01	0.155E+00	-0.248E+00
29	0.280E+02	0.510E-01	0.155E+00	-0.248E+00
30	0.290E+02	0.510E-01	0.155E+00	-0.248E+00
31	0.300E+02	0.510E-01	0.155E+00	-0.248E+00
32	0.310E+02	0.510E-01	0.155E+00	-0.248E+00
33	0.320E+02	0.510E-01	0.155E+00	-0.248E+00
34	0.330E+02	0.510E-01	0.155E+00	-0.248E+00
35	0.340E+02	0.510E-01	0.155E+00	-0.248E+00
36	0.350E+02	0.510E-01	0.155E+00	-0.248E+00
37	0.360E+02	0.510E-01	0.155E+00	-0.248E+00
38	0.370E+02	0.510E-01	0.155E+00	-0.248E+00
39	0.380E+02	0.510E-01	0.155E+00	-0.248E+00
40	0.390E+02	0.510E-01	0.155E+00	-0.248E+00
41	0.400E+02	0.510E-01	0.155E+00	-0.248E+00
42	0.410E+02	0.510E-01	0.155E+00	-0.248E+00
43	0.420E+02	0.510E-01	0.155E+00	-0.248E+00
44	0.430E+02	0.510E-01	0.155E+00	-0.248E+00
45	0.440E+02	0.510E-01	0.155E+00	-0.248E+00
46	0.450E+02	0.510E-01	0.155E+00	-0.248E+00
47	0.460E+02	0.510E-01	0.155E+00	-0.248E+00
48	0.470E+02	0.510E-01	0.155E+00	-0.248E+00
49	0.480E+02	0.510E-01	0.155E+00	-0.248E+00
50	0.490E+02	0.510E-01	0.155E+00	-0.248E+00
51	0.500E+02	0.510E-01	0.155E+00	-0.248E+00
52	0.510E+02	0.510E-01	0.155E+00	-0.248E+00
53	0.520E+02	0.510E-01	0.155E+00	-0.248E+00
54	0.530E+02	0.510E-01	0.155E+00	-0.248E+00
55	0.540E+02	0.510E-01	0.155E+00	-0.248E+00
56	0.550E+02	0.510E-01	0.155E+00	-0.248E+00
57	0.560E+02	0.510E-01	0.155E+00	-0.248E+00
58	0.570E+02	0.510E-01	0.160E+00	-0.247E+00
59	0.580E+02	0.510E-01	0.388E+00	-0.234E+00
60	0.590E+02	0.510E-01	0.100E+01	0.000E+00

1

U. S. E N V I R O N M E N T A L P R O T E C T I O N A G E N C Y

E X P O S U R E A S S E S S M E N T

M U L T I M E D I A M O D E L

MULTIMED - (Version 2.00 Beta - October 1996)

1

Run options
--- -------

Cannon AFB SD-11 - Vadose Zone

Benzo(a)pyrene - Pulse Source - Sorption/Biodegradation
Chemical simulated is Benzo(a)pyrene

Option Chosen	Saturated and unsaturated zone models
Run was	DETERMIN

Infiltration input by user
Run was transient
Reject runs if Y coordinate outside plume
Do not reject runs if Z coordinate outside plume
Gaussian source used in saturated zone model

1

1

UNSATURATED ZONE FLOW MODEL PARAMETERS
(input parameter description and value)

NP	- Total number of nodal points	240
NMAT	- Number of different porous materials	1
KPROP	- Van Genuchten or Brooks and Corey	1
IMSHGN	- Spatial discretization option	1
NVFLAYR	- Number of layers in flow model	1

OPTIONS CHOSEN
------- ------
Van Genuchten functional coefficients
User defined coordinate system

1

Layer information

LAYER NO.	LAYER THICKNESS	MATERIAL PROPERTY
1	59.00	1

DATA FOR MATERIAL 1

VADOSE ZONE MATERIAL VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Saturated hydraulic conductivity	cm/hr	CONSTANT	21.0	-999.	0.100E-10	0.100E+05
Unsaturated zone porosity	--	CONSTANT	0.437	-999.	0.100E-08	0.990
Air entry pressure head	m	CONSTANT	0.726E-01	-999.	0.000	-999.
Depth of the unsaturated zone	m	CONSTANT	59.0	-999.	0.100E-08	-999.

DATA FOR MATERIAL 1

VADOSE ZONE FUNCTION VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Residual water content	--	CONSTANT	0.200E-01	-999.	0.100E-08	1.00
Brook and Corey exponent,EN	--	CONSTANT	0.000	-999.	0.000	10.0
ALFA coefficient	1/cm	CONSTANT	0.145	-999.	0.000	1.00
Van Genuchten exponent, ENN	--	CONSTANT	2.68	-999.	1.00	5.00

1

UNSATURATED ZONE TRANSPORT MODEL PARAMETERS

Currently Not Used in Multimed Version 2.0		1
NTSTPS	- Number of time values concentration calc	20
DUMMY	- Not presently used	1
ISOL	- Type of scheme used in unsaturated zone	1
N	- Stehfest terms or number of increments	18
NTEL	- Points in Lagrangian interpolation	3
NGPTS	- Number of Gauss points	104
NIT	- Convolution integral segments	2

IBOUND - Type of boundary condition		2
ITSGEN - Time values generated or input		1
TMAX - Max simulation time	--	0.0
WTFUN - Weighting factor	--	1.2
Used only for Numerical Model	--	0.0
Used only for Numerical Model	--	0.0
Used only for Numerical Model	--	0.0
Used only for Numerical Model	--	0.0
Used only for Numerical Model	--	0.0

OPTIONS CHOSEN
------- ------
Analytical unsaturated zone model
Stehfest numerical inversion algorithm
Nondecaying pulse source
Computer generated times for computing concentrations
1

DATA FOR MATERIAL 1
---- --- --------
VADOSE TRANSPORT VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Longitudinal dispersivity of material	m	CONSTANT	1.00	-999.	0.100E-02	0.100E+05
Percent organic matter	--	CONSTANT	0.700E-01	-999.	0.000	100.
Bulk density of soil for material	g/cc	CONSTANT	1.49	-999.	0.100E-01	5.00
Biological decay coefficient	1/yr	CONSTANT	0.690E-01	-999.	0.000	-999.
Parameter not used by the Analytical Model		CONSTANT	0.000	0.000	0.000	0.000
Parameter not used by the Analytical Model		CONSTANT	0.000	0.000	0.000	0.000

