NASA GODDARD SPACE FLIGHT CENTER
WALLOPS FLIGHT FACILITY

FORMER FIRE TRAINING AREA REMEDIAL INVESTIGATION FINAL REPORT

February 28, 1996

Environmental A/E Services
Contract NAS5-35042
Delivery Order 18

Submitted to:
National Aeronautics and Space Administration
Goddard Space Flight Center
Wallops Flight Facility
Wallops Island, Virginia

Metcalf & Eddy
An Air & Water Technologies Company

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REMEDIAL INVESTIGATION REPORT
NASA - WALLOPS FLIGHT FACILITY
FORMER FIRE TRAINING AREA
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LIST OF ACRONYMS AND ABBREVIATIONS

ACWB	-	Accomack County Wetlands Board
AQUIRE	-	Aquatic Information Retrieval Toxicity Database
ARAR	-	Applicable or Relevant and Appropriate Requirement
ATSDR	-	Agency for Toxic Substances and Disease Registry
AVS	-	Acid-Volatile Sulfide
AWQC	-	Ambient Water Quality Criteria
BHC	-	Benzenehexachloride
CDC	-	Centers for Disease Control
CERCLA	-	Comprehensive Environmental Response, Compensation, and Liability Act
CLP	-	Contract Laboratory Program
CRQL	-	Contract Required Quantitation Limit
DDD	-	Dichlorodiphenyldichloroethane
DDE	-	Dichlorodiphenyldichloroethylene
DDT	-	Dichlorodiphenyltrichloroethane
DEQ	-	Department of Environmental Quality
dl	-	deciliter
DOT	-	Department of Transportation
DQO	-	Data Quality Objective
EPA	-	Environmental Protection Agency
FOP	-	Field Operations Plan
FS	-	Feasibility Study
FTA	-	Fire Training Area
GI	-	Gastro-Instestinal
H	-	Henry's Law Constant
HASP	-	Health and Safety Plan
HEAST	-	Health Effects Assessment Summary Tables
HI	-	Hazard Index
HRS	-	Hazard Ranking System
IDL	-	Instrument Detection Limit
IRIS	-	Integrated Risk Information System
K_{oc}	-	Organic Carbon Partition Coefficient
LC50	-	Lethal Concentration to 50 Percent of Test Organisms
LD50	-	Lethal Dose to 50 Percent of Test Organisms
LOAEL	-	Lowest Observable Adverse Effects Level
log K_{ow}	-	log Octanol/Water Partition Coefficient
M&E	-	Metcalf & Eddy, Inc.
MCL	-	Maximum Contaminant Level
MCLG	-	Maximum Contaminant Level Goal
mg/kg	-	millligrams per kilogram
MSL	-	Mean Sea Level
NASA	-	National Aeronautics and Space Administration
NCP	-	National Contingency Plan
NOAA	-	National Oceanic and Atmospheric Administration
NOAEL	-	No Observable Adverse Effects Level
NPL	-	National Priorities List

LIST OF ACRONYMS AND ABBREVIATIONS (continued)

NWI	-	National Wetlands Inventory
OC	-	Organic Carbon
O.D.	-	Outside Diameter
OVA	-	Organic Vapor Analyzer
PAH	-	Polycyclic Aromatic Hydrocarbon
PCBs	-	Polychlorinated Biphenyls
PCE	-	Tetrachloroethene
PID	-	Photoionization Detector
ppb	-	parts per billion
ppm	-	parts per million
PVC	-	Polyvinyl Chloride
QA/QC	-	Quality Assurance/Quality Control
RAGS II	-	Risk Assessment Guidance for Superfund, Volume II
RBCs	-	Risk-Based Concentrations
RfD	-	Reference Dose
RI	-	Remedial Investigation
RME	-	Reasonable Maximum Exposure
SARA	-	Superfund Amendments Reauthorization Act
SDWA	-	Safe Drinking Water Act
SEM	-	Simultaneously-Extracted Metal
SOP	-	Standard Operating Procedures
SWCB	-	State Water Control Board
T&E	-	Threatened and Endangered (Species)
TAL	-	Target Analyte List
TCE	-	Trichloroethene
TCL	-	Target Compound List
TCLP	-	Toxicity Characteristic Leaching Procedure
TEL	-	Tetraethyl Lead
TICs	-	Tentatively Identified Compounds
TOC	-	Town of Chicoteague
UCL	-	Upper Confidence Limit
USCS	-	Unified Soils Classification System
VDGIF	-	Commonwealth of Virginia Department of Game and Inland Fisheries
VOA	-	Volatile Organics Analysis
VOCs	-	Volatile Organic Compounds
VPDES	-	Virginia Pollutant Discharge Elimination System
WFF	-	Wallops Flight Facility
°F	-	Degrees Fahrenheit
μg/kg	-	micrograms per kilogram
μg/l	-	micrograms per liter

EXECUTIVE SUMMARY

The former Fire Training Area (FTA) is located on the Main Base of the National Aeronautics and Space Administration (NASA) Goddard Space Flight Center (GSFC) Wallops Flight Facility (WFF) in Accomack County, Virginia. Based on a Preliminary Assessment (PA) and a Site Inspection (SI) Report prepared by Ebasco Services, Inc., in 1988 and 1990, and a revised SI in 1992 by Metcalf & Eddy, Inc., the former FTA was identified as an area of concern at WFF. The SI indicated evidence of contamination in surface soils and groundwater. Four potential sources of contamination were identified at the site: the former fire training pit area, a former drum storage area, the sludge pile, and the construction debris disposal area.

In 1986, approximately 20 truckloads of soil contaminated with a mixture of jet fuel and crankcase oil were removed from the fire training pit area. Drums of unknown contents were stored near the pit area for an undetermined amount of time. The sludge pile was used for the disposal of sludge from the WFF Wastewater Treatment Facility. The dates of disposal are unknown. The construction debris disposal area was primarily used for storage of clean fill, but over the years became the unauthorized disposal area for construction debris such as concrete and metal.

As a part of this Remedial Investigation (RI), a field investigation was conducted to determine the physical characteristics of the site and the nature and extent of contamination. The field activities were conducted in December 1993 and January 1994. The field investigation consisted of a soil gas survey; soil borings; monitoring well installation; sample collection, analysis, and data validation; and a site survey. The soil gas survey was performed to determine potential contaminant migration since the 1990 SI Report, and to provide guidance for the selection of locations for monitoring wells and sampling locations.

Surface and subsurface soil samples were collected in the vicinity of the FTA training pit, former tank location, former drum storage area, sludge pile, and the construction debris disposal area. A total of 10 surface soil and 46 subsurface soil samples were collected. The groundwater investigation included the installation of 10 monitoring wells to determine the extent of contamination in the shallow aquifer. Fourteen wells, including four previously installed wells were sampled. In addition, four surface water and sediment samples were taken from bodies of ponded water near the FTA. Each sample was analyzed for concentrations of volatiles, semivolatiles, pesticides/polychlorinated biphenyls (PCBs), and metals.

The analysis and verification of data was performed as required under the Contract Laboratory Program (CLP). The data were further validated following U.S. Environmental Protection Agency (EPA) Region III data validation guidelines.

A human health risk assessment was conducted to characterize current and potential threats to human health that may be posed by the contaminants found at the site and migrating off-site. Conservative assumptions were used to estimate potential carcinogenic risks and noncarcinogenic hazards. Current land use was judged to be industrial with usage limited by the proximity of the active runway. Future land use, at the request of EPA Region III, was assessed as being residential. The analytical data were screened to focus the risk assessment on the chemicals expected to present the greatest risk at the site. The resulting chemicals of concern included several volatiles, semivolatiles, pesticides, and metals. The volatile chemicals of concern were 1,1-dichloroethene, cis-1,2-dichloroethene, methylene chloride, chloroform, benzene, tetrachloroethene, toluene, trimethylbenzene, and tetramethylbenzene. The semivolatiles included: 2-methylnaphthalene, naphthalene, phenanthrene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and benzo(g,h,i) perylene. The pesticides were alpha-BHC, heptachlor epoxide, and gamma-chlordane. The metals of concern were arsenic and lead. An exposure assessment and risk characterization were then conducted. Under the current land use scenario, the two chemicals which pose the greatest noncarcinogenic risk are arsenic and lead. The U.S. EPA Biokinetic Uptake Model was used to evaluate potential health impacts from the lead concentrations found at the site. The model results indicated that the site concentrations detected do not result in blood lead levels in excess of the EPA minimum action criterion of 10 micrograms (μg) lead/deciliter (dl) blood. Exposure to arsenic and several other chemicals such as 1,1-dichloroethene, methylene chloride, chloroform, benzene, tetrachloroethene, alpha-BHC, heptachlor epoxide, and gamma-chlordane may pose a carcinogenic risk.

An ecological risk assessment was also conducted. Observations were made of the flora and fauna present at the site as well as any potential exposure routes through which site-related contaminants could affect ecological receptors. After identifying the potential receptors and complete ecological pathways, the chemicals of ecological concern were determined. The semivolatile chemicals of concern included: di-n-butylphthalate, toxaphene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, benzo(g,h,i)perylene, bis(2-ethylhexyl)phthalate, di-n-octylphthalate, dibenz(a,h)anthracene, and diethylphthalate. The pesticides of ecological concern included: delta-BHC, endosulfan I, endosulfan sulfate, endrin aldehyde, endrin ketone, and 4,4-DDT. Finally, the

metals of concern included: aluminum, arsenic, barium, cadmium, calcium, copper, iron, lead, magnesium, manganese, mercury, potassium, sodium, and vanadium. An ecological risk was determined, using a worst case scenario for soil and sediment, by calculating maximum hazard quotients. The total hazard quotient was 0.72, which is less than the risk comparison value of one. Based upon the results of this assessment, it is unlikely that chemicals in environmental media at the former FTA present an ecological risk.

The primary source for groundwater and residual soil contamination is the former pit area. The estimated area and volume of contaminated groundwater in the water table (Pleistocene) aquifer is 40,272 square feet and 587,971 cubic feet. The estimated area and volume of contaminated soil is 22,240 square feet and 324,704 cubic feet. The direction of groundwater flow in the shallow aquifer is northeast toward Little Mosquito Creek. The contaminant plume extends approximately 400 feet northeast of the former pit area, while the creek is located 2500 feet northeast.

The results of the baseline risk assessment indicate that no remedial action is warranted for current land use conditions. For future residential land use, a scenario requested by the U.S. EPA Region III, risk to human health could result from use of contaminated groundwater as a potable water source. Since the residual soil contamination may serve as a continuing source to groundwater contamination, remedial alternatives for both media should be evaluated.

A Feasibility Study (FS) is recommended to evaluate remedial alternatives, including no action. Additional alternatives include institutional controls, such as a deed restriction, and remedial action alternatives to address groundwater contamination, using methods such as pump-and-treat, and soil contamination, encompassing in situ or ex situ treatment.

1.0 INTRODUCTION

1.1 REMEDIAL INVESTIGATION OBJECTIVES

The objectives of the Remedial Investigation (RI) are to provide the database and technical understanding needed to complete a Feasibility Study (FS) and, ultimately, to allow the selection of a cost-effective remedy which adequately protects human health and the environment. As a part of the RI process, a risk assessment is performed to evaluate the potential risks to human health and the environment associated with contamination detected at the former Fire Training Area (FTA) at the National Aeronautics and Space Administration (NASA) Wallops Flight Facility (WFF), and to provide the basis for remedial action decision-making.

The objectives of this RI are to:

- Characterize the nature, magnitude, and extent of contamination in soil, sediment, surface water, and groundwater, and the potential impacts contaminant migration may have on the environment and potential receptors; and

- Evaluate the potential risks to public health and the environment posed by contamination at the site.

Based upon the conclusions derived from performing these tasks, an evaluation of the necessity for, and extent of, remedial action at the site will be conducted as part of the FS. The FS will be submitted under separate cover and will consist of:

- Determination of need for source control actions;

- Determination of need for migration control actions;

- Identification of source and migration control actions appropriate to the site conditions, particularly those actions that would offer a permanent solution or reduction in waste mobility, toxicity, or volume; and

- Development and evaluation of appropriate migration and source control actions as well as the no action alternative.

1.2 SITE BACKGROUND

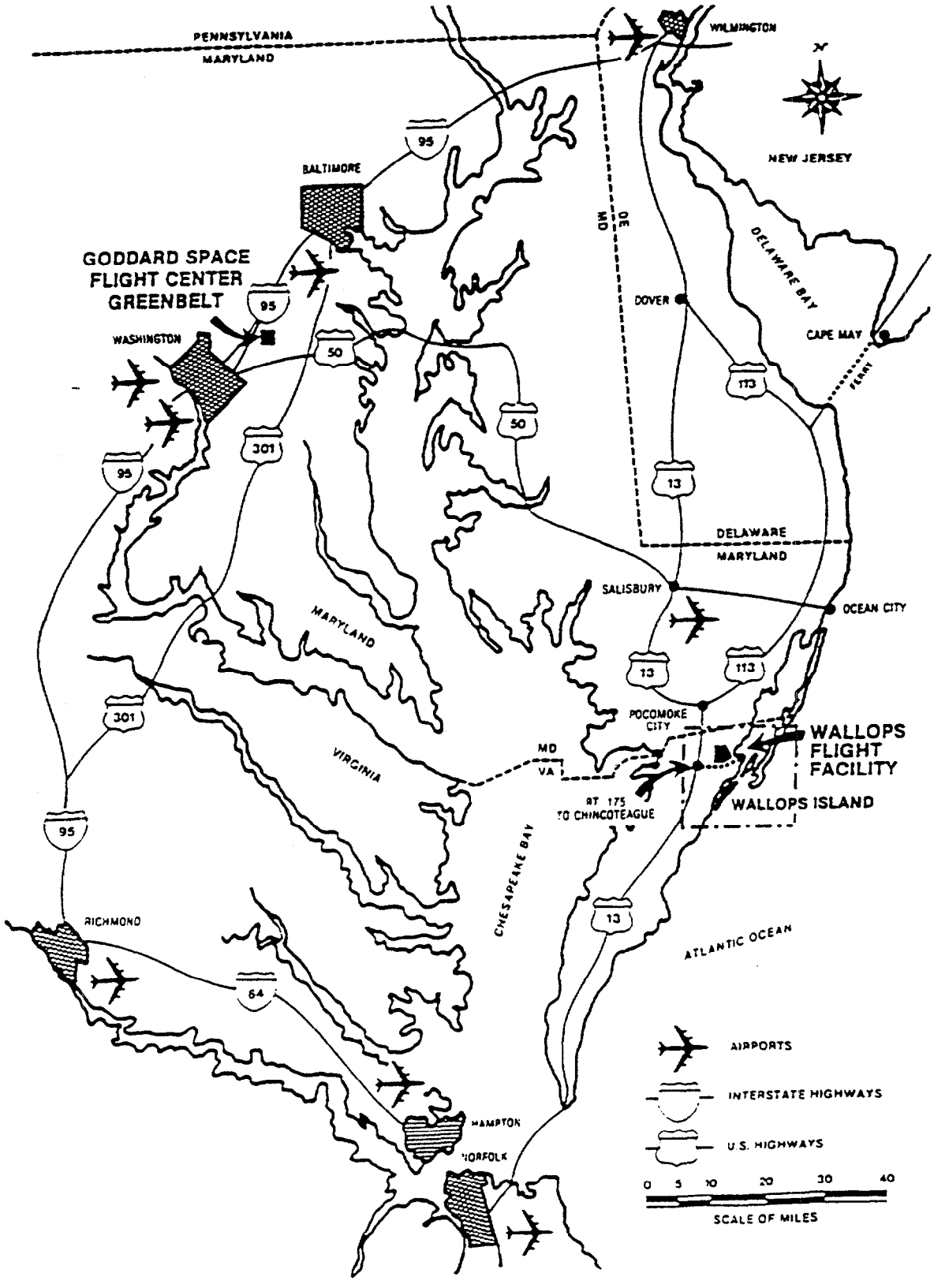
1.2.1 Site Description

WFF is located in Accomack County, Virginia, on the Atlantic Coast of the Delmarva Peninsula (Figure 1-1), approximately 160 miles southeast of Washington, D. C. The nearest private home is approximately 1000 feet west of the Main Gate of the WFF Main Base. Farms and residences are located north across Little Mosquito Creek, approximately 3500 feet from the former FTA. A closed Accomack County landfill is located south of State Route 798, approximately 4500 feet southwest of the former FTA, and 1000 feet west of the WFF Main Gate (Figure 1-2). The nearest commercial business (a small store) is located 8000 feet southwest of the site, at the intersection of State Routes 175 and 679. Little Mosquito Creek forms the northern boundary of the WFF Main Base. Jenneys Gut, Little Simoneaston Creek, and Simoneaston Bay form the eastern boundary.

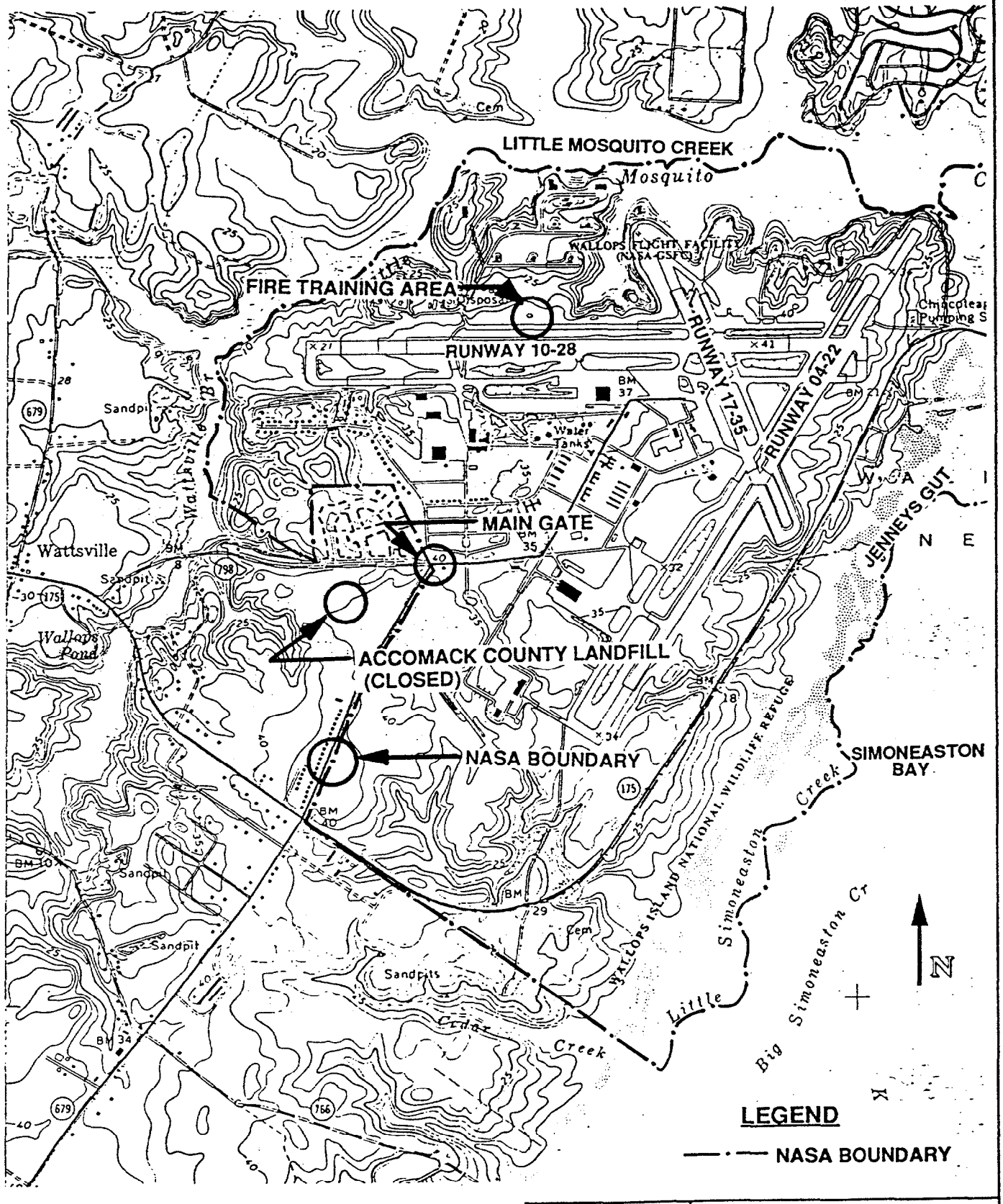
Three separate land areas comprise WFF: the Main Base, Mainland, and Wallops Island. The Main Base of WFF includes the WFF headquarters, administrative offices, tracking facilities, a range control center, launch support facilities and shops, housing units, and an active research airport. The former FTA is located on the Main Base in the vicinity of the airfield, north of Runway 10-28 and a former taxiway.

The FTA was designated as M-30 by NASA, which served as a location identifier. For ease of reference, the location of a tank used to simulate an airplane fuselage during training exercises is designated as Tank M-30 in this document. The site encompasses approximately one acre, and is located approximately 2200 feet south of Little Mosquito Creek. According to WFF personnel, the FTA was in operation from 1965 to 1987. The WFF Fire Department used the facility twice a week for training purposes.

The FTA is cleared land with grassy vegetation. The land slopes gently to the north (at 1.5 to 2 percent) from the former Tank M-30 location at the edge of the old taxiway for a distance of 300 feet. The slope then increases at less than 1 percent for a distance of about 60 feet before rising sharply at approximately 12 percent across an earthen berm which, in part, separates the FTA from the magazine area located to the



M&E Metcalf & Eddy	**FIGURE 1-1**	**WALLOPS FLIGHT FACILITY LOCATION MAP**



BASE MAP: USGS - CHINCOTEAGUE WEST QUADRANGLE

SCALE: 1" = 2000'

Metcalf & Eddy

FIGURE 1-2
SITE LOCATION MAP
FIRE TRAINING AREA
NASA/WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA

north. The berm is located at the southern edge of a treeline (Figure 1-3), and is six feet high directly north of the FTA.

The forested area extends 450 feet north from the earthen berm. At the northern edge of the forested area is a barbed wire fence which surrounds the magazine area, and immediately north of the fence is Kneeland Road. Further to the north, between Kneeland Road and Little Mosquito Creek, are several wooded areas, Blough Road (in the magazine area), and Building M-15.

In general, surface runoff from the FTA occurs by overland flow, and accumulates in low-lying areas between the FTA and the earthen berm. The site does not contain or immediately border surface water bodies, other than intermittent ponded areas.

1.2.2 History of Land Use

The original facilities at WFF Main Base were constructed from 1941 through 1958 for use by the U.S. Navy as a base for flight operations, and ordnance and weapons testing. In 1959, the Navy closed the station, and NASA acquired the Main Base facility.

NASA personnel originated use of the FTA site for fire fighting training in 1965. Combustible waste substances were discharged onto the ground or into an unlined pit located an estimated 100 feet north of Tank M-30. The waste substances were then ignited and extinguished as part of the training exercise. NASA later used an open tank (Tank M-30) to simulate an airplane fuselage. Flames were allowed to engulf the tank, and were then extinguished. A protective berm was constructed around the tank to reduce runoff, and a 500-gallon tank was installed to collect surface runoff during training exercises. The tank was removed intact in August 1990.

The Training Pit was estimated to be two to three feet deep from photographs taken in 1986 prior to a cleanup effort at the site (NASA, 1986). NASA personnel did not maintain specific records of the substances burned during the fire fighting training exercises. NASA records of correspondence from the Virginia State Water Control Board (now part of the Department of Environmental Quality) following a 1986 site inspection indicate that the pit contained a mixture of jet fuel and crankcase oil (Commonwealth of Virginia, 1986). Substances that may have been used include gasoline, jet fuel, waste oils, waste

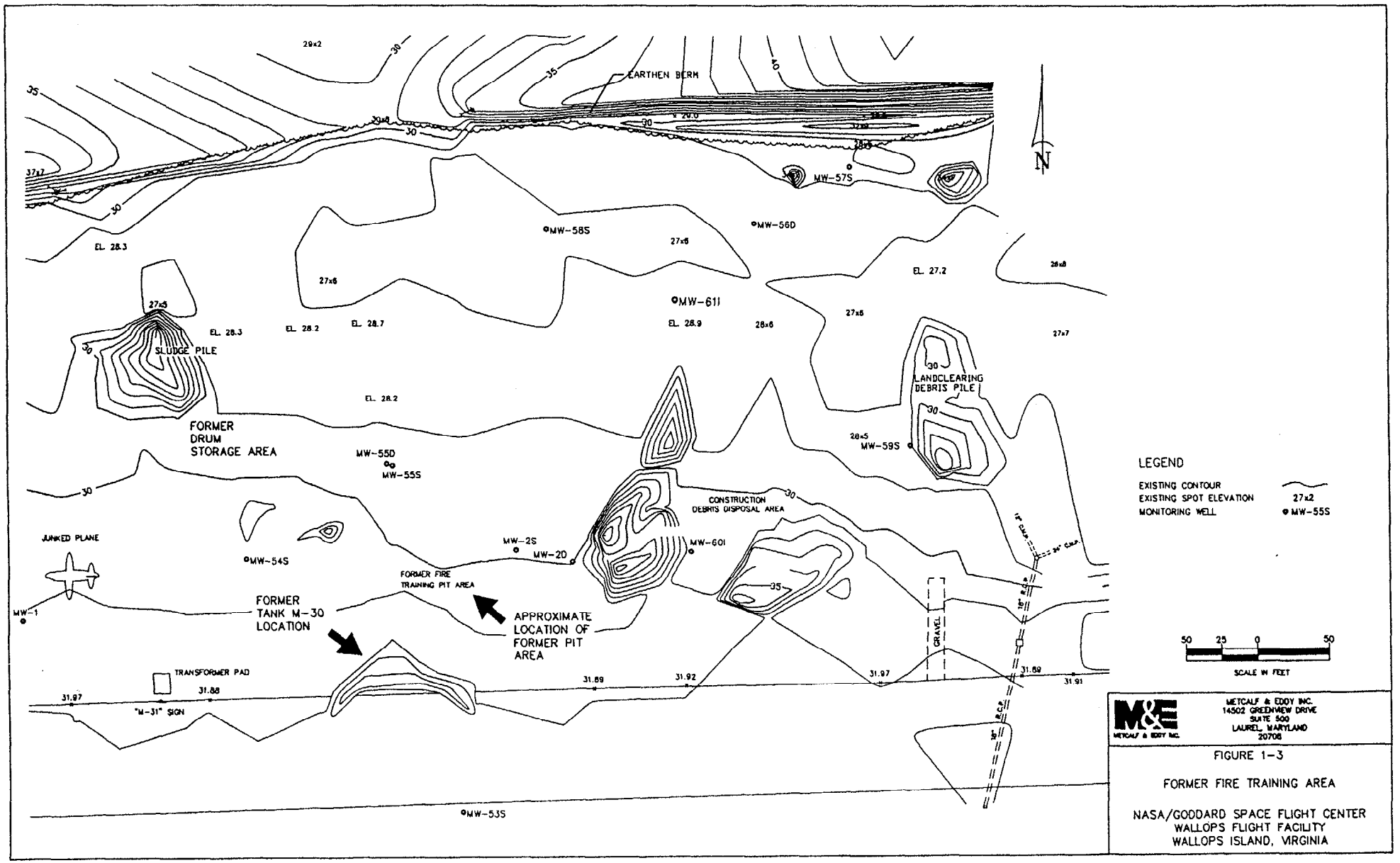


FIGURE 1-3

FORMER FIRE TRAINING AREA

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WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA

solvents, and debris. Following a removal order from the Virginia Department of Waste Management, approximately 20 truckloads (about 120 cubic yards) of potentially contaminated soil were removed from the pit area in November 1986. The work crew excavated until no visual signs of oil contamination were apparent. The area was not surveyed, and analytical samples were not collected.

The Sludge Pile is a mound of material disposed from the WFF wastewater treatment plant. Details regarding the dates of sludge disposal are unknown. The estimated areal extent of the Sludge Pile is 4800 square feet. The volume is estimated to be 38,400 cubic feet, based on an estimated average height of eight feet.

The Construction Debris Disposal Area encompasses several soil piles, ranging from about three to eight feet in height, containing concrete and metal debris. Two of the piles are primarily from land clearing, containing tree stumps and other debris. In particular, the land clearing debris pile located east of MW-59S is composed of material resulting from line-of-sight land clearing for the research airport activities and is unrelated to the FTA. The combined areal extent of the stockpiles is approximately 8,700 square feet. The volume is roughly estimated to be 37,000 cubic feet. The disposal area was used until about 1991, with the soil piles originally serving as stockpiles for construction fill.

The former Drum Storage Area is located approximately 200 feet west of the former FTA and was detected during previous investigations from historical aerial photographs which are no longer available. More than 50 drums of unknown contents were stored at the site. The date of drum removal is unknown, as are data concerning the contents and the integrity of the drums.

1.2.3 Previous Investigations

The former Fire Training Area was investigated previously by Ebasco Services, Inc., (October, 1990) and further reviewed by Metcalf & Eddy, Inc., (M&E) under Delivery Order 11, in support of NASA Contract NAS5-35042 in March 1993. As a result, a Work Plan and Field Operations Plan (FOP) were developed. The Work Plan proposed a staged remedial investigation, and the FOP specified the field investigation procedures and included the Health and Safety Plan (HASP).

The following documents provide a summary of previous investigations and the basis for development of the RI process.

- *Supplemental Site Characterization/Collective Action Work Plan for WFF*, Wallops Island, VA. Prepared by Ebasco Services, Inc. November, 1989.

- *Final Report of Site Investigation for Wallops Flight Facility.* National Aeronautics and Space Administration, Goddard Space Flight Center, Wallops Flight Facility, Wallops Island, VA. Prepared by Ebasco Services, Inc. January 1990.

- *Final Soil Gas Report.* National Aeronautics and Space Administration, Goddard Space Flight Center, Wallops Flight Facility, Wallops Island, VA. Prepared by Ebasco Services, Inc. September 1990.

- *Revision of Site Investigation for Wallops Flight Facility, Wallops Island, Virgina.* National Aeronautics and Space Administration, Goddard Space Flight Center, Wallops Flight Facility, Wallops Island, VA. Prepared by Metcalf & Eddy, Inc. August 1992.

Results from the Soil Gas Study (NASA, September 1990) and the Site Investigation (SI) Report (NASA, January 1990), both conducted by Ebasco Services, Inc., were presented in the Work Plan. Overall, the Soil Gas Study concluded that significant soil contamination exists, and groundwater contamination may exist. The data indicate the presence of trichloroethene (TCE), toluene, tetrachloroethene (PCE), and unknown volatile hydrocarbons in the soil gases. PCE was the most widely detected compound; the highest detection was 3,900 parts per billion (ppb) by volume.

Headspace analysis was performed on samples from the three monitoring wells in the FTA vicinity (MW-01, 45-55 feet deep; MW-02S, 10-30 feet deep; and MW-02D, 45-55 feet deep). The analysis indicated the presence of TCE and PCE contamination in well MW-02S, at levels of 16 and 33 ppb, respectively.

Overall, surface soil and groundwater samples showed indications of contamination. Surface soil samples collected as part of the SI showed high semi-volatile organic concentrations, which are probably reflective of high molecular weight hydrocarbons. Groundwater contaminants include the pesticide delta-BHC (0.02

micrograms per liter (µg/l) in well MW-02D), 1,2-dichloroethene (10 µg/l in well MW-02S), carbon tetrachloride (6 µg/l in well MW-02S), and 1,1,1-trichloroethane (52 µg/l and 6 µg/l in wells MW-02S and MW-02D, respectively). Of these, carbon tetrachloride was present in well MW-02S at a concentration which slightly exceeded the EPA Maximum Contaminant Level (MCL) for drinking water.

Based upon the data collected, the FTA had a preliminary Hazard Ranking System (HRS) score of 40.1, which is above the 28.5 criteria for National Priorities List (NPL) consideration. Therefore, the site may be a candidate for the NPL.

Since continued use of the FTA under current operating conditions would exacerbate existing environmental contamination, the SI Report (January 1990) recommended use of the FTA be discontinued until an engineered facility could be developed. In addition, an environmental investigation was recommended. Preparation of the RI/FS Work Plan and FOP followed that recommendation. The documents were completed in 1993.

1.2.4 Preliminary Identification of Contamination

The data collected during the SI led to the generation of the following list of suspected contaminants at the FTA. The suspected volatiles included: PCE, toluene, TCE, 2,4-trinitrotoluene, 1,2-dichloroethene, carbon tetrachloride, trichlorotrifluoroethane, 1,1,1-trichloroethane, and chlorobenzene. The semivolatiles included: di-n-octylphthalate and 4-nitrophenol. The pesticides suspected at the site included: 4,4-DDT, 4,4-DDE, and 4,4-DDD.

1.3 REPORT ORGANIZATION

Section 2.0 is a description of the RI field investigation methodologies, environmental sampling, analytical data validation and review, and site surveying. Section 3.0 discusses the site characteristics including geographic setting, geology, hydrogeology, and ecological setting. Section 4.0 is a description of the nature and extent of contamination at the site, consisting of a discussion of contaminant sources, contamination distribution and trends, and the significance of the findings. Section 5.0 discusses

contaminant fate and transport including the physical and chemical properties of site contaminants and the contaminant migration trends.

Section 6.0 is the Human Health Assessment. This section characterizes potential risk from exposure to chemicals of concern to human health for current and future land use scenarios. Included are a data summary, evaluation, characterization of exposure setting, identification of exposure pathways, quantification of potential exposure, toxicity assessment, risk characterization, lead biokinetic uptake model results, risk assessment results, and uncertainties and limitations.

Section 7.0 is the Ecological Risk Assessment, in which observations were made of the flora and fauna present, as well as any potential exposure routes through which site-related contaminants could affect the ecological receptors. This risk assessment, along with the human health risk assessment, comprise the baseline risk assessment for the site. Section 8.0 discusses the remedial investigation summary, conclusions, and recommendations.

2.0 REMEDIAL INVESTIGATION

2.1 FIELD INVESTIGATION OVERVIEW AND TECHNICAL APPROACH

M&E completed a field investigation as part of the RI of the former FTA. The field investigation activities were completed in December 1993 and January 1994.

The field investigation was designed to collect the data required to determine the nature and extent of contamination, and provide the basis for an evaluation of remedial action alternatives as part of the FS. The specific objectives were:

- Evaluate potential migration since the 1990 SI.
- Determine the nature and extent of contamination in the surface soil, subsurface soil, groundwater, surface water, and sediment which may be related to former FTA operations.
- Determine the nature and extent of any contamination potentially related to the former drum storage area, sludge pile, and construction debris disposal area.
- Gather data to support the human health and ecological risk evaluations.
- Gather sufficient data to evaluate potential remedial action alternatives and technologies.

Scope of Field Investigation

The field investigation included a soil gas survey; soil borings; monitoring well installation; sample collection, analysis, and validation; and a site survey. The soil gas survey was conducted to evaluate potential contaminant migration since the 1990 SI, and to provide guidance for selection of locations for monitoring wells and sample collection.

Surface and subsurface soil samples were collected in the vicinity of the FTA training pit, tank location, the former drum storage area, the sludge pile, and the construction debris disposal area. These data were used to evaluate the nature and extent of soil contamination in these areas. Table 2-1 provides a summary of samples collected during the RI field activities.

TABLE 2-1

SAMPLE SUMMARY

LOCATION	NUMBER OF BORINGS	NUMBER OF SAMPLES			
		Subsurface Soil	Surface Soil	Groundwater	Surface Water/Sediment
Upgradient	1	3	-	3	-
Training Pit and Downgradient	7	21	10	11	-
Drum Storage Area	1	3	-	-	-
Construction Debris Disposal Area and Downgradient	3	11	-	-	-
Sludge Pile	2	8	-	-	-
Drainage Areas/ Intermittent Ponds	-	-	-	-	4/4
TOTAL	14	46	10	14	4/4

Notes

1. All borings were completed to the groundwater table with three samples recovered per boring. Two additional samples were collected from both the Sludge Pile and the Construction Debris Disposal Area.

2. The groundwater samples from existing wells included sampling one existing background well and the three wells located in the FTA vicinity. Filtered and unfiltered samples were collected from each well for TAL analysis.

3. QA/QC samples were collected, at a minimum, as follows:
   - One duplicate for every 20 environmental samples.
   - One field blank per medium for each day of sampling.
   - One equipment blank for each sampling process.
   - One trip blank shipped in each cooler storing samples for volatile analyses.

   The numbers of QA/QC samples are not reflected in this table.

The initial site reconnaissance results indicated that the former FTA is a non-point source area for surface runoff. The site has no direct discharges to surface water bodies including Little Mosquito Creek and its tributaries. Surface water and sediment samples were collected from ponded areas downgradient of the former FTA training pit area to assess the nature of contamination in the runoff. Some recharge to groundwater of the ponded surface water and runoff may occur, but no direct connection between the two media exists at the site.

Air monitoring was performed during on-site activities as part of the general health and safety program and prior to any intrusive work. Equipment used for air monitoring consisted of a photoionization detector (PID) or organic vapor analyzer (OVA). Calibration of equipment was performed according to the manufacturer's instructions.

2.2 FIELD METHODOLOGIES

The field investigation was conducted in accordance with the Work Plan and the FOP. Field activities consisted of a soil gas survey; soil borings and subsurface soil sample collection; monitoring well installation and development; collection of surface water, sediment, surface soil, and groundwater samples; and a topographic site survey.

2.2.1 Soil Gas Survey

A soil gas survey was completed to update site information from the 1990 survey (NASA, September 1990). The soil gas survey provided estimated contamination levels, probable limits of the contaminated groundwater plume location, and data to assist in the selection of the monitoring well and soil boring locations. General methodology guidance was provided in the Metcalf & Eddy Standard Operating Procedure for subsurface soil gas sampling and analytical procedures.

The procedure for the soil gas survey was outlined in the Site Screening Report prepared by TARGET Environmental Services, Inc. Initially, a hydraulic probe was used to drive a 1-inch diameter threaded steel casing into the ground to the desired sampling depth. By raising the casing, a disposable drive point was released and the casing bottom was opened. Then a teflon line with a perforated hollow stainless steel

probe end was inserted into the casing to the bottom of the hole. An inflatable packer was used to isolate the line perforations at the bottom of the hole from the up-hole annulus. Two soil gas samples were withdrawn through the probe, one to purge the system and the second one for chemical analysis. The second sample was collected in a self-sealing vial at two atmospheres of pressure. The vial was then detached from the system, packaged, labeled, and stored for laboratory analysis. After sampling, the holes were backfilled with bentonite and the surface was repaired with like material. The soil gas sample locations are presented in Figure 2-1. The samples were analyzed using an on-site, mobile laboratory. A gas chromatograph and flame ionization detector (GC/FID) were used to analyzed the soil gas samples for selected volatile organic compounds (VOCs). The soil gas survey results are shown in Table 2-2.

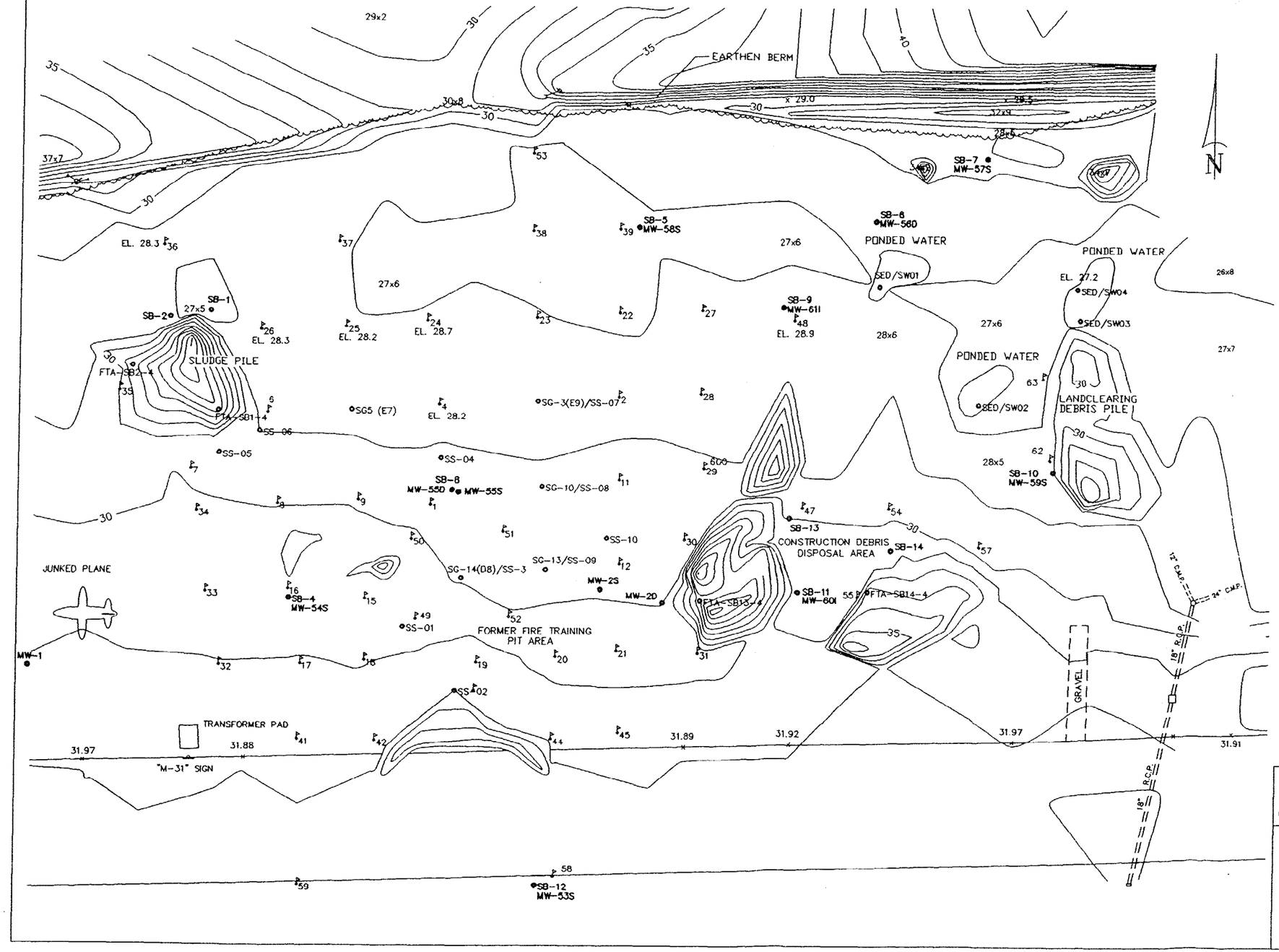
2.2.2 Soil Boring and Monitoring Well Installation

Fourteen soil borings were conducted to provide sampling data for the evaluation of subsurface contamination downgradient of the FTA pit area, and to evaluate potential contamination resulting from other sources. The soil boring logs are presented in Appendix A. A total of ten groundwater monitoring wells were installed and one round of groundwater samples was collected from each of the wells, including both filtered and unfiltered samples for Target Analyte List (TAL) analysis.

2.2.2.1 Rationale for Well Locations and Construction

The primary purpose of the wells was to determine the extent of contamination in the Pleistocene age surficial aquifer. The well locations are shown in Figure 2-2 and the well completion diagrams are presented in Appendix A. Screened intervals were determined during well installation based on the hydrogeologic conditions encountered. According to the Virginia State Water Control Board (SWCB), now part of the Virginia Department of Environmental Quality (DEQ), the groundwater table occurs at depths of 5 to 60 feet below the ground surface on the Eastern Shore of Virginia. In the FTA, the groundwater table occurs at depths of approximately 14 to 20 feet, based on field measurements from the previously installed monitoring wells.

Wells were installed both upgradient and downgradient of the site, at the leading edge of the plume, and laterally to determine the extent of contamination. Ten additional wells were installed and three existing wells were redeveloped. The additional wells were completed in the shallow (Pleistocene) aquifer, with



LEGEND

EXISTING CONTOUR	
EXISTING SPOT ELEVATION	27x2
MONITORING WELL	MW
SOIL BORING	SB
SURFACE SOIL SAMPLE	SS
SEDIMENT SAMPLE	SD
SURFACE WATER SAMPLE	SW
SOIL GAS SAMPLE	

NOTE:
THE LOCATIONS OF SB-1, 2, 13, & 14 ARE APPROXIMATE.

50 25 0 50

SCALE IN FEET

METCALF & EDDY INC.
14502 GREENVIEW DRIVE
SUITE 500
LAUREL, MARYLAND
20708

FIGURE 2-1

SOIL GAS AND MEDIA SAMPLING LOCATIONS

FORMER FIRE TRAINING AREA
NASA/GODDARD SPACE FLIGHT CENTER
WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA

TABLE 2-2
SOIL GAS SURVEY RESULTS

SOIL GAS SAMPLE***	SUBSTANCE (ug/l) (Detection Limit) BEN (1.0)	TOL (1.0)	ETH (1.0)	XYL (1.0)	FID** (10)	11DCE (1.0)	t12DCE (1.0)	11DCA (1.0)	c12DCE (1.0)	111TCA (1.0)	TCE (1.0)	PCE (1.0)
SG-1	<1.0	65	<1.0	<1.0	259	209	3.2	11	12	439	2.8	31
SG-2	<1.0	<1.0	<1.0	<1.0	<10	6	<1.0	<1.0	<1.0	9.2	<1.0	2
SG-3	<1.0	<1.0	<1.0	<1.0	23	30	<1.0	<1.0	7	114	3.9	42
SG-4	<1.0	<1.0	<1.0	<1.0	<10	2	<1.0	<1.0	<1.0	3.2	<1.0	<1.0
SG-5	<1.0	<1.0	<1.0	<1.0	<10	12	<1.0	<1.0	<1.0	6.5	<1.0	1.7
SG-6	<1.0	<1.0	<1.0	<1.0	<10	1.1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
SG-8	<1.0	<1.0	<1.0	<1.0	<10	3.4	<1.0	<1.0	<1.0	1.1	<1.0	<1.0
SG-9-6	<1.0	<1.0	<1.0	<1.0	<10	24	<1.0	<1.0	<1.0	11	<1.0	1.6
SG-9-6R	<1.0	<1.0	<1.0	<1.0	<10	23	<1.0	<1.0	<1.0	11	<1.0	1.5
SG-9-12	<1.0	<1.0	<1.0	<1.0	<10	30	<1.0	<1.0	<1.0	14	<1.0	2.2
SG-10	<1.0	26	<1.0	<1.0	321	129	<1.0	22	148	866	14	87
SG-11	<1.0	<1.0	<1.0	<1.0	<10	16	<1.0	<1.0	6.2	74	2.1	8.6
SG-12	<1.0	<1.0	<1.0	<1.0	<10	11	<1.0	<1.0	<1.0	12	<1.0	1.6
SG-13	<1.0	4.5	<1.0	<1.0	38	97	<1.0	12	<1.0	176	<1.0	2.6
SG-14	11	707	25	74	7,184	209	<1.0	18	243	144	<1.0	1.6
SG-15	<1.0	<1.0	<1.0	<1.0	<10	43	<1.0	<1.0	<1.0	7.3	<1.0	1.2
SG-16	<1.0	<1.0	<1.0	<1.0	<10	6.6	<1.0	<1.0	<1.0	1	<1.0	<1.0
SG-17	<1.0	<1.0	<1.0	<1.0	<10	1.6	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
SG-18	<1.0	<1.0	<1.0	<1.0	<10	7.5	3.4	<1.0	<1.0	<1.0	<1.0	<1.0
SG-19	<1.0	<1.0	<1.0	<1.0	<10	21	<1.0	<1.0	<1.0	5.6	<1.0	<1.0
SG-20	<1.0	<1.0	<1.0	<1.0	<10	11	3.7	<1.0	<1.0	4	<1.0	<1.0
SG-21	<1.0	<1.0	<1.0	<1.0	<10	4.5	<1.0	<1.0	<1.0	1.3	<1.0	<1.0
SG-22	<1.0	<1.0	<1.0	<1.0	<10	4.8	<1.0	<1.0	<1.0	3.7	<1.0	<1.0
SG-22R	<1.0	<1.0	<1.0	<1.0	<10	4.9	<1.0	<1.0	<1.0	3.8	<1.0	<1.0
SG-23	<1.0	<1.0	<1.0	<1.0	<10	2.6	<1.0	<1.0	<1.0	2.7	<1.0	<1.0
SG-25	<1.0	<1.0	<1.0	<1.0	<10	4.3	<1.0	<1.0	<1.0	1.4	<1.0	<1.0

KEY: BEN=Benzene
TOL=Toluene
ETH=Ethylbenzene
XYL=Xylenes
FID=Total FID Volatiles
11DCE=1,1-dichloroethene
t12DCE=trans-1,2-dichloroethene
11DCA=1,1-dichloroethane
c12DCE=cis-1,2-dichloroethene
111TCA=1,1,1-trichloroethane
TCE=trichloroethene
PCE=tetrachloroethene

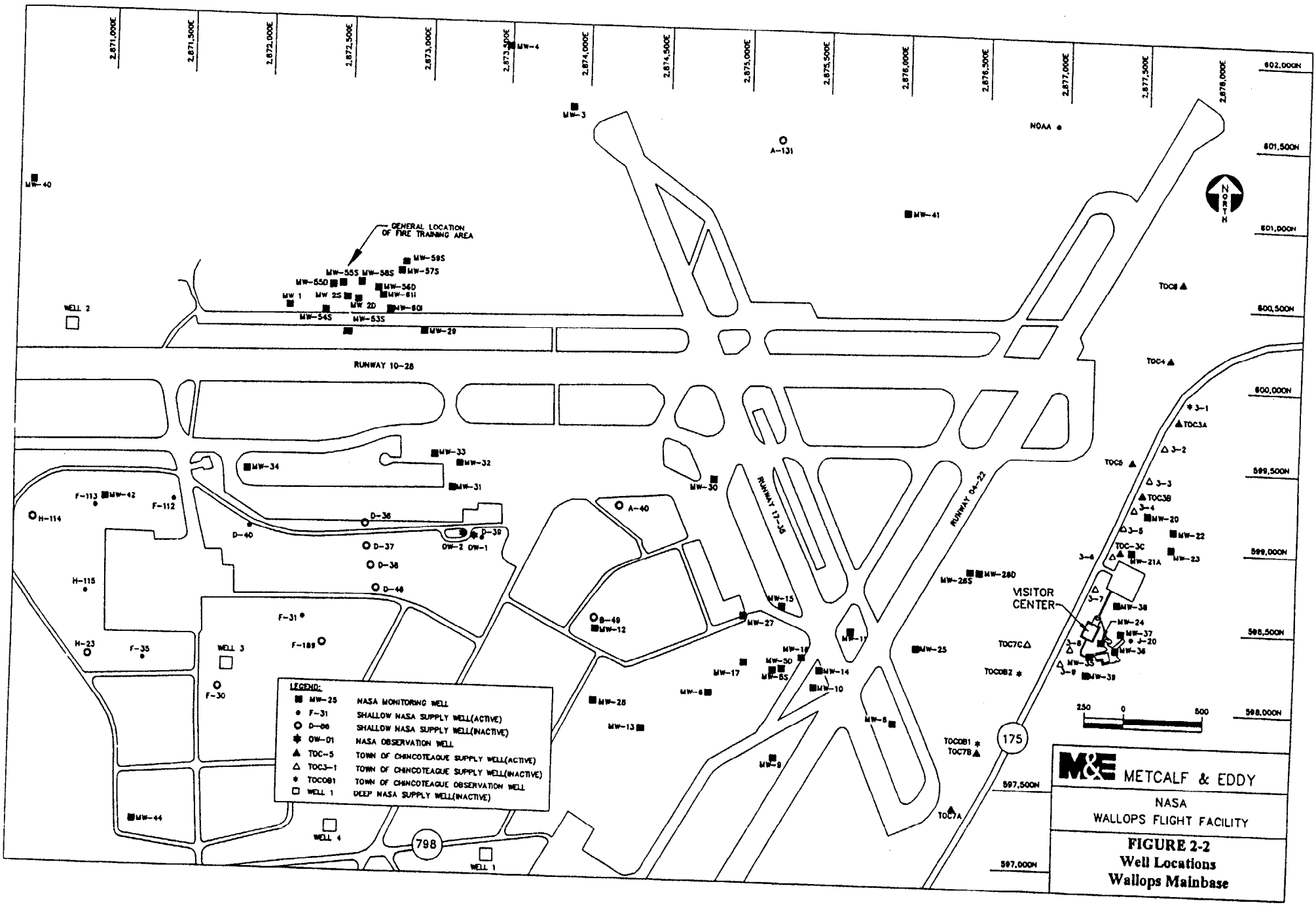
*Actual concentration may be higher than reported.
**Calculated using the sum of the areas of all integrated chromatogram peaks and the instrument response factor for toluene.
***Only samples with at least one (1) detection were included.

TABLE 2-2 cont
SOIL GAS SURVEY RESULTS

SOIL GAS SAMPLE***	SUBSTANCE (ug/l) (Detection Limit) BEN (1.0)	TOL (1.0)	ETH (1.0)	XYL (1.0)	FID** (10)	11DCE (1.0)	t12DCE (1.0)	11DCA (1.0)	c12DCE (1.0)	111TCA (1.0)	TCE (1.0)	PCE (1.0)
SG-27	<1.0	<1.0	<1.0	<1.0	<10	1.4	<1.0	<1.0	<1.0	1.5	<1.0	<1.0
SG-29	<1.0	<1.0	<1.0	<1.0	<10	2.3	<1.0	<1.0	<1.0	4.8	<1.0	1.1
SG-30	<1.0	<1.0	<1.0	<1.0	<10	3.7	<1.0	<1.0	<1.0	4.9	<1.0	<1.0
SG-38	<1.0	<1.0	<1.0	<1.0	<10	2.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
SG-41	<1.0	<1.0	<1.0	<1.0	<10	<1.0	14	<1.0	<1.0	<1.0	<1.0	<1.0
SG-44	<1.0	<1.0	<1.0	<1.0	<10	<1.0	1.3	<1.0	<1.0	<1.0	<1.0	<1.0
SG-46	<1.0	<1.0	<1.0	<1.0	<10	<1.0	4.9	<1.0	<1.0	<1.0	<1.0	<1.0
SG-47	<1.0	<1.0	<1.0	<1.0	<10	<1.0	2.7	<1.0	<1.0	<1.0	<1.0	<1.0
SG-49-6	<1.0	<1.0	<1.0	<1.0	<10	45	11	<1.0	<1.0	5.4	<1.0	<1.0
SG-49-12	<1.0	<1.0	<1.0	<1.0	<10	68	<1.0	<1.0	<1.0	10	<1.0	2.2
SG-50-6	<1.0	<1.0	<1.0	<1.0	12	85	3.8	2.6	4.7	75	<1.0	4
SG-50-12	<1.0	<1.0	<1.0	<1.0	<10	18	<1.0	<1.0	1.6	9.2	<1.0	1.1
SG-50-12R	<1.0	<1.0	<1.0	<1.0	<10	21	<1.0	<1.0	1.9	11	<1.0	1.2
SG-51-6	<1.0	<1.0	<1.0	<1.0	15	33	<1.0	1.3	8.3	61	<1.0	2.2
SG-51-12	<1.0	5	<1.0	<1.0	45	56	<1.0	3.3	18	107	<1.0	2.6
SG-52-6	<1.0	3.9	<1.0	<1.0	20	2.4	<1.0	<1.0	<1.0	2.3	<1.0	<1.0
SG-52-12	<1.0	1.3	<1.0	<1.0	<10	10	<1.0	<1.0	<1.0	5.5	<1.0	<1.0
SG-54	<1.0	<1.0	<1.0	<1.0	<10	<1.0	1.9	<1.0	<1.0	<1.0	<1.0	<1.0
SG-55	<1.0	2.2	<1.0	<1.0	33	<1.0	4.2	<1.0	<1.0	<1.0	<1.0	<1.0
SG-56	<1.0	<1.0	<1.0	<1.0	<10	<1.0	4.8	<1.0	<1.0	<1.0	<1.0	<1.0
SG-57	<1.0	<1.0	<1.0	<1.0	<10	<1.0	12	<1.0	<1.0	<1.0	<1.0	<1.0
SG-58	<1.0	<1.0	<1.0	<1.0	<10	<1.0	3.7	<1.0	<1.0	<1.0	<1.0	<1.0
W-11	17	613	35	74	1,144	41	<1.0	34	634	639	4.1	6.2
W-15	<1.0	<1.0	<1.0	<1.0	<10	2.5	<1.0	<1.0	<1.0	4.1	<1.0	<1.0
W-19	<1.0	<1.0	<1.0	<1.0	<10	3.2	<1.0	<1.0	<1.0	5.9	<1.0	<1.0
W-51	17	1,774	134	375	11,330	139	3	39	371	120*	12	38*

KEY: BEN=Benzene
TOL=Toluene
ETH=Ethylbenzene
XYL=Xylenes
FID=Total FID Volatiles
11DCE=1,1-dichloroethene
t12DCE=trans-1,2-dichloroethene
11DCA=1,1-dichloroethane
c12DCE=cis-1,2-dichloroethene
111TCA=1,1,1-trichloroethane
TCE=trichloroethene
PCE=tetrachloroethene

*Actual concentration may be higher than reported.
**Calculated using the sum of the areas of all integrated chromatogram peaks and the instrument response factor for toluene.
***Only samples with at least one (1) detection were included.


2,871,000E
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600,000N
599,500N
599,000N
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598,000N
597,500N
597,000N
MW-3
MW-4
A-131
NOAA
MW-40
MW-41
GENERAL LOCATION OF FIRE TRAINING AREA
MW-59S
MW-55S
MW-58S
MW-57S
MW-55D
MW-56D
MW-61I
MW 1
MW 2S
MW 2D
MW-60I
MW-54S
MW-53S
WELL 2
MW-29
RUNWAY 10-28
TOC8
TOC4
MW-33
MW-32
MW-34
MW-31
MW-30
RUNWAY 17-35
RUNWAY 04-22
A-40
F-113
MW-42
F-112
H-114
D-36
D-40
D-39
D-37
OW-2
OW-1
D-38
D-46
H-115
F-31
B-49
MW-12
MW-15
MW-27
MW-17
MW-16
MW-50
MW-55
MW-14
MW-10
MW-6
MW-28
MW-13
MW-8
MW-9
H-23
F-35
WELL 3
F-189
F-30
MW-44
WELL 4
798
WELL 1
TOC5
TOC3A
TOC3B
TOC3C
MW-21A
MW-20
MW-22
MW-23
MW-26S
MW-26D
VISITOR CENTER
MW-38
MW-24
MW-37
MW-36
MW-39
TOC7C
TOC8Z
MW-25
TOC8B1
TOC7B
TOC7A
175
3-1
3-2
3-3
3-4
3-5
3-6
3-7
3-8
3-9
250
0
500
LEGEND:
MW-25 NASA MONITORING WELL
F-31 SHALLOW NASA SUPPLY WELL(ACTIVE)
D-36 SHALLOW NASA SUPPLY WELL(INACTIVE)
OW-01 NASA OBSERVATION WELL
TOC-5 TOWN OF CHINCOTEAGUE SUPPLY WELL(ACTIVE)
TOC3-1 TOWN OF CHINCOTEAGUE SUPPLY WELL(INACTIVE)
TOC081 TOWN OF CHINCOTEAGUE OBSERVATION WELL
WELL 1 DEEP NASA SUPPLY WELL(INACTIVE)
M&E METCALF & EDDY
NASA
WALLOPS FLIGHT FACILITY
FIGURE 2-2
Well Locations
Wallops Mainbase

shallow, intermediate, and deep (base of shallow aquifer) screened intervals. All wells were constructed of 2-inch diameter Schedule 40 polyvinyl chloride (PVC) with 15-foot screened sections. Well MW-55, located approximately in the center of the Training Pit, was used as a cluster well with two completions in the Pleistocene age aquifer. An existing well (MW-01D) located cross-gradient from the former FTA site was used for background comparisons. One other existing well (MW-34S) and one newly constructed well (MW-53S) are located upgradient of the former FTA and provide data for background evaluations.

2.2.2.2 Soil Borings Installation and Sampling

Soil boring locations were dictated by the locations selected for installation of monitoring wells to define the extent of the groundwater plume. During the installation of the monitoring wells, split-spoon samples were collected from the deepest boring or monitoring well at each location. The soil borings were completed using hollow-stem auger techniques. The split-spoon samples were collected using a 3-inch outside diameter (O.D.) stainless-steel split-spoon sampler. Split-spoon samples were collected every five feet, unless a zone of concern was encountered. The interval was then reduced to two feet. A zone of concern was defined by visible apparent contamination and/or elevated PID readings. At the discretion of the site geologist, selected split-spoon samples were sent to the laboratory and analyzed for full Target Compound List (TCL)/TAL compounds. At least three samples per boring were collected.

The split-spoons were driven using a 140-pound drive hammer dropped approximately 30 inches. The split-spoon samples were classified using a combination of the Burmister Classification System and Unified Soils Classification System (USCS).

A total of 46 subsurface soil samples were collected from 14 borings to evaluate soil contamination. One of the borings was upgradient of the former FTA and provided background data for screening purposes. Two borings were completed immediately downgradient of the sludge pile, and two samples were collected in the sludge pile, to evaluate any contribution to contamination found at the former FTA. Two borings were also completed immediately downgradient of the construction debris piles, and two samples were collected from the piles, to provide an evaluation of contribution to site contamination. The nine remaining borings were completed at the locations selected for monitoring well installations.

All of the samples collected for chemical analysis were labeled, preserved, packaged, and shipped in

accordance with EPA requirements and the applicable Standard Operating Procedures (SOPs) included in the Work Plan and FOP. Drill cuttings were monitored for VOC contamination using the PID. Any cuttings with readings elevated above background were placed in Department of Transportation (DOT) specification 17E drums for disposal by NASA. The remaining cuttings were scattered at the site in a manner which would not result in erosion. All down-hole drilling and sampling equipment was decontaminated, in accordance with the SOPs, between borehole locations to prevent cross-contamination. The split-spoon sampler was decontaminated between sample collections. Boreholes not completed as monitoring wells were backfilled with clean drill cuttings (based on PID readings) or bentonite.

2.2.2.3 Monitoring Well Installation Procedures

The 10 shallow aquifer wells were installed using hollow-stem auger techniques. Soil borings were drilled to the target depth. Decontaminated (steam-cleaned) PVC casings and 15-foot screens were placed into the soill borings. The annulus was backfilled with sand to a level two feet above the top of the screened interval. A two-foot layer of bentonite pellets was placed above the sand pack and hydrated. Following hydration, the boring was grouted with a cement/bentonite mixture (4:1) to the ground surface. Surface completions were flush-mount "road boxes" or steel protective casings, as appropriate. A 1/4-inch diameter "weep drain" was drilled near the bottom of each protective casing. The well completion diagrams are included in Appendix A.

2.2.2.4 Monitoring Well Development

The three existing groundwater wells, MW-01D, MW-02S, and MW-02D, were evaluated and redeveloped in accordance with the SOP for Evaluation of Existing Monitoring Wells. These wells were redeveloped to ensure that representative samples could be collected. The newly installed monitoring wells were developed using a submersible pump. The wells were pumped until the development water was visibly free of fine material, and the pH, conductivity, and temperature had stabilized within 10 percent for three consecutive readings. Development fluids were collected in DOT 17E drums, labeled, and staged at the site for disposal by NASA. Development equipment was decontaminated between wells in accordance with the SOPs to prevent cross-contamination.

2.2.3 Groundwater Elevation Measurements

Groundwater depth measurements were collected at the time of well development and during the sampling event in January 1994. The measurements were collected from a marked measurement point at the top of the PVC casings using a Solinst water level indicator accurate to 0.01 foot. Readings were recorded in the field logbook. Following the field topographic survey, the depth data were converted to groundwater elevations for use in developing contour maps.

2.2.4 Groundwater Sampling Protocol

The objective of the groundwater sampling program was to determine the nature and extent of groundwater contamination in the Pleistocene age aquifer. The data provide the basis for evaluation of potential health hazards and the feasibility of potential remedial alternatives.

Groundwater samples were collected from the three existing FTA wells, the previously installed background well (MW-34S), and the 10 wells installed during the field program. A minimum of one week elapsed between well development and sample collection. Headspace in each of the wells was monitored upon initial opening using a PID. Readings were recorded on the well purging worksheets. The deep wells were monitored for the presence of dense non-aqueous phase liquids (DNAPLs) by lowering an interface probe to the bottom. The probe was decontaminated after each well. Although the presence of DNAPLs was not indicated by the probe, DNAPL samples were collected, prior to purging, from four wells (MW-02D, MW-55D, MW-56D, and MW-61I). The DNAPL samples were collected by lowering a dedicated, disposable, bottom-loading bailer to the bottom of the screened interval. The extracted sample volume was transferred to a 40-ml Volatile Organics Analysis (VOA) vial with the minimum disturbance possible.

Each well was purged of three to five well volumes to remove stagnant water which may have accumulated in the well. Groundwater temperature, pH, and conductivity were measured for each well volume removed during purging. Purging continued until stabilization within 10 percent of the field parameters was recorded for three consecutive readings or five well volumes had been removed. Sampling occurred within twenty-four hours of purging, and was performed with disposable, dedicated bailers and suspension lines. Sampling was performed in accordance the SOP for Groundwater Sample Acquisition.

Groundwater Sampling Procedure

1. Wear appropriate health and safety equipment as outlined in the HASP. Samplers will change disposable gloves between wells. Place clean plastic sheeting on ground around each wellhead location. Preserve and label laboratory-supplied sample containers using a waterproof marker. Secure labels to bottles using a full wrap of water-resistant clear tape.

2. Unlock well cap. Lift PVC cap slightly and insert PID probe tip to monitor headspace. Record reading.

3. Measure the static water level in the well using a Solinst or equivalent water level meter reading to +/- 0.01 foot. Record reading.

4. Use interface probe to determine presence of DNAPLs. If indicated, sample the DNAPLs by gently lowering a bottom-loading bailer for sample collection. Remove the bailer from the well slowly and place the sample in a preserved 40-ml vial. Cap tightly and tilt to ensure that no air bubbles are present in the sample. If air bubbles are present, recollect the sample.

5. Calculate the volume of water in the well as follows:

   $$\text{Volume (gallons)} = 0.163 \times T \times r^2$$

   Where T = well depth (feet) - static water level (feet)

   r = radius (inches)

6. Purge three to five volumes of water from the well, using decontaminated or disposable dedicated equipment as follows:

   Use bailer, or submersible or centrifugal pump. Hose for the submersible or centrifugal pump will be made of polyethylene. Set intake line or pump at the surface level of the groundwater and start pump; continue to lower the intake line or the pump through the well to just above screen depth, ensuring that all standing water in the well is purged.

7. Measure and record temperature, pH, and specific conductance while purging. The well will be considered properly purged when the indicator parameters are observed to vary less than 10 percent over the removal of three to five well volumes.

8. After purging, remove pump or suction line from well and allow static water level to recover approximately to the original level.

9. Obtain sample from the well with a dedicated disposable bailer suspended on a dedicated, disposable polyethylene line. The maximum time between purging and sampling will be twenty-four hours.

10. Remove first sample for TCL VOA, followed by additional organic and inorganic samples, directly from bailers. Place samples in laboratory-supplied, pre-preserved, and pre-labeled sample containers. Collect additional sample aliquots to be filtered for TAL analyses.

11. Filter aliquot for dissolved TAL analysis directly into preserved and labeled sample containers using a dedicated disposible 0.45 micron filter, dedicated, disposable tubing, and a MasterFlex peristaltic pump.

12. Cap all sample bottles tightly and store on ice in a cooler.

13. Decontaminate submersible pump and cable by scrubbing with Alconox detergent solution. Pump approximately 20 gallons of potable water through pump.

14. Discard dedicated suction line used for purging wells.

15. Replace PVC well cap and re-lock steel well cap.

16. Dispose of dedicated bailer and sampling line, by the methods described in the SOP.

17. Keep samples cool (to 4°C) on ice.

18. Fill out field notebook, sample log sheet, and Chain-of-Custody forms.

2.2.5 Surface Water and Sediment Sampling Procedures

Surface Water Sampling

Four surface water samples were collected from the ponded areas found at the site. Background sampling locations were not available in the vicinity of the former FTA. Background surface water data from a sample collected in Jenneys Gut during a previous investigation was used for screening surface water data.

Surface Water Sampling Procedure

1. Wear protective equipment as specified in the HASP.

2. Label sample bottles using waterproof marker. Secure labels to bottles by applying a full wrap of water-resistant label tape.

3. Lower sample container or, if necessary, decontaminated stainless steel bucket into surface water, avoiding stirring of soil/sediment. Remove container from surface water.

4. Cap the container tightly, or fill the sample container from the bucket, as appropriate, and cap tightly.

5. Take a temperature and pH reading of the aliquot remaining in the bucket or collect an additional aliquot to measure these parameters.

6. Preserve inorganic samples to pH 2 or less by adding concentrated nitric acid. Preserve VOA samples to pH 2 or less using hydrochloric acid. Check pH with broad range pH paper to ensure samples are less than pH 2. Preserve cyanide samples to pH greater than 12 using sodium hydroxide.

8. Keep samples cool (to 4°C) on ice.

9. Complete field notebook entry, sample log sheet, and Chain-of-Custody forms.

Sediment Sampling

The locations of sediment samples are shown in Figure 2-1. The sediment samples were collected at surface water sampling locations following collection of those samples. Data collected during previous investigations at WFF provides facility background levels for chemical detections in sediment samples.

Sediment sampling was performed in accordance with the general procedure outlined in the SOP for Soil and Rock Sample Acquisition. Sediment was gathered with a dedicated stainless steel scoop, placed in an appropriate sample jar, labeled,and preserved on ice (to 4°C) for shipment to the laboratory. Chain-of-Custody forms, sample log sheets, and field notebook entries were completed following collection and preservation of the samples.

Surface Soil Sampling

Ten surface soil samples were collected from areas in and downgradient of the former FTA. Data collected during previous investigations at WFF provides facility background concentrations for chemicals detected at the FTA. The soil samples were collected using dedicated stainless steel trowels. Surface debris and grasses were scraped away to expose the surface soil. The collected soil was packed into laboratory-supplied sample containers. The containers were tightly capped, labeled with waterproof marker and tape, and chilled on ice to 4°C. The samples were delivered to the laboratory in ice-filled coolers via overnight express service accompanied by chain-of-custody documentation.

2.3 CHEMICAL ANALYSIS

Surface soil, subsurface soil, groundwater, surface water, and sediment samples were collected and forwarded to the analytical laboratory for chemical analysis. The sample analyses were performed by a laboratory utilizing EPA Contract Laboratory Program (CLP) protocols and procedures. A summary of chemical analyses and methods is shown in Table 2-3.

TABLE 2-3

SUMMARY OF CHEMICAL ANALYSES AND METHODS

LOCATION	SAMPLE TYPE			
	Subsurface Soil	Surface Soil	Groundwater	Surface Water/Sediment
Full TCL/TAL - OLMO 1.9, ILMO 3.0	X	X	X	X
- Filtered TAL (ILMO 3.0)			X	
Lower Detection Limit VOAs - EPA Superfund Analytical Method 10/92			X	
TPH - EPA Method 418.1	X	X		
TCLP - Federal Register 55 FR 11798 (3/29/90)	X			
Grain Size Distribution - ASTM Method E-422	X			
Heating Value - ASTM Method D-2382	X			
Porosity - Shelby Tube via Merlin, Grant, Splangler	X			
Bulk Density - ASTM Method D-4531	X			

NOTES:

OLMO 1.9 = Organic Analysis Multi-Media, Multi-Concentration, Revision 1.9 (CLP Method for Organic Compounds, All Matrices.)

ILMO 3.0 = Inorganic Analysis Multi-Media, Multi-Concentration, Revision 3.0 (CLP Method for Inorganic Compounds, All Matrices.)

2.3.1 Soil Analysis

Fifty-six soil samples (46 soil boring samples and 10 surface soil samples) sent to the laboratory were analyzed for Total Petroleum Hydrocarbons (TPH) and full TCL and TAL analyses. The same analyses were performed on QA/QC samples, consisting of field blanks, field duplicates, and equipment blanks. The trip blanks were analyzed for TCL volatile organics only. Three composite samples, and one duplicate were collected from the drum containing the drill cuttings. These samples were analyzed using the EPA Toxicity Characteristic Leaching Procedure (TCLP) to provide soil disposal parameters.

Three samples (from borings SB-4, SB-7, and SB-10) were analyzed for grain size distribution, heating value, porosity, and moisture content. The results are shown in Table 2-4 and the grain size distribution curves are presented in Appendix A. These analyses provide data on physical soil characteristics for the risk assessment and feasibility study.

TABLE 2-4
SUMMARY OF GEOTECHNICAL SOILS TESTS

SAMPLE NO.	SAMPLE DATE	SOIL DESCRIPTION	HEATING VALUE (BTU/lb)	POROSITY	SPECIFIC GRAVITY	DRY UNIT WEIGHT (pcf)	MOISTURE CONTENT (%)
SB-4	12/3/93	Tan moist fine sand with trace silt	45.0	0.39	2.69	102.7	14.6
SB-7	12/2/93	Brown silty fine sand	52.0	0.46	2.69	90.4	22.3
SB-10	12/8/93	Brown silty moist sand with trace clay	66.0	0.49	2.69	85.0	38.0

2.3.2 Groundwater Analysis

All 14 groundwater wells, including the existing background well MW-34S, the three existing FTA wells, and the 10 additional wells, were sampled once. Unfiltered samples and filtered samples from each well were analyzed for TAL parameters. Samples from the wells were analyzed for the full TCL using low-detection limit methods for drinking water criteria. QA/QC samples collected, consisting of a field duplicate, field blanks, and an equipment blank, were analyzed for the full TCL and TAL (both total and dissolved constituents). Trip blanks were analyzed for the full TCL using the low-detection limit methods.

2.3.3 Surface Water & Sediment Analysis

Surface water and sediment samples were collected from the ponded areas on site. A total of four surface water and four sediment samples were collected and analyzed for full TCL/TAL, in accordance with EPA CLP protocols and procedures. Surface water samples were not filtered for TAL analysis.

2.4 ANALYTICAL DATA VALIDATION AND REVIEW

Data validation was completed by an independent, third-party validation subcontractor in accordance with EPA Region III procedures and guidelines. Based on the QA/QC data provided by the laboratory and from field evaluations, the data were considered acceptable, estimated, or rejected. Data were acceptable if the reviewer identified no significant problems with field or laboratory blank contamination, spike or surrogate recoveries, and replicate analyses. Data were flagged as estimated if spike recovery, surrogate recovery, replicate results, or blank results were outside acceptable EPA criteria.

A value which fell below the contract required quanitation limit (CRQL) but above the instrument detection limit (IDL) was also considered estimated and flagged accordingly. Estimated data were flagged with a "J" following the analytical results.

Data were rejected when the results of surrogates, spikes, duplicates, or blanks indicated that the reliablility of the reported data was questionable. No data were rejected under the data validation guidelines. Other flags used included "U" for values below the IDL, and "B" for compounds detected in the laboratory blanks.

2.5 SITE SURVEY

Upon completion of field operations, the topographic survey of the FTA site was completed by a subcontracted surveyor licensed in the Commonwealth of Virginia. Final sampling locations, monitoring well locations, well casing elevations, and site topography were established by the surveying subcontractor. A topographic site map complete with sample locations and elevations was prepared and is shown in Figure 2- 1.

3.0 SITE CHARACTERISTICS

3.1 GEOGRAPHIC SETTING

3.1.1 Demographics

WFF is located in a rural area where year-round population densities are relatively low for neighboring areas. Chincoteague Island, which lies approximately five miles from the Main Base area of the facility, is the largest, most densely populated area near WFF. It has a resident population of approximately 3600 people. Area populations are seasonal and can vastly fluctuate. During the summer months, the population expands due to tourists and vacationers visiting the nature reserves and beaches of Assateague Island. Daily populations can reach up to 15,000 in the summer months. During special events like the carnival and the pony roundup, sponsored by the Chincoteague Volunteer Fire Department each July, the daily summer population doubles. As a result, businesses in the Chincoteague area are generally targeted to the seasonal tourist industry, with the exception of fishing.

3.1.2 Land Use

The WFF Main Base contains offices, tracking facilities, range control center, rocket and fuel storage depot, shops, housing, and an airfield. Off-site, the nearest private home is approximately 1000 feet west of the Main Gate. Farms and residences are located north across Little Mosquito Creek, approximately 3500 feet from the FTA. The Accomack County landfill (now closed) is located south of State Route 798, approximately 4500 feet southwest of the FTA and 1000 feet west of the Main Gate. Figure 1-2 shows the relative locations of the landfill, the Main Gate, and the FTA. The nearest commercial business (a small store) is located 8000 feet southwest of the site, at the intersection of State Routes 175 and 679. Little Mosquito Creek forms the northern boundary and Simoneaston Bay, Little Simoneaston Creek, and Jenneys Gut form the eastern boundary of the Main Base.