1

CHEMICAL SPECIFIC VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS, MEAN	STD DEV	LIMITS MIN	MAX
Solid phase decay coefficient	1/yr	DERIVED	-999.	-999.	0.000	0.100E+11
Dissolved phase decay coefficient	1/yr	DERIVED	-999.	-999.	0.000	0.100E+11
Overall chemical decay coefficient	1/yr	DERIVED	-999.	-999.	0.000	0.100E+11
Acid catalyzed hydrolysis rate	1/M-yr	CONSTANT	0.000	-999.	0.000	-999.
Neutral hydrolysis rate constant	1/yr	CONSTANT	0.000	-999.	0.000	-999.
Base catalyzed hydrolysis rate	1/M-yr	CONSTANT	0.000	-999.	0.000	-999.
Reference temperature	C	CONSTANT	25.0	-999.	0.000	100.
Normalized distribution coefficient	ml/g	CONSTANT	0.102E+07	-999.	0.000	-999.
Distribution coefficient	--	DERIVED	420.	-999.	0.000	0.100E+11
Biodegradation coefficient (sat. zone)	1/yr	CONSTANT	0.000	-999.	0.000	-999.
Air diffusion coefficient	cm2/s	CONSTANT	0.000	-999.	0.000	10.0
Reference temperature for air diffusion	C	CONSTANT	25.0	-999.	0.000	100.
Molecular weight	g/M	CONSTANT	0.000	-999.	0.000	-999.
Mole fraction of solute	--	CONSTANT	0.000	-999.	0.100E-08	1.00
Vapor pressure of solute	mm Hg	CONSTANT	0.000	-999.	0.000	100.
Henry`s law constant	atm-m^3/M	CONSTANT	0.000	-999.	0.100E-09	1.00
Overall 1st order decay sat. zone	1/yr	DERIVED	0.000	0.000	0.000	1.00
Soil/Air Boundary Layer Thickness	cm	CONSTANT	-999.	-999.	0.000	-999.
Not currently used		CONSTANT	-999.	-999.	0.000	1.00

1

SOURCE SPECIFIC VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	STD DEV	LIMITS MIN	MAX
Infiltration rate	m/yr	CONSTANT	0.510E-01	-999.	0.100E-09	0.100E+11
Area of waste disposal unit	m^2	CONSTANT	0.100E+04	-999.	0.100E-01	-999.
Duration of pulse	yr	CONSTANT	100.	-999.	0.100E-08	-999.
Spread of contaminant source	m	DERIVED	-999.	-999.	0.100E-08	0.100E+11
Recharge rate	m/yr	CONSTANT	0.510E-01	-999.	0.000	0.100E+11
Source decay constant	1/yr	CONSTANT	0.000	-999.	0.000	-999.
Initial concentration at landfill	mg/l	CONSTANT	1.00	-999.	0.000	-999.
Length scale of facility	m	DERIVED	-999.	-999.	0.100E-08	0.100E+11
Width scale of facility	m	DERIVED	-999.	-999.	0.100E-08	0.100E+11
Near field dilution		DERIVED	1.00	0.000	0.000	1.00

1

AQUIFER SPECIFIC VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Particle diameter	cm	CONSTANT	0.200	-999.	0.100E-08	100.
Aquifer porosity	--	CONSTANT	0.400	-999.	0.100E-08	0.990
Bulk density	g/cc	CONSTANT	1.59	-999.	0.100E-01	5.00
Aquifer thickness	m	CONSTANT	37.0	-999.	0.100E-08	0.100E+06
Source thickness (mixing zone depth)	m	DERIVED	-999.	-999.	0.100E-08	0.100E+06
Conductivity (hydraulic)	m/yr	CONSTANT	0.320E+04	-999.	0.100E-06	0.100E+09
Gradient (hydraulic)		CONSTANT	0.150E-02	-999.	0.100E-07	-999.
Groundwater seepage velocity	m/yr	DERIVED	12.0	-999.	0.100E-09	0.100E+09
Retardation coefficient	--	DERIVED	0.167E+04	-999.	1.00	0.100E+09
Longitudinal dispersivity	m	CONSTANT	0.100	-999.	0.100E-02	0.100E+05
Transverse dispersivity	m	CONSTANT	0.333E-01	-999.	0.100E-02	0.100E+05
Vertical dispersivity	m	CONSTANT	0.560E-02	-999.	0.100E-02	0.100E+05
Temperature of aquifer	C	CONSTANT	12.0	-999.	0.000	100.
pH	--	CONSTANT	6.80	-999.	0.300	14.0
Organic carbon content (fraction)		CONSTANT	0.400E-03	-999.	0.100E-05	1.00
Well distance from site	m	CONSTANT	1.00	-999.	1.00	-999.
Angle off center	degree	CONSTANT	0.000	-999.	0.000	360.
Well vertical distance	m	CONSTANT	0.000	-999.	0.000	1.00

1

TIME	CONCENTRATION
-.815E+05	0.00000E+00
0.000E+00	0.00000E+00

SD11PSB


```
CONCENTRATION AT BOTTOM OF VADOSE ZONE
 RUN NO.    1
     AT TIME = 0.3422E+06  CONC = 0.0000E+00
     AT TIME = 0.4619E+06  CONC = 0.0000E+00
     AT TIME = 0.5616E+06  CONC = 0.0000E+00
     AT TIME = 0.6447E+06  CONC = 0.0000E+00
     AT TIME = 0.7140E+06  CONC = 0.0000E+00
     AT TIME = 0.7140E+06  CONC = 0.0000E+00
     AT TIME = 0.7140E+06  CONC = 0.0000E+00
     AT TIME = 0.7140E+06  CONC = 0.0000E+00
     AT TIME = 0.7140E+06  CONC = 0.0000E+00
     AT TIME = 0.7140E+06  CONC = 0.0000E+00
     AT TIME = 0.7140E+06  CONC = 0.0000E+00
     AT TIME = 0.7140E+06  CONC = 0.0000E+00
     AT TIME = 0.7141E+06  CONC = 0.0000E+00
     AT TIME = 0.7141E+06  CONC = 0.0000E+00
     AT TIME = 0.7141E+06  CONC = 0.0000E+00
     AT TIME = 0.7833E+06  CONC = 0.0000E+00
     AT TIME = 0.8664E+06  CONC = 0.0000E+00
     AT TIME = 0.9662E+06  CONC = 0.0000E+00
     AT TIME = 0.1086E+07  CONC = 0.0000E+00
     AT TIME = 0.1553E+07  CONC = 0.0000E+00
```