The FTA is no longer active for fire fighter training. The taxiway located immediately south of the site is now used only for vehicle traffic to access areas north of runway 10-28, which continues to be active for airfield research and transport activities.

3.1.3 Drinking Water Resources

Groundwater is the principal source of potable water for WFF and the general vicinity. No major streams or other fresh surface water supplies are available as alternative sources of water for human consumption. A groundwater management planning program has been established by the Virginia DEQ, for the Eastern Shore of Virginia to ensure an optimal balance between groundwater withdrawal and recharge rates. This balance helps to minimize the problems of water quality due to salt water intrusion, aquifer dewatering, and well interference in the general area.

Groundwater appropriation within WFF and its immediate vicinity can be categorized into agricultural, private, public, and industrial uses. Agricultural uses include crop irrigation and poultry. Based on reported 1990 water usage data in the Commonwealth of Virginia, Accomack County withdrew a total of more than 936 million gallons of water for crop irrigation (SWCB, 1991, Bulletin 85). In addition, based on an estimate of 0.09 gallons of water per day (gpd) per chicken (SWCB, 1983), an estimated 234,000 gpd were used in 1990 for poultry production in the Eastern Shore area (HWH, 1991).

SWCB permits are required for industrial and public water users withdrawing at least 10,000 gpd. WFF is presently limited to approximately 8.2 million gallons per month (1991 SWCB Permit ES 0038900). No record of total annual withdrawal is available for WFF. The Town of Chincoteague (TOC) is also supplied with water from wells. The 1991 water usage data from the TOC Department of Public Works indicates a total annual withdrawal of approximately 193.3 million gallons from eight wells located within WFF property.

Extensive pumping of the upper and lower aquifers is associated with the Town of Chincoteague and WFF well fields. The Town of Chincoteague well fields are located on the eastern portion of the Main Base, with wells screened in both the Pleistocene and Miocene age aquifers. The WFF wells are located in various areas of the facility; however, most of the WFF Main Base supply wells are located in the central portion of the facility. NASA has recently converted all shallow supply wells to inactive status. Potable water is now supplied to WFF operations and facilities from five deep wells installed in the Miocene age aquifers. The well locations and descriptions are presented in Figures 3-1 and Table 3-1. The water table elevations are presented in Figures 3-2 and 3-3.

TABLE 3-1. WELL DESCRIPTIONS - WALLOPS FLIGHT FACILITY

ID	OWNER	DATE OF INSTAL-LATION	DIAMETER (INCHES)	DEPTH (FEET)	SCREENED INTERVAL (FEET)	CASING TYPE	ELEVATION OF TOP OF CASING (FEET ABOVE 1929 MSL)	WELL TYPE
PLEISTOCENE AGE AQUIFER								
MW01	NASA	1989	2	57	45-55	PVC	34.35	Monitoring Well
MW02S	NASA	1989	2	30	10-30	PVC	33.01	Monitoring Well
MW02D	NASA	1989	2	57	45-55	PVC	33.35	Monitoring Well
MW03	NASA	1989	2	30	10-30	PVC	34.01	Monitoring Well
MW04	NASA	1989	2	23	3-23	PVC	10.75	Monitoring Well
MW05S	NASA	1989	2	30	10-30	PVC	38.87	Monitoring Well
MW05D	NASA	1989	2	45	35-45	PVC	37.72	Monitoring Well
MW06	NASA	1989	2	35	15-35	PVC	36.34	Monitoring Well
MW07	NASA	1989	2	34	24-34	PVC	38.70	Monitoring Well
MW08	NASA	1989	2	29	19-29	PVC	32.97	Monitoring Well
MW09	NASA	1989	2	28.9	18.8-28.8	PVC	32.36	Monitoring Well
MW10	NASA	1989	2	26.5	6-26	PVC	34.50	Monitoring Well
MW11	NASA	1990	2	26	16-26	PVC	34.66	Monitoring Well
MW12	NASA	1990	2	30	18-28	PVC	38.01	Monitoring Well
MW13	NASA	1990	2	25	15-25	PVC	33.53	Monitoring Well
MW14	NASA	1990	2	62	52-62	PVC	34.55	Monitoring Well
MW15	NASA	1990	2	29	18-28	PVC	37.23	Monitoring Well
MW16	NASA	1990	2	26	16-26	PVC	34.57	Monitoring Well
MW17	NASA	1990	2	35	17-27	PVC	36.92	Monitoring Well
MW20	NASA	1991	2	62	45-60	PVC	17.64	Monitoring Well
MW21A	NASA	1991	2	62	45-60	PVC	14.03	Monitoring Well
MW22	NASA	1991	2	37	22-37	PVC	9.02	Monitoring Well
MW23	NASA	1991	2	31	14-29	PVC	7.97	Monitoring Well
MW24	NASA	1991	2	20	5-20	PVC	11.65	Monitoring Well (Destroyed)
MW25	NASA	1991	2	30	15-30	PVC	34.85	Monitoring Well
MW26S	NASA	1991	2	30	15-30	PVC	35.37	Monitoring Well

TABLE 3.1. WELL DESCRIPTIONS - WALLOPS FLIGHT FACILITY (Continued)

ID	OWNER	DATE OF INSTAL-LATION	DIAMETER (INCHES)	DEPTH (FEET)	SCREENED INTERVAL (FEET)	CASING TYPE	ELEVATION OF TOP OF CASING (FEET ABOVE 1929 MSL)	WELL TYPE
PLEISTOCENE AGE AQUIFER (Continued)								
MW26D	NASA	1991	2	61	45-60	PVC	34.98	Monitoring Well
MW27	NASA	1991	2	30	15-30	PVC	36.48	Monitoring Well
MW28	NASA	1991	2	27	12-27	PVC	33.50	Monitoring Well
MW29	NASA	1991	2	45	30-45	PVC	32.18	Monitoring Well
MW30	NASA	1991	2	30	15-30	PVC	38.16	Monitoring Well
MW31	NASA	1992	2	26	16-26	PVC	Unknown	Monitoring Well
MW32	NASA	1992	2	26	16-26	PVC	Unknown	Monitoring Well
MW33	NASA	1992	2	25	15-25	PVC	Unknown	Monitoring Well
MW34	NASA	1992	2	27	17-27	PVC	Unknown	Monitoring Well
MW35	NASA	1992	2	13	3-13	PVC	Unknown	Monitoring Well
MW36	NASA	1992	2	13	3-13	PVC	Unknown	Monitoring Well
MW37	NASA	1992	2	14	4-14	PVC	Unknown	Monitoring Well
MW38	NASA	1992	2	18.5	8.5-18.5	PVC	Unknown	Monitoring Well
MW39	NASA	1992	2	19	9-19	PVC	Unknown	Monitoring Well
OW-1 (D-39)	NASA	1991	2	42	17-42	PVC	33.32	Observation Well
OW-2 (D-39)	NASA	1991	2	50	20-50	PVC	34.08	Observation Well
MW40	NASA	1992	2	23	8-23	PVC	Unknown	Monitoring Well
MW41	NASA	1992	2	33.5	23.5-33.5	PVC	Unknown	Monitoring Well
MW42	NASA	1992	2	33.5	18.5-33.5	PVC	Unknown	Monitoring Well
MW43	NASA	1992	2	25	15-25	PVC	Unknown	Monitoring Well
MW44	NASA	1992	2	30	15-30	PVC	Unknown	Monitoring Well
H-114	NASA	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Retired Drinking Water
H-23	NASA	1948	8	67	40-45,48-53	Unknown	37.0	Retired Drinking Water
F-30	NASA	1948	8	69	49-59	Unknown	37.0	Retired Drinking Water
F-189	NASA	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Retired Drinking Water
D-36	NASA	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Retired Drinking Water

TABLE 3.1. WELL DESCRIPTIONS - WALLOPS FLIGHT FACILITY (Continued)

ID	OWNER	DATE OF INSTAL-LATION	DIAMETER (INCHES)	DEPTH (FEET)	SCREENED INTERVAL (FEET)	CASING TYPE	ELEVATION OF TOP OF CASING (FEET ABOVE 1929 MSL)	WELL TYPE
PLEISTOCENE AGE AQUIFER (Continued)								
D-37	NASA	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Retired Drinking Water
D-38	NASA	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Retired Drinking Water
A-40	NASA	1947	8	60	50-60	Unknown	35.0	Retired Drinking Water
B-49	NASA	Unknown	Unknown	60	Unknown	Unknown	30.0	Retired Drinking Water
A-131	NASA	1963	Unknown	Unknown	Unknown	Unknown	Unknown	Retired Drinking Water
D-39	NASA	1947	8	45	28-33,35-40	Steel	37.0	Retired Drinking Water
D-40	NASA	1947	8	50	28-33,40-45	Unknown	30.0	Retired Drinking Water
F-31	NASA	1948	8	59	49-59	Unknown	33.0	Retired Drinking Water
TOC 3-1	TOC	1975	4	50	40-50	Steel w/SS Screen	Unknown	Retired Drinking Water
TOC 3-2	TOC	1975	4	50	40-50	Steel w/SS Screen	Unknown	Retired Drinking Water
TOC 3-3	TOC	1975	4	50	40-50	Steel w/SS Screen	Unknown	Retired Drinking Water
TOC 3-4	TOC	1975	4	50	40-50	Steel w/SS Screen	Unknown	Retired Drinking Water
TOC 3-5	TOC	1975	4	50	40-50	Steel w/SS Screen	Unknown	Retired Drinking Water
TOC 3-6	TOC	1975	4	50	40-50	Steel w/SS Screen	Unknown	Retired Drinking Water
TOC 3-7	TOC	1975	4	50	40-50	Steel w/SS Screen	Unknown	Retired Drinking Water
TOC 3-8	TOC	1975	4	50	40-50	Steel w/SS Screen	Unknown	Retired Drinking Water
TOC 3-9	TOC	1975	4	50	40-50	Steel w/SS Screen	Unknown	Retired Drinking Water
TOC-3A	TOC	1989	6	55	40-55	Steel w/SS Screen	Unknown	Active Drinking Water
TOC-3B	TOC	1989	6	60	45-60	Steel w/SS Screen	Unknown	Active Drinking Water
TOC-3C	TOC	1989	6	60	45-60	Steel w/SS Screen	Unknown	Active Drinking Water
MIOCENE AGE AQUIFER								
NOAA	NASA	1966	8	260	151-?	Unknown	35.0	Active Drinking Water
F-113	NASA	1953	8	241	220-230	Unknown	32.0	Retired Drinking Water
D-46	NASA	1948	8	131	110-120	Unknown	33.0	Retired Drinking Water
J-20	NASA	1991	4	255	245-255	PVC	Unknown	Active Drinking Water
F-35	NASA	1948	8	120	110-120	Unknown	37.0	Retired Drinking Water

TABLE 3.1. WELL DESCRIPTIONS - WALLOPS FLIGHT FACILITY (Continued)

ID	OWNER	DATE OF INSTAL-LATION	DIAMETER (INCHES)	DEPTH (FEET)	SCREENED INTERVAL (FEET)	CASING TYPE	ELEVATION OF TOP OF CASING (FEET ABOVE 1929 MSL)	WELL TYPE
MIOCENE AGE AQUIFER (Continued)								
F-112	NASA	1983	4	220	210-220	Stainless Steel	34.0	Retired Drinking Water
H-115	NASA	1990	8	260	190-250	Stainless Steel	33.0	Active Drinking Water
TOC-4	TOC	1965	8	262	216-245	Unknown	24.0	Active Drinking Water
TOC-5	TOC	1972	6	256	223-256	Unknown	20.0	Active Drinking Water
TOC-6	TOC	1977	6	260	154-159,180-185, 192-197,210-225	Unknown	12.0	Active Drinking Water
TOC-7A	TOC	1983	6	107	97-107	Unknown	25.00	Active Drinking Water
TOC-7B	TOC	1983	6	106	96-106	Unknown	28.00	Active Drinking Water
TOC-7C	TOC	1983	6	100	90-100	Unknown	25.00	Inactive Drinking Water
WELL 1	NASA	1992	8	260	190-225	Stainless Steel	36.67	Active Drinking Water
WELL 2	NASA	1993	8	150	100-145	Stainless Steel	35.10	Active Drinking Water
WELL 3	NASA	1992	8	253	198-248	Stainless Steel	35.80	Active Drinking Water
WELL 4	NASA	1992	8	265	220-260	Stainless Steel	36.50	Active Drinking Water

Abbreviations:

D - Deep
MSL - Mean Sea Level
MW - Monitoring Well
NOAA - National Oceanic and Atmospheric Administration
OW - Observation Well
PVC - Polyvinyl Chloride
S - Shallow
SS - Stainless Steel
TOC - Town of Chincoteague

3.1.4 Climate

The climate at WFF is humid with hot summers and no distinct dry season. From October through March, the weather at the facility is dominated by continental air masses with relatively low moisture content. From April through September, the air is more maritime with high moisture content at low levels due to circulation around the Bermuda high which reaches its peak intensity during late summer.

The average annual precipitation is 36.8 inches. The average mean temperature is 56 degrees Fahrenheit (°F), with a mean maximum of 64°F and mean minimum of 48°F. The prevailing wind direction is southerly during the summer and northwesterly during the winter. The average wind speed is 10 knots.

The cloud cover varies from month to month, being at a minimum in August and at a maximum in January. From June through November, the WFF and surrounding areas are subject to severe thunderstorms, high tides, heavy rains, and phenomena generally associated with hurricane season. From December through March, the area is subject to cold fronts, snow storms, and sleet.

3.2 GEOLOGY

3.2.1 Regional Geology

WFF is part of the Atlantic Coastal Plain physiographic province, a seaward sloping stratified body of sediments bounded on the west by the Fall Line and on the east by the Atlantic Ocean. The facility is underlain by approximately 7,000 feet of unconsolidated sediments dating back to the Cretaceous era. Below this group of sediments are crystalline basement rocks of igneous and metamorphic origins.

The water-bearing formations within the WFF area consist of sedimentary units ranging in age from Cretaceous to Quaternary. The two uppermost stratigraphic units, the Yorktown Formation and the overlying Columbia Group, are the most important water supply formations for agricultural, domestic, public, and industrial uses.

The Yorktown Formation is the uppermost unit in the Chesapeake Group. The formation consists of fine to coarse, greenish gray, glauconitic quartz sand, which is clayey, silty, and in part, shelly. The formation

generally occurs at depths of 60 to 140 feet in Accomack County.

The Columbia Group sediments represent the Holocene and Pleistocene epochs. Lithologies of the Columbia Group consist of sand, sandy clay, and minor amounts of gravel deposited during the sea level fluctuations in the Pleistocene epoch.

3.2.2 Site Geology

WFF ranges in elevations from mean sea level (MSL) to 42 feet above MSL, yet is mostly flat with slope ranges of 1 to 2 percent. The Columbia group, as encountered in borings completed at the FTA, is comprised of light brown to tan silty sand to sand with trace clay. The upper aquitard of the Yorktown Formation was encountered at depths of 32 feet to greater than 50 feet, and consisted of gray silty clay.

3.3 HYDROGEOLOGY

3.3.1 Surface Water Receptors and Drainage Patterns

The generally level topography of WFF is typical of the Atlantic Coastal Plain physiographic province in Virginia. WFF is surrounded by a shallow estuarine environment which is composed of several marsh areas and creeks. Surface water generally flows toward the nearest marsh or creek. Drainage is poorly defined on Wallops Main Base.

General drainage patterns in the FTA vicinity ultimately flow north toward Little Mosquito Creek and adjacent marshlands through percolation into the Pleistocene age aquifer and recharge into the surface water. The topography in the vicinity of the FTA is generally flat, with slopes ranging from 1 to 2 percent. Surface water in the immediate vicinity of the FTA is limited to intermittent ponds formed by surface runoff to low-lying areas north and northeast of the former training pit area. No direct connection between site surface runoff and more permanent tributaries or creeks were observed at the site.

3.3.2 Regional Hydrogeology

The Virginia DEQ identified four major aquifers on the Eastern Shore of Virginia: the Pleistocene age

aquifer (Columbia Group) and the three separate units of Miocene age aquifers in the Yorktown Formation. The water table aquifer, or Pleistocene age aquifer, is unconfined and typically overlain by wind-deposited beach sands, silts, and gravel. This aquifer occurs between depths of 5 and 60 feet below the ground surface. The water table ranges from depths of 0 to 30 feet below the ground surface.

The top of the shallowest confined Miocene age aquifer of the Yorktown Formation is found at depths of approximately 100 feet below the ground surface at WFF. It is separated from the overlying Pleistocene age aquifer by a 20- to 30-foot confining layer (aquitard) of clay and silt. The Miocene age aquifers are classified as the upper, the middle, and the lower Miocene age aquifers. Correspondingly, each Miocene age aquifer is overlain by the upper, middle, and lower Miocene age confining units.

In general, the water table (Pleistocene) aquifer on the Delmarva Peninsula is recharged by surface waters or infiltration of precipitation. The confined aquifers are recharged by the same process, but from more distal areas located beyond the immediate vicinity of WFF. The annual average rainfall for WFF is 36.8 inches, with an estimated annual net precipitation of 14 inches. Recent aquifer tests estimated hydraulic conductivity values ranging from approximately 80 to 200 feet per day, and specific yield values from 0.01 to 0.13 for the unconfined aquifer. These values are typical of unconfined aquifers with mainly sand units, and demonstrate the ease of recharge from surface water and/or precipitation. The tests also indicated no significant vertical leakage through the aquitard below the unconfined aquifer. The confined aquifers are believed to be recharged laterally from an area with greater vertical leakages. Aquifer tests performed on the upper and middle Miocene age aquifers indicated a transmissivity range of 8500 to 14,500 gallons per day per foot (gpd/ft), a storativity of ± 0.003, and a vertical leakage rate of 0.0352 feet per day for the upper Miocene aquifer. The middle Miocene age aquifer indicated a transmissivity of 4000 gpd/ft and a storativity range of 0.002 to 0.0002.

3.3.3 Site Hydrogeology

On the Main Base, groundwater flow in the Pleistocene age aquifer is generally east and north toward nearby creeks and to the marsh area which separates Chincoteague Island from the mainland. However, the shallow groundwater flow appears to be locally influenced on WFF by cones of depression and a groundwater divide along Runway 04-22. The cones of depression result from water supply wells installed in the Pleistocene age aquifer by the Town of Chincoteague. The groundwater divide separates groundwater flow on either side of Runway 04-22.

Figures 3-1 and 3-2 are groundwater contour maps developed from data collected from monitoring wells completed in the Pleistocene age aquifer at the FTA. Groundwater flow in this portion of the Pleistocene age aquifer is generally northeast toward an unnamed tributary to Little Mosquito Creek. The unnamed tributary flows north and is located approximately 500 feet east of the FTA.

Geologic cross-sections across the former FTA site are presented in Figures 3-6 and 3-7. Cross-section locations are indicated in Figure 3-8. The water table depth ranged from 14 to 16 feet below the ground surface during the January 1994 sampling event. Groundwater flow in the water table (Pleistocene) aquifer is toward the north-northeast, and generally follows the topographical trends of the site.

3.4 ECOLOGICAL SETTING

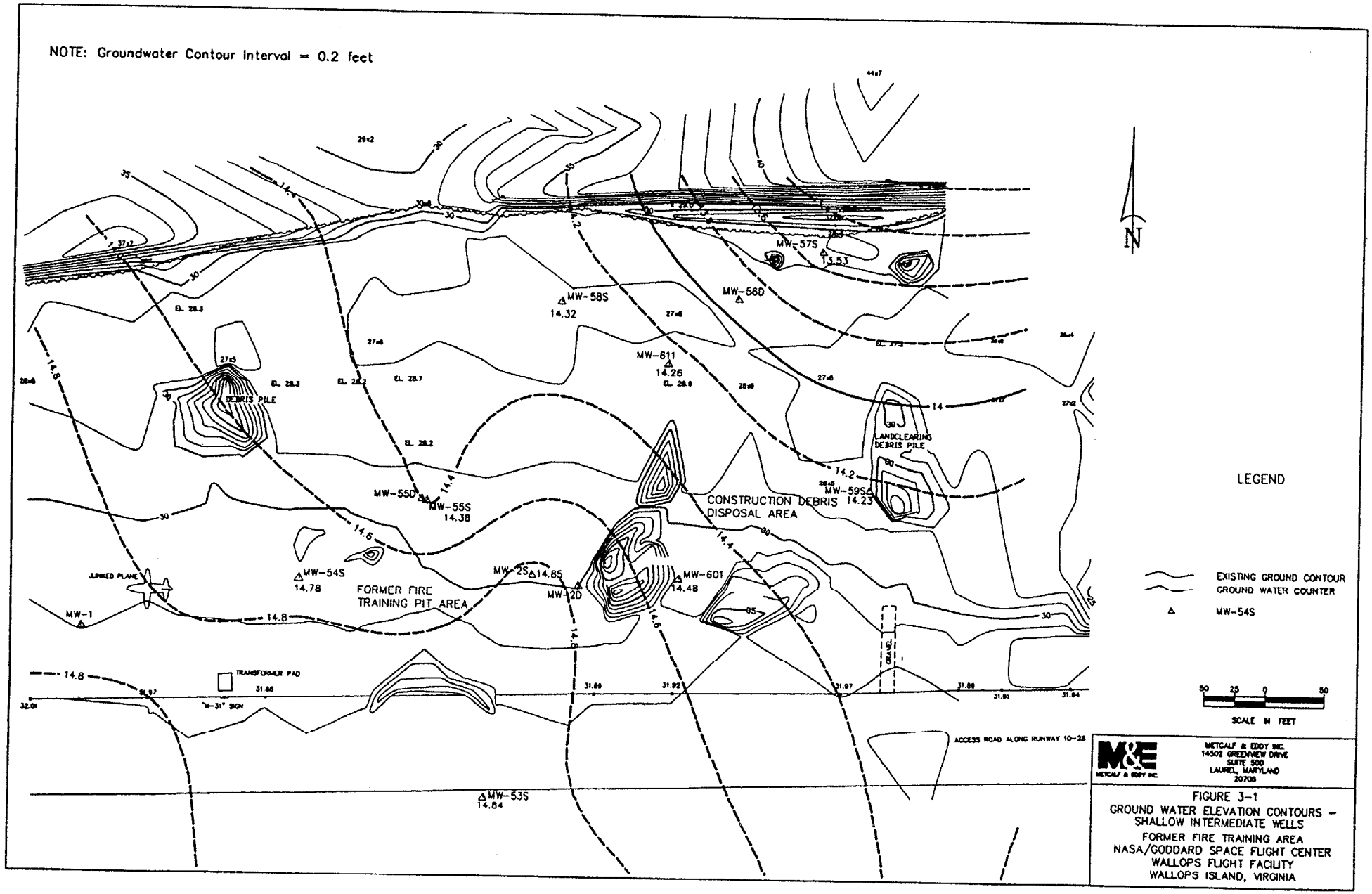
3.4.1 Wildlife

3.4.1.1 Birds

There are approximately 250 species of birds that may reside or migrate through the WFF vicinity. During the August 1994 site survey, significant bird activity was noted in the woodland area bordering the former FTA. Also, several perching bird species were observed in other areas of the FTA. Potential bird species at WFF are discussed in the Ecological Risk Assessment (Section 7.0).

3.4.1.2 Mammals

The setting at WFF provides several habitat types that may include approximately 61 mammal species. Few wildlife signs or tracks of these species were observed. Signs observed during the August 1994 site reconnaissance indicate the potential existence of white-tailed deer (*Odocoileus virginianus*) and raccoon (*Procyon lotor*) at or near the former FTA. Although, they were not observed during the ecological site survey, rabbits and bats may also be present. Additional information concerning the animal species present at the FTA can be found in Section 7.0.



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LAUREL, MARYLAND
20708

FIGURE 3-1
GROUND WATER ELEVATION CONTOURS - SHALLOW INTERMEDIATE WELLS
FORMER FIRE TRAINING AREA
NASA/GODDARD SPACE FLIGHT CENTER
WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA

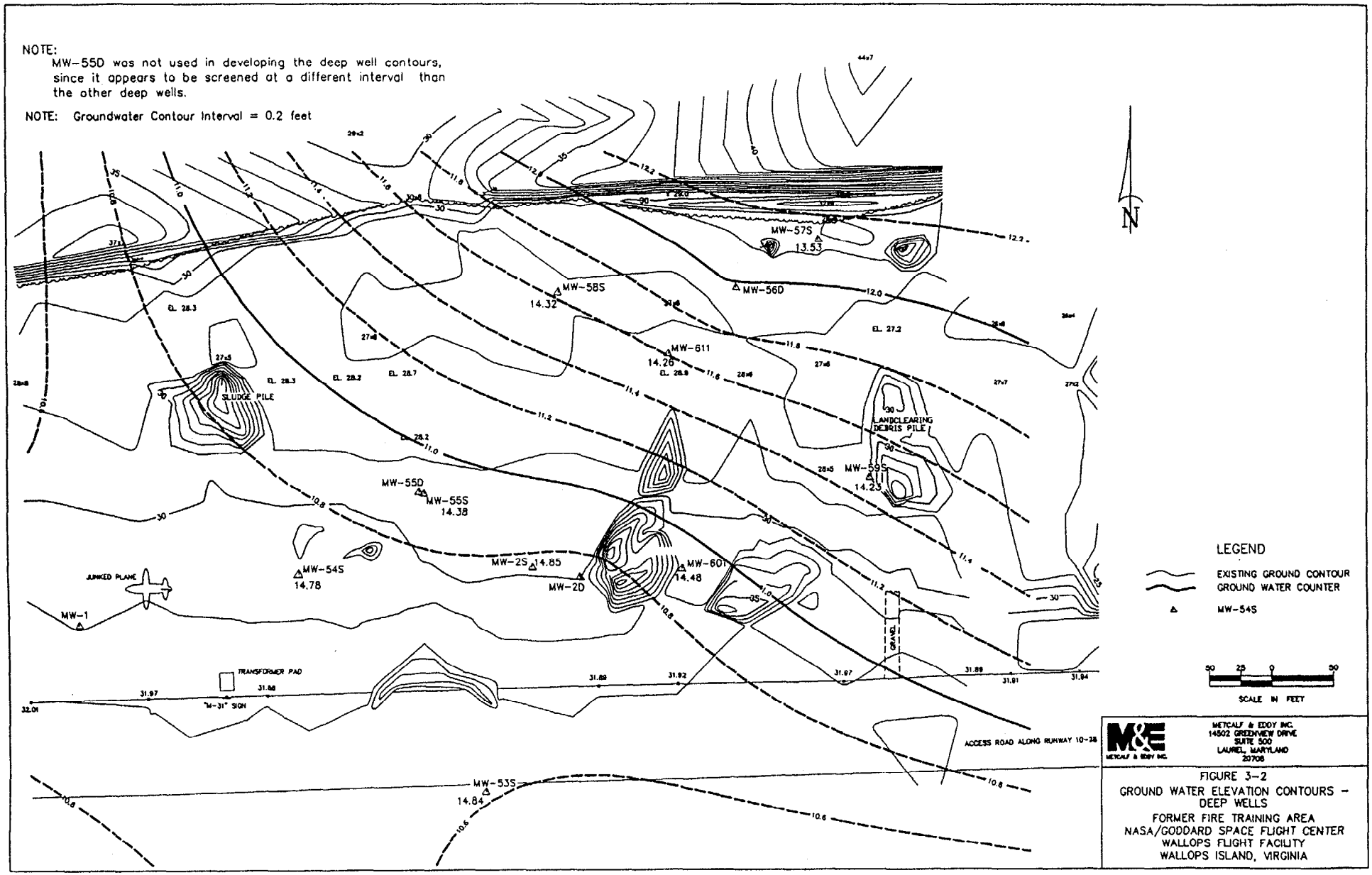

FIGURE 3-2
GROUND WATER ELEVATION CONTOURS - DEEP WELLS
FORMER FIRE TRAINING AREA
NASA/GODDARD SPACE FLIGHT CENTER
WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA

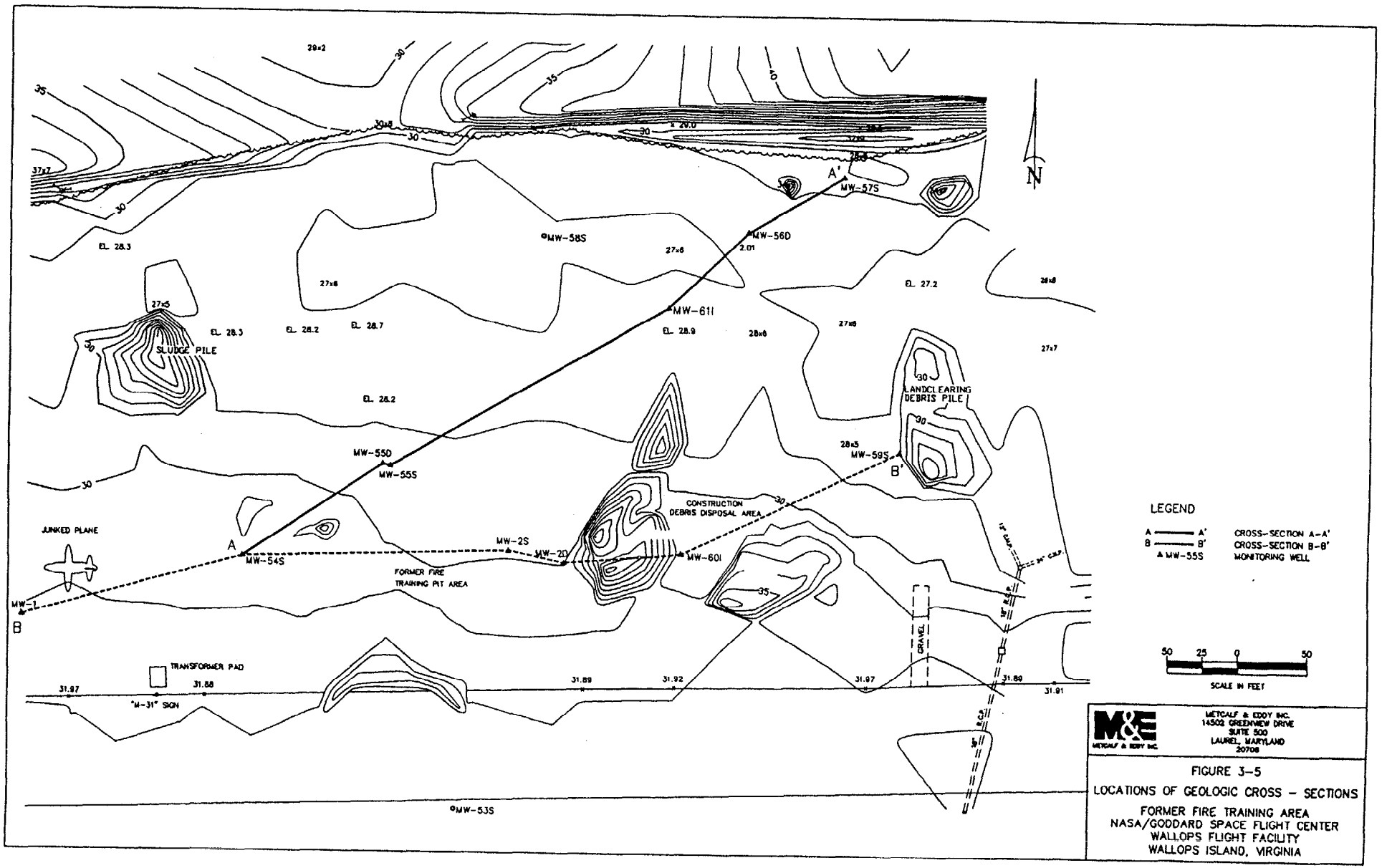

FIGURE 3-5

LOCATIONS OF GEOLOGIC CROSS - SECTIONS

FORMER FIRE TRAINING AREA
NASA/GODDARD SPACE FLIGHT CENTER
WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA

3.4.1.3 Reptiles and Amphibians

According to the WFF Environmental Resources Document, some species of reptiles such as the black rat snake (*Elapha obsoleta*), hognose snake (*Heterodon platyrhinos*), box turtle (*Terrapene caolina)*, and northern fence lizard (*Sceloporus undulatus*) can be found in low lying shrubs at the WFF. Based upon the observed habitats, these snakes and terrestrial turtles may be present at the former FTA.

3.4.2 Threatened and Endangered Species

The Commonwealth of Virginia Department of Game and Inland Fisheries (VDGIF) provided information for the WFF Environmental Resources Document (NASA, 1994) on the Threatened and Endangered (T&E) species of plants and animals potentially present at WFF. None of these species were observed at the former FTA, nor were they expected, since the majority of these species live in or near the ocean, and the FTA is inland (on the main land portion of WFF). No suspect growing or nesting areas were observed at, or in the vicinity of, the FTA.

3.4.3 Habitat Types

The four primary terrestrial habitat types on WFF are dune systems, island forest, upland grasslands, and upland forest. The former FTA is dominated by upland field habitat, with a nearby upland forest. The field habitat at this site is mowed, limiting its potential as a habitat for wildlife. Also, the former FTA is bounded by an active runway.

The important habitats at, or near, the FTA are the pine woodland north of the site (not actually part of the FTA), and the scrub-shrub habitats forming on the dirt and brush piles scattered over the site. The ecological setting is described in greater detail in Sections 7.3 and 7.4.

The aquatic environment at WFF is varied, comprising freshwater, brackish, and saltwater; tidal and non-tidal; lotic and lentic; and intermittent and perennial systems. However, the only aquatic systems noted in the immediate vicinity of the former FTA during the August 1994 site reconnaissance were a small, 10- by 15-foot, shallow (depth less than 2 inches) intermittent pool, and a tributary to Little Mosquito Creek, located over 500 feet to the east of the site. Due to the topography of the FTA and the surrounding area,

surface runoff from the FTA is not expected to enter this tributary. Several small intermittent pools were present at the site during the January 1994 sampling event.

3.4.4 Wetlands

Wetlands on WFF can be classified as tidal and non-tidal wetlands. Wetland delineations at WFF are coordinated with the Accomack County Wetlands Board (ACPC, 1983), the Commonwealth of Virginia, and the U.S. Army Corp of Engineers. There are three predominant wetland systems in the WFF area: marine wetlands, estuarine wetlands, and palustrine wetlands (ERD, 1992). However, no wetlands were reported or noted for the former FTA area.

4.0 NATURE AND EXTENT OF CONTAMINATION

4.1 POTENTIAL CONTAMINANT SOURCES

Potential sources contributing to contamination of groundwater and other environmental media were identified from the previous investigation. The four sources of possible contamination at the site are: the former fire training pit area, the sludge pile, the construction debris disposal area, and the former drum storage area. These four source areas were targeted for investigation during the RI field activities.

4.1.1 Former Fire Training Area

Approximately 20 truckloads of soil, suspected to contain a mixture of jet fuel and crankcase oil, as well as other waste products, were removed from the former fire training pit area in 1986. Although fire training exercises are no longer conducted at the site and much of the contaminated soil may have been removed, contaminated media including soil may still be present at the site. Therefore, based on the previous fire training activities, the fire training pit area is considered the most likely source of contamination of environmental media at this site.

4.1.2 Sludge Pile

The sludge pile is located west of the former fire training pit area, and resulted from the disposal of sludge from the WFF wastewater treatment plant. The pile is approximately eight to ten feet tall. Subsurface soil samples were collected downgradient of the pile and samples were removed from the pile itself to characterize potential contribution to site contamination.

4.1.3 Construction Debris Disposal Area

The construction debris disposal area is located to the east of the former fire training pit area . This area was previously referred to as a construction debris landfill. Originally the pile was intended for clean fill storage, but was used also for construction debris disposal. Subsurface and surface soil samples were collected in and around the area. Two other piles in the area of the construction debris piles were identified, but they appeared to contain only land clearing debris generated during the summer of 1993. The piles range from 3 to 8 feet tall.

4.1.4 Former Drum Storage Area

Drums were reportedly stored on wooden pallets in the area east of the sludge pile. The contents of the drums are unknown, but may have been materials used in the training exercises. The date of removal of the drums and the integrity of the drums are unknown.

4.2 CONTAMINANT DISTRIBUTION AND TRENDS

4.2.1 Data Presentation

Each sample was analyzed for volatiles, semivolatiles, pesticides/PCBs, and metals. The data were then verified and validated. The resulting data are presented in Tables 4-1 through 4-5. The tables include only TAL and TCL chemicals for which detections were reported.

Surface soil analytical results are presented in Table 4-1. Samples SS-01 through SS-04, and SS-07 through SS-10 were collected in the area of the former fire training pit and downgradient. Samples SS-05 and SS-06 were collected in the former drum storage area. Sample SS-03 contained several Polycyclic Aromatic Hydrocarbons (PAHs), but there were few detections in the other samples. Total petroleum hydrocarbon levels range from 39.7 to 5890 micrograms per kilogram (μg/kg) in the surface soil samples.

Forty-six subsurface soil samples were taken during the 1993 boring program. Samples SB1-1 through SB2-4 were taken in the area of the sludge pile. Samples SB13-1 through SB14-4 were taken in and around the construction debris disposal area. The remaining subsurface soil samples were collected upgradient and downgradient of the former fire training pit. The data are presented in Table 4-2.

The groundwater analytical data are presented in Table 4-3. The two wells with the most elevated contamination were MW-02S and MW-55S. These samples were collected in the suspected area of the former fire training pit.

Surface water analytical results are presented in Table 4-4. Very few volatiles, pesticides, or semivolatiles were detected, but several metals were reported in the surface water samples. Sediment analytical results are presented in Table 4-5. Trace amounts of volatiles, pesticides/PCBs, semivolatiles, and metals were detected in the four sediment samples. Results from analytical testing conducted in 1990 as a part of the SI are presented in Table 4-6 (Groundwater) and Table 4-7 (Surface Soil). Only those compounds with at least one detection are presented in the data summary table for each medium sampled.

TABLE 4-1
1994 SURFACE SOIL ANALYTICAL RESULTS

	SS01	SS02	SS03	SS04	SS05	SS06	SS07	SS08	SS09	SS10	Dup of SS03 SS11
VOLATILE ORGANICS (µg/kg)											
Methylene Chloride	7 B	18 B	6 B	11 B	33 B	24 B	31 B	15 B	15 B	18 B	11 B
Acetone	U<10	9 B	U<10	U<10	110 B	29 B	70 B	18 B	20 B	12 B	8 B
PESTICIDES AND PCBs (µg/kg)											
Heptachlor	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	0.18 B	0.10 B	0.13 B	U<1.7	U<1.7
Heptachlor epoxide	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	0.24 J
Endosulfan I	U<1.7	U<1.7	U<1.7	0.16 J	3.6	U<1.7	U<1.7	U<1.7	U<1.7	0.19 J	U<1.7
Dieldrin	U<1.7	U<1.7	0.20 J	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7
4,4'-DDE	16	1 J	1.1 J	3.2 J	5.8	3.3 J	4.6	4.4	20	3 J	1.1 J
4,4'-DDD	1.1	U<3.3	U<3.3	0.56 J	U<3.3	U<3.3	U<3.3	0.29 J	0.56 J	0.42 J	U<3.3
Endosulfan sulfate	U<3.3	0.22 J	0.35 J	U<3.3	0.38 J	U<3.3	U<3.3	U<3.3	U<3.3	0.11 J	0.31 J
4,4'-DDT	33	4.2	3.1 J	3.3 J	U<3.3	1.9 J	2.5 J	2.1 J	18	10	2.9 J
Methoxychlor	3.9 B	U<17	U<17	U<17	0.96 B	U<17	0.38 B	0.28 B	0.26 J	0.60 B	U<17
Endrin ketone	1 J	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	0.30 J	U<3.3
Endrin aldehyde	0.47 J	U<3.3	U<3.3	U<3.3	4.4	U<3.3	U<3.3	U<3.3	0.21 J	U<3.3	U<3.3
alpha-Chlordane	U<1.7	U<1.7	U<1.7	U<1.7	1.8 J	U<1.7	U<1.7	U<1.7	U<1.7	0.17 J	U<1.7
gamma-Chlordane	U<1.7	U<1.7	U<1.7	U<1.7	3 J	U<1.7	U<1.7	U<1.7	U<1.7	0.20 B	U<1.7
SEMIVOLATILES (µg/kg)											
4-Nitrophenol	41 J	U<800	U<800	U<800	U<800	U<800	U<800	U<800	U<800	U<800	U<800
Phenanthrene	U<330	U<330	71 J	U<330	U<330	U<330	U<330	U<330	U<330	U<330	46 J
Fluoranthene	U<330	U<330	210 J	U<330	U<330	U<330	U<330	U<330	U<330	86 J	78 J
Pyrene	U<330	U<330	190 J	U<330	U<330	U<330	U<330	U<330	U<330	84 J	78 J
Benz(a)anthracene	U<330	U<330	150 J	U<330	U<330	U<330	U<330	U<330	U<330	51 J	47 J
Chrysene	U<330	U<330	130 J	U<330	U<330	U<330	U<330	U<330	U<330	64 J	56 J
Bis(2-ethylhexyl)phthalate	U<330	47 B	68 B	630 B	U<330	200 B	140 B	110 B	39 B	470 B	79 B
Benzo(b)fluoranthene	U<330	U<330	260 J	U<330	U<330	U<330	U<330	U<330	U<330	93 J	94 J
Benzo(k)fluoranthene	U<330	U<330	260 J	U<330	U<330	U<330	U<330	U<330	U<330	93 J	94 J
Benzo(a)pyrene	U<330	U<330	130 J	U<330	U<330	U<330	U<330	U<330	U<330	39 J	U<330
Indeno(1,2,3-cd)pyrene	U<330	U<330	99 J	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330
Benzo(g,h,i)perylene	U<330	U<330	91 J	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330
Di-n-butylphthalate	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10
Bis(2-ethylhexyl)phthalate	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10
INORGANICS (mg/kg)											
Aluminum	6420	8650	8080	5800	7180	8930	6920	9400	4880	12600	9030
Arsenic	1.5 J	2.2 J	5.1 J	1.4 J	1.5 J	1.7 J	2.3 J	4.8 J	1.3 J	2.8 J	6.3 J
Barium	11.0	18.6	37.3	12.1	30.6	24.2	22.3	41.1	10.7	34.5	38.0
Cadmium	U<0.92	U<0.94	U<1.0	U<1.0	3.4	U<0.99	U<1.0	U<0.98	U<0.92	U<0.94	U<1.0
Calcium	322 J	108 J	522 J	398 J	328 J	504 J	359 J	587 J	184 J	482 J	589 J
Chromium	5.5	5.8	9	4.7	7.8	7.9	7	9.6	4	12.3	9.6
Cobalt	U<2.2	U<2.2	2.8	U<2.4	U<2.6	U<2.3	U<2.3	3	U<2.2	3	3.2
Copper	U<2.7	U<2.8	7.4	U<3.0	58.1	19.7	5.8	6.2	U<2.7	5.9	7.5
Iron	2730	3540	6890	2680	3350	4380	4260	6720	2270	9040	6770
Lead	33.8 K	7 J	18.6	7.4 J	15.6	7.1	8.4	12.4	7.9 J	9.9	19.6 K
Magnesium	315	335	714	331	422	564	475	765	268	846	789
Manganese	27.5	30.8	130	36.6	41.2	53.4	68.7	119	30.4	70.5	139
Nickel	U<7.5	U<7.6	U<8.2	U<8.3	U<8.3	U<8.0	U<8.1	U<7.9	U<7.4	8	U<8.3
Potassium	U<394	U<401	U<433	U<437	U<464	U<422	U<426	U<417	U<390	541	U<437
Sodium	U<59.7	U<60.8	U<65.7	U<66.2	U<70.4	U<64.0	U<64.6	U<63.3	U<59.2	U<60.9	U<66.2
Vanadium	8.6	8.9	14.3	7.4	8.4	11	11.5	14.4	7.4	19.5	15.9
Zinc	17.6 B	12.2 B	27.4	11.1 B	63.4	17.3 B	14.6 B	20.6	14.2 B	17.8 B	24.9

KEY:

SS01 = Fire Training Area Surface Soil Sample No. 1

U<8 = Undetected above numerical detection limit (e.g., 8)

J = Analyte present. Reported value may not be accurate or precise.

B = Not detected substantially above the level reported in lab or field blanks.

L = Analyte present. Reported value may be biased low. Actual value is expected to be higher.

K = Analyte present. Reported value may be biased high. Actual value is expected to be lower.

µg/kg = microgram/kilogram

mg/kg = milligram/kilogram

TABLE 4-2
1993 SUBSURFACE SOIL ANALYTICAL RESULTS

	SB1-1	SB1-2	SB1-3	SB1-4	SB2-1	SB2-2	SB2-3	SB2-4	SB3-1	SB3-2	SB3-3	SB4-1	SB4-2	SB4-3 (Dup of SB15-1)
VOLATILE ORGANICS (µg/kg)														
Acetone	11 B	28 B	24 B	41 B	12 B	19 B	72 B	33 B	17 B	20 B	78 B	30 B	21 B	18 B
cis-1,2-Dichloroethene	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10
Methylene Chloride	4 B	7 B	8 B	33 B	4 B	5 B	12 B	11 B	7 B	10 B	17 B	10 B	7 B	8 B
2-Butanone	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	2 B	U<10	U<10	U<10	U<10	U<10
1,1,1-Trichloroethane	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10
Toluene	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10
Ethylbenzene	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10
Total Xylenes	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10
PESTICIDES AND PCBs (µg/kg)														
alpha-BHC	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7
delta-BHC	U<1.7	0.23 J	U<1.7	0.062 J	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7
gamma-BHC (Lindane)	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7
Heptachlor	U<1.7	0.59 B	U<1.7	0.13 B	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	0.11 B	U<1.7	U<1.7	U<1.7	U<1.7
Aldrin	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7
Heptachlor epoxide	U<1.7	0.19 J	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7
Endosulfan I	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	0.090 J	U<1.7	U<1.7
Dieldrin	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	0.095 J	U<3.3	U<3.3	U<3.3	U<3.3
4,4'-DDE	U<3.3	U<3.3	U<3.3	U<3.3	0.92 J	U<3.3	U<3.3	3.2 J	U<3.3	0.12 J	U<3.3	U<3.3	U<3.3	U<3.3
Endrin	U<3.3	0.65 J	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3
Endosulfan II	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3
4,4'-DDD	U<3.3	0.68 J	U<3.3	1.3 J	0.39 J	0.11 J	0.16 J	2.1 J	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3
Endosulfan sulfate	U<3.3	U<3.3	U<3.3	0.64 J	U<3.3	0.097 J	U<3.3	0.30 J	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3
4,4'-DDT	U<3.3	1.6 J	U<3.3	0.78 J	0.93 J	0.21 J	0.66 J	4.5	U<3.3	0.41 J	U<3.3	U<3.3	U<3.3	U<3.3
Methoxychlor	U<17	U<17	U<17	U<17	U<17	U<17	U<17	U<17	U<17	U<17	U<17	U<17	U<17	U<17
Endrin ketone	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3
Endrin aldehyde	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3
alpha-Chlordane	U<1.7	7.5	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	2	U<1.7	U<1.7	U<1.7	U<1.7
gamma-Chlordane	U<1.7	6.3	0.064 B	U<1.7	0.058 B	U<1.7	U<1.7	U<1.7	U<1.7	1.6 J	0.38 B	U<1.7	U<1.7	U<1.7
Aroclor-1260	U<33	U<33	U<33	U<33	U<33	U<33	U<33	U<33	U<33	U<33	U<33	U<33	U<33	U<33
Toxaphene	U<170	U<170	U<170	U<170	U<170	U<170	U<170	U<170	U<170	U<170	U<170	10 J	U<170	U<170

KEY:

SB1-1 = Fire Training Area Soil Boring Sample No. 1 at 5 feet deep
SB1-2 = Fire Training Area Soil Boring Sample No. 1 at 10 feet deep
SB1-3 = Fire Training Area Soil Boring Sample No. 1 at 15 feet deep
SB1-4 = Fire Training Area Soil Boring Sample No. 1 at 20 feet deep
U<8 = Undetected above numerical detection limit (e.g., 8)

J = Analyte present. Reported value may not be accurate or precise.
B = Not detected substantially above the level reported in lab or field blanks.
L = Analyte present. Reported value may be biased low. Actual value is expected to be higher.
K = Analyte present. Reported value may be biased high. Actual value is expected to be lower.
µg/kg = microgram/kilogram

TABLE 4-2 cont
1993 SUBSURFACE SOIL ANALYTICAL RESULTS

	SB5-1	SB5-2	SB5-3	SB6-1	SB6-2	SB6-3	SB7-1	SB7-2	SB7-3	SB8-1	SB8-2	SB8-3	SB9-1	SB9-2
VOLATILE ORGANICS (µg/kg)														
Acetone	35 B	34 B	150 B	27 B	100 B	72 B	41 B	34 B	91 B	50 B	210 J	66 B	28 B	46 B
cis-1,2-Dichloroethene	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	3 J	U<10	U<10
Methylene Chloride	9 B	8 B	14 B	9 B	12 B	16 B	13 B	10 B	23 B	28 B	10 B	13 B	14 B	13 B
2-Butanone	2 B	5 B	2 B	U<10	U<10	2 B	U<10	1 B	U<10	U<10	2 J	U<10	U<10	U<10
1,1,1-Trichloroethane	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	3 J	U<10	U<10
Toluene	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	26	U<10	U<10
Ethylbenzene	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	10 J	U<10	U<10
Total Xylenes	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	27	U<10	U<10
PESTICIDES AND PCBs (µg/kg)														
alpha-BHC	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	0.24 J	U<1.7	U<1.7
delta-BHC	U<1.7	U<1.7	U<1.7	0.15 J	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7
Heptachlor	U<1.7	U<1.7	U<1.7	0.36 B	U<1.7	U<1.7	U<1.7	U<1.7	0.089 B	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7
Aldrin	U<1.7	U<1.7	U<1.7	U<1.7	0.068 J	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	0.82 J	U<1.7	U<1.7
Endosulfan I	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	0.073 J
Dieldrin	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	0.085 J	U<3.3	U<3.3
4,4'-DDE	U<3.3	U<3.3	1.2 J	0.24 J	0.13 J	U<3.3	U<3.3	1.2 J	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	0.22 J
Endrin	U<3.3	U<3.3	U<3.3	0.33 J	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3
4,4'-DDD	U<3.3	U<3.3	U<3.3	0.37 J	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3
4,4'-DDT	U<3.3	U<3.3	0.36 J	1.4 J	U<3.3	U<3.3	U<3.3	0.82 J	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3
Methoxychlor	U<17	U<17	0.28 B	U<17	U<17	2.6 B	U<17	U<17	U<17	U<17	U<17	U<17	0.62 B	0.26 B
Heptachlor epoxide	U<1.7	U<1.7	U<1.7	0.14 J	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7
Toxaphene	U<170	U<170	U<170	U<170	U<170	U<170	U<170	U<170	U<170	U<170	U<170	10 J	U<170	U<170
beta-BHC	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	1.1 J	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7
alpha-Chlordane	U<1.7	U<1.7	U<1.7	6	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7
gamma-Chlordane	U<1.7	U<1.7	U<1.7	4.8	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7
VOLATILE TICS (µg/kg)														
Dimethylpentane												41 J		
Tetramethylbutane												270 J		
Dimethylhexane RT = 9.80												81 J		
Dimethylhexane RT = 10.32												100 J		
Trimethylpentane												95 J		
Nonane												51 J		
Ethylmethylbenzene												33 J		
Trimethylbenzene												32 J		

KEY:

SB1-1 = Fire Training Area Soil Boring Sample No. 1 at 5 feet deep
SB1-2 = Fire Training Area Soil Boring Sample No. 1 at 10 feet deep
SB1-3 = Fire Training Area Soil Boring Sample No. 1 at 15 feet deep
SB1-4 = Fire Training Area Soil Boring Sample No. 1 at 20 feet deep
U<8 = Undetected above numerical detection limit (e.g., 8)

J = Analyte present. Reported value may not be accurate or precise.
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µg/kg = microgram/kilogram

TABLE 4-2 cont
1993 SUBSURFACE SOIL ANALYTICAL RESULTS

	SB9-3	SB10-1	SB10-2	*SB10-3	SB11-1	SB11-2	SB11-3	SB12-1	(Dup of SB16-1) SB12-2	SB12-3	SB13-1	SB13-2	SB13-3	SB13-4
VOLATILE ORGANICS (µg/kg)														
Acetone	30 B	42 B	11 B	17 B	24 B	21 B	47 B	16 B	12 B	30 B	U<10	36 B	69 B	U<10
cis-1,2-Dichloroethene	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10
Methylene Chloride	12 B	9 B	9 B	12 B	4 B	6 B	18 B	8 B	3 B	7 B	7 B	9 B	13 B	8 B
2-Butanone	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10
1,1,1-Trichloroethane	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10
Toluene	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10
Ethylbenzene	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10
Total Xylenes	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10	U<10
PESTICIDES AND PCBs (µg/kg)														
alpha-BHC	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7
delta-BHC	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7
gamma-BHC (Lindane)	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	1 J
Heptachlor	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	0.27 B
Aldrin	U<1.7	0.11 J	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7
Heptachlor epoxide	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	0.23 J
Endosulfan I	U<1.7	0.13 J	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7
Dieldrin	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3
4,4'-DDE	U<3.3	2.3 J	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	0.36 J	U<3.3	U<3.3	U<3.3	U<3.3	59
Endrin	U<3.3	2.9 J	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3
Endosulfan II	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3
4,4'-DDD	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	160
Endosulfan sulfate	U<3.3	0.82 J	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3
4,4'-DDT	U<3.3	8.4	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	210
Methoxychlor	U<17	U<17	U<17	U<17	U<17	U<17	0.24 B	U<17	U<17	U<17	U<17	U<17	U<17	U<17
Endrin ketone	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	0.38 J
Endrin aldehyde	U<3.3	4	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3	U<3.3
alpha-Chlordane	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7
gamma-Chlordane	U<1.7	0.22 J	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	U<1.7	0.047
Aroclor-1260	U<33	U<33	U<33	U<33	U<33	U<33	U<33	U<33	U<33	U<33	U<33	U<33	U<33	U<33

KEY:

SB1-1 = Fire Training Area Soil Boring Sample No. 1 at 5 feet deep
SB1-2 = Fire Training Area Soil Boring Sample No. 1 at 10 feet deep
SB1-3 = Fire Training Area Soil Boring Sample No. 1 at 15 feet deep
SB1-4 = Fire Training Area Soil Boring Sample No. 1 at 20 feet deep
U<8 = Undetected above numerical detection limit (e.g., 8)

J = Analyte present. Reported value may not be accurate or precise.
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K = Analyte present. Reported value may be biased high. Actual value is expected to be lower.
µg/kg = microgram/kilogram

*SB10-3 = Fire Training Area Soil Boring Sample No. 3 at 20 feet deep

TABLE 4-2 cont
1993 SUBSURFACE SOIL ANALYTICAL RESULTS

	SB14-1	SB14-2	SB14-3	SB14-4
VOLATILE ORGANICS (µg/kg)				
Acetone	U<10	**25 B**	U<10	U<10
cis-1,2-Dichloroethene	U<10	U<10	U<10	U<10
Methylene Chloride	**7 B**	**6 B**	**8 B**	**4 B**
2-Butanone	U<10	U<10	U<10	U<10
1,1,1-Trichloroethane	U<10	U<10	U<10	U<10
Toluene	U<10	U<10	U<10	U<10
Ethylbenzene	U<10	U<10	U<10	U<10
Total Xylenes	U<10	U<10	U<10	U<10
PESTICIDES AND PCBs (µg/kg)				
alpha-BHC	U<1.7	U<1.7	U<1.7	U<1.7
delta-BHC	U<1.7	U<1.7	U<1.7	**1.3 J**
gamma-BHC (Lindane)	U<1.7	U<1.7	U<1.7	**0.13 J**
Heptachlor	U<1.7	U<1.7	U<1.7	U<1.7
Aldrin	U<1.7	U<1.7	U<1.7	U<1.7
Heptachlor epoxide	U<1.7	U<1.7	U<1.7	U<1.7
Endosulfan I	U<1.7	U<1.7	U<1.7	U<1.7
Dieldrin	U<3.3	U<3.3	U<3.3	**110**
4,4'-DDE	**0.64 J**	U<3.3	U<3.3	U<3.3
Endrin	U<3.3	U<3.3	U<3.3	U<3.3
Endosulfan II	U<3.3	U<3.3	U<3.3	**13**
4,4'-DDD	U<3.3	U<3.3	U<3.3	U<3.3
Endosulfan sulfate	U<3.3	U<3.3	U<3.3	U<3.3
4,4'-DDT	**0.43 J**	U<3.3	U<3.3	**90**
Methoxychlor	U<17	U<17	U<17	U<17
Endrin ketone	U<3.3	U<3.3	U<3.3	**0.72 J**
Endrin aldehyde	U<3.3	U<3.3	U<3.3	U<3.3
alpha-Chlordane	U<1.7	U<1.7	U<1.7	U<1.7
gamma-Chlordane	U<1.7	U<1.7	U<1.7	**0.21 B**
Aroclor-1260	U<33	U<33	U<33	**460**

KEY:

SB1-1 = Fire Training Area Soil Boring Sample No. 1 at 5 feet deep
SB1-2 = Fire Training Area Soil Boring Sample No. 1 at 10 feet deep
SB1-3 = Fire Training Area Soil Boring Sample No. 1 at 15 feet deep
SB1-4 = Fire Training Area Soil Boring Sample No. 1 at 20 feet deep
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K = Analyte present. Reported value may be biased high. Actual value is expected to be lower.
µg/kg = microgram/kilogram

TABLE 4-2 cont
1993 SUBSURFACE SOIL ANALYTICAL RESULTS

SEMIVOLATILES (µg/kg)	SB1-1	SB1-2	SB1-3	SB2-1	SB2-2	SB2-3	SB2-4	SB3-1	SB3-2	SB3-3	SB4-1	SB4-2	SB4-3 (Dup of SB15-1)	SB5-1
Di-n-butylphthalate	170 B	67 B	100 B	200 B	62 B	74 B	120 B	86 B	77 B	120 B	36 B	76 B	57 B	77 B
Butylbenzylphthalate	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	130 B
Bis(2-ethylhexyl)phthalate	U<330	U<330	U<330	U<330	U<330	U<330	80 B	U<330	U<330	U<330	U<330	100 J	44 J	U<330
Di-n-octylphthalate	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	53 J	U<330	U<330

SEMIVOLATILES (µg/kg)	SB5-2	SB5-3	SB6-1	SB6-2	SB6-3	SB7-1	SB7-2	SB7-3	SB8-2	SB8-3	SB9-1	SB10-1	*SB10-3	SB11-1
2-Methylnaphthalene	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	5800	U<330	U<330	U<330	U<330
Phenanthrene	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	610 J	U<330	U<330
Anthracene	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	120 J	U<330	U<330
Di-n-butylphthalate	57 B	71 B	200 B	81 B	100 B	90 B	76 B	69 B	69 B	U<330	85 B	5300	U<330	63 B
Fluoranthene	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	6900	U<330	U<330
Pyrene	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	7800	U<330	U<330
Butylbenzylphthalate	130 B	160 B	U<330	190 B	220 B	220 B	210 B	140 B	U<330	U<330	180 B	U<330	U<330	U<330
Benz(a)anthracene	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	6200	U<330	U<330
Chrysene	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	5100	U<330	U<330
Bis(2-ethylhexyl)phthalate	U<330	U<330	92 B	37 B	U<330	98 J	42 J	U<330	72 J	1300 J	U<330	290 J	75 J	62 J
Di-n-octylphthalate	U<330	U<330	46 J	U<330	U<330	100 J	U<330	U<330	64 J	U<330	U<330	U<330	91 J	U<330
Benzo(b)fluoranthene	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	6900	U<330	U<330
Benzo(k)fluoranthene	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	6900	U<330	U<330
Benzo(a)pyrene	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	3300	U<330	U<330
Indeno(1,2,3-cd)pyrene	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	2300	U<330	U<330
Dibenz(a,h)anthracene	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	630	U<330	U<330
Benzo(g,h,i)perylene	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	U<330	2300	U<330	U<330

KEY:

SB1-1 = Fire Training Area Soil Boring Sample No. 1 at 5 feet deep
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SB1-4 = Fire Training Area Soil Boring Sample No. 1 at 20 feet deep
U<8 = Undetected above numerical detection limit (e.g., 8)

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K = Analyte present. Reported value may be biased high. Actual value is expected to be lower.
µg/kg = microgram/kilogram

***SB10-3 = Fire Training Area Soil Boring Sample No. 3 at 20 feet deep**

TABLE 4-2 cont
1993 SUBSURFACE SOIL ANALYTICAL RESULTS

	S311-2	SB11-3	SB12-1	SB12-2 (Dup of SB16-1)	SB13-1	SB13-2	SB13-3	SB13-4	SB14-1	SB14-2	SB14-3	SB14-4	SB16-1 (Dup of SB12-2)
SEMIVOLATILES (µg/kg)													
Phenanthrene	U<330	U<330	U<330	U<330	U<330	U<330	U<330	54 J	U<330	U<330	U<330	U<330	U<330
Di-n-butylphthalate	75 B	110 B	U<330	U<330	94 B	49 B	49 B	60 B	77 B	60 B	54 B	56 B	U<330
Fluoranthene	U<330	U<330	U<330	U<330	U<330	U<330	U<330	110 J	U<330	U<330	U<330	U<330	U<330
Pyrene	U<330	U<330	U<330	U<330	U<330	U<330	U<330	75 J	U<330	U<330	U<330	U<330	U<330
Benz(a)anthracene	U<330	U<330	U<330	U<330	U<330	U<330	U<330	62 J	U<330	U<330	U<330	U<330	U<330
Chrysene	U<330	U<330	U<330	U<330	U<330	U<330	U<330	55 J	U<330	U<330	U<330	U<330	U<330
Bis(2-ethylhexyl)phthalate	60 J	69 J	61 J	39 J	54 J	39 J	82 J	340 B	52 J	U<330	U<330	340 B	37 J
Di-n-octylphthalate	U<330	45 J	69 J	U<330	U<330	U<330	92 J	U<330	U<330	U<330	U<330	U<330	U<330
Benzo(b)fluoranthene	U<330	U<330	U<330	U<330	U<330	U<330	U<330	82 J	U<330	U<330	U<330	46 J	U<330
Benzo(k)fluoranthene	U<330	U<330	U<330	U<330	U<330	U<330	U<330	82 J	U<330	U<330	U<330	46 J	U<330
Benzo(a)pyrene	U<330	U<330	U<330	U<330	U<330	U<330	U<330	42 J	U<330	U<330	U<330	U<330	U<330

	SB17-1	SB19-1	SB19-2	SB20-1	SB20-2	SB29-1	SB30-4	SB40-4
SEMIVOLATILES (µg/kg)								
Diethylphthalate	2 J	U<330	U<330	U<330	U<330	U<330	U<330	U<330
Di-n-butylphthalate	U<330	U<330	U<330	U<330	U<330	U<330	41 B	2 J
Bis(2-ethylhexyl)phthalate	16 B	2 B	3 B	3 B	2 B	2 B	560 B	1 B

KEY:

SB1-1 = Fire Training Area Soil Boring Sample No. 1 at 5 feet deep
SB1-2 = Fire Training Area Soil Boring Sample No. 1 at 10 feet deep
SB1-3 = Fire Training Area Soil Boring Sample No. 1 at 15 feet deep
SB1-4 = Fire Training Area Soil Boring Sample No. 1 at 20 feet deep
U<8 = Undetected above numerical detection limit (e.g., 8)
J = Analyte present. Reported value may not be accurate or precise.
B = Not detected substantially above the level reported in lab or field blanks.
L = Analyte present. Reported value may be biased low. Actual value is expected to be higher.
K = Analyte present. Reported value may be biased high. Actual value is expected to be lower.
µg/kg = microgram/kilogram

TABLE 4-2 cont
1993 SUBSURFACE SOIL ANALYTICAL RESULTS

	SB1-1	SB1-2	SB1-3	SB1-4	SB2-1	SB2-2	SB2-3	SB2-4	SB3-1	SB3-2	SB3-3	SB4-1	SB4-2	SB4-3 (Dup of SB15-1)
INORGANICS (mg/kg)														
Aluminum	5170 J	5160 J	862 J	17800	9620 J	4020 J	2480 J	13000	12900 J	12500 J	3200 J	9550 J	4390 J	1240 J
Arsenic	U<1.1	1.9	2.7	3.8	2.5	2.9	1.7	3.2	5.8	3.7	2.4	2	2.2	1.2
Barium	9.4	13.2	2.9	50.8	19.7	9.7	3.9	40.3	17.8	19.4	9.6	16.4	7.1	2.2
Beryllium	U<0.87	U<0.88	U<1.0	0.82	U<0.96	U<0.87	U<1.0	U<0.8	U<0.91	U<0.90	U<1.0	U<0.91	U<0.92	U<0.96
Calcium	164	231	69.3	915 J	332	139	118	924 J	265	277	98.5	198	123	60.8 B
Chromium	4.2	4.7	1.9	16.5	8.7	4.9	6.6	11.1	13.6	12.4	3.4	8.2	5.4	5.2
Cobalt	U<1.5	U<1.5	U<1.8	5.2	1.8	U<1.5	3	3.8	1.8	1.9	U<1.8	U<1.6	U<1.6	U<1.7
Copper	2.6	U<2.5	U<3.0	7	U<2.8	U<2.5	U<3	5.5	U<2.6	U<2.6	U<3	U<2.7	U<2.7	U<2.8
Iron	1630	2030	1360	12300	4580	2890	2230	7790	9810	7890	2070	4180	2490	1040
Lead	1	3.6	1.7	7.7 J	3.5	1.5	1.1	6.4	3.8	3.1	0.93	3.5	2.1	0.78
Magnesium	228	253	101	1370	587	278	385	983	811	796	196	574	264	80.8
Manganese	9.9	26.4	8.9	165	43.8	29.9	17.1	132	36.6	29.5	12.5	29.6	16.5	7.4
Mercury	0.15	U<0.1	U<0.12	U<0.11	U<0.11	U<0.1	U<0.12	U<0.11	U<0.11	U<0.11	U<0.12	0.11	0.11	0.11
Nickel	U<7.6	U<7.6	U<9.1	9.6	U<8.3	U<7.6	U<9.2	8.9	U<7.9	U<7.8	U<8.9	U<8.6	U<8	U<8.4
Potassium	571	570	540	U<411	607	U<387	1030	409	1030	1090	U<456	513	U<406	U<428
Silver	U<1	U<1	U<1.2	U<1.7	U<1.1	U<1	1.7	U<1.7	U<1.1	U<1.1	U<1.2	U<1.1	U<1.1	U<1.1
Sodium	135 B	165 B	162 B	110 B	150 B	140 B	156 B	65.7 B	146 B	162 B	163 B	106 B	82.6 B	80.2 B
Vanadium	4.9	5.6	2.5	25.9	11.7	6.3	6.4	17.4	17.6	15.9	4	9.7	5	1.8
Zinc	3.4 B	4.5 B	2.7 B	28.7 B	7.9	4.1 B	5.4 B	22.2 B	7.9	8.8	3.9 B	7.3 B	4 B	2 B

KEY:

SB1-1 = Fire Training Area Soil Boring Sample No. 1 at 5 feet deep
SB1-2 = Fire Training Area Soil Boring Sample No. 1 at 10 feet deep
SB1-3 = Fire Training Area Soil Boring Sample No. 1 at 15 feet deep
SB1-4 = Fire Training Area Soil Boring Sample No. 1 at 20 feet deep
U<8 = Undetected above numerical detection limit (e.g., 8)

J = Analyte present. Reported value may not be accurate or precise.
B = Not detected substantially above the level reported in lab or field blanks.
L = Analyte present. Reported value may be biased low. Actual value is expected to be higher.
K = Analyte present. Reported value may be biased high. Actual value is expected to be lower.
mg/kg = milligram/kilogram

TABLE 4-2 cont
1993 SUBSURFACE SOIL ANALYTICAL RESULTS

	SB5-1	SB5-2	SB5-3	SB6-1	SB6-2	SB6-3	SB7-1	SB7-2	SB7-3	SB8-1	SB8-2	SB8-3	SB9-1	SB9-2
INORGANICS (mg/kg)														
Aluminum	3140 J	1100 J	10800 J	11500 J	4630 J	5830 J	7520 J	14200 J	8380 J	5310 J	4860 J	878 J	4870 J	6490 J
Arsenic	2	1.5	2.7	4.3	2.1	3.5	2.8	5.3	2.2	2.2	1.9	U<1.3	1.4	1.4
Barium	3	3.8	21	13.2	19.8	16.9	7.8	17.4	12.1	10.8	10.4	3.2	6.4	13
Beryllium	U<0.92	U<0.86	U<1.0	U<1.1	U<0.89	U<1.0	U<1.1	U<0.90	U<1.0	U<0.90	U<0.88	U<1.1	U<0.89	U<0.94
Calcium	76.9 B	51.7 B	305	93.3	77.7	148	157	409	292	143	114	60.2 B	76.5 B	112
Chromium	3.2	U<1.4	11.6	20.7	5.1	6.3	9.1	21.5	13.9	6.3	6.1	1.7	4.6	7.5
Cobalt	U<1.6	U<1.5	2.1	U<1.9	1.6	U<1.8	U<1.9	U<1.6	1.9	U<1.6	U<1.5	U<1.8	U<1.5	U<1.6
Copper	U<2.7	U<2.5	U<2.9	U<3.2	U<2.6	U<3	U<3.1	U<2.6	U<3	U<2.6	U<2.5	U<3.1	2.6	U<2.7
Iron	2020	964	6840	10300	3200	6510	9540	15600	8080	2080	2060	896	2890	2910
Lead	1.4	U<0.41	1.5	5	1.3	1.3	2.5	4.4	1 J	2.1	2	0.91	U<0.42	2.8
Magnesium	231	58.2	746	876	340	408	375	1090	674	197	222	86.3	262	388
Manganese	12.6	5.3 B	40.8	16.1	37.6	60.1	7.9	22.9	26.7	20.6	23.6	2	16.1	16.4
Mercury	U<0.11	U<0.1	U<0.12	U<0.13	U<0.11	U<0.12	U<0.13	U<0.11	U<0.12	U<0.11	U<0.10	U<0.13	U<0.11	U<0.11
Nickel	U<8.0	U<7.5	U<8.7	U<9.5	U<7.8	U<9	U<9.3	U<7.9	U<8.9	U<7.8	U<7.6	U<9.2	U<7.8	U<8.2
Potassium	546	U<384	1050	1140	478	713	943	1250	1290	U<398	U<390	U<471	468	670
Silver	U<1.1	U<1.0	U<1.2	U<1.3	U<1.1	U<1.2	U<1.3	U<1.1	U<1.2	U<1.1	U<1.0	U<1.3	U<1.1	U<1.1
Sodium	125 B	122 B	169 B	162 B	144 B	151 B	168 B	172 B	192 B	91.5 B	79 B	93.6 B	134 B	93.8 B
Vanadium	4	1.9	15.2	20.4	6.1	9.7	12	28.1	15.8	5.7	5.8	U<1.8	5.9	7.3
Zinc	2.6 B	1.6 B	8.5 B	12.5	7.6	7.2 B	6 B	13.4	10.9 B	3 B	3.4 B	2.1 B	2.7 B	8.4 B

KEY:

SB1-1 = Fire Training Area Soil Boring Sample No. 1 at 5 feet deep
SB1-2 = Fire Training Area Soil Boring Sample No. 1 at 10 feet deep
SB1-3 = Fire Training Area Soil Boring Sample No. 1 at 15 feet deep
SB1-4 = Fire Training Area Soil Boring Sample No. 1 at 20 feet deep
U<8 = Undetected above numerical detection limit (e.g., 8)

J = Analyte present. Reported value may not be accurate or precise.
B = Not detected substantially above the level reported in lab or field blanks.
L = Analyte present. Reported value may be biased low. Actual value is expected to be higher.
K = Analyte present. Reported value may be biased high. Actual value is expected to be lower.
mg/kg = milligram/kilogram

TABLE 4-2 cont
1993 SUBSURFACE SOIL ANALYTICAL RESULTS

	SB9-3	SB10-1	SB10-2	*SB10-3	SB11-1	SB11-2	SB11-3	SB12-1	SB12-2 (Dup of SB16-1)	SB12-3	SB13-1	SB13-2	SB13-3	SB13-4
INORGANICS (mg/kg)														
Aluminum	4530 J	7620 J	9720 J	22400 J	27600 J	1970 J	6160 J	5690 J	1470 J	1300 J	6940 J	2450 J	5260 J	17000
Arsenic	2.1	2.1	2.6	8.4	1.5 L	U<1.1	U<1.4	1.5 K	U<1.1	U<1.3	2.9	1.3 L	1.9	4.5
Barium	12.5	19.1	14.6	39.7	32.2	2.9	10.7	14.5	1.5	2.6	15.3	4.9	10.7	57.5
Beryllium	U<1.0	U<0.91	U<0.89	U<1.2	U<0.92	U<0.89	U<1.1	U<0.93	U<0.92	U<1	U<1.2	U<0.88	U<1.0	U<0.83
Calcium	96.5 B	290	351	759	775	64.6 B	170 B	252	45 B	63.4 B	148 B	67.7 B	122 B	1520 J
Chromium	5.5	7.2	11.4	48.3	32.2	1.6	8.2	5.2	2	2.4	7.2	3.6	7.1	14.9
Cobalt	U<1.8	U<1.6	6.5	4.9	2	U<1.5	U<2	U<1.6	U<1.6	U<1.8	2.2	U<1.5	U<1.8	6
Copper	U<3	U<2.6	U<2.6	7.7	7.6	U<2.6	U<3.3	U<2.7	U<2.7	U<3	U<3.4	U<2.6	U<2.9	10.1
Iron	2540	3910	9370	33900	11400	522	2190	2840 J	476 J	775 J	3010	1300	2540	12500
Lead	0.98 J	0.46 K	4.5	6.4	5.9	0.94	2.1 J	1.9 J	U<0.44	U<0.49	2.6	1	1.6	12.2
Magnesium	294	427	691	2190	1680	82.3	320	299	53.8	76	364	127	290	1630
Manganese	21.1	69.1	162	130	67.9	4.5	16	71.6 J	3.3 J	7.1 J	24.1	9.6	29.8	216
Mercury	U<0.12	U<0.11	U<0.11	U<0.11	U<0.11	U<0.11	U<0.14	U<0.11	U<0.11	U<0.12	U<0.14	U<0.11	U<0.12	0.13
Nickel	U<9	U<7.9	U<7.7	16.4	9.2	U<7.8	U<9.9	8.7	U<8	U<9	U<10.2	U<7.7	U<8.8	8.2
Potassium	U<457	467	623	2490	1750	U<395	U<506	U<413	U<409	U<461	U<521	421	U<449	1020
Silver	U<1.2	U<1.1	U<1.1	U<1.4	U<1.1	U<1.1	U<1.4	U<1.1	U<1.1	U<1.2	U<1.4	U<1.1	U<1.2	U<1.8
Sodium	116 B	92 B	97 B	192 B	116 B	76.9 B	114 B	105 B	120 B	115 B	108 B	100 B	122 B	70.6 B
Vanadium	5.7	9.1	16.5	45	32.9	U<1.5	5.3	5.3	U<1.5	2.5	8.3	3	5.4	27.2
Zinc	4.7 B	5.1 B	10.6	35.2	15.3	2.7 B	5.2 B	20	11.7	10.3 B	4.5 B	2.3 B	4 B	44.5

KEY:

SB1-1 = Fire Training Area Soil Boring Sample No. 1 at 5 feet deep
SB1-2 = Fire Training Area Soil Boring Sample No. 1 at 10 feet deep
SB1-3 = Fire Training Area Soil Boring Sample No. 1 at 15 feet deep
SB1-4 = Fire Training Area Soil Boring Sample No. 1 at 20 feet deep
U<8 = Undetected above numerical detection limit (e.g., 8)

J = Analyte present. Reported value may not be accurate or precise.
B = Not detected substantially above the level reported in lab or field blanks.
L = Analyte present. Reported value may be biased low. Actual value is expected to be higher.
K = Analyte present. Reported value may be biased high. Actual value is expected to be lower.
mg/kg = milligram/kilogram

***SB10-3 = Fire Training Area Soil Boring Sample No. 3 at 20 feet deep**

TABLE 4-2 cont
1993 SUBSURFACE SOIL ANALYTICAL RESULTS

	SB14-1	SB14-2	SB14-3	SB14-4	SB15-1	(Dup of SB12-2) SB16-1	(Dup of SB1-4) SB30-4
INORGANICS (mg/kg)							
Aluminum	4890 J	6290 J	1920 J	15800	2720 J	4100 J	80.4 B
Arsenic	U<1.1	2.6	1.3	3.3	2.4	1.1 K	4.1
Barium	13.6	15.4	4.6	67.8	8.4	10.3	51.6
Beryllium	U<0.90	U<0.86	U<1.0	U<0.84	U<1.0	U<0.87	U<0.40
Calcium	163 B	198 B	68 B	701 J	92.7 B	168	942 J
Chromium	5.1	6.9	3.5	13	2.3	5.4	16.3
Cobalt	U<1.6	U<1.5	U<1.8	5	U<1.8	U<1.5	5
Copper	U<2.6	U<2.5	U<2.9	6.3	U<3	3.9	7.4
Iron	2390	4170	1620	10800	1540	2200 J	13800
Lead	2.1	0.6 K	3.9	10.7	1.6	6.2 J	6.5
Magnesium	287	460	121	1250	104	230	1370
Manganese	22.2	37.2	7.8	297	12.6	23.4 J	154
Mercury	U<0.11	U<0.10	U<0.12	U<0.12	U<0.12	U<0.10	U<0.20
Nickel	U<7.8	8.9	U<8.8	8.7	U<9.0	U<7.6	9.2
Potassium	U<400	396	U<451	504	509	U<385	611
Silver	U<1.1	U<1	U<1.2	U<1.8	U<1.2	U<1.0	U<5.5
Sodium	94.1 B	119 B	110 B	65 B	168 B	91.6 B	119 B
Vanadium	6.1	9.5	4	23.4	3.6	4.3	26.4
Zinc	11.5	6.3 B	5.5 B	28.7 B	2 B	6.6 B	28.3 B

KEY:

SB1-1 = Fire Training Area Soil Boring Sample No. 1 at 5 feet deep
SB1-2 = Fire Training Area Soil Boring Sample No. 1 at 10 feet deep
SB1-3 = Fire Training Area Soil Boring Sample No. 1 at 15 feet deep
SB1-4 = Fire Training Area Soil Boring Sample No. 1 at 20 feet deep
U<8 = Undetected above numerical detection limit (e.g., 8)
J = Analyte present. Reported value may not be accurate or precise.
B = Not detected substantially above the level reported in lab or field blanks.
L = Analyte present. Reported value may be biased low. Actual value is expected to be higher.
K = Analyte present. Reported value may be biased high. Actual value is expected to be lower.
mg/kg = milligram/kilogram

TABLE 4-3
1994 GROUNDWATER ANALYTICAL RESULTS

	(Cross gradient) MW-01D	(DNAPL) MW-02-1	MW-02D	MW-02S	(Upgradient) MW-34S	Upgradient) MW-53S	MW-54S	(DNAPL) MW-55D-1	MW-55D
VOLATILE ORGANICS (µg/l)									
Acetone	10 L	7 L	U<5	U<5	U<5	U<5	U<5	U<5	U<5
1,1-Dichloroethane	U<1	U<1	U<1	10 J	U<1	U<1	U<1	11	15
1,1-Dichloroethene	U<1	U<1	U<1	U<1	U<1	U<1	U<1	U<1	U<1
cis-1,2-Dichloroethene	1	U<1	U<1	420	U<1	U<1	U<1	23	48
Methylene Chloride	6 B	U<2	U<2	U<2	0.9 B	0.7 B	1 B	11 B	34 J
Chloroform	2	4	5	U<1	U<1	U<1	U<1	U<1	U<1
2-Butanone	U<5	U<5	U<5	U<5	U<5	U<5	U<5	U<5	U<5
1,1,1-Trichloroethane	U<1	U<1	U<1	160	U<1	U<1	1	95	140
Benzene	U<1	U<1	U<1	9 J	U<1	U<1	U<1	U<1	U<1
Tetrachloroethene	U<1	U<1	U<1	U<1	U<1	U<1	U<1	5	6
Toluene	U<1	U<1	U<1	U<1	U<1	U<1	U<1	U<1	32
Ethylbenzene	U<1	U<1	U<1	U<1	U<1	U<1	U<1	7	12
Total Xylenes	U<1	U<1	U<1	28	U<1	U<1	U<1	50	60
VOLATILE TICS (µg/l)									
Ethylmethylbenzene									60 J
Trimethylbenzene								53 J	53 J
Tetramethylbenzene								36 J	28 J
Alkyl Benzene								52 J	
Trichlorofluoromethane									
PESTICIDES AND PCBs (µg/l)									
alpha-BHC	U<0.05	U<0.05	U<0.05	0.0037 J	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05
delta-BHC	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05
gamma-BHC (Lindane)	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05
Aldrin	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05
Heptachlor epoxide	U<0.05	U<0.05	U<0.05	0.010 J	U<0.05	U<0.05	U<0.05	U<0.05	0.0042 J
Endosulfan I	U<0.05	U<0.05	U<0.05	0.0097 J	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05
Dieldrin	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10
4,4'-DDE	U<0.10	U<0.10	U<0.10	0.0023 J	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10
Endrin	U<0.10	U<0.10	U<0.10	0.0032 J	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10
Endosulfan II	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10
Endosulfan sulfate	U<0.10	U<0.10	U<0.10	0.0029 J	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10
4,4'-DDT	U<0.10	U<0.10	U<0.10	0.012 J	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10
Methoxychlor	U<0.50	U<0.50	U<0.50	U<0.50	U<0.50	U<0.50	U<0.50	U<0.50	U<0.50
Endrin ketone	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	0.0068 J
Endrin aldehyde	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10
alpha-Chlordane	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05
gamma-Chlordane	U<0.05	U<0.05	U<0.05	0.0049 J	U<0.05	U<0.05	U<0.05	U<0.05	0.0023 J

KEY:

MW-01D = Fire Training Area Deep Groundwater Sample No. 1

MW-02I = Fire Training Area Intermediate Groundwater Sample No. 2

MW-03S = Fire Training Area Shallow Groundwater Sample No. 3

MW-55D-1= Fire Training Area DNAPL Sample

U<8 = Undetected above numerical detection limit (e.g., 8)

J = Analyte present. Reported value may not be accurate or precise.

B = Not detected substantially above the level reported in lab or field blanks.

L = Analyte present. Reported value may be biased low. Actual value is expected to be higher.

µg/l = microgram/liter

TABLE 4-3 cont
1994 GROUNDWATER ANALYTICAL RESULTS

	MW-55S	(DNAPL) MW-56D-1	MW-56D	MW-57S	MW-58S	MW59S	MW-60I	(DNAPL) MW-61I-1	MW-61I	(Dup of MW-55S) MW-62S
VOLATILE ORGANICS (µg/l)										
Acetone	U<5	3600 L	U<5	U<5	U<5	7L	U<5	U<5	3 J	U<5
1,1-Dichloroethane	U<1	U<1	U<1	13	6 J	U<1	U<1	57 J	0.7 J	U<1
1,1-Dichloroethene	U<1	U<1	U<1	18	U<1	U<1	U<1	U<1	0.7 J	U<1
cis-1,2-Dichloroethene	98 J	2200	1700	530	96	U<1	U<1	3000	23	U<1
Methylene Chloride	U<2	730 J	250	52 J	6 B	6 B	1 B	120 J	3 B	270 J
Chloroform	U<1	U<1	U<1	U<1	U<1	U<1	U<1	U<1	U<1	U<1
2-Butanone	U<5	1100 J	U<5	U<5	U<5	U<5	U<5	U<5	U<5	U<5
1,1,1-Trichloroethane	550	660	420	190	48	U<1	11	670	16	620
Benzene	U<1	100 J	U<1	U<1	U<1	U<1	U<1	120	U<1	U<1
Tetrachloroethene	U<1	64 J	U<1	U<1	9	U<1	0.9 J	U<1	2	U<1
Toluene	1400	U<1	U<1	U<1	U<1	U<1	U<1	U<1	U<1	1800
Ethylbenzene	360 J	U<1	U<1	U<1	U<1	U<1	U<1	U<1	U<1	600 J
Total Xylenes	860 J	U<1	U<1	U<1	U<1	U<1	U<1	82 J	U<1	1600 J
VOLATILE TICS (µg/l)										
Ethylmethylbenzene	330 J									
Trimethylbenzene	700 J									
Tetramethylbenzene										
Alkyl Benzene										
Trichlorofluoromethane							4 J			
PESTICIDES AND PCBs (µg/l)										
alpha-BHC	0.0098 J	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	0.049 J
delta-BHC	0.018 J	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05
gamma-BHC (Lindane)	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	0.014 J
Aldrin	0.081	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	0.017 J
Heptachlor epoxide	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	0.016 J	U<0.05	U<0.05	U<0.05	0.0042 J
Endosulfan I	0.029 J	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05
Dieldrin	0.0054 J	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	0.0050 J
4,4'-DDE	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10
Endrin	0.060 J	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	0.013 J
Endosulfan II	0.099 J	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	0.013 J
Endosulfan sulfate	0.046 J	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10
4,4'-DDT	0.023 J	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	0.0056 J
Methoxychlor	0.058 J	U<0.50	U<0.50	U<0.50	U<0.50	U<0.50	U<0.50	U<0.50	U<0.50	0.0094 J
Endrin ketone	0.018 J	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	0.0062 J
Endrin aldehyde	0.085 J	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10	U<0.10
alpha-Chlordane	0.0095 J	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05
gamma-Chlordane	0.055	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	U<0.05	0.0020 J

KEY:
MW-01D = Fire Training Area Deep Groundwater Sample No. 1
MW-02I = Fire Training Area Intermediate Groundwater Sample No. 2
MW-03S = Fire Training Area Shallow Groundwater Sample No. 3
MW-55D-1=Fire Training Area DNAPL Sample
U<8 = Undetected above numerical detection limit (e.g., 8)
J = Analyte present. Reported value may not be accurate or precise.
B = Not detected substantially above the level reported in lab or field blanks.
L = Analyte present. Reported value may be biased low. Actual value is expected to be higher.
µg/l = microgram/liter

TABLE 4-3 cont
1994 GROUNDWATER ANALYTICAL RESULTS

	(Cross gradient) MW-01D	MW-02D	MW-02S	(Upgradient) MW-34S	(Upgradient) MW-53S	MW-54S	MW-55D	MW-55S	MW-56D
SEMIVOLATILES (µg/l)									
4-Methylphenol	U<10	U<10	5 J	U<10	U<10	U<10	3 J	U<10	U<10
Naphthalene	U<10	U<10	34	U<10	U<10	U<10	37	2000 J	U<10
2-Methylnaphthalene	U<10	U<10	18	U<10	U<10	U<10	16	3000 J	U<10
Diethylphthalate	U<10	U<10	2 J	U<10	U<10	U<10	U<10	U<10	1 J
Fluorene	U<10	U<10	U<10	U<10	U<10	U<10	U<10	75 J	U<10
Phenanthrene	U<10	U<10	U<10	U<10	U<10	U<10	U<10	82 J	U<10
Bis(2-ethylhexyl)phthalate	1 B	2 B	3 B	2 B	10 B	6 B	16 B	87	2 B
Di-n-butylphthalate	U<10	U<10	U<10	U<10	U<10	U<10			U<10
INORGANICS (µg/L)									
Aluminum	2530	3170	2920	5460 J	59200	240000 J	16900	17300	240000 J
Arsenic	U<3.4	U<3.4	U<3.4	12.6	17.7 L	34	11.4 L	29.6 L	U<3.4
Barium	14.2	22.1	28.4	59.7	167	741	89.3	140	16.4
Beryllium	U<0.4	U<0.4	U<0.4	U<0.4	1.9	9.1	0.76	1.2	U<0.4
Cadmium	U<4.8	5.5	U<4.8	U<4.8	U<4.8	U<4.8	U<4.8	U<4.8	U<4.8
Calcium	3430	3770	4420	19300	5200	6840	7090	6380	6520
Chromium	U<6	6.9	U<6	U<6	45.5	187	16.7	21	U<6
Cobalt	U<10.4	U<10.4	U<10.4	18.6	12.3	44.6	U<10.4	19.8	U<10.4
Copper	9.5	12.8	3.6	3.4	15.3	47.7	9.5	24.8	U<2.7
Iron	2140 J	2520 J	14700 J	50000 J	30400 J	145000 J	23900 J	53100 J	1510 J
Lead	U<2	U<3	U<2	U<2	12.7	38	9.7	747	U<2
Magnesium	1900	2200	5470	12700	4080	11200	3880	6250	8940
Manganese	23.6	18.2	1180	3110	288	1480	1040	2750	865
Nickel	U<14.3	U<14.3	U<14.3	U<14.3	U<14.3	49.5	U<14.3	15.1	U<14.3
Potassium	8460	2040	1660	4110	4010	9280	2560	2580	1380
Sodium	12800 J	10700 J	4760 J	8900	2970 J	5080	6970 J	6050 J	4210
Thallium	U<2.7	U<2.7	U<2.7	U<13.5	U<2.7	U<2.7	U<2.7	U<2.7	U<2.7
Vanadium	4.5	U<4.1	U<4.1	4.2	69.6	260	23.5	53.6	U<4.1
Zinc	34.7	52.1	21.1 B	31.3 B	84.5	251	51.1	81.1	22.2 B

KEY:
MW-01D = Fire Training Area Deep Groundwater Sample No. 1
MW-02I = Fire Training Area Intermediate Groundwater Sample No. 2
MW-03S = Fire Training Area Shallow Groundwater Sample No. 3
U<8 = Undetected above numerical detection limit (e.g., 8)
J = Analyte present. Reported value may not be accurate or precise.
B = Not detected substantially above the level reported in lab or field blanks.
L = Analyte present. Reported value may be biased low. Actual value is expected to be higher.
µg/l = microgram/liter

TABLE 4-3 cont
1994 GROUNDWATER ANALYTICAL RESULTS

	MW-57S	MW-58S	MW-59S	MW-60I	MW-61I	(Dup. of MW55S) MW-62S
SEMIVOLATILES (µg/l)						
4-Methylphenol	U<10	U<10	U<10	U<10	U<10	U<10
Naphthalene	U<10	U<10	U<10	U<10	7 J	1400 J
2-Methylnaphthalene	U<10	U<10	U<10	U<10	4 J	1900 J
Diethylphthalate	U<10	U<10	U<10	U<10	U<10	U<10
Fluorene	U<10	U<10	U<10	U<10	U<10	37 J
Phenanthrene	U<10	U<10	U<10	U<10	U<10	41 J
Bis(2-ethylhexyl)phthalate	3 B	8 B	4 B	5 B	3 B	49
Di-n-butylphthalate	U<10	U<10	U<10	U<10	U<10	U<10
INORGANICS (µg/L)						
Aluminum	22400 J	24200	33300	992	823 J	207000
Arsenic	12.7	11.5 L	8.6 L	U<3.4	7.9	11.4 L
Barium	56.7	89.8	121	28.6	19	800
Beryllium	0.93 B	0.88	1.7	U<0.4	U<0.4	12.1
Cadmium	U<4.8	U<4.8	U<4.8	U<4.8	U<4.8	U<4.8
Calcium	4830	12200	6850	40800	10400	9370
Chromium	16.9	23.5	50	U<6	U<6	193
Cobalt	U<10.4	U<10.4	11.6	U<10.4	U<10.4	89
Copper	5.5	9.7	11.8	U<2.7	U<2.7	54.4
Iron	14000 J	17300 J	32000 J	867 J	8750 J	215000 J
Lead	5.2 B	5.9 L	13.3	U<2	U<2	161
Magnesium	6320	10500	7950	14700	6820	17000
Manganese	166	345	264	17	1610	4130
Nickel	U<14.3	U<14.3	29	U<14.3	U<14.3	89.6
Potassium	3220	3240	4750	1880	1830	10600
Sodium	4440	4510	6950 J	7840 J	3980	6850 J
Thallium	U<2.7	U<2.7	U<2.7	2.8 L	U<2.7	U<2.7
Vanadium	27.3	32.9	63.7	U<4.1	U<4.1	327
Zinc	55.5	42.2	74.1	22.5 B	21.2	377

KEY:
MW-01D = Fire Training Area Deep Groundwater Sample No. 1
MW-02I = Fire Training Area Intermediate Groundwater Sample No. 2
MW-03S = Fire Training Area Shallow Groundwater Sample No. 3
U<8 = Undetected above numerical detection limit (e.g., 8)
J = Analyte present. Reported value may not be accurate or precise.
B = Not detected substantially above the level reported in lab or field blanks.
L = Analyte present. Reported value may be biased low. Actual value is expected to be higher.
µg/l = microgram/liter

TABLE 4-3 cont
1994 GROUNDWATER ANALYTICAL RESULTS

FILTERED	(Cross gradient) MW-01DF	MW-02DF	MW-02SF	(Upgradient) MW-34SF	(Upgradient) MW-53SF	MW-54SF	MW-55DF	MW-55SF	MW-56DF	MW-57SF	MW-58SF	MW-59SF	MW-60IF	MW-61IF	(Dup. of MW-55SF) MW-62-F
INORGANICS (µg/l)															
Aluminum	U<68	168 B	105 B	U<68	U<68	U<68	U<68	U<68	U<68	U<68	U<68	U<68	U<68	U<68	1220 J
Arsenic	U<3.4	6.7 L	U<3.4	U<3.4	U<3.4	U<3.4	4.8 L	9.7 L	U<3.4	U<3.4	U<3.4	U<3.4	U<3.4	U<3.4	11.1 L
Barium	9.1	55.2	15	32	7	6.6	22.2	33.6	10.3	12.9	9.6	15.4	25.1	18.4	56.4
Beryllium	U<3.6	U<3.6	U<3.6	U<3.6	U<3.6	U<3.6	U<3.6	U<3.6	U<3.6	U<3.6	U<3.6	U<3.6	U<3.6	U<3.6	U<3.6
Cadmium	U<4.3	U<4.3	U<4.3	U<4.3	U<4.3	U<4.3	U<4.3	U<4.3	U<4.3	U<4.3	U<4.3	U<4.3	U<4.3	U<4.3	U<4.3
Calcium	3160	6450	3570	19100	4380	3900	5710	6410	6350	3640	11700	6250	35900	7210	7140
Chromium	U<6.2	U<6.2	U<6.2	U<6.2	U<6.2	U<6.2	U<6.2	U<6.2	U<6.2	U<6.2	U<6.2	U<6.2	U<6.2	U<6.2	U<6.2
Cobalt	U<10.1	13.5 B	U<10.1	14.4	U<10.1	U<10.1	U<10.1	16.4	U<10.1	U<10.1	U<10.1	U<10.1	U<10.1	U<10.1	17
Copper	U<12.7	U<12.7	U<12.7	U<12.7	U<12.7	U<12.7	U<12.7	U<12.7	U<12.7	U<12.7	U<12.7	U<12.7	U<12.7	U<12.7	U<12.7
Iron	19.1 B	35700	6660	33200	U<100	U<100	11800	42600	25.3 B	U<100	U<100	15.9 B	U<100	1720	42300
Lead	U<2	7.9 L	U<2	U<2	U<2	2.4 L	3.1 L	8.3 J	U<2	2.1 J	U<2	U<2	U<2	U<2	10.6 J
Magnesium	2130	6030	4830	12900	2190	3240	3560	6250	9140	4320	9610	6200	14200	3970	7120
Manganese	U<6.7	2870	950	3080	24.5	123	1080	3120	857	10.2	122	U<6.7	6.9	404	3550
Nickel	U<34.7	U<34.7	U<34.7	U<34.7	U<34.7	U<34.7	U<34.7	U<34.7	U<34.7	U<34.7	U<34.7	U<34.7	U<34.7	U<34.7	U<34.7
Potassium	6310	U<1830	U<1830	3170	U<1830	U<1830	U<1830	U<1830	U<1830	U<1830	U<1830	U<1830	U<1830	U<1830	U<1830
Sodium	11800	6420	3380	9180	2160 B	4530	6690	5790	3790	3160	3870	6330	7370	3510	5850
Thallium	U<2.7	U<2.7	U<2.7	U<2.7	U<2.7	U<2.7	U<2.7	U<2.7	U<2.7	U<2.7	U<2.7	U<2.7	U<2.7	U<2.7	U<2.7
Vanadium	U<9.8	U<9.8	U<9.8	U<9.8	U<9.8	U<9.8	U<9.8	U<9.8	U<9.8	U<9.8	U<9.8	U<9.8	U<9.8	U<9.8	U<9.8
Zinc	13.8	23.2	12.8 B	23.9 B	13.3 B	10.6 B	18.6	8	5.6 B	20.7 B	8 B	9.3 B	16.1 B	6.1 B	14.6 B

KEY:

MW-01DF = Fire Training Area Deep Filtered Groundwater Sample No. 1
MW-02IF = Fire Training Area Intermediate Filtered Groundwater Sample No. 2
MW-03SF = Fire Training Area Shallow Filtered Groundwater Sample No. 3
U<8 = Undetected above numerical detection limit (e.g., 8)
J = Analyte present. Reported value may not be accurate or precise.
B = Not detected substantially above the level reported in lab or field blanks.
L = Analyte present. Reported value may be biased low. Actual value is expected to be higher.
µg/l = microgram/liter

TABLE 4-4
1994 SURFACE WATER ANALYTICAL RESULTS

	SW01	SW02	SW03	SW04	(Dup of SW01) SW05
VOLATILE ORGANICS (µg/l)					
Methylene Chloride	U<10	U<10	U<10	6 B	2 B
Toluene	U<10	U<10	U<10	U<10	1 J
PESTICIDES AND PCBs (µg/l)					
Heptachlor	U<0.05	U<0.05	U<0.05	0.0016 J	U<0.05
4,4'-DDE	0.0020 J	U<0.10	U<0.10	U<0.10	0.0065 J
4,4'-DDT	0.0032 J	0.0033 J	U<0.10	U<0.10	0.0056 J
gamma-Chlordane	U<0.05	U<0.05	U<0.05	U<0.05	0.0020 J
SEMIVOLATILES (µg/l)					
Bis(2-ethylhexyl)phthalate	2 B	3 B	1 B	2 B	2 B
INORGANICS (µg/L)					
Aluminum	5410	1840	756	1110	5450 J
Arsenic	U<3.4	U<3.4	U<3.4	U<3.4	5.3 K
Barium	25.6	17.2	12.9	8.8	24.1
Calcium	2070	5800	2160	2070	1980
Copper	3.6	6.9	U<25	4.3	U<2.7
Iron	2730 J	1190	348	526	2010 J
Lead	2.5	3.4 L	U<2	U<2	7 B
Magnesium	1150	1000	499	487	1110
Manganese	27.2	27.8	2.2	4	22.2
Potassium	1910	1940	1760	2000	1870
Sodium	2030 J	2250 J	1500 B	1690 J	1880
Vanadium	6.8	U<4.1	U<4.1	U<4.1	5.3
Zinc	30.5	26.7	11.2	25.3	17.2

KEY:

SW01 = Fire Training Area Surface Water Sample No. 1
U<8 = Undetected above numerical detection limit (e.g., 8)
J = Analyte present. Reported value may not be accurate or precise.
B = Not detected substantially above the level reported in lab or field blanks.
L = Analyte present. Reported value may be biased low. Actual value is expected to be higher.
K = Analyte present. Reported value may be biased high. Actual value is expected to be lower.
µg/l = microgram/liter

TABLE 4-5
1994 SEDIMENT ANALYTICAL RESULTS

	SED01	SED02	SED03	SED04	(Dup of SED01) SED05
VOLATILE ORGANICS (µg/kg)					
Methylene Chloride	10 B	10 B	8 B	13 B	7 B
Acetone	U<10	U<10	7 B	7 B	U<10
PESTICIDES AND PCBs (µg/kg)					
gamma-BHC (Lindane)	0.75 J	1.9 J	1.2 J	0.78 J	U<1.7
Heptachlor	0.24 B	.42 B	0.23 B	0.28 B	0.25 J
4,4'-DDE	14	67	21	10	11
Endrin	U<3.3	5.2	0.22 J	0.19 J	U<3.3
4,4'-DDD	1.7 J	34	6.4	2.3	1 J
Endosulfan sulfate	U<3.3	5.2	5.1	0.5	0.68 J
4,4'-DDT	16	52	7.1	9.4	13
Methoxychlor	8.8 J	23	2.2 B	U<1.7	U<1.7
Endrin ketone	U<3.3	11	0.38 J	U<3.3	U<3.3
Endrin aldehyde	U<3.3	2.1 J	U<3.3	U<3.3	U<3.3
alpha-Chlordane	U<1.7	U<1.7	U<1.7	U<1.7	0.16 J
gamma-Chlordane	U<1.7	U<1.7	U<1.7	U<1.7	0.27 J
SEMIVOLATILE (µg/kg)					
Phenanthrene	U<330	140 J	U<330	U<330	U<330
Di-n-butylphthalate	48 B	590 B	65 J	49 B	50 J
Fluoranthene	U<330	980	62 J	U<330	U<330
Pyrene	U<330	680 J	69 J	U<330	U<330
Benzo(a)anthracene	U<330	810	42 J	U<330	U<330
Chrysene	U<330	1200	61 J	U<330	U<330
Bis(2-ethylhexyl)phthalate	U<330	U<330	U<330	110 B	U<330
Benzo(b)fluoranthene	U<330	1600 J	72 J	U<330	U<330
Benzo(k)fluoranthene	U<330	1600 J	72 J	U<330	U<330
Benzo(a)pyrene	U<330	550 J	U<330	U<330	U<330
Indeno(1,2,3-od)pyrene	U<330	570 J	U<330	U<330	U<330
Dibenz(a,h)anthracene	U<330	240 J	U<330	U<330	U<330
Benzo(g,h,i)perylene	U<330	340 J	U<330	U<330	U<330
INORGANICS (mg/kg)					
Aluminum	14100	22800	10500	8570	9570
Arsenic	2.9 K	9.0	6.1	2.1	4.4
Barium	36.0	85.0	26.4	13.4	23.7
Beryllium	U<0.86	U<0.97	U<0.86	U<0.91	0.23 B
Cadmium	U<1.0	U<1.2	1.3	U<1.1	U<1.1
Calcium	272 J	1390 J	468 J	183 J	250
Chromium	11.2	23.2	9.9	7.2	9
Cobalt	2.7	7.2	U<2.4	U<2.5	2.6
Copper	5.5	28.0	10.4	8.4	3.1
Iron	6460	14100	5570	3200	6110
Lead	8.7	67.5	19.8	39.9	7.1 K
Magnesium	710	1830	659	367	496
Manganese	50.5	192	57.7	20.4	42.6
Mercury	U<0.12	0.21	U<0.12	U<0.13	U<0.12
Nickel	U<8.3	15.4	U<8.3	U<8.7	3.9
Potassium	U<439	842	U<437	U<461	351
Sodium	U<66.5	76.0	U<66.2	U<69.9	125 B
Vanadium	17.3	38.9	13.5	8.9	11.4
Zinc	15.6	69.4	21.1	14.2	13.3

KEY:
SED01 = Fire Training Area Sediment Sample No. 1
U<8 = Undetected above numerical detection limit (e.g., 8)
J = Analyte present. Reported value may not be accurate or precise.
B = Not detected substantially above the level reported in lab or field blanks.
L = Analyte present. Reported value may be biased low. Actual value is expected to be higher.
K = Analyte present. Reported value may be biased high. Actual value is expected to be lower.
µg/kg = microgram/kilogram

TABLE 4-6
1990 GROUNDWATER ANALYTICAL RESULTS

	MW01	MW02S	MW02D
VOLATILES(µg/l)			
Methylene Chloride	<5	<5	<5
Acetone	<10	12B	41B
Trichlorofluoromethane	<5	<5	<5
Chlorobenzene	<5	<5	<5
1,1,1-Trichloroethane	<5	52	6
1,2-Dichloroethene	<5	10	<5
Carbon Tetrachloride	<5	6	<5
Tetrachloroethene	<5	9	<5
Total-Other Volatiles	U	146	119
SEMIVOLATILES (µg/l)			
Bis(2-ethylhexyl)phthalate	46	9J	31
Di-n-octyl phthalate	<10	14	<10
2,4-Dinitrotoluene	<10	<10	<10
Fluoroanthene	<10	<10	<10
Pyrene	<10	<10	<10
Benzo(a)anthracene	<10	<10	<10
2,4-Dimethylphenol	<10	<10	<10
4-Nitrophenol	<50	<50	<50
Total-Other Semivolatiles	1400	202	85
PESTICIDES (µg/l)			
4,4'-DDE	<0.10	<0.10	<0.10
4,4'-DDD	<0.10	<0.10	<0.10
4,4'-DDT	<0.10	<0.10	<0.10
Delta-BHC	<0.05	<0.05	0.02J
INORGANICS (µg/l)			
Aluminum	19,300	59,000	27,500
Antimony	<60	<60	<60
Arsenic	<10	12	<10
Barium	<200	318	<200
Beryllium	<5	<5	<5
Cadmium	<5	<5	<5
Calcium	6660	9500	6340
Chromium	13	38	13
Cobalt	<50	<50	<50
Copper	<25	<25	<25
Iron	21,200	39,000	32,800
Lead	6.9	20	<5
Magnesium	<5,000	6,790	<5,000
Manganese	233	1,010	504
Mercury	R	R	R
Nickel	<40	40	<40
Potassium	<5,000	<5,000	<5,000
Selenium	<5	<5	<5
Silver	<10	<10	<10
Sodium	9,180	9,370	10,400
Thallium	<10	<10	<10
Vanadium	R	R	R
Zinc	21	46	<20
Cyanide	<10	<10	<10

Source: Site Inspection Report
Ebasco Services, Inc (1990)

KEY:
J=Estimated B=Detected in Blank
R=Rejected U=Undetected (Detection Limits Not Available)
<5=Not Detected Above Reported Numerical Detection Limit

TABLE 4-7
1990 SURFACE SOIL ANALYTICAL RESULTS

	SS01	SS02	SS03	SS04	SS04D
VOLATILES(mg/kg)					
Methylene Chloride	0.023	0.027	0.023	0.014	0.031
Acetone	0.013JB	0.048JB	U	0.029JB	0.029JB
Trichlorofluoromethane	0.014	0.005J	0.014	U	0.025
Chlorobenzene	U	U	U	0.014	U
1,1,1-Trichloroethane	U	U	U	U	U
1,2-Dichloroethene	U	U	U	U	U
Carbon Tetrachloride	U	U	U	U	U
Tetrachloroethene	U	U	U	U	U
Total-Other Volatiles	0.257	U	0.371	U	U
SEMIVOLATILES (mg/kg)					
Bis(2-ethylhexyl)phthalate	U	0.840	0.180J	2.1	1.8
Di-n-octyl phthalate	U	U	U	U	U
2,4-Dinitrotoluene	U	0.220J	U	1.4	0.560J
Fluoroanthene	U	U	U	0.430J	0.330J
Pyrene	U	U	U	0.700J	0.460J
Benzo(a)anthracene	U	U	U	0.190J	1.6J
2,4-Dimethylphenol	U	U	U	0.480J	U
4-Nitrophenol	U	U	U	2.5	1.2J
Total-Other Semivolatiles	205	1,145	161	478	3,524
PESTICIDES (mg/kg)					
4,4'-DDE	U	U	U	0.056	0.060
4,4'-DDD	U	U	U	0.076	0.120
4,4'-DDT	U	U	U	0.120	0.096
Delta-BHC	U	U	U	U	U
INORGANICS (mg/kg)					
Aluminum	4,570	6,270	4,870	6,480	6,540
Antimony	<13	<14	<13	<14	<15
Arsenic	<2.2	<2.4	<2.2	4.1	4.4
Barium	<45	<48	<43	<48	<49
Beryllium	<1.1	<1.2	<1.1	<1.2	<1.2
Cadmium	<1.1	<1.2	<1.1	<1.2	<1.2
Calcium	2,240	<1,190	<1,080	<1,200	<1,230
Chromium	3.8J	5.1J	3.5J	5.5J	5.1J
Cobalt	<11	<12	<11	<12	<12
Copper	<5.6	<6	<5.4	<6	<6.1
Iron	2,830	4,210	2,330	2,960	3,140
Lead	5.3J	15J	4.6J	19J	24J
Magnesium	<1,110	<1,190	<1,080	<1,200	<1,230
Manganese	40	35	38	28	30
Mercury	<0.11	<0.12	<0.11	<0.12	<0.12
Nickel	10	<9.5	<8.6	<0.96	<9.8
Potassium	<1,110	<1,190	<1,080	<1,200	<1,230
Selenium	<1.1	<1.2	<1.1	<1.2	<1.2
Silver	<2.2	<2.4	<2.2	<2.4	<2.5
Sodium	<1,110	<1,190	<1,080	<1,200	<1,230
Thallium	<2.2	<2.4	<2.2	<2.4	<2.5
Vanadium	<11	12J	<11	<12	14J
Zinc	<4.5	17	4.5	24	28
Cyanide	<1.1	<1.2	<1.1	<1.2	<1.2

Source: **Site Inspection Report**
Ebasco Services, Inc (1990)

KEY:
J=Estimated B=Detected in Blank
R=Rejected U=Undetected (Detection Limits Not Available)
<5=Not Detected Above Reported Numerical Detection Limit

4.2.2 Surface Soils

4.2.2.1 Background

Background surface soil data for the WFF Mainbase are presented in Table 4-8 and sample locations are shown in Figure 4-1. No volatiles, semivolatiles, or pesticides were reported in the background samples. Metals detected in the background samples included: aluminum, barium, beryllium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, sodium, thallium, vanadium, and zinc.

4.2.2.2 Former Fire Training Pit Area

Eight surface soil samples were collected from the area of the former fire training pit and downgradient (SS-01, SS-02, SS-03, SS-04, SS-07, SS-08, SS-09, and SS-10). Analytical results are presented in Table 4-1. Acetone, methylene chloride, and bis(2-ethylhexyl)phthalate were detected in almost all of the samples, but at concentrations not substantially above the levels reported in the laboratory and field blanks. Samples SS-03, SS-10, and SS-11 (duplicate of SS-03) contained several semivolatiles which included: phenanthrene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)-fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, and benzo(g,h,i)perylene. These PAH compounds are possible indicators of used automotive crankcase oil or fuel oil which are suspected combustibles used in fire fighter training exercises. Various inorganics were detected including: aluminum, arsenic, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, nickel, potassium, sodium, vanadium, and zinc. Many of these inorganics occur at concentrations comparable to background levels. Arsenic, chromium, and lead may be associated with used crankcase oil; lead may also be associated with leaded gasoline, which may have served as a combustible.

4.2.2.3 Former Drum Storage Area

Two surface soil samples were collected near the sludge pile in the area identified as the former drum storage area. The volatiles detected in samples SS-05 and SS-06 included acetone and methylene chloride, which are common laboratory contaminants. The only semivolatile detected was bis(2-ethylhexyl)-phthalate, which is also a common sampling and laboratory contaminant. The levels of these three

TABLE 4-8

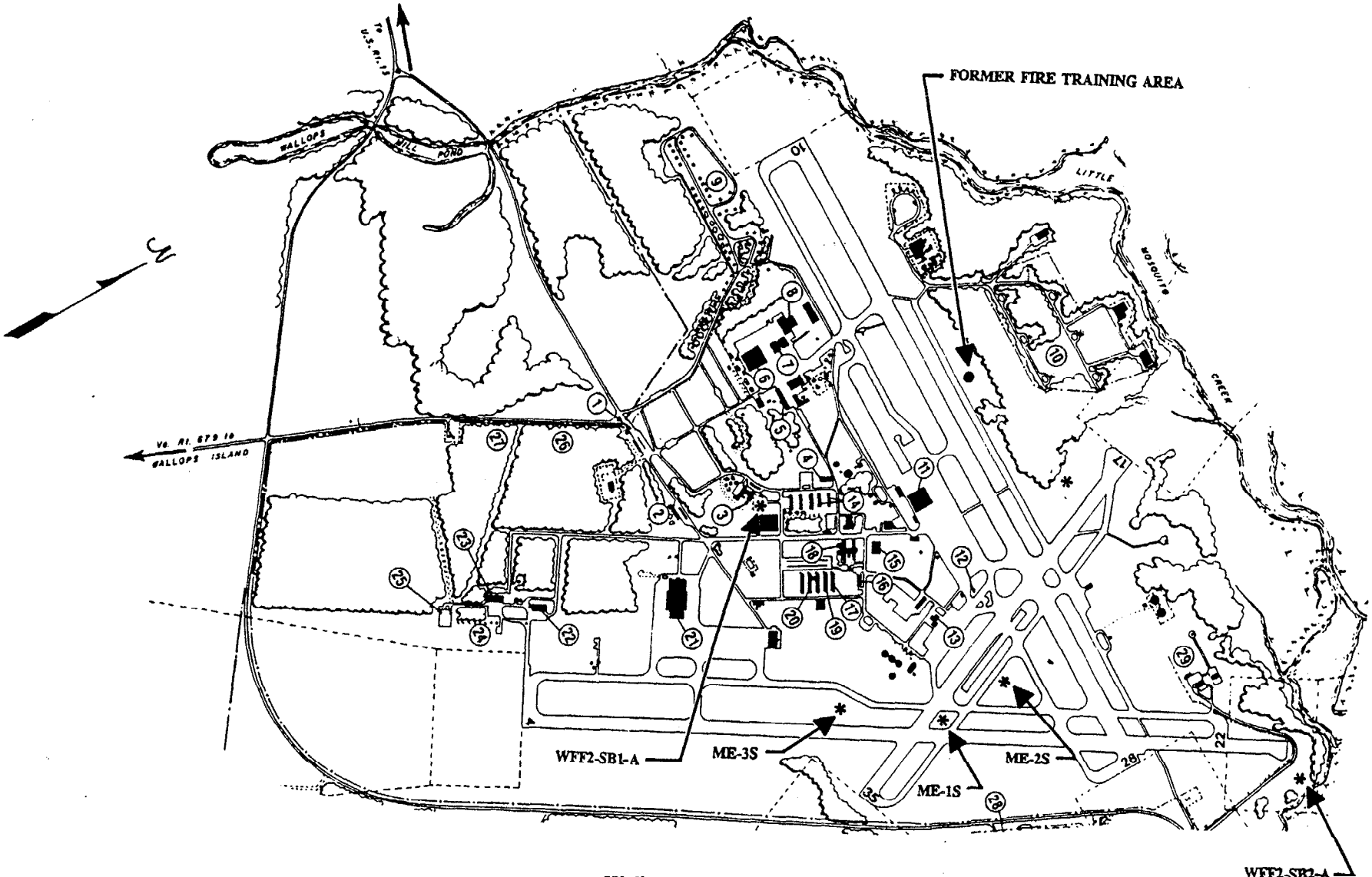
BACKGROUND SURFACE SOIL DATA FOR WFF MAINBASE

DEPTHS OF 0 - 2 ft (mg/kg)

SAMPLE ID	ME-1S	ME-2S	ME-3S	WFF2-SB1A	WFF2-SB2A
DATE	11/91	11/91	11/91	9/91	9/91
Aluminum	11185	5838	2974	17700	16700
Antimony	<0.02	<0.02	<0.02	<12	<12
Arsenic	<0.03	<0.03	<0.03	<20	<20
Barium	37.73	9.17	3.24	<40	68.00
Beryllium	0.37	0.05	0.00	<1.0	<1.0
Cadmium	<0.009	<0.009	<0.009	<1.0	<1.0
Calcium	424	187	68	NA	NA
Chromium	12.55	4.17	9.31	<20	<20
Cobalt	3.75	1.27	0.53	<10	<10
Copper	0.22	<0.007	<0.007	<5.0	<5.0
Iron	11893	3410	1585	NA	NA
Lead	0.57	<0.05	<0.05	<20	<20
Magnesium	1157	261	120	NA	NA
Manganese	237.50	40.16	13.19	NA	NA
Mercury	<0.01	<0.01	<0.01	<0.04	0.15
Nickel	5.01	0.94	1.25	<8.0	<8.0
Potassium	481	152	98.20	NA	NA
Selenium	<0.03	<0.03	<0.03	<20	<20
Silver	<0.01	<0.01	<0.01	<2.0	<2.0
Sodium	25.05	12.00	8.78	NA	NA
Thallium	17.77	5.60	1.21	<2.0	<2.0
Vanadium	23.41	7.80	4.27	16	22
Zinc	20.85	2.66	2.42	<4.0	5.99
Cyanide	NA	NA	NA	NA	NA

KEY: NA = Not Analyzed

Reference: NASA, 1992a. *Final Design Investigation of the Aviation Fuel Tank Farm Area*



Wallops Main Base

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Metcalf & Eddy	**FIGURE 4-1**	**Background Surface Soil Sample Locations** **NASA, Wallops Flight Facility**

compounds were not significantly higher than those found in the laboratory and field blanks. Trace amounts of the following pesticides were detected: endosulfan I, endosulfan sulfate, 4,4-DDE, 4,4-DDT, methoxychlor, endrin aldehyde, alpha-chlordane, and gamma-chlordane. These pesticides are not suspected site contaminants. The metals detected in these surface soil samples included: aluminum, arsenic, barium, cadmium, calcium, chromium, copper, iron, lead, magnesium, manganese, nickel, vanadium, and zinc.

4.2.2.4 Construction Debris Disposal Area and Sludge Pile

No surface soil samples were collected from the construction debris disposal area or the sludge pile, although two shallow subsurface soil samples were collected from each location and are discussed in Sections 4.2.3.3 and 4.2.3.4.

4.2.3 Subsurface Soil

4.2.3.1 Background

Background subsurface soil data for the FTA site is provided by samples collected from boring SB-12 (developed as monitoring well MW-53S) and general WFF Main Base subsurface samples (Table 4-9) from a previous investigation (NASA, 1992a). The sample locations are shown in Figure 4-2. No volatiles, semivolatiles, or pesticides were detected in the background samples. Metals detected in the background samples included: aluminum, arsenic, barium, beryllium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, sodium, thallium, vanadium, and zinc.

4.2.3.2 Former Fire Training Pit Area

Thirty subsurface soil samples were collected in the area downgradient of the former fire training pit in soil borings completed as part of the monitoring well installation program. Sample locations were dictated by well locations, which were selected to define the extent of the groundwater plume. The volatile compounds detected in these samples included: acetone, cis-1,2-dichloroethene, methylene chloride, 2-butanone, 1,1,1-trichloroethane, toluene, ethylbenzene, and xylenes. Most of these values were qualified with a "B", indicating they were not detected substantially above the level reported in laboratory or field

TABLE 4-9

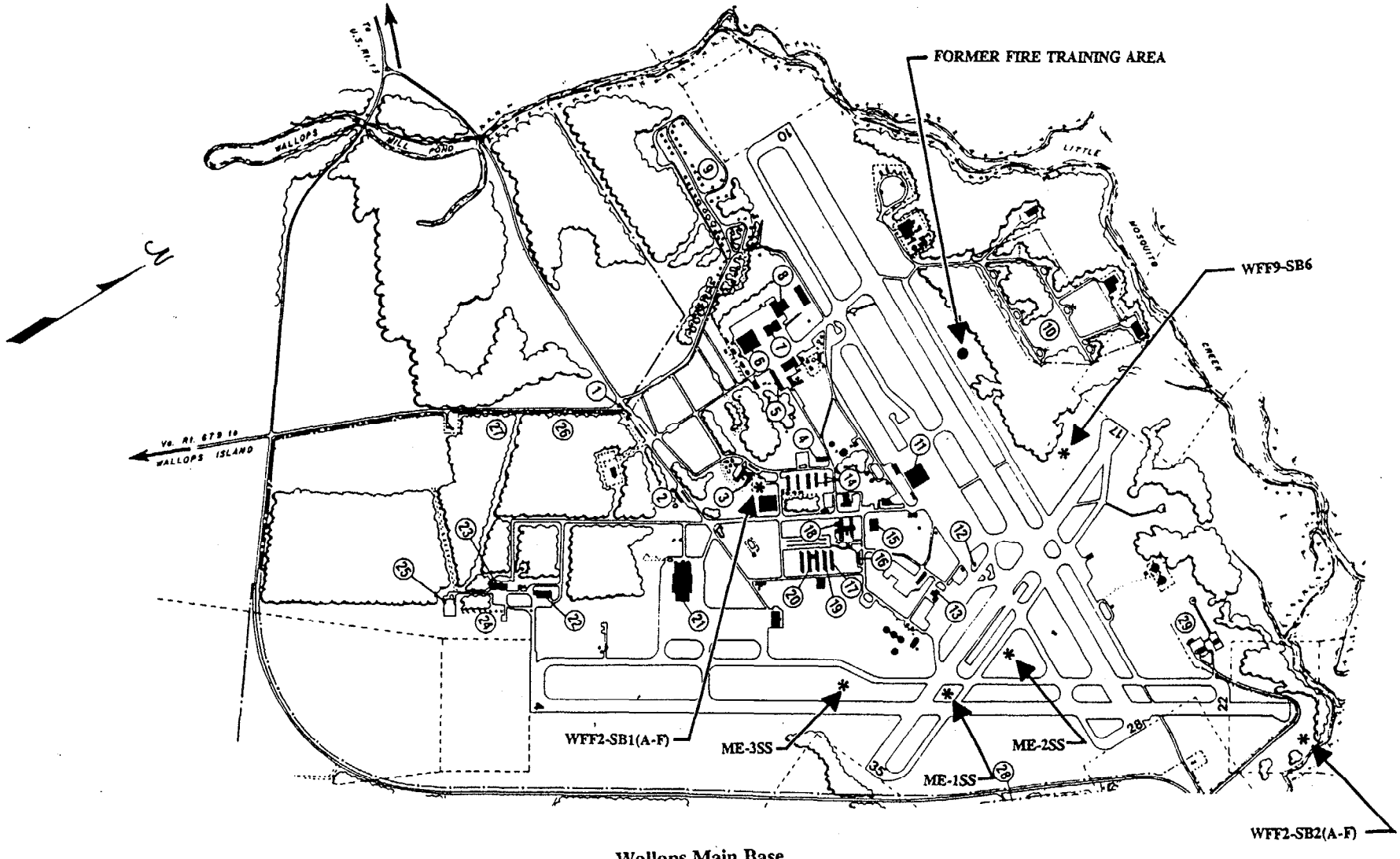
BACKGROUND SUBSURFACE SOIL DATA FOR WFF MAINBASE

(mg/kg)

SAMPLE ID	ME-1SS	ME-2SS	ME-3SS	WFF2-SB1B	WFF2-SB1BD	WFF2-SB1C	WFF2-SB1D	WFFS2-SB1E	WFFS2-SB1F	WFF2-SB2B	WF2-SB2BD	WFF2-SB2C	WFF2-SB2D	WFF2-SB2E	WFF9-SB6
DEPTH (ft)	3-6	3-6	3-6	2-4	2-4	4-6	6-8	8-10	10-12	2-4	2-4	4-6	6-8	8-10	1.5-2.5
DATE:	11/91	11/91	11/91	9/91	9/91	9/91	9/91	9/91	9/91	9/91	9/91	9/91	9/91	9/91	6/93
Aluminum	9,748	5,499	3,357	5,880	6,490	3,430	3,680	5,840	7,040	13,300	19,000	9,350	5,570	4,690	7,520 J
Antimony	<0.02	<0.02	<0.02	<12	<12	<12	<12	<12	<12	<12	<12	<12	<12	<12	<5.0
Arsenic	<0.03	<0.03	<0.03	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	1.1
Barium	17.75	8.96	4.3	<40	<40	<40	<40	<40	<40	<40	49	<40	<40	<40	16
Beryllium	0.10	0.04	0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.21
Cadmium	<0.009	<0.009	<0.009	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.83
Calcium	227	148	96	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	189 J
Chromium	8.06	10.85	3.82	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	5.7
Cobalt	2.35	1.46	0.62	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	1.2
Copper	0.07	<0.007	<0.007	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	1.6
Iron	8,529	4,091	1,425	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	3,040
Lead	<0.05	<0.05	<0.05	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	1.7
Magnesium	68	256	144	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	279
Manganese	63.79	37.22	11.14	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	18.4
Mercury	<0.01	<0.01	<0.01	<0.04	0.14	0.08	0.13	0.14	<0.04	0.13	<0.04	<0.04	0.08	0.15	<0.11
Nickel	1.69	4.45	1.17	<8.0	<8.0	<8.0	<8.0	<8.0	<8.0	<8.0	<8.0	<8.0	<8.0	<8.0	3.4
Potassium	456	196	105	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<223
Selenium	<0.03	<0.03	<0.03	<20	<20	<20	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0.23
Silver	<0.01	<0.01	<0.01	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<0.83
Sodium	14.11	12.61	10.28	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	37.8 B
Thallium	12.44	3.3	1.8	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<0.4
Vanadium	16.78	9.13	4.78	<10	<10	<10	<10	<10	<10	<10	27	<10	<10	<10	6.2
Zinc	11.61	5.63	2.72	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	4.56	<4.0	<4.0	<4.0	4.4 B
Cyanide	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

KEY: NA = Not Analyzed

Reference: NASA, 1992a. *Final Design Investigation of the Aviation Fuel Tank Farm Area*



Wallops Main Base

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FIGURE 4-2

Background Subsurface Soil Sample Locations
NASA, Wallops Flight Facility

blanks. The sample with the greatest number of volatile detections was SB8-3, collected from the well boring for MW-55D, immediately downgradient of the suspected former pit area. This sample also contained several volatile tentatively identified compounds (TICs): dimethylpentane, tetramethylbutane, dimethylhexane, trimethylpentane, nonane, ethylmethylbenzene, and trimethylbenzene. These volatile compounds may be residues from hydrocarbon fuels used as combustibles during training exercises.

Several pesticides and PCBs were detected at low concentrations in the subsurface soil samples. The pesticides/PCBs detected included: alpha-benzenehexachloride (BHC), delta-BHC, heptachlor, aldrin, endosulfan I, endosulfan sulfate, dieldrin, 4,4-DDD, 4,4-DDE, 4,4-DDT, endrin, methoxychlor, heptachlor epoxide, toxaphene, beta-BHC, alpha-chlordane, gamma-chlordane, and Aroclor 1260. Sample SB6-1 had several low concentration pesticide detections.

The semivolatile compounds detected in the subsurface soil samples included: di-n-butylphthalate, butylbenzylphthalate, bis(2-ethylhexyl)phthalate, di-n-octylphthalate, 2-methylnaphthalene, fluoranthene, pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, dibenz(a,h) anthracene, and benzo(g,h,i)perylene. Overall, sample SB10-1, collected from the boring for MW-59S, had the largest number of detections of semivolatiles and pesticides. The PAH compounds may be associated with the use of used crankcase oil and/or fuel oils as combustibles for fire fighter training exercises.

The metals detected in the subsurface soil included: aluminum, arsenic, barium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, sodium, vanadium, and zinc. Some of the inorganics may be site-related, as discussed in Section 4.2.2.2. Others are naturally occurring at levels comparable to background concentrations.

4.2.3.3 Sludge Pile

Subsurface soil samples taken from the sludge pile and immediately downgradient contained trace amounts of volatile organics, several pesticides, and metals. The downgradient samples (SB1-1,-2,-3 and SB2-1,-2, -3) had detected levels of the volatile organics acetone and methylene chloride, common laboratory solvents, both reported at concentrations not significantly higher than those found in laboratory and field blanks. The semivolatiles were di-n-butylphthalate and bis(2-ethylhexyl)phthalate, also not detected

substantially above the levels reported in laboratory or field blanks. The pesticides identified included delta-BHC, heptachlor, heptachlor epoxide, 4,4-DDD, 4,4-DDE, 4,4-DDT, endrin, endosulfan sulfate, alpha-chlordane, and gamma-chlordane. Pesticides have been found throughout WFF at comparable concentrations, and are not believed to be related to activities at the former FTA.

Samples SB1-4 and SB2-4 were shallow subsurface samples collected from the sludge pile. They contained detected levels of acetone, methylene chloride, di-n-butylphthalate, bis(2-ethylhexyl)phthalate, delta-BHC, heptachlor, 4,4-DDD, endosulfan sulfate, and 4,4-DDT. These compounds are not suspected site contaminants as discussed above. The levels of aluminum, arsenic, barium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, vanadium, and zinc were higher in the samples taken from the sludge pile than in the downgradient samples. Beryllium and nickel were also detected in the sludge pile samples.

4.2.3.4 Construction Debris Disposal Area

Subsurface soil samples collected in and around the construction debris piles contained few detected contaminants, and those identified occurred at low concentrations. Methylene chloride and di-n-butylphthalate were detected, but only at concentrations slightly above the levels reported in the laboratory or field blanks. Several pesticides were found in low concentrations in samples SB13-4 and SB14-4. The pesticides and PCBs identified included: gamma-BHC, heptachlor, heptachlor epoxide, 4,4-DDD, 4,4-DDE, 4,4-DDT, endrin ketone, gamma-chlordane, dieldrin, endosulfan II, and Aroclor 1260. Because these piles contain mostly construction debris and fill from other locations around WFF, the pesticides found do not appear to be site-related.

Several semivolatiles and PAHs were also detected in sample SB13-4. Chemicals identified included: phenanthrene, di-n-butylphthalate, fluoranthene, pyrene, benzo(a)anthracene, chrysene, bis(2-ethylhexyl)phthalate, di-n-octylphthalate, benzo(b)fluoranthene, benzo(k)fluoranthene, and benzo(a)pyrene. Moderately high values of aluminum, arsenic, iron, and lead were detected in samples SB13-4 and SB14-4.

4.2.4 Groundwater

4.2.4.1 Background

Monitoring wells upgradient and cross-gradient of the site were sampled. The results are presented in Table 4-3. Trace amounts of methylene chloride and bis(2-ethylhexyl)phthalate were detected in MW-34S and MW-53S, both located upgradient of the site. These organic compounds may be attributable to laboratory contamination. Metals detected in these samples included: aluminum, arsenic, barium, beryllium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, potassium, sodium, vanadium, and zinc. No other contaminants were detected in these samples.

Sample MW-01D (cross-gradient) contained low levels of acetone, cis-1,2-dichloroethene, methylene chloride, chloroform, and bis(2-ethylhexyl)phthalate. No pesticides were detected in this sample. The metals detected included: aluminum, barium, calcium, copper, iron, magnesium, manganese, potassium, sodium, vanadium, and zinc.

4.2.4.2 Shallow Aquifer

Sixteen samples, consisting of four DNAPL samples and 12 samples including one duplicate sample, collected following purging activities, were obtained from monitoring wells screened in the Pleistocene age aquifer. Several contained detected levels of volatiles, semivolatiles, pesticides/PCBs, and metals. The detected volatile organic compounds included: acetone, chloroform, 1,1-dichloroethane, 1,1-dichloroethene, methylene chloride, 2-butanone, 1,1,1-trichloroethane, benzene, tetrachloroethene, toluene, ethylbenzene, and xylene. The TICs detected included: ethylmethylbenzene, trimethylbenzene, tetramethylbenzene, and alkylbenzene. The semivolatiles detected included: 4-methylphenol, naphthalene, 2-methylnaphthalene, diethylphthalate, fluorene, phenanthrene, and bis(2-ethylhexyl)phthalate. The pesticides/PCBs detected included: alpha-BHC, delta-BHC, gamma-BHC, aldrin, heptachlor epoxide, endosulfan I, endosulfan II, dieldrin, endrin, endosulfan sulfate, 4,4-DDE, 4,4-DDT, methoxychlor, endrin ketone, endrin aldehyde, alpha-chlordane, and gamma-chlordane. The inorganic compounds detected in the monitoring wells included: aluminum, chromium, cobalt, copper, iron, lead, magnesium, manganese, nickel, potassium, sodium, vanadium, and zinc. Samples from wells located near the FTA with the most detected compounds included MW-02S, MW-55D-1 (a DNAPL sample), MW-55D, and MW-62S (a duplicate of MW-55S).

Most of the volatile and semivolatile compounds detected are suspected site-related contaminants. Some of the inorganics, including arsenic and lead, may be site-related. The nature of pesticide use in the area is unknown, but is expected to be consistent with usage in the vicinity of runways in other areas of WFF. These compounds will be evaluated in the risk assessment screening (Section 6.0) to determine their relative contribution, if any, to risk posed by the site.

Groundwater samples taken near the construction debris piles (MW-02D and MW-60I) contained low levels of chloroform, methylene chloride, 1,1,1-trichloroethane, tetrachloroethene, and trichlorofluoromethane. Most of the detected concentrations were significantly lower than those detected in the other well locations around the former FTA. The groundwater results are presented in Table 4-3.

4.2.5 Surface Water/Sediment

No surface water was present in the actual fire training pit area during the site reconnaissance and sampling event. Four surface water/sediment samples were taken from several shallow surface water pools resulting from ponding of surface runoff in low-lying areas northeast of the FTA. The analytical results for the surface water and sediment are presented in Tables 4-4 and 4-5. Background surface water results from the WFF Main Base are presented in Table 4-10 and the approximate sample location is shown on Figure 4-3.

The surface water samples contained trace amounts of pesticides and metals. All of the sediment samples contained trace amounts of volatiles, semivolatiles, pesticides, and metals. Sample SED-02 had the largest frequency of detections. The sediment results were compared to general background surface soil samples since the sampled areas are intermittent, and the sediment samples are more reflectible of surface soil conditions.

4.3 SUMMARY AND SIGNIFICANCE OF FINDINGS

4.3.1 Surface Soil Summary

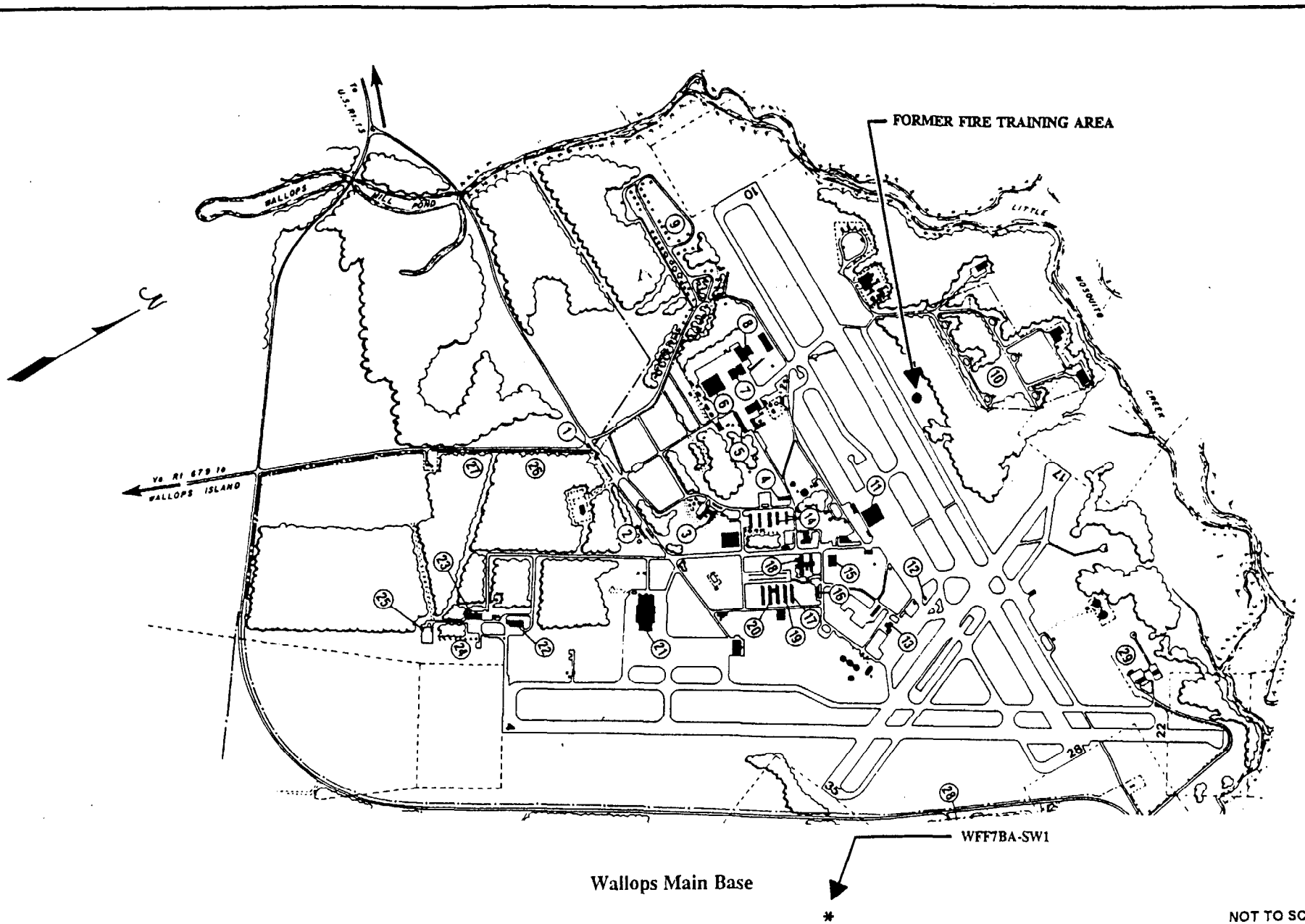
The surface soil analytical data were compared to both background concentrations and EPA Region III Risk-Based Concentrations (RBCs) (USEPA, 1994g). The guidance information and updated list of RBCs is presented as Appendix B and C.

TABLE 4-10 BACKGROUND SURFACE WATER ANALYTICAL RESULTS

ANALYTE	SAMPLE ID: WFF7BA-SW1 (mg/L)
Aluminum	U<0.10
Arsenic	U<0.002
Calcium	190
Chromium	U<0.02
Copper	0.033
Iron	0.16
Magnesium	57
Manganese	0.027
Potassium	200
Sodium	4800
Vanadium	U<0.025
Zinc	U<0.02

Note: No VOC's, SVOC's or Pesticides were detected. U<0.10 indicates the compound was not detected above the reported numerical detection limit. Sample was collected from Jenney's Gut during a previous investigation (5/21/92).

Reference: NASA, 1992b. *Revision of Site Investigation, Wallops Flight Facility*



Metcalf & Eddy	**FIGURE 4-3**	**Background Surface Water Sample Location** **NASA, Wallops Flight Facility**

A more detailed screening is described in Section 6.0 and summarized in Table 6-4. The chemicals which exceeded the RBCs for residential soil exposure included: benzo(a)pyrene, benzo(g,h,i)perylene, aluminum, arsenic, and lead. Most of these have been identified as human health chemicals of concern in Section 6.0.

4.3.2 Subsurface Soil Summary

The subsurface soil contaminants which exceeded the residential soil exposure RBCs included: phenanthrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, dibenz(ah)anthracene, benzo(g,h,i)perylene, Aroclor 1260, aluminum, arsenic, and lead. More detailed screening in Section 6.0 led to the identification of many of these compounds as chemicals of concern for the human health risk assessment.

4.3.3 Groundwater Summary

The groundwater analytical data were compared to both background concentrations and tap water RBCs. The volatile organic compounds which exceeded recommended limits included: 1,1-dichloroethene, cis-1,2-dichloroethene, methylene chloride, chloroform, benzene, tetrachloroethene, toluene, trimethylbenzene, and tetramethylbenzene. The semivolatiles which exceeded the RBCs included: alkylbenzene, phenanthrene, 2-methylnaphthalene, naphthalene, and bis(2-ethylhexyl)phthalate. The detected pesticides which exceeded the RBCs included: alpha-BHC, aldrin, heptachlor epoxide, and gamma-chlordane. The inorganics detected above the RBCs included arsenic, lead, and managanese. Many of these compounds are identified as chemicals of concern in the human health risk assessment in Section 6.0.

4.3.4 Significance of Findings

Comparison of the analytical data to the RBCs allowed determination of contaminants of greatest concern for the FTA. The contaminant list includes:

> Volatile Organic Compounds - 1,1-dichloroethene, cis-1,2-dichloroethene, methylene chloride, chloroform, benzene, tetrachloroethene, toluene, trimethylbenzene, and tetramethylbenzene.

Semivolatile Compounds - alkylbenzene, phenanthrene, 2-methylnaphthalene, naphthalene, bis(2-ethylhexyl)phthalate, benz(a)anthracene, benzo(b)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, dibenz(ah)anthracene, benzo(g,h,i)perylene.

Pesticides/PCBs - alpha-BHC, aldrin, heptachlor epoxide, gamma-chlordane, and Aroclor 1260.

Inorganics - aluminum, arsenic, lead, and manganese.

This information is further screened and utilized in the development of the Human Health and Ecological Risk Assessments in Sections 6.0 and 7.0. These compounds, with the exception of the pesticides, PCBs, aluminum, and manganese, may be site-related contaminants. The volatile organic compounds may have resulted from the use of waste solvents and hydrocarbon fuels as combustibles during fire fighting training exercises. The semivolatiles may be attributable to the burning of used automotive crankcase oil or fuel oils. Arsenic and lead may also be attributable to used crankcase oil, and lead may have resulted from the use of leaded gasoline.

Based on the concentrations of the chemicals of concern, estimates of the area and volume of contaminated media were detemined. The estimated area and volume of contaminated groundwater in the water table (Pleistocene) aquifer is 40,272 ft^2 and 587,971 ft^3. This estimate is based upon the cis-1,2-dichloroethene groundwater data, which resulted in the most extensive groundwater plume. The approximate area and volume of contaminated soil is 22,240 ft^2 and 324,704 ft^3. The estimate of soil contamination was determined using a conversion of soil gas data, due to the high mobility of volatiles from soil to groundwater (volatiles were detected in the groundwater, but rarely in the surface and subsurface soil samples). This estimatation is further described and presented in Appendix D.

5.0 CONTAMINANT FATE AND TRANSPORT

5.1 SITE CONTAMINANTS

Additional screening of the chemicals of concern from Section 4.3.4, based on comparisons to background levels, led to the identification of the following potential site contaminants. The volatile chemicals of concern include: benzene, chloroform, 1,1-dichloroethene, cis-1,2-dichloroethene, methylene chloride, tetrachloroethene, tetramethylbenzene, toluene, and trimethylbenzene. The semivolatile chemicals of concern include: 2-methylnaphthalene, naphthalene, phenanthrene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, and dibenz(a,h)anthracene. The pesticides include: alpha-BHC, heptachlor epoxide, and gamma-chlordane. The metals of concern are arsenic and lead. Detailed screening and evaluation information is further discussed in the Human Health and Ecological Risk Assessments in Sections 6.0 and 7.0.

5.2 PHYSICAL AND CHEMICAL PROPERTIES OF CONTAMINANTS OF CONCERN

Chemical and physical properties are important factors in determining the movement and environmental fate of a contaminant and subsequently assessing exposure pathways. The following section presents a discussion of the physical and chemical properties associated with the chemicals of concern and how these apply to the transport properties of each contaminant group. Properties for the compounds found at the former FTA are presented in Table 5-1. Each of the properties presented for organic compounds are discussed relative to the effects they might have on mobility.

The water solubility of a chemical is defined as the maximum concentration of that chemical that will dissolve in pure water at a specific temperature and pH. Neutral pH and temperatures from 20 to 30°C are generally used. Water solubility is a critical property affecting environmental fate (EPA, 1986). Highly soluble chemicals can be rapidly leached from wastes or contaminated soils and are generally mobile in both groundwaters and surface waters (EPA, 1986). The water solubilities of most common organic compounds fall between 1 and 100,000 mg/l (Lyman et. al., 1981).

Vapor pressure and Henry's Law Constant are two measures of chemical volatility and are important factors in evaluating potential air exposure pathways. Vapor pressure is a measure of the volatility of a

TABLE 5-1.
CHEMICAL AND PHYSICAL PROPERTIES OF CHEMICALS OF CONCERN

Chemical Name	Molecular Weight (MW) (g/mole)	Water Solubility (mg/L)	Partition Coefficients Log K_{ow}	* Koc (ml/g)	Distribution Coefficient, K_d (ml/g)	Vapor Pressure (torr)	Henry's Law Constant (atm m^3/mol)	Environmental Freshwater Bioconcentration Factor (BCF)
VOLATILES								
Benzene	78.12	1.8E+03	2.1E+00	8.3E+01	4.7E+00	9.5E+01	5.6E-03	2.3E+02
Chloroform	119.37	8.0E+03	2.0E+00	3.1E+01	6.8E+00	2.0E+02	3.7E-03	6.0E+00
1,1-Dichloroethene	96.94	2.3E+03	2.1E+00	6.5E+01	5.2E+01	6.0E+02	2.6E-02	*5.6E+00
cis-1,2-Dichloroethene	96.94	3.5E+03	1.9E+00	4.9E+01	7.6E+00	2.0E+02	4.1E-03	*1.6E+00
Methylene Chloride	84.93	1.3E+04	1.3E+00	8.8E+00	NR	4.4E+02	2.2E-03	*5.0E+00
Tetrachloroethene	165.82	2.0E+02	3.4E+00	3.6E+02	3.6E+01	1.9E+01	1.8E-02	4.9E+01
1,2,4,5-Tetramethylbenzene	134.11	insoluble	NR	NR	NR	NR	NR	NR
Toluene	92.15	5.3E+02	2.7E+00	3.0E+02	1.4E+01	2.8E+01	6.6E-03	** 3.1E+01
1,3,5-Trimethylbenzene	120.21	insoluble	NR	NR	NR	NR	NR	NR
SEMI-VOLATILES								
2-Methylnaphthalene	142.08	2.5E+01	-1.9E+00	NR	NR	NR	NR	*** 2.6E+03
Naphthalene	128.06	3.1E+01	3.6E+00	1.3E+03	NR	8.5E-02	4.8E-04	3.1E+02
Phenanthrene	178.24	1.2E+00	4.5E+00	1.4E+04	3.5E+03	1.1E-04	2.3E-05	5.1E+03
Benzo(a)anthracene	228.30	9.4E-03	5.7E+00	1.4E+06	2.1E+05	3.1E-08	9.8E-07	1.0E+04
Benzo(b)fluoranthene	252.32	1.5E-03	6.6E+00	NR	NR	5.0E-07	1.1E-04	NR
Benzo(k)fluoranthene	252.32	8.0E-04	6.1E+00	5.5E+05	NR	1.0E-09	4.0E-07	1.3E+04
Benzo(g,h,i)perylene	276.34	2.6E-04	6.6E+00	1.6E+06	NR	1.0E-10	1.6E-06	2.8E+04
Benzo(a)pyrene	252.32	1.6E-03	6.0E+00	5.5E+06	7.7E+05	5.5E-09	1.1E-04	8.3E+04
Dibenz(a,h)anthracene	278.36	2.5E-06	6.5E+00	3.3E+06	3.1E+05	1.0E-10	1.2E-04	5.0E+04
PESTICIDES								
alpha-BHC	290.82	2.0E+00	3.8E+00	3.8E+03	3.0E+02	4.5E-05	1.1E-05	3.5E+02
Chlordane	409.76	5.6E-02	5.5E+00	1.4E+05	5.8E+02	9.8E-06	4.9E-05	3.8E+04
Heptachlor Epoxide	389.30	2.0E-01	5.4E+00	2.2E+02	1.6E+00	2.0E-05	3.2E-05	1.4E+04
METALS								
Arsenic	74.92	very low	NR	NR	2.0E+02	*1.00E+00	NA	1.7E+01
Lead	207.19	very low	NR	NR	9.0E+02	*1.00E+01	NA	1.7E+03

Note: NA - Not Applicable
NR - Not Reported

Source: Superfund Chemical Data Matrix (SCDM), March 9, 1993
* Buckingham, Evans, and LaGrega. Hazardous Waste Management. McGraw-Hill, Inc., New York, 1994.

Note: ** Value for saltwater, no freshwater value was available

chemical in its pure state at a specific temperature, generally 20 to 30°C (EPA, 1986). The vapor pressures of liquids range from 0.001 to 760 mm Hg (EPA, 1986). A higher vapor pressure indicates a greater tendency for movement from water or soil to air.

The Henry's Law Constant (H), which considers the interaction between aqueous solubility and vapor pressure, is a more important predictor of volatilization from water (Andelman et. al., 1987). This constant is estimated by the following ratio (EPA, 1986):

$$H = \frac{Vapor\ Pressure\ (atm)\ x\ MW\ (\frac{g}{mol})}{Water\ Solubility\ (\frac{g}{m^3})}$$

A large Henry's Law Constant, greater than $1x10^{-3}$ atm m^3/mole, indicates a tendency for a contaminant to move from water into air.

A log octanol/water partition coefficient (log K_{ow}) value represents the tendency of a chemical to partition between an organic phase, such as soil or fish, and an aqueous phase. Chemicals with a low log K_{ow} value (e.g. less than 1) may be considered hydrophilic. Hydrophilic compounds tend to remain dissolved in water rather than in non-polar solvents. These compounds also have low organic carbon partition coefficients (K_{oc}). Chemicals with a high log K_{ow} value (e.g. greater than 4) may be considered hydrophobic (Lyman et. al., 1981), which indicates that they are more likely to remain sorbed to organics in soil than to partition to water.

The organic carbon partition coefficient (K_{oc}) indicates the tendency of an organic chemical to be adsorbed to organic material in soil or sediment. This property is largely independent of soil characteristics (EPA, 1986). The K_{oc} can be expressed as (EPA, 1986):

$$K_{oc} = \frac{chemical\ adsorbed\ (mg)\ /\ organic\ carbon\ (kg)}{chemical\ dissolved\ (mg)\ /\ solution\ (L)}$$

For groundwater pathways, a low K_{oc} value indicates that a chemical can be easily leached from the waste source and relatively rapidly transported through the aquifer (EPA, 1986), depending on aquifer characteristics. For surface water pathways, a high K_{oc} indicates that the chemical is tightly bound to the

soil or sediment and the chemical is not likely to dissolve in site runoff. However, the high K_{oc} value also indicates that runoff containing contaminated soil particles may be a long term concern. A chemical with a high K_{oc} value may be of great concern if it is detected in surface waters because a high K_{oc} is usually indicative of a tendency to bioaccummulate (EPA, 1986).

The normal range of K_{oc} values is from 1 to $1x10^7$, with higher values indicating greater sorption potential (Lyman et. al., 1981). K_{oc} values greater than 1000 generally indicate immobile compounds or compounds with greater sorption potential. A K_{oc} between 100 and 1000 is considered intermediate, while compounds with K_{oc} values less than 100 are considered highly mobile in water.

The Bioconcentration Factor (BCF) of an analyte is a measure of the extent to which it will partition between a specific biological tissue and an environmental medium. Generally, the biological tissue is fish tissue and the environmental medium is water.

5.2.1 Volatile Organics

Volatile organic compounds tend to have large to moderate Henry's Law Constants (H), moderate to high water solubility, and low organic carbon partitioning values (K_{oc}). These properties result in high mobility from water to air and from soil to air. They also exhibit moderate to high mobility through groundwater. The volatile organic compounds detected, such as benzene ring compounds, follow this pattern.

5.2.2 Semivolatile Organics

The evaluated semivolatiles, including several PAHs, are characterized by very low water solubility, high K_{oc} values, and low Henry's Law Constants. They are highly persistent, tending to sorb strongly to soil particles and not to solubilize into water or volatilize into air.

5.2.3 Pesticides

The pesticides of concern have relatively low water solubility, moderately high K_{oc} values, and are only slightly mobile. They also have relatively high bioconcentration values.

5.2.4 Metals

The CLP procedures used for metals analyses do not distinguish between chemical forms. Many factors, such as solution pH, salinity, ionic strength, and medium, affect metal concentrations and compositions. This composite of factors makes predicting the environmental fate and transport of metals difficult. It may be assumed that most of the metals at the WFF are present in inorganic compounds. The metals of toxicologic interest are relatively insoluble in the presence of naturally occurring ions such as sulfates and hydroxides. Metals are generally not volatile except in certain forms, usually involving organic complexation (e.g., tetraethyl lead). Tetraethyl lead (TEL) is a component of aviation (jet) fuel. TEL is volatile but with low water solubility. The lead found at the FTA may be a result of the additive TEL in the aviation fuel or may be inorganic lead.

5.3 FATE AND TRANSPORT PROCESSES

5.3.1 Shallow Aquifer Transport

Chemicals released at the site may have been leached from surface soils into the underlying shallow aquifer. Two wells completed in the shallow aquifer (MW-02S and MW-55S) downgradient from the FTA showed contamination with a number of volatile compounds, at total levels over 600 μg/l and 3200 μg/l respectively. Detected levels of semivolatiles were reported in the wells, especially MW-55S which had high levels of naphthalene and 2-methylnaphthalene. The concentrations of several toxic metals (arsenic, lead, chromium) are slightly elevated in these wells, as are some of the less toxic elements (aluminum, iron, manganese). These may be due to either site activities or the geochemistry of the site. There is no evidence that groundwater contamination from the FTA has reached surface water at Little Mosquito Creek, or has adversely affected groundwater quality in the area of the Town of Chincoteague or NASA drinking water wells.

Based on the data collected as part of this RI, the contaminant plume is contained within the area downgradient of the former pit area, extending at a maximum to the area of the earthen berm north of the site. The Town of Chincoteague drinking water wells completed in the shallow aquifer are located approximately 5000 feet from this site, and are separated from the site by a groundwater divide in the

vicinity of runway 04-22. The NASA wells currently used for drinking water supply are all screened in the Miocene age aquifer and are upgradient of the former FTA.