1 UNSATURATED ZONE TRANSPORT RESULTS

SERIAL NUMBER	TIME	DEPTH	CONCENTRATION	NORMALIZED CONCENTRATION

Cannon AFB SD-11 - Vadose Zone

Benzo(a)pyrene - Pulse Source - Sorption/Biodegradation

VADOSE FLOW MODEL: INPUT PARAMETERS AND OUTPUT

SIMULATION RUN FOR Benzo(a)pyrene

	CONSTANT PARMS FOR MATERIAL 1	
Saturated hydraulic conductivity	cm/hr	21.0
Unsaturated zone porosity	--	0.437
Air entry pressure head	m	0.726E-01
Depth of the unsaturated zone	m	59.0
Residual water content	--	0.200E-01
Brook and Corey exponent,EN	--	0.000
ALFA coefficient	1/cm	0.145
Van Genuchten exponent, ENN	--	2.68

MONTE CARLO AND MODEL DERIVED PARMS ARE LISTED BELOW,
ONE LINE FOR EACH MATERIAL, FOR EXAMPLE:

RUN NO.	NLAYER
1	1

THESE ARE THE MONTE CARLO AND DERIVED VALUES USED
FOR THE FIRST ITERATION, LAYER 1
VALUES FOR OTHER ITERATIONS FOLLOW THE LAST CONSTANT PARM LISTING

VADOSE FLOW MODEL RESULTS FOR RUN NO. 1

STEADY-STATE UNSATURATED FLOW MODEL RESULTS

	NODE DEPTH	DARCY VELOCITY	WATER SATURATION	HEAD
1	0.000E+00	0.510E-01	0.155E+00	-0.248E+00
2	0.100E+01	0.510E-01	0.155E+00	-0.248E+00
3	0.200E+01	0.510E-01	0.155E+00	-0.248E+00
4	0.300E+01	0.510E-01	0.155E+00	-0.248E+00
5	0.400E+01	0.510E-01	0.155E+00	-0.248E+00
6	0.500E+01	0.510E-01	0.155E+00	-0.248E+00
7	0.600E+01	0.510E-01	0.155E+00	-0.248E+00
8	0.700E+01	0.510E-01	0.155E+00	-0.248E+00
9	0.800E+01	0.510E-01	0.155E+00	-0.248E+00
10	0.900E+01	0.510E-01	0.155E+00	-0.248E+00
11	0.100E+02	0.510E-01	0.155E+00	-0.248E+00
12	0.110E+02	0.510E-01	0.155E+00	-0.248E+00
13	0.120E+02	0.510E-01	0.155E+00	-0.248E+00
14	0.130E+02	0.510E-01	0.155E+00	-0.248E+00
15	0.140E+02	0.510E-01	0.155E+00	-0.248E+00

16	0.150E+02	0.510E-01	0.155E+00	-0.248E+00
17	0.160E+02	0.510E-01	0.155E+00	-0.248E+00
18	0.170E+02	0.510E-01	0.155E+00	-0.248E+00
19	0.180E+02	0.510E-01	0.155E+00	-0.248E+00
20	0.190E+02	0.510E-01	0.155E+00	-0.248E+00
21	0.200E+02	0.510E-01	0.155E+00	-0.248E+00
22	0.210E+02	0.510E-01	0.155E+00	-0.248E+00
23	0.220E+02	0.510E-01	0.155E+00	-0.248E+00
24	0.230E+02	0.510E-01	0.155E+00	-0.248E+00
25	0.240E+02	0.510E-01	0.155E+00	-0.248E+00
26	0.250E+02	0.510E-01	0.155E+00	-0.248E+00
27	0.260E+02	0.510E-01	0.155E+00	-0.248E+00
28	0.270E+02	0.510E-01	0.155E+00	-0.248E+00
29	0.280E+02	0.510E-01	0.155E+00	-0.248E+00
30	0.290E+02	0.510E-01	0.155E+00	-0.248E+00
31	0.300E+02	0.510E-01	0.155E+00	-0.248E+00
32	0.310E+02	0.510E-01	0.155E+00	-0.248E+00
33	0.320E+02	0.510E-01	0.155E+00	-0.248E+00
34	0.330E+02	0.510E-01	0.155E+00	-0.248E+00
35	0.340E+02	0.510E-01	0.155E+00	-0.248E+00
36	0.350E+02	0.510E-01	0.155E+00	-0.248E+00
37	0.360E+02	0.510E-01	0.155E+00	-0.248E+00
38	0.370E+02	0.510E-01	0.155E+00	-0.248E+00
39	0.380E+02	0.510E-01	0.155E+00	-0.248E+00
40	0.390E+02	0.510E-01	0.155E+00	-0.248E+00
41	0.400E+02	0.510E-01	0.155E+00	-0.248E+00
42	0.410E+02	0.510E-01	0.155E+00	-0.248E+00
43	0.420E+02	0.510E-01	0.155E+00	-0.248E+00
44	0.430E+02	0.510E-01	0.155E+00	-0.248E+00
45	0.440E+02	0.510E-01	0.155E+00	-0.248E+00
46	0.450E+02	0.510E-01	0.155E+00	-0.248E+00
47	0.460E+02	0.510E-01	0.155E+00	-0.248E+00
48	0.470E+02	0.510E-01	0.155E+00	-0.248E+00
49	0.480E+02	0.510E-01	0.155E+00	-0.248E+00
50	0.490E+02	0.510E-01	0.155E+00	-0.248E+00
51	0.500E+02	0.510E-01	0.155E+00	-0.248E+00
52	0.510E+02	0.510E-01	0.155E+00	-0.248E+00
53	0.520E+02	0.510E-01	0.155E+00	-0.248E+00
54	0.530E+02	0.510E-01	0.155E+00	-0.248E+00
55	0.540E+02	0.510E-01	0.155E+00	-0.248E+00
56	0.550E+02	0.510E-01	0.155E+00	-0.248E+00
57	0.560E+02	0.510E-01	0.155E+00	-0.248E+00
58	0.570E+02	0.510E-01	0.160E+00	-0.247E+00
59	0.580E+02	0.510E-01	0.388E+00	-0.234E+00
60	0.590E+02	0.510E-01	0.100E+01	0.000E+00

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U. S. ENVIRONMENTAL PROTECTION AGENCY

EXPOSURE ASSESSMENT

MULTIMEDIA MODEL

MULTIMED - (Version 2.00 Beta - October 1996)

1

Run options
--- -------

Cannon AFB SD-11 - Vadose Zone

Benzo(a)pyrene - Decay Source - Sorption
Chemical simulated is Benzo(a)pyrene

Option Chosen Saturated and unsaturated zone models
Run was DETERMIN
Infiltration input by user
Run was transient
Reject runs if Y coordinate outside plume
Do not reject runs if Z coordinate outside plume
Gaussian source used in saturated zone model

1

1

UNSATURATED ZONE FLOW MODEL PARAMETERS
(input parameter description and value)

NP	- Total number of nodal points	240
NMAT	- Number of different porous materials	1
KPROP	- Van Genuchten or Brooks and Corey	1
IMSHGN	- Spatial discretization option	1
NVFLAYR	- Number of layers in flow model	1

OPTIONS CHOSEN
------- ------
Van Genuchten functional coefficients
User defined coordinate system

1

Layer information

LAYER NO.	LAYER THICKNESS	MATERIAL PROPERTY
1	59.00	1

DATA FOR MATERIAL 1

VADOSE ZONE MATERIAL VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Saturated hydraulic conductivity	cm/hr	CONSTANT	21.0	-999.	0.100E-10	0.100E+05
Unsaturated zone porosity	--	CONSTANT	0.437	-999.	0.100E-08	0.990
Air entry pressure head	m	CONSTANT	0.726E-01	-999.	0.000	-999.
Depth of the unsaturated zone	m	CONSTANT	59.0	-999.	0.100E-08	-999.

DATA FOR MATERIAL 1

VADOSE ZONE FUNCTION VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Residual water content	--	CONSTANT	0.200E-01	-999.	0.100E-08	1.00
Brook and Corey exponent,EN	--	CONSTANT	0.000	-999.	0.000	10.0
ALFA coefficient	1/cm	CONSTANT	0.145	-999.	0.000	1.00
Van Genuchten exponent, ENN	--	CONSTANT	2.68	-999.	1.00	5.00

1

UNSATURATED ZONE TRANSPORT MODEL PARAMETERS

Currently Not Used in Multimed Version 2.0		1
NTSTPS	- Number of time values concentration calc	20
DUMMY	- Not presently used	1
ISOL	- Type of scheme used in unsaturated zone	1
N	- Stehfest terms or number of increments	18
NTEL	- Points in Lagrangian interpolation	3
NGPTS	- Number of Gauss points	104
NIT	- Convolution integral segments	2

IBOUND - Type of boundary condition		3
ITSGEN - Time values generated or input		1
TMAX - Max simulation time	--	0.0
WTFUN - Weighting factor	--	1.2
Used only for Numerical Model	--	0.0
Used only for Numerical Model	--	0.0
Used only for Numerical Model	--	0.0
Used only for Numerical Model	--	0.0
Used only for Numerical Model	--	0.0

OPTIONS CHOSEN
------- ------
Analytical unsaturated zone model
Stehfest numerical inversion algorithm
Exponentially decaying continuous source
Computer generated times for computing concentrations
1

DATA FOR MATERIAL 1
---- --- --------
VADOSE TRANSPORT VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Longitudinal dispersivity of material	m	CONSTANT	1.00	-999.	0.100E-02	0.100E+05
Percent organic matter	--	CONSTANT	0.700E-01	-999.	0.000	100.
Bulk density of soil for material	g/cc	CONSTANT	1.49	-999.	0.100E-01	5.00
Biological decay coefficient	1/yr	CONSTANT	0.000	-999.	0.000	-999.
Parameter not used by the Analytical Model		CONSTANT	0.000	0.000	0.000	0.000
Parameter not used by the Analytical Model		CONSTANT	0.000	0.000	0.000	0.000

1

CHEMICAL SPECIFIC VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Solid phase decay coefficient	1/yr	DERIVED	-999.	-999.	0.000	0.100E+11
Dissolved phase decay coefficient	1/yr	DERIVED	-999.	-999.	0.000	0.100E+11
Overall chemical decay coefficient	1/yr	DERIVED	-999.	-999.	0.000	0.100E+11
Acid catalyzed hydrolysis rate	1/M-yr	CONSTANT	0.000	-999.	0.000	-999.
Neutral hydrolysis rate constant	1/yr	CONSTANT	0.000	-999.	0.000	-999.
Base catalyzed hydrolysis rate	1/M-yr	CONSTANT	0.000	-999.	0.000	-999.
Reference temperature	C	CONSTANT	25.0	-999.	0.000	100.
Normalized distribution coefficient	ml/g	CONSTANT	0.102E+07	-999.	0.000	-999.
Distribution coefficient	--	DERIVED	420.	-999.	0.000	0.100E+11
Biodegradation coefficient (sat. zone)	1/yr	CONSTANT	0.000	-999.	0.000	-999.
Air diffusion coefficient	cm2/s	CONSTANT	0.000	-999.	0.000	10.0
Reference temperature for air diffusion	C	CONSTANT	25.0	-999.	0.000	100.
Molecular weight	g/M	CONSTANT	0.000	-999.	0.000	-999.
Mole fraction of solute	--	CONSTANT	0.000	-999.	0.100E-08	1.00
Vapor pressure of solute	mm Hg	CONSTANT	0.000	-999.	0.000	100.
Henry`s law constant	atm-m^3/M	CONSTANT	0.000	-999.	0.100E-09	1.00
Overall 1st order decay sat. zone	1/yr	DERIVED	0.000	0.000	0.000	1.00
Soil/Air Boundary Layer Thickness	cm	CONSTANT	-999.	-999.	0.000	-999.
Not currently used		CONSTANT	-999.	-999.	0.000	1.00