5.3.2 Surface Water Transport

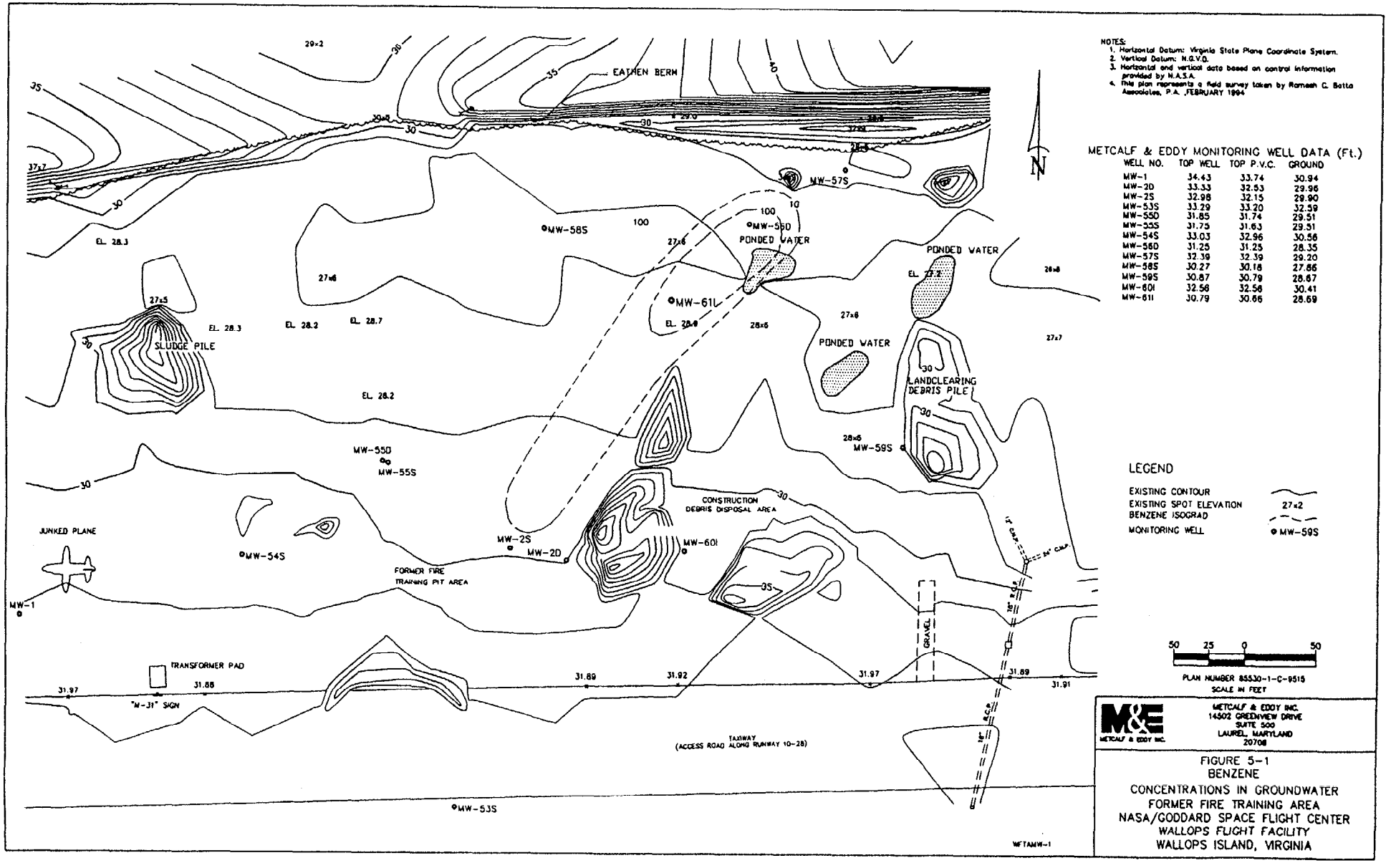
Surface water transport in the immediate vicinity of the FTA is limited to surface runoff which accumulates downgradient in low-lying areas to form intermittent pools. No direct transport to surface waters such as Little Mosquito Creek and its tributaries was observed and would not be anticipated.

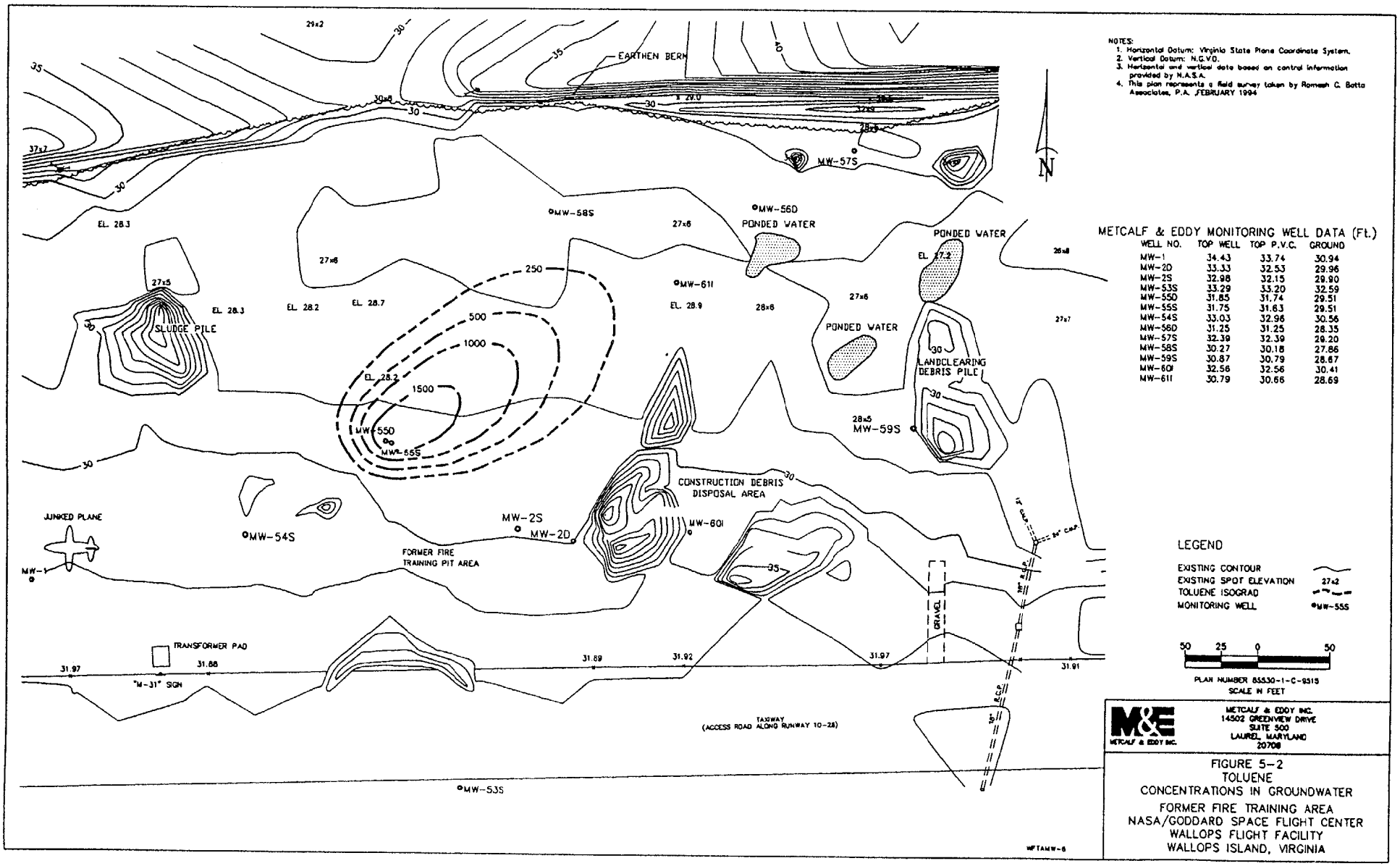
5.3.3 Surface Soil/Sediment Transport

Available data indicate that chemical contamination potentially related to past activities at the FTA is present in surface soil at the site. Chemical analyses indicate the presence of low levels of semivolatiles in one or more samples. Samples SS-03, SS-10, and SS-11 (duplicate of SS-03) had low levels of PAHs. The levels of volatile organic compounds were not substantially higher than levels reported in laboratory or field blanks. Low levels of pesticides were also detected in the surface soils. The concentrations of metals appear to be within the normal background range, with the possible exception of arsenic and lead, which were slightly elevated in several surface soil samples. The transport of contaminants in surface soil from the FTA by surface runoff may occur, but has not been identified in surface water samples.

5.4 CONTAMINANT MIGRATION TRENDS

Based upon analysis of soil gas and groundwater samples, a plume of volatile organic contamination extends about 400 feet to the north of the FTA. The concentrations in groundwater of benzene, toluene, and cis-1,2-dichloroethene are presented in Figures 5-1, 5-2, and 5-3. The concentrations in soil gas of 1,1-dichloroethene, cis-1,2-dichloroethene, tetrachloroethene, and toluene are presented in Figures 5-4 through 5-7. Most of the groundwater plumes are centered in the fire training area and continue downgradient, therefore, it does appear that some contaminant migration is occurring in the groundwater. The soil gas plumes are centered in the suspected location of the former training pit area and downgradient, and are more radial in nature than the groundwater plume. The soil gas plumes are thought to be indicative of groundwater contamination downgradient of the former pit area, as well as residual soil contamination.


NOTES:
1. Horizontal Datum: Virginia State Plane Coordinate System.
2. Vertical Datum: N.G.V.D.
3. Horizontal and vertical data based on control information provided by N.A.S.A.
4. This plan represents a field survey taken by Ramesh C. Batta Associates, P.A. ,FEBRUARY 1994
METCALF & EDDY MONITORING WELL DATA (Ft.)
WELL NO. TOP WELL TOP P.V.C. GROUND
MW-1 34.43 33.74 30.94
MW-2D 33.33 32.53 29.96
MW-2S 32.98 32.15 29.90
MW-53S 33.29 33.20 32.59
MW-55D 31.85 31.74 29.51
MW-55S 31.75 31.63 29.51
MW-54S 33.03 32.96 30.56
MW-56D 31.25 31.25 28.35
MW-57S 32.39 32.39 29.20
MW-58S 30.27 30.18 27.86
MW-59S 30.87 30.79 28.67
MW-60I 32.56 32.56 30.41
MW-61I 30.79 30.66 28.69
LEGEND
EXISTING CONTOUR
EXISTING SPOT ELEVATION 27x2
BENZENE ISOGRAD
MONITORING WELL ⊕ MW-59S
EATHEN BERM
MW-57S
MW-58S
MW-56D
PONDED WATER
MW-61I
SLUDGE PILE
LANDCLEARING DEBRIS PILE
MW-55D
MW-55S
MW-59S
CONSTRUCTION DEBRIS DISPOSAL AREA
JUNKED PLANE
MW-54S
MW-2S
MW-2D
MW-60I
FORMER FIRE TRAINING PIT AREA
MW-1
TRANSFORMER PAD
"M-31" SIGN
GRAVEL
TAXIWAY (ACCESS ROAD ALONG RUNWAY 10-28)
MW-53S
50 25 0 50
PLAN NUMBER 85530-1-C-9515
SCALE IN FEET
METCALF & EDDY INC.
14502 GREENVIEW DRIVE
SUITE 500
LAUREL, MARYLAND
20708
FIGURE 5-1
BENZENE
CONCENTRATIONS IN GROUNDWATER
FORMER FIRE TRAINING AREA
NASA/GODDARD SPACE FLIGHT CENTER
WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA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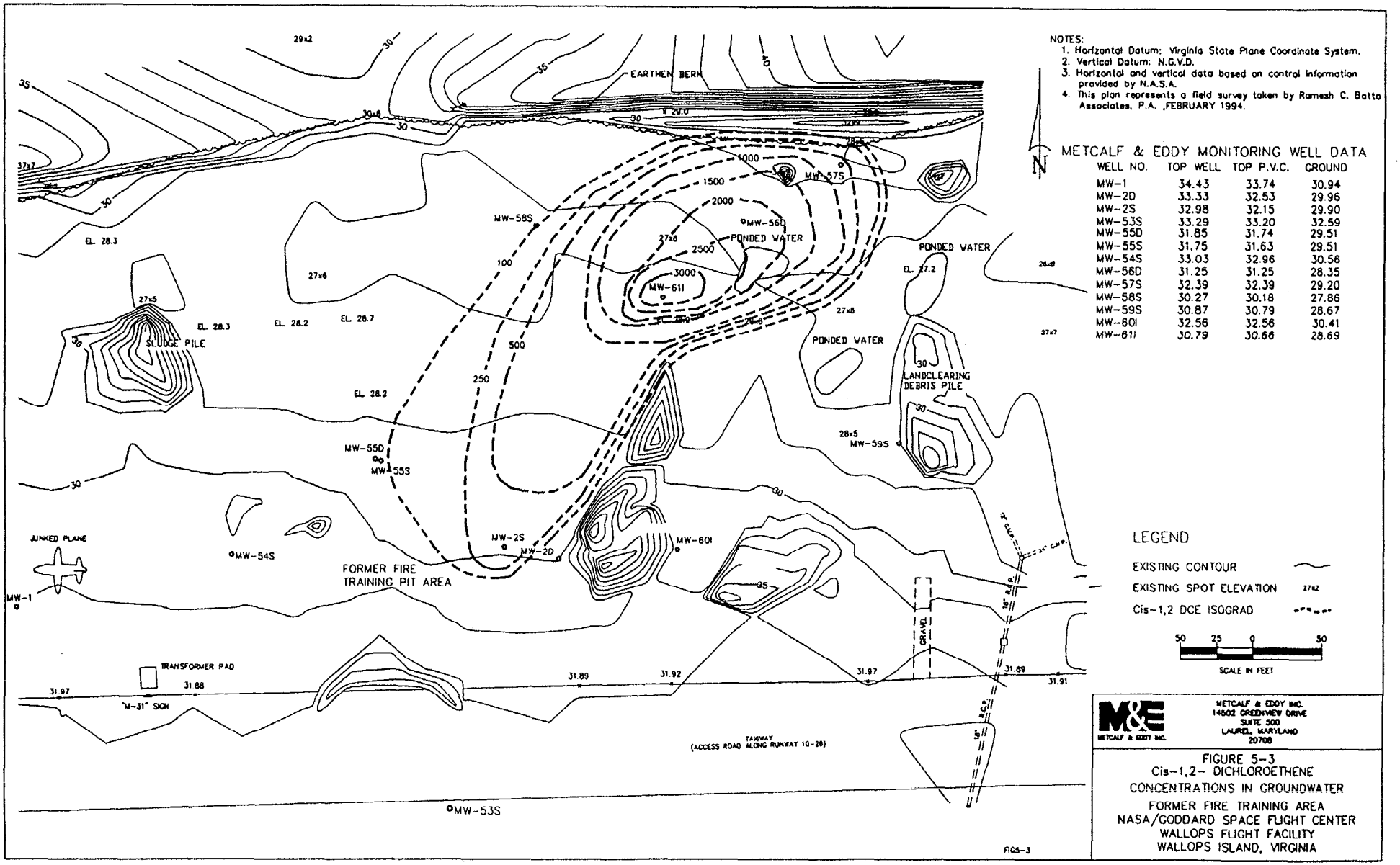
MW-57S
MW-58S
MW-56D
PONDED WATER
MW-61I
SLUDGE PILE
MW-55D
MW-55S
LANDCLEARING DEBRIS PILE
MW-59S
CONSTRUCTION DEBRIS DISPOSAL AREA
MW-60I
MW-2S
MW-2D
MW-54S
JUNKED PLANE
MW-1
FORMER FIRE TRAINING PIT AREA
TRANSFORMER PAD
"M-31" SIGN
TAXIWAY (ACCESS ROAD ALONG RUNWAY 10-28)
MW-53S
GRAVEL
LEGEND
EXISTING CONTOUR
EXISTING SPOT ELEVATION
TOLUENE ISOGRAD
MONITORING WELL
50 25 0 50
PLAN NUMBER 85530-1-C-9515
SCALE IN FEET
METCALF & EDDY INC.
14502 GREENVIEW DRIVE
SUITE 500
LAUREL, MARYLAND
20708
FIGURE 5-2
TOLUENE
CONCENTRATIONS IN GROUNDWATER
FORMER FIRE TRAINING AREA
NASA/GODDARD SPACE FLIGHT CENTER
WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA


NOTES:
1. Horizontal Datum: Virginia State Plane Coordinate System.
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N
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WELL NO. TOP WELL TOP P.V.C. GROUND
MW-1 34.43 33.74 30.94
MW-2D 33.33 32.53 29.96
MW-2S 32.98 32.15 29.90
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EARTHEN BERM
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MW-2S
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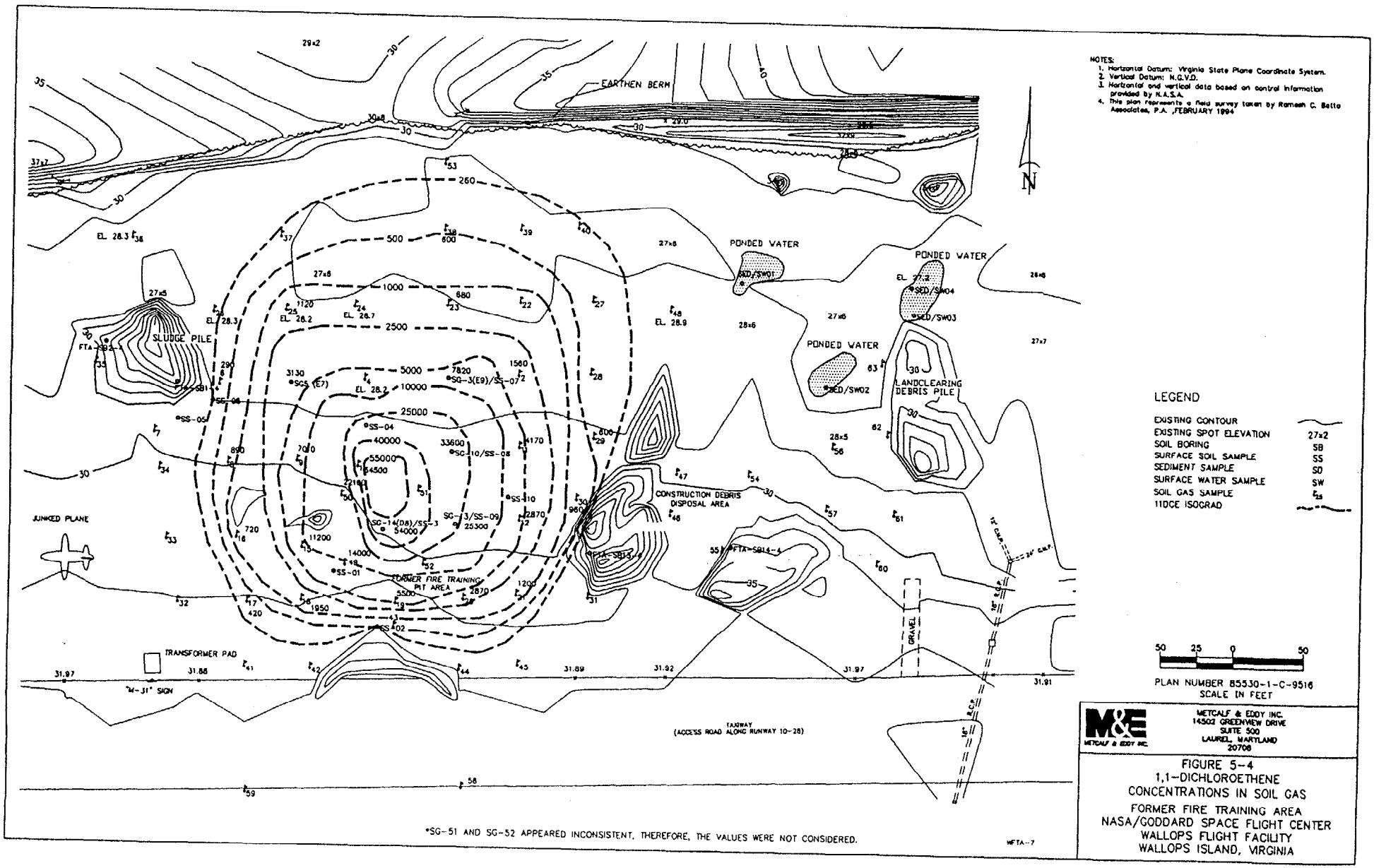
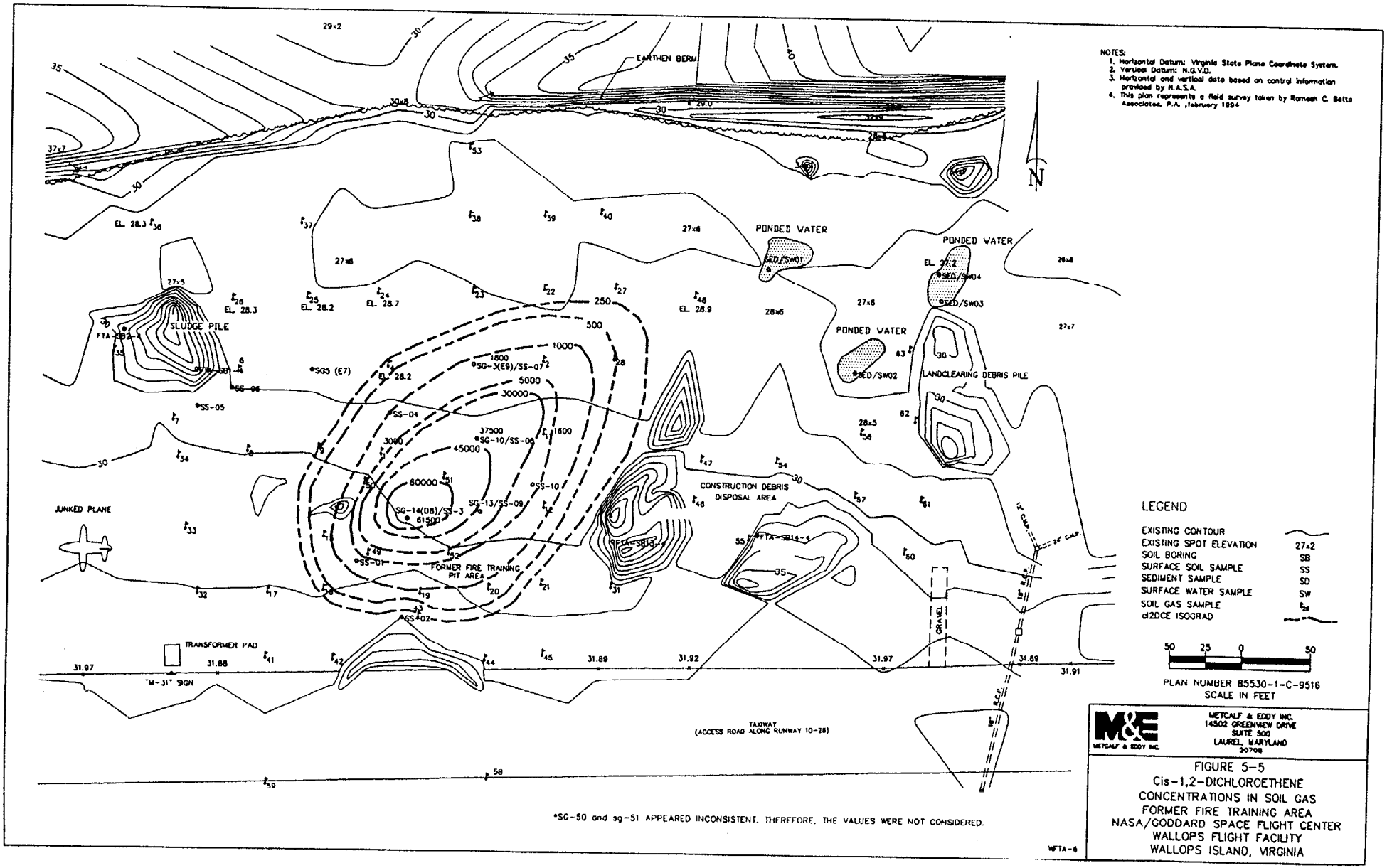
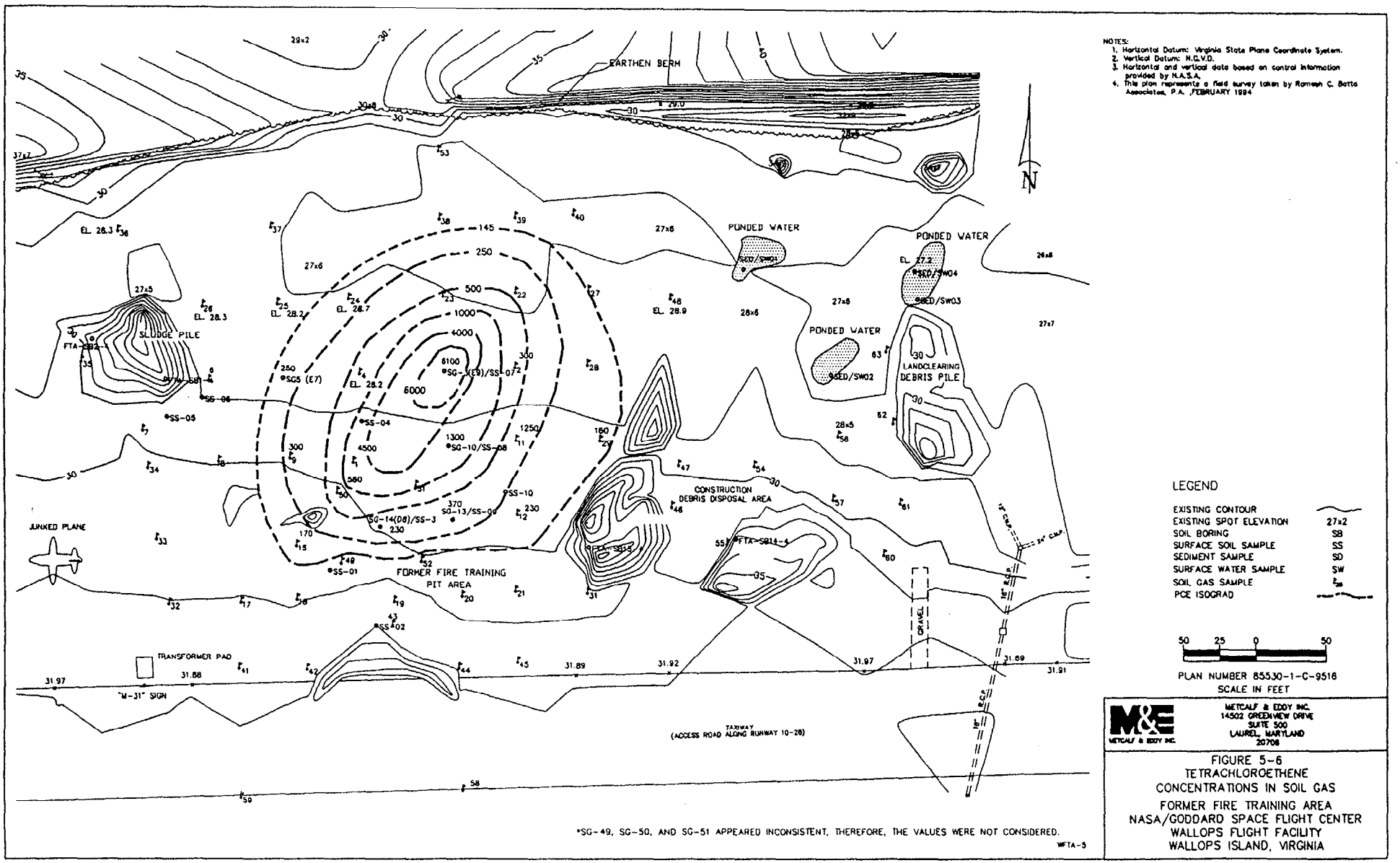
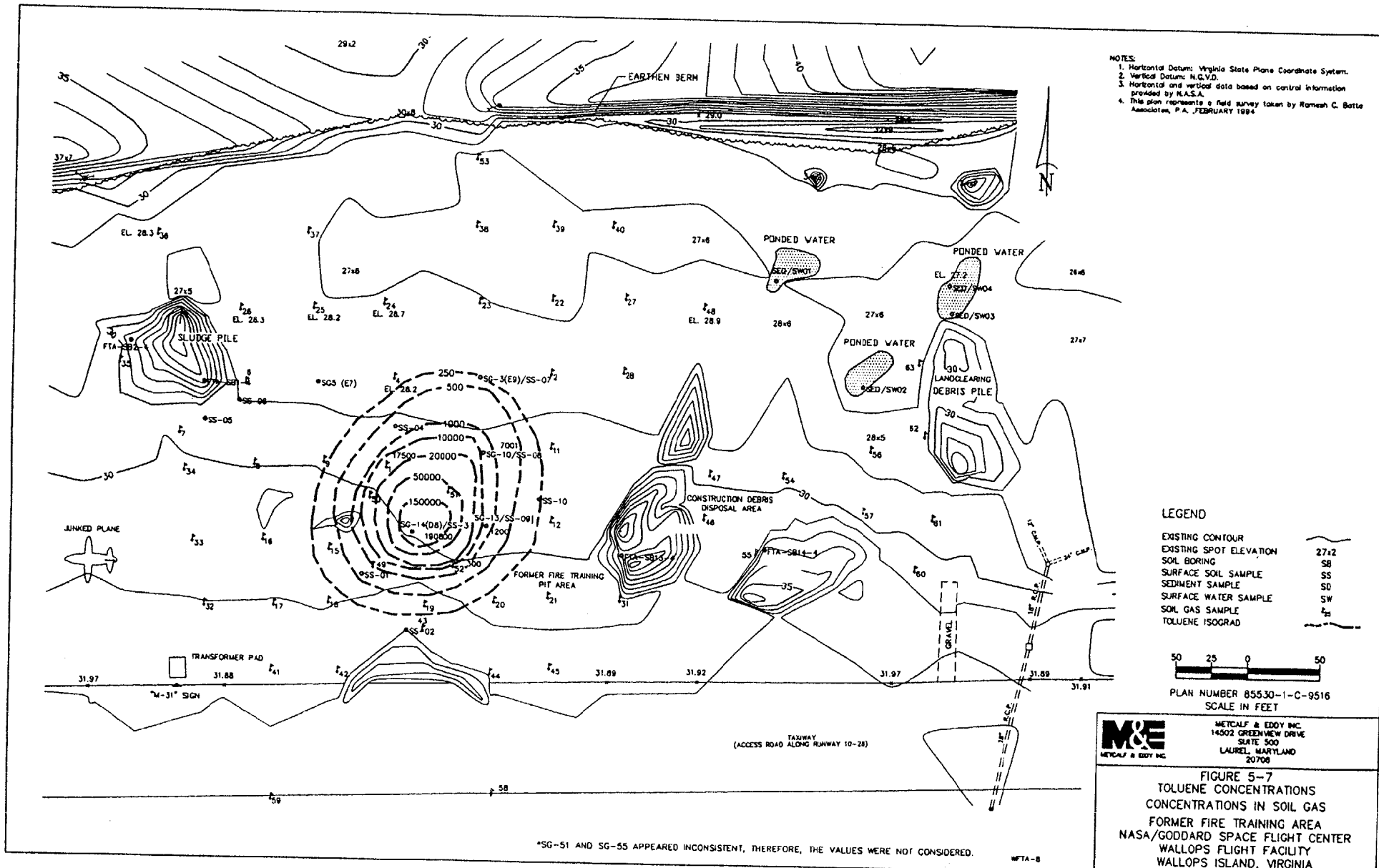
TRANSFORMER PAD
"M-31" SIGN
TAXIWAY (ACCESS ROAD) ALONG RUNWAY 10-28)
MW-53S
GRAVEL
EL. 28.3
EL. 28.2
EL. 28.7
EL. 27.2
LEGEND
EXISTING CONTOUR
EXISTING SPOT ELEVATION
Cis-1,2 DCE ISOGRAD
50 25 0 50
SCALE IN FEET
METCALF & EDDY INC.
14502 GREENVIEW DRIVE
SUITE 500
LAUREL, MARYLAND
20708
FIGURE 5-3
Cis-1,2- DICHLOROETHENE
CONCENTRATIONS IN GROUNDWATER
FORMER FIRE TRAINING AREA
NASA/GODDARD SPACE FLIGHT CENTER
WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA
FIG5-3


NOTES:
1. Horizontal Datum: Virginia State Plane Coordinate System.
2. Vertical Datum: N.G.V.D.
3. Horizontal and vertical data based on control information provided by N.A.S.A.
4. This plan represents a field survey taken by Ramesh C. Batta Associates, P.A. ,FEBRUARY 1994
EARTHEN BERM
PONDED WATER
PONDED WATER
PONDED WATER
SLUDGE PILE
LANDCLEARING DEBRIS PILE
CONSTRUCTION DEBRIS DISPOSAL AREA
JUNKED PLANE
FORMER FIRE TRAINING PIT AREA
TRANSFORMER PAD
"M-31" SIGN
TAXIWAY (ACCESS ROAD ALONG RUNWAY 10-28)
GRAVEL
LEGEND
EXISTING CONTOUR
EXISTING SPOT ELEVATION 27x2
SOIL BORING SB
SURFACE SOIL SAMPLE SS
SEDIMENT SAMPLE SD
SURFACE WATER SAMPLE SW
SOIL GAS SAMPLE
1,1DCE ISOCRAD
50 25 0 50
PLAN NUMBER 85530-1-C-9516
SCALE IN FEET
METCALF & EDDY INC.
14502 GREENVIEW DRIVE
SUITE 500
LAUREL, MARYLAND
20708
FIGURE 5-4
1,1-DICHLOROETHENE
CONCENTRATIONS IN SOIL GAS
FORMER FIRE TRAINING AREA
NASA/GODDARD SPACE FLIGHT CENTER
WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA
*SG-51 AND SG-52 APPEARED INCONSISTENT, THEREFORE, THE VALUES WERE NOT CONSIDERED.
WFTA-7


NOTES:
1. Horizontal Datum: Virginia State Plane Coordinate System.
2. Vertical Datum: N.G.V.D.
3. Horizontal and vertical data based on control information provided by N.A.S.A.
4. This plan represents a field survey taken by Ramesh C. Batta Associates, P.A., February 1994
EARTHEN BERM
PONDED WATER
PONDED WATER
PONDED WATER
SED/SW01
SED/SW04
SED/SW03
SED/SW02
SLUDGE PILE
LANDCLEARING DEBRIS PILE
CONSTRUCTION DEBRIS DISPOSAL AREA
FORMER FIRE TRAINING PIT AREA
JUNKED PLANE
TRANSFORMER PAD
"M-31" SIGN
GRAVEL
TAXIWAY (ACCESS ROAD ALONG RUNWAY 10-28)
SG-14(D8)/SS-3
SG-13/SS-09
SG-10/SS-08
SG-3(E9)/SS-07
SG5 (E7)
SS-01
SS-02
SS-04
SS-05
SS-10
FTA-SB14-1
FTA-SB2-1
LEGEND
EXISTING CONTOUR
EXISTING SPOT ELEVATION 27x2
SOIL BORING SB
SURFACE SOIL SAMPLE SS
SEDIMENT SAMPLE SD
SURFACE WATER SAMPLE SW
SOIL GAS SAMPLE
cl2DCE ISOGRAD
50 25 0 50
PLAN NUMBER 85530-1-C-9516
SCALE IN FEET
METCALF & EDDY INC.
14502 GREENVIEW DRIVE
SUITE 300
LAUREL, MARYLAND
20708
FIGURE 5-5
Cis-1,2-DICHLOROETHENE
CONCENTRATIONS IN SOIL GAS
FORMER FIRE TRAINING AREA
NASA/GODDARD SPACE FLIGHT CENTER
WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA
*SG-50 and sg-51 APPEARED INCONSISTENT. THEREFORE, THE VALUES WERE NOT CONSIDERED.
WFTA-6


NOTES:
1. Horizontal Datum: Virginia State Plane Coordinate System.
2. Vertical Datum: N.G.V.D.
3. Horizontal and vertical data based on control information provided by N.A.S.A.
4. This plan represents a field survey taken by Ramesh C. Batta Associates, P.A. ,FEBRUARY 1994
EARTHEN BERM
PONDED WATER
PONDED WATER
PONDED WATER
SLUDGE PILE
LANDCLEARING DEBRIS PILE
CONSTRUCTION DEBRIS DISPOSAL AREA
FORMER FIRE TRAINING PIT AREA
JUNKED PLANE
TRANSFORMER PAD
"M-31" SIGN
GRAVEL
TAXIWAY (ACCESS ROAD ALONG RUNWAY 10-28)
LEGEND
EXISTING CONTOUR
EXISTING SPOT ELEVATION
SOIL BORING
SURFACE SOIL SAMPLE
SEDIMENT SAMPLE
SURFACE WATER SAMPLE
SOIL GAS SAMPLE
PCE ISOGRAD
50 25 0 50
PLAN NUMBER 85530-1-C-9516
SCALE IN FEET
METCALF & EDDY INC.
14502 GREENVIEW DRIVE
SUITE 500
LAUREL, MARYLAND
20708
FIGURE 5-6
TETRACHLOROETHENE
CONCENTRATIONS IN SOIL GAS
FORMER FIRE TRAINING AREA
NASA/GODDARD SPACE FLIGHT CENTER
WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA
*SG-49, SG-50, AND SG-51 APPEARED INCONSISTENT, THEREFORE, THE VALUES WERE NOT CONSIDERED.
WFTA-5


NOTES:
1. Horizontal Datum: Virginia State Plane Coordinate System.
2. Vertical Datum: N.G.V.D.
3. Horizontal and vertical data based on control information provided by N.A.S.A.
4. This plan represents a field survey taken by Ramesh C. Batta Associates, P.A. ,FEBRUARY 1994
EARTHEN BERM
PONDED WATER
PONDED WATER
PONDED WATER
SLUDGE PILE
LANDCLEARING DEBRIS PILE
CONSTRUCTION DEBRIS DISPOSAL AREA
FORMER FIRE TRAINING PIT AREA
JUNKED PLANE
TRANSFORMER PAD
"M-31" SIGN
TAXIWAY (ACCESS ROAD ALONG RUNWAY 10-28)
GRAVEL
LEGEND
EXISTING CONTOUR
EXISTING SPOT ELEVATION
SOIL BORING
SURFACE SOIL SAMPLE
SEDIMENT SAMPLE
SURFACE WATER SAMPLE
SOIL GAS SAMPLE
TOLUENE ISOGRAD
50 25 0 50
PLAN NUMBER 85530-1-C-9516
SCALE IN FEET
METCALF & EDDY INC.
14502 GREENVIEW DRIVE
SUITE 500
LAUREL, MARYLAND
20708
FIGURE 5-7
TOLUENE CONCENTRATIONS
CONCENTRATIONS IN SOIL GAS
FORMER FIRE TRAINING AREA
NASA/GODDARD SPACE FLIGHT CENTER
WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA
*SG-51 AND SG-55 APPEARED INCONSISTENT, THEREFORE, THE VALUES WERE NOT CONSIDERED.
WFTA-8

6.0 HUMAN HEALTH RISK ASSESSMENT

6.1 SUMMARY OF HUMAN HEALTH RISK ASSESSMENT PROCESS

The purpose of the human health risk assessment is to characterize current and potential threats to human health that may be posed by chemicals found at a site, and migrating or potentially migrating off-site. The characterization includes identification of site-related chemicals of concern, an estimate of the magnitude of potential impact of those chemicals to human health, both current and future, and a comparison of that magnitude to U.S. EPA target, or acceptable, risk levels.

The approach for this human health risk assessment generally follows U.S. EPA guidance in the "Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors" (U.S. EPA, 1991a). The EPA document "Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual" (U.S. EPA, 1989c), also referred to as RAGS I, provides the basis for completing human health risk assessments as part of the RI/FS process at sites regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

U.S. EPA Region III guidance, including the document " Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening" (U.S. EPA, 1993), provides the basis for the initial data screening to focus the risk assessment on the chemicals of concern which contribute significantly to overall site risk. Additional guidance on dose estimation for the dermal exposure route received from EPA Region III is incorporated into the exposure assessment.

6.2 IDENTIFICATION OF CHEMICALS OF POTENTIAL CONCERN

The risk assessment process incorporates site-specific environmental, physical, and demographic data into numerical estimates of risk. Environmental data are screened, using comparison to risk-based concentrations, comparison to background concentrations, frequency of detection in on-site media, designation as an essential nutrient, and blank contamination, to focus the risk assessment on the chemicals expected to constitute the largest portion of risk at the site.

6.2.1 Data Summary

6.2.1.1 Data Collected by Medium

The validated results of analyses of the samples collected during the 1993 and 1994 field investigation are presented by medium in Tables 4-1 through 4-5. Only chemicals with at least one detection in at least one medium are included in the data summary tables. Non-validated data collected during a 1990 site investigation are presented by medium in Tables 4-6 and 4-7. The non-validated data are not used in the human health risk evaluation.

The detection of a chemical, as presented in the summary tables, is not always indicative of or representative of contamination from past operations at the former FTA. The elements of the screening process, including comparison to background and blank contamination validation, aid in the identification of site-related contamination.

The analyses of the samples were completed in accordance with the Data Quality Objectives (DQO) established in Section 4.5 of the Final Work Plan (NASA, 1993). CLP procedures and documentation were provided by the subcontracted laboratory. The groundwater samples collected were analyzed using the Superfund Analytical Method for low concentration volatile organics (EPA, 1992b) to ensure that the detection levels were less than or equal to drinking water standards. Samples from each medium investigated were analyzed for TCL volatiles, semi-volatiles, pesticides, and PCBs; and TAL metals and cyanide.

6.2.1.2 Data Validation

Data validation was completed in accordance with EPA procedures and guidelines. Based on the QA/QC data provided by the laboratory and from field evaluations, the data are considered acceptable, estimated, or rejected. The validated analytical results for chemicals detected are presented by medium in Tables 4-1 through 4-5.

6.2.2 Site-Specific Data Evaluation

In evaluating data collected during the RI, the site is treated as one unit. The training pit area, the sludge pile, construction debris disposal area, and the former drum storage area, are treated as one investigative unit for the purposes of assessing overall site risk. The relative contribution of any contamination detected in each of these areas is then evaluated separately.

For screening purposes, the maximum concentration detected in duplicate samples is used in the data evaluation process. The duplicate results are treated as one sample in evaluating the frequency of occurrence of chemicals detected at the site.

6.2.2.1 Screening Methodology

The data presented in the summary tables represent the contamination of environmental media at the former FTA. Screening of the data allows the risk assessment to be focused on the dominant contaminants and primary exposure routes.

An EPA Region III Technical Guidance Manual for risk assessment provides the basis for the screening methodology. The document, "Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening" (U.S. EPA, 1994g), details the use of an absolute comparison of risk-based concentrations to maximum detected site concentrations for selection of the contaminants of concern (Appendix B).

The guidance document provides a table of risk-based concentrations, by media, which correspond to a systemic hazard quotient of 1.0 or a lifetime cancer risk of 10^{-6}. The maximum concentration of each substance in each medium is compared to the risk-based concentrations for that medium included in the risk-based concentration table that is updated quarterly (Appendix C). Contaminants in each medium with a maximum detected concentration greater than the risk-based concentration are retained in the risk assessment for all exposure routes involving that medium. All other contaminants for that medium are dropped from further evaluation.

If a contaminant concentration does not exceed the risk-based concentration for any medium, the contaminant is dropped from the risk assessment. If no contaminant in a specific medium exceeds its risk-

based concentration, the medium is dropped from the risk assessment.

The chemicals of concern for each medium which remain in the risk assessment following the risk-based screen are further screened on the basis of comparison to background, frequency of detection, levels of compounds detected in laboratory blanks, and essential human nutrients.

For comparison of soil and sediment data, the risk-based concentrations for residential soil exposure are used for initial screening. These concentrations are more conservative than those calculated for industrial soil exposure.

For surface water and groundwater, the tap water values are used as a screening tool for comparison of site-specific data to risk-based concentrations. The risk-based concentrations presented in the U.S. EPA guidance for residential water use include a volatilization term for volatile organic compounds (VOCs) to address inhalation as well as ingestion exposure routes.

6.2.2.2 Comparison to Background

The maximum levels of inorganic chemicals detected in each medium at the former FTA and downgradient are compared to background levels at upgradient locations. Chemicals detected at maximum levels less than twice the average upgradient levels are screened out. Use of this screening criteria allows for natural variations of inorganics in soils and ground and surface waters.

Groundwater. Monitoring wells MW-34S and MW-53S are hydraulically upgradient of the former FTA. In addition, monitoring well MW-01D is cross-gradient to the former FTA and is also used as a background well.

Subsurface Soils. Soil boring SB-12 (completed as monitoring well MW-53S) is upgradient of the former FTA. Soil boring samples SB-12-1, SB-12-2, and SB-12-3, collected at depth intervals of five to seven, 10 to 12, and 15 to 17 feet, respectively, serve as background samples for comparisons. In addition, background data collected as part of other site investigation activities throughout the WFF Main Base are used for comparison purposes. Background data and a location map indicating sample collection sites are presented in Table 4-9 and Figure 4-2.

Surface Soils. Analytical results from shallow surface soil samples collected during previous site investigation activities at the WFF Main Base are used for a background comparison of inorganic surface soil results in the former FTA and downgradient. Background data are presented in Table 4-8 and Figure 4-1.

Sediment. Since no direct connection to surface waters is evident at the former FTA, the sediment samples were collected on-site from ponded areas that are intermittent in nature. The screening of sediment samples uses a comparison to background surface soil data (Table 4-8) since these data are most representative of background conditions.

Surface Water. As stated above, no direct connection to surface waters is evident at the former FTA. The surface water samples were collected from intermittent ponded areas located downgradient of the former FTA. No background sampling locations were available in the immediate area. The surface water inorganics data from this investigation are therefore compared to analytical results for a sample collected from Jenneys Gut as part of a previous investigation. These data are summarized in Table 4-10.

6.2.2.3 Detection Frequency

Chemicals detected in fewer than two samples in a given medium or at a detection frequency of five percent or less, and detected at estimated levels in other media, are screened out of the risk assessment on the basis of detection frequency. Duplicate samples are not treated as individual samples in this screening.

6.2.2.4 Blank Contamination

Chemicals which are common laboratory contaminants and detected in at least one laboratory blank sample in each medium are eliminated from further consideration. This comparison is based on the results of data validation using U.S. EPA functional guidelines. Methylene chloride, a common laboratory contaminant, is retained for consideration in groundwater since the levels detected are up to 100 times greater than the reported blank contamination level.

6.2.2.5 Essential Nutrient

A number of metals are considered common elements and essential human nutrients. These nutrients are generally not toxic except at very high doses, and are therefore eliminated from the risk assessment process. Site-specific chemicals eliminated from all media as essential nutrients are calcium, iron, magnesium, potassium, and sodium. Other inorganics may be essential nutrients, but are much more dose-sensitive. These elements are not screened out on the basis of essential nutrient criteria.

6.2.3 Summary of Chemicals of Potential Concern

The results of the screening process and the rationale for elimination of chemicals from further consideration in the human health risk assessment are presented in Tables 6-1 through 6-5. The initial basis for the screening, as described above, is an absolute comparison of risk, in which the maximum site concentrations are compared to EPA Region III risk-based concentrations. The application of additional screening factors (background levels, frequency of detection, blank contamination, and essential nutrient considerations) completes the screening process. Table 6-6 summarizes the chemicals of concern by medium. A discussion of the chemicals retained in the human health assessment follows below.

Groundwater. Chemicals detected in groundwater and retained in the human health risk assessment include 1,1-dichloroethene, cis-1,2-dichloroethene, methylene chloride, chloroform, benzene, tetrachloroethene, toluene, trimethylbenzene, tetramethylbenzene, phenanthrene, 2-methylnaphthalene, naphthalene, alpha-BHC, heptachlor epoxide, gamma-chlordane, arsenic, and lead. The bases for elimination of all other chemicals detected in groundwater are presented in Table 6-1.

Surface Water. Lead and arsenic were detected in ponded surface water at the site and retained in the risk assessment. The bases for elimination of other detected chemicals are presented in Table 6-2.

Sediment. Phenanthrene, benzo(b)fluoranthene, benzo(a)pyrene, dibenz(a,h)anthracene, benzo(g,h,i)perylene, arsenic, and lead are the chemicals detected in sediment and retained in the human health risk assessment. The bases for elimination of other detected chemicals are presented in Table 6-3.

TABLE 6-1
SUMMARY OF GROUNDWATER DATA SCREENING

SUBSTANCE	MAX. CONC. DETECTED (µg/l)	RISK-BASED CONC.* (µg/l)	MAX CONC GREATER THAN RISK-BASED?	CARRY THROUGH SCREEN PROCESS?	FREQ. DETECTED	ESSENTIAL NUTRIENT?	MAX. BACK-GROUND (µg/l)	LESS THAN 2X BACK-GROUND?	FOUND IN BLANK?	RETAIN IN RISK ASSESS-MENT?	REASON ELIMINATED
Acetone	3,600	3,700	NO	NO	-----	NO	-----	-----	NO	NO	R
1,1-Dichloroethane	57	810	NO	NO	-----	-----	-----	-----	-----	NO	R
1,1-Dichloroethene	18	0.044	YES	YES	2/21	-----	ND	NO	NO	YES	
cis-1,2-Dichloroethene	3,000	61	YES	YES	12/21	-----	ND	NO	NO	YES	
Methylene Chloride	730	4.1	YES	YES	14/21	NO	0.9	NO	YES	YES	
Chloroform	5	0.15	YES	YES	3/21	NO	ND	NO	NO	YES	
2-Butanone	1,100	1,900	NO	NO	-----	NO	-----	-----	NO	NO	R
1,1,1-Trichloroethane	670	1,300	NO	NO	-----	NO	-----	-----	NO	NO	R
Benzene	120	0.36	YES	YES	3/21	-----	ND	NO	NO	YES	
Tetrachloroethene	64	1.1	YES	YES	7/21	-----	ND	NO	NO	YES	
Toluene	1,800	750	YES	YES	2/21	NO	ND	NO	NO	YES	
Ethylbenzene	600	1,300	NO	NO	-----	NO	-----	-----	NO	NO	R
Total Xylenes	1,600	12,000	NO	NO	-----	NO	-----	-----	NO	NO	R
Ethylmethylbenzene	330	1300 [a]	NO	NO	2/21	NO	-----	-----	NO	NO	R
Trimethylbenzene	700	2.4	YES	YES	3/21	NO	ND	NO	NO	YES	
Tetramethylbenzene	36	2.4 [b]	YES	YES	2/21	NO	ND	NO	NO	YES	
Alkyl Benzene	52	2.4 [b]	YES	YES	1/21	NO	-----	-----	NO	NO	F
Trichlorofluoromethane	4	1,300	NO	NO	-----	-----	-----	-----	-----	NO	R
Phenanthrene	82	0.0092 [c]	YES	YES	1/17	NO	ND	NO	NO	YES	
4-Methylphenol	5	180	NO	NO	-----	-----	-----	-----	-----	NO	R
Diethylphthalate	2	29,000	NO	NO	-----	-----	-----	-----	-----	NO	R
Fluorene	75	1,500	NO	NO	-----	-----	-----	-----	-----	NO	R
2-Methylnaphthalene	3,000	1,500 [d]	YES	YES	4/17	NO	ND	NO	NO	YES	
Naphthalene	2,000	1,500	YES	YES	4/17	NO	ND	NO	NO	YES	
Bis(2-ethylhexyl)phthalate	87	4.8	YES	YES	17/17	NO	2	NO	YES	NO	B
alpha-BHC	0.049	0.011	YES	YES	2/17	NO	ND	NO	NO	YES	
delta-BHC	0.018	0.037	NO	NO	-----	NO	-----	-----	NO	NO	R
gamma-BHC (Lindane)	0.014	0.052	NO	NO	-----	-----	-----	-----	-----	NO	R
Aldrin	0.081	0.004	YES	YES	1/17	NO	-----	-----	NO	NO	F
Heptachlor epoxide	0.016	0.0012	YES	YES	3/17	NO	ND	NO	NO	YES	

* Values presented are for tap water.
For screening purposes, these values represent the most conservative screening criteria. The values were obtained from "Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening," EPA Region III Technical Guidance Manual - Risk Assessment (November 1994).

KEY:
E=Essential Nutrient
R=Absolute Risk
F=Detection Frequency
B=Blank Contamination
BG=Background
ND=Not Detected In Background
----- = Not considered

NOTES:
[a] Risk-based concentration for ethylbenzene
[b] Risk-based concentration for trimethylbenzene
[c] Risk-based concentration for benzo(a)pyrene
[d] Risk-based concentration for naphthalene

TABLE 6-1, cont
SUMMARY OF GROUNDWATER DATA SCREENING

SUBSTANCE	MAX. CONC. DETECTED (µg/l)	RISK-BASED CONC.* (µg/l)	MAX CONC GREATER THAN RISK-BASED?	CARRY THROUGH SCREEN PROCESS?	FREQ. DETECTED	ESSENTIAL NUTRIENT?	MAX. BACK-GROUND (µg/l)	LESS THAN 2X BACK-GROUND?	FOUND IN BLANK?	RETAIN IN RISK ASSESS-MENT?	REASON ELIMINATED
Endosulfan I	0.029	220	NO	NO	-----	-----	-----	-----	-----	NO	R
4,4'-DDE	0.0023	0.2	NO	NO	-----	-----	-----	-----	-----	NO	R
Endrin	0.060	11	NO	NO	-----	-----	-----	-----	-----	NO	R
Endosulfan II	0.099	220	NO	NO	-----	-----	-----	-----	-----	NO	R
Endosulfan sulfate	0.046	220	NO	NO	-----	-----	-----	-----	NO	NO	R
4,4'-DDT	0.023	0.2	NO	NO	-----	-----	-----	-----	NO	NO	R
Methoxychlor	0.058	180	NO	NO	-----	-----	-----	-----	-----	NO	R
Endrin ketone	0.018	11 [•]	NO	NO	2/17	NO	-----	-----	NO	NO	R
Endrin aldehyde	0.085	11 [•]	NO	NO	1/17	NO	-----	-----	NO	NO	R
alpha-Chlordane	0.0095	0.052	NO	NO	1/17	NO	-----	-----	NO	NO	R
gamma-Chlordane	0.055	0.052	YES	**YES**	3/17	NO	ND	NO	NO	**YES**	
Aluminum	1,200	37,000	NO	NO	-----	-----	-----	-----	-----	NO	R
Arsenic	11.1	0.038	YES	**YES**	3/14	NO	ND	NO	NO	**YES**	
Barium	56.4	2,600	NO	NO	-----	-----	-----	-----	-----	NO	R
Calcium	35,900	NOT AVAIL.		**YES**	14/14	YES	-----	-----	NO	NO	E
Cobalt	17	2,200	NO	NO	3/14	NO	14.4	YES	NO	NO	BG
Iron	42,600	NOT AVAIL.		**YES**	9/14	YES	-----	-----	NO	NO	E
Lead	10.5	0.0037	YES	**YES**	5/14	NO	ND	NO	NO	**YES**	
Magnesium	14,200	NOT AVAIL.		**YES**	14/14	YES	-----	-----	NO	NO	E
Manganese	3,550	180	YES	**YES**	12/14	NO	3080	YES	NO	NO	BG
Potassium	6,310	NOT AVAIL.		**YES**	2/14	YES	-----	-----	NO	NO	E
Sodium	11,800	NOT AVAIL.		**YES**	14/14	YES	-----	-----	NO	NO	E
Zinc	377	11,000	NO	NO	-----	-----	-----	-----	-----	NO	R

* Values presented are for tap water.
For screening purposes, these values represent the most conservative screening criteria. The values were obtained from "Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening," EPA Region III Technical Guidance Manual - Risk Assessment (November 1994).

KEY:
E=Essential Nutrient
R=Absolute Risk
F=Detection Frequency
B=Blank Contamination
BG=Background
ND=Not Detected In Background
----- = Not considered

NOTES:
[•] Risk-based concentration for endrin

TABLE 6-2
SUMMARY OF SURFACE WATER DATA SCREENING

SUBSTANCE	MAX CONC. DETECTED (µg/l)	RISK-BASED CONC.* (µg/l)	MAX CONC GREATER THAN RISK-BASED?	CARRY THROUGH SCREEN PROCESS?	FREQ. DETECTED	ESSENTIAL NUTRIENT?	MAX. BACK-GROUND (µg/l)	LESS THAN 2X BACK-GROUND?	FOUND IN BLANK?	RETAIN IN RISK ASSESS-MENT?	REASON ELIMINATED
Methylene Chloride	6	4.1	YES	YES	2/4	NO	ND	NO	YES	NO	B
Toluene	1	750	NO	NO	-----	-----	-----	-----	-----	NO	R
Bis(2-ethylhexyl)phthalate	3	4.8	NO	NO	-----	-----	-----	-----	-----	NO	R
Heptachlor	0.0016	0.0023	NO	NO	-----	-----	-----	-----	-----	NO	R
4,4'-DDE	0.0065	0.2	NO	NO	-----	-----	-----	-----	-----	NO	R
4,4'-DDT	0.0056	0.2	NO	NO	-----	-----	-----	-----	-----	NO	R
gamma-Chlordane	0.0020	0.052	NO	NO	-----	-----	-----	-----	-----	NO	R
Aluminum	5,450	37,000	NO	NO	-----	-----	-----	-----	-----	NO	R
Arsenic	5.3	0.038	YES	YES	1/4	NO	<100	NO	NO	YES	
Barium	25.6	2,600	NO	NO	-----	-----	-----	-----	-----	NO	R
Calcium	5,800	NOT AVAIL.		YES	4/4	YES	-----	-----	NO	NO	E
Copper	6.9	1,400	NO	NO	-----	-----	-----	-----	-----	NO	R
Iron	2,730	NOT AVAIL.		YES	-----	YES	-----	-----	NO	NO	E
Lead	7	0.0037	YES	YES	2/4	NO	<50	NO	NO	YES	
Magnesium	1,150	NOT AVAIL.		YES	4/4	YES	-----	-----	NO	NO	E
Manganese	27.8	180	NO	NO	-----	-----	-----	-----	-----	NO	R
Potassium	2,000	NOT AVAIL.		YES	-----	YES	-----	-----	-----	NO	E
Sodium	2,250	NOT AVAIL.		YES	4/4	YES	-----	-----	YES	NO	E,B
Vanadium	6.8	260	NO	NO	-----	-----	-----	-----	-----	NO	R
Zinc	30.5	11,000	NO	NO	-----	-----	-----	-----	-----	NO	R

* Values presented are for tap water.
For screening purposes, these values represent the most conservative screening criteria. The values were obtained from "Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening," EPA Region III Technical Guidance Manual - Risk Assessment (November 1994).

KEY:
E=Essential Nutrient
R=Absolute Risk
F=Detection Frequency
BG=Background
ND=Not Detected in Background
B=Blank Contaminant
----- = Not considered

TABLE 6-3
SUMMARY OF SEDIMENT DATA SCREENING

SUBSTANCE	MAX. CONC. DETECTED (µg/kg)	RISK-BASED CONC.* (µg/kg)	MAX CONC GREATER THAN RISK-BASED?	CARRY THROUGH SCREEN PROCESS?	FREQ. DETECTED	ESSENTIAL NUTRIENT?	MAX. BACK-GROUND (µg/kg)	LESS THAN 2X BACK-GROUND?	FOUND IN BLANK?	RETAIN IN RISK ASSESS-MENT?	REASON ELIMINATED
Acetone	7	7,800,000	NO	NO	-----	-----	-----	-----	----	NO	R
Methylene Chloride	13	85,000	NO	NO	-----	-----	-----	-----	----	NO	R
Phenanthrene	140	88 [a]	YES	**YES**	1/4	NO	ND	-----	NO	**YES**	
Di-n-butylphthalate	590	1,600,000 [c]	NO	NO	4/4	NO	-----	-----	YES	NO	R,B
Fluoranthene	980	3,100,000	NO	NO	-----	-----	-----	-----	-----	NO	R
Pyrene	680	2,300,000	NO	NO	-----	-----	-----	-----	-----	NO	R
Benzo(a)anthracene	810	880	NO	NO	-----	-----	-----	-----	-----	NO	R
Chrysene	1,200	88,000	NO	NO	-----	-----	-----	-----	-----	NO	R
Bis(2-ethylhexyl)phthalate	110	46,000	NO	NO	-----	-----	-----	-----	-----	NO	R
Benzo(b)fluoranthene	1,600	880	YES	**YES**	2/4	NO	ND	-----	NO	**YES**	
Benzo(k)fluoranthene	1,600	8,800	NO	NO	-----	-----	-----	-----	-----	NO	R
Benzo(a)pyrene	550	88	YES	**YES**	1/4	NO	ND	-----	NO	**YES**	
Indeno(1,2,3-cd)pyrene	570	880	NO	NO	-----	-----	-----	-----	----	NO	R
Dibenz(a,h)anthracene	240	88	YES	**YES**	1/4	NO	ND	-----	NO	**YES**	
Benzo(g,h,i)perylene	340	88 [a]	YES	**YES**	1/4	NO	ND	-----	NO	**YES**	
gamma-BHC (Lindane)	1.9	490	NO	NO	-----	-----	-----	-----	----	NO	R
Heptachlor	0.42	140	NO	NO	-----	-----	-----	-----	-----	NO	R
4,4'-DDE	67	1,900	NO	NO	-----	-----	-----	-----	-----	NO	R
Endrin	5.2	23,000	NO	NO	-----	-----	-----	-----	-----	NO	R
4,4'-DDD	34	2,700	NO	NO	-----	-----	-----	-----	----	NO	R
Endosulfan sulfate	5.2	470,000	NO	NO	-----	-----	-----	-----	-----	NO	R
4,4'-DDT	52	1,900	NO	NO	-----	-----	-----	-----	-----	NO	R
Methoxychlor	23	390,000	NO	NO	-----	-----	-----	-----	-----	NO	R
Endrin ketone	11	23,000 [b]	NO	NO	2/4	NO	-----	-----	NO	NO	R
Endrin aldehyde	2.1	23,000 [b]	NO	NO	1/4	NO	-----	-----	NO	NO	R
alpha-Chlordane	0.2	490	NO	NO	-----	-----	-----	-----	-----	NO	R
gamma-Chlordane	0.3	490	NO	NO	-----	-----	-----	-----	----	NO	R

* Values presented are for residential soil exposure.
For screening purposes, these values represent the most conservative screening criteria. The values were obtained from "Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening," EPA Region III Technical Guidance Manual - Risk Assessment (November 1994).

KEY:
E=Essential Nutrient
R=Absolute Risk
F=Detection Frequency
BG=Background
B=Blank Contaminant
ND=Not Detected in Background
----- =Not Considered

NOTES:
[a] Risk-based concentration for benzo(a)pyrene
[b] Risk-based concentration for endrin
[c] Risk-based concentration for di-n-octyl-phthalate
[d] Risk-based concentration for naphthalene

TABLE 6-3, cont
SUMMARY OF SEDIMENT DATA SCREENING

SUBSTANCE	MAX. CONC. DETECTED (µg/kg)	RISK-BASED CONC.* (µg/kg)	MAX CONC GREATER THAN RISK-BASED?	CARRY THROUGH SCREEN PROCESS?	FREQ. DETECTED	ESSENTIAL NUTRIENT?	MAX. BACK-GROUND (µg/kg)	LESS THAN 2X BACK-GROUND?	FOUND IN BLANK?	RETAIN IN RISK ASSESS-MENT?	REASON ELIMINATED
Aluminum	22,800,000	7,800,000	YES	YES	4/4	NO	11,005,000	YES	—	NO	BG
Arsenic	9,000	370	YES	YES	4/4	NO	ND	-----	—	YES	
Barium	85,000	5,500,000	NO	NO	-----	-----	-----	-----	—	NO	R
Beryllium	230	150	YES	YES	1/4	NO	-----	-----	YES	NO	F,B
Cadmium	1,300	39,000	NO	NO	-----	-----	-----	-----	—	NO	R
Calcium	1,390,000	NOT AVAIL.		YES	4/4	YES	-----	—	NO	NO	E
Chromium	23,200	390,000	NO	NO	-----	-----	—	-----	—	NO	R
Cobalt	7,200	4,700,000	NO	NO	-----	-----	-----	-----	—	NO	R
Copper	28,000	2,900,000	NO	NO	-----	-----	-----	-----	—	NO	R
Iron	14,100,000	NOT AVAIL.		YES	4/4	YES	-----	-----	NO	NO	E
Lead	67,500	7.8	YES	YES	-----	NO	571	NO	NO	YES	
Magnesium	1,830,000	NOT AVAIL.		YES	4/4	YES	-----	-----	NO	NO	E
Manganese	192,000	390,000	NO	NO	-----	-----	-----	-----	—	NO	R
Mercury	210	23,000	NO	NO	-----	-----	-----	-----	—	NO	R
Nickel	15,400	1,600,000	NO	NO	-----	-----	-----	-----	—	NO	R
Potassium	842,000	NOT AVAIL.		YES	2/4	YES	-----	-----	NO	NO	E
Sodium	125,000	NOT AVAIL.		YES	2/4	YES	-----	-----	YES	NO	E,B
Vanadium	38,900	550,000	NO	NO	-----	-----	-----	-----	—	NO	R
Zinc	69,400	23,000,000	NO	NO	-----	-----	-----	-----	—	NO	R

* Values presented are for residential soil exposure.
For screening purposes, these values represent the most conservative screening criteria. The values were obtained from "Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening," EPA Region III Technical Guidance Manual - Risk Assessment (November 1994).

KEY:
E=Essential Nutrient
R=Absolute Risk
F=Detection Frequency
B=Blank Contaminant
BG=Background
ND=Not Detected in Background
----- =Not Considered

NOTES:
[a] Risk-based concentration for benzo(a)pyrene
[b] Risk-based concentration for endrin
[c] Risk-based concentration for di-n-octyl-phthalate
[d] Risk-based concentration for naphthalene

TABLE 6-4
SUMMARY OF SURFACE SOIL DATA SCREENING

SUBSTANCE	MAX CONC. DETECTED (µg/kg)	RISK-BASED CONC.* (µg/kg)	MAX CONC GREATER THAN RISK-BASED?	CARRY THROUGH SCREEN PROCESS?	FREQ. DETECTED	ESSENTIAL NUTRIENT?	MAX. BACK-GROUND (µg/kg)	LESS THAN 2X BACK-GROUND?	FOUND IN BLANK?	RETAIN IN RISK ASSESS-MENT?	REASON ELIMINATED
Acetone	110	7,800,000	NO	NO	-----	NO	-----	-----	-----	NO	R
Methylene Chloride	33	85,000	NO	NO	-----	NO	-----	-----	-----	NO	R
2,4-Dinitrotoluene	1,400	160,000	NO	NO	-----	NO	-----	-----	-----	NO	R
Trichlorofluoromethane	25	23,000,000	NO	NO	-----	NO	-----	-----	-----	NO	R
4-Nitrophenol	41	4,800,000	NO	NO	-----	NO	-----	-----	-----	NO	R
Phenanthrene	71	88 [a]	NO	NO	-----	NO	-----	-----	-----	NO	R
Fluoranthene	430	3,100,000	NO	NO	-----	NO	-----	-----	-----	NO	R
Pyrene	700	2,300,000	NO	NO	-----	NO	-----	-----	-----	NO	R
Benzo(a)anthracene	150	880	NO	NO	-----	-----	-----	-----	-----	NO	R
Chrysene	130	88,000	NO	NO	-----	NO	-----	-----	-----	NO	R
Bis(2-ethylhexyl)phthalate	2,100	46,000	NO	NO	-----	NO	-----	-----	-----	NO	R
Benzo(b)fluoranthene	260	880	NO	NO	-----	NO	-----	-----	-----	NO	R
Benzo(k)fluoranthene	260	8,800	NO	NO	-----	NO	-----	-----	-----	NO	R
Benzo(a)pyrene	130	88	YES	**YES**	2/14	NO	ND	NO	NO	**YES**	
Indeno(1,2,3-od)pyrene	99	880	NO	NO	-----	NO	-----	-----	-----	NO	R
Benzo(g,h,i)perylene	91	88 [a]	YES	**YES**	1/14	NO	ND	NO	NO	**YES**	
Heptachlor	0.18	140	NO	NO	-----	NO	-----	-----	-----	NO	R
Heptachlor epoxide	0.24	70	NO	NO	-----	NO	-----	-----	-----	NO	R
4,4'-DDE	16	1,900	NO	NO	-----	NO	-----	-----	-----	NO	R
4,4'-DDD	1.1	2,700	NO	NO	-----	NO	-----	-----	-----	NO	R
Endosulfan sulfate	0.38	470,000	NO	NO	-----	NO	-----	-----	-----	NO	R
4,4'-DDT	33	1,900	NO	NO	-----	NO	-----	-----	-----	NO	R
Methoxychlor	3.9	390,000	NO	NO	-----	NO	-----	-----	-----	NO	R
Endrin ketone	1	23,000 [b]	NO	NO	-----	NO	-----	-----	-----	NO	R
Endrin aldehyde	4.4	23,000 [b]	NO	NO	-----	NO	-----	-----	-----	NO	R
alpha-Chlordane	1.8	490	NO	NO	-----	NO	-----	-----	-----	NO	R
gamma-Chlordane	3.0	490	NO	NO	-----	NO	-----	-----	-----	NO	R
Aluminum	12,600,000	7,800,000	YES	**YES**	-----	NO	11,185,000	YES	-----	NO	BG
Arsenic	6,300	370	YES	**YES**	11/14	NO	ND	NO	NO	**YES**	
Barium	41,100	5,500,000	NO	NO	-----	NO	-----	-----	-----	NO	R
Cadmium	3,400	39,000	NO	NO	-----	NO	-----	-----	-----	NO	R

* Values presented are for residential soil exposure.
For screening purposes, these values represent the most conservative screening criteria. The values were obtained from "Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening," EPA Region III Technical Guidance Manual - Risk Assessment (November 1994).

KEY:
E=Essential Nutrient
R=Absolute Risk
F=Detection Frequency
BG=Background
B=Blank Contaminant
ND=Not Detected in Background
----- =Not Considered

NOTES:
[a] Risk-based concentration for benzo(a)pyrene
[b] Risk-based concentration for endrin
[c] Risk-based concentration for di-n-octyl-phthalate
[d] Risk-based concentration for naphthalene

TABLE 6-4, cont
SUMMARY OF SURFACE SOIL DATA SCREENING

SUBSTANCE	MAX CONC. DETECTED (µg/kg)	RISK-BASED CONC.* (µg/kg)	MAX CONC GREATER THAN RISK-BASED?	CARRY THROUGH SCREEN PROCESS?	FREQ. DETECTED	ESSENTIAL NUTRIENT?	MAX. BACK-GROUND (µg/kg)	LESS THAN 2X BACK-GROUND?	FOUND IN BLANK?	RETAIN IN RISK ASSESS-MENT?	REASON ELIMINATED
Calcium	2,240,000	NOT AVAIL.		YES	11/14	YES	-----	-----	-----	NO	E
Chromium	12,300	390,000	NO	NO	-----	NO	-----	-----	-----	NO	R
Cobalt	3,200	4,700,000	NO	NO	-----	NO	-----	-----	-----	NO	R
Copper	58,100	2,900,000	NO	NO	-----	NO	-----	-----	-----	NO	R
Iron	9,040,000	NOT AVAIL.		YES	10/14	YES	-----	-----	-----	NO	E
Lead	19,600	7.8	YES	YES	14/14	NO	571	NO	NO	YES	
Magnesium	846,000	NOT AVAIL.		YES	10/14	YES	-----	-----	-----	NO	E
Manganese	139,000	390,000	NO	NO	-----	NO	-----	-----	-----	NO	R
Nickel	10,000	1,600,000	NO	NO	-----	NO	-----	-----	-----	NO	R
Potassium	541,000	NOT AVAIL.		YES	1/14	YES	-----	-----	-----	NO	E
Vanadium	19,500	550,000	NO	NO	-----	NO	-----	-----	-----	NO	R
Zinc	63,400	23,000,000	NO	NO	-----	NO	-----	-----	-----	NO	R

* Values presented are for residential soil exposure.
For screening purposes, these values represent the most conservative screening criteria. The values were obtained from "Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening," EPA Region III Technical Guidance Manual - Risk Assessment (November 1994).

KEY:
E=Essential Nutrient
R=Absolute Risk
F=Detection Frequency
BG=Background
B=Blank Contaminant
ND=Not Detected in Background
----- =Not Considered

NOTES:
[a] Risk-based concentration for benzo(a)pyrene
[b] Risk-based concentration for endrin
[c] Risk-based concentration for di-n-octyl-phthalate
[d] Risk-based concentration for naphthalene

TABLE 6-5
SUMMARY OF SUBSURFACE SOIL DATA SCREENING

SUBSTANCE	MAX. CONC. DETECTED (µg/kg)	RISK-BASED CONC.* (µg/kg)	MAX CONC GREATER THAN RISK-BASED?	CARRY THROUGH SCREEN PROCESS?	FREQ. DETECTED	ESSENTIAL NUTRIENT?	MAX. BACK-GROUND (µg/kg)	LESS THAN 2X BACK-GROUND?	FOUND IN BLANK?	RETAIN IN RISK ASSESS-MENT?	REASON ELIMINATED
Acetone	210	7,800,000	NO	NO	-----	-----	-----	-----	----	NO	R
Methylene Chloride	50	85,000	NO	NO	-----	-----	-----	-----	----	NO	R
2-Butanone	5	47,000,000	NO	NO	-----	-----	-----	-----	----	NO	R
1,1,1-Trichloroethane	3	7,000,000	NO	NO	-----	-----	-----	-----	----	NO	R
Toluene	26	16,000,000	NO	NO	-----	-----	-----	-----	----	NO	R
Ethylbenzene	10	7,800,000	NO	NO	-----	-----	-----	-----	----	NO	R
Total Xylenes	27	160,000,000	NO	NO	-----	-----	-----	-----	----	NO	R
Dimethylpentane	41	7,800,000 [e]	NO	NO	1/46	NO	-----	-----	NO	NO	F,R
Tetramethlybutane	270	7,800,000 [e]	NO	NO	1/46	NO	-----	-----	NO	NO	F,R
Dimethylhexane	100	4,700,000 [f]	NO	NO	1/46	NO	-----	-----	NO	NO	F,R
Trimethlypentane	95	7,800,000 [e]	NO	NO	1/46	NO	-----	-----	NO	NO	F,R
Nonane	51	7,800,000 [e]	NO	NO	1/46	NO	-----	-----	NO	NO	F,R
Ethylmethylbenzene	33	7,800,000 [e]	NO	NO	1/46	NO	-----	-----	NO	NO	F,R
Trimethylbenzene	32	31,000,000	NO	NO	1/46	NO	-----	-----	NO	NO	F,R
2-Methylnaphthalene	5,800	3,100,000 [d]	NO	NO	1/46	NO	-----	-----	NO	NO	F,R
Phenanthrene	610	88 [a]	YES	**YES**	2/46	NO	ND	NO	NO	**YES**	
Anthracene	120	23,000,000	NO	NO	-----	-----	-----	-----	----	NO	R
Di-n-butylphthalate	5,300	7,800,000	NO	NO	-----	-----	-----	-----	----	NO	R
Fluoranthene	6,900	3,100,000	NO	NO	-----	-----	-----	-----	----	NO	R
Pyrene	7,800	2,300,000	NO	NO	-----	-----	-----	-----	----	NO	R
Butylbenzlphthalate	220	16,000,000	NO	NO	-----	-----	-----	-----	----	NO	R
Benzo(a)anthracene	6,200	880	YES	**YES**	2/46	NO	ND	NO	NO	**YES**	
Chrysene	5,100	88,000	NO	NO	-----	-----	-----	-----	----	NO	R
Bis(2-ethylhexyl)phthalate	1,300	46,000	NO	NO	-----	-----	-----	-----	----	NO	R
Di-n-octylphthalate	100	1,600,000	NO	NO	-----	-----	-----	-----	----	NO	R
Benzo(b)fluoranthene	6,900	880	YES	**YES**	3/46	NO	ND	NO	NO	**YES**	
Benzo(k)fluoranthene	6,900	8,800	NO	NO	-----	-----	-----	-----	----	NO	R

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KEY:
E=Essential Nutrient
R=Absolute Risk
F=Detection Frequency
BG=Background
B=Blank Contaminant
ND=Not Detected in Background
----- =Not Considered

NOTES:
[a] Risk-based concentration for benzo(a)pyrene
[b] Risk-based concentration for endrin
[c] Risk-based concentration for di-n-octyl-phthalate
[d] Risk-based concentration for naphthalene
[e] Risk-based concentration for ethylbenzene.
[f] Risk-based concentration for n-hexane

TABLE 6-5 cont
SUMMARY OF SUBSURFACE SOIL DATA SCREENING

SUBSTANCE	MAX. CONC. DETECTED (µg/kg)	RISK-BASED CONC.* (µg/kg)	MAX CONC GREATER THAN RISK-BASED?	CARRY THROUGH SCREEN PROCESS?	FREQ. DETECTED	ESSENTIAL NUTRIENT?	MAX. BACK-GROUND (µg/kg)	LESS THAN 2X BACK-GROUND?	FOUND IN BLANK?	RETAIN IN RISK ASSESS-MENT?	REASON ELIMINATED
Benzo(a)pyrene	3,300	88	YES	YES	2/46	NO	ND	NO	NO	YES	
Indeno(1,2,3-cd)pyrene	2,300	880	YES	YES	1/46	NO	-----	-----	NO	NO	F
Dibenz(a,h)anthracene	630	88	YES	YES	1/46	NO	-----	-----	NO	NO	F
Benzo(g,h,i)perylene	2,300	88 [a]	YES	YES	1/46	NO	-----	-----	NO	NO	F
alpha-BHC	0.24	100	NO	NO	-----	-----	-----	-----	-----	NO	R
delta-BHC	1.3	350	NO	NO	-----	-----	-----	-----	-----	NO	R
gamma-BHC (Lindane)	1	490	NO	NO	-----	-----	-----	-----	-----	NO	R
Heptachlor	0.27	140	NO	NO	-----	-----	-----	-----	-----	NO	R
Aldrin	0.11	38	NO	NO	-----	-----	-----	-----	-----	NO	R
Heptachlor epoxide	0.82	70	NO	NO	-----	-----	-----	-----	-----	NO	R
4,4'-DDE	59	1,900	NO	NO	-----	-----	-----	-----	-----	NO	R
4,4'-DDD	160	2,700	NO	NO	-----	-----	-----	-----	-----	NO	R
Endrin	2.9	23,000	NO	NO	-----	-----	-----	-----	-----	NO	R
4,4'-DDT	210	1,900	NO	NO	-----	-----	-----	-----	-----	NO	R
Methoxychlor	2.5	390,000	NO	NO	-----	-----	-----	-----	-----	NO	R
Endrin ketone	0.72	23,000 [b]	NO	NO	-----	-----	-----	-----	-----	NO	R
Toxaphene	10	580	NO	NO	-----	-----	-----	-----	-----	NO	R
beta-BHC	1.1	350	NO	NO	-----	-----	-----	-----	-----	NO	R
Endrin aldehyde	4.0	23,000 [b]	NO	NO	1/46	NO	-----	-----	NO	NO	F
alpha-Chlordane	7.5	490	NO	NO	-----	-----	-----	-----	-----	NO	R
gamma-Chlordane	6.3	490	NO	NO	-----	-----	-----	-----	-----	NO	R
Aroclor 1260	460	83	YES	YES	1/46	-----	-----	-----	NO	NO	F
Aluminum	27,600,000	7,800,000	YES	YES	46/46	NO	19,000,000	YES	NO	NO	BG
Arsenic	8,400	370	YES	YES	40/46	-----	1,100	NO	YES	YES	
Barium	67,800	5,500,000	NO	NO	-----	-----	-----	-----	-----	NO	R
Calcium	1,520,000	NOT AVAIL.		YES	-----	YES	-----	-----	-----	NO	E
Chromium	48,300	390,000	NO	NO	-----	-----	-----	-----	-----	NO	R

* Values presented are for residential soil exposure. For screening purposes, these values represent the most conservative screening criteria. The values were obtained from "Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening," EPA Region III Technical Guidance Manual - Risk Assessment (November 1994).

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NOTES:
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[b] Risk-based concentration for endrin
[c] Risk-based concentration for di-n-octyl-phthalate
[d] Risk-based concentration for naphthalene
[e] Risk-based concentration for ethylbenzene.
[f] Risk-based concentration for n-hexane

TABLE 6-5 cont
SUMMARY OF SUBSURFACE SOIL DATA SCREENING

SUBSTANCE	MAX. CONC. DETECTED (µg/kg)	RISK-BASED CONC.* (µg/kg)	MAX CONC GREATER THAN RISK-BASED?	CARRY THROUGH SCREEN PROCESS?	FREQ. DETECTED	ESSENTIAL NUTRIENT?	MAX. BACK-GROUND (µg/kg)	LESS THAN 2X BACK-GROUND?	FOUND IN BLANK?	RETAIN IN RISK ASSESS-MENT?	REASON ELIMINATED
Cobalt	6,000	4,700,000	NO	NO	-----	-----	-----	-----	-----	NO	R
Copper	10,100	2,900,000	NO	NO	-----	-----	-----	-----	-----	NO	R
Iron	33,900,000	NOT AVAIL.		**YES**	-----	YES	-----	-----	-----	NO	E
Lead	12,200	7.8	YES	**YES**	42/46	NO	1,900	NO	NO	**YES**	
Magnesium	1,680,000	NOT AVAIL.		**YES**	-----	YES	-----	-----	-----	NO	E
Manganese	297,000	390,000	NO	NO	-----	NO	-----	-----	-----	NO	R
Mercury	150	23,000	NO	NO	-----	-----	-----	-----	-----	NO	R
Nickel	16,400	1,600,000	NO	NO	-----	-----	-----	-----	-----	NO	R
Potassium	2,490,000	NOT AVAIL.		**YES**	-----	YES	-----	-----	-----	NO	E
Silver	1,700	390,000	NO	NO	-----	-----	-----	-----	-----	NO	R
Sodium	192,000	NOT AVAIL.		**YES**	-----	YES	-----	-----	-----	NO	E
Vanadium	27,200	550,000	NO	NO	-----	-----	-----	-----	-----	NO	R
Zinc	28,700	23,000,000	NO	NO	-----	-----	-----	-----	-----	NO	R

* Values presented are for residential soil exposure.
For screening purposes, these values represent the most conservative screening criteria. The values were obtained from "Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening," EPA Region III Technical Guidance Manual - Risk Assessment (November 1994).

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NOTES:
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[b] Risk-based concentration for endrin
[c] Risk-based concentration for di-n-octyl-phthalate
[d] Risk-based concentration for naphthalene
[e] Risk-based concentration for ethylbenzene.
[f] Risk-based concentration for n-hexane

TABLE 6-6. SUMMARY OF CHEMICALS OF CONCERN

Chemical of Concern	Ground-water	Surface Water	Sediment	Surface Soil	Subsurface Soil
1,1-Dichloroethene	X				
cis-1,2 Dichloroethene	X				
Methylene Chloride	X				
Chloroform	X				
Benzene	X				
Tetrachloroethene	X				
Toluene	X				
Trimethylbenzene	X				
Tetramethylbenzene	X				
2-Methylnaphthalene	X				
Naphthalene	X				
Phenanthrene	X		X		X
Benzo(a)anthracene					X
Benzo(a)pyrene			X	X	X
Benzo(b)fluoranthene			X		X
Dibenz(a,h)anthracene			X		
Benzo(g,h,i)perylene			X	X	
alpha-BHC	X				
Heptachlor epoxide	X				
gamma-Chlordane	X				
Arsenic	X	X	X	X	X
Lead	X	X	X	X	X

Surface Soil. Chemicals detected in surface soil and retained in the risk assessment include benzo(a)pyrene, benzo(g,h,i)perylene, arsenic, and lead. The bases for elimination of all other detected chemicals are presented in Table 6-4.

Subsurface Soil. Six chemicals detected in subsurface soil are retained in the human health risk assessment. The retained chemicals are phenanthrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(a)pyrene, and lead. The screening process rationale for elimination of all other detected chemicals is presented in Table 6-5.

In general, these chemicals were detected in on-site media and may be site-related contaminants. The chlorinated solvents may have originated from combustion of used solvents. The PAHs may be constituents of fuels or crankcase oil burned during training exercises, or combustion products. Arsenic and lead may be present at levels exceeding background due to the use of leaded gasolines and used crankcase oil, which can become enriched with PAH compounds and metals including lead and arsenic. The pesticides are not apparently site-related, but are retained in the risk assessment to evaluate potential contribution to overall site risk.

6.3 EXPOSURE ASSESSMENT

The exposure assessment provides an estimate of the potential type and magnitude of exposures to the chemicals of concern which may occur at the former FTA. The risk characterization combines the results of the exposure assessment with toxicity data. The exposure assessment includes three steps: characterization of the exposure setting, identification of exposure pathways, and quantitation of exposure.

6.3.1 Characterization of Exposure Setting

6.3.1.1 Physical Setting

The physical setting including climate, surface hydrology, regional geology, regional hydrogeology, land use, water use, and demographics are discussed in Section 3.0. That information provides the basis for characterizing the exposure setting.

6.3.1.2 Chemical Contamination and Potential Migration Routes

Available data from the 1989 (NASA, 1990) and 1994 (Section 4.0) investigations indicate that chemical contamination related to past activities at the FTA is present in surface soil at the site. Total petroleum hydrocarbon levels range from 39.7 to 5890 micrograms per kilogram (μg/kg) in surface soil samples. Volatile organics detected include only acetone and methylene chloride, which were also detected in the laboratory blanks at similar levels. Pesticide detections are low concentrations of DDT (120 μg/kg), its breakdown products, and other compounds at low concentrations.

PAHs, including benzo(a)pyrene, are present in samples FTA-SS03 and FTA-SS10. Figure 2-1 shows the sample locations. Both of these locations are on the fringes of the projected location of the former pit area. These PAHs and other semivolatiles may be associated with the waste products ignited as part of the fire training exercises, and the fire fighting agents used to extinguish the fires.

The concentrations of metals in the surface soils appear to be within the normal background ranges, with the exceptions of lead and arsenic. The levels of these two metals are slightly elevated in several samples. Transport of contaminants in surface soil by surface runoff can occur only locally at the site as direct discharges to surface water do not occur.

The results of the 1994 field investigation indicate that groundwater contamination from the FTA does not appear to have reached surface water at Little Mosquito Creek, nor the Town of Chincoteague or NASA drinking water wells. The FTA is cross-gradient of the Town of Chincoteague supply wells screened in the Pleistocene aquifer. The active NASA supply wells are upgradient of the FTA site and are screened in the Miocene aquifer. The groundwater contamination plume in the Pleistocene (water table aquifer) lies immediately downgradient of the former FTA and does not appear to extend beyond the earthen berm located immediately north of the site. The estimated plume for cis-1,2-dichloroethene is the most extensive and provides an indication of the extent of the groundwater contamination (Figure 5-3).

In general, the groundwater flow direction in the water table aquifer is to the north and east, toward the many creeks and inlets, with eventual discharge to the Atlantic Ocean. The general flow direction in the

immediate vicinity of the former FTA is northeast. None of the WFF or Town of Chincoteague supply wells are located north or directly east of the former FTA. The flow direction in the lower confined (Miocene) aquifers is also generally toward the north and east in the vicinity of WFF. Recharge occurs near the spine of the peninsula that forms the Eastern Shore of Virginia (Horsley Witten Hegemann, 1991). Although some downward flow from the upper unconfined aquifer to the lower confined aquifer occurs on the Eastern Shore of Virginia (Horsley Witten Hegemann, 1991), the pump tests conducted on the WFF Main Base indicated little or no leakage (NASA, 1994).

6.3.1.3 Potentially Exposed Populations

The risk assessment process requires identification and evaluation of potential receptors (i.e., individuals exposed to contaminants) for both current land use and future land use scenarios. Standard risk assessment practice utilizes a reasonable maximum exposure (RME) to estimate the magnitude of the potential impact. The RME is the "highest exposure that is reasonably expected to occur at a site" (U.S. EPA, 1989). The RME is designed to be both reasonable and protective of the overall population. Given the small area (about one acre) and the low number of samples collected per medium, the maximum detected concentration of each chemical of concern is the basis for the RME for this human health risk assessment. This approach provides a conservative RME estimate of risk associated with the site. The risks associated with an average exposure are based on the arithmetic averages of concentrations detected at the site.

Current Land Use Conditions. WFF is NASA-owned and operated property, with generally restricted access. Fencing provides a physical security barrier along the southeast and southwest boundaries. Natural water barriers to the northeast and northwest limit access to the remainder of the facility. A continuously-manned Main Gate, with a badge and vehicle identification system for all facility personnel and visitors, controls access to the facility. NASA maintains a Visitor Information Center outside the secured facility east of State Route 175 (NASA, May 1992).

Populations at the facility include approximately 1200 employees (military, civilian, and contractor support personnel) and 11,000 visitors per year, predominantly at the Visitor Information Center. Children are not generally allowed in the active areas of WFF (inside the fenced areas). During occasional recreational events and tours, children and adults visiting the facility are closely supervised and restricted to specific areas (NASA, May 1992). Adjacent to the FTA is an active runway, and access is therefore strictly

controlled. Only employees involved with operational and service areas and employees responsible for maintenance or groundskeeping activities are expected to frequent the FTA. According to NASA, approximately 72 of the 1200 employees (or 6 percent) are presently involved with maintenance activities (NASA, May 1992).

Use of the FTA for training purposes ceased in 1987. The other areas are also inactive, including the former drum storage area (dates of use unknown), the sludge pile (dates of disposal unknown), and the construction debris disposal area (disposal reportedly ceased in 1991).

An active runway is located approximately 250 feet south of the FTA site. The runway is separated from the FTA by a grass median and the paved former taxiway located immediately south of the FTA. The area is accessed by crossing Runway 10-28 at an approved crossing located approximately 1000 feet west of the FTA. Access to the site is generally controlled by personnel in the WFF Air Traffic Control Tower who monitor activities in the vicinity of the airfield. In addition, the WFF Security personnel complete routine patrols of the Main Base facility.

Future Land Use Conditions. The Accomack County Comprehensive Plan (Accomack County, 1989) indicates the WFF Main Base is zoned for industrial land use. NASA currently has no plans to close the WFF facility.

Although development of the FTA for residential use is unlikely due to the proximity to the runway, EPA has requested the use of a future land use scenario which considers residential adult and child exposures. These receptors represent the most significant potential exposure. Exposures under future industrial land use are assumed to be of similar magnitude to a maintenance worker's exposure under current land use. Only the future residential receptors are evaluated.

6.3.2 Identification of Exposure Pathways

Potential pathways for human exposure to chemicals of potential concern at the former FTA are evaluated on the basis of exposure points, possible exposure routes, and human activities. Three criteria define pathway completeness: 1) a source or chemical release from a source must exist; 2) an exposure point

where contact can occur must be identified; and 3) an exposure route by which contact can occur (e.g., ingestion or skin contact) must exist.

6.3.2.1 Potential Exposure Pathways for Current Land Use Conditions

Table 6-7 is a summary of potential exposure pathways to contaminants from the FTA for current land use conditions. The pathways are briefly described below.

Groundwater. Water supply wells for the Town of Chincoteague located on the eastern border of WFF are approximately 5000 feet from the FTA. The wells are essentially cross-gradient, and are not considered to be potentially impacted by groundwater contaminants found in the vicinity of the FTA. A remedial design investigation conducted for the former Aviation Fuel Tank Farm at WFF, located 1700 to 3500 feet upgradient of the Town of Chincoteague supply wells, did not indicate current contamination to the supply wells from this closer, upgradient source (NASA, 1992). The residents of the Town of Chincoteague are not potential receptors for the groundwater pathway under current land use.

Potable water supply wells for NASA operations are located hydraulically upgradient of the FTA (Figure 3-1). NASA is currently drawing potable water supplies from five deep wells in the upper and middle Miocene aquifers. Current evidence does not indicate contamination of the Miocene aquifers from the FTA, and pump tests conducted in 1981, 1987, and 1991 did not indicate leakage between the shallow (Pleistocene) aquifer and the upper and middle Miocene aquifers (NASA, 1993). Therefore NASA employees and visitors are not considered potential receptors for the groundwater pathway under current land use.

Surface Water. The WFF Main Base does not encompass any significant surface water bodies. Surface water bodies border WFF to the north and east of the facility. These water bodies are not sources of potable water due to brackish conditions. Contamination of surface water by direct runoff of stormwater from the FTA is not expected to occur. Direct discharges to surface water were not observed. Some intermittent ponding of surface water occurs in several areas located downgradient of the former FTA. These areas were sampled as part of the RI. Maintenance workers may be exposed to surface water in these areas during routine tasks such as groundskeeping. Exposure of other personnel is not expected to

TABLE 6-7. POTENTIAL EXPOSURE PATHWAYS FOR THE NASA FTA, CURRENT LAND USE

Exposure Medium	Mechanism of Release	Exposure Point	Potential Receptor	Route of Exposure	Pathway Complete? Basis	Type of Evaluation
Soil	Release to surface soil	Fire Training Area	Maintenance Workers	Incidental ingestion, dermal absorption	Yes. Workers may contact soil during routine maintenance (i.e., mowing) and any excavation activities.	Quantitative
Soil	Release to surface soil	Fire Training Area	Base Visitors and Personnel	Incidental ingestion, dermal absorption	Yes. Exposure is unlikely. Maintenance worker exposure to soil represents the worst case.	Not evaluated.
Groundwater	Leaching to groundwater from soil	Town of Chincoteague or NASA water supply wells	Residents of Chincoteague or NASA personnel and visitors.	Direct ingestion, dermal absorption, and inhalation	No. These wells are located hydraulically upgradient or cross-gradient from the site.	Not evaluated.
Surface Water	Groundwater discharge to surface water	Little Mosquito Creek	Residents	Incidental ingestion, dermal absorption	No. No evidence to indicate that contaminants are currently being discharged to surface waters.	Not evaluated.
Sediment/ Surface Water	Surface water runoff from site (stormwater)	Low-lying areas immediately north and northeast of the Fire Training Area	Maintenance Workers	Incidental ingestion, dermal absorption	Yes. Exposure to sediment and ponded surface water is possible for workers during maintenance and excavation activities. Only dermal route is considered complete for surface water.	Quantitative for dermal route for surface water. Sediment evaluated as soil.
Air	Volatilization of chemicals from exposed soil.	Fire Training Area	Maintenance Workers	Inhalation	Yes. Volatilization possible, but dilution and dispersion expected to be relatively large. Volatile organic levels in soil are relatively low.	Not evaluated.
Air	Wind dispersion of outdoor soil.	Fire Training Area	Maintenance Workers	Inhalation	Yes. Dust generation possible, but dilution and dispersion expected to be relatively large. FTA is generally well vegetated. Volatile organic levels in soil are relatively low.	Not evaluated.

occur. Therefore the maintenance worker represents the RME. Direct contact with the ponded surface water may result in dermal absorption of chemicals of concern.

Current evidence does not indicate discharge of contaminated groundwater to surface water is occurring. Based on the delineation of the contaminant plume in groundwater downgradient of the site, the chemicals of concern are not reaching surface water under current conditions. This pathway is not complete and will not be analyzed.

Soil and Sediment. On-site sediment is found in the area of intermittent ponded surface water. The sediment is considered as surface soil in the current land use scenario. Worker exposure to contaminated soil and on-site sediment is likely during routine maintenance, including groundskeeping, excavation, or construction activities. Maintenance workers are expected to have more frequent contact with soil than other personnel, and therefore represent the RME. An evaluation utilizing a maintenance worker is expected to provide an exposure estimate that is protective of other personnel at the facility. The maintenance worker is also considered for the average exposure, but at a reduced frequency of exposure. Direct contact with soil can result in incidental ingestion through hand to mouth contact, particularly during activities such as eating or smoking. Dermal absorption may result from direct contact of contaminated soil and the skin. Incidental ingestion and dermal absorption are considered likely pathways and are quantitatively analyzed.

Under current land use conditions, exposure to subsurface soils is unlikely, and would be infrequent if it occurred. Construction and excavation activities do not generally occur in the area. Therefore, the surface soil and on-site sediment data are used to evaluate risk associated with soil exposure under current land use conditions.

Air. The inhalation route is not evaluated under current land use conditions. The site is generally stabilized and routine air monitoring during RI field investigation activities did not indicate volatile levels above background levels in the breathing zone. Exposure via this route is considered unlikely.

6.3.2.2 Potential Exposure Pathways for Future Land Use Conditions

Table 6-8 summarizes potential exposure pathways to contaminants from the FTA for future land use conditions. The pathways are briefly described below.

Groundwater. For a future residential land use scenario, it is possible that new water supply wells could be installed. The potential exists that these wells could be screened in the unconfined Pleistocene aquifer, as well as in the upper and middle Miocene aquifers. Current evidence does not indicate contamination of the Miocene aquifers from the FTA; evidence of contamination of the Pleistocene immediately down-gradient of the FTA is confirmed by the RI field investigation results. Therefore this pathway will be evaluated for future land use conditions. The routes of possible exposure for the groundwater pathway include ingestion, dermal absorption (during bathing), and inhalation (during bathing).

Soil. Surface and subsurface soils at the site could be disturbed as a result of excavation and construction activities. Residential exposure to contaminants in soil is considered unlikely but possible under future land use conditions. This pathway is evaluated, assuming a blending of surface and subsurface soils and on-site sediment. Exposure via ingestion and dermal absorption are considered for adult and child receptors.

Surface Water. Contaminants from the FTA may reach surface water via groundwater plume migration and discharge of groundwater to surface water. Little Mosquito Creek is tidally influenced and subject to daily flushing. The tidal effects will result in a high level of dilution and dispersion of any contaminants which may reach the surface water. As in the current land use scenario, surface water is not considered a source for potable water due to brackish conditions. In addition, the area is not expected to be utilized for recreation due to the availability of nearby superior recreational areas and limited access due to significant marshland located between the FTA and Little Mosquito Creek. This pathway will not be analyzed for future conditions.

Sediment. With future residential development of the FTA, drainage channels and systems to handle increased runoff due to development could be required. Residents could be exposed to contaminants in sediment transported from the FTA into drainage channels via stormwater runoff. Exposure could occur through incidental ingestion or dermal absorption. The types and concentrations of contaminants in sediment would be similar to those encountered in soil at the site, particularly following development and the resultant

TABLE 6-8. POTENTIAL EXPOSURE PATHWAYS FOR THE NASA FTA, FUTURE LAND USE

Exposure Medium	Mechanism of Release	Exposure Point	Potential Receptor	Route of Exposure	Pathway Complete? Basis	Type of Evaluation
Soil	Release to surface soil	Fire Training Area	Residents	Incidental ingestion, dermal absorption	Yes. Although residential development of the FTA and the NASA facility is not expected to occur, future land use is unknown.	Quantitative
Groundwater	Leaching to groundwater from soil	Town of Chincoteague water supply wells	Residents	Direct ingestion, dermal absorption	No. Future exposure of Town of Chincoteague residents to groundwater contamination by plume migration from the FTA is not expected to occur.	Not evaluated.
Groundwater	Leaching to groundwater from soil; irrigation of agricultural with groundwater	Residential water supply wells	Residents	Direct ingestion, dermal absorption, inhalation, ingestion of agricultural products	Yes. Future residential development could result in installation of shallow water supply wells. Plume migration is not expected to impact any existing supply wells.	Quantitative
Air	Volatilization of chemicals from exposed soil	Fire Training Area	Residents	Inhalation	Yes. Volatilization possible, but dilution and dispersion expected to be relatively large. Levels of volatile organics in soil relatively low.	Not evaluated.
Air	Wind dispersion of outdoor soil	Fire Training Area	Residents	Inhalation	Yes. Dust generation possible, but dilution and dispersion expected to be relatively large. Area will remain partially grassed even under residential development scenario.	Not evaluated.
Surface Water	Groundwater discharge to surface water	Little Mosquito Creek	Residents	Incidental ingestion, dermal absorption	Yes. Groundwater contamination may reach surface water by plume migration, but dilution and dispersion are expected to be relatively large due to tidal nature.	Not evaluated.
Sediment	Surface water runoff from site (stormwater)	Drainage channels	Residents	Incidental ingestion, dermal absorption	Yes. Exposure to sediment is possible for residents.	Qualitative

blending of surface and subsurface soils. Residential exposure to sediment is expected to be similar to, but less frequent than, exposures to soil. The exposure assessment for sediment is not expected to vary significantly from the soil exposure assessment. Therefore, the sediment exposure pathway will be discussed qualitatively to identify any additional risks posed to residents from exposure to sediment as compared to soil exposure, and the sediment data will be incorporated in the evaluation of risks due to soil exposure.

Air. Inhalation of volatiles during showering is a possible exposure route. Other inhalation exposures are considered unlikely under the future residential exposure. Inhalation of volatiles during showering may contribute to the overall site risk. For the purposes of this assessment, it is assumed that the conservative assumptions used in evaluating ingestion, dermal absorption, and inhalation will provide a reasonable assessment of overall risk due to future residential exposures.

6.3.2.3 Summary of Potential Exposure Pathways

Current land use conditions:

- Worker exposure to contaminants in surface soil and sediment by incidental ingestion and dermal absorption will be quantitatively analyzed.

- Dermal absorption from on-site ponded surface water will be evaluated.

Future land use conditions:

- Resident (both adult and child) exposure to contaminants in soil (including surface and subsurface soil, and sediment) by incidental ingestion and dermal absorption will be quantitatively analyzed.

- Resident (both adult and child) exposure to contaminants in groundwater by ingestion, dermal absorption , and inhalation will be quantitatively analyzed.

6.3.3 Quantification of Potential Exposure

Exposure of potential receptors to chemicals of concern detected at the former FTA is quantified using the exposure point concentration and the frequency, duration, and magnitude of contact. The U.S. EPA has developed standard guidance for exposure quantification. The standard guidance, presented in "Human Health Evaluation Manual Supplemental Guidance: Standard Default Exposure Factors" (U.S. EPA, 1991a), is used in the exposure quantification.

The level of remedial action required at a given site may be determined by a risk assessment based upon the RME as defined by the U.S. EPA. The RME is the highest exposure that may reasonably occur at a site, and is designed to be both reasonable and protective of the overall population. The RME is pathway-dependent; if a given population is exposed via multiple pathways, the exposures are combined to determine the RME.

The RME is typically derived using the 95 percent upper confidence limit (UCL) of the arithmetic mean of chemical concentrations detected in an environmental medium. U.S. EPA guidelines suggest that in cases with limited amounts of data (less than 20 samples) or significant data variability, the 95 UCL or the maximum detected level, whichever is lower, be employed to calculate the RME (U.S. EPA, 1989b). For this risk assessment, the RME utilizes the maximum detected site concentration rather the 95 percent UCL due to the limited number of data points. The use of maximum detected levels provides a conservative estimate of risk.

The average exposure is calculated based on the arithmetic mean of site-specific chemical concentration data. In calculating the arithmetic mean, the laboratory reported CRQL is used for samples in which a chemical of concern was not detected. This approach is conservative and is employed in this risk assessment to offset the effects of limited data points. The average exposure is used for comparison purposes to assess the median exposure level.

The RME and the average exposure for current and future land use are based on the exposure parameters summarized below for each completed pathway. The parameters provide the basis for dose estimation and exposure quantification.

6.3.3.1 Soil or Sediment Exposure Under Current Land Use

Under current land use conditions, an adult maintenance worker may be exposed to chemicals of concern through the incidental ingestion or dermal absorption routes. Tables 6-9 and 6-10 provide the exposure parameters for ingestion of and dermal absorption from soil or sediment. These exposure parameters are for the RME and the average exposure assessment. In determining the exposure levels, the maximum chemical concentrations encountered at the FTA are used for calculating the RME. The average exposure assessment utilizes average chemical concentration values. The values of exposure frequency are estimated based upon the potential exposure of a maintenance worker for 5 days/week and 50 weeks/year. The exposure factors are combined with the maximum or average exposure point concentration in the following Equation 1 to estimate exposure doses via incidental ingestion.

Equation 1 - Ingestion of Soil or Sediment

$$CDI = \frac{CS * CF * IR * FI * EF * ED}{BW * AT}$$

where CDI = chronic daily chemical intake (mg/kg/day)
CS = chemical concentration in soil or sediment (μg/kg)
CF = conversion factor (1 kg/10^9 μg)
IR = soil or sediment ingestion rate (mg/day)
FI = fraction ingested from source (unitless)
EF = exposure frequency (days/365 days)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time (70 years for carcinogens, or exposure duration value for noncarcinogens)

Exposure dose estimates for dermal absorption are obtained from the following Equation 2. The equation provides an estimate of absorption of chemicals of concern due to skin contact with soil or sediment.

Equation 2 - Dermal Absorption from Soil or Sediment

$$AD = \frac{CS * CF * SA * AF * ABS * EF * ED}{BW * AT}$$

where AD = absorbed dose (mg/kg/day)
CS = chemical concentration in soil or sediment (μg/kg)
CF = conversion factor (1 kg/10^9 μg)
SA = skin surface area exposed (cm^2)
AF = soil to skin adherence factor (mg/cm^2)
ABS = dermal absorption factor (unitless)
EF = exposure frequency (days/365 days)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time (70 years for carcinogens, exposure duration value for noncarcinogens)

TABLE 6-9. EXPOSURE PARAMETERS FOR INGESTION OF SOIL OR SEDIMENT FOR CURRENT LAND USE

		EXPOSURE PARAMETER	REFERENCE
Maintenance Worker:			
IR	Soil ingestion rate	50 mg/day	(1)
FI	Fraction ingestion from source	100%	(Conservative)
EF	Exposure frequency	250 days/year	(1)
ED	Exposure duration	25 years	(1)
BW	Body weight	70 kg (adult)	(1)
AT	Averaging time:		
	Noncarcinogens	25 years	(1)
	Carcinogens	70 years	(1)

(1) U.S. EPA, 1991a. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors" memorandum.

TABLE 6-10. EXPOSURE PARAMETERS FOR DERMAL ABSORPTION FROM SOIL OR SEDIMENT FOR CURRENT LAND USE

		EXPOSURE PARAMETER	REFERENCE
Maintenance Worker:			
SA	Skin surface area exposed	1890 sq. cm. (hands and forearms)	(2)
AF	Soil to skin adherence factor	1.45 mg/sq. cm	(3)
ABS	Dermal absorption factors:		
	Volatiles	25%	(4)
	Semi-volatiles other than PCP	10%	(4)
	Pesticides other than DDT	10%	(4)
	Arsenic	3%	(4)
	Metals other than Arsenic	1%	(4)
EF	Exposure frequency	250 days/year	(1)
ED	Exposure duration	25 years	(1)
BW	Body weight	70 kg (adult)	(1)
AT	Averaging time:		
	Noncarcinogens	25 years	(1)
	Carcinogens	70 years	(1)

(1) U.S. EPA, 1991a. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors" memorandum.
(2) U.S. EPA, 1989a. Exposure Factors Handbook. Office of Health and Environmental Assessment.
(3) U.S. EPA, 1989b. Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual. Office of Emergency and Remedial Response.
(4) U.S. EPA, 1995. Interim guidance provided by EPA Region III.

6.3.3.2 Surface Water Exposure Under Current Land Use

Under current land use conditions, an adult maintenance worker may be exposed to chemicals of concern through dermal absorption of ponded surface water during maintenance activities. Exposure parameters for dermal absorption from surface water are presented in Table 6-11. The exposure frequency is estimated at 50 days per year, since the surface water is intermittently ponded and exposure on a daily basis is unlikely. These parameters are combined with maximum and average exposure point chemical concentrations in the following Equation 3 to obtain dose estimates.

Equation 3 - Dermal Absorption from Surface Water

$$AD = \frac{CW * SA * PC * ET * EF * ED * CF}{BW * AT}$$

where AD = absorbed dose (mg/kg/day)
CW = chemical concentration in water (mg/*l*)
SA = skin surface area available for contact (cm^2)
PC = chemical-specific dermal permeability constant (cm/hr)
ET = exposure time (hours/day)
EF = exposure frequency (days/365 days)
ED = exposure duration (years)
CF = volumetric conversion factor for water (1 *l*/1000 cm^3)
BW = body weight (kg)
AT = averaging time (70 years for carcinogens, exposure duration value for noncarcinogens)

6.3.3.3 Groundwater Exposure Under Future Land Use

Under potential future land use conditions, residential exposure from site contaminants in groundwater could include ingestion, dermal absorption, and inhalation by both children and adults. The exposure parameters for ingestion of and dermal absorption from groundwater are presented in Tables 6-12 through 6-14. The RME and average exposure point concentrations are combined with the exposure parameters in Equation 4 to estimate the dose from ingestion of groundwater. The exposure frequency is estimated as 350 days/year based upon the residential exposure of 7 days/week for 50 weeks.

TABLE 6-11. EXPOSURE PARAMETERS FOR DERMAL ABSORPTION FROM SURFACE WATER FOR CURRENT LAND USE

		EXPOSURE PARAMETER	REFERENCE
Maintenance Worker:			
SA	Skin surface area exposed	1890 sq. cm. (hands and forearms)	(2)
PC	Chemical-specific dermal permeability factor	Chemical specific	(3)
EF	Exposure frequency	50 days/year	(1)
ED	Exposure duration	25 years	(1)
BW	Body weight	70 kg (adult)	(1)
AT	Averaging time:		
	Noncarcinogens	25 years	(1)
	Carcinogens	70 years	(1)

(1) U.S. EPA, 1991a. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors" memorandum.
(2) U.S. EPA, 1989a. Exposure Factors Handbook. Office of Health and Environmental Assessment.
(3) U.S. EPA, 1992. Dermal Exposure Assessment: Principles and Applications.

TABLE 6-12. EXPOSURE PARAMETERS FOR INGESTION OF GROUNDWATER FOR FUTURE LAND USE

		EXPOSURE PARAMETER	REFERENCE
Resident:			
IR	Ingestion rate	1 liter/day (child) 2 liters/day (adult)*	(1) (1)
EF	Exposure Frequency	350 days/year	(1)
ED	Exposure Duration	6 years (child) 24 years (adult)*	(1) (1)
BW	Body Weight	15 kg (child) 70 kg (adult)*	(1) (1)
AT	Averaging Time:		
	Noncarcinogens	6 years (child) 24 years (adult)*	(1) (1)
	Carcinogens	70 years	(1)

* The term "adult" refers to persons 6 years of age and older.

(1) U.S. EPA, 1991a. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors" memorandum.

TABLE 6-13. EXPOSURE PARAMETERS FOR DERMAL ABSORPTION FROM GROUNDWATER FOR FUTURE LAND USE

		EXPOSURE PARAMETER	REFERENCE
Resident:			
SA	Skin surface area exposed	9,400 sq cm. (child) 18,150 sq. cm. (adult)*	(3) (2)
PC	Chemical-specific dermal permeability constant	Chemical-specific	(4)
EF	Exposure frequency	350 days/year	(1)
ED	Exposure duration	6 years (child) 24 years (adult)*	(1) (1)
BW	Body Weight	15 kg (child) 70 kg (adult)*	(1) (1)
AT	Averaging time:		
	Noncarcinogens	6 years (child) 24 years (adult)*	(1) (1)
	Carcinogens	70 years	(1)

* The term "adult" refers to persons 6 years of age and older.

(1) U.S. EPA, 1991a. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors" memorandum.
(2) U.S. EPA, 1989a. Exposure Factors Handbook. Office of Health and Environmental Assessment.
(3) U.S. EPA, 1989b. Superfund Exposure Assessment Manual.
(4) U.S. EPA, 1992. Dermal Exposure Assessment: Principles and Applications.

TABLE 6-14. EXPOSURE PARAMETERS FOR INHALATION OF GROUNDWATER FOR FUTURE LAND USE

		EXPOSURE PARAMETER	REFERENCE
Resident:			
IRa	daily indoor inhalation rate	15 m^3/day	(1)
EF	Exposure Frequency	350 days/year	(1)
ED	Exposure Duration	6 years (child) 30 years (adult)*	(1) (1)
BW	Body Weight	15 kg (child) 70 kg (adult)*	(1) (1)
AT	Averaging Time:		
	Noncarcinogens	6 years (child) 30 years (adult)*	(1) (1)
	Carcinogens	70 years	(1)

* The term "adult" refers to persons 6 years of age and older.

(1) U.S. EPA, 1991a. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors" memorandum.

Equation 4 - Ingestion of Groundwater

$$CDI = \frac{CW * IR * EF * ED}{BW * AT}$$

where
- CDI = chronic daily chemical intake (mg/kg/day)
- CW = chemical concentration in groundwater (mg/ℓ)
- IR = ingestion rate (l/day)
- EF = exposure frequency (days/365 days)
- ED = exposure duration (years)
- BW = body weight (kg)
- AT = averaging time (70 years for carcinogens, or exposure duration value for noncarcinogens)

Dose estimates for dermal absorption from groundwater are calculated using the following Equation 5 and the exposure parameters presented in Table 6-13.

Equation 5 - Dermal Absorption from Groundwater

$$AD = \frac{CW * SA * PC * ET * CF * EF * ED}{BW * AT}$$

where
- AD = absorbed dose (mg/kg/day)
- CW = chemical concentration in groundwater (mg/ℓ)
- PC = chemical-specific dermal permeability constant (cm/hr)
- ET = exposure time (bathing) (hr/day)
- CF = volumetric conversion factor for water (ℓ/1000cm^3)
- EF = exposure frequency (days/365 days)
- ED = exposure duration (years)
- BW = body weight (kg)
- AT = averaging time (70 years for carcinogens, or exposure duration value for noncarcinogens)

Inhalation dose estimates are calculated using Equation 6 and the exposure parameters listed in Table 6-14.

Equation 6 - Inhalation of Groundwater

$$CDI = \frac{CW * K * IRa * EF * ED}{CF * BW * AT * 365}$$

where

CDI	=	cronic daily intake (mg/kg/day)
CW	=	chemical concentration in groundwater (μg/ℓ)
K	=	volatilization factor (L/m^3)
IRa	=	daily indoor inhalation rate (m^3/day)
EF	=	exposure frequency (days/365 days)
ED	=	exposure duration (years)
CF	=	conversion factor (1000 μg/mg)
BW	=	body weight (kg)
AT	=	averaging time (70 years for carcinogens, or exposure duration value for noncarcinogens)

6.3.3.4 Soil Exposure Under Future Land Use

Surface and subsurface soils at the site could be disturbed as a result of excavation and construction activities for future development. A blending of the surface and subsurface soils would likely occur. Based on that assumption, the RME is the maximum level of a chemical of concern detected in surface soils, subsurface soils, or on-site sediment. The average exposure point concentration is the highest average from the three media. The RME and average exposure assume a duration of 6 years for young children and a 24-year exposure duration for older children and adults. The exposure parameters for ingestion of soil (and indoor dust) and dermal absorption from soil are presented in Tables 6-15 and 6-16. The equations used for calculating soil exposure dose estimates for future land use conditions are the same as for current land use conditions (Equations 1 and 2). The work sheets for calculation of the dose estimates are presented in Appendix E. The site-specific exposure dose estimates provide the basis for characterization of risk to human receptors as a result of exposure to chemicals of concern.

TABLE 6-15. EXPOSURE PARAMETERS FOR INGESTION OF SOIL OR SEDIMENT FOR FUTURE LAND USE

		EXPOSURE PARAMETER	REFERENCE
Resident:			
IR	Soil ingestion rate	100 mg/day (adult) 200 mg/day (child)	(1)
FI	Fraction ingestion from source	100%	(Conservative)
EF	Exposure frequency	350 days/year	(1)
ED	Exposure duration	24 years (adult) 6 years (child)	(1)
BW	Body weight	70 kg (adult) 15 kg (child)	(1)
AT	Averaging time:		
	Noncarcinogens	24 years (adult) 6 years (child)	(1)
	Carcinogens	70 years	(1)

(1) U.S. EPA, 1991a. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors" memorandum.

TABLE 6-16. EXPOSURE PARAMETERS FOR DERMAL ABSORPTION FROM SOIL OR SEDIMENT FOR FUTURE LAND USE

		EXPOSURE PARAMETER	REFERENCE
Resident:			
SA	Skin surface area exposed	1890 sq. cm. (adult) 830 sq. cm. (child) (hands and forearms)	(2)
AF	Soil to skin adherence factor	1.45 mg/sq. cm	(3)
ABS	Dermal absorption factors:		
	Volatiles	25%	(4)
	Semi-volatiles other than PCP	10%	(4)
	Pesticides other than DDT	10%	(4)
	Arsenic	3%	(4)
	Metals other than Arsenic	1%	(4)
EF	Exposure frequency	350 days/year	(1)
ED	Exposure duration	24 years (adult) 6 years (child)	(1)
BW	Body weight	70 kg (adult) 15 kg (child)	(1)
AT	Averaging time:		
	Noncarcinogens	24 years (adult) 6 years (child)	(1)
	Carcinogens	70 years	(1)

(1) U.S. EPA, 1991a. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors" memorandum.
(2) U.S. EPA, 1989a. Exposure Factors Handbook. Office of Health and Environmental Assessment.
(3) U.S. EPA, 1989b. Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual. Office of Emergency and Remedial Response.
(4) U.S. EPA, 1995. Interim guidance provided by EPA Region III.

6.4 TOXICITY ASSESSMENT

The toxicity assessment consists of hazard identification and dose-response evaluation. Hazard identification is an evaluation of the likelihood that exposure to a chemical of concern could result in an increased incidence of adverse effects (e.g., cancer, birth defects, organ toxicity). The dose response evaluation is a quantitative assessment of the relationship between administered doses and the incidence of adverse health effects in each exposed population. Toxicity values are developed by EPA on the basis of the dose-response evaluation. For carcinogenic effects (i.e., cancer), cancer slope factors are developed. For noncarcinogenic effects (e.g., organ toxicity), estimates of safe human exposures (i.e., no adverse effects levels) are developed.

Toxicity data are obtained, in the order of preference, from the EPA Integrated Risk Information System (IRIS) and the EPA Health Effects Assessment Summary Tables (HEAST).

6.4.1 Toxicity Information for Carcinogenic Effects

Toxicity data for carcinogenic effects are developed by the EPA on the assumption that any level of exposure could result in a carcinogenic response. No safe exposure level exists under this assumption. Carcinogenic effects are measured on the basis of weight-of-evidence classifications and slope factors. The weight-of-evidence classification is generally not route-specific, and provides a characterization of the evidence of carcinogenicity of a chemical based on available human and animal studies. The EPA weight-of-evidence classification system is summarized in Table 6-17.

Based on the weight-of-evidence classification, slope factors are generally calculated for known or probable human carcinogens (i.e., Classes A, B1, and B2). The slope factors provide a quantification of the relationship between dose and response. The slope factor is used in this risk assessment to determine the increased likelihood of an individual developing cancer as a result of exposure to a particular level of a potential carcinogen. For comparison of relative toxicity, a larger slope factor indicates a more potent carcinogen.

TABLE 6-17. U.S. EPA WEIGHT-OF-EVIDENCE CLASSIFICATION SYSTEM FOR CARCINOGENICITY

GROUP	DESCRIPTION
A	Human carcinogen
B1 or B2	Probable human carcinogen B1 indicates that limited human data is available. B2 indicates sufficient evidence in animals and inadequate or no evidence in humans
C	Possible human carcinogen
D	Not classifiable as to human carcinogenicity
E	Evidence of noncarcinogenicity for humans

Source: U.S. EPA, 1989b. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part A), Interim Final. December, 1989.

6.4.2 Toxicity Information for Noncarcinogenic Effects

Estimation of noncarcinogenic risk is based on a reference dose (RfD). Route-specific values for ingestion and inhalation are developed by EPA. Values are not currently available for the dermal absorption exposure route. The chronic RfD is an estimate of the daily exposure level unlikely to cause significant adverse health effects over a long time period. EPA generates the RfD values based on the assumption that a threshold value exists for the occurrence of noncarcinogenic effects. Although the types of adverse effects vary among chemicals, the RfD provides a measure of relative toxicity.

6.4.3 Dermal Toxicity Values

RfDs and slope factors are not currently available for exposure via dermal absorption of chemicals. Noncarcinogenic and carcinogenic risks for the dermal absorption exposure scenarios are evaluated using oral RfDs and oral slope factors, respectively. The oral RfDs and slope factors are based on administered doses and are adjusted using chemical-specific absorption factors, when available.

6.4.4 Chemicals for Which No EPA Toxicity Values are Available

Toxicity values are not available for inorganic lead. A substantial amount of evidence links exposure to lead with adverse noncarcinogenic health effects, and inorganic lead is considered a probable human carcinogen (Class B2). However, the EPA has not yet issued toxicity values for inorganic lead. Potential health impacts due to exposure to inorganic lead are evaluated through use of a biokinetic uptake model which is applicable to children ages 0 to 6 years. EPA Region III has requested the use of the model to evaluate risk due to lead exposure. The model results are presented in Section 6.6.

6.4.5 Uncertainties Related to Toxicity Information

RfDs and slope factors are developed using uncertainty factors to account for intra-species extrapolation, extrapolation of high-dose concentrations from actual studies to low-dose environmental exposures, prediction of long-term exposure effects from the results of short-term exposure studies, variations in individual sensitivities, and other uncertainties associated with experimental data. Use of uncertainty

factors results in estimates of exposure risks which are likely to be equal to or greater than the actual health hazard.

6.4.6 Summary of Toxicity Information

Table 6-18 provides a summary of toxicity data for the chemicals of concern at the former FTA. The summary includes, as available, the RfD, critical effect, weight-of-evidence classification, and cancer slope factor for each chemical of concern.

6.5 RISK CHARACTERIZATION

The risk characterization summarizes and integrates the exposure and toxicity assessment results to provide a numerical indication or qualitative discussion of the risk posed by the chemicals of concern detected at the former FTA. Risk is characterized by a comparison of site-specific contaminant levels to applicable or relevant and appropriate requirements (ARARs), a comparison of estimated human doses to a reference dose (noncarcinogenic effects), and a calculation of the increased lifetime cancer risk (carcinogenic effects). The risk characterization focuses on the exposure pathways identified in the exposure assessment as potentially complete for the former FTA site.

6.5.1 Comparison with ARARs

6.5.1.1 Superfund Amendments Reauthorization Act (SARA) Requirements

The Superfund Amendments Reauthorization Act (SARA) requires that remedial actions at CERCLA sites meet or consider ARARs, which are defined as follows.

> Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection standards, criteria, or limitations promulgated under Federal or State law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a hazardous waste site.

TABLE 6-18.
TOXICITY DATA FOR CHEMICALS OF CONCERN

	NONCARCINOGENIC EFFECTS		CARCINOGENIC EFFECTS	
Chemical of Concern	Oral Reference Dose (RfD) (mg/kg/day)	Target and Effects	Oral Slope Factor $(mg/kg/day)^{-1}$	U.S. EPA Weight-of Evidence
1,1-Dichloroethene	9.00E-03	Liver - lesions (1,2)	6.00E-01	C (1)
cis-1,2-Dichloroethene	1.00E-02	Blood - decreased hematocrit and hemoglobin (2)	NC	D (1)
Methylene Chloride	6.00E-02	Liver - toxicity (1)	7.50E-03	B2 (1)
Chloroform	1.00E-02	Liver - lesions (2)	6.10E-03	B1 (1)
Benzene	NA	NA	2.90E-02	A (1)
Tetrachloroethene	1.00E-02	Liver - hepatotoxicity (1)	5.20E-02	
Toluene	2.00E-01	Liver, kidney - altered weight Central nervous system - neurological effects Eyes, nose - irritation (1)	NC	D (1)
Trimethylbenzene	5.00E-04	NA	NC	D (2)
Tetramethylbenzene	NA	NA	NA	NA
2-Methylnaphthalene	NA	NA	NA	NA
Naphthalene	4.00E-02	Whole body - decreased weight (2)	NC	D (1)
Phenanthrene	NA	NA	NC	D (1)
Benzo(a)anthracene	NA	NA	7.30E-01	B2 (1)
Benzo(b)fluoranthene	NA	NA	7.30E-01	B2 (1,2)
Benzo(a)pyrene	NA	NA	7.30E+00	B2 (1)
Dibenz(a,h)anthracene	NA	NA	NA	B2 (1)
Benzo(g,h,i)perylene	NA	NA	NC	D (1)
alpha-BHC	6.00E-05	Liver and kidney-toxicity (2)	6.30E+00	B2 (1)
Heptachlor epoxide	1.30E-05	Liver - increased relative weight (1)	9.00E+00	B2 (1)
gamma-Chlordane	6.00E-05	NA	1.30E+00	NA
Arsenic	3.00E-04	Skin - keratosis and hyperpigmentation (1)	1.75E+00	A (1)
Lead (a)	NA	NA	NA	NA

Notes:
(a) Toxicity values are not available for inorganic lead.

NA - Not Available
NC - Non-Carcinogenic

Sources:
(1) U.S. EPA Integrated Risk Information System (IRIS).
(2) U.S. EPA Health Effects Assessment Summary Tables (HEAST)

Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection standards, criteria, or limitations promulgated under Federal or State law that, while not "applicable", address problems or situations sufficiently similar to those encountered at a site that their use is well suited to the particular site.

SARA requires that cleanup standards meet the most stringent ARAR. The NASA former FTA site is not currently a CERCLA site, but has been proposed for inclusion on the NPL. ARARs may include Federal as well as Commonwealth of Virginia environmental standards. For groundwater, the Commonwealth of Virginia Department of Environmental Quality (DEQ) has adopted the Federal Drinking Water Maximum Contaminant Levels (MCLs) and has promulgated specific groundwater quality standards. For soils, the criteria are determined by risk-based evaluations. Chemical-specific criteria are not defined for the chemicals of concern detected in soils.

6.5.1.2 Safe Drinking Water Act

The Safe Drinking Water Act (SDWA) of 1974 and as amended in 1986 established criteria for protection of public drinking water supplies. The major elements of the program include drinking water standards and treatment techniques, filtration and disinfection of surface supplies, disinfection by-product standards, the coliform rule, and radionuclide standards.

Section 1412 of the SDWA requires the EPA to promulgate national drinking water regulations and publish Maximum Contaminant Level Goals (MCLGs). Under Section 1401, the EPA must develop enforceable MCLs and "criteria and procedures to assure a supply of drinking water which dependably complies" with such MCLs. MCLs and MCLGs are specified in 40 CFR Part 141, Subparts B and F.

MCLs are enforceable, chemical-specific drinking water standards developed under the SDWA. MCLs are based on use of best technology, treatment techniques, and other factors including costs. Health risks are factored into the MCLs, along with the technical and economic feasibility criteria.

The Pleistocene aquifer is still currently a drinking water supply for the Town of Chincoteague and other communities on the Eastern Shore of Virginia. No downgradient receptors were identified for current land use. However, future residential land use could result in the installation of drinking water wells

downgradient of the site. The SDWA MCLs are therefore relevant and appropriate in characterizing risk for the potential future land use of the former FTA.

The MCLGs are nonenforceable health goals for public water systems. Under SARA, the MCLGs are considered as ARARs. Non-zero MCLGs will be used for evaluation of risk associated with future land use of the former FTA.

6.5.1.3 State Criteria

State criteria that may be considered ARARs are the Virginia Groundwater Standards, Water Quality Criteria for Groundwater, and the Drinking Water Standards. In addition, the Virginia Surface Water Standards with General, Statewide Application provide chemical-specific numerical limits for public water supplies.

The Commonwealth of Virginia Groundwater Standards (VR680-21-04) apply statewide to all groundwater occurring at or below the uppermost seasonal limits of the water table. In recognition of local variability of natural groundwater quality, Virginia is divided into four physiographic provinces with distinct groundwater standards. WFF lies in the Coastal Plain Physiographic Province. The groundwater standards for the Coastal Plain Province do not address any of the contaminants of concern identified for the former FTA. The groundwater standards applicable statewide include concentration limits for arsenic, lead, and heptachlor epoxide.

The Water Quality Criteria for Groundwater do not address any of the chemicals of concern for the former FTA. The Virginia Drinking Water Standards are adopted from the Federal MCLs.

The Commonwealth of Virginia Surface Water Standards with General, Statewide Application (VR680-21-01) include numerical, chemical-specific criteria for public water supplies. Although not directly applicable to groundwater, these ARARs provide another basis for comparison of site-specific data to human health criteria.

6.5.2 Comparison to Reference Doses

An evaluation of noncarcinogenic effects from exposures to contaminants of concern at the former FTA is based on comparison of exposure dose estimates to RfDs. The RfDs represent a measure of chemical-specific toxicity. The ratio of the estimated daily intake to the RfD is the hazard quotient.

The hazard quotient assumes that a level of exposure (i.e., the RfD) exists below which adverse health effects are unlikely to occur, even in sensitive populations. The RfD then serves as a threshold for determining the likelihood of noncancer effects resulting from exposure.

To assess the overall potential for noncarcinogenic effects posed by an exposure pathway, the hazard quotients for each chemical of concern are summed for each pathway. This total, known as the hazard index (HI), assumes that simultaneous exposures to several chemicals could have a cumulative effect, resulting in adverse noncancer health effects. When the HI exceeds unity, adverse health effects may potentially occur.

6.5.3 Estimation of Cancer Risk

An evaluation of carcinogenic effects from exposures to chemicals of concern from the former FTA is based on the estimation of increased lifetime cancer risk. The carcinogenic risk is estimated as the incremental probability of an individual developing cancer over the course of a lifetime as a result of exposure to a carcinogenic substance. The probability is often referred to as increased or excess lifetime cancer risk.

Increased lifetime cancer risk is estimated using a slope factor to directly convert estimated daily intakes (or exposures), averaged over a lifetime of exposure, to the incremental risk of an individual developing cancer as a result of that exposure. The increased lifetime cancer risk is estimated by multiplying a route-specific dose by a route-specific carcinogenic slope factor. This calculation is valid only at low risk levels (less than $1x10^{-2}$) where a linear slope is expected (U.S. EPA, 1989b). Ingestion slope factors are generally used to assess carcinogenic risk from dermal exposure, since dermal slope factors have not been developed. The oral slope factors are adjusted for percent absorption before being used as dermal slope factors.

The increased lifetime cancer risks estimated for each chemical of concern are summed for each exposure route to determine the route-specific carcinogenic risk. Estimated carcinogenic risks in the range of $1x10^{-4}$ to $1x10^{-6}$ may be acceptable, within the context of current and future uses of the property. Estimated carcinogenic risks at, or below, $1x10^{-6}$ are considered insignificant, or de minimus, and require no further action.

6.5.4 Risk Characterization for Current Land Use Conditions

Dose estimates for worker exposure to soil and sediment under current land use for the ingestion and dermal exposure routes (Appendix E) are compared to toxicity values for risk estimations. Each pathway is evaluated individually for both current and future land use.

6.5.4.1 Soil Ingestion Under Current Land Use

The HIs for the RME and average exposure for ingestion of soil and sediment under current land use do not exceed unity (Table 6-19). The HI for arsenic, the only chemical of concern with known non-carcinogenic impacts and an available RfD, is two to three orders of magnitude less than unity. Cancer risks estimated are $3x10^{-6}$ for the RME and $2x10^{-6}$ for the average exposure (Table 6-19). The $1x10^{-6}$ de minimus level is exceeded for both the RME and average exposure. Four of the seven chemicals of concern are designated as carcinogenic - benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and arsenic. The individual increased lifetime cancer risk for arsenic exceeded the de minimus value of $1x10^{-6}$. The total risk contributed by the other chemicals of concern did not exceed the de minimus level.

6.5.4.2 Dermal Absorption from Soil Under Current Land Use

The HIs for dermal absorption of contaminants at on-site concentrations for the RME and average exposure under current land use (Table 6-20) do not exceed unity. As is the case for ingestion of soils, the HI for arsenic is two orders of magnitude less than unity. RfD values are not available for the other chemicals of concern. Lead is evaluated using the EPA Biokinetic Uptake Model (Section 6.6).

The increased lifetime cancer risks for dermal absorption for the RME and average exposure are $8x10^{-6}$ and $5x10^{-6}$, respectively (Table 6-20). Arsenic and dibenz(a,h)anthracene provide the majority of the

TABLE 6-19. RISK FROM INGESTION OF SOIL AND SEDIMENT- CURRENT CHRONIC EXPOSURE

			Noncarcinogenic					Carcinogenic				
Chemical of Concern	Max. Detected Conc. (2) (µg/kg)	Ave. Detected Conc. (3) (µg/kg)	RME Chronic Dose (mg/kg/day)	Ave. Chronic Dose (mg/kg/day)	Chronic Oral Reference Dose (mg/kg/day)	RME Hazard Quotient	Ave. Hazard Quotient	RME Chronic Dose (mg/kg/day)	Ave. Chronic Dose (mg/kg/day)	Oral Slope Factor $(mg/kg/day)^{-1}$	RME Increased Cancer Risk	Ave. Increased Cancer Risk
Benzo(a)pyrene	130	84.5	6.36E-08	4.13E-08	NA	ND	ND	2.27E-08	1.48E-08	7.30E+00	2E-07	1E-07
Benzo(g,h,i)perylene	340	340	1.66E-07	1.66E-07	NA	ND	ND	5.94E-08	5.94E-08	NC	ND	ND
Benzo(b)fluoranthene	1,600	583	7.83E-07	2.85E-07	NA	ND	ND	2.80E-07	1.02E-07	7.30E-01	2E-07	7E-08
Phenanthrene	140	140	6.85E-08	6.85E-08	NA	ND	ND	2.45E-08	2.45E-08	NC	ND	ND
Dibenz(a,h)anthracene	240	240	1.17E-07	1.17E-07	NA	ND	ND	4.19E-08	4.19E-08	7.30E+00	3E-07	3E-07
Arsenic	9,000	5,400	4.40E-06	2.64E-06	3.00E-04	1.47E-02	8.81E-03	1.57E-06	9.44E-07	1.75E+00	3E-06	2E-06
Lead(1)	67,500	40,000	3.30E-05	1.96E-05	NA	ND	ND	1.18E-05	6.99E-06	NA	ND	ND
					Total Hazard Index	1.47E-02	8.81E-03			Total Increased Lifetime Cancer Risk	3E-06	2E-06

NOTES:
Hazard Quotient = Chronic Dose/Chronic Reference Dose
Increased Lifetime Cancer Risk = Chronic Dose x Oral Slope Factor
NA - Not Available
NC - Noncarcinogenic
ND - Not Determined

The slope factor for benzo(a)pyrene is used for PAHs with no published slope factor.
(1) Reference dose values are not available for inorganic lead. Lead is evaluated using the EPA Biokinetic Uptake Model (Section 6.6).
(2) Concentration is maximum detected in soil or sediment.
(3) Concentration is larger of averages for soil and sediment.

TABLE 6-20. RISK FROM DERMAL ABSORPTION FROM SOIL AND SEDIMENT- CURRENT CHRONIC EXPOSURE

Chemical of Concern	Max. Detected Conc. (2) (µg/kg)	Ave. Detected Conc. (3) (µg/kg)	Noncarcinogenic					Carcinogenic				
			RME Chronic Dose (mg/kg/day)	Ave. Chronic Dose (mg/kg/day)	Chronic Oral Reference Dose (mg/kg/day)	RME Hazard Quotient	Ave. Hazard Quotient	RME Chronic Dose (mg/kg/day)	Ave. Chronic Dose (mg/kg/day)	Oral Slope Factor $(mg/kg/day)^{-1}$	RME Increased Cancer Risk	Ave. Increased Cancer Risk
Benzo(a)pyrene	130	84.5	3.49E-07	2.27E-07	NA	ND	ND	1.24E-07	8.09E-08	7.30E+00	9E-07	6E-07
Benzo(g,h,i)perylene	340	340	9.12E-07	9.12E-07	NA	ND	ND	3.26E-07	3.26E-07	NC	ND	ND
Benzo(b)fluoranthene	1,600	583	4.29E-06	1.56E-06	NA	ND	ND	1.53E-06	5.58E-07	7.30E-01	1E-06	4E-07
Phenanthrene	140	140	3.75E-07	3.75E-07	NA	ND	ND	1.34E-07	1.34E-07	NC	ND	ND
Dibenz(a,h)anthracene	240	240	6.44E-07	6.44E-07	NA	ND	ND	2.30E-07	2.30E-07	7.30E+00	2E-06	2E-06
Arsenic	9,000	5,400	7.24E-06	4.34E-06	3.00E-04	2.41E-02	1.45E-02	2.59E-06	1.55E-06	1.75E+00	5E-06	3E-06
Lead (1)	67,500	40,000	1.81E-05	1.07E-05	1.00E-07	1.81E+02	1.07E+02	6.46E-06	3.83E-06	NA	ND	ND
					Total Hazard Index	1.81E+02	1.07E+02			Total Increased Lifetime Cancer Risk	8E-06	5E-06

NOTES:
Hazard Quotient = Chronic Dose/Chronic Reference Dose
Increased Lifetime Cancer Risk = Chronic Dose x Oral Slope Factor
NA - Not Available
NC - Noncarcinogenic
ND - Not Determined

The slope factor for benzo(a)pyrene is used for PAHs with no published slope factor.
(1) Reference dose values are not available for inorganic lead. Lead is evaluated using the EPA Biokinetic Uptake Model (Section 6.6).
(2) Concentration is maximum detected in soil or sediment.
(3) Concentration is larger of averages for soil and sediment.

cancer risk. Arsenic was not detected in background surface soils or sediment. The individual increased lifetime cancer risk for benzo(b)fluoranthene equals the $1x10^{-6}$ de mininus level for the RME.

6.5.4.3 Dermal Absorption from Surface Water

Only lead and arsenic are identified as chemicals of concern in the on-site ponded surface water. Health impacts from exposure to lead are evaluated using the EPA Biokinetic Uptake Model (Section 6.6). The noncarcinogenic level of risk associated with dermal absorption of arsenic from on-site ponded water is four orders of magnitude below the level of concern (Table 6-21). The increased carcinogenic risk for exposure to arsenic is two orders of magnitude less than the de minimus risk level.

6.5.4.4 Summary of Risk for Current Land Use

Table 6-22 is a summary of the HIs for a maintenance worker's noncarcinogenic risk due to exposure under current land use. Arsenic is the only chemical of concern for which an RfD is available. The total risk associated with exposure to arsenic, summed across all pathways, is two orders of magnitude below the 1.0 level of concern.

Table 6-23 is a summary of increased lifetime cancer risks associated with a maintenance worker's on-site exposure. Arsenic, benzo(b)fluoranthene, and dibenz(a,h)anthracene (based on the toxicity values for benzo(a)pyrene) contribute significantly to the carcinogenic risk under the RME. Arsenic provides the most significant contribution to risk under the average exposure scenario.

6.5.5 Risk Characterization for Future Exposure to Soils

The assumption for future land use is residential, with exposures of both children and adults. The age group for children is up to six years. Children seven and older are included as adults in the exposure dose estimates (Appendix E).

TABLE 6-21. RISK FROM DERMAL ABSORPTION FROM SURFACE WATER - CURRENT CHRONIC EXPOSURE

Chemical of Concern	Max. Detected Conc. (µg/l)	Ave. Detected Conc. (µg/l)	Noncarcinogenic					Carcinogenic				
			RME Chronic Dose (mg/kg/day)	Ave. Chronic Dose (mg/kg/day)	Chronic Oral Reference Dose (mg/kg/day)	RME Hazard Quotient	Ave. Hazard Quotient	RME Chronic Dose (mg/kg/day)	Ave. Chronic Dose (mg/kg/day)	Oral Slope Factor $(mg/kg/day)^{-1}$	RME Increased Cancer Risk	Ave. Increased Cancer Risk
Arsenic	5.30	3.90	6.62E-08	4.87E-08	3.00E-04	2.21E-04	1.62E-04	2.36E-08	1.74E-08	1.75E+00	4E-08	3E-08
Lead(1)	7.00	1.85	8.74E-08	2.31E-08	NA	ND	ND	3.12E-08	8.25E-09	NA	ND	ND
					Total Hazard Index	2.21E-04	1.62E-04			Total Increased Lifetime Cancer Risk	4E-08	3E-08

NOTES:
Hazard Quotient = Chronic Dose/Chronic Reference Dose
Increased Lifetime Cancer Risk = Chronic Dose x Oral Slope Factor
NA - Not Available
NC - Noncarcinogenic
ND - Not Determined
(1) Reference dose values are not available for inorganic lead. Lead is evaluated using the EPA Biokinetic Uptake Model (Section 6.6).

TABLE 6-22. SUMMARY OF NONCARCINOGENIC RISKS FOR CURRENT LAND USE CONDITIONS

Chemical of Concern	SOIL/SEDIMENT EXPOSURE HAZARD INDICES						SURFACE WATER EXPOSURE HAZARD INDICES		TOTAL WORKER EXPOSURE	
	Soil Ingestion		Dermal Absorption		Total Soil		Dermal Absorption			
	RME	Average	RME	Average	RME	Average	RME	Average	RME	Average
Benzo(a)pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(g,h,i)perylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(b)fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibenz(a,h)anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	1.47E-02	8.81E-03	2.41E-02	1.45E-02	3.88E-02	2.33E-02	2.21E-04	1.62E-04	3.90E-02	2.35E-02
Lead	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
				TOTAL	3.88E-02	2.33E-02	2.21E-04	1.62E-04	3.90E-02	2.35E-02

TABLE 6-23. SUMMARY OF CARCINOGENIC RISKS FOR CURRENT LAND USE CONDITIONS

Chemical of Concern	INCREASED LIFETIME CANCER RISK						SURFACE WATER EXPOSURE INCREASED LIFETIME RISK		TOTAL WORKER EXPOSURE	
	Soil Ingestion		Dermal Absorption		Total Soil		Dermal Absorption			
	RME	Average	RME	Average	RME	Average	RME	Average	RME	Average
Benzo(a)pyrene	2E-07	1E-07	9E-07	6E-07	1E-06	7E-07	ND	ND	1E-06	7E-07
Benzo(g,h,i)perylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(b)fluoranthene	2E-07	7E-08	1E-06	4E-07	1E-06	5E-07	ND	ND	1E-06	5E-07
Phenanthrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibenz(a,h)anthracene	3E-07	3E-07	2E-06	2E-06	2E-06	2E-06	ND	ND	2E-06	2E-06
Arsenic	3E-06	2E-06	5E-06	3E-06	8E-06	5E-06	4E-08	3E-08	8E-06	5E-06
Lead	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
				TOTAL	1E-05	8E-06	ND	ND	1E-05	8E-06

6.5.5.1 Risk Resulting from Ingestion of Soil

Arsenic is the only chemical of concern for which noncarcinogenic toxicity values are available. The noncarcinogenic risk resulting from exposure to arsenic is one to two orders of magnitude less than unity for both a child and and adult residential receptor (Tables 6-24a and 6-24b). Impacts associated with exposure to lead are evaluated using the EPA Biokinetic Uptake Model (Section 6.6). The model evaluates blood levels in children resulting from exposure to lead.

Increased lifetime cancer risks exceed the $1x10^{-6}$ target level for both the child and adult resident under the RME and average exposure for ingestion of soil. Five of the eight contaminants of concern are carcinogenic: benzo(a)anthracene, benzo(b)fluoranthene, benzo(a)pyrene, dibenz(a,h)anthracene, and arsenic. The individual risks associated with each of these five contaminants exceed the $1x10^{-6}$ de minimus level under the RME for both the child and adult resident receptor (Tables 6-24a and 6-24b).

Under the average exposure scenario, the individual cancer risks for a child exposed to benzo(a)pyrene, dibenz(a,h)-anthracene (based on toxicity values for benzo(a)pyrene), and arsenic exceed the $1x10^{-6}$ level. Only arsenic and dibenz(a,h)anthracene have risks in excess of the $1x10^{-6}$ target level for the adult average exposure. The total cancer risk for ingestion of soil by a child resident is $3x10^{-5}$ for the RME and $1x10^{-5}$ for the average exposure. For an adult, total cancer risks are $1x10^{-5}$ and $4x10^{-6}$ for the RME and average exposure, respectively.

The carcinogenic risk associated with exposure to background concentrations of arsenic in soil is $1x10^{-6}$ for a child's exposure and $5x10^{-7}$ for an adult's exposure. Although these risk values are significant, the risk values associated with exposure to arsenic concentrations in soil in excess of the background still exceed the de minimus level. The risk levels associated with exposure to the maximum background concentrations of arsenic are presented in Appendix F, Table F-1.

TABLE 6-24a. RISK FROM INGESTION OF SOIL - FUTURE CHRONIC EXPOSURE (CHILD)

Chemical of Concern	Max. Detected Conc. (1) (µg/kg)	Ave. Detected Conc. (µg/kg)	Noncarcinogenic					Carcinogenic				
			RME Chronic Dose (mg/kg/day)	Ave. Chronic Dose (mg/kg/day)	Chronic Oral Reference Dose (mg/kg/day)	RME Hazard Quotient	Ave. Hazard Quotient	RME Chronic Dose (mg/kg/day)	Ave. Chronic Dose (mg/kg/day)	Oral Slope Factor $(mg/kg/day)^{-1}$	RME Increased Cancer Risk	Ave. Increased Cancer Risk
Phenanthrene	610	332	3.90E-06	2.12E-06	NA	ND	ND	3.34E-07	1.82E-07	NA	ND	ND
Benzo(a)anthracene	6,200	460	3.96E-05	2.94E-06	NA	ND	ND	3.40E-06	2.52E-07	7.30E-01	2E-06	2E-07
Benzo(b)fluoranthene	6,900	583	4.41E-05	3.73E-06	NA	ND	ND	3.78E-06	3.19E-07	7.30E-01	3E-06	2E-07
Benzo(a)pyrene	3,300	392	2.11E-05	2.51E-06	NA	ND	ND	1.81E-06	2.15E-07	7.30E+00	1E-05	2E-06
Benzo(g,h,i)perylene	2300	2300	1.47E-05	1.47E-05	NA	ND	ND	1.26E-06	1.26E-06	NC	ND	ND
Dibenz(a,h)anthracene	630	630	4.03E-06	4.03E-06	NA	ND	ND	3.45E-07	3.45E-07	7.30E+00	3E-06	3E-06
Arsenic	9,000	5,400	5.75E-05	3.45E-05	3.00E-04	1.92E-01	1.15E-01	4.93E-06	2.96E-06	1.75E+00	9E-06	5E-06
Lead(2)	67,500	40,000	4.32E-04	2.56E-04	NA	ND	ND	3.70E-05	2.19E-05	NA	ND	ND
					Total Hazard Index	1.92E-01	1.15E-01			Total Increased Lifetime Cancer Risk	3E-05	1E-05

NOTES:
Hazard Quotient = Chronic Dose/Chronic Reference Dose
Increased Lifetime Cancer Risk = Chronic Dose x Oral Slope Factor
NA - Not Available
NC - Noncarcinogenic
ND - Not Determined

The oral slope factor for benzo(a)pyrene is used for carcinogenic PAHs with no published slope factor.
(1) Maximum detected concentration in surface soil, sediment, or subsoil.
(2) Reference dose values are not available for inorganic lead. Lead is evaluated using the EPA Biokinetic Uptake Model (Section 6.6).

TABLE 6-24b. RISK FROM INGESTION OF SOIL - FUTURE CHRONIC EXPOSURE (ADULT)

Chemical of Concern	Max. Detected Conc. (1) (µg/kg)	Ave. Detected Conc. (µg/kg)	Noncarcinogenic					Carcinogenic				
			RME Chronic Dose (mg/kg/day)	Ave. Chronic Dose (mg/kg/day)	Chronic Oral Reference Dose (mg/kg/day)	RME Hazard Quotient	Ave. Hazard Quotient	RME Chronic Dose (mg/kg/day)	Ave. Chronic Dose (mg/kg/day)	Oral Slope Factor $(mg/kg/day)^{-1}$	RME Increased Cancer Risk	Ave. Increased Cancer Risk
Phenanthrene	610	332	4.18E-07	2.27E-07	NA	ND	ND	1.43E-07	7.80E-08	NA	ND	ND
Benzo(a)anthracene	6,200	460	4.25E-06	3.15E-07	NA	ND	ND	1.46E-06	1.08E-07	7.30E-01	1E-06	8E-08
Benzo(b)fluoranthene	6,900	583	4.73E-06	3.99E-07	NA	ND	ND	1.62E-06	1.37E-07	7.30E-01	1E-06	1E-07
Benzo(a)pyrene	3,300	392	2.26E-06	2.68E-07	NA	ND	ND	7.75E-07	9.21E-08	7.30E+00	6E-06	7E-07
Benzo(g,h,i)perylene	2300	2300	1.58E-06	1.58E-06	NA	ND	ND	5.40E-07	5.40E-07	NC	ND	ND
Dibenz(a,h)anthracene	630	630	4.32E-07	4.32E-07	NA	ND	ND	1.48E-07	1.48E-07	7.30E+00	1E-06	1E-06
Arsenic	9,000	5,400	6.16E-06	3.70E-06	3.00E-04	2.05E-02	1.23E-02	2.11E-06	1.27E-06	1.75E+00	4E-06	2E-06
Lead(2)	67,500	40,000	4.62E-05	2.74E-05	NA	ND	ND	1.58E-05	9.39E-06	NA	ND	ND
					Total Hazard Index	2.05E-02	1.23E-02			Total Increased Lifetime Cancer Risk	1E-05	4E-06

NOTES:
Hazard Quotient = Chronic Dose/Chronic Reference Dose
Increased Lifetime Cancer Risk = Chronic Dose x Oral Slope Factor
NA - Not Available
NC - Noncarcinogenic
ND - Not Determined

The oral slope factor for benzo(a)pyrene is used for carcinogenic PAHs with no published slope factor.
(1) Maximum detected concentration in surface soil, sediment, or subsoil.
(2) Reference dose values are not available for inorganic lead. Lead is evaluated using the EPA Biokinetic Uptake Model (Section 6.6).

6.5.5.2 Risk Resulting from Dermal Absorption from Soil

Arsenic is the only chemical of concern under this exposure pathway for which toxicity values are available to evaluate noncarcinogenic effects. The total His for the RME and average exposure are two orders of magnitude less than unity, indicating no significant impact from exposure to arsenic.

Increased cancer risks due to dermal absorption for the child resident are $3x10^{-5}$ and $7x10^{-6}$ for the RME and average exposure, respectively. Increased cancer risk for an adult due to dermal absorption for the RME and average exposure are $6x10^{-5}$ and $1x10^{-5}$, respectively (Tables 6-25a and 6-25b). Risk associated with exposure to background concentrations of arsenic in soil is $4x10^{-7}$ for a child and $7x10^{-7}$ for an adult (Table F-1). These values do not significantly impact the total carcinogenic risk under this exposure scenario.

6.5.5.3 Summary of Risk Due to Future Soil Exposure

Table 6-26 is a summary of the HIs for soil exposures for a child and adult resident. Noncancer risk from exposure to arsenic, the only chemical of concern for which toxicity values are available, does not exceed the level of concern (one).

Table 6-27 is a summary of increased cancer risk associated with residential exposures to soil. Under the RME, benzo(a)anthracene, benzo(b)fluoranthene, benzo(a)pyrene, dibenz(a,h)anthracene, and arsenic all contribute to risk in excess of the target level ($1x10^{-6}$). Under the average residential exposure scenario, benzo(b)fluoranthene, benzo(a)pyrene, dibenz(a,h)anthracene, and arsenic contribute risk in excess of the $1x10^{-6}$ de minimus level.

6.5.6 Risk Characterization of Future Exposure to Groundwater

A characterization of risk for groundwater exposure includes a comparison of on-site levels to the MCLs. Dose estimates for ingestion and dermal absorption are then compared to toxicity values for noncarcinogenic and carcinogenic risk characterization.

TABLE 6-25a. RISK FROM DERMAL ABSORPTION FROM SOIL - FUTURE CHRONIC EXPOSURE (CHILD)

Chemical of Concern	Max. Detected Conc. (1) (µg/kg)	Ave. Detected Conc. (µg/kg)	Noncarcinogenic					Carcinogenic				
			RME Chronic Dose (mg/kg/day)	Ave. Chronic Dose (mg/kg/day)	Chronic Oral Reference Dose (mg/kg/day)	RME Hazard Quotient	Ave. Hazard Quotient	RME Chronic Dose (mg/kg/day)	Ave. Chronic Dose (mg/kg/day)	Oral Slope Factor $(mg/kg/day)^{-1}$	RME Increased Cancer Risk	Ave. Increased Cancer Risk
Phenanthrene	610	332	4.69E-06	2.55E-06	NA	ND	ND	4.02E-07	2.19E-07	NA	ND	ND
Benzo(a)anthracene	6,200	460	4.77E-05	3.54E-06	NA	ND	ND	4.09E-06	3.03E-07	7.30E-01	3E-06	2E-07
Benzo(b)fluoranthene	6,900	583	5.31E-05	4.49E-06	NA	ND	ND	4.55E-06	3.84E-07	7.30E-01	3E-06	3E-07
Benzo(a)pyrene	3,300	392	2.54E-05	3.02E-06	NA	ND	ND	2.18E-06	2.59E-07	7.30E+00	2E-05	2E-06
Benzo(g,h,i)perylene	2300	2300	1.77E-05	1.77E-05	NA	ND	ND	1.52E-06	1.52E-06	NC	ND	ND
Dibenz(a,h)anthracene	630	630	4.85E-06	4.85E-06	NA	ND	ND	4.15E-07	4.15E-07	7.30E+00	3E-06	3E-06
Arsenic	9,000	5,400	2.08E-05	1.25E-05	3.00E-04	6.92E-02	4.15E-02	1.78E-06	1.07E-06	1.75E+00	3E-06	2E-06
Lead(2)	67,500	40,000	5.19E-05	3.08E-05	NA	ND	ND	4.45E-06	2.64E-06	NA	ND	ND
					Total Hazard Index	6.92E-02	4.15E-02			Total Increased Lifetime Cancer Risk	3E-05	7E-06

NOTES:
Hazard Quotient = Chronic Dose/Chronic Reference Dose
Increased Lifetime Cancer Risk = Chronic Dose x Oral Slope Factor
NA - Not Available
NC - Noncarcinogenic
ND - Not Determined

The oral slope factor for benzo(a)pyrene is used for carcinogenic PAHs with no published slope factor.
(1) Maximum detected concentration in surface soil, sediment, or subsoil.
(2) Reference dose values are not available for inorganic lead. Lead is evaluated using the EPA Biokinetic Uptake Model (Section 6.6).