1

SOURCE SPECIFIC VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Infiltration rate	m/yr	CONSTANT	0.510E-01	-999.	0.100E-09	0.100E+11
Area of waste disposal unit	m^2	CONSTANT	0.100E+04	-999.	0.100E-01	-999.
Duration of pulse	yr	CONSTANT	100.	-999.	0.100E-08	-999.
Spread of contaminant source	m	DERIVED	-999.	-999.	0.100E-08	0.100E+11
Recharge rate	m/yr	CONSTANT	0.510E-01	-999.	0.000	0.100E+11
Source decay constant	1/yr	CONSTANT	0.690E-01	-999.	0.000	-999.
Initial concentration at landfill	mg/l	CONSTANT	1.00	-999.	0.000	-999.
Length scale of facility	m	DERIVED	-999.	-999.	0.100E-08	0.100E+11
Width scale of facility	m	DERIVED	-999.	-999.	0.100E-08	0.100E+11
Near field dilution		DERIVED	1.00	0.000	0.000	1.00

1

AQUIFER SPECIFIC VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Particle diameter	cm	CONSTANT	0.200	-999.	0.100E-08	100.
Aquifer porosity	--	CONSTANT	0.400	-999.	0.100E-08	0.990
Bulk density	g/cc	CONSTANT	1.59	-999.	0.100E-01	5.00
Aquifer thickness	m	CONSTANT	37.0	-999.	0.100E-08	0.100E+06
Source thickness (mixing zone depth)	m	DERIVED	-999.	-999.	0.100E-08	0.100E+06
Conductivity (hydraulic)	m/yr	CONSTANT	0.320E+04	-999.	0.100E-06	0.100E+09
Gradient (hydraulic)		CONSTANT	0.150E-02	-999.	0.100E-07	-999.
Groundwater seepage velocity	m/yr	DERIVED	12.0	-999.	0.100E-09	0.100E+09
Retardation coefficient	--	DERIVED	0.167E+04	-999.	1.00	0.100E+09
Longitudinal dispersivity	m	CONSTANT	0.100	-999.	0.100E-02	0.100E+05
Transverse dispersivity	m	CONSTANT	0.333E-01	-999.	0.100E-02	0.100E+05
Vertical dispersivity	m	CONSTANT	0.560E-02	-999.	0.100E-02	0.100E+05
Temperature of aquifer	C	CONSTANT	12.0	-999.	0.000	100.
pH	--	CONSTANT	6.80	-999.	0.300	14.0
Organic carbon content (fraction)		CONSTANT	0.400E-03	-999.	0.100E-05	1.00
Well distance from site	m	CONSTANT	1.00	-999.	1.00	-999.
Angle off center	degree	CONSTANT	0.000	-999.	0.000	360.
Well vertical distance	m	CONSTANT	0.000	-999.	0.000	1.00

CONCENTRATION AFTER SATURATED ZONE MODEL 0.0000

SD11DS


```
CONCENTRATION AT BOTTOM OF VADOSE ZONE
 RUN NO.    1
     AT TIME = 0.3422E+06  CONC = -.7880E-06
     AT TIME = 0.4351E+06  CONC = 0.1997E-05
     AT TIME = 0.5281E+06  CONC = 0.2180E-04
     AT TIME = 0.6210E+06  CONC = 0.3845E-04
     AT TIME = 0.7140E+06  CONC = 0.3935E-04
     AT TIME = 0.1553E+07  CONC = -.4999E-06
```

1 UNSATURATED ZONE TRANSPORT RESULTS

SERIAL NUMBER	TIME	DEPTH	CONCENTRATION	NORMALIZED CONCENTRATION

Cannon AFB SD-11 - Vadose Zone

Benzo(a)pyrene - Decay Source - Sorption

VADOSE FLOW MODEL: INPUT PARAMETERS AND OUTPUT

SIMULATION RUN FOR Benzo(a)pyrene

CONSTANT PARMS FOR MATERIAL 1		
Saturated hydraulic conductivity	cm/hr	21.0
Unsaturated zone porosity	--	0.437
Air entry pressure head	m	0.726E-01
Depth of the unsaturated zone	m	59.0
Residual water content	--	0.200E-01
Brook and Corey exponent,EN	--	0.000
ALFA coefficient	1/cm	0.145
Van Genuchten exponent, ENN	--	2.68

MONTE CARLO AND MODEL DERIVED PARMS ARE LISTED BELOW,
ONE LINE FOR EACH MATERIAL, FOR EXAMPLE:

RUN NO.	NLAYER
1	1

THESE ARE THE MONTE CARLO AND DERIVED VALUES USED
FOR THE FIRST ITERATION, LAYER 1
VALUES FOR OTHER ITERATIONS FOLLOW THE LAST CONSTANT PARM LISTING

VADOSE FLOW MODEL RESULTS FOR RUN NO. 1

STEADY-STATE UNSATURATED FLOW MODEL RESULTS

	NODE DEPTH	DARCY VELOCITY	WATER SATURATION	HEAD
1	0.000E+00	0.510E-01	0.155E+00	-0.248E+00
2	0.100E+01	0.510E-01	0.155E+00	-0.248E+00
3	0.200E+01	0.510E-01	0.155E+00	-0.248E+00
4	0.300E+01	0.510E-01	0.155E+00	-0.248E+00
5	0.400E+01	0.510E-01	0.155E+00	-0.248E+00
6	0.500E+01	0.510E-01	0.155E+00	-0.248E+00
7	0.600E+01	0.510E-01	0.155E+00	-0.248E+00
8	0.700E+01	0.510E-01	0.155E+00	-0.248E+00
9	0.800E+01	0.510E-01	0.155E+00	-0.248E+00
10	0.900E+01	0.510E-01	0.155E+00	-0.248E+00
11	0.100E+02	0.510E-01	0.155E+00	-0.248E+00
12	0.110E+02	0.510E-01	0.155E+00	-0.248E+00
13	0.120E+02	0.510E-01	0.155E+00	-0.248E+00
14	0.130E+02	0.510E-01	0.155E+00	-0.248E+00
15	0.140E+02	0.510E-01	0.155E+00	-0.248E+00

16	0.150E+02	0.510E-01	0.155E+00	-0.248E+00
17	0.160E+02	0.510E-01	0.155E+00	-0.248E+00
18	0.170E+02	0.510E-01	0.155E+00	-0.248E+00
19	0.180E+02	0.510E-01	0.155E+00	-0.248E+00
20	0.190E+02	0.510E-01	0.155E+00	-0.248E+00
21	0.200E+02	0.510E-01	0.155E+00	-0.248E+00
22	0.210E+02	0.510E-01	0.155E+00	-0.248E+00
23	0.220E+02	0.510E-01	0.155E+00	-0.248E+00
24	0.230E+02	0.510E-01	0.155E+00	-0.248E+00
25	0.240E+02	0.510E-01	0.155E+00	-0.248E+00
26	0.250E+02	0.510E-01	0.155E+00	-0.248E+00
27	0.260E+02	0.510E-01	0.155E+00	-0.248E+00
28	0.270E+02	0.510E-01	0.155E+00	-0.248E+00
29	0.280E+02	0.510E-01	0.155E+00	-0.248E+00
30	0.290E+02	0.510E-01	0.155E+00	-0.248E+00
31	0.300E+02	0.510E-01	0.155E+00	-0.248E+00
32	0.310E+02	0.510E-01	0.155E+00	-0.248E+00
33	0.320E+02	0.510E-01	0.155E+00	-0.248E+00
34	0.330E+02	0.510E-01	0.155E+00	-0.248E+00
35	0.340E+02	0.510E-01	0.155E+00	-0.248E+00
36	0.350E+02	0.510E-01	0.155E+00	-0.248E+00
37	0.360E+02	0.510E-01	0.155E+00	-0.248E+00
38	0.370E+02	0.510E-01	0.155E+00	-0.248E+00
39	0.380E+02	0.510E-01	0.155E+00	-0.248E+00
40	0.390E+02	0.510E-01	0.155E+00	-0.248E+00
41	0.400E+02	0.510E-01	0.155E+00	-0.248E+00
42	0.410E+02	0.510E-01	0.155E+00	-0.248E+00
43	0.420E+02	0.510E-01	0.155E+00	-0.248E+00
44	0.430E+02	0.510E-01	0.155E+00	-0.248E+00
45	0.440E+02	0.510E-01	0.155E+00	-0.248E+00
46	0.450E+02	0.510E-01	0.155E+00	-0.248E+00
47	0.460E+02	0.510E-01	0.155E+00	-0.248E+00
48	0.470E+02	0.510E-01	0.155E+00	-0.248E+00
49	0.480E+02	0.510E-01	0.155E+00	-0.248E+00
50	0.490E+02	0.510E-01	0.155E+00	-0.248E+00
51	0.500E+02	0.510E-01	0.155E+00	-0.248E+00
52	0.510E+02	0.510E-01	0.155E+00	-0.248E+00
53	0.520E+02	0.510E-01	0.155E+00	-0.248E+00
54	0.530E+02	0.510E-01	0.155E+00	-0.248E+00
55	0.540E+02	0.510E-01	0.155E+00	-0.248E+00
56	0.550E+02	0.510E-01	0.155E+00	-0.248E+00
57	0.560E+02	0.510E-01	0.155E+00	-0.248E+00
58	0.570E+02	0.510E-01	0.160E+00	-0.247E+00
59	0.580E+02	0.510E-01	0.388E+00	-0.234E+00
60	0.590E+02	0.510E-01	0.100E+01	0.000E+00

1

U. S. ENVIRONMENTAL PROTECTION AGENCY

EXPOSURE ASSESSMENT

MULTIMEDIA MODEL

MULTIMED - (Version 2.00 Beta - October 1996)

1
Run options
--- -------

Cannon AFB SD-11 - Vadose Zone

Benzo(a)pyrene - Decay Source - Sorption/Biodegradation
Chemical simulated is Benzo(a)pyrene

Option Chosen Saturated and unsaturated zone models
Run was DETERMIN
Infiltration input by user
Run was transient
Reject runs if Y coordinate outside plume
Do not reject runs if Z coordinate outside plume
Gaussian source used in saturated zone model
1
1
UNSATURATED ZONE FLOW MODEL PARAMETERS
(input parameter description and value)

NP	- Total number of nodal points	240
NMAT	- Number of different porous materials	1
KPROP	- Van Genuchten or Brooks and Corey	1
IMSHGN	- Spatial discretization option	1
NVFLAYR	- Number of layers in flow model	1

OPTIONS CHOSEN
------- ------
Van Genuchten functional coefficients
User defined coordinate system
1

Layer information

LAYER NO.	LAYER THICKNESS	MATERIAL PROPERTY
1	59.00	1

DATA FOR MATERIAL 1

VADOSE ZONE MATERIAL VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Saturated hydraulic conductivity	cm/hr	CONSTANT	21.0	-999.	0.100E-10	0.100E+05
Unsaturated zone porosity	--	CONSTANT	0.437	-999.	0.100E-08	0.990
Air entry pressure head	m	CONSTANT	0.726E-01	-999.	0.000	-999.
Depth of the unsaturated zone	m	CONSTANT	59.0	-999.	0.100E-08	-999.

DATA FOR MATERIAL 1

VADOSE ZONE FUNCTION VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Residual water content	--	CONSTANT	0.200E-01	-999.	0.100E-08	1.00
Brook and Corey exponent,EN	--	CONSTANT	0.000	-999.	0.000	10.0
ALFA coefficient	1/cm	CONSTANT	0.145	-999.	0.000	1.00
Van Genuchten exponent, ENN	--	CONSTANT	2.68	-999.	1.00	5.00

1

UNSATURATED ZONE TRANSPORT MODEL PARAMETERS

Currently Not Used in Multimed Version 2.0		1
NTSTPS	- Number of time values concentration calc	20
DUMMY	- Not presently used	1
ISOL	- Type of scheme used in unsaturated zone	1
N	- Stehfest terms or number of increments	18
NTEL	- Points in Lagrangian interpolation	3
NGPTS	- Number of Gauss points	104
NIT	- Convolution integral segments	2

IBOUND - Type of boundary condition		3
ITSGEN - Time values generated or input		1
TMAX - Max simulation time	--	0.0
WTFUN - Weighting factor	--	1.2
Used only for Numerical Model	--	0.0
Used only for Numerical Model	--	0.0
Used only for Numerical Model	--	0.0
Used only for Numerical Model	--	0.0
Used only for Numerical Model	--	0.0