TABLE 6-25b. RISK FROM DERMAL ABSORPTION FROM SOIL - FUTURE CHRONIC EXPOSURE (ADULT)

Chemical of Concern	Max. Detected Conc. (1) (µg/kg)	Ave. Detected Conc. (µg/kg)	Noncarcinogenic					Carcinogenic				
			RME Chronic Dose (mg/kg/day)	Ave. Chronic Dose (mg/kg/day)	Chronic Oral Reference Dose (mg/kg/day)	RME Hazard Quotient	Ave. Hazard Quotient	RME Chronic Dose (mg/kg/day)	Ave. Chronic Dose (mg/kg/day)	Oral Slope Factor $(mg/kg/day)^{-1}$	RME Increased Cancer Risk	Ave. Increased Cancer Risk
Phenanthrene	610	332	2.29E-06	1.25E-06	NA	ND	ND	7.85E-07	4.27E-07	NA	ND	ND
Benzo(a)anthracene	6,200	460	2.33E-05	1.73E-06	NA	ND	ND	7.98E-06	5.92E-07	7.30E-01	6E-06	4E-07
Benzo(b)fluoranthene	6,900	583	2.59E-05	2.19E-06	NA	ND	ND	8.88E-06	7.50E-07	7.30E-01	6E-06	5E-07
Benzo(a)pyrene	3,300	392	1.24E-05	1.47E-06	NA	ND	ND	4.25E-06	5.05E-07	7.30E+00	3E-05	4E-06
Benzo(g,h,i)perylene	2300	2300	8.63E-06	8.63E-06	NA	ND	ND	2.96E-06	2.96E-06	NC	ND	ND
Dibenz(a,h)anthracene	630	630	2.37E-06	2.37E-06	NA	ND	ND	8.11E-07	8.11E-07	7.30E+00	6E-06	6E-06
Arsenic	9,000	5,400	1.01E-05	6.08E-06	3.00E-04	3.38E-02	2.03E-02	3.48E-06	2.09E-06	1.75E+00	6E-06	4E-06
Lead (2)	67,500	40,000	2.53E-05	1.50E-05	NA	ND	ND	8.69E-06	5.15E-06	NA	ND	ND
					Total Hazard Index	3.38E-02	2.03E-02			Total Increased Lifetime Cancer Risk	6E-05	1E-05

NOTES:
Hazard Quotient = Chronic Dose/Chronic Reference Dose
Increased Lifetime Cancer Risk = Chronic Dose x Oral Slope Factor
NA - Not Available
NC - Noncarcinogenic
ND - Not Determined

The oral slope factor for benzo(a)pyrene is used for carcinogenic PAHs with no published slope factor.
(1) Maximum detected concentration in surface soil, sediment, or subsoil.
(2) Reference dose values are not available for inorganic lead. Lead is evaluated using the EPA Biokinetic Uptake Model (Section 6.6).

TABLE 6-26. SUMMARY OF NONCARCINOGENIC RISKS FOR RESIDENTIAL SOIL EXPOSURE

Chemical of Concern	SOIL EXPOSURE HAZARD INDICES								TOTAL RESIDENTIAL SOIL EXPOSURE	
	Soil Ingestion (Adult)		Soil Ingestion (Child)		Dermal Absorption (Adult)		Dermal Absorption (Child)			
	RME	Average	RME	Average	RME	Average	RME	Average	RME	Average
Phenanthrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(a)anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(b)fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(a)pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(g,h,i)perylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibenz(a,h)anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	2.05E-02	1.23E-02	1.92E-01	1.15E-01	3.38E-02	2.03E-02	6.92E-02	4.15E-02	3.16E-01	1.89E-01
Lead	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
								TOTAL	3.16E-01	1.89E-01

TABLE 6-27. SUMMARY OF CARCINOGENIC RISKS FOR RESIDENTIAL SOIL EXPOSURE

Chemical of Concern	SOIL EXPOSURE INCREASED LIFETIME CANCER RISK								TOTAL RESIDENTIAL SOIL EXPOSURE	
	Soil Ingestion (Adult)		Soil Ingestion (Child)		Dermal Absorption (Adult)		Dermal Absorption (Child)			
	RME	Average	RME	Average	RME	Average	RME	Average	RME	Average
Phenanthrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(a)anthracene	1E-06	8E-08	2E-06	2E-07	6E-06	4E-07	3E-06	2E-07	1E-05	9E-07
Benzo(b)fluoranthene	1E-06	1E-07	3E-06	2E-07	6E-06	5E-07	3E-06	3E-07	1E-05	1E-06
Benzo(a)pyrene	6E-06	7E-07	1E-05	2E-06	3E-05	4E-06	2E-05	2E-06	7E-05	9E-06
Benzo(g,h,i)perylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibenz(a,h)anthracene	1E-06	1E-06	3E-06	3E-06	6E-06	6E-06	3E-06	3E-06	1E-05	1E-05
Arsenic	4E-06	2E-06	9E-06	5E-06	6E-06	4E-06	3E-06	2E-06	2E-05	1E-05
Lead	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
								TOTAL	1E-04	4E-05

6.5.6.1 Comparison to ARARs

Chemical-specific or chemical class-specific Federal MCLs are established for 12 of the 17 chemicals of concern detected in groundwater in the vicinity of the former FTA. A treatment technique requirement is established for lead in public drinking water supplies. Table 6-28 lists chemical-specific ARARs for chemicals of concern detected in groundwater.

The maximum concentrations for 1,1-dichloroethene and toluene exceed the Federal MCLs; the average values are less than the MCLs. Both the maximum and average values of the following chemicals of concern exceed the Federal MCLs: cis-1,2-dichloroethene, benzene, and tetrachloroethene.

The maximum and average values for heptachlor epoxide (0.016 and 0.010 μg/l, respectively) do not exceed the Federal MCL (0.2 μg/l), but do exceed the Virginia Groundwater Standard of 0.001 μg/l. The maximum and average values for gamma-chlordane (0.055 and 0.021 μg/l, respectively) do not exceed the Federal MCL for chlordane, but do exceed the Virginia Groundwater Standard (0.01 μg/l) and the Virginia Surface Water Standard (0.0058 μg/l) for chlordane. The site-specific values for alpha-BHC (maximum of 0.049 μg/l) do not exceed the Virginia Surface Water Standard of 7 μg/l for gamma-BHC.

The interim Federal MCL for arsenic is 50 μg/l. Virginia also uses this value for both the surface water and groundwater quality standards. The maximum and average site-specific values based on filtered data are both less than the interim standard.

The Federal MCL for lead has been dropped and a requirement for implementation of a treatment technique has been adopted in its place. The treatment technique must accomplish a lead concentration of 15 μg/l or less at the tap for public water supply systems. The Virginia groundwater standard is 50 μg/l, and the surface water standard for lead is 15μg/l. The maximum filtered lead concentration in groundwater at the former FTA is 10.5 μg/l.

TABLE 6-28

CHEMICAL-SPECIFIC ARARs FOR GROUNDWATER

Chemicals of Concern Detected in Groundwater	Maximum Detected Concentration (µg/l)	FEDERAL CRITERIA		STATE CRITERIA	
		USEPA PRIMARY DRINKING WATER STANDARDS (a)		Virginia Groundwater Standards (b) (µg/l)	Virginia Surface Water Standards (c) (µg/l)
		MCL (µg/l)	MCLG (µg/l)		
1,1-Dichloroethene	18	7	7	-	-
cis-1,2-Dichloroethene	3,000	70	70	-	-
Methylene Chloride	730	5	0	-	47
Chloroform	5	100	0	-	57
Benzene	120	5	0	-	12
Tetrachloroethene	64	5	0	-	318
Toluene	1,800	1000	1000	-	6800
Trimethylbenzene	700	-	-	-	-
Tetramethylbenzene	36	-	-	-	-
Phenanthrene	82	-	-	-	-
2-Methylnaphthalene	3,000	-	-	-	-
Naphthalene	2,000	-	-	-	-
alpha-BHC	0.049	-	-	-	7^
Heptachlor epoxide	0.016	0.2	0	0.001	0.0021**
gamma-Chlordane	0.055	2 *	0*	0.01*	0.0058*
Arsenic	11.1	50 (I)	50 (I)	50	50
Lead	10.5	TT (15)	0	50	15

(a) National Primary Drinking Water Standards, EPA 822-R-94-003, November 1994.
(b) Commonwealth of Virginia Groundwater Standards, VR680-21-04.3, May 1992.
(c) Commonwealth of Virginia Surface Water Standards with General, Statewide Application, VR680-21-01.14, May 1992.

TT = Treatment Technique requirement
I = Interim Standard
* Value given is for chlordane.
** Value given is for heptachlor.
^ Value given is for gamma-BHC.
- Standard not available or reported.

6.5.6.2 Noncarcinogenic Risk Due to Groundwater Exposure

The completed pathways for future groundwater exposure are ingestion, dermal absorption, and inhalation (during bathing). The potentially exposed population is residents, including adults and children (6 years of age and younger).

Dermal Absorption. The noncarcinogenic HIs for children and adults resulting from dermal exposure to contaminated groundwater exceed unity for both the average exposure and RME (Tables 6-29a and 6-29b). For the adult resident, the HIs are $1.34x10^{1}$ and 4.58, respectively, for the RME and average exposure. The HIs for the child resident are $3.25x10^{1}$ and $1.11x10^{1}$ for the RME and average exposure.

The majority of the noncarcinogenic risk for dermal absorption results from exposure to trimethylbenzene. Cis-1,2-dichloroethene and naphthalene also contribute significantly to the risk under the RMEs.

Ingestion. The noncarcinogenic HIs for children and adults resulting from ingestion of contaminated groundwater exceed the level of concern by a factor of three (Tables 6-30a and 6-30b) for both the RME and average exposure. For the child's RME, only chloroform, heptachlor epoxide, and gamma-chlordane do not contribute significantly to the risk. Under the child's RME and average exposure, cis-1,2-dichloroethene, trimethylbenzene, naphthalene, and arsenic provide the greatest risk contributions (Table 6-30a).

For the adult's RME, 1,1-dichloroethene, chloroform, heptachlor epoxide, and gamma-chlordane do not contribute significantly to the overall noncarcinogenic risk. Under both the RME and the average exposure scenario, cis-1,2-dichloroethene, trimethylbenzene, and arsenic contribute the greatest portion of noncarcinogenic risk.

Inhalation. The noncarcinogenic HIs for children and adults resulting from inhalation of contaminated groundwater during bathing were less than unity (Tables 6-31a and 6-31b) for both the RME and average exposure. Only those chemicals of concern with volatilization potential based on the Henry's Law Constants were evaluated.

TABLE 6-29a. RISK FROM DERMAL ABSORPTION OF GROUNDWATER - FUTURE CHRONIC EXPOSURE (CHILD)

Chemical of Concern	Max. Detected Conc. (µg/l)	Ave. Detected Conc. (µg/l)	Noncarcinogenic					Carcinogenic				
			RME Chronic Dose (mg/kg/day)	Ave. Chronic Dose (mg/kg/day)	Chronic Oral Reference Dose (mg/kg/day)	RME Hazard Quotient	Ave. Hazard Quotient	RME Chronic Dose (mg/kg/day)	Ave. Chronic Dose (mg/kg/day)	Oral Slope Factor $(mg/kg/day)^{-1}$	RME Increased Cancer Risk	Ave. Increased Cancer Risk
1,1-Dichloroethene	18	2.04	4.33E-05	4.90E-06	9.00E-03	4.81E-03	5.45E-04	3.71E-06	4.20E-07	6.00E-01	2E-06	3E-07
cis-1,2-Dichloroethene	3,000	509	4.51E-03	7.65E-04	1.00E-02	4.51E-01	7.65E-02	3.86E-04	6.55E-05	NC	ND	ND
Methylene Chloride	730	93.1	4.94E-04	6.29E-05	6.00E-02	8.23E-03	1.05E-03	4.23E-05	5.39E-06	7.50E-03	3E-07	4E-08
Chloroform	5	1.24	6.69E-06	1.66E-06	1.00E-02	6.69E-04	1.66E-04	5.73E-07	1.42E-07	6.10E-03	3E-09	9E-10
Benzene	120	15.1	3.79E-04	4.76E-05	NA	ND	ND	3.24E-05	4.08E-06	2.90E-02	9E-07	1E-07
Tetrachloroethene	64	6.06	4.62E-04	4.37E-05	1.00E-02	4.62E-02	4.37E-03	3.96E-05	3.75E-06	5.20E-02	2E-06	2E-07
Toluene	1,800	115	1.22E-02	7.77E-04	2.00E-01	6.08E-02	3.89E-03	1.04E-03	6.66E-05	NC	ND	ND
Trimethylbenzene	700	269	7.78E-03	2.99E-03	5.00E-04	1.56E+01	5.98E+00	6.67E-04	2.56E-04	NC	ND	ND
Tetramethylbenzene	36	32	4.00E-04	3.56E-04	NA	ND	ND	3.43E-05	3.05E-05	NA	ND	ND
Phenanthrene	82	16.5	0.00E+00	0.00E+00	NA	ND	ND	0.00E+00	0.00E+00	NC	ND	ND
2-Methylnaphthalene	3,000	260	3.11E-02	2.70E-03	NA	ND	ND	2.67E-03	2.31E-04	NA	ND	ND
Naphthalene	2,000	18	2.07E-02	1.87E-04	4.00E-02	5.18E-01	4.66E-03	1.78E-03	1.60E-05	NC	ND	ND
alpha-BHC	0.049	0.047	1.03E-07	9.89E-08	NA	ND	ND	8.83E-09	8.47E-09	6.30E+00	6E-08	5E-08
Heptachlor epoxide	0.016	0.010	2.64E-08	1.65E-08	1.30E-05	2.03E-03	1.27E-03	2.27E-09	1.42E-09	9.00E+00	2E-08	1E-08
gamma-Chlordane	0.055	0.021	8.26E-09	3.15E-09	6.00E-05	1.38E-04	5.26E-05	7.08E-10	2.70E-10	1.30E+00	9E-10	4E-10
Arsenic	11.1	4.43	1.67E-06	6.66E-07	3.00E-04	5.56E-03	2.22E-03	1.43E-07	5.70E-08	1.75E+00	3E-07	1E-07
Lead (1)	10.5	3.33	1.58E-06	5.00E-07	NA	ND	ND	1.35E-07	4.29E-08	NA	ND	ND
					Total Hazard Index	1.67E+01	6.08E+00			Total Increased Lifetime Cancer Risk	6E-06	8E-07

NOTES:
Hazard Quotient = Chronic Dose/Chronic Reference Dose
Increased Lifetime Cancer Risk = Chronic Dose x Oral Slope Factor
NA - Not Available
NC - Noncarcinogenic
ND - Not Determined
(1) Reference dose value is not available for inorganic lead.
Lead is evaluated using the EPA Biokinetic Uptake Model (Section 6.6).

TABLE 6-29b. RISK FROM DERMAL ABSORPTION OF GROUNDWATER - FUTURE CHRONIC EXPOSURE (ADULT)

Chemical of Concern	Max. Detected Conc. (µg/l)	Ave. Detected Conc. (µg/l)	Noncarcinogenic					Carcinogenic				
			RME Chronic Dose (mg/kg/day)	Ave. Chronic Dose (mg/kg/day)	Chronic Oral Reference Dose (mg/kg/day)	RME Hazard Quotient	Ave. Hazard Quotient	RME Chronic Dose (mg/kg/day)	Ave. Chronic Dose (mg/kg/day)	Oral Slope Factor $(mg/kg/day)^{-1}$	RME Increased Cancer Risk	Ave. Increased Cancer Risk
1,1-Dichloroethene	18	2.04	1.79E-05	2.03E-06	9.00E-03	1.99E-03	2.25E-04	6.14E-06	6.96E-07	6.00E-01	4E-06	4E-07
cis-1,2-Dichloroethene	3,000	509	1.86E-03	3.16E-04	1.00E-02	1.86E-01	3.16E-02	6.39E-04	1.08E-04	NC	ND	ND
Methylene Chloride	730	93.1	2.04E-04	2.60E-05	6.00E-02	3.40E-03	4.34E-04	7.00E-05	8.93E-06	7.50E-03	5E-07	7E-08
Chloroform	5	1.24	2.77E-06	6.86E-07	1.00E-02	2.77E-04	6.86E-05	9.48E-07	2.35E-07	6.10E-03	6E-09	1E-09
Benzene	120	15.1	1.57E-04	1.97E-05	NA	ND	ND	5.37E-05	6.76E-06	2.90E-02	2E-06	2E-07
Tetrachloroethene	64	6.06	1.91E-04	1.81E-05	1.00E-02	1.91E-02	1.81E-03	6.55E-05	6.20E-06	5.20E-02	3E-06	3E-07
Toluene	1,800	115	5.03E-03	3.22E-04	2.00E-01	2.52E-02	1.61E-03	1.73E-03	1.10E-04	NC	ND	ND
Trimethylbenzene	700	269	3.22E-03	1.24E-03	5.00E-04	6.44E+00	2.47E+00	1.10E-03	4.24E-04	NC	ND	ND
Tetramethylbenzene	36	32	1.66E-04	1.47E-04	NA	ND	ND	5.68E-05	5.05E-05	NA	ND	ND
Phenanthrene	82	16.5	0.00E+00	0.00E+00	NA	ND	ND	0.00E+00	0.00E+00	NC	ND	ND
2-Methylnaphthalene	3,000	260	1.29E-02	1.12E-03	NA	ND	ND	4.41E-03	3.82E-04	NA	ND	ND
Naphthalene	2,000	18	8.58E-03	7.72E-05	4.00E-02	2.14E-01	1.93E-03	2.94E-03	2.65E-05	NC	ND	ND
alpha-BHC	0.049	0.047	4.26E-08	4.09E-08	NA	ND	ND	1.46E-08	1.40E-08	6.30E+00	9E-08	9E-08
Heptachlor epoxide	0.016	0.010	1.09E-08	6.84E-09	1.30E-05	8.42E-04	5.26E-04	3.75E-09	2.34E-09	9.00E+00	3E-08	2E-08
gamma-Chlordane	0.055	0.021	3.42E-09	1.31E-09	6.00E-05	5.70E-05	2.18E-05	1.17E-09	4.48E-10	1.30E+00	2E-09	6E-10
Arsenic	11.1	4.43	6.90E-07	2.75E-07	3.00E-04	2.30E-03	9.18E-04	2.37E-07	9.44E-08	1.75E+00	4E-07	2E-07
Lead (1)	10.5	3.33	6.53E-07	2.07E-07	NA	ND	ND	2.24E-07	7.10E-08	NA	ND	ND
					Total Hazard Index	6.89E+00	2.51E+00			Total Increased Lifetime Cancer Risk	1E-05	1E-06

NOTES:
Hazard Quotient = Chronic Dose/Chronic Reference Dose
Increased Lifetime Cancer Risk = Chronic Dose x Oral Slope Factor
NA - Not Available
NC - Noncarcinogenic
ND - Not Determined
(1) Reference dose value is not available for inorganic lead.
Lead is evaluated using the EPA Biokinetic Uptake Model (Section 6.6).

TABLE 6-30a. RISK FROM INGESTION OF GROUNDWATER - FUTURE CHRONIC EXPOSURE (CHILD)

Chemical of Concern	Max. Detected Conc. (µg/l)	Ave. Detected Conc. (µg/l)	Noncarcinogenic					Carcinogenic				
			RME Chronic Dose (mg/kg/day)	Ave. Chronic Dose (mg/kg/day)	Chronic Oral Reference Dose (mg/kg/day)	RME Hazard Quotient	Ave. Hazard Quotient	RME Chronic Dose (mg/kg/day)	Ave. Chronic Dose (mg/kg/day)	Oral Slope Factor $(mg/kg/day)^{-1}$	RME Increased Cancer Risk	Ave. Increased Cancer Risk
1,1-Dichloroethene	18	2.04	1.15E-03	1.30E-04	9.00E-03	1.28E-01	1.45E-02	9.86E-05	1.12E-05	6.00E-01	6E-05	7E-06
cis-1,2-Dichloroethene	3,000	509	1.92E-01	3.25E-02	1.00E-02	1.92E+01	3.25E+00	1.64E-02	2.79E-03	NC	ND	ND
Methylene Chloride	730	93.1	4.67E-02	5.95E-03	6.00E-02	7.78E-01	9.92E-02	4.00E-03	5.10E-04	7.50E-03	3E-05	4E-06
Chloroform	5	1.24	3.20E-04	7.93E-05	1.00E-02	3.20E-02	7.93E-03	2.74E-05	6.79E-06	6.10E-03	2E-07	4E-08
Benzene	120	15.1	7.67E-03	9.65E-04	NA	ND	ND	6.58E-04	8.27E-05	2.90E-02	2E-05	2E-06
Tetrachloroethene	64	6.06	4.09E-03	3.87E-04	1.00E-02	4.09E-01	3.87E-02	3.51E-04	3.32E-05	5.20E-02	2E-05	2E-06
Toluene	1,800	115	1.15E-01	7.35E-03	2.00E-01	5.75E-01	3.68E-02	9.86E-03	6.30E-04	NC	ND	ND
Trimethylbenzene	700	269	4.47E-02	1.72E-02	5.00E-04	8.95E+01	3.44E+01	3.84E-03	1.47E-03	NC	ND	ND
Tetramethylbenzene	36	32	2.30E-03	2.05E-03	NA	ND	ND	1.97E-04	1.75E-04	NA	ND	ND
Phenanthrene	82	16.5	5.24E-03	1.05E-03	NA	ND	ND	4.49E-04	9.04E-05	NC	ND	ND
2-Methylnaphthalene	3,000	260	1.92E-01	1.66E-02	NA	ND	ND	1.64E-02	1.42E-03	NA	ND	ND
Naphthalene	2,000	18	1.28E-01	1.15E-03	4.00E-02	3.20E+00	2.88E-02	1.10E-02	9.86E-05	NC	ND	ND
alpha-BHC	0.049	0.047	3.13E-06	3.00E-06	NA	ND	ND	2.68E-07	2.58E-07	6.30E+00	2E-06	2E-06
Heptachlor epoxide	0.016	0.010	1.02E-06	6.39E-07	1.30E-05	7.87E-02	4.92E-02	8.77E-08	5.48E-08	9.00E+00	8E-07	5E-07
gamma-Chlordane	0.055	0.021	3.52E-06	1.34E-06	6.00E-05	5.86E-02	2.24E-02	3.01E-07	1.15E-07	1.30E+00	4E-07	1E-07
Arsenic	11.1	4.43	7.10E-04	2.83E-04	3.00E-04	2.37E+00	9.44E-01	6.08E-05	2.43E-05	1.75E+00	1E-04	4E-05
Lead (1)	10.5	3.33	6.71E-04	2.13E-04	NA	ND	ND	5.75E-05	1.82E-05	NA	ND	ND
					Total Hazard Index	1.16E+02	3.89E+01			Total Increased Lifetime Cancer Risk	2E-04	6E-05

NOTES:
Hazard Quotient = Chronic Dose/Chronic Reference Dose
Increased Lifetime Cancer Risk = Chronic Dose x Oral Slope Factor
NA - Not Available
NC - Noncarcinogenic
ND - Not Determined
(1) Reference dose value is not available for inorganic lead.
Lead is evaluated using the EPA Biokinetic Uptake Model (Section 6.6).

TABLE 6-30b. RISK FROM INGESTION OF GROUNDWATER - FUTURE CHRONIC EXPOSURE (ADULT)

Chemical of Concern	Max. Detected Conc. (µg/l)	Ave. Detected Conc. (µg/l)	Noncarcinogenic					Carcinogenic				
			RME Chronic Dose (mg/kg/day)	Ave. Chronic Dose (mg/kg/day)	Chronic Oral Reference Dose (mg/kg/day)	RME Hazard Quotient	Ave. Hazard Quotient	RME Chronic Dose (mg/kg/day)	Ave. Chronic Dose (mg/kg/day)	Oral Slope Factor $(mg/kg/day)^{-1}$	RME Increased Cancer Risk	Ave. Increased Cancer Risk
1,1-Dichloroethene	18	2.04	4.93E-04	5.59E-05	9.00E-03	5.48E-02	6.21E-03	1.69E-04	1.92E-05	6.00E-01	1E-04	1E-05
cis-1,2-Dichloroethene	3,000	509	8.22E-02	1.39E-02	1.00E-02	8.22E+00	1.39E+00	2.82E-02	4.78E-03	NC	ND	ND
Methylene Chloride	730	93.1	2.00E-02	2.55E-03	6.00E-02	3.33E-01	4.25E-02	6.86E-03	8.75E-04	7.50E-03	5E-05	7E-06
Chloroform	5	1.24	1.37E-04	3.40E-05	1.00E-02	1.37E-02	3.40E-03	4.70E-05	1.16E-05	6.10E-03	3E-07	7E-08
Benzene	120	15.1	3.29E-03	4.14E-04	NA	ND	ND	1.13E-03	1.42E-04	2.90E-02	3E-05	4E-06
Tetrachloroethene	64	6.06	1.75E-03	1.66E-04	1.00E-02	1.75E-01	1.66E-02	6.01E-04	5.69E-05	5.20E-02	3E-05	3E-06
Toluene	1,800	115	4.93E-02	3.15E-03	2.00E-01	2.47E-01	1.58E-02	1.69E-02	1.08E-03	NC	ND	ND
Trimethylbenzene	700	269	1.92E-02	7.37E-03	5.00E-04	3.84E+01	1.47E+01	6.58E-03	2.53E-03	NC	ND	ND
Tetramethylbenzene	36	32	9.86E-04	8.77E-04	NA	ND	ND	3.38E-04	3.01E-04	NA	ND	ND
Phenanthrene	82	16.5	2.25E-03	4.52E-04	NA	ND	ND	7.70E-04	1.55E-04	NC	ND	ND
2-Methylnaphthalene	3,000	260	8.22E-02	7.12E-03	NA	ND	ND	2.82E-02	2.44E-03	NA	ND	ND
Naphthalene	2,000	18	5.48E-02	4.93E-04	4.00E-02	1.37E+00	1.23E-02	1.88E-02	1.69E-04	NC	ND	ND
alpha-BHC	0.049	0.047	1.34E-06	1.29E-06	NA	ND	ND	4.60E-07	4.41E-07	6.30E+00	3E-06	3E-06
Heptachlor epoxide	0.016	0.010	4.38E-07	2.74E-07	1.30E-05	3.37E-02	2.11E-02	1.50E-07	9.39E-08	9.00E+00	1E-06	8E-07
gamma-Chlordane	0.055	0.021	1.51E-06	5.75E-07	6.00E-05	2.51E-02	9.59E-03	5.17E-07	1.97E-07	1.30E+00	7E-07	3E-07
Arsenic	11.1	4.43	3.04E-04	1.21E-04	3.00E-04	1.01E+00	4.05E-01	1.04E-04	4.16E-05	1.75E+00	2E-04	7E-05
Lead (1)	10.5	3.33	2.88E-04	9.12E-05	NA	ND	ND	9.86E-05	3.13E-05	NA	ND	ND
					Total Hazard Index	4.98E+01	1.67E+01			Total Increased Lifetime Cancer Risk	4E-04	1E-04

NOTES:
Hazard Quotient = Chronic Dose/Chronic Reference Dose
Increased Lifetime Cancer Risk = Chronic Dose x Oral Slope Factor
NA - Not Available
NC - Noncarcinogenic
ND - Not Determined
(1) Reference dose value is not available for inorganic lead.
Lead is evaluated using the EPA Biokinetic Uptake Model (Section 6.6).

TABLE 6-31a. RISK FROM INHALATION OF GROUNDWATER - FUTURE CHRONIC EXPOSURE (CHILD)

			Noncarcinogenic					Carcinogenic				
Chemical	Max. Detected Conc. (µg/l)	Ave. Detected Conc. (µg/l)	RME Chronic Dose (mg/kg/day)	Ave. Chronic Dose (mg/kg/day)	Inhalation Reference Dose (mg/kg/day)	RME Hazard Quotient	Ave. Hazard Quotient	RME Chronic Dose (mg/kg/day)	Ave. Chronic Dose (mg/kg/day)	Inhalation Slope Factor $(mg/kg/day)^{-1}$	RME Increased Cancer Risk	Ave. Increased Cancer Risk
1,1-Dichloroethene	18	2.04	2.36E-05	2.68E-06	ND	NA	NA	2.03E-06	2.30E-07	1.75E-01	4E-07	4E-08
cis-1,2-Dichloroethene	3000	509	3.94E-03	6.69E-04	ND	NA	NA	3.38E-04	5.73E-05	ND	NA	NA
Methylene Chloride	730	93.1	9.59E-04	1.22E-04	8.57E-01	1.12E-03	1.43E-04	8.22E-05	1.05E-05	1.64E-03	1E-07	2E-08
Chloroform	5	1.24	6.57E-06	1.63E-06	ND	NA	NA	5.63E-07	1.40E-07	8.05E-02	5E-08	1E-08
Benzene	120	15.1	1.58E-04	1.98E-05	1.71E-03	9.22E-02	1.16E-02	1.35E-05	1.70E-06	2.90E-02	4E-07	5E-08
Tetrachloroethene	64	6.06	8.41E-05	7.96E-06	ND	NA	NA	7.21E-06	6.82E-07	2.03E-03	1E-08	1E-09
Toluene	1800	115	2.36E-03	1.51E-04	1.14E-01	2.07E-02	1.33E-03	2.03E-04	1.29E-05	ND	NA	NA
Trimethylbenzene	700	269	9.19E-04	3.53E-04	ND	NA	NA	7.88E-05	3.03E-05	ND	NA	NA
Tetramethylbenzene	36	32	4.73E-05	4.20E-05	ND	NA	NA	4.05E-06	3.60E-06	ND	NA	NA
					Total Hazard Index	1.14E-01	1.31E-02			Total Increased Lifetime Cancer Risk	9E-07	1E-07

NOTES:
Hazard Quotient = Chronic Dose/Reference Dose
Increased Lifetime Cancer Risk = Chronic Dose x Inhalation Slope Factor
NA = Not Available
ND = Not Determined
Only chemicals of concern with potential to volatize (based on the Henry's Constant) were evaluated.

TABLE 6-31b. RISK FROM INHALATION OF GROUNDWATER - FUTURE CHRONIC EXPOSURE (ADULT)

			Noncarcinogenic					Carcinogenic				
Chemical	Max. Detected Conc. (µg/l)	Ave. Detected Conc. (µg/l)	RME Chronic Dose (mg/kg/day)	Ave. Chronic Dose (mg/kg/day)	Inhalation Reference Dose (mg/kg/day)	RME Hazard Quotient	Ave. Hazard Quotient	RME Chronic Dose (mg/kg/day)	Ave. Chronic Dose (mg/kg/day)	Inhalation Slope Factor $(mg/kg/day)^{-1}$	RME Increased Cancer Risk	Ave. Increased Cancer Risk
1,1-Dichloroethene	18	2.04	6.33E-06	7.18E-07	NA	ND	ND	2.17E-06	2.46E-07	1.75E-01	4E-07	4E-08
cis-1,2-Dichloroethene	3000	509	1.06E-03	1.79E-04	NA	ND	ND	3.62E-04	6.14E-05	NA	ND	ND
Methylene Chloride	730	93.1	2.57E-04	3.28E-05	8.57E-01	3.00E-04	3.82E-05	8.81E-05	1.12E-05	1.64E-03	1E-07	2E-08
Chloroform	5	1.24	1.76E-06	4.36E-07	NA	ND	ND	6.03E-07	1.50E-07	8.05E-02	5E-08	1E-08
Benzene	120	15.1	4.22E-05	5.31E-06	1.71E-03	2.47E-02	3.11E-03	1.45E-05	1.82E-06	2.90E-02	4E-07	5E-08
Tetrachloroethene	64	6.06	2.25E-05	2.13E-06	NA	ND	ND	7.72E-06	7.31E-07	2.03E-03	2E-08	1E-09
Toluene	1800	115	6.33E-04	4.05E-05	1.14E-01	5.56E-03	3.55E-04	2.17E-04	1.39E-05	NA	ND	ND
Trimethylbenzene	700	269	2.46E-04	9.46E-05	NA	ND	ND	8.44E-05	3.25E-05	NA	ND	ND
Tetramethylbenzene	36	32	1.27E-05	1.13E-05	NA	ND	ND	4.34E-06	3.86E-06	NA	ND	ND
					Total Hazard Index	3.05E-02	3.50E-03			Total Increased Lifetime Cancer Risk	1E-06	1E-07

NOTES:
Hazard Quotient = Chronic Dose/Reference Dose
Increased Lifetime Cancer Risk = Chronic Dose x Inhalation Slope Factor
NA = Not Available
ND = Not Determined
Only chemicals of concern with potential to volatize (based on the Henry's Constant) were evaluated.

Noncarcinogenic Risk Summary. Table 6-32 provides a summary of the HIs for exposure to groundwater under the future land use scenario. When summed across the ingestion, dermal, and inhalation pathways, the total HIs for cis-1,2-dichloroethene, methylene chloride, trimethylbenzene, naphthalene, and arsenic exceed unity for the RME. Under the average exposure, the total HIs for cis-1,2-dichloroethene, trimethylbenzene, arsenic, and lead exceed unity. These contaminants of concern provide the most significant contributions to noncarcinogenic risk for groundwater exposure.

6.5.6.3 Carcinogenic Risk Due to Groundwater Exposure

The carcinogenic risk due to groundwater exposure results from the dermal absorption, ingestion, and inhalation pathways. The potentially exposed population includes children and adults in a residential scenario.

Dermal Absorption. The carcinogenic risk resulting from a child's dermal exposure to contaminated groundwater (Table 6-29a) exceeds the $1x10^{-6}$ de minimus level for the RME ($6x10^{-6}$), and is less than the de minimus level for the average exposure ($8x10^{-7}$). An adult's carcinogenic risk from the dermal absorption pathway is $1x10^{-5}$ for the RME and $1x10^{-6}$ for the average exposure (Table 6-29b). The most significant portions of the overall risk result from exposure to 1,1-dichloroethene, benzene, and tetrachloroethene.

Ingestion. The carcinogenic risk for ingestion of contaminated groundwater by a child (Table 6-30a) exceeds the de minimus level of $1x10^{-6}$ for both the RME ($2x10^{-4}$) and the average exposure ($6x10^{-5}$). Arsenic provides the greatest contribution to the carcinogenic risk; other significant contributors are 1,1-dichloroethene, methylene chloride, benzene, tetrachloroethene, and alpha-BHC.

The carcinogenic risk resulting from an adult's exposure via ingestion of contaminated groundwater (Table 6-30b) exceeds the $1x10^{-6}$ de minimus risk level for both the RME ($4x10^{-4}$) and the average exposure ($1x10^{-4}$). Arsenic again contributes the greatest portion of the risk. Other significant contributions to the risk result from exposure to 1,1-dichloroethene, methylene chloride, benzene, tetrachloroethene, alpha-BHC, and heptachlor epoxide.

TABLE 6-32. SUMMARY OF NONCARCINOGENIC HAZARDS FOR RESIDENTIAL EXPOSURE TO GROUNDWATER

Chemical of Concern	GROUNDWATER EXPOSURE HAZARD INDICES												TOTAL RESIDENTIAL GROUNDWATER EXPOSURE	
	Ingestion (Adult)		Ingestion (Child)		Dermal Absorption (Adult)		Dermal Absorption (Child)		Inhalation (Adult)		Inhalation (Child)			
	RME	Average	RME	Average	RME	Average	RME	Average	RME	Average	RME	Average	RME	Average
1,1-Dichloroethene	5.48E-02	6.21E-03	1.28E-01	1.45E-02	1.99E-03	2.25E-04	4.81E-03	5.45E-04	ND	ND	ND	ND	1.89E-01	2.15E-02
cis-1,2-Dichloroethene	8.22E+00	1.39E+00	1.92E+01	3.25E+00	1.86E-01	3.16E-02	4.51E-01	7.65E-02	ND	ND	ND	ND	2.80E+01	4.76E+00
Methylene Chloride	3.33E-01	4.25E-02	7.78E-01	9.92E-02	3.40E-03	4.34E-04	8.23E-03	1.05E-03	3.00E-04	3.82E-05	1.12E-03	1.43E-04	1.12E+00	1.43E-01
Chloroform	1.37E-02	3.40E-03	3.20E-02	7.93E-03	2.77E-04	6.86E-05	6.69E-04	1.66E-04	ND	ND	ND	ND	4.66E-02	1.16E-02
Benzene	ND	ND	ND	ND	ND	ND	ND	ND	2.47E-02	3.11E-03	9.22E-02	1.16E-02	1.17E-01	1.47E-02
Tetrachloroethene	1.75E-01	1.66E-02	4.09E-01	3.87E-02	1.91E-02	1.81E-03	4.62E-02	4.37E-03	ND	ND	ND	ND	6.50E-01	6.15E-02
Toluene	2.47E-01	1.58E-02	5.75E-01	3.68E-02	2.52E-02	1.61E-03	6.08E-02	3.89E-03	5.56E-03	3.55E-04	2.07E-02	1.33E-03	9.34E-01	5.97E-02
Trimethylbenzene	3.84E+01	1.47E+01	8.95E+01	3.44E+01	6.44E+00	2.47E+00	1.56E+01	5.98E+00	ND	ND	ND	ND	1.50E+02	5.76E+01
Tetramethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	ND	ND	ND	ND	ND	ND	ND	ND	ND (2)	ND (2)	ND (2)	ND (2)	ND	ND
2-Methylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND (2)	ND (2)	ND (2)	ND (2)	ND	ND
Naphthalene	1.37E+00	1.23E-02	3.20E+00	2.88E-02	2.14E-01	1.93E-03	5.18E-01	4.66E-03	ND (2)	ND (2)	ND (2)	ND (2)	5.30E+00	4.77E-02
alpha-BHC	ND	ND	ND	ND	ND	ND	ND	ND	ND (2)	ND (2)	ND (2)	ND (2)	ND	ND
Heptachlor epoxide	3.37E-02	2.11E-02	7.87E-02	4.92E-02	8.42E-04	5.26E-04	2.03E-03	1.27E-03	ND (2)	ND (2)	ND (2)	ND (2)	1.15E-01	7.20E-02
gamma-Chlordane	2.51E-02	9.59E-03	5.86E-02	2.24E-02	5.70E-05	2.18E-05	1.38E-04	5.26E-05	ND (2)	ND (2)	ND (2)	ND (2)	8.39E-02	3.20E-02
Arsenic	1.01E+00	4.05E-01	2.37E+00	9.44E-01	2.30E-03	9.18E-04	5.56E-03	2.22E-03	ND (2)	ND (2)	ND (2)	ND (2)	3.39E+00	1.35E+00
Lead (1)	ND	ND	ND	ND	ND	ND	ND	ND	ND (2)	ND (2)	ND (2)	ND (2)	ND	ND
TOTAL HAZARD INDEX	**4.98E+01**	**1.67E+01**	**1.16E+02**	**3.89E+01**	**6.89E+00**	**2.51E+00**	**1.67E+01**	**6.08E+00**	**3.05E-02**	**3.50E-03**	**1.14E-01**	**1.31E-02**	**1.90E+02**	**6.42E+01**

Notes:
ND = Not Determined
(1) Reference dose value is not available for inorganic lead. Lead is evaluated separately using the EPA Biokinetic Uptake Model (Section 6.6).
(2) Chemicals are only considered for groundwater inhalation if the Henry's Law Constant is 1 x 10^{-5} atm-m^3/mol or greater and the molecular weight is less than 200 g/mol.

Inhalation. The carcinogenic risk for the inhalation of groundwater during bathing is presented in Tables 6-31a and 6-31b. The carcinogenic risk for a child (Table 6-31a) is below the de minimus level of $1x10^{-6}$ for both the RME ($9x10^{-7}$) and the average exposure ($1x10^{-7}$). The carcinogenic risk resulting from an adult's exposure via inhalation of contaminated groundwater (Table 6-31b) is essentially at the de minimus level for the RME ($1x10^{-6}$), but is below the de minimus level for the average exposure ($1x10^{-7}$). Benzene and 1,1-dichloroethene contribute the greatest portion of the risk.

Carcinogenic Risk. Table 6-33 provides a summary of the increased lifetime cancer risk associated with exposure to groundwater under the future land use scenario. The total increased lifetime cancer risk summed across all pathways and chemicals is $7x10^{-4}$ for the RME and $2x10^{-4}$ for the average exposure. Of the carcinogenic chemicals of concern, chloroform and gamma-chlordane do not contribute significantly to the carcinogenic risk under the RME and average exposures scenario. The significant contributions under the RME result from exposure to 1,1-dichloroethene, methylene chloride, tetrachloroethene, alpha-BHC, heptachlor epoxide, and arsenic.

6.6 RESULTS OF LEAD BIOKINETIC UPTAKE MODEL EVALUATION

Lead exposure is typically measured and reported in terms of blood lead levels (μg lead/deciliter (dl) blood) in the scientific literature. Blood concentrations are associated with clinical signs of toxicity. Similarly, lead exposure levels associated with toxic endpoints are reported in terms of blood lead levels. The U.S. EPA has developed a biokinetic uptake model for the personal computer which can be used to estimate blood lead levels in children from 0 to 84 months of age (U.S. EPA, 1994a). Site-specific information (e.g., site-specific lead concentrations in soil, air, house dust, and drinking water) can be incorporated into the model along with well documented default settings. The lead biokinetic uptake model is used to estimate the lead exposure which may be experienced by a child under a future residential exposure scenario at the former FTA. The site-specific groundwater, sediment, and soil lead concentrations are evaluated using the biokinetic uptake model presented in Appendix G.

Young children are more sensitive to the toxic effects of lead than older children and adults. Concentrations of lead in environmental media which do not contribute to an increase in blood lead

TABLE 6-33. SUMMARY OF CARCINOGENIC RISKS FOR RESIDENTIAL EXPOSURE TO GROUNDWATER

Chemical of Concern	GROUNDWATER EXPOSURE INCREASED LIFETIME CANCER RISK												TOTAL RESIDENTIAL GROUNDWATER EXPOSURE	
	Ingestion (Adult)		Ingestion (Child)		Dermal Absorption (Adult)		Dermal Absorption (Child)		Inhalation (Adult)		Inhalation (Child)			
	RME	Average	RME	Average	RME	Average	RME	Average	RME	Average	RME	Average	RME	Average
1,1-Dichloroethene	1E-04	1E-05	6E-05	7E-06	4E-06	4E-07	2E-06	3E-07	4E-07	4E-08	4E-07	4E-08	2E-04	2E-05
cis-1,2-Dichloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	5E-05	7E-06	3E-05	4E-06	5E-07	7E-08	3E-07	4E-08	1E-07	2E-08	1E-07	2E-08	8E-05	1E-05
Chloroform	3E-07	7E-08	2E-07	4E-08	6E-09	1E-09	3E-09	9E-10	5E-08	1E-08	5E-08	1E-08	6E-07	1E-07
Benzene	3E-05	4E-06	2E-05	2E-06	2E-06	2E-07	9E-07	1E-07	4E-07	5E-08	4E-07	5E-08	6E-05	7E-06
Tetrachloroethene	3E-05	3E-06	2E-05	2E-06	3E-06	3E-07	2E-06	2E-07	2E-08	1E-09	1E-08	1E-09	5E-05	5E-06
Toluene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trimethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetramethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	ND	ND	ND	ND	ND	ND	ND	ND	ND (2)	ND (2)	ND (2)	ND (2)	ND	ND
2-Methylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND (2)	ND (2)	ND (2)	ND (2)	ND	ND
Naphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND (2)	ND (2)	ND (2)	ND (2)	ND	ND
alpha-BHC	3E-06	3E-06	2E-06	2E-06	9E-08	9E-08	6E-08	5E-08	ND (2)	ND (2)	ND (2)	ND (2)	5E-06	5E-06
Heptachlor epoxide	1E-06	8E-07	8E-07	5E-07	3E-08	2E-08	2E-08	1E-08	ND (2)	ND (2)	ND (2)	ND (2)	2E-06	1E-06
gamma-Chlordane	7E-07	3E-07	4E-07	1E-07	2E-09	6E-10	9E-10	4E-10	ND (2)	ND (2)	ND (2)	ND (2)	1E-06	4E-07
Arsenic	2E-04	7E-05	1E-04	4E-05	4E-07	2E-07	3E-07	1E-07	ND (2)	ND (2)	ND (2)	ND (2)	3E-04	1E-04
Lead (1)	ND	ND	ND	ND	ND	ND	ND	ND	ND (2)	ND (2)	ND (2)	ND (2)	ND	ND
TOTAL INCREASED LIFETIME CANCER RISK	**4E-04**	**1E-04**	**2E-04**	**6E-05**	**1E-05**	**1E-06**	**6E-06**	**8E-07**	**1E-06**	**1E-07**	**9E-07**	**1E-07**	**7E-04**	**2E-04**

Notes:
ND = Not Determined
(1) *Reference dose value is not available for inorganic lead.* Lead is evaluated separately using the EPA Biokinetic Uptake Model (Section 6.6).
(2) Chemicals are only considered for groundwater inhalation if the Henry's Law Constant is 1 x 10^{-5} atm-m^3/mol or greater and the molecular weight is less than 200 g/mol.

concentrations in young children (as predicted by the biokinetic uptake model) are also considered to be of no consequence to adults. The potential toxicity of lead concentrations detected onsite is evaluated by comparing blood lead levels predicted by the U.S. EPA lead biokinetic uptake model (Appendix G) to the Centers for Disease Control (CDC) recommendation that environmental conditions associated with blood lead levels exceeding 10 μg lead/dl blood be avoided, as concentrations above this level may be associated with toxic effects (ATSDR, 1988a).

The range within which the earliest signs of adverse effects such as neurotoxicity may be observed in young children is considered to be from 10 to 25 μg lead/dl blood. The CDC issued a statement on Childhood Lead Poisoning in 1991 which identified a hierarchy of child blood levels and associated clinical and community actions (CDC, 1991). Child blood lead concentrations of 10 μg lead/dl blood should trigger community concern as to potential sources of exposure. Lead levels from 10 to 20 μg lead/dl blood may signal undue exposure and should stimulate appropriate community action. Children with blood lead levels between 20 and 49 μg/dl should be medically evaluated for appropriate intervention, and levels over 49 μg/dl should be considered a medical emergency.

No distinctions in these ranges of blood lead levels have been made between children and adults, although it is known that adults are less sensitive than children to the effects of lead exposure. With respect to interpolation of the expression "level of concern", it should be noted that such a level represents blood lead levels which warrant evaluation from a medical and/or regulatory governmental perspective. However, the threshold for expression of lead toxicity has not been well defined. The results of the U.S. EPA's uptake biokinetic model are typically interpreted based on the criterion that blood lead levels (estimated from site-specific information) should not exceed 10 μg/dl for more than five percent of children aged zero to seven years old.

Use of the lead uptake biokinetic model to evaluate potential exposure to lead at the former FTA indicates that the criterion value of 10 μg/dl blood lead level in more than five percent of the population is not exceeded when site-specific soil, sediment, and filtered groundwater lead concentrations are input to the model. Unfiltered groundwater lead concentrations are however associated with an exceedance of the criterion for blood lead level. The biokinetic uptake model calculates blood lead levels for children aged zero to seven years old. The potential for exposure and the relative sensitivity to the toxicity of lead will likely be lower for the adult receptor compared to a residential child receptor.

6.7 SUMMARY OF HUMAN HEALTH RISK ASSESSMENT RESULTS

6.7.1 Summary of Risk Assessment Results for Current Land Use Conditions

Under the current land use scenario, arsenic provides the most significant contribution to overall site risk due to exposure to soils and on-site sediment. Dibenz(a,h)anthracene also contributes significantly to the overall carcinogenic risk for these exposure routes. The U.S. EPA lead biokinetic uptake model does not indicate exceedance of the 10 μg lead/dl blood criterion for these exposure routes.

Arsenic. Arsenic was detected in one of four surface soil samples collected during the 1990 investigation at a level of 4400 μg/kg. The frequency of occurrence in the samples collected during the 1994 investigation is 100 percent for surface soils and sediment. Values range from 1400 to 2800 μg/kg in surface soil, and from 2100 to 9000 μg/kg in on-site sediment.

The average for eastern U.S. soils is 5100 μg/kg (Dragun and Chaisson, 1991). The levels detected at the former FTA are generally comparable to the reported average for U.S. soils. However, arsenic was not detected in WFF background soils samples.

The increased lifetime excess cancer calculated for arsenic exposure under the RME ($8x10^{-6}$) and average exposure ($5x10^{-6}$) exceed the $1x10^{-6}$ de minimus level, but fall within the range of $1x10^{-4}$ to $1x10^{-6}$ which may be acceptable within the context of the land use.

Dibenz(a,h)anthracene. As with arsenic, the carcinogenic risk associated with dibenz(a,h)anthracene exceeds the $1x10^{-6}$ de minimus level for the RME ($2x10^{-6}$) and average exposure ($2x10^{-6}$), but falls within the $1x10^{-4}$ to $1x10^{-6}$ target risk range.

Lead. Lead was detected in four of four surface soil samples collected in the 1990 investigation (NASA, 1990) at values ranging from 5300 to 24,000 μg/kg. Lead was detected in all of the surface soil and sediment samples collected during the 1994 investigation. Values ranged from 7000 to 33,800 μg/kg in surface soil, and from 8700 to 67,500 μg/kg in on-site sediment.

The average for U.S. background soils (based on an arithmetic mean of data for the eastern U.S.) is 35,000 μg/kg (Dragun and Chaisson, 1991). The background level detected in WFF soils is 571 μg/kg. The levels detected at the former FTA are generally comparable to the U.S. background levels, but are one to 10 orders of magnitude greater than the reported WFF background levels.

The U.S. EPA interim soil lead guidance for CERCLA sites (U.S. EPA, 1994f) recommends a screening level for lead in soil of 400 parts per million (ppm) for residential land use. This screening level is more than five times greater than the maximum lead level detected in on-site soil or sediment (67.5 ppm). Residential areas with soil lead levels below the screening level generally require no further action. Special situations, including wetland areas, ecological risk, and higher than expected human exposures, which might warrant further study or action are not applicable at the former FTA.

The EPA requested an evaluation of potential adverse effects from lead in environmental media using the Biokinetic Uptake Model. The results of the model evaluation indicate that blood levels in children resulting from exposure at the former FTA would be less than the 10 µg lead/dl blood criterion level.

6.7.2 Summary of Risk Assessment Results for Future Land Use Conditions

6.7.2.1 Future Soil Exposure Scenario

A blending of surface soil, on-site sediment, and subsurface soil would be expected to occur during construction for future residential land use. This blending is expected to result in a dilution of the lead concentrations. However, for risk assessment purposes, no dilution is assumed; rather, the maximum value found in surface soil, subsurface soil, or onsite sediment is used as the concentration for RME dose estimation. The highest average value from the three substrates is used for the average exposure assessment. This conservative approach is expected to increase the likelihood of an overestimation of risk.

The HIs for soil exposure under future residential land use do not exceed unity. For future residential soil exposure, carcinogenic risk exceeds the $1x10^{-6}$ de minimus level, but falls within the $1x10^{-4}$ to $1x10^{-6}$ target range for acceptable risk.

Use of the U.S. EPA lead uptake biokinetic model does not indicate exceedance of the 10 μg lead/dl blood criterion for soil exposure under the assumed future land use conditions. The EPA considers this model an acceptable evaluation for lead toxicity in lieu of published toxicity values.

6.7.2.2 Future Groundwater Exposure Scenario

Noncarcinogenic Effects. The total HI for the RME, assuming additive effects, is $1.9x10^{2}$. The total additive HIs for the average exposure is $6.4x10^{1}$. The HIs for exposure to cis-1,2,-dichloroethene, methylene chloride (for the RME), trimethylbenzene, naphthalene, and arsenic all exceed one.

Carcinogenic Effects. The overall carcinogenic risk, based on the conservative assumptions included in the risk assessment, exceeds the $1x10^{-4}$ to $1x10^{-6}$ target risk range for a residential exposure to carcinogens in groundwater at the former FTA. The relative contribution of the chemicals of concern in groundwater is discussed below.

1,1-Dichloroethene. This chemical of concern was detected in two of 11 samples collected from downgradient wells. Additionally, four DNAPL samples were collected; 1,1-dichloroethene was not reported in the DNAPL samples. The highest level reported was a spike of 18 μg/l in MW-57S, which is furthest downgradient. The second detection was in MW61I at an estimated value of 0.7 μg/l. Some uncertainty exists as to whether 1,1-dichloroethene may have migrated beyond the location of MW-57S. No downgradient receptors are identified, and dispersion and dilution are likely to negate any risk contribution should the plume reach surface waters. The nearest surface water body in the direction of suspected migration is Little Mosquito Creek, at a distance of more than 2000 feet. Risk associated with 1,1-dichloroethene is unlikely to play a significant role in exposure related to future surface water exposure. However, some uncertainty remains as to the significance of exposure to 1,1-dichloroethene should wells for future residential groundwater use be installed northeast of MW-57S.

Methylene Chloride. Methylene chloride was detected in 11 of 15 samples collected from 11 downgradient wells. Although detected in laboratory blanks and upgradient wells, the levels of methylene chloride in samples collected from MW-56D (780 μg/l in a DNAPL sample and 250 μg/l), a duplicate sample from MW-55S (270 μg/l), and MW-57S (52 μg/l) are significantly higher. Levels detected in other samples were comparable to blank detections.

The MCL for methylene chloride (synonym of dichloromethane) is 5 μg/l. Methylene chloride is a common laboratory contaminant, and the detections may be related, even at the higher levels, to laboratory contamination. In addition, the levels reported for the duplicate samples collected from MW-55S are not comparable (not detected above 1 μg/l vs. 270 μg/l). MW-55S is located in the suspected former pit area, while MW-56D and MW-57S are located downgradient. Methylene chloride was detected in a sample collected from MW-61I at 3 μg/l, which is comparable to the levels associated with laboratory blank contamination. MW-61I is located intermediate between MW-55S and MW-56D in the direction of groundwater flow. MW-57S is located downgradient of MW-56D. The pattern of detections does not indicate a consistent plume of methylene chloride contamination in groundwater, but could result from continuing sources in the soil.

Chloroform. Chloroform was detected in three samples collected from two wells. One of the samples was a DNAPL sample collected prior to purging. The groundwater sample collected in that same well following purging also contained chloroform. The third reported occurrence of chloroform is in monitoring well MW-01D, which is essentially cross-gradient from the former pit and training areas. Due to the detection in a cross-gradient sample and in only one other well, the risk contributed by exposure to chloroform in groundwater is not significant to the overall site risk.

Benzene. Benzene was detected in two of 15 samples collected from 11 downgradient wells. The two detections were found in DNAPL samples collected from MW-56D and MW-61I prior to purging. The levels (100 and 120 μg/l) are significantly higher than the MCL (5 μg/l).

Tetrachloroethene. This chemical of concern was detected in two of four DNAPL samples collected prior to purging. It was also detected in four of 11 samples collected in downgradient wells following purging. Tetrachloroethene was detected in MW-56D during DNAPL sampling, but not following purging. The detections were in wells located near the suspected location of the former pit area (MW-55D) and downgradient (MW-56D, MW-58S, and MW-61I). The detection reported for MW-60I is an estimated value of 0.9 μg/l, and appears to be an isolated occurrence.

Alpha-BHC. Alpha-BHC does not contribute any known noncarcinogenic risk. It is an insecticide which may have been used in the vicinity of the former FTA. The chemical does not appear to be otherwise related to site activities and is therefore not considered site-related.

The highest level detected (0.049 μg/l) was in a duplicate sample from MW-55S. The two detections in MW-55S vary by a factor of 5 (0.0098 vs 0.049 μg/l). The other detection, in MW-2S, was reported as 0.0037 μg/l, which is comparable to the lower values detected in MW-55S. Given the limited detections and the significant variation between the duplicate samples, alpha-BHC does not appear to contribute significantly to overall site risk.

Heptachlor epoxide. Heptachlor epoxide is used as an insecticide and it is also a degradation product of heptachlor, another insecticide. It may have been used in the vicinity of the former FTA, but the chemical does not appear to be otherwise related to site activities and is therefore not considered site-related.

The MCL for heptachlor expoxide is 0.2 μg/l, and the Virginia Groundwater Standards list a maximum level of 0.001μg/l. The levels detected at the former FTA range from 0.0042 to 0.016 μg/l, which exceed the Virginia Groundwater Standards.

Gamma-Chlordane. Gamma-chlordane is an insecticide and fumigant which may have been used in the vicinity of the FTA. The chemical does not appear to be otherwise related to site activities and is therefore not considered site-related.

The risk calculated for gamma-chlordane does not exceed the $1x10^{-6}$ target risk level. This chemical of concern does not appear to contribute significantly to overall site carcinogenic risk.

Arsenic. Arsenic is found in used automotive crankcase oil which may have been used as a combustible for the fire training activities. Arsenic was detected in three of 11 downgradient filtered well samples. None of the values for the filtered samples exceed the interim MCL for arsenic (50 μg/l). The highest value detected in MW-55S (11.1 μg/l) is located in the suspected former pit area.

Arsenic was detected in seven of 11 downgradient unfiltered well samples. None of these values exceed the interim MCL for arsenic. The highest detections are from wells MW-54S (34 μg/l) and MW-55S (29.6 μg/l). Although arsenic levels detected at the FTA do not exceed the interim MCL, the risk associated with exposure to arsenic in groundwater at the former FTA exceeds the $1x10^{-4}$ upper bound of the acceptable risk range for the RME and equals the upper bound for the average exposure scenario.

6.8 UNCERTAINTIES AND LIMITATIONS

Uncertainties in this risk assessment arise from uncertainty associated with the data, with the assumptions necessary for development of the exposure scenarios, and with the use of default parameters and models for calculation of exposure and risk. General sources of uncertainty include:

- Environmental sampling
- Analytical chemistry
- Selection of substances used to calculate risk
- Modeling, fate, and transport assumptions
- Exposure scenario development
- Toxicological data, including substitution of data for similar chemicals
- Characterizing risks from multiple chemicals and multiple exposure pathways
- Interactions and compounding of combinations of the above uncertainty factors (Maughan, 1993).

Uncertainties associated with environmental sampling include the assumptions that the samples collected from each media are sufficient to characterize the nature and extent of contamination in that media, and that the samples collected are truly representative of that media. Uncertainties associated with analytical chemistry include the assumption that the list of parameters that samples are analyzed for is inclusive of all site contaminants, the assumption that the detection limits employed allow adequate characterization of the level of contamination, and the limitations of the analytical instrumentation itself. The quality of both environmental sampling and analytical chemistry is highly dependent upon human skills and judgement. The use of the analytical detection limit for reported nondetections in calculating average exposure point concentrations is conservative.

Uncertainties associated with selection of substances used to calculate risk include the assumption that these chemicals are the most representative of the level of risk associated with the site. The initial screening of the data are dependent upon comparison to risk-based concentrations. When risk-based concentrations are not available for a specific substance, a risk-based concentration for a similar chemical is used. When toxicological data are not available for a given chemical substance, data for a similar chemical or class of chemicals are used to provide some estimate of risk. An example of this uncertainty is the use of the

cancer slope factor for benzo(a)pyrene for other carcinogenic PAHs. This assumption may be very conservative.

The underlying assumption in calculation of noncarcinogenic risk is that a hazard quotient greater than one indicates the possibility that adverse health effects may occur. However, the risk calculations cannot indicate whether those adverse effects will occur. For carcinogenic risk, the assessment presents an estimate of the incremental increase, due to exposure to chemicals of concern at the site, in an individual's lifetime chance of developing cancer. This risk estimate is an upper-bound estimate and it is likely that the actual risk is less than the estimated value.

Toxicological data provide significant uncertainties to the risk assessment process. The data include uncertainties associated with animal experimentation, extrapolation of high experimental doses to the much lower doses generally associated with environmental exposures, and extrapolation of human response and health effects from animal data (Maughan, 1993).

The use of oral RfDs and slope factors for the estimation of risk due to dermal exposure provides significant uncertainty to the risk assessment. The oral dose values are adjusted through the use of dermal absorption factors, which are chemical- or chemical class-specific.

When an individual may be exposed to chemicals of concern through multiple exposure routes, the calculated risks are summed across pathways. In addition, the carcinogenic risks for individual chemicals are assumed to be additive, and the noncarcinogenic risks are assumed to be additive when the toxic impacts of individual chemicals are similar. Using this assumption, the total risk is calculated by summing the individual carcinogenic and noncarcinogenic risks. This assumption may lead to an underestimation or overestimation of risk. If the effects are synergistic, the additive approach will underestimate risk. If the mixture of chemicals includes an antagonistic effect, the assumption will result in an overestimate of risk.

A numerical estimate of the uncertainty associated with this risk assessment cannot readily be made. This risk assessment is not intended to be a predictor of absolute risks. Rather, the risk assessment provides an identification of the areas and chemicals of greatest concern for the evaluation of remedial objectives and alternatives.

7.0 ECOLOGICAL RISK ASSESSMENT

7.1 INTRODUCTION

As a component of the RI for the former FTA, two M&E ecologists visited the site to observe and record the ecological setting. Field work was conducted by these ecologists on August 15, 1994. During the visit, observations were made of the flora and fauna present, as well as any potential exposure routes through which site-related contaminants could affect the ecological receptors. If present, evidence of ecological stress was noted. This information is used to develop this ecological risk assessment, which, in conjunction with the human health risk assessment, comprises the baseline risk assessment for the site.

The ecological risk assessment is prepared based on the Risk Assessment Guidance for Superfund, Volume II: Environmental Evaluation Manual (RAGS II)(U.S. EPA, 1989).

7.2 FIELD INVESTIGATION METHODS

The Environmental Resources Document, Wallops Flight Facility (NASA, 1994) was reviewed by M&E ecologists before field work at the former FTA commenced. This document provided ecological information for WFF, including information on Threatened and Endangered (T&E) species, wetlands, streams, habitat types, and plants and animals potentially occurring at WFF. On August 15, 1994, the FTA was surveyed for habitat types, dominant vegetation, common plant species, and animals (or signs of animals) present. In addition, the FTA was surveyed for evidence of stress and contaminant migration pathways. The site was surveyed using random and irregular transects. Methods of identification included direct observation, calls, footprints, scat, nests, and burrows. Due to the limited, shallow, and intermittent nature of surface waters at this site, no aquatic sampling was performed.

In general, the former FTA and a buffer zone of approximately 100 yards was surveyed. However, if migration pathways presented routes for impact beyond the buffer zone, the survey area was broadened to better define the nature and extent of the impact.

7.3 GENERAL ECOLOGICAL CONDITIONS AT WFF

WFF is located on the Delmarva Peninsula in Accomack County, on the eastern shore of the Commonwealth of Virginia. The Delmarva Peninsula is bordered by the Atlantic Ocean on the east, the Chesapeake Bay on the west, and the Delaware Bay and River on the northeast.

In general terms, WFF provides a natural setting which is ecologically complex and includes a wide range of habitat types for a diverse assemblage of plants and animals. Approximately 61 mammal species, 250 bird species, and 54 species of reptiles and amphibians may reside at or migrate through the WFF vicinity. Approximately 934 plant species may be present in the area of WFF (NASA, 1994).

7.3.1 Terrestrial Environment

The four primary terrestrial habitat types on WFF are dune systems, island forest, upland grasslands, and forest. The former FTA, on the Main Base, is dominated by upland field habitat, with a nearby upland forest. The field habitat at this site is mowed, limiting its potential as a habitat for wildlife. Also, the former FTA is bounded by an active runway.

7.3.2 Aquatic Environment

The aquatic environment at WFF is varied, comprising freshwater, brackish, and saltwater; tidal and non-tidal; lotic and lentic; and intermittent and perennial systems. However, the only aquatic systems in the immediate vicinity of the former FTA are one small, 10 foot by 15 foot, shallow (depth less than 2 inches) intermittent pool (after a rain event the night before the survey), and a tributary to Little Mosquito Creek, located over 500 feet to the east of the site. Due to the topography of the FTA and the surrounding area, surface runoff is not expected to enter this stream.

7.3.3 Wetlands

According to National Wetland Inventory (NWI) maps, a variety of forested, scrub-shrub, emergent, aquatic bed, and open-water wetlands (freshwater and brackish, tidal and non-tidal) occur throughout the WFF. However, no wetlands were reported or noted for the former FTA area.

7.3.4 Threatened and Endangered (T&E) Species

The Commonwealth of Virginia Department of Game and Inland Fisheries (VDGIF) provided information for the WFF Environmental Resources Document (NASA, 1994) on the T&E species of plants and animals potentially present at WFF (Table 7-1). The Virginia Department of Conservation and Recreation, Division of Natural Heritage, also provided data on T&E and rare species, based on an ecological survey performed at the WFF. None of these species were observed at the former FTA, nor were they expected, since the majority of these species live in or near the ocean, and the FTA is inland (on the main land portion of WFF). No suspect growing or nesting areas were observed at, or in the vicinity of, the FTA.

7.4 FIRE TRAINING AREA - ECOLOGICAL RISK ASSESSMENT

The FTA, which is no longer in use, is located north of Runway 10-28 on the WFF Main Base. The site encompasses approximately one acre, and is located approximately 2200 feet south of Little Mosquito Creek. According to WFF personnel, the FTA was in operation from 1965 to 1987. The WFF Fire Department used the site twice a week for training purposes (NASA, 1993).

7.4.1 Site Description

Portions of this site and adjacent areas were recently cleared of trees, presumably to remove obstructions and to reduce sight distance complications in the runway area. Grasses, clover, and other forbs, and taller herbaceous growth and some woody saplings (Figure 7-1, Tables 7-2, 7-3) supported by numerous dirt and brush piles, now characterize the sites. The FTA appears to be routinely mowed. A steep (up to 60 degrees) earthen berm (maximum height 7 feet) is to the north of the FTA. At the top of this berm is a pine woodland, with scattered oaks and wild black cherry trees in the understory. The forest floor appears to be mowed, so ground cover is generally lacking. Significant bird activity was noted in this woodland at the time of the ecological reconnaissance. Elsewhere on the FTA, observations of wildlife or their signs were limited, although several small burrows (possibly those of hognose snake, which are common to the area), raccoon scat, and deer tracks were seen in the area, in addition to several passerine (perching) bird species and numerous invertebrates (Table 7-4). A tributary to Mosquito Creek located over 500 feet east of the FTA is an NPDES-monitored discharge. No surface runoff connection between the FTA and this tributary was observed. In terms of surface runoff, the FTA appears to be a self-contained unit. No T&E

Table 7-1 Listing of Potential Threatened and Endangered Species NASA - Wallops Flight Facility and Vicinity

Reptiles*

Scientific Name	Common Name	Status	Presence at Fire Training Area?
Caretta caretta	Loggerhead sea turtle	Federal Threatened	Impossible, No Habitat
Chelonia mydas	Atlantic green sea turtle	Federal Threatened	Impossible, No Habitat
Dermochelys coriaces	Leatherback sea turtle	Federal Endangered	Impossible, No Habitat
Eretmochelys imbricata	Hawksbill sea turtle	Federal Endangered	Impossible, No Habitat
Lepidochelys kempi	Kemp's Ridley sea turtle	Federal Endangered	Impossible, No Habitat

Birds*

Scientific Name	Common Name	Status	Presence at Fire Training Area?
Bartramia longicauda	Upland sandpiper	State Threatened	Highly Unlikely, No Habitat
Charadrius melodus	Piping plover	Federal Endangered	Highly Unlikely, No Habitat
Charadrius wilsonia	Wilson's plover	State Endangered	Highly Unlikely, No Habitat
Falco peregrinus	Peregrine falcon	Federal Endangered	Highly Unlikely, No Habitat
Haliaeetus leucocephalus	Bald eagle	Federal Threatened	Highly Unlikely, No Habitat
Sterna nilotica	Gull-billed tern	State Threatened	Highly Unlikely, No Habitat

Marine Mammals*

Scientific Name	Common Name	Status	Presence at Fire Training Area?
Balaenoptera borealis	Sei whale	Federal Endangered	Impossible, No Habitat
Balaenoptera musculus	Blue whale	Federal Endangered	Impossible, No Habitat
Balaenoptera physalus	Fin whale	Federal Endangered	Impossible, No Habitat
Eubalaena glacialis	Northern right whale	Federal Endangered	Impossible, No Habitat
Megaptera novaeangliae	Humpback whale	Federal Endangered	Impossible, No Habitat
Physeter catodon	Sperm whale	Federal Endangered	Impossible, No Habitat

Rare Flora**

Scientific Name	Common Name	Status	Presence at Fire Training Area?
Carex straminea	Straw sedge	Very rare	Highly Unlikely, No Habitat
Chamaecyse bombensis	Southern beach spurge	Rare	Highly Unlikely, No Habitat
Diplachne maritima	Saltmeadow sprangletop	Rare	Highly Unlikely, No Habitat
Eleocharis rostellata	Beaked spikerush	Extremely rare	Highly Unlikely, No Habitat
Eriocaulon decangulare	Ten-angle pipewort	Extremely rare	Highly Unlikely, No Habitat
Fimbristylis caroliniana	Carolina fimbristylis	Rare	Highly Unlikely, No Habitat
Helianthemum propinquum	Low frostweed	Rare	Highly Unlikely, No Habitat
Juncus megacephalus	Big-head rush	Very rare	Highly Unlikely, No Habitat
Plantago maritima	Seaside plantain	Extremely rare	Highly Unlikely, No Habitat
Sclerolepis uniflora	One-flowered sclerolepis	Extremely rare	Highly Unlikely, No Habitat

Rare Invertebrates*

Scientific Name	Common Name	Status	Presence at Fire Training Area?
Brachymesia gravida	not listed (odonate)	Rare	Highly Unlikely, No Habitat
Argia bipunctulata	Seepage dancer (odonate)	Rare	Highly Unlikely, No Habitat

*Source: Virginia Department of Game and Inland Fisheries, 1992. "Federal and State Endangered and Threatened Species in Virginia." Taken from Environmental Resources Document - Wallops Flight Facility (NASA, 1994)

**Sources: Virginia Department of Conservation and Recreation, Division of Natural Heritage, 1992. Taken from Environmental Resources Document - Wallops Flight Facility (NASA, 1994)

Virginia Department of Conservation and Recreation, Division of Natural Heritage, 1994. Wallops Flight Facility Natural Heritage Inventory Progress Report (Project Period: June1 - Sept. 15, 1994)

NOTES:
1. Horizontal Datum: Virginia State Plane Coordinate System.
2. Vertical Datum: N.G.V.D.
3. Horizontal and vertical data based on control information provided by N.A.S.A.
4. This plan represents a field survey taken by Ramesh C. Batta Associates, P.A. ,FEBRUARY 1994

PINE WOODLAND (60'-70' TREES)
(SOME OAKS, BLACK CHERRY IN UNDERSTORY)

EARTHEN BERM

SLOPE UP TO 60°

WOOD PILE WITH POKEWEED DOMINANT

DISCARDED BRUSH & POKEWEED

GRASSES

PLANTED TREES

ENGLISH PLANTAIN & FENNEL

GRASSES & FORBS

CLOVER

RAGWEED DOMINANT

SED/SW01

SED/SW04

SED/SW03

NUTSEDGE & GRASSES

SLUDGE PILE

FTA-SB2-4

FTA-SB1-4

SS-06

SS-05

1190
SG5 (E7)

SOME EXPOSED SOILS

SG-3(E9)/SS-07

HORSEWEED DOMINANT

DRY AT TIME OF ECOLOGICAL UNIT RECONNAISANCE

SED/SW02

DRAINAGE

DEBRIS PILE

ASTER & GOLDENROD DOMINANT
ALSO: HERCULES' CLUB, WHITE SWEET CLOVER

BLACK CHERRY DOMINANT
ALSO: HOLLY, BAYBERRY, OAKS, DOGWOOD, SWEETGUM

GRASSES

SS-04

BENTONITE

SG-10/SS-08

DUMPED CONCRETE

SS-10

PATHWAY

DEBRIS PILE

DEBRIS PILE

SG-13/SS-09

SG-14(D8)/SS-3

JUNKED PLANE

BAYBERRY DOMINANT
ALSO: BLACKCHERRY, OAKS, DOGWOOD, SASSAFRAS

SS-01

BURROW

NUMEROUS BURROWS

SS-02

DRAINAGE

POKEWEED, HORSEWEED DOMINANT
ALSO: HERCULES' CLUB, *LACTUCA* SP., RAGWEED, ASTER

DEBRIS PILE

FTA-SB13-4

FTA-SB14-4

DEBRIS PILE

LOBLOLLY PINE (5'-6')
DOMINANT
ALSO: WINGED SUMAC, BLACK CHERRY, POKEWEED

RAGWEED & ASTER

GRAVEL

SMALL WASHOUT

WATER VALVE

FIRE HYDRANT

OUTFALL NOT INDICATED

12" C.M.P.

24" C.M.P.

CATCH BASIN
TOP = 28.60
INV IN = 25.83
INV OUT = 23.74

18" R.C.P.

CATCH BASIN
TOP = 31.28
INV = 27.55

8" C.M.P.

16" R.C.P.

CATCH BASIN
TOP = 31.84
INV = 29.44

TRANSFORMER PAD

"M-31" SIGN

CAMPHORWEED DOMINANT
ALSO: CRABGRASS, RABBIT FOOT CLOVER, SANDBUR, HORSEWEED

SOME EXPOSED SOIL & CRUSHED CONCRETE

TAXIWAY
(ACCESS ROAD ALONG RUNWAY 10-28)

N

LEGEND

~	EXISTING CONTOUR
27x2	EXISTING SPOT ELEVATION
SB	SOIL BORING
SS	SURFACE SOIL
SD	SEDIMENT
SW	SURFACE WATER
	GRASSES, CLOVER & OTHER FORBS
	MIXED HERBACEOUS & WOODY SPECIES
	SCRUB SHRUB/YOUNG TREES (<10' HIGH)
	TALLER HERBACEOUS PLANTS
	WOODLAND
	DRAINAGE/SHALLOW POOLED WATER
	PAVED OVER

50 25 0 50

PLAN NUMBER 85530-1-C-9516

METCALF & EDDY INC.
14502 GREENVIEW DRIVE
SUITE 500
LAUREL, MARYLAND
20708

FIGURE 7-1
GENERAL ECOLOGICAL SETTING
OF THE FORMER FIRE TRAINING AREA
NASA/GODDARD SPACE FLIGHT CENTER
WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA

013516 NASA-1.DWG

Table 7-2 Listing of Herbaceous Species
Former Fire Training Area; NASA - Wallops Flight Facility

Herbaceous Species	
Scientific Name	Common Name
Achillea millefolium	Yarrow
Agrostis sp.	Redtop grass
Allium canadense	Wild garlic
*Ambrosia artemisiifolia**	Common ragweed*
Apocynum cannabinum	Indian hemp
Artemisia caudata	Tall wormwood
*Aster sp.**	Aster, unidentified*
Athyrium thelypteroides	Silvery spleenwort
Bromus sp.	Brome
Campsis radicans	Trumpet vine
Cenchrus longispinus	Sandbur
*Conyza canadensis**	Horseweed*
Cyperus sp.	Nutsedge
Daucus carota	Queen Anne's lace
*Digitaria sanguinalis**	Crabgrass*
Diodia teres	Buttonweed
Erigeron sp.	Fleabane
Eupatorium altissimum	Tall boneset
Foeniculum vulgare	Fennel
Gelsemium sempervirens	Yellow jessamine
*Heterotheca subaxillaris**	Camphorweed*
Hieracium sp.	Hawkweed
Juncus sp.	Rush, unidentified
Lathyrus latifolius	Perennial pea
Lepiduim campestre	Peppergrass
Lespedeza sp.	Bushclover
Mitchella repens	Partridgeberry
Mollugo verticillata	Carpetweed
Oenothera laciniata	Cut-leaved evening primrose
Panicum clandestinum	Deer tongue
Parthenocissus quinquefolia	Virginia creeper
Paspalum sp.	Paspalum
Phytolacca americana	Pokeweed
Plantago aristata	Bracted plantain
*Plantago lanceolata**	English plantain*
Prenanthes alba	White lettuce
Rhus radicans	Poison ivy
Rumex crispus	Curled dock
Setaria sp.	Foxtail grass
Smilax sp.	Greenbrier
Strophostyles umbellata	Pink wildbean
Trifolium arvense	Rabbit-foot clover
*Trifolium pratense**	Red Clover*
Verbascum thapsus	Common mullein
Vitis labrusca	Fox grape
Vitis rotundifolia	Muscadine

* denotes dominant species

Table 7-3 Listing of Woody Species
Former Fire Training Area; NASA - Wallops Flight Facility

Trees

Scientific Name	Common Name
Acer sp.	Ornamental maple
*Aralia spinosa**	Hercules' Club*
Carya tomentosa	Mockernut hickory
*Cornus florida**	Flowering dogwood*
Juniperus virginiana	Red cedar
*Liquidambar styraciflua**	Sweetgum*
Pinus sylvestris	Scotch pine
*Pinus taeda**	Loblolly pine*
*Prunus serotina**	Wild black cherry*
Quercus alba	White oak
Quercus laevis	Turkey oak
Quercus palustris	Pin oak
*Quercus rubra**	Southern red oak*
Rhus copallina	Winged sumac
Sassafras albidum	Sassafras

Shrubs

Scientific Name	Common Name
Diervilla lonicera	Bush honeysuckle
*Ilex opaca**	American holly*
Ligustrum vulgare	Privet
*Myrica pensylvanica**	Northern bayberry*

* denotes dominant species

species or economically important species (other than deer) were observed at this site.

The important habitats at, or near, the FTA are the pine woodland (not actually part of the FTA), and the scrub-shrub habitats forming on the dirt and brush piles scattered over the site.

7.4.2 Receptor Identification

M&E ecologists identified ecological resources at the FTA through the field survey and literature search. Plant and animal species seen at or near the FTA (Tables 7-2, 7-3, and 7-4) are considered to be potential receptors for the chemicals of ecological concern at this site.

These potential receptors include herbaceous flora such as grasses and forbs; woody flora such as saplings and shrubs; terrestrial invertebrates; passerine birds; raptors; rodents; raccoons; and deer. Based on observed habitats, snakes, terrestrial turtles, insectivores, rabbits, and bats are potentially present at this site, but none were observed during the August 1994 ecological survey.

7.4.3 Exposure Pathways

The media of concern for the FTA are groundwater, surface water (highly intermittent) and surface and subsurface soil. Ecological exposure pathways to groundwater are incomplete, meaning that the potential ecological receptors will not experience direct contact with contaminants detected in this medium. Ecological pathways to the remainder of these media are complete, meaning that the potential ecological receptors may experience direct contact with contaminants contained within these media. In the case of subsurface soil, only samples taken at a depth of five feet or less are considered, as most burrowing animals are not expected to burrow to depths exceeding five feet and most plant root systems will not exceed this depth. All exposure pathways are summarized in Figure 7-2.

7.4.4 Chemicals Detected in Ecological Media of Concern

The chemicals detected in surface water are toluene, heptachlor, DDE, DDT, gamma-chlordane, aluminum, arsenic, barium, calcium, copper, iron, lead, magnesium, manganese, potassium, sodium,

Table 7-4 Listing of Animal Species
Former Fire Training Area; NASA - Wallops Flight Facility

Mammals

Scientific Name	Common Name
Odocoileus virginianus	White-tailed deer
Procyon lotor	Raccoon

Birds

Scientific Name	Common Name
Cardinalis cardinalis	Cardinal
*Carduelis tristis**	American goldfinch*
Carthartes aura	Turkey vulture
Colaptes auratus	Common flicker
Contopus virens	Eastern pewee
Corvus brachyrhynchos	Common crow
Corvus ossifragus	Fish crow
*Parus carolinensis**	Carolina chickadee*
Picoides pubescens	Downy woodpecker
*Sialia sialis**	Bluebird*
*Spizella passerina**	Chipping sparrow*
Thryothorus ludovicianus	Carolina wren
Troglodytes aedon	House wren
Tyrannus tyrannus	Eastern kingbird
Zonotrichia leucophrys	White-crowned sparrow
	Owl, unidentified

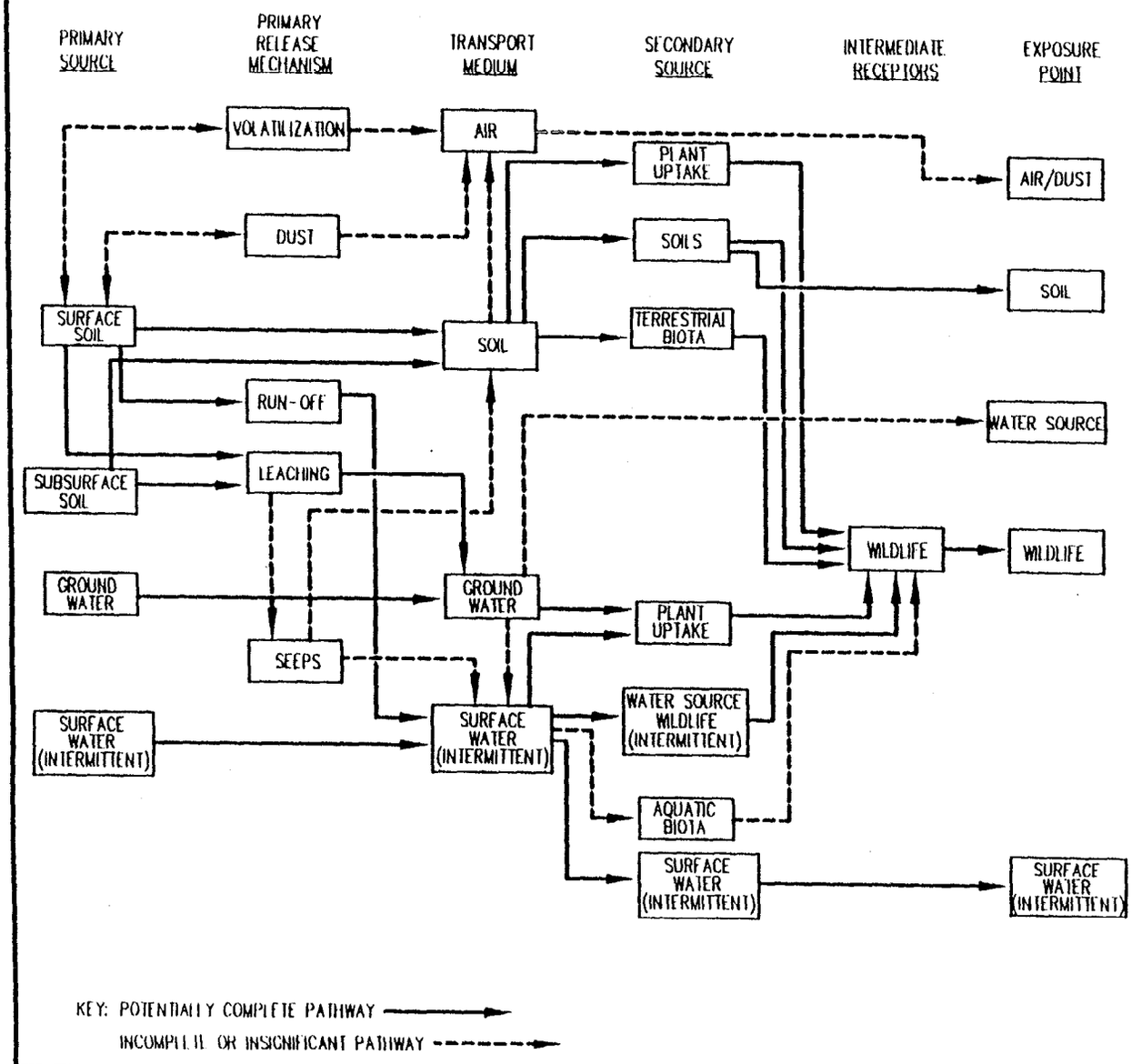
Reptiles and Amphibians**

Scientific Name	Common Name
Elaphe obsoleta obsoleta	Black rat snake
Heterodon platyrhinos	Eastern hognose snake
Bufo woodhousii fowleri	Fowler's toad

Insects

Ground cricket
Short-horned grasshopper*
Monarch
Bald-face hornet
Tent caterpillar
Cicada*
Tiger swallowtail
Mosquito*
Club-tail dragonfly
Halictid bee
Ladybird beetle
Japanese beetle
Vespid wasp
Leaf bug
Katydid

* denotes dominant species
** no herptiles were observed during the ecological survey, but NASA personnel reported these species to be common



POTENTIAL ECOLOGICAL RECEPTORS

ROUTE	ANIMALS TERRESTRIAL	ANIMALS AQUATIC	PLANTS TERRESTRIAL	PLANTS AQUATIC
INHALATION/RESPIRATION INGESTION/UPTAKE DERMAL CONTACT/UPTAKE				
INGESTION/UPTAKE	X		X	
DERMAL CONTACT/UPTAKE	X		X	
INHALATION/RESPIRATION INGESTION/UPTAKE DERMAL CONTACT/UPTAKE				
INGESTION	X			
INGESTION/UPTAKE	X		X	
DERMAL CONTACT/UPTAKE				

KEY: POTENTIALLY COMPLETE PATHWAY ——→

INCOMPLETE OR INSIGNIFICANT PATHWAY - - - - →

Metcalf & Eddy

NASA/GODDARD SPACE FLIGHT CENTER

SITE CONCEPTUAL MODEL FOR THE FORMER FIRE TRAINING AREA

WALLOPS FLIGHT FACILITY, VIRGINIA

Project Number 013516-0006

File Name NASA-2

Figure 7-2

vanadium, and zinc (Table 7-5). The chemicals detected in surface soil at the FTA are gamma-BHC (lindane), heptachlor, heptachlor epoxide, DDD, DDE, DDT, endosulfan I, endrin, dieldrin, endosulfan sulfate, methoxychlor, endrin ketone, endrin aldehyde, alpha-chlordane, gamma-chlordane, 4-nitrophenol, phenanthrene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene, benzo(g,h,i)perylene, di-n-butylphthalate, total petroleum hydrocarbons, aluminum, arsenic, barium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, sodium, vanadium, and zinc (Table 7-6).

The chemicals detected in subsurface soil are acetone, delta-BHC, aldrin, heptachlor epoxide, DDD, DDE, DDT, endosulfan I, endosulfan sulfate, endrin, endrin aldehyde, alpha-chlordane, gamma-chlordane, toxaphene, phenanthrene, anthracene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, benzo(g,h,i)perylene, di-n-butylphthalate, bis(2-ethylhexyl)phthalate, di-n-octylphthalate, dibenz(a,h)anthracene, diethylphthalate, total petroleum hydrocarbons, aluminum, arsenic, barium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, vanadium, and zinc (Table 7-7).

7.4.4.1 Comparison with Background, ARARs, and Guidance Values

In order to determine which chemicals should be addressed in the ecological risk assessment, detected chemical concentrations in FTA surface water, surface soil, and subsurface soil to a depth of five feet (those media of concern with complete ecological exposure pathways) are compared to background concentrations, ARARs, and guidance values (Tables 7-5, 7-6, and 7-7).

The background concentrations (for soils only) represent data obtained from background locations at WFF. Background samples taken from the ground surface to a depth of two feet are used for surface soil background. Background samples taken from two feet to a depth of six feet are used for subsurface soil background. The maximum detected background concentrations from these depth ranges are used for comparative purposes.

TABLE 7-5. Comparison of Water Quality Criteria and Guidelines for Chemicals Detected in Surface Water Former Fire Training Area; NASA - Wallops Flight Facility, VA

ANALYTES	EXPOSURE CONC.§ (µg/L)	Freq. of Detection (fraction)	Freq. of Detection (percent)	VA AWQC* (µg/L)	USEPA AWQC** (µg/L)	NOAA Guidelines* (µg/L)	Evaluate? ¥	Rationale Codes ¥¥
Toluene	1.00	1/5	16.67	NA	175.00	NA	No	BFC
Heptachlor	0.0016	1/5	16.67	0.0038	0.0038	0.0038	No	BFC, BSC
4,4'-DDE	0.0065	1/5	33.33	NA	10.50	NA	No	BFC
4,4'-DDT	0.0056	2/5	50.00	0.001	0.001	0.001	Yes	exceeds SC,FC,NG
gamma-Chlordane	0.0020	1/5	16.67	0.0043	0.0043	0.0043	No	BFC, BSC, BNG
Aluminum	5450.00	4/5	83.33	NA	87.00	NA	Yes	exceeds FC
Arsenic	5.30	1/5	16.67	NA	190.00	NA	No	BFC
Barium	25.60	4/5	83.33	NA	NA	NA	Yes	no criteria
Calcium (EE)	5800.00	4/5	83.33	NA	NA	NA	Yes	no criteria
Copper (EE)	6.90	3/5	50.00	3.61	2.89	12.00+	No	BNG
Iron (EE)	2730.00	4/5	83.33	NA	1000.00	1000.00	Yes	exceeds FC,NG
Lead	3.40	2/5	33.33	0.54	0.39	3.20+	Yes	exceeds SC,FC,NG
Magnesium (EE)	1150.00	4/5	83.33	NA	NA	NA	Yes	no criteria
Manganese (EE)	27.80	4/5	83.33	NA	NA	NA	Yes	no criteria
Potassium (EE)	2000.00	4/5	83.33	NA	NA	NA	Yes	no criteria
Sodium (EE)	2250.00	3/5	66.67	NA	NA	NA	Yes	no criteria
Vanadium	6.80	1/5	33.33	NA	NA	NA	Yes	no criteria
Zinc (EE)	30.50	4/5	83.33	32.70	26.20	110.00+	No	BNG, BSC

§ Exposure concentration represents the maximum detected surface water concentration

*All values used are chronic Ambient Water Quality Criteria (AWQC) (default of 25 mg $CaCO_3$/L used to calculate State standards, since a hardness <25 is not to be used, according to State guidance).

** All values used are U.S. EPA chronic Ambient Water Quality Criteria. Hardness-dependent criteria were calculated using the site-specific hardness of 10.53 mg $CaCO_3$/L

¥ A "Yes" in this column indicates further evaluation is needed; "No" indicates that the chemical is not a concern, based on the criteria (or criterion) listed in the "Rationale Codes" column.

¥¥ Rationale Codes:

BSC - exposure concentration is Below State Criteria for ambient water quality
BFC - exposure concentration is Below Federal Criteria for ambient water quality
BNG - Below NOAA Guidelines for ambient water quality
no criteria - no State or Federal Ambient Water Quality Criteria available for this chemical
exceeds FC - exposure concentration exceeds Federal Criteria for ambient water quality
exceeds FC, NG - exposure concentration exceeds Federal Criteria and NOAA Guidelines for water quality
exceeds SC, FC, NG - exposure concentration exceeds State and Federal Criteria and NOAA Guidelines for water quality

+ Hardness-dependent value (hardness default value not reported, equation not provided in NOAA Guidelines)

NA - Not Available/Not Applicable

EE - naturally-occurring Essential Element; no toxicity expected, but chemical will be evaluated for potential toxicity (see Section 7.4.4.1)

Shading indicates chemicals for which further evaluation is necessary.

TABLE 7-6. Comparison of Background Concentrations and Guidelines for Chemicals Detected in Surface Soil

Former Fire Training Area; NASA - Wallops Flight Facility, VA

ANALYTE	EXPOSURE CONC.£ (µg/kg)	Freq. of Detect. (fraction)	Freq. of Detect. (percent)	NASA-WFF Bkgd.* (µg/kg)	Nat'l Soil Bkgd.** (µg/kg)	NOAA § Guidelines (µg/kg)	EE? §§	Evaluate? ¥	Rationale Codes ¥¥
gamma-BHC (lindane)	1.90	4/4	100.00	NA	NA	<2000.00	NA	No	BNG
Heptachlor	0.25	1/4	25.00	NA	NA	NA	NA	Yes	no criteria
Heptachlor epoxide	0.24	1/14	7.14	NA	NA	<2000.00	NA	No	BNG
Endosulfan I	3.60	3/14	21.43	NA	NA	NA	NA	Yes	no criteria
Dieldrin	0.20	1/14	7.14	NA	NA	<2000.00	NA	No	BNG
4,4'-DDE	67.00	15/18	83.33	NA	NA	<2000.00	NA	No	BNG
4,4'-DDD	34.00	9/18	50.00	NA	NA	<2000.00	NA	No	BNG
Endosulfan sulfate	5.20	7/18	38.89	NA	NA	NA	NA	Yes	no criteria
4,4'-DDT	33.00	14/18	77.78	NA	NA	<2000.00	NA	No	BNG
Endrin	5.20	3/4	75.00	NA	NA	<2000.00	NA	No	BNG
Methoxychlor	23.00	3/18	16.67	NA	NA	<2000.00	NA	No	BNG
Endrin ketone	11.00	4/18	22.22	NA	NA	NA	NA	Yes	no criteria
Endrin aldehyde	4.40	4/18	22.22	NA	NA	NA	NA	Yes	no criteria
alpha-Chlordane	1.80	3/18	16.67	NA	NA	<2000.00	NA	No	BNG
gamma-Chlordane	3.00	2/18	11.11	NA	NA	<2000.00	NA	No	BNG
4-Nitrophenol	41.00	1/14	7.14	NA	NA	1000.00	NA	No	BNG
Phenanthrene	140.00	3/18	16.67	NA	NA	5000.00	NA	No	BNG
Fluoranthene	980.00	5/18	27.78	NA	NA	10000.00	NA	No	BNG
Pyrene	680.00	5/18	27.78	NA	NA	10000.00	NA	No	BNG
Benzo(a)anthracene	810.00	5/18	27.78	NA	NA	1000.00	NA	No	BNG
Chrysene	1200.00	5/18	27.78	NA	NA	1000.00	NA	No	BNG
Benzo(b)fluoranthene	1600.00	5/18	27.78	NA	NA	1000.00	NA	Yes	exceeds NG
Benzo(k)fluoranthene	1600.00	5/18	27.78	NA	NA	1000.00	NA	Yes	exceeds NG
Benzo(a)pyrene	550.00	2/18	11.11	NA	NA	1000.00	NA	No	BNG
Dibenz(a,h)anthracene	240.00	1/4	25.00	NA	NA	1000.00	NA	No	BNG
Indeno(1,2,3-cd)pyrene	570.00	2/18	11.11	NA	NA	1000.00	NA	No	BNG
Benzo(g,h,i)perylene	340.00	2/18	11.11	NA	NA	1000.00	NA	No	BNG
Di-n-butylphthalate	65.00	4/18	22.22	NA	NA	NA	NA	Yes	no criteria
Total Petro. Hydrocarbs.	5890.00	11/14	78.57	NA	NA	NA	NA	Yes	no criteria
Aluminum	2.28E+07	15/18	83.33	1.77E+07	5.70E+07	7.10E+07	No	No	BNG, BNB
Arsenic	9.00E+03	14/18	77.78	ND	5.10E+03	5.00E+03	No	Yes	exceeds NG,NB
Barium	8.50E+04	14/18	77.78	6.80E+04	4.36E+05	4.30E+05	No	No	BNG, BNB
Cadmium	3.40E+03	2/18	11.11	ND	4.00E+3 u	6.00E+01	No	Yes	exceeds NG
Calcium	1.39E+06	14/18	77.78	4.24E+05	6.30E+06	NA	Yes	No	BNB, EE
Chromium	2.32E+04	14/18	77.78	1.26E+04	5.40E+04	1.00E+05	No	No	BNG, BNB
Cobalt	7.20E+03	6/18	33.33	3.76E+03	9.40E+03	8.00E+03	Yes	No	BNG, BNB, EE
Copper	5.81E+04	11/18	61.11	2.17E+02	3.30E+04	3.00E+04	Yes	Yes	exceeds SB,NG,NB
Iron	1.41E+07	14/18	77.78	1.19E+07	2.50E+07	3.80E+07	Yes	No	BNG, BNB, EE
Lead	6.75E+04	14/18	77.78	5.71E+02	3.50E+04	1.00E+04	No	Yes	exceeds SB,NG,NB
Magnesium	1.83E+06	14/18	77.78	1.16E+06	4.60E+06	5.00E+06	Yes	No	BNG, BNB, EE
Manganese	1.92E+05	14/18	77.78	2.38E+05	6.40E+05	6.00E+05	Yes	No	BB, BNG, BNB, EE
Mercury	2.10E+02	1/4	25.00	1.40E+02	1.08E+02	3.00E+01	No	Yes	exceeds SB,NG,NB
Nickel	1.54E+04	2/18	11.11	5.01E+03	1.60E+04	4.00E+04	No	No	BNG, BNB
Potassium	8.42E+05	2/18	11.11	4.81E+05	1.20E+07	NA	Yes	No	BNB, EE
Sodium	7.60E+04	1/4	25.00	1.41E+04	7.80E+03	NA	Yes	Yes	exceeds SB, NB
Vanadium	3.89E+04	14/18	77.78	2.34E+04	7.70E+04	1.00E+05	No	No	BNG, BNB
Zinc	6.94E+04	9/18	50.00	2.09E+04	2.33E+05	5.00E+04	Yes	No	BNB, EE

£ Exposure concentration represents the maximum detected concentration for soil

*Background is defined as the maximum detected concentration from background samples for NASA - WFF

**Source: Dragun and Chaisson, 1991. Values represent arithmetic means for Virginia or eastern USA soils, unless otherwise noted ("u" indicates upper end of range for eastern USA soils; arithmetic mean not listed)

§ National Oceanic and Atmospheric Association (NOAA) Screening Guidelines. Inorganic values are based on US averages, those for organics are based on Canadian target values.

§§ Is the chemical a naturally-occurring Essential Element (EE)? (see Section 7.4.4.1)

¥ A "Yes" in this column indicates further evaluation is needed; "No" indicates that the chemical is not a concern. The reasoning for this determination is listed in the "Rationale Codes" column.

¥¥ Rationale Codes:

BB - Below Background for NASA - WFF soil
BNB - Below National Background for soil
BNG - Below NOAA Screening Guidelines for soil
EE - Essential Element (macro- or micronutrient)
no criteria - screening criteria are unavailable; therefore, estimated intakes will be compared against toxicological benchmarks.
exceeds NG - exposure concentration exceeds NOAA Guidelines for soil
exceeds NG,NB - exposure concentration exceeds NOAA Guidelines for soil and National Background for soil
exceeds SB, NB - exposure concentration exceeds site-specific soil background and National Background for soil
exceeds SB,NG,NB - exposure concentration exceeds site-specific background, NOAA Guidelines, and National Background for soil

NA - Not Available/Not Applicable

Shading indicates chemicals for which further evaluation is necessary

TABLE 7-7. Comparison of Background Concentrations and Guidelines for Chemicals Detected in Subsurface Soil
Former Fire Training Area; NASA - Wallops Flight Facility, VA

ANALYTE	EXPOSURE CONC.£ (µg/kg)	Freq. of Detect. (fraction)	Freq. of Detect. (percent)	NASA-WI Bkgd.* (µg/kg)	Nat'l Soil Bkgd.** (µg/kg)	NOAA § Guidelines (µg/kg)	EE? §§	Evaluate? ¥	Rationale Codes ¥¥
Acetone	10.00	1/21	4.76	NA	NA	NA	NA	No	<5%
delta-BHC	0.15	1/17	5.88	NA	NA	NA	NA	Yes	no criteria
Aldrin	0.11	1/17	5.88	NA	NA	<2000.00	NA	No	BNG
Heptachlor epoxide	0.14	1/21	4.76	NA	NA	<2000.00	NA	No	BNG
Endosulfan I	0.13	2/21	9.52	NA	NA	NA	NA	Yes	no criteria
4,4'-DDE	2.30	3/21	14.29	NA	NA	<2000.00	NA	No	BNG
4,4'-DDD	0.39	2/21	9.52	NA	NA	<2000.00	NA	No	BNG
Endosulfan sulfate	0.82	1/17	5.88	NA	NA	NA	NA	Yes	no criteria
4,4'-DDT	8.40	4/17	23.53	NA	NA	<2000.00	NA	No	BNG
Endrin	2.90	2/21	9.52	NA	NA	<2000.00	NA	No	BNG
Endrin aldehyde	4.00	1/17	5.88	NA	NA	NA	NA	Yes	no criteria
alpha-Chlordane	6.00	1/17	5.88	NA	NA	<2000.00	NA	No	BNG
gamma-Chlordane	4.80	2/17	11.76	NA	NA	<2000.00	NA	No	BNG
Toxaphene	10.00	1/4	25.00	NA	NA	NA	NA	Yes	no criteria
Phenanthrene	610.00	1/5	20.00	NA	NA	5000	NA	No	BNG
Anthracene	120.00	1/5	20.00	NA	NA	10000	NA	No	BNG
Fluoranthene	6900.00	1/5	20.00	NA	NA	10000	NA	No	BNG
Pyrene	7800.00	1/5	20.00	NA	NA	10000	NA	No	BNG
Benzo(a)anthracene	6200.00	1/5	20.00	NA	NA	1000	NA	Yes	exceeds NG
Chrysene	5100.00	1/5	20.00	NA	NA	1000	NA	Yes	exceeds NG
Benzo(b)fluoranthene	6900.00	1/8	12.50	NA	NA	1000	NA	Yes	exceeds NG
Benzo(k)fluoranthene	6900.00	1/8	12.50	NA	NA	1000	NA	Yes	exceeds NG
Benzo(a)pyrene	3300.00	1/5	20.00	NA	NA	1000	NA	Yes	exceeds NG
Indeno(1,2,3-cd)pyrene	2300.00	1/5	20.00	NA	NA	1000	NA	Yes	exceeds NG
Benzo(g,h,i)perylene	2300.00	1/5	20.00	NA	NA	1000	NA	Yes	exceeds NG
Di-n-butylphthalate	5300.00	1/17	5.88	NA	NA	NA	NA	Yes	no criteria
Bis(2-ethylhexyl)phthalate	290.00	6/17	35.29	NA	NA	NA	NA	Yes	no criteria
Di-n-octylphthalate	100.00	3/13	23.08	NA	NA	NA	NA	Yes	no criteria
Dibenz(a,h)anthracene	630.00	1/5	20.00	NA	NA	100	NA	Yes	exceeds NG
Diethylphthalate	2.00	1/4	25.00	NA	NA	NA	NA	Yes	no criteria
Total Petro. Hydrocarbs.	124.00	14/19	73.68	NA	NA	NA	NA	Yes	no criteria
Aluminum	2.76E+07	18/18	100.00	1.90E+07	5.70E+07	7.10E+07	No	No	BNG, BNB
Arsenic	5.80E+03	12/14	85.71	ND	5.10E+03	5.00E+03	No	Yes	exceeds NG,NB
Barium	3.22E+04	14/14	100.00	4.90E+04	4.36E+05	4.30E+05	No	No	BB, BNG, BNB
Calcium	7.75E+05	11/18	61.11	2.27E+05	6.30E+06	NA	Yes	No	BNB, EE
Chromium	3.22E+04	14/14	100.00	1.09E+04	5.40E+04	1.00E+05	No	No	BNG, BNB
Cobalt	2.20E+03	4/14	28.57	2.36E+03	9.40E+03	8.00E+03	Yes	No	BB, BNG, BNB, EE
Copper	7.60E+03	3/14	21.43	7.00E+01	3.30E+04	3.00E+04	Yes	No	BNG, BNB, EE
Iron	1.14E+07	15/18	83.33	6.53E+06	2.50E+07	3.80E+07	Yes	No	BNG, BNB, EE
Lead	5.00E+03	13/14	92.86	ND	3.50E+04	1.00E+04	No	No	BNG, BNB
Magnesium	1.68E+06	14/14	100.00	2.56E+05	4.60E+06	5.00E+06	Yes	No	BNG, BNB, EE
Manganese	7.16E+04	15/18	83.33	6.38E+04	6.40E+05	6.00E+05	Yes	No	BNG, BNB, EE
Mercury	1.50E+02	1/6	16.67	1.40E+02	1.08E+02	3.00E+01	No	Yes	exceeds NG
Nickel	9.20E+03	3/9	33.33	4.45E+03	1.60E+04	4.00E+04	No	No	BNG, BNB
Potassium	1.75E+06	11/14	78.57	4.56E+05	1.20E+07	NA	Yes	No	BNB, EE
Vanadium	3.29E+04	14/14	100.00	2.70E+04	7.70E+04	1.00E+05	No	No	BNG, BNB
Zinc	2.00E+04	6/14	42.86	1.16E+04	2.33E+05	5.00E+04	Yes	No	BNG, BNB, EE

£ Exposure concentration represents the maximum detected concentration for soil

*Background is defined as the maximum detected concentration from background samples for NASA - WFF

**Source: Dragun and Chaisson, 1991. Values represent arithmetic means for Virginia or eastern USA soils

§ National Oceanic and Atmospheric Association (NOAA) Screening Guidelines. Inorganic values are based on US averages, those for organics are based on Canadian target values.

§§ Is the chemical a naturally-occurring Essential Element (EE)? (see Section 7.4.4.1)

¥ A "Yes" in this column indicates further evaluation is needed; "No" indicates that the chemical is not a concern. The reasoning for this determination is listed in the "Rationale Codes" column.

¥¥ Rationale Codes:

<5% - chemical was detected in less than 5% of the samples
BB - Below Background for NASA - WFF soil
BNB - Below National Background for soil
BNG - Below NOAA Screening Guidelines for soil
EE - Essential Element (macro- or micronutrient)
no criteria - screening criteria are unavailable; therefore, estimated intakes will be compared against toxicological benchmarks
exceeds NG - exposure concentration exceeds NOAA Guidelines for soil
exceeds NG,NB - exposure concentration exceeds NOAA Guidelines for soil and National Background for soil

NA - Not Available/Not Applicable

Shading indicates chemicals for which further evaluation is necessary

The surface water criteria are Federal and Virginia Ambient Water Quality Criteria (AWQC). The guidance values are the Screening Guidelines set by the National Oceanic and Atmospheric Administration (NOAA) for surface water and soil and a U.S. average for soil, taken from Dragun and Chaisson (1991).

Maximum exposure concentrations are based on the maximum detected concentration for the FTA in surface water, surface soil, and subsurface soil. Chemicals with maximum exposure concentrations below background concentrations (for inorganic chemicals only) or the NOAA Screening Guidelines (for both organic and inorganic chemicals) are "screened out" from further risk analysis. These chemicals are not expected to present ecological risk, and therefore are not considered in the exposure assessment and risk characterization. No chemicals in soil are dropped from consideration based solely on a comparison with the U.S. average. Naturally-occurring essential elements for life (including potassium, calcium, iron, magnesium, and sodium) in soil are not carried through the risk characterization. Those essential elements in soil which are of greater ecological risk concern (cobalt, copper, manganese, and zinc), due to established toxic effects, are never excluded based on their essential element status, unless the detected concentration is below a background concentration or guidance value. In addition, chemicals which are detected in fewer than five percent of the samples are screened from consideration. The ecological risk assessment includes any chemicals with concentrations in soil exceeding these comparative criteria.

7.4.4.2 Chemicals of Ecological Concern

Based on a comparison with background concentrations, ARARs, and guidance values, one organic chemical and 10 inorganic chemicals in surface water, nine organic chemicals and six inorganic chemicals in surface soil, and 18 organic chemicals and two inorganic chemicals in subsurface soil are of potential ecological concern at the FTA (Tables 7-5, 7-6, and 7-7).

7.4.5 Exposure Assessment

Maximum exposure concentrations for aquatic indicators are compared with toxic effect concentrations reported in the toxicological literature. For the purposes of a stress-response analysis, indicator species are chosen from among these observed potential receptors or other potential receptors that may be attracted by the habitat present at the FTA. For terrestrial species, exposure levels are calculated and the resulting estimated doses are compared with toxic effect levels reported in the toxicological literature.

Where available, toxicological studies on the indicator species are used, but in many cases, comparisons must be based on toxicological studies performed on laboratory animals, such as rats, or fathead minnows, due to a lack of receptor-specific data. The assessment endpoints used are those reported in the toxicological literature. Discussion of the conservative assumptions and selection of toxicological benchmarks appears in Section 7.4.6.

7.4.5.1 Indicator Species

The indicator taxa selected for the FTA represent a variety of taxonomic Orders at various trophic levels (Table 7-8). The indicator taxa for this site represent aquatic and terrestrial organisms, in accordance with the media of concern and the availability of aquatic (intermittent) and terrestrial habitat at or near the FTA.

The aquatic indicator species selected for the FTA are phytoplankton (primary producer), and mosquito larvae (primary consumer). Due to the shallowness and frequent drying of surface water at this site, higher trophic level aquatic receptors are not expected to become established at the FTA. It should be noted that no macroinvertebrates or other aquatic organisms were observed in the shallow, standing water at the FTA at the time of the ecological unit reconnaissance.

The terrestrial indicator species selected for the FTA are grass (primary producer), meadow vole (burrowing primary consumer), and the owl (secondary consumer).

Phytoplankton and grass are selected to help characterize effects on ecological receptors at the primary producer trophic level. The animals represent primary and secondary consumers (primary consumer only for surface water). These consumers are selected to address food-chain effects (i.e., biomagnification). For the terrestrial scenario, selection of a burrowing primary consumer addresses the increased level and duration of soil exposure that a burrowing receptor would experience. Life history and habitat requirement information on these indicator species is presented in Table 7-8.

It should be noted that these indicator taxa may not be the most sensitive receptors at the FTA, but, taken together, they represent a simple, feasible community through which potential ecological impacts may be assessed. Summarized exposure pathways are presented in Figure 7-2.

TABLE 7-8. Indicator Species Life History Matrix
Former Fire Training Area; NASA - Wallops Flight Facility, VA

Indicator Species or Taxa Group	Habitat Preference	Reproduction	Food Preferences	Comments
Phytoplankton	aquatic habitat	asexual and sexual	basic nutrients	may accumulate metals and other chemicals
Mosquito Larva (Culicidae)	aquatic larval/pupal stage; often remain around wet areas in adult fly form	sexual, eggs deposited in water	organic detritus, bacteria, algae, protozoa - filtered from water	may accumulate metals and other chemicals
Grass	fields/grasslands	vegetative and sexual	basic nutrients	may accumulate metals and other chemicals
Meadow Vole *(Microtus pennsyl-vanicus)*	grasslands, open swamps, roadside ditches, fencerows	sexual, breeds year-long, usually 1-10 young in litter, 17 litters/yr. possible	seeds and fruit, various grasses and weeds	may experience prolonged exposure to soil contaminants in burrow walls
Owl	wooded swamps and other forested areas	sexual, usually 2-3 eggs/clutch, eggs laid in March - early April	rodents, rabbits, some invertebrates	may consume large numbers of exposed prey items, increasing exposure

Indicator species were selected based on observations and professional judgement of species which are possible for the area.

Sources:
Barbour and Davis, 1974
McCafferty, 1983
Peterjohn and Rice, 1991
Stern, 1988

7.4.5.2 Aquatic Exposure

Due to the complete exposure pathways they present, surface water, surface soil, and subsurface soil are the media of ecological concern for the FTA. The presence of surface water at the FTA is not expected for significant periods. However, the basic assumption for the aquatic scenario is that phytoplankton and mosquito larvae will experience continuous, prolonged exposure to the surface water. This highly conservative approach to assessing ecological risk from these media is consistent with current ecological risk guidance.

Soil contaminants may affect aquatic receptors, but only indirectly through surface runoff. For the purposes of the ecological risk assessment, any leaching of contaminants from the soil is assumed to have already occurred, and therefore, this contamination is accounted for in the surface water results. Aquatic exposure to surface water contaminants may be increased by the additive effects of chemicals and trophic effects (e.g., biomagnification), but this cannot be quantified, using existing site-specific data; hence, very conservative assumptions for lower trophic levels are used in order to be protective of higher trophic levels.

7.4.5.3 Terrestrial Exposure

Terrestrial receptors may be exposed to surface water at the FTA through feeding, drinking, and other activities which could bring these receptors in contact with this medium. However, the frequency and duration of these exposures are expected to be insignificant in comparison with the nearly continuous exposures for aquatic organisms.

Soil exposure is addressed as a terrestrial exposure. For the terrestrial scenario, it is assumed that the chipmunk and owl will experience periodic (daily), long-term exposure to the soil, either directly or by consuming plants or prey with dust or dirt on their surface. Plants, such as grass, experience continuous, long-term exposure to soils. In the case of the FTA, this means that grass could experience prolonged exposure to the ecological chemicals of concern in FTA soils. Terrestrial animal receptors may be exposed to soil contaminants through feeding, dust bathing, resting, burrowing, grooming, and other activities which bring the receptors in direct contact with soil. Terrestrial exposure to soil contaminants may be increased by the additive effects of chemicals and trophic effects (e.g., biomagnification), but this

cannot be quantified, using existing site-specific data; hence, very conservative assumptions for lower trophic levels are used in order to be protective of higher trophic levels.

7.4.6 Risk Characterization/Stress-Response Assessment

The effect levels for surface water (Table 7-9), surface soil (Table 7-10), and subsurface soil (Table 7-11) are selected as follows. Preference is given to chronic No Observable Adverse Effect Levels (NOAELs) and Lowest Observable Adverse Effect Levels (LOAELs). Where these are not available, sublethal effect levels are used. In the absence of NOAELs, LOAELs, and sublethal effects information, acute effect levels and lethal doses (LD50s) or lethal concentrations (LC50s) are used. Acute effect levels and acute effect concentrations are avoided, where possible, to improve the predictive value and preserve the conservative nature of the ecological risk assessment. In addition, conservative assumptions are used in order to be protective of higher trophic level receptors via food-chain effects.

Toxicological studies from a variety of sources are used for reference effect levels and concentrations. These include Agency for Toxic Substances and Disease Registry (ATSDR) Toxicological Profiles (various dates), Handbook of Environmental Data on Organic Chemicals (Verschueren, 1983), and the Aquatic Information Retrieval (AQUIRE) database (1994).

To assess ecological risk from soil contamination at the FTA, this risk assessment uses a terrestrial exposure scenario based on a burrowing terrestrial receptor (vole) which consumes one percent of its own body weight (17 g animal consumes 0.17 g) in soil daily, with 25 percent of its time spent in the area of highest contamination, and 50 percent of the ingested chemical absorbed through the gastro-intestinal (GI) tract. Based on reported values, conservative assumptions, assumptions acceptable to other agencies, and professional judgment, these percentage values are established and used. Incidental ingestion of soil is assumed to be the most significant route of exposure for the vole, although additional exposure may occur through dermal and inhalation routes and through the ingestion of plants. Given that plant growth at and near the FTA is extensive and abundant, very little plant matter will likely be consumed directly in the areas of highest contamination. Dermal and inhalation exposure are also expected to make only a small contribution to ecological risk at the FTA. The conservative nature of the ingestion pathway assumptions are expected to compensate for the slight effect from these routes of exposure.

TABLE 7-9. Effect Levels vs. Detected Chemical Concentrations in Surface Water
Former Fire Training Area; NASA - Wallops Flight Facility, VA

ANALYTES	EXPOSURE CONC.* (µg/L)	Effect Conc. (µg/L)	Exp. Conc.< Effect Conc.?	Difference Factor¥	Effect¥¥	Test Subject
4,4'-DDT	0.01	1.53	Yes	273.21	effect on growth	fathead minnow
		0.50	Yes	89.29	EC50IM (immobilization)	daphnid
Aluminum	5450.00	2500.00	No	0.46	EC50BM (reduction in biomass)	water milfoil
		26980.00	Yes	4.95	acutely toxic	salmon fry
Barium	25.60	26000.00	Yes	1015.63	EC50GR (effect on growth)	water milfoil
Calcium	5800.00	40000.00	Yes	6.90	biochemical effect	blue-green algae
Iron (EE)	2730.00	7000.00	Yes	2.56	change in population growth	diatom
		58800.00	Yes	21.54	biochemical effect	blue-green algae
Lead	3.40	4400.00	Yes	1294.12	LC50	daphnid
		90.00	Yes	26.47	enzyme effect	pumpkinseed sunfish
Magnesium (EE)	1150.00	64700	Yes	56.26	LC50	scud
		240000	Yes	208.70	enzyme effect	euglenoid
Manganese (EE)	27.80	31000.00	Yes	1115.11	EC50GR (effect on growth)	duckweed
		70000.00	Yes	2517.99	lethal	scud
Potassium (EE)	2000.00	53200.00	Yes	26.60	LC50	scud
		391000.00	Yes	195.50	change in enzyme activity	euglenoid
Sodium (EE)	2250.00	230000.00	Yes	102.22	change in enzyme activity	euglenoid
		1820000.00	Yes	808.89	EC50IM (immobilization)	daphnid
Vanadium	6.80	1800.00	Yes	264.71	EC50GR (effect on growth)	dinoflagellate

* Exposure concentration represents the maximum detected concentration for surface water
¥ Difference Factor = effect concentration/exposure concentration
¥¥ SOURCES: AQUIRE (AQUatic Information REtrieval database). Accessed July, 1994; September, 1994.
EE - naturally-occurring Essential Element
Shading indicates chemicals with an exposure concentration which exceeds the selected effect concentration(s)

TABLE 7-10. Effect Levels vs. Calculated Burrowing Terrestrial Receptor Intake Concentrations for Surface Soil Former Fire Training Area; NASA - Wallops Flight Facility, VA

ANALYTES	EXPOSURE CONC.* (mg/kg)	Receptor Intake** (mg/kg BW)	Effect Level ¥ (mg/kg BW)	Intake < Effect Level?	Difference Factor ¥¥	Effect, type of exposure ¥	Test Subject ¥
Heptachlor	0.00025	3.13E-07	100.00	Yes	3.20E+08	acute LD50, oral	rat
Endosulfan I	0.0036	4.50E-06	18.00	Yes	4.00E+06	LD50, oral	rat
			30.00	Yes	6.67E+06	no ill effects after 2 yrs., oral (in diet)	rat
Endosulfan sulfate §	0.00038	4.75E-07	18.00	Yes	3.79E+07	LD50, oral	rat
			30.00	Yes	6.32E+07	no ill effects after 2 yrs., oral (in diet)	rat
Endrin ketone §§	0.001	1.25E-06	0.75	Yes	6.00E+05	NOAEL (10 days 1x/d), oral	hamster
			0.25	Yes	2.00E+05	NOAEL (24 mos.), oral	rat
Endrin aldehyde §§	0.0044	5.50E-06	0.75	Yes	1.36E+05	NOAEL (10 days 1x/d), oral	hamster
			0.25	Yes	4.55E+04	NOAEL (24 mos.), oral	rat
Benzo(b)fluoranthene + +	1.6	2.00E-03	923.00	Yes	4.62E+05	adverse eff. on blood, liver (6 mos.), oral	mouse
			308.00	Yes	1.54E+05	birth defects (10 days), oral	mouse
Benzo(k)fluoranthene + +	1.6	2.00E-03	923.00	Yes	4.62E+05	adverse eff. on blood, liver (6 mos.), oral	mouse
			308.00	Yes	1.54E+05	birth defects (10 days), oral	mouse
Di-n-butylphthalate	0.003	3.75E-06	2500.00	Yes	6.67E+08	decreased weight, oral	rat
			4000.00	Yes	1.07E+09	no effect, oral	rat
Total petro. hydrocarbs.	5.89	7.36E-03	NA	NA	NA	NA	NA
Arsenic	6.30	0.01	400.00	Yes	5.08E+04	reduced survival after 2 yrs., oral	rat
Cadmium	3.40	4.25E-03	200.00	Yes	4.71E+04	LD50, oral	mouse
			1.00	Yes	2.35E+02	breeding failure, oral	rat
Copper	58.10	0.07	4.20	Yes	5.78E+01	LOAEL, oral (decreased weight gain)	mouse
Lead	33.80	0.04	300.00	Yes	7.10E+03	LD50 of lead acetate, oral	dog
			17.00	Yes	2.16E+03	LD50 of tetraethyl lead, oral	rat
Mercury	0.21	2.63E-04	0.32	Yes	1.22E+03	NOAEL (for renal effects; 7d/wk, 2 yr)	rat
			0.42	Yes	1.60E+03	NOAEL (immunological effects; 7 wk)	mouse
Sodium	76.00	9.50E-02	NA	NA	NA	NA	NA

* Exposure concentration represents the maximum detected concentration for soil

** Intake (or dose) = exposure concentration x daily ingestion rate x appropriate unit conversion factors, where daily ingestion of soil = 1.0% of the body weight of the ecological receptor, 25% of the consumed soil originates from the area of highest contamination, and 50% of the consumed chemical is absorbed by the GI tract.

¥ SOURCES: ATSDR Toxicological Profiles. various dates.
Verschueren. 1983.

¥¥ Difference Factor = effect level/intake (dose) concentration

§ Toxicological benchmarks for endosulfan used

§§ Toxicological benchmarks for endrin used

\+ Toxicological benchmarks for delta-BHC

\+ + Polycyclic Aromatic Hydrocarbon (PAH) - toxicological benchmarks used are those for benzo(a)pyrene

TABLE 7-11. Effect Levels vs. Calculated Burrowing Terrestrial Receptor Intake Concentrations for Subsurface Soil
Former Fire Training Area; NASA - Wallops Flight Facility, VA

ANALYTES	EXPOSURE CONC.* (mg/kg)	Receptor Intake** (mg/kg BW)	Effect Level ¥ (mg/kg BW)	Intake < Effect Level?	Difference Factor ¥¥	Effect, type of exposure ¥	Test Subject ¥
delta-BHC	0.00015	1.88E-07	2.90	Yes	1.55E+07	NOAEL (104 wks.), oral	dog
			4.70	Yes	2.51E+07	hepato-cellular carcinoma (96 wks.), oral	mouse
Endosulfan I	0.00013	1.63E-07	18.00	Yes	1.11E+08	LD50, oral	rat
			30.00	Yes	1.85E+08	no ill effects after 2 yrs., oral (in diet)	rat
Endosulfan sulfate §	0.00082	1.03E-06	18.00	Yes	1.76E+07	LD50, oral	rat
			30.00	Yes	2.93E+07	no ill effects after 2 yrs., oral (in diet)	rat
Endrin aldehyde §§	0.004	5.00E-06	0.75	Yes	1.50E+05	NOAEL (10 days 1x/d), oral	hamster
			0.25	Yes	5.00E+04	NOAEL (24 mos.), oral	rat
Toxaphene	0.01	1.25E-05	12.90	Yes	1.03E+06	abdominal distension, diarrhea, oral	mouse
			0.20	Yes	1.60E+04	NOAEL (13wk, 1x/d), oral	dog
Benzo(a)anthracene +	6.20	7.75E-03	923.00	Yes	1.19E+05	adverse eff. on blood,liver (6 mos.), oral	mouse
			308.00	Yes	3.97E+04	birth defects (10 days), oral	mouse
Chrysene +	5.10	6.38E-03	923.00	Yes	1.45E+05	adverse eff. on blood,liver (6 mos.), oral	mouse
			308.00	Yes	4.83E+04	birth defects (10 days), oral	mouse
Benzo(b)fluoranthene +	6.90	8.63E-03	923.00	Yes	1.07E+05	adverse eff. on blood,liver (6 mos.), oral	mouse
			308.00	Yes	3.57E+04	birth defects (10 days), oral	mouse
Benzo(k)fluoranthene +	6.90	8.63E-03	923.00	Yes	1.07E+05	adverse eff. on blood,liver (6 mos.), oral	mouse
			308.00	Yes	3.57E+04	birth defects (10 days), oral	mouse
Benzo(a)pyrene	3.30	4.13E-03	923.00	Yes	2.24E+05	adverse eff. on blood,liver (6 mos.), oral	mouse
			308.00	Yes	7.47E+04	birth defects (10 days), oral	mouse
Indeno(1,2,3-cd)pyrene +	2.30	2.88E-03	923.00	Yes	3.21E+05	adverse eff. on blood,liver (6 mos.), oral	mouse
			308.00	Yes	1.07E+05	birth defects (10 days), oral	mouse
Benzo(g,h,i)perylene +	2.30	2.88E-03	923.00	Yes	3.21E+05	adverse eff. on blood,liver (6 mos.), oral	mouse
			308.00	Yes	1.07E+05	birth defects (10 days), oral	mouse
Di-n-butylphthalate	5.30	6.63E-03	2500.00	Yes	3.77E+05	decreased weight, oral	rat
			4000.00	Yes	6.04E+05	no effect, oral	rat
Bis(2-ethylhexyl)phthalate	0.29	3.63E-04	NA	NA	NA	NA	NA
Di-n-octylphthalate	0.10	1.25E-04	NA	NA	NA	NA	NA
Dibenz(a,h)anthracene +	0.63	7.88E-04	923.00	Yes	1.17E+06	adverse eff. on blood,liver (6 mos.), oral	mouse
			308.00	Yes	3.91E+05	birth defects (10 days), oral	mouse
Diethylphthalate	0.002	2.50E-06	25.00	Yes	1.00E+07	NOAEL (for liver toxicity; 14d)	rat
			0.06	Yes	2.34E+04	abnormal hepatic scintillation liver scans	monkey
Total petro. hydrocarbs.	0.124	1.55E-04	NA	NA	NA	NA	NA
Arsenic	5.80	0.01	400.00	Yes	5.52E+04	reduced survival after 2 yrs., oral	rat
Mercury	0.15	1.88E-04	0.32	Yes	1.71E+03	NOAEL (for renal effects; 7d/wk,2yr)	rat
			0.42	Yes	2.24E+03	NOAEL (immunological effects; 7wk)	mouse

* Exposure concentration represents the maximum detected concentration for soil

**Intake (or dose) = exposure concentration x daily ingestion rate x appropriate unit conversion factors, where daily ingestion of soil = 1.0% of the body weight of the ecological receptor, 25% of the consumed soil originates from the area of highest contamination, and 50% of the consumed chemical is absorbed by the GI tract.

¥ SOURCES: ATSDR Toxicological Profiles. various dates.
Verschueren. 1983.

¥¥ Difference Factor = effect level/intake (dose) concentration

§ Toxicological benchmarks for endosulfan used

§§ Toxicological benchmarks for endrin used

\+ Polycyclic Aromatic Hydrocarbon (PAH) - toxicological benchmarks used are those for benzo(a)pyrene

As an additional means of assessing potential risk for the former FTA, a hazard quotient method is developed to address risk to terrestrial receptors from additive effects from multiple chemicals in soil at the site. A worst-case scenario is used, assessing the exposure of a burrowing receptor to the maximum detected chemical concentrations of the chemicals of ecological concern detected in surface soil and subsurface soil. The hazard quotient is calculated by dividing the estimated intake by the toxicological effect level (reference dose). These quotients are then multiplied by a safety factor of 1, 10, or 100, based on the severity of the associated toxicological effect (Table 7-12). NOAELs are assigned a safety factor of 1, LD50s are assigned a safety factor of 100, and intermediate effects are assigned a safety factor of 10. The larger (i.e., more conservative) of these adjusted hazard quotients (where two benchmarks were reported) for each chemical are added together to estimate the potential for ecological impacts across the entire site. Using this approach, if an individual chemical is associated with an estimated intake which exceeds a toxicological effect level, the sum of these adjusted quotients will exceed one. This sum would indicate a potential ecological risk at the FTA. In addition, if several chemicals are associated with estimated intakes which are at approximately half of their toxicological effect level, the sum of the adjusted quotients will also exceed one. For the purposes of this hazard quotient approach, it is assumed that no potential risk to ecological receptors exists from soils at the former FTA if the sum of the adjusted quotients is less than one.

In general terms, exposure to the chemicals of ecological concern in surface water and soils can potentially have a variety of acute and chronic impacts on receptors. These impacts include reduced survival rates, health effects (e.g., liver deterioration), developmental effects (e.g., reduced growth), reproductive effects (e.g., lowered fecundity), and teratogenic effects (e.g., fetal deformation). Ecologically, any of these potential impacts are of concern, and could negatively impact receptor populations at the FTA. The assessment endpoints used in the stress-response assessment are those reported in the toxicological literature (Tables 7-9, 7-10, 7-11, and 7-12).

7.4.6.1 Ecological Risk from Surface Water

Aluminum and iron in surface water at the FTA exceed Federal AWQC. DDT and lead exceed both State and Federal AWQC (Table 7-5). However, only aluminum presents potential ecological risk. The maximum aluminum exposure concentration exceed an effect concentration shown to cause a reduction in biomass for water milfoil (Table 7-9).

TABLE 7-12. Effect Levels vs. Calculated Burrowing Terrestrial Receptor Intake Concentrations for Soils

Former Fire Training Area; NASA - Wallops Flight Facility, VA

ANALYTES	MAXIMUM EXPOSURE CONC.* (mg/kg)	Med-ium**	Receptor Intake¥ (mg/kg BW)	Effect Level ¥¥ (mg/kg BW)	Intake< Effect Level?	Effect, type of exposure ¥¥	Test Subject ¥¥
delta-BHC	0.00015	SB	1.88E-07	2.90	Yes	NOAEL (104 wks.), oral	dog
				4.70	Yes	hepato-cellular carcinoma (96 wks.), oral	mouse
Heptachlor	0.00025	SS	3.13E-07	100	Yes	acute LD50, oral	rat
Endosulfan I	0.0036	SS	4.50E-06	18.00	Yes	LD50, oral	rat
				30.00	Yes	no ill effects after 2 yrs., oral (in diet)	rat
Endosulfan sulfate §	0.0052	SS	6.50E-06	18.00	Yes	LD50, oral	rat
				30.00	Yes	no ill effects after 2 yrs., oral (in diet)	rat
Endrin ketone §§	0.011	SS	1.38E-05	0.75	Yes	NOAEL (10 days 1x/d), oral	hamster
				0.25	Yes	NOAEL (24 mos.), oral	rat
Endrin aldehyde §§	0.0044	SS	5.50E-06	0.75	Yes	NOAEL (10 days 1x/d), oral	hamster
				0.25	Yes	NOAEL (24 mos.), oral	rat
Toxaphene	0.01	SB	1.25E-05	12.90	Yes	abdominal distension, diarrhea, oral	mouse
				0.20	Yes	NOAEL (13wk, 1x/d), oral	dog
Benzo(a)anthracene	6.20	SB	7.75E-03	923.00	Yes	adverse eff. on blood,liver (6 mos.), oral	mouse
				308.00	Yes	birth defects (10 days), oral	mouse
Chrysene +	5.10	SB	6.38E-03	923.00	Yes	adverse eff. on blood,liver (6 mos.), oral	mouse
				308.00	Yes	birth defects (10 days), oral	mouse
Benzo(b)fluoranthene	6.90	SB	8.63E-03	923.00	Yes	adverse eff. on blood,liver (6 mos.), oral	mouse
				308.00	Yes	birth defects (10 days), oral	mouse
Benzo(k)fluoranthene	6.90	SB	8.63E-03	923.00	Yes	adverse eff. on blood,liver (6 mos.), oral	mouse
				308.00	Yes	birth defects (10 days), oral	mouse
Benzo(a)pyrene	3.30	SB	4.13E-03	923.00	Yes	adverse eff. on blood,liver (6 mos.), oral	mouse
				308.00	Yes	birth defects (10 days), oral	mouse
Indeno(1,2,3-cd)pyre	2.30	SB	2.88E-03	923.00	Yes	adverse eff. on blood,liver (6 mos.), oral	mouse
				308.00	Yes	birth defects (10 days), oral	mouse
Benzo(g,h,i)perylene	2.30	SB	2.88E-03	923.00	Yes	adverse eff. on blood,liver (6 mos.), oral	mouse
				308.00	Yes	birth defects (10 days), oral	mouse
Di-n-butylphthalate	5.30	SB	6.63E-03	2500.00	Yes	decreased weight, oral	rat
				4000.00	Yes	no effect, oral	rat
Bis(2-ethylhexyl)phth	0.29	SB	3.63E-04	NA	NA	NA	NA
Di-n-octylphthalate	0.10	SB	1.25E-04	NA	NA	NA	NA
Dibenz(a,h)anthracen	0.63	SB	7.88E-04	923.00	Yes	adverse eff. on blood,liver (6 mos.), oral	mouse
				308.00	Yes	birth defects (10 days), oral	mouse
Diethylphthalate	0.002	SB	2.50E-06	25.00	Yes	NOAEL (for liver toxicity; 14d)	rat
				0.06	Yes	abnormal hepatic scintillation liver scans	monkey
Total petro. hydrocar	5.89	SS	7.36E-03	NA	NA	NA	NA
Arsenic	6.30	SS	0.01	400.00	Yes	reduced survival after 2 yrs., oral	rat
Cadmium	3.4	SS	4.25E-03	200.00	Yes	LD50, oral	mouse
				1.00	Yes	breeding failure, oral	rat
Copper	58.1	SS	7.26E-02	4.20	Yes	LOAEL, oral (decreased weight gain)	mouse
Lead	67.5	SS	8.44E-02	300.00	Yes	LD50 of lead acetate, oral	dog
				17.00	Yes	LD50 of tetraethyl lead, oral	rat
Mercury	0.21	SS	2.63E-04	0.32	Yes	NOAEL (for renal effects; 7d/wk,2yr)	rat
				0.42	Yes	NOAEL (immunological effects; 7wk)	mouse
Sodium	76.0	SS	9.50E-02	NA	NA	NA	NA

* Exposure concentration represents the maximum detected concentration for surface soil, subsurface soil, or sediment

** Medium in which maximum concentration was detected

¥ Intake (or dose) = exposure concentration x daily ingestion rate x appropriate unit conversion factors, where daily ingestion of soil = 1.0%of the body weight of the ecological receptor, 25% of the consumed soil originates from the area of highest contamination, and 50% of the consumed chemical is absorbed by the GI tract.

¥¥ SOURCES: ATSDR Toxicological Profiles. various dates.
Verschueren. 1983.

§ Toxicological benchmarks for endosulfan used

§§ Toxicological benchmarks for endrin used

+ Polycyclic Aromatic Hydrocarbon (PAH) - toxicological benchmarks used are those for benzo(a)pyrene

NA - Not Available/Not Applicable

Based on this ecological risk assessment, continuously exposed phytoplankton and mosquito larvae could experience non-lethal chronic impacts from surface water at the FTA, resulting from aluminum concentrations. However, due to the frequent drying of the shallow, standing water at this site, trophic impacts to these species and higher-level aquatic receptors are unlikely. In addition, conservative toxicological values selected for the receptors at lower trophic levels should be protective of secondary and tertiary consumers.

No other organic or inorganic chemicals detected in FTA surface water appear to present a potential risk to ecological receptors.

7.4.6.2 Ecological Risk from Soil (Surface and Subsurface)

Toxicological studies on plants for the ecological chemicals of concern are unavailable; hence, surface and subsurface soil contaminant effects on plants cannot be characterized. The few signs of vegetative stress observed at the FTA are attributed to drainage patterns and soil compaction caused by heavy equipment. No other signs of vegetative stress were observed at this site.

As shown in Tables 7-10 and 7-11, the comparison of calculated receptor intakes and benchmark toxicological values reported in the literature, indicates that no surface or subsurface soil contaminants appear to present a risk to ecological receptors at the FTA.

It should be noted that the owl, a secondary consumer, may feed on prey, such as voles, which have accumulated elevated levels of the ecological chemicals of concern in their body tissues. A lack of site-specific data precludes a detailed assessment of soil-related risk for this receptor. However, the conservative values used as reference toxicity values are expected to be protective of secondary and tertiary consumers.

The chemicals of concern for surface and subsurface soils are also assessed together in a worst-case scenario, using the maximum detected concentrations from these media (Table 7-12). This combined scenario addresses potential additive effects from multiple chemicals. The hazard quotient approach indicates no potential ecological risk from these media, since the total hazard quotient (0.72) is below a value of one (Table 7-12).

7.5 UNCERTAINTIES IN THE ECOLOGICAL RISK ASSESSMENT

Ecological risk assessment is a complex process that relies on many assumptions regarding exposure and the effects of exposure. These assumptions result in unquantifiable uncertainties, which may contribute to an overestimation or underestimation of risk. The major sources of uncertainties are described in this section:

1. Data on factors affecting exposure rates are insufficient and often unavailable, and therefore, certain assumptions are made regarding the level of exposure to ecological receptors. In this assessment, the conservative assumptions are that a burrowing terrestrial receptor would consume 1 percent of its own body weight in soil daily, 25 percent of the ingested soil would originate from the area of highest contamination, and 50 percent of the ingested chemical would be absorbed through the GI tract. Most animals do not consume this much soil. These conservative assumptions may lead to an overestimation of risk.

2. Receptor-specific data for exposure effects is lacking. This deficit necessitates the extrapolation of toxic effect data from laboratory studies of mice, rats, and aquatic organisms to ecological receptors at the FTA. This extrapolation may lead to an overestimation or underestimation of risk, for the following reasons:

    - Toxicity values generated by laboratory studies may involve less than lifetime exposures.

    - Laboratory studies typically expose animals to a single chemical by a single route. Animals living in the ambient environment will simultaneously contact multiple chemicals by several routes of exposure.

    - For practical purposes, laboratory animals are exposed to much higher doses and/or exposure concentrations than animals in the wild. Exposure concentration can have significant effects on biotransformation and the ultimate expression of toxicity. In other words, the dose-response (stress-response) relationship for any given chemical may not be linear in all regions of the curve.

- Responses to the same dose of chemical are not necessarily comparable between different species or even different strains of the same species. Wild populations are inherently more genetically diverse than laboratory animals, making comparisons even more difficult.

3. In nature, ecological receptors may experience continuous, long-term exposure to relatively low concentrations of contaminants, whereas many laboratory studies focus on short-term, relatively high concentration or high dose exposures. In addition, most of the effect levels found in the literature do not reflect LOAELs. These factors may lead to an underestimation of risk.

4. The effects of chemical interactions on toxicity are not known. Toxic effects are assumed to have an additive effect, but some chemicals may magnify toxic effects by acting synergistically, while other chemicals may interact to negate toxic effects. Risk may be overestimated or underestimated, depending on the chemical interactions involved.

5. Due to the mobility of animals within home ranges and migration routes, the exposure to contamination can vary among species and individuals. Assuming continuous exposure may lead to an overestimation of risk.

In general, the ecological risk assessment assumptions lead to conservative results, and to an overestimation of risk. Site-specific maximum exposure point concentrations are used to determine potential ecological impacts and, in most cases, these maximum levels are much higher than the concentrations found at and near the FTA. Therefore, estimations of risk based on these concentrations are conservative.

7.6 ECOLOGICAL RISK ASSESSMENT CONCLUSIONS

At the former FTA, surface water, surface soil, and subsurface soil media were sampled, as appropriate. From the sampling results, an ecological risk assessment was performed as part of the baseline risk assessment. Additionally, chemical concentrations were compared to appropriate ecological ARARs (i.e., AWQC).

This ecological risk assessment shows that only minimal potential ecological risk exists at this site. A summary of these potential risks and AWQC exceedances is presented in Table 7-13. FTA surface water had aluminum and iron concentrations that exceed Federal AWQC, and DDT and lead concentrations which exceed both Federal and State AWQC. Aluminum, however, is the only chemical detected in surface water found to present a potential ecological risk. Due to the intermittent nature of this water, no aquatic receptors are expected to become established at this site. This lack of established receptors effectively eliminates this exposure pathway, so aquatic receptors are actually highly unlikely to be impacted by the FTA.

Based on the screening-level approach and estimated intakes of chemicals of potential ecological concern, no contaminants in surface or subsurface soil are shown to present a potential ecological risk. None of the estimated intakes exceed representative effect levels from the toxicological literature. In fact, the majority of the estimated intakes are below their respective effect levels by at least a factor of 1000.

To complement the ecological risk assessment findings, the chemicals of concern for soils (surface and subsurface) are assessed together in a worst-case scenario, using the maximum detected concentrations across the soil profile. This assessment addresses potential additive effects from multiple chemicals. The hazard quotient approach (total hazard quotient 0.72) indicates no potential ecological risk from the maximum chemical concentrations detected in surface and subsurface soil (Table 7-12).

Considering the risk assessment findings for all media with complete ecological pathways and site-specific factors regarding surface water at the site, no ecological risk is expected at the FTA.

TABLE 7-13. Summary of Potential Ecological Risk Concerns and Ambient Water Quality Criteria Exceedances
Former Fire Training Area; NASA - Wallops Flight Facility, VA

MEDIUM	FTA	
	Ecological Risk§	>AWQC §§
Ground Water	N/A	N/A
Surface Water (intermittent)	None	Federal: **Al, Fe** Federal & State: **DDT, Pb**
Surface Soil	None	N/A
Subsurface Soil	None	N/A

§ Ecological Risk (chemicals listed present potential risks to ecological receptors)
§§ Ambient Water Quality Criteria (AWQC) exceedance (chemicals listed exceeded Federal or State AWQC, as noted)
N/A - Not Applicable
None - no chemicals in this medium were shown to present a potential ecological risk

8.0 SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

8.1 SUMMARY

8.1.1 Site Characteristics

The WFF Main Base is located at the southern end of the Delmarva Peninsula in Accomack County, Virginia. The Main Base consists of offices, tracking facilities, a range control center, rocket and fuel storage depot, shops, housing, and an airfield. It is located in a rural area approximately five miles from Chincoteague Island which has a resident population of 3600 people. In this area, groundwater is the principal source of potable water. The climate is humid with hot summers and no distinct dry season.

WFF is part of the Atlantic Coastal Plain physiographic province and underlain by approximately 7000 feet of unconsolidated sediments. The water-bearing formations within the WFF area consist of sedimentary units ranging in age from Cretaceous to Quaternary. The two uppermost stratigraphic units, the Yorktown Formation and the overlying Columbia Group, are the most important water supply formations for agricultural, domestic, public, and industrial uses. The topography in the vicinity of the FTA is generally flat, and drainage patterns ultimately release north toward Little Mosquito Creek and adjacent marshlands.

The wildlife at WFF includes a variety of species of birds, mammals, reptiles and amphibians, and other organisms. Yet very few species or their signs were actually observed in the former FTA. Those observed included: several species of perching birds, white-tailed deer, raccoon, saltmarsh mosquitos, and greenhead flies. Although not observed, signs were found which indicate the presence of rabbits, bats, snakes, and terrestrial turtles. No threatened or endangered species were observed at the former FTA.

The site is dominated by an upland field habitat, with a nearby upland forest. The field habitat at the site is mowed, limiting its potential as a habitat for wildlife. The former FTA is also bounded by an active runway. No wetlands were reported or noted for the former FTA area.

8.1.2 Nature and Extent of Contamination

Three main sources of potential contamination were identified at the site: the former fire training pit area, the sludge pile, and the construction debris disposal area. The former FTA pit area was used for training

exercises from 1965 to 1987. Fuels, waste solvents, and other combustibles were released into the unlined pit and ignited as part of the exercises. In 1986, approximately 20 truckloads of soil reportedly contaminated with a mixture of jet fuel and crankcase oil were removed from the fire training pit area. The results of the field investigation indicate that the primary source of contamination is the former FTA pit area. Residual surface and subsurface soil contamination and contamination of the water table (Pleistocene) aquifer were detected.

The sludge pile was used for the disposal of sludge from the WFF Wastewater Treatment Facility. Drums with unknown contents were stored near the sludge pile for an undetermined length of time. The construction debris disposal area was primarily used for storage of clean fill, but over the years became the unauthorized disposal area for construction debris such as concrete and metal. Based on previous assessments and analytical results from the data collected during this investigation, these sites do not contribute significantly to the residual soil and groundwater contamination observed at the FTA.

The estimated area and volume of contaminated groundwater in the water table (Pleistocene) aquifer is 40,272 square feet and 587,971 cubic feet. The estimated area and volume of contaminated soil is 22,240 square feet and 324,704 cubic feet. In general, the samples analyzed indicated some volatile organic contamination from fuels and solvents; PAH contamination from fuels and used crankcase oil; and arsenic and lead contamination, which is most likely due to crankcase oil and leaded fuel.

8.1.3 Contaminant Fate and Transport

8.1.3.1 Shallow Aquifer Transport

Chemicals released at the site may have been leached from surface soils into the underlying shallow aquifer. The sandy soil types at the former FTA most likely facilitated vertical transport to the upper aquifer from the unlined pit area. Two wells completed in the shallow aquifer (MW-02S and MW-55S), downgradient from the FTA showed contamination with a number of volatile compounds, at total levels over 600 μg/l and 3200 μg/l respectively. Detected levels of semivolatiles were reported in the wells, especially MW-55S which had high levels of naphthalene and 2-methylnaphthalene. The concentrations of several toxic metals (arsenic, lead, chromium) are slightly elevated in these wells, as are some of the less toxic elements (aluminum, iron, manganese).

There is no evidence that groundwater contamination from the FTA has reached surface water at Little Mosquito Creek, or has adversely affected groundwater quality in the area of the Town of Chincoteague or NASA drinking water wells. The Town of Chincoteague and NASA Supply wells are located upgradient, or cross-gradient at a significant distance, of the former FTA. The Town of Chincoteague wells are separated from the area of the FTA by a groundwater divide located near Runway 04-22. The NASA supply wells are screened in the Miocene age aquifers upgradient of the FTA.

Based on water level data collected from monitoring wells in the vicinity of the former FTA, the direction of groundwater flow is northeast toward Little Mosquito Creek. In the direction of groundwater flow the nearest receptor is Little Mosquito Creek, which is not a potable water source due to brackish conditions, and has shellfish condemnation as a precautionary measure because of the Virginia Pollutant Discharge Elimination System (VPDES) permitted outfall for the WFF wastewater treatment plant.

The groundwater plume appears to be confined to the area immediately downgradient of the former FTA. The plume, as defined by the concentrations of cis-1,2-dichloroethene, extends approximately 400 feet northeast (Figure 6-1).

8.1.3.2 Soil

Available data indicate that chemical contamination related to past activities at the FTA is present in surface soil at the site. Chemical analyses indicate the presence of low levels of semivolatiles in one or more samples. Samples SS-03, SS-10, and SS-11 (duplicate of SS-03) all from the same area, had low levels of PAHs. The levels of volatile organic compounds were not substantially higher than levels reported in laboratory or field blanks. The lack of volatile detections is probably attributable to volatilization from the upper soil layer. Low levels of pesticides were also detected in the surface soils. The concentrations of metals appear to be within the normal background range, with the possible exception of arsenic and lead, which were slightly elevated in several surface soil samples. The transport of contaminants in surface soil from the FTA by surface runoff may occur, but has not been identified in surface water samples.

8.1.4 Human Health Risk Assessment

The human health risk assessment characterizes current and potential threats to human health that may be posed by chemicals found at the site, and migrating or potentially migrating off-site. This characterization included the identification of site-related chemicals of concern, an estimate of the magnitude of potential impacts of those chemicals to human health, both current and future, and a comparison of that magnitude to U.S. EPA de minimus, or acceptable, risk levels.

The initial data was screened to focus the risk assessment on the chemicals expected to present the highest level of risk at the site. This screening was accomplished by comparing the analytical data to risk-based and background concentrations, determining the frequency of detection in on-site media, designating essential nutrients, and evaluating blank contamination. The resulting chemicals of concern included several volatiles, semivolatiles, pesticides, and metals. The volatile chemicals of concern were 1,1-dichloroethene, cis-1,2-dichloroethene, methylene chloride, chloroform, benzene, tetrachloroethene, toluene, trimethylbenzene, and tetramethylbenzene. The semivolatiles included: 2-methylnaphthalene, naphthalene, phenanthrene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and benzo(g,h,i) perylene. The pesticides were alpha-BHC, heptachlor epoxide, and gamma-chlordane. The metals of concern were arsenic and lead.

After determining the chemicals of concern, an exposure assessment was conducted to estimate the potential type and magnitude of exposure at the former FTA. This task was followed by a toxicity assessment, which consisted of hazard identification and dose-response evaluation. The risk characterization then summarized and integrated the exposure and toxicity assessment results to provide a numerical estimation or a qualitative discussion of the risk posed by the chemicals of concern.

Overall, under the current land use scenario, the chemicals which pose the greatest risk are arsenic and dibenz(a,h)anthracene. Arsenic was detected in all of the soil and sediment samples at values comparable to the average for U.S. soils, but no arsenic was detected in the WFF background soil samples. Arsenic did not contribute significantly to noncarcinogenic risk. The carcinogenic risk associated with arsenic exceeds the $1x10^{-6}$ de minimus level, but is within the $1x10^{-4}$ to $1x10^{-6}$ risk range, which may be acceptable for current land use conditions. Dibenz(a,h)anthracene also did not contribute significantly to noncarcinogenic risk. The associated carcinogenic risk for dibenz(a,h)anthracene exceeds the $1x10^{-6}$ de minimus level, but is within the EPA target risk range.

A separate biokinetic uptake model evaluation was conducted for lead. Using this model, it was determined that the lead concentration in the soil, sediment, and filtered groundwater at the former FTA did not result in blood levels in excess of the criterion value of 10 μg lead/dl blood. Also, the maximum lead concentration detected in on-site soil or sediment was below the screening level of 400 ppm recommended by the EPA for evaluating the need for remedial action for residential land use.

The overall carcinogenic risk for future residential exposure to chemicals in groundwater at the former FTA exceeds the upper bound value of the EPA target risk range ($1x10^{-4}$). The carcinogenic chemicals of concern included: 1,1-dichloroethene, methylene chloride, chloroform, benzene, tetrachloroethene, alpha-BHC, heptachlor epoxide, gamma-chlordane, and arsenic. Chemicals which did not contribute risk in excess of the $1x10^{-6}$ de minimus value were chloroform and gamma-chlordane.

8.1.5 Ecological Risk Assessment

The ecological risk assessment was conducted after a field visit to the former FTA on August 15, 1994. Observations were made of the flora and fauna present, as well as any potential exposure routes through which site-related contaminants could affect the ecological receptors.

The identified potential receptors included: herbaceous flora such as grasses and forbs; woody flora such as saplings and shrubs; terrestrial invertebrates; passerine birds; raptors; rodents; raccoons; and deer. Based on observed habitats, snakes, terrestrial turtles, insectivores, rabbits, and bats are potentially present at this site, but none were observed.

Complete ecological pathways exist for the surface water, sediment, surface soil, and subsurface soil; therefore, potential receptors may experience direct contact with contaminants contained within these media. The ecological pathways to groundwater are incomplete.

The chemicals of ecological concern evaluated for surface water include: 4,4-DDT, aluminum, barium, calcium, iron, lead, magnesium, manganese, potassium, sodium, and vanadium. The chemicals of concern evaluated for surface soil include: endosulfan I, endosulfan sulfate, endrin ketone, endrin aldehyde, di-n-butylphthalate, arsenic, cadmium, copper, and lead. The chemicals of concern evaluated for subsurface soil include: delta-BHC, endosulfan I, endosulfan sulfate, endrin aldehyde, toxaphene,

benzo(a)anthracene, chrysene, benzo(b) fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, benzo(g,h,i)perylene, di-n-butylphthalate, bis(2-ethylhexyl)phthalate, di-n-octylphthalate, dibenz(a,h)anthracene, diethylphthalate, arsenic, and mercury.

The chemicals of concern detected in the surface water which exceeded the Federal Ambient Water Quality Criteria (AWQC) included: aluminum, iron, and 4,4-DDT. Of these, aluminum is the only chemical of concern which presents a potential ecological risk (reduction in biomass for water milfoil.) Due to the intermittent nature of the surface water at the site, the sediment was considered dry soil in the assessment. When considered surface soil, the concentration of aluminum is lower than the risk-based concentration, and is therefore not considered a significant concern.

The ecological risk from the chemicals of concern in the soil and sediment was determined using a worse-case scenario. Maximum hazard quotients with safety factors were calculated by dividing the intake (dose) concentration by the effect level for each chemical. The total hazard quotient for the soil and sediment was 0.72. This indicates no potential ecological risk from these media, since the total was below a value of one.

Uncertainty in the ecological risk assessment is due to limited data on factors affecting exposure rates and receptor-specific data for exposure effects. The resulting assumptions may have led to an overestimation or underestimation of risk, but conservatism was inherent in the evaluation performed.

8.2 CONCLUSIONS AND RECOMMENDATIONS

8.2.1 Data Limitations and Gaps

The soil borings were placed in locations selected for the installation of monitoring wells. The well locations were selected to characterize both the area of most significant groundwater contamination and the lateral extent of contamination in the Pleistocene age aquifer. The soil gas survey provided the basis for selecting the area of greatest contamination, as well as the lateral limits of the groundwater plume. Because the soil boring locations were selected on the basis discussed above, a full characterization of residual subsurface soil contamination remaining following the 1986 removal action may not have been achieved. Given the presence of significant volatile organic contamination in the shallow aquifer, a continuing source (contaminated soil) may be postulated. That source area is most likely upgradient of

wells MW-55S and MW-55D, which exhibited the most significant levels of volatile and semivolatile organic contamination. These wells are thought to be immediately downgradient of the location of the former fire training pit area, where residual soil contamination is most likely to be encountered.

Due to this data gap, the area and volume of residual soil contamination was estimated based on the monitoring well data, surface soil results, soil boring results, and contaminant migration potential.

8.2.2 Recommendations and Conclusions

The results of the baseline risk assessment, which is based on conservative assumptions and maximum detected concentrations, indicate that remedial action is not warranted for current land use conditions. This conclusion assumes that the FTA will remain a mowed, undeveloped area with no subsurface disturbance and no groundwater receptors (i.e., wells).

The U.S. EPA Region III requested, as part of their review of the draft Work Plan, an assessment of risks associated with future development of the site for residential use. Under this scenario, also based on conservative assumptions and maximum detected concentrations, the baseline risk assessment indicates risk to human health associated with use of groundwater as a potable water source. Since residual soil contamination may serve as a continuing source to groundwater contamination, soil and groundwater remedial alternatives must be considered, based on the evaluation of the future residential land use scenario.