OPTIONS CHOSEN
--- ---

Analytical unsaturated zone model
Stehfest numerical inversion algorithm
Exponentially decaying continuous source
Computer generated times for computing concentrations

1

DATA FOR MATERIAL 1
--- --- ---

VADOSE TRANSPORT VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Longitudinal dispersivity of material	m	CONSTANT	1.00	-999.	0.100E-02	0.100E+05
Percent organic matter	--	CONSTANT	0.700E-01	-999.	0.000	100.
Bulk density of soil for material	g/cc	CONSTANT	1.49	-999.	0.100E-01	5.00
Biological decay coefficient	1/yr	CONSTANT	0.690E-01	-999.	0.000	-999.
Parameter not used by the Analytical Model		CONSTANT	0.000	0.000	0.000	0.000
Parameter not used by the Analytical Model		CONSTANT	0.000	0.000	0.000	0.000

1

CHEMICAL SPECIFIC VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Solid phase decay coefficient	1/yr	DERIVED	-999.	-999.	0.000	0.100E+11
Dissolved phase decay coefficient	1/yr	DERIVED	-999.	-999.	0.000	0.100E+11
Overall chemical decay coefficient	1/yr	DERIVED	-999.	-999.	0.000	0.100E+11
Acid catalyzed hydrolysis rate	1/M-yr	CONSTANT	0.000	-999.	0.000	-999.
Neutral hydrolysis rate constant	1/yr	CONSTANT	0.000	-999.	0.000	-999.
Base catalyzed hydrolysis rate	1/M-yr	CONSTANT	0.000	-999.	0.000	-999.
Reference temperature	C	CONSTANT	25.0	-999.	0.000	100.
Normalized distribution coefficient	ml/g	CONSTANT	0.102E+07	-999.	0.000	-999.
Distribution coefficient	--	DERIVED	420.	-999.	0.000	0.100E+11
Biodegradation coefficient (sat. zone)	1/yr	CONSTANT	0.000	-999.	0.000	-999.
Air diffusion coefficient	cm2/s	CONSTANT	0.000	-999.	0.000	10.0
Reference temperature for air diffusion	C	CONSTANT	25.0	-999.	0.000	100.
Molecular weight	g/M	CONSTANT	0.000	-999.	0.000	-999.
Mole fraction of solute	--	CONSTANT	0.000	-999.	0.100E-08	1.00
Vapor pressure of solute	mm Hg	CONSTANT	0.000	-999.	0.000	100.
Henry`s law constant	atm-m^3/M	CONSTANT	0.000	-999.	0.100E-09	1.00
Overall 1st order decay sat. zone	1/yr	DERIVED	0.000	0.000	0.000	1.00
Soil/Air Boundary Layer Thickness	cm	CONSTANT	-999.	-999.	0.000	-999.
Not currently used		CONSTANT	-999.	-999.	0.000	1.00

1

SOURCE SPECIFIC VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Infiltration rate	m/yr	CONSTANT	0.510E-01	-999.	0.100E-09	0.100E+11
Area of waste disposal unit	m^2	CONSTANT	0.100E+04	-999.	0.100E-01	-999.
Duration of pulse	yr	CONSTANT	100.	-999.	0.100E-08	-999.
Spread of contaminant source	m	DERIVED	-999.	-999.	0.100E-08	0.100E+11
Recharge rate	m/yr	CONSTANT	0.510E-01	-999.	0.000	0.100E+11
Source decay constant	1/yr	CONSTANT	0.690E-01	-999.	0.000	-999.
Initial concentration at landfill	mg/l	CONSTANT	1.00	-999.	0.000	-999.
Length scale of facility	m	DERIVED	-999.	-999.	0.100E-08	0.100E+11
Width scale of facility	m	DERIVED	-999.	-999.	0.100E-08	0.100E+11
Near field dilution		DERIVED	1.00	0.000	0.000	1.00

1

AQUIFER SPECIFIC VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Particle diameter	cm	CONSTANT	0.200	-999.	0.100E-08	100.
Aquifer porosity	--	CONSTANT	0.400	-999.	0.100E-08	0.990
Bulk density	g/cc	CONSTANT	1.59	-999.	0.100E-01	5.00
Aquifer thickness	m	CONSTANT	37.0	-999.	0.100E-08	0.100E+06
Source thickness (mixing zone depth)	m	DERIVED	-999.	-999.	0.100E-08	0.100E+06
Conductivity (hydraulic)	m/yr	CONSTANT	0.320E+04	-999.	0.100E-06	0.100E+09
Gradient (hydraulic)		CONSTANT	0.150E-02	-999.	0.100E-07	-999.
Groundwater seepage velocity	m/yr	DERIVED	12.0	-999.	0.100E-09	0.100E+09
Retardation coefficient	--	DERIVED	0.167E+04	-999.	1.00	0.100E+09
Longitudinal dispersivity	m	CONSTANT	0.100	-999.	0.100E-02	0.100E+05
Transverse dispersivity	m	CONSTANT	0.333E-01	-999.	0.100E-02	0.100E+05
Vertical dispersivity	m	CONSTANT	0.560E-02	-999.	0.100E-02	0.100E+05
Temperature of aquifer	C	CONSTANT	12.0	-999.	0.000	100.
pH	--	CONSTANT	6.80	-999.	0.300	14.0
Organic carbon content (fraction)		CONSTANT	0.400E-03	-999.	0.100E-05	1.00
Well distance from site	m	CONSTANT	1.00	-999.	1.00	-999.
Angle off center	degree	CONSTANT	0.000	-999.	0.000	360.
Well vertical distance	m	CONSTANT	0.000	-999.	0.000	1.00

CONCENTRATION AFTER SATURATED ZONE MODEL 0.0000

SD11DSB


```
CONCENTRATION AT BOTTOM OF VADOSE ZONE
 RUN NO.    1
     AT TIME = 0.3422E+06  CONC = 0.0000E+00
     AT TIME = 0.4351E+06  CONC = 0.0000E+00
     AT TIME = 0.5281E+06  CONC = 0.0000E+00
     AT TIME = 0.6210E+06  CONC = 0.0000E+00
     AT TIME = 0.7140E+06  CONC = 0.0000E+00
     AT TIME = 0.1553E+07  CONC = 0.0000E+00
```