Based on these results, the following conclusions and recommendations are offered.

- Consistent with the NCP, a Feasibility Study should be completed to evaluate remedial alternatives, including no action.

- For current land use, the no action alternative is appropriate, based on the results of the baseline risk assessment.

- Remedial alternatives, such as a pump-and-treat system for groundwater, in-situ and ex-situ

biological treatment for soil and groundwater, soil solidification/stabilization, and excavation and off-site disposal should be screened and evaluated using the nine EPA criteria. EPA presumptive remedies for groundwater contamination should be evaluated, as available.

- Since future development of the FTA for residential use is considered unlikely, the FS should place an emphasis on the no action and institutional controls alternatives.

Chemicals of Concern. The human health risk assessment provides the basis for final selection of chemicals of concern. No chemicals of concern were identified in the ecological risk assessment.

Current Land Use. Under current land use, only arsenic and dibenz(a,h)anthracene in soil were identified as significant contributors to overall site risk. Use of the U.S. EPA Biokinetic Uptake Model for lead indicated that maximum site levels do not result in blood lead levels in excess of the 10 μg lead/dl blood maximum criterion for children. In addition, the maximum concentrations of lead detected in on-site soils were less than the current U.S. EPA screening level of 400 ppm in soil for residential use. The risk associated with arsenic and dibenz(a,h)anthracene under current land use conditions is based on the maximum levels detected in sediment collected from the on-site, intermittent ponded areas. The increased lifetime cancer risk falls within the U.S. EPA target risk range of $1x10^{-4}$ to $1x10^{-6}$, even using the maximum detected values. The noncarcinogenic risk for arsenic and dibenz(a,h)anthracene under current land use conditions is below the U.S. EPA target risk value of 1.0.

Future Land Use. Risk associated with the unlikely future residential land use of the former FTA results from the assumption that groundwater at the site could be used as a source of potable water. For exposure to soil under a residential scenario, the carcinogenic risk falls within the $1x10^{-4}$ to $1x10^{-6}$ target range for acceptable risk, and the U.S. EPA biokinetic model indicates that the 10 μg lead/dl blood criterion value is not exceeded.

Chemicals of concern which provided significant contribution to risk associated with future use of groundwater include: methylene chloride, benzene, tetrachloroethene, heptachlor epoxide, and arsenic. Since residual soil contamination may be contributing to continuing groundwater contamination, these chemicals are also considered to be of concern in soil under future residential land use.

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APPENDIX A

SOIL BORING LOGS, WELL COMPLETION DIAGRAMS, AND GEOTECHNICAL SOILS LABORATORY RESULTS

APPENDIX A-1

SOIL BORING LOGS

Metcalf & Eddy, Inc. **GEOLOGIC LOG**

PROJECT: NASA D.O. 18	**JOB NO.:** 013516-0003		**BORING NO.:** SB-1
LOCATION: NASA/WFF Fire Training Area	**ELEVATION:**		**DEPTH:** 17 feet
	DATE BEGUN: 12-1-93		**DATE FINISHED:** 12-1-93
DRILL CONTRACTOR: Environmental Exploration, Inc.	**GEOLOGIST:** Michael 'Diran		
DRILLING RIG: B-57	**DRILLER:** C. Wenzel		
DRILLING METHOD: Hollow Stem Auger	**DRILL FLUID:** N/A		**HOLE SIZE:** 8-inch
WEATHER: Mild, approx. 45°F	**DEPTH TO WATER:** 12 feet		**DATE:** 12-1-93
COMPLETED AS WELL? No	**WELL PERMIT NO.:**		

DEPTH	SAMPLE #	SAMPLE DEPTH (Feet)	RECOVERY	BLOW COUNTS	SAMPLE DESCRIPTION	HNu/OVA (ppm)	NOTES
5	1	5 - 7	24"	5-6-8-8	Sand - lt. brn., loose, silty to fine grained (SM)	1.8	Dry
10	2	10 - 12	24"	14-14-17-17	Sand - as above (SM)	7.5	Moist
15	3	15 - 17	24"	5-7-10-11	Sand - as above (SM)	1.2	Wet
20							
25							

Metcalf & Eddy, Inc. **GEOLOGIC LOG**

PROJECT: NASA D.O. 18	**JOB NO.:** 013516-0003	**BORING NO.:** SB-2
LOCATION: NASA/WFF Fire Training Area	**ELEVATION:**	**DEPTH:** 17 feet
	DATE BEGUN: 12-1-93	**DATE FINISHED:** 12-1-93
DRILL CONTRACTOR: Environmental Exploration, Inc.	**GEOLOGIST:** Michael 'Diran	
DRILLING RIG: B-57	**DRILLER:** C. Wenzel	
DRILLING METHOD: Hollow Stem Auger	**DRILL FLUID:** N/A	**HOLE SIZE:** 8-inch
WEATHER: Cold, approx. 40°F	**DEPTH TO WATER:** 13 feet	**DATE:** 12-1-93
COMPLETED AS WELL? No	**WELL PERMIT NO.:**	

DEPTH	SAMPLE #	SAMPLE DEPTH (Feet)	RECOVERY	BLOW COUNTS	SAMPLE DESCRIPTION	HNu/OVA (ppm)	NOTES
5	1	5 - 7	24"	2-1-2-1	Sand - lt. brn., silty to fine grained (SM)	6.9	Dry to slightly moist
10	2	10 - 12	24"	7-8-10-11	Sand - lt. brn., loose, fine to med. grained(SM)	6.5	Moist
15	3	15 - 17	24"	9-12-17-18	Sand - as above, with trace clay (SM)	3.2	Wet
20							
25							

Metcalf & Eddy, Inc.

GEOLOGIC LOG

PROJECT: NASA D.O. 18	**JOB NO.:** 013516-0003	**BORING NO.:** SB-3
LOCATION: NASA/WFF Fire Training Area	**ELEVATION:**	**DEPTH:** 17 feet
	DATE BEGUN: 12-1-93	**DATE FINISHED:** 12-1-93
DRILL CONTRACTOR: Environmental Exploration, Inc.	**GEOLOGIST:** Michael 'Diran	
DRILLING RIG: B-57	**DRILLER:** C. Wenzel	
DRILLING METHOD: Hollow Stem Auger	**DRILL FLUID:** N/A	**HOLE SIZE:** 8-inch
WEATHER: Cold	**DEPTH TO WATER:** 15 feet	**DATE:** 12-1-93
COMPLETED AS WELL? No	**WELL PERMIT NO.:**	

DEPTH	SAMPLE #	SAMPLE DEPTH (Feet)	RECOVERY	BLOW COUNTS	SAMPLE DESCRIPTION	HNu/OVA (ppm)	NOTES
5	1	5 - 7	24"	5-7-16-20	Sand - lt. brn., loose, silty to fine grained (SM)	5.3	Moist
10	2	10 - 12	24"	10-13-10-20	Sand - as above (SM)	5.1	Moist
15	3	15 - 17	24"	12-14-16-16	Sand - as above (SM)	3.5	Wet
20							
25							

Metcalf & Eddy, Inc. **GEOLOGIC LOG**

PROJECT: NASA D.O. 18	JOB NO.: 013516-0003	BORING NO.: SB-4
LOCATION: NASA/WFF Fire Training Area	ELEVATION:	DEPTH: 24 feet
	DATE BEGUN: 12-3-93	DATE FINISHED: 12-8-93
DRILL CONTRACTOR: Environmental Exploration, Inc.	GEOLOGIST: Michael 'Diran	
DRILLING RIG: B-57	DRILLER: C. Wenzel / B. Mills	
DRILLING METHOD: Hollow Stem Auger	DRILL FLUID: N/A	HOLE SIZE:10-inch
WEATHER: Cold, approx. 35°F	DEPTH TO WATER: 14 feet	DATE: 12-8-93
COMPLETED AS WELL? MW-54S	WELL PERMIT NO.:	

DEPTH	SAMPLE #	SAMPLE DEPTH (Feet)	RECOVERY	BLOW COUNTS	SAMPLE DESCRIPTION	HNu/OVA (ppm)	NOTES
5	1	5 - 7	24"	6-12-17-20	Sand - lt. brn. to buff, loose, fine grained, trace silt (SM)	0.0	Dry
10	2	10 - 12	18"	10-10-14-13	Sand - as above (SM)	2.7	Dry to slightly moist
15	3	15 - 17	24"	2-3-4-4	Sand - lt. brn. to buff, loose, fine to med. grained (SM)	8.5	Wet
	A	17-19			Shelby Tube Sample		Good Recovery
20	4	20 -22	24"	2-3-3-5	Sand - lt. brn., loose, med. to coarse grained (SM)	2.5	Wet
25	5	22 - 24	24"	7-14-24-22	Sand - as above (SM)	1.0	Wet

Metcalf & Eddy, Inc. **GEOLOGIC LOG**

PROJECT: NASA D.O. 18	**JOB NO.:** 013516-0003	**BORING NO.:** SB-5
LOCATION: NASA/WFF Fire Training Area	**ELEVATION:**	**DEPTH:** 22 feet
	DATE BEGUN: 12-2-93	**DATE FINISHED:** 12-2-93
DRILL CONTRACTOR: Environmental Exploration, Inc.	**GEOLOGIST:** Michael 'Diran	
DRILLING RIG: B-57	**DRILLER:** C. Wenzel	
DRILLING METHOD: Hollow Stem Auger	**DRILL FLUID:** N/A	**HOLE SIZE:**10-inch
WEATHER: Approx. 60°F	**DEPTH TO WATER:** 14.5 feet	**DATE:** 12-2-93
COMPLETED AS WELL? MW-58S	**WELL PERMIT NO.:**	

DEPTH	SAMPLE #	SAMPLE DEPTH (Feet)	RECOVERY	BLOW COUNTS	SAMPLE DESCRIPTION	HNu/OVA (ppm)	NOTES
5	1	5 - 7	24"	5-6-7-10	Sand - lt. brn., loose, fine grained, trace silt (SM)	1.5	Dry to slightly moist
10	2	10 - 12	24"	7-10-11-12	Sand - lt. brn., loose, fine to med. grained, trace silt (SM)	5.1	Dry to moist
15	3	15 - 17	24"	5-9-13-14	Sand - as above (SM)	7.0	Wet
20	4	20 - 22	18"	16-17-23-27	Sand - lt. brn., loose, fine grained (SM)	0.0	Wet
25							

Metcalf & Eddy, Inc. **GEOLOGIC LOG**

PROJECT: NASA D.O. 18	**JOB NO.:** 013516-0003	**BORING NO.:** SB-6
LOCATION: NASA/WFF	**ELEVATION:**	**DEPTH:** 47 feet
Fire Training Area	**DATE BEGUN:** 12-1-93	**DATE FINISHED:** 12-1-93
DRILL CONTRACTOR: Environmental Exploration, Inc.	**GEOLOGIST:** Michael 'Diran	
DRILLING RIG: B-57	**DRILLER:** C. Wenzel	
DRILLING METHOD: Hollow Stem Auger	**DRILL FLUID:** N/A	**HOLE SIZE:**10-Inch
WEATHER: Mild, approx. 50°F	**DEPTH TO WATER:** 13 feet	**DATE:** 12-1-93
COMPLETED AS WELL? MW-56D	**WELL PERMIT NO.:**	

DEPTH	SAMPLE #	SAMPLE DEPTH (Feet)	RECOVERY	BLOW COUNTS	SAMPLE DESCRIPTION	HNu/OVA (ppm)	NOTES
5	1	5 - 7	24"	6-8-11-11	Sand - lt. brn., loose, fine grained, with some silt and clay (SM)	3.0	Moist
10	2	10 - 12	24"	12-6-7-18	Sand - same as above (SM)	3.2	Moist
15	3	15 - 17	24"	12-9-6-17	Sand - same as above (SM)	5.3	Wet
20	4	20 - 22	24"	19-27-38-39	Sand - lt. brn. to buff, loose to slightly dense, fine to silty (SM)	4.8	Wet
25	5	25 - 27	24"	14-10-14-14	Sand - same as above (SM)	4.5	Wet
30	6	30 - 32	24"	8-12-9-7	Sand - lt. brn. to dark gray, loose, silty to fine (SM)	3.9	Wet

Metcalf & Eddy, Inc. **GEOLOGIC LOG**

PROJECT: NASA D.O. 18	JOB NO.: 013516-0003	BORING NO.: SB-6
LOCATION: NASA/WFF, Fire Training Area		SHEET 2 OF 2

DEPTH	SAMPLE #	SAMPLE DEPTH (Feet)	RECOVERY	BLOW COUNTS	SAMPLE DESCRIPTION	HNu/OVA (ppm)	NOTES
35	7	34 - 36	24"	3-4-5-22	Sand - lt. brn. to orangish, loose, silty to fine grained (SM)	4.0	Wet
40	8	40 - 42	24"	4-9-39-50/4"	Sand - lt. brn., loose to slightly consolidated, poorly sorted, med. to very coarse, w/ some gravel (SP)	3.5	Wet
45	9	45 - 47	0"	31 - 50/4"	No sample		

Metcalf & Eddy, Inc. **GEOLOGIC LOG**

PROJECT: NASA D.O. 18	**JOB NO.:** 013516-0003	**BORING NO.:** SB-7	
LOCATION: NASA/WFF	**ELEVATION:**	**DEPTH:** 27 feet	
Fire Training Area	**DATE BEGUN:** 12-2-93	**DATE FINISHED:** 12-2-93	
DRILL CONTRACTOR: Environmental Exploration, Inc.	**GEOLOGIST:** Michael 'Diran		
DRILLING RIG: B-57	**DRILLER:** C. Wenzel		
DRILLING METHOD: Hollow Stem Auger	**DRILL FLUID:** N/A	**HOLE SIZE:** 10-inch	
WEATHER: Approx. 50°F	**DEPTH TO WATER:** 13 feet	**DATE:** 12-2-93	
COMPLETED AS WELL? MW-57S	**WELL PERMIT NO.:**		

DEPTH	SAMPLE #	SAMPLE DEPTH (Feet)	RECOVERY	BLOW COUNTS	SAMPLE DESCRIPTION	HNu/OVA (ppm)	NOTES
5	1	5 - 7	24"	8-14-14-14	Sand - lt. brn., loose, fine to med. grained, trace silt (SM)	7.1	Moist
10	2	10 - 12	24"	7-6-9-10	Sand - lt. brn., loose, fine to med. grained, trace silt and clay (SM)	7.0	Moist
15	3	15 - 17	18"	11-12-16-16	Sand - as above (SM)	10.7	Wet
		17 - 19			Shelby Tube Sample		Good recovery
20	4	20 - 22	24"	12-21-30-27	Sand - lt. brn. to buff, loose to slightly consolidated, clayey to silty, fine grained (SM)	BG = 16.5 23.5	Wet
25	5	25 - 27	24"	4-4-5-8	Sand - as above (SM)	BG = 16.9 21.5	Wet
					Note: BG = background PID reading		

Metcalf & Eddy, Inc. **GEOLOGIC LOG**

PROJECT: NASA D.O. 18	**JOB NO.:** 013516-0003	**BORING NO.:** SB-8
LOCATION: NASA/WFF Fire Training Area	**ELEVATION:**	**DEPTH:** 27 feet
	DATE BEGUN: 12-3-93	**DATE FINISHED:** 12-7-93
DRILL CONTRACTOR: Environmental Exploration, Inc.	**GEOLOGIST:** Michael 'Diran	
DRILLING RIG: B-57	**DRILLER:** C. Wenzel / B. Mills	
DRILLING METHOD: Hollow Stem Auger	**DRILL FLUID:** N/A	**HOLE SIZE:**10-inch
WEATHER: Mild, approx. 40°F	**DEPTH TO WATER:** 13.5 feet	**DATE:** 12-3-93
COMPLETED AS WELL? MW-55S, D	**WELL PERMIT NO.:**	

DEPTH	SAMPLE #	SAMPLE DEPTH (Feet)	RECOVERY	BLOW COUNTS	SAMPLE DESCRIPTION	HNu/OVA (ppm)	NOTES
5	1	5 - 7	24"	4-6-6-8	Sand - lt. brn. to buff, loose fine grained, trace silt (SM)	7.2	Dry, slight petrol. product odor
10	2	10 - 12	24"	10-12-16-16	Sand - same as above (SM)	14.6	Dry, strong petrol. product odor
15	3	15 - 17	24"	3-5-5-6	Sand - same as above (SM)	35.5	Wet, slight petrol. product stain and strong odor
20	4	20 - 22	24"	5-6-6-10	Sand - lt. brn., loose, fine to coarse, poorly sorted, w/ some pebbles (SP-SM)	85.6	Wet, strong petrol. petroleum product odor and stain
25	5	25 - 27	24"	12-6-6-4	Sand - same as above (SP-SM)	126.5	Wet, strong petrol. petroleum product odor and stain
30	6	29 - 31	24"	2-2-3-4	Clay - gray, dense, highly plastic (CH)	12.0	Moist to dry

Metcalf & Eddy, Inc. **GEOLOGIC LOG**

PROJECT: NASA D.O. 18	**JOB NO.:** 013516-0003	**BORING NO.:** SB-9
LOCATION: NASA/WFF Fire Training Area	**ELEVATION:**	**DEPTH:** 17 feet
	DATE BEGUN: 12-2-93	**DATE FINISHED:** 12-2-93
DRILL CONTRACTOR: Environmental Exploration, Inc.	**GEOLOGIST:** Michael 'Diran	
DRILLING RIG: B-57	**DRILLER:** C. Wenzel	
DRILLING METHOD: Hollow Stem Auger	**DRILL FLUID:** N/A	**HOLE SIZE:** 8-inch
WEATHER: Mild, approx. 60°F	**DEPTH TO WATER:** 13 feet	**DATE:** 12-2-93
COMPLETED AS WELL? MW-61I	**WELL PERMIT NO.:**	

DEPTH	SAMPLE #	SAMPLE DEPTH (Feet)	RECOVERY	BLOW COUNTS	SAMPLE DESCRIPTION	HNu/OVA (ppm)	NOTES
5	1	5 - 7	24"	5-6-7-8	Sand - lt. brn., loose, silty to fine grained, poorly sorted (SM)	3.1	Dry
10	2	10 - 12	24"	8-12-16-16	Sand - same as above (SM)	1.3	Moist
15	3	15 - 17	24"	8-9-10-13	Sand - lt. brn. to buff, loose, med. to coarse grained, trace silt (SM)	6.5	Wet
20							
25							

Metcalf & Eddy, Inc.

GEOLOGIC LOG

PROJECT: NASA D.O. 18	**JOB NO.:** 013516-0003	**BORING NO.:** SB-10
LOCATION: NASA/WFF Fire Training Area	**ELEVATION:**	**DEPTH:** 26 feet
	DATE BEGUN: 12-8-93	**DATE FINISHED:** 12-8-93
DRILL CONTRACTOR: Environmental Exploration, Inc.	**GEOLOGIST:** Michael 'Diran	
DRILLING RIG: B-57	**DRILLER:** B. Mills	
DRILLING METHOD: Hollow Stem Auger	**DRILL FLUID:** N/A	**HOLE SIZE:**10-inch
WEATHER: Sunny and mild, approx. 45°F	**DEPTH TO WATER:** 17.3 feet	**DATE:** 12-8-93
COMPLETED AS WELL? MW-59S	**WELL PERMIT NO.:**	

DEPTH	SAMPLE #	SAMPLE DEPTH (Feet)	RECOVERY	BLOW COUNTS	SAMPLE DESCRIPTION	HNu/OVA (ppm)	NOTES
5	1	5 - 7	12"	3-5-5-4	Sand - lt. brn., loose, silty to fine grained, poorly sorted (SM)	12.9	Dry to slightly moist
10	2	10 - 12	24"	10-14-15-15	Sand - lt. brn., dense to loose, clayey to fine to med. grained (SC-SM)	11.5	Moist
15	3	15 - 17	24"	2-2-2-7	Sand & Clay - lt. brn. w/ reddish patches, fine to med. grained, loose, sand (SM) to dense, soft, w/ some sand and silt (CL)	6.0	Moist
20	4	20 - 22	24"	2-4-17-17	Sand & Clay - gray to brn., silty and clayey (SC) to lt. brn., plastic, dense, soft (CL)	11.5	Moist to wet
	5	22 - 24	24"	3-4-5-8	Sand - orangish brn., loose, fine to gravelly, poorly sorted (SM-SP)	7.9	Wet
25	6	24 - 26	24"	10-24-29-19	Sand - same as above (SM-SP)	0.0	Wet

Metcalf & Eddy, Inc.

GEOLOGIC LOG

PROJECT: NASA D.O. 18	JOB NO.: 013516-0003	BORING NO.: SB-11
LOCATION: NASA/WFF Fire Training Area	ELEVATION:	DEPTH: 17 feet
	DATE BEGUN: 12-6-93	DATE FINISHED: 12-6-93
DRILL CONTRACTOR: Environmental Exploration, Inc.	GEOLOGIST: Michael 'Diran	
DRILLING RIG: B-57	DRILLER: B. Mills	
DRILLING METHOD: Hollow Stem Auger	DRILL FLUID: N/A	HOLE SIZE: 8-inch
WEATHER: Mild, approx. 60°F	DEPTH TO WATER: 17 feet	DATE: 12-6-93
COMPLETED AS WELL? MW-60I	WELL PERMIT NO.:	

DEPTH	SAMPLE #	SAMPLE DEPTH (Feet)	RECOVERY	BLOW COUNTS	SAMPLE DESCRIPTION	HNu/OVA (ppm)	NOTES
5	1	4 - 6	24"	3-4-5-8	Sand - lt. brn. to buff, silty to fine grained, poorly sorted (SM)	8.6	Dry to slightly moist
10	2	9 - 11	24"	6-7-8-9	Sand - same as above (SM)	6.5	Dry to slightly moist
15	3	14 - 16	12"	6-7-4-5	Sand - same as above (SM)	4.2	Moist
20							
25							

Metcalf & Eddy, Inc.

GEOLOGIC LOG

PROJECT: NASA D.O. 18	**JOB NO.:** 013516-0003	**BORING NO.:** SB-12
LOCATION: NASA/WFF Fire Training Area	**ELEVATION:**	**DEPTH:** 31 feet
	DATE BEGUN: 12-8-93	**DATE FINISHED:** 12-8-93
DRILL CONTRACTOR: Environmental Exploration, Inc.	**GEOLOGIST:** Michael 'Diran	
DRILLING RIG: B-57	**DRILLER:** B. Mills	
DRILLING METHOD: Hollow Stem Auger	**DRILL FLUID:** N/A	**HOLE SIZE:** 8-inch
WEATHER: Cold, <35°F	**DEPTH TO WATER:** 19 feet	**DATE:** 12-8-93
COMPLETED AS WELL? MW-53S	**WELL PERMIT NO.:**	

DEPTH	SAMPLE #	SAMPLE DEPTH (Feet)	RECOVERY	BLOW COUNTS	SAMPLE DESCRIPTION	HNu/OVA (ppm)	NOTES
5	1	4 - 6	24"	4-8-7-8	Sand - lt. brn., loose, silty to fine grained (SM)	2.7	Slightly moist
10	2	10 - 12	24"	3-12-25-29	Sand - lt. brn., loose, fine to med. grained (SM)	7.6	Slightly moist
15	3	15 - 17	24"	4-8-12-25	Sand - same as above (SM)	8.2	Dry
20	4	19 - 21	24"	3-4-6-11	Sand - same as above (SM)	14.3	Wet
25	5	24 - 26	24"	1-1-10-12	Sand - same as above (SM)	11.5	Wet
30	6	29 - 31	24"	10-2-4-2	Sand & Clay - lt. brn. to reddish, loose, fine to coarse (SM) to clay w/ some silt and sand (CL)	9.5	Wet

Metcalf & Eddy, Inc.

GEOLOGIC LOG

PROJECT: NASA D.O. 18	JOB NO.: 013516-0003	BORING NO.: SB-13
LOCATION: NASA/WFF Fire Training Area	ELEVATION:	DEPTH: 17 feet
	DATE BEGUN: 12-6-93	DATE FINISHED: 12-6-93
DRILL CONTRACTOR: Environmental Exploration, Inc.	GEOLOGIST: Michael 'Diran	
DRILLING RIG: B-57	DRILLER: B. Mills	
DRILLING METHOD: Hollow Stem Auger	DRILL FLUID: N/A	HOLE SIZE: 8-inch
WEATHER: Mild, approx. 45°F	DEPTH TO WATER: Dry	DATE: 12-6-93
COMPLETED AS WELL? No	WELL PERMIT NO.:	

DEPTH	SAMPLE #	SAMPLE DEPTH (Feet)	RECOVERY	BLOW COUNTS	SAMPLE DESCRIPTION	HNu/OVA (ppm)	NOTES
5	1	5 - 7	24"	9-8-7-9	Sand - lt. brn. to buff, loose, fine grained w/ some silt (SM)	0.0	Dry
10	2	10 - 12	24"	9-8-9-9	Sand - same as above (SM)	3.0	Dry
15	3	15 - 17	18"	9-12-15-16	Sand - same as above (SM)	0.0	Moist
20							
25							

Metcalf & Eddy, Inc. **GEOLOGIC LOG**

PROJECT: NASA D.O. 18	**JOB NO.:** 013516-0003		**BORING NO.:** SB-14
LOCATION: NASA/WFF Fire Training Area	**ELEVATION:**		**DEPTH:** 17 feet
	DATE BEGUN: 12-6-93		**DATE FINISHED:** 12-6-93
DRILL CONTRACTOR: Environmental Exploration, Inc.	**GEOLOGIST:** Michael 'Diran		
DRILLING RIG: B-57	**DRILLER:** B. Mills		
DRILLING METHOD: Hollow Stem Auger	**DRILL FLUID:** N/A		**HOLE SIZE:** 8-inch
WEATHER: Mild, approx. 45°F	**DEPTH TO WATER:** 16 feet		**DATE:** 12-6-93
COMPLETED AS WELL? No	**WELL PERMIT NO.:**		

DEPTH	SAMPLE #	SAMPLE DEPTH (Feet)	RECOVERY	BLOW COUNTS	SAMPLE DESCRIPTION	HNu/OVA (ppm)	NOTES
5	1	5 - 7	24"	9-9-8-9	Sand - lt. brn. to buff, loose, fine to silty (SM)	1.6	Dry
10	2	10 - 12	24"	10-10-11-12	Sand - same as above (SM)	3.5	Dry to moist
15	3	15 - 17	24"	7-8-11-11	Sand - same as above (SM)	5.8	Moist to wet
20							
25							

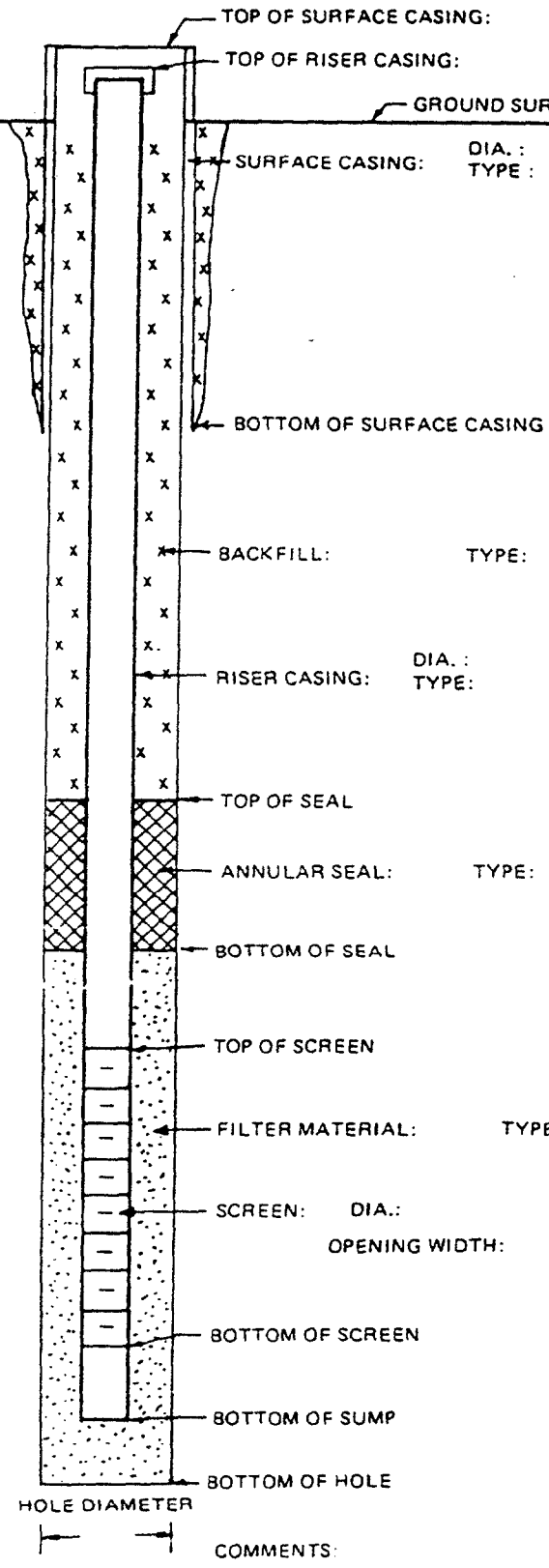
APPENDIX A-2
WELL COMPLETION DIAGRAMS

GROUND WATER INSTALLATION	PROJECT: NASA WFF	JOB NO. 013516-0003	WELL NO. MW-543
DRILLING CONTRACTOR: Environmental Exploration Inc	COORDINATES:		
BEGUN: FINISHED: 12/8/93	SUPERVISOR: M. Diran DRILLER:	WELL SITE: Fire Training Area	WATER LEVEL. DEPTH/ELEV

REFERENCE POINT & ELEVATION:

GENERALIZED GEOLOGIC LOG

See Log for SB-4



	DEPTH IN	ELEV. IN
TOP OF SURFACE CASING:	2.47	33.03
TOP OF RISER CASING:	2.4	32.96
GROUND SURFACE	0	30.56
TOP OF SEAL	5	25.56
BOTTOM OF SEAL	7	23.56
TOP OF SCREEN	9	21.56
BOTTOM OF SCREEN	24	6.56
BOTTOM OF SUMP	24	6.56

METHOD DRILLED: HSA

METHOD DEVELOPED:

TIME DEVELOPED:

COMMENTS:

M&E Metcalf & Eddy

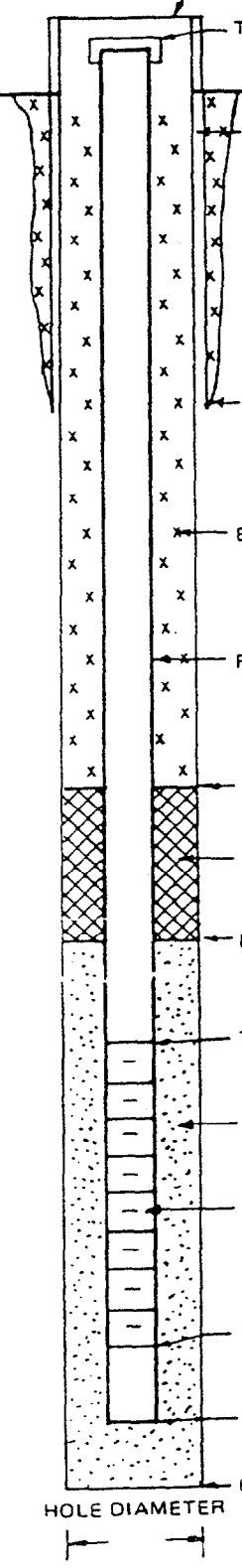
GROUND WATER INSTALLATION

PROJECT: NASA WFF	JOB NO. 013516	WELL NO. MW-535
DRILLING CONTRACTOR: Environmental Exploration Inc	COORDINATES:	
BEGUN: FINISHED: 12/8	SUPERVISOR: M. Diran DRILLER:	WELL SITE: Fire Training Area	WATER LEVEL: DEPTH/ELEV

REFERENCE POINT & ELEVATION:

GENERALIZED GEOLOGIC LOG

See log for Boring SB-12



	DEPTH IN	ELEV. IN
TOP OF SURFACE CASING:	0.70	33.29
TOP OF RISER CASING:	0.61	33.2
GROUND SURFACE	0	32.59
TOP OF SEAL	10	22.59
BOTTOM OF SEAL	12	20.59
TOP OF SCREEN	14	18.59
BOTTOM OF SCREEN	29	3.59
BOTTOM OF SUMP		

METHOD DRILLED: HSA

METHOD DEVELOPED:

TIME DEVELOPED:

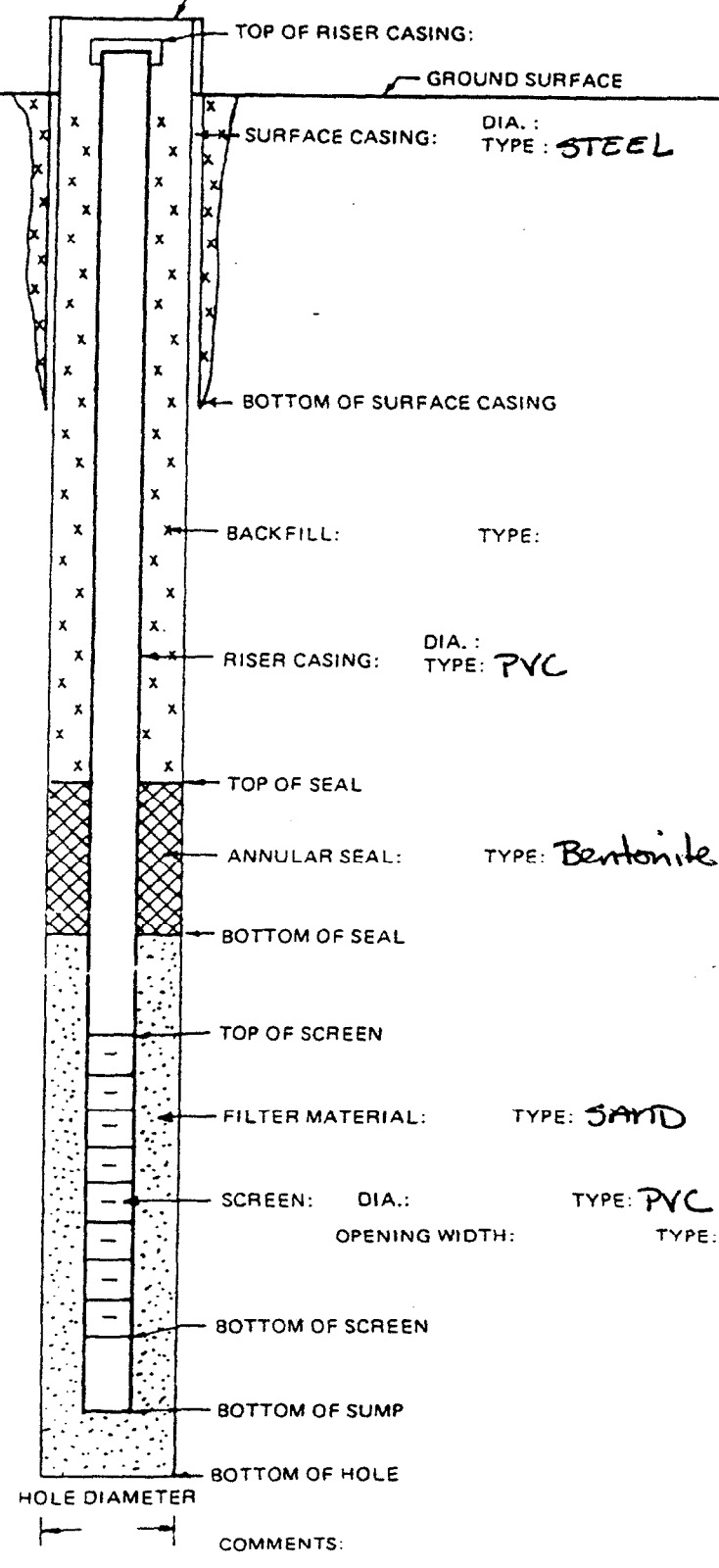
COMMENTS:

Metcalf & Eddy

GROUND WATER INSTALLATION

PROJECT: NASA WFF	JOB NO. 013516-0003	WELL NO. MW-555
DRILLING CONTRACTOR: Environmental Exploration	COORDINATES:	
BEGUN: / FINISHED:	SUPERVISOR: M. Diran / DRILLER:	WELL SITE: Fire Training Area	WATER LEVEL. DEPTH/ELEV

REFERENCE POINT & ELEVATION:



	DEPTH IN feet	ELEV. IN feet
TOP OF SURFACE CASING:	2.24	31.75
TOP OF RISER CASING:	2.12	31.63
GROUND SURFACE	0	29.51
TOP OF SEAL	4'	25.51
BOTTOM OF SEAL	6'	23.51
TOP OF SCREEN	8'	21.51
BOTTOM OF SCREEN	23'	3.51
BOTTOM OF SUMP	23'	3.51

METHOD DRILLED: HSA

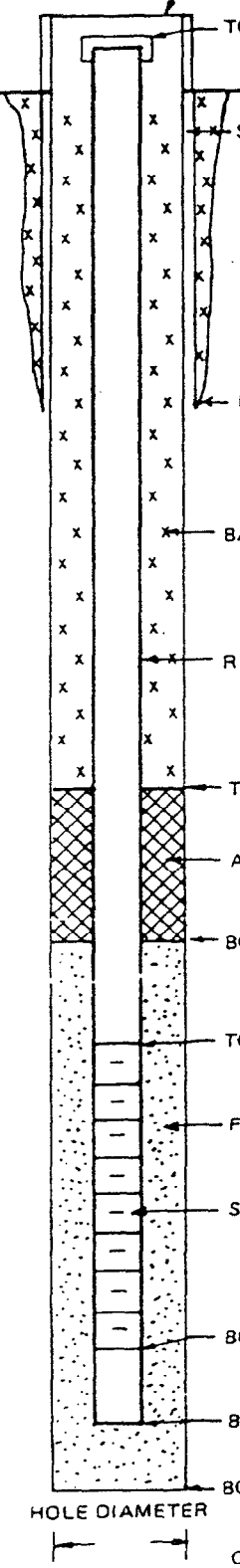
METHOD DEVELOPED:

TIME DEVELOPED:

Metcalf & Eddy

GROUND WATER INSTALLATION	PROJECT: NASA WFF	JOB NO. 013516-0003	WELL NO MW-55D
DRILLING CONTRACTOR: Environmental Exploration	COORDINATES:		
BEGUN: FINISHED: 12/7/93	SUPERVISOR: M. Dimm DRILLER:	WELL SITE: Fire Training Area	WATER LEVEL. DEPTH/ELEV.

REFERENCE POINT & ELEVATION:



	DEPTH IN	ELEV. IN
TOP OF SURFACE CASING:	2.34	31.85
TOP OF RISER CASING:	2.23	31.74
GROUND SURFACE	0	29.51
TOP OF SEAL	10	19.51
BOTTOM OF SEAL	12	17.51
TOP OF SCREEN	14	15.5
BOTTOM OF SCREEN	29	0.51
BOTTOM OF SUMP	29	0.51
BOTTOM OF HOLE		

GENERALIZED GEOLOGIC LOG

See Boring Log for SB-8

METHOD DRILLED: HSA

METHOD DEVELOPED:

TIME DEVELOPED:

COMMENTS:

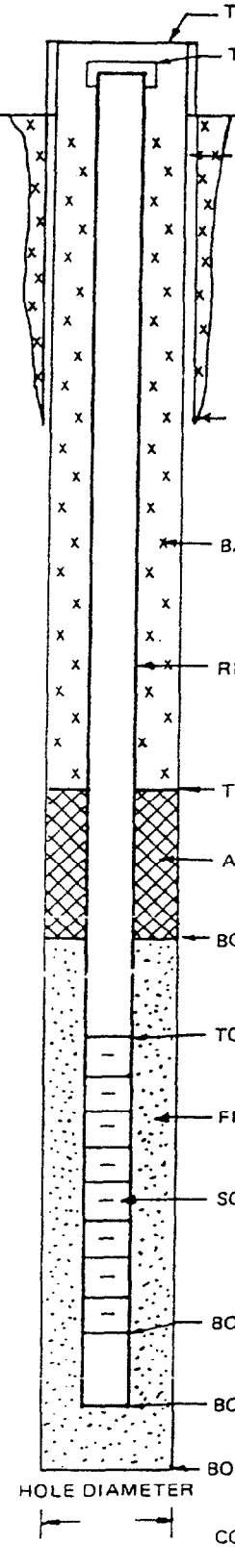
Metcalf & Eddy

GROUND WATER INSTALLATION	PROJECT: NASA/WFF	JOB NO. 013516-0003	WELL NO. MW-56D
DRILLING CONTRACTOR: Environmental Exploration Inc.	COORDINATES:		
BEGUN: / FINISHED:	SUPERVISOR: M. Diran / DRILLER:	WELL SITE: Fire Training Area	WATER LEVEL: DEPTH/ELEV. 17 ft / 11.35 ft

REFERENCE POINT & ELEVATION:

GENERALIZED GEOLOGIC LOG

See Log for boring SB-6



	DEPTH IN feet	ELEV. IN
TOP OF SURFACE CASING:	2.9	31.25
TOP OF RISER CASING:	2.9	31.25
GROUND SURFACE	0	28.35
TOP OF SEAL	12 ft	16.35
BOTTOM OF SEAL	15 ft	13.35
TOP OF SCREEN	28 ft ?	0.35
BOTTOM OF SCREEN	43 ft	-14.65
BOTTOM OF SUMP	?	

METHOD DRILLED: HSA

METHOD DEVELOPED:

TIME DEVELOPED:

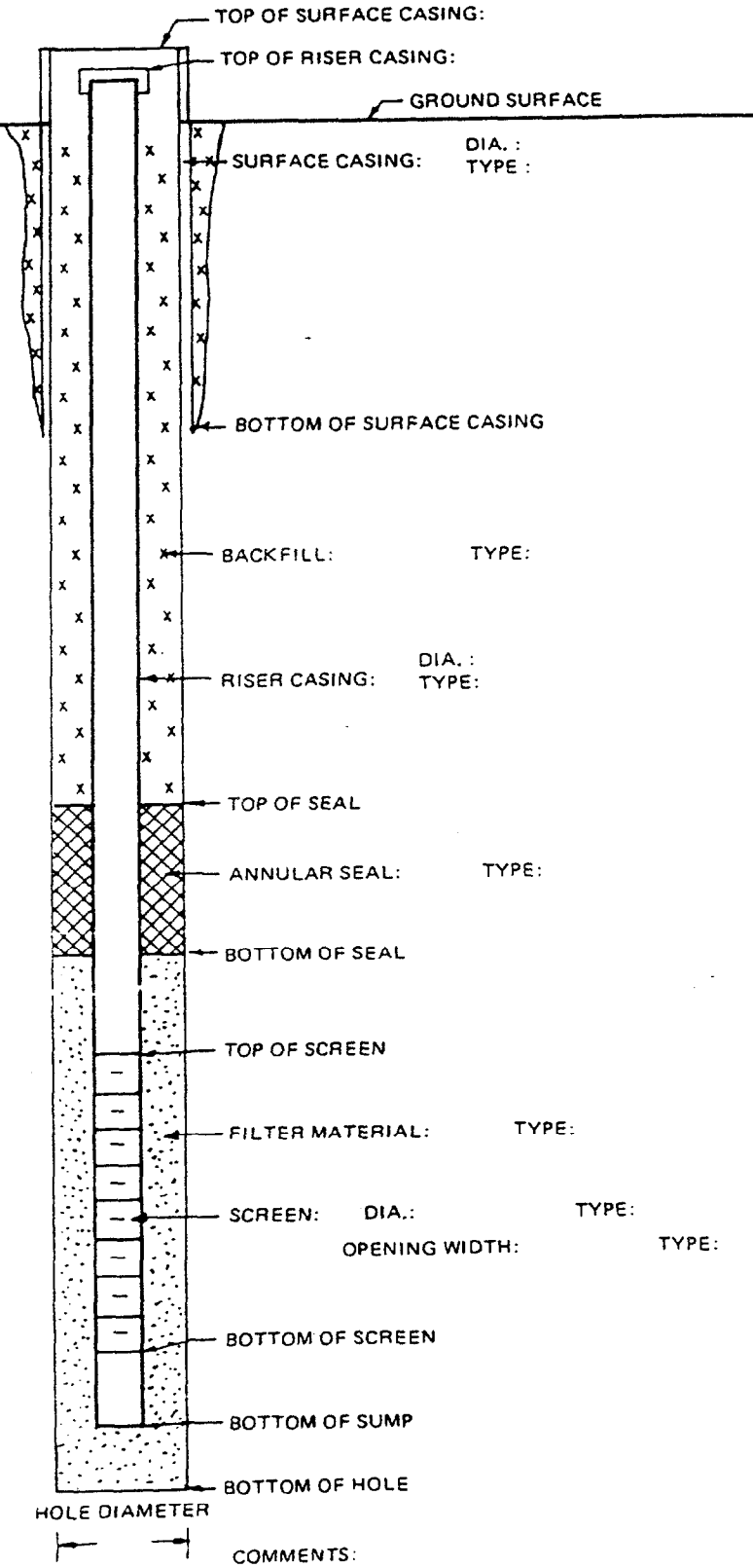
COMMENTS:

Metcalf & Eddy

GROUND WATER INSTALLATION

PROJECT: NASA WFF	JOB NO. 013516.0003	WELL NO. MW-575
DRILLING CONTRACTOR: Environmental Exploration Inc	COORDINATES:	
BEGUN: / FINISHED:	SUPERVISOR: M. Diran / DRILLER:	WELL SITE: Fire Training Area	WATER LEVEL. DEPTH/ELEV 15.53 / 13.67

REFERENCE POINT & ELEVATION:



	DEPTH IN feet	ELEV. IN feet
TOP OF SURFACE CASING:		32.39
TOP OF RISER CASING:	3.19	32.39
GROUND SURFACE	0	29.2
TOP OF SEAL	5	24.2
BOTTOM OF SEAL	7	22.2
TOP OF SCREEN	9	20.2
BOTTOM OF SCREEN	24	5.2
BOTTOM OF SUMP	24	5.2

GENERALIZED GEOLOGIC LOG

See Boring Log for SB-7

METHOD DRILLED: HSA

METHOD DEVELOPED: Removed 3 well Volumes = 54 gallons

TIME DEVELOPED:

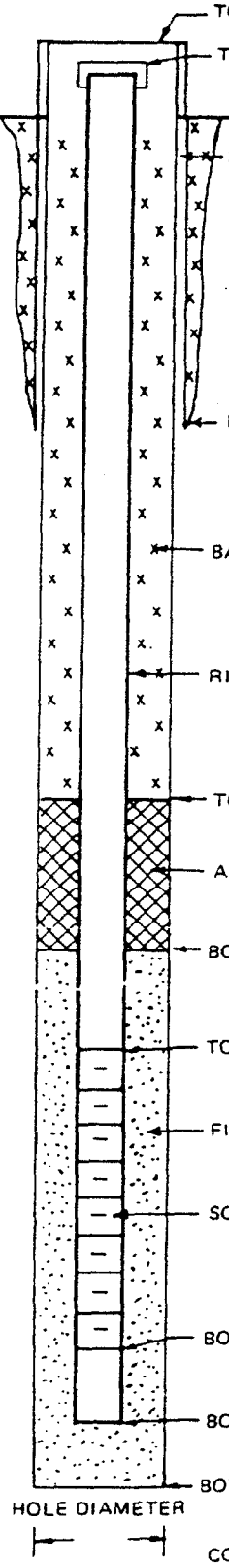
Metcalf & Eddy

GROUND WATER INSTALLATION	PROJECT: NASA WFF	JOB NO. 013516	WELL NO. MW-585
DRILLING CONTRACTOR: Environmental Exploration	COORDINATES:		
BEGUN: FINISHED: 12/7/93	SUPERVISOR: M. Diran DRILLER:	WELL SITE: Fire Training Area	WATER LEVEL: DEPTH/ELEV

REFERENCE POINT & ELEVATION:

GENERALIZED GEOLOGIC LOG

See geologic Log for Boring SB-5



	DEPTH IN feet	ELEV. IN
TOP OF SURFACE CASING:	2.41	30.27
TOP OF RISER CASING:	2.32	30.18
GROUND SURFACE	0	27.86
TOP OF SEAL	3.5	24.36
BOTTOM OF SEAL	6	21.86
TOP OF SCREEN	8	19.86
BOTTOM OF SCREEN	23	4.86
BOTTOM OF SUMP	23	4.86

METHOD DRILLED: HSA

METHOD DEVELOPED:

TIME DEVELOPED:

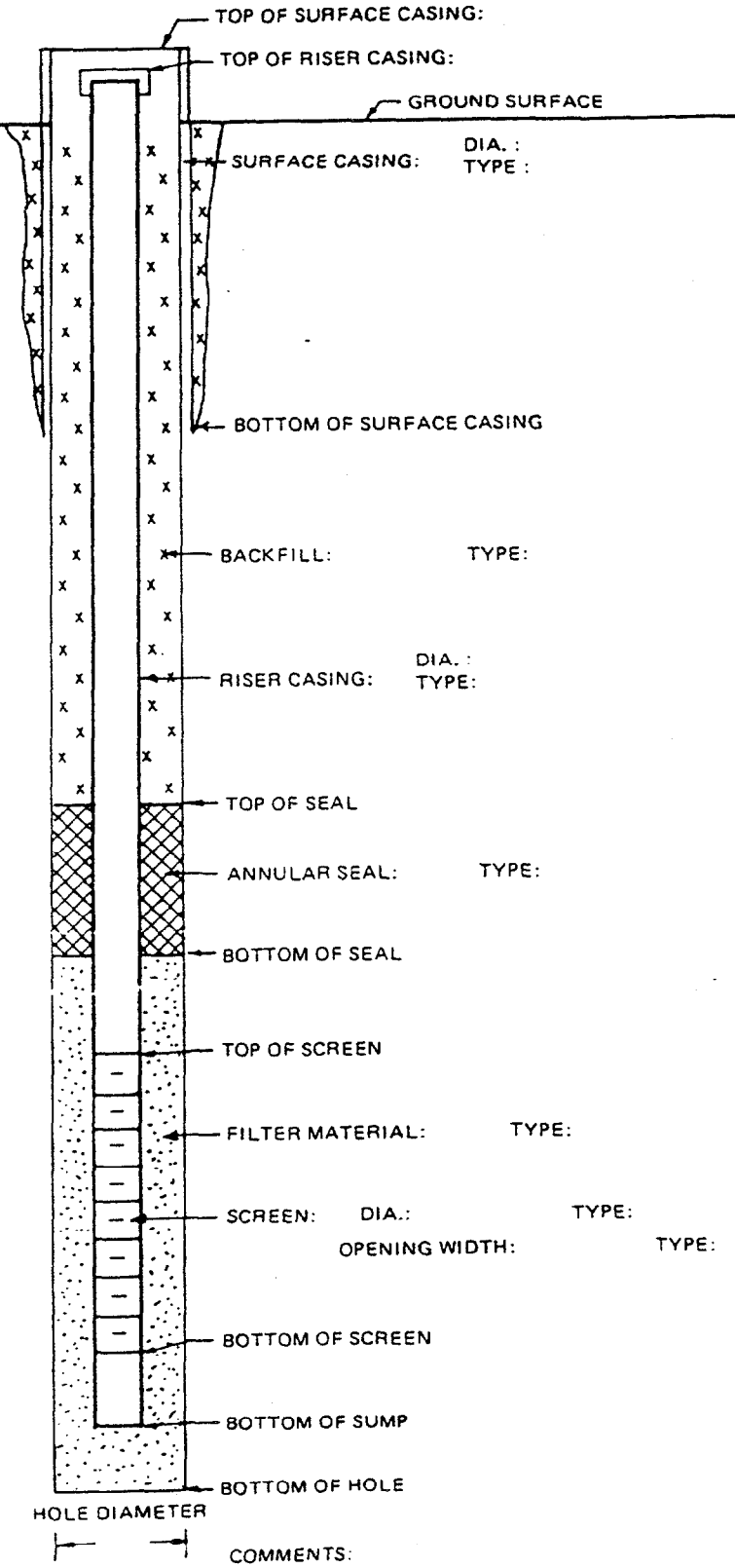
COMMENTS:

Metcalf & Eddy

GROUND WATER INSTALLATION

PROJECT: NASA WFF	JOB NO. 013516-0003	WELL NO. MW 595
DRILLING CONTRACTOR: Environmental Exploration	COORDINATES:	
BEGUN: / FINISHED:	SUPERVISOR: M. Diran / DRILLER:	WELL SITE: Fire Training Area	WATER LEVEL: DEPTH/ELEV

REFERENCE POINT & ELEVATION:



	DEPTH IN	ELEV. IN
TOP OF SURFACE CASING:	2.20	30.87
TOP OF RISER CASING:	2.12	30.79
GROUND SURFACE	0	28.67
TOP OF SEAL	7	21.67
BOTTOM OF SEAL	9	19.67
TOP OF SCREEN	11	17.67
BOTTOM OF SCREEN	26	2.67
BOTTOM OF SUMP	26	2.67

GENERALIZED GEOLOGIC LOG

See Log for Boring SB-10

METHOD DRILLED: HSA

METHOD DEVELOPED:

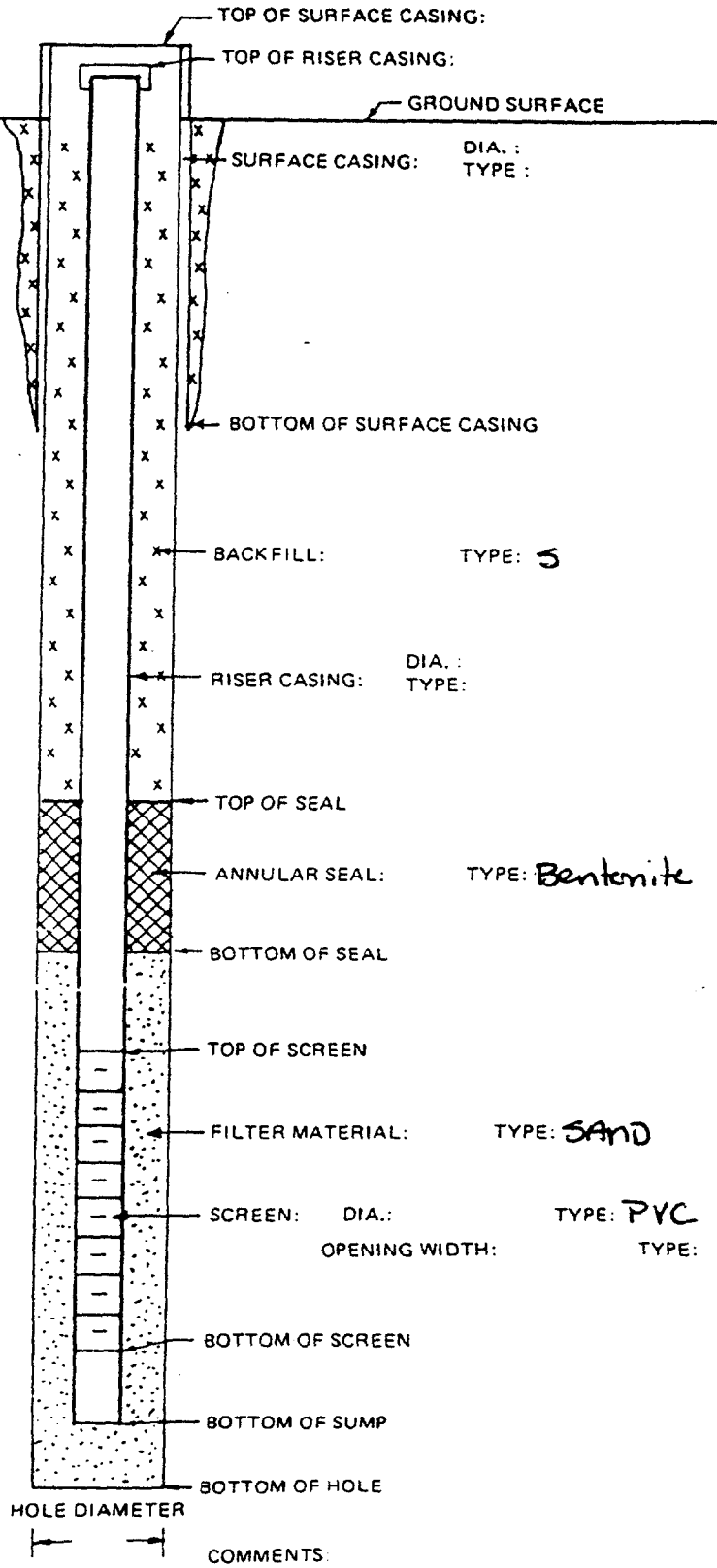
TIME DEVELOPED:

COMMENTS:

Metcalf & Eddy

GROUND WATER INSTALLATION	PROJECT: NASA WFF	JOB NO. 013516-0003	WELL NO. MW-60I
DRILLING CONTRACTOR: Environmental Exploration	COORDINATES:		
BEGUN: FINISHED: Dec 7/93	SUPERVISOR: M. Diran DRILLER:	WELL SITE: Fire Training Area	WATER LEVEL. DEPTH/ELEV

REFERENCE POINT & ELEVATION:



	DEPTH IN feet	ELEV. IN feet
TOP OF SURFACE CASING:	2.15	32.56
TOP OF RISER CASING:	2.15	32.56
GROUND SURFACE	0	30.41
TOP OF SEAL	10	20.41
BOTTOM OF SEAL	12	18.41
TOP OF SCREEN	20	10.41
BOTTOM OF SCREEN	35	-4.59
BOTTOM OF SUMP	35	-4.59

GENERALIZED GEOLOGIC LOG

See Boring Log for SB-11

METHOD DRILLED: HSA

METHOD DEVELOPED:

TIME DEVELOPED:

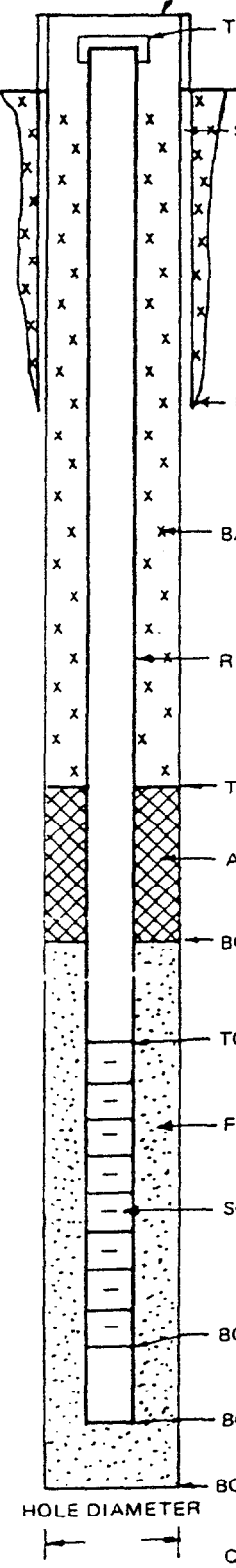
Metcalf & Eddy

GROUND WATER INSTALLATION	PROJECT: NASA WFF	JOB NO. 013516-0003	WELL NO. MW-61I
DRILLING CONTRACTOR: Environmental Exploration	COORDINATES:		
BEGUN: FINISHED: 12/7/93	SUPERVISOR: M. Diran DRILLER:	WELL SITE: Fire Training Area	WATER LEVEL: DEPTH/ELEV. 12' / 16.69

REFERENCE POINT & ELEVATION:

GENERALIZED GEOLOGIC LOG

See Boring Log for SB-9



	DEPTH IN feet	ELEV. IN feet
TOP OF SURFACE CASING:	2.10	30.79
TOP OF RISER CASING:	1.97	30.66
GROUND SURFACE	0	28.69
TOP OF SEAL	9	19.69
BOTTOM OF SEAL	11	17.69
TOP OF SCREEN	18	10.69
BOTTOM OF SCREEN	33	-4.31
BOTTOM OF SUMP	33	-4.31

METHOD DRILLED: HSA

METHOD DEVELOPED:

TIME DEVELOPED:

COMMENTS:

Metcalf & Eddy

APPENDIX A-3

GEOTECHNICAL SOILS LABORATORY RESULTS

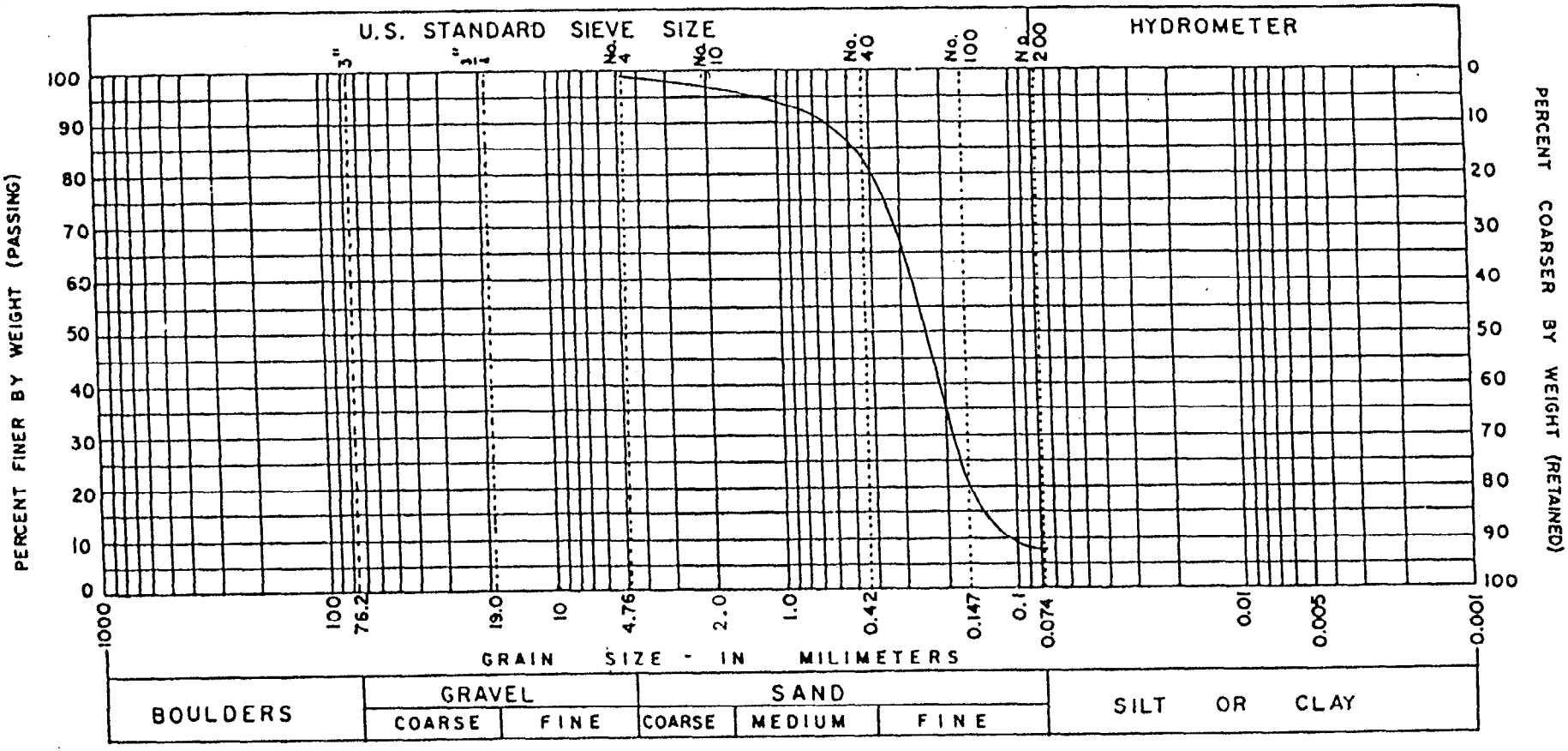
SUMMARY OF LABORATORY TEST RESULTS

SAMPLE TYPE		JAR SAMPLE		SHELBY TUBE			
Sample Designation	Date Received by E2Si	Grain Size Analyses	Heating Valve BTU/lb	Porosity **	Specific Gravity	Dry Unit Weight, pcf	Moisture Content, %
FTA-SB4 (12/3/93)	12/08/93	*	45	0.39	2.69	102.7	14.6
FTA-SB7 (12/2/93)	12/08/93	*	52	0.46	2.69	90.4	22.3
FTA-SB10 (12/8/93)	12/15/93	*	66	0.49	2.69	85.0	38.0

* See attached Grain Size Distribution Curves.

** Porosity was computed using the relationship between unit weight, specific gravity and void ratio.

PROJECT: NASA Wallops Flight Facility		LOCATION: Wallops Island, VA	
BORING NO. FTA-SB4	SAMPLE NO.	DEPTH:	CONTRACT NO. 93-225



SAMPLE NO.	DEPTH	L.L.	P.I.	M.C.	USDA Class.	Soil Description
SB-4	-	-	-	14.2	-	Tan moist fine sand with
						trace of Silt

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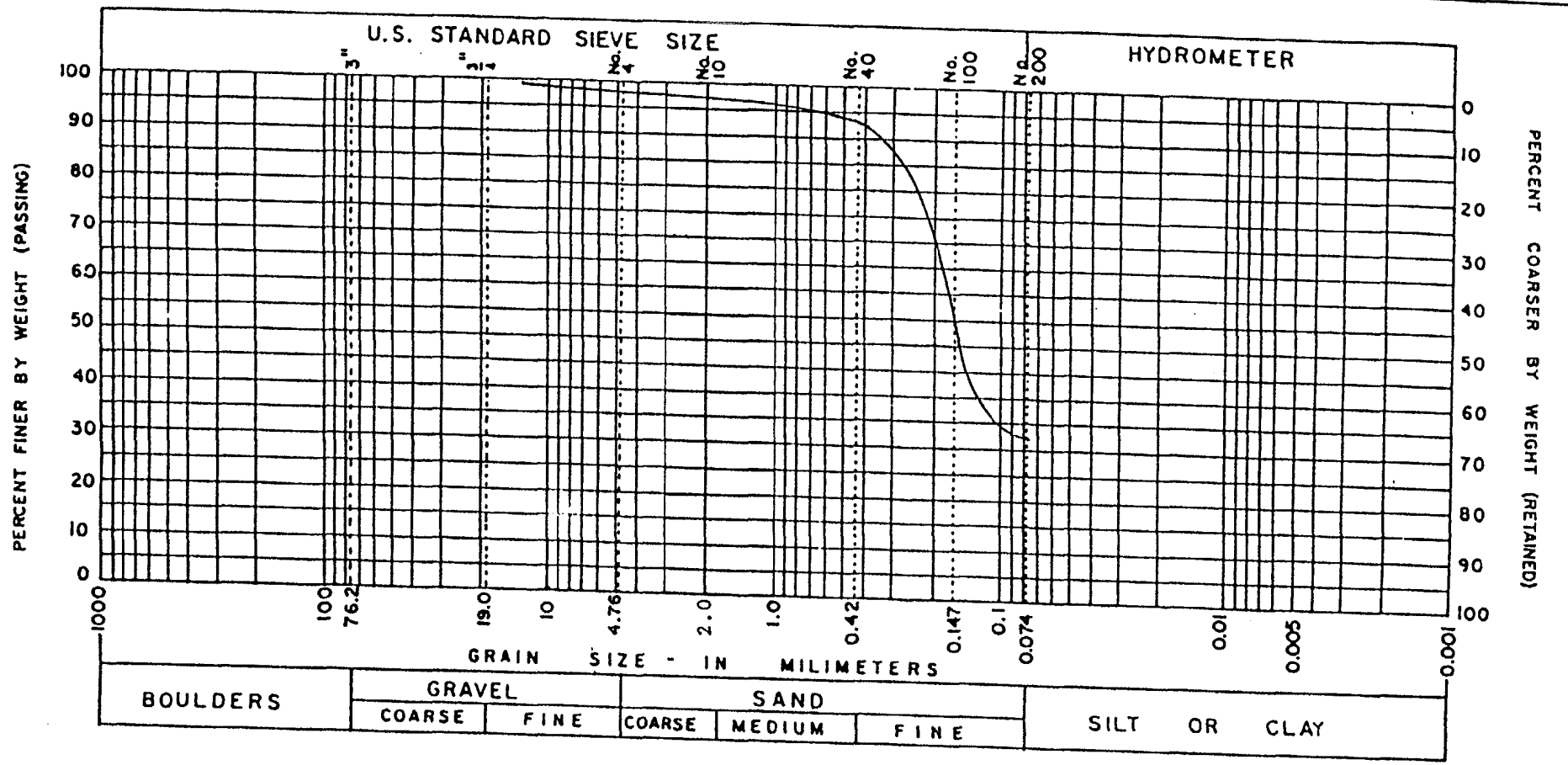
GRAIN-SIZE DISTRIBUTION

TESTED BY: RMP	DATE: 12/22/93
CHECKED BY:	SHEET No. 1 OF 3

PROJECT: NASA Wallops Flight Facility		LOCATION: Wallops Island, VA	
BORING NO. FTA-SB7	SAMPLE NO.	DEPTH:	CONTRACT NO. 93-225



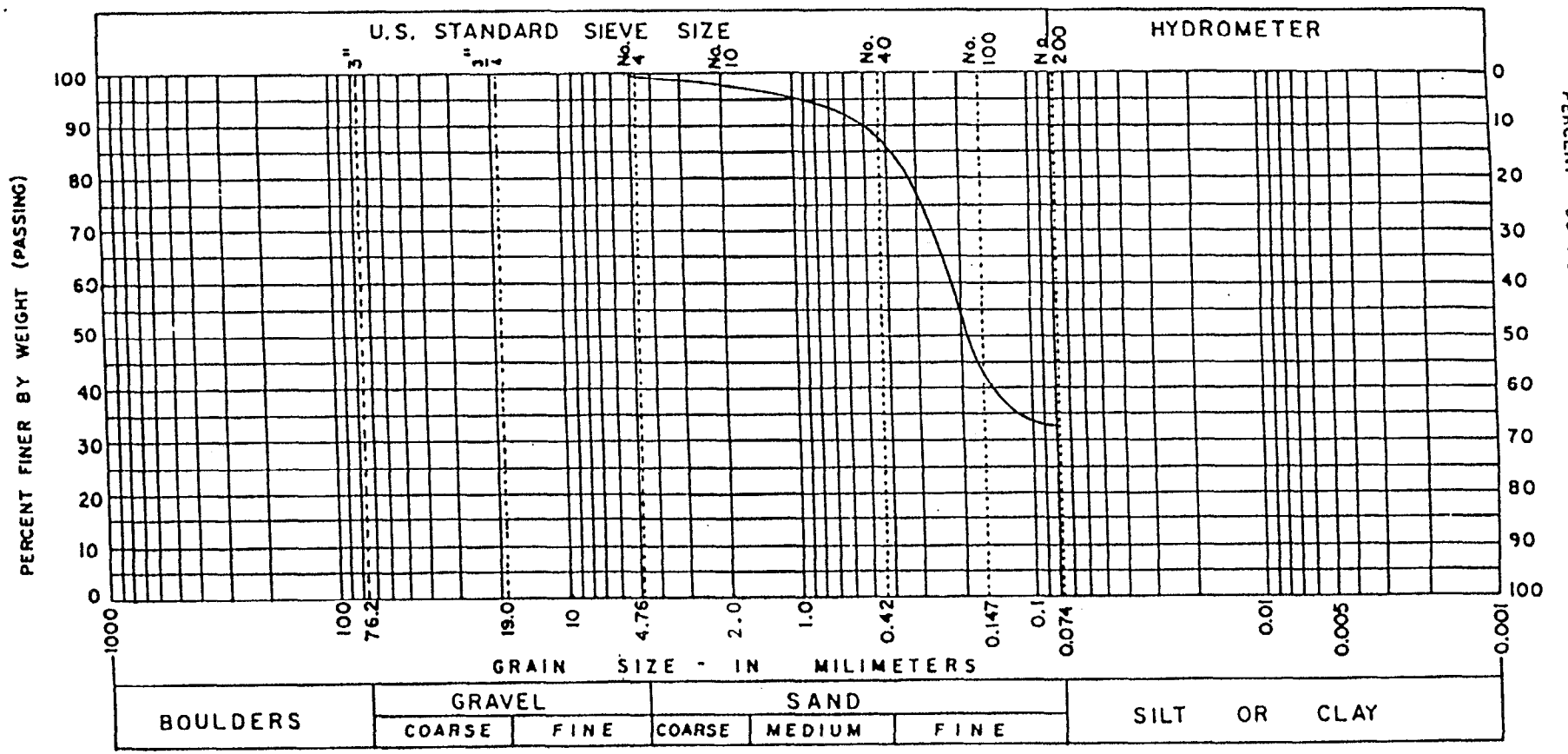
SAMPLE NO.	DEPTH	L.L.	P.I.	M.C.	USDA Class.	Soil Description
SB-7	-	-	-	16.0		Brown Silty fine Sand

Earth Engineering & Sciences, Inc.

GRAIN-SIZE DISTRIBUTION

TESTED BY: RMP	DATE: 12/22/93
CHECKED BY:	SHEET No. 2 OF 3

PROJECT: NASA Wallops Flight Facility		LOCATION: Wallops Island, VA	
BORING NO. FTA-SB10	SAMPLE NO.	DEPTH:	CONTRACT NO. 93-225



SAMPLE NO.	DEPTH	L.L.	P.I.	M.C.	USDA Class.	Soil Description
SB-10	10'- 17'	-	-	24.2	-	Brown silty moist sand
						with trace of clay

Earth Engineering & Sciences, Inc.

GRAIN-SIZE DISTRIBUTION

TESTED BY: RMP	DATE: 12/22/93
CHECKED BY:	SHEET No. 3 OF 3

APPENDIX B

"SELECTING EXPOSURE ROUTES AND CONTAMINANTS OF CONERN BY RISK-BASED SCREENING"

EPA REGION III GUIDANCE DOCUMENT

United States
Environmental Protection Agency

Region III
Philadelphia, PA 19107

EPA/903/R-93-001
January 1993

Region III
Technical Guidance Manual
Risk Assessment

Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening

EPA Contact: Dr. Roy L. Smith

EPA
Region III

Hazardous Waste Management Division
Office of Superfund Programs
January 1993

Human health risk assessment includes effort-intensive steps which require many detailed calculations by experts. Most baseline risk assessments are dominated by a few chemicals and a few routes of exposure. Effort expended on minor contaminants and exposure routes, i.e., those which do not influence overall risk, is essentially wasted. This guidance is intended to identify and focus on dominant contaminants of concern and exposure routes at the earliest feasible point in the baseline risk assessment. Use of these methods will decrease effort and time spent assessing risk, without loss of protectiveness. This guidance is not intended for other risk assessment activities, such as determining preliminary remediation goals.

SELECTING CONTAMINANTS AND EXPOSURE ROUTES OF CONCERN

Most samples from hazardous waste sites are analyzed for 103 target compounds and analytes recommended by the EPA Superfund program. Semi-volatile analysis can detect additional tentatively identified compounds not on the target lists. Special analytical services procedures, if used, may find still more contaminants. The combined number of contaminants detected at a site sometimes exceeds one hundred.

While EPA considers it necessary to gather information on many contaminants, very little of this data actually influences the overall quantitative assessment of health risk. For most sites, baseline risk assessments are dominated by a few contaminants and a few routes of exposure. The remaining tens, or hundreds, of detected contaminants have a minimal influence on total risk. This small impact is lost by rounding. Entire environmental media may contain not a single contaminant at a concentration which could adversely affect public health. Quantitative risk calculations using data from such "risk-free" media have no effect on the overall risk estimate for the site.

The EPA baseline risk assessment process at several points requires careful data evaluation by scientific experts. These evaluations, which are contaminant-specific, include: (1) statistical comparisons between site-related and background samples, (2) special handling of undetected contaminants, (3) calculation of toxicity equivalence, (4) evaluation of frequency of detection, and (5) comparison with ARARs. Because overall risk is usually driven by a few contaminants and exposure routes, effort spent in detailed evaluation of minor contaminants and routes of exposure is essentially wasted. For some sites, this wasted effort exceeds 90% of the total.

The baseline risk assessment process can be made more efficient by focusing on dominant contaminants and routes of exposure at the earliest feasible stage. The mechanisms recommended for this are (1) a re-ordering of the process of eliminating contaminants and routes of exposure, and (2) use of a risk-based concentration screen. Appropriately used, this process can dramatically reduce the effort of risk assessment, while not changing the result significantly.

EXISTING GUIDANCE

Chapter 5 of "RAGS IA" (Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A); EPA, 1989) provides a detailed procedure for evaluating data for a baseline risk assessment. This

procedure includes steps by which the risk assessor selects contaminants of concern in each exposure medium. These steps are summarized in Table 1.

There are two major limitations to the RAGS procedure. First, the eliminating step (a concentration toxicity screen) comes late in the process. Many of the preceding steps (e.g., evaluation of quantitation limits, comparison with background, calculation of toxicity equivalence, and evaluation of frequency of detection) are contaminant- and medium-specific. They require the sustained attention of an expert, and