1 UNSATURATED ZONE TRANSPORT RESULTS

SERIAL NUMBER	TIME	DEPTH	CONCENTRATION	NORMALIZED CONCENTRATION

Cannon AFB SD-11 - Vadose Zone

Benzo(a)pyrene - Decay Source - Sorption/Biodegradation

VADOSE FLOW MODEL: INPUT PARAMETERS AND OUTPUT

SIMULATION RUN FOR Benzo(a)pyrene

	CONSTANT PARMS FOR MATERIAL 1	
Saturated hydraulic conductivity	cm/hr	21.0
Unsaturated zone porosity	--	0.437
Air entry pressure head	m	0.726E-01
Depth of the unsaturated zone	m	59.0
Residual water content	--	0.200E-01
Brook and Corey exponent,EN	--	0.000
ALFA coefficient	1/cm	0.145
Van Genuchten exponent, ENN	--	2.68

MONTE CARLO AND MODEL DERIVED PARMS ARE LISTED BELOW,
ONE LINE FOR EACH MATERIAL, FOR EXAMPLE:

RUN NO.	NLAYER
1	1

THESE ARE THE MONTE CARLO AND DERIVED VALUES USED
FOR THE FIRST ITERATION, LAYER 1
VALUES FOR OTHER ITERATIONS FOLLOW THE LAST CONSTANT PARM LISTING

VADOSE FLOW MODEL RESULTS FOR RUN NO. 1

STEADY-STATE UNSATURATED FLOW MODEL RESULTS

	NODE DEPTH	DARCY VELOCITY	WATER SATURATION	HEAD
1	0.000E+00	0.510E-01	0.155E+00	-0.248E+00
2	0.100E+01	0.510E-01	0.155E+00	-0.248E+00
3	0.200E+01	0.510E-01	0.155E+00	-0.248E+00
4	0.300E+01	0.510E-01	0.155E+00	-0.248E+00
5	0.400E+01	0.510E-01	0.155E+00	-0.248E+00
6	0.500E+01	0.510E-01	0.155E+00	-0.248E+00
7	0.600E+01	0.510E-01	0.155E+00	-0.248E+00
8	0.700E+01	0.510E-01	0.155E+00	-0.248E+00
9	0.800E+01	0.510E-01	0.155E+00	-0.248E+00
10	0.900E+01	0.510E-01	0.155E+00	-0.248E+00
11	0.100E+02	0.510E-01	0.155E+00	-0.248E+00
12	0.110E+02	0.510E-01	0.155E+00	-0.248E+00
13	0.120E+02	0.510E-01	0.155E+00	-0.248E+00
14	0.130E+02	0.510E-01	0.155E+00	-0.248E+00
15	0.140E+02	0.510E-01	0.155E+00	-0.248E+00

16	0.150E+02	0.510E-01	0.155E+00	-0.248E+00
17	0.160E+02	0.510E-01	0.155E+00	-0.248E+00
18	0.170E+02	0.510E-01	0.155E+00	-0.248E+00
19	0.180E+02	0.510E-01	0.155E+00	-0.248E+00
20	0.190E+02	0.510E-01	0.155E+00	-0.248E+00
21	0.200E+02	0.510E-01	0.155E+00	-0.248E+00
22	0.210E+02	0.510E-01	0.155E+00	-0.248E+00
23	0.220E+02	0.510E-01	0.155E+00	-0.248E+00
24	0.230E+02	0.510E-01	0.155E+00	-0.248E+00
25	0.240E+02	0.510E-01	0.155E+00	-0.248E+00
26	0.250E+02	0.510E-01	0.155E+00	-0.248E+00
27	0.260E+02	0.510E-01	0.155E+00	-0.248E+00
28	0.270E+02	0.510E-01	0.155E+00	-0.248E+00
29	0.280E+02	0.510E-01	0.155E+00	-0.248E+00
30	0.290E+02	0.510E-01	0.155E+00	-0.248E+00
31	0.300E+02	0.510E-01	0.155E+00	-0.248E+00
32	0.310E+02	0.510E-01	0.155E+00	-0.248E+00
33	0.320E+02	0.510E-01	0.155E+00	-0.248E+00
34	0.330E+02	0.510E-01	0.155E+00	-0.248E+00
35	0.340E+02	0.510E-01	0.155E+00	-0.248E+00
36	0.350E+02	0.510E-01	0.155E+00	-0.248E+00
37	0.360E+02	0.510E-01	0.155E+00	-0.248E+00
38	0.370E+02	0.510E-01	0.155E+00	-0.248E+00
39	0.380E+02	0.510E-01	0.155E+00	-0.248E+00
40	0.390E+02	0.510E-01	0.155E+00	-0.248E+00
41	0.400E+02	0.510E-01	0.155E+00	-0.248E+00
42	0.410E+02	0.510E-01	0.155E+00	-0.248E+00
43	0.420E+02	0.510E-01	0.155E+00	-0.248E+00
44	0.430E+02	0.510E-01	0.155E+00	-0.248E+00
45	0.440E+02	0.510E-01	0.155E+00	-0.248E+00
46	0.450E+02	0.510E-01	0.155E+00	-0.248E+00
47	0.460E+02	0.510E-01	0.155E+00	-0.248E+00
48	0.470E+02	0.510E-01	0.155E+00	-0.248E+00
49	0.480E+02	0.510E-01	0.155E+00	-0.248E+00
50	0.490E+02	0.510E-01	0.155E+00	-0.248E+00
51	0.500E+02	0.510E-01	0.155E+00	-0.248E+00
52	0.510E+02	0.510E-01	0.155E+00	-0.248E+00
53	0.520E+02	0.510E-01	0.155E+00	-0.248E+00
54	0.530E+02	0.510E-01	0.155E+00	-0.248E+00
55	0.540E+02	0.510E-01	0.155E+00	-0.248E+00
56	0.550E+02	0.510E-01	0.155E+00	-0.248E+00
57	0.560E+02	0.510E-01	0.155E+00	-0.248E+00
58	0.570E+02	0.510E-01	0.160E+00	-0.247E+00
59	0.580E+02	0.510E-01	0.388E+00	-0.234E+00
60	0.590E+02	0.510E-01	0.100E+01	0.000E+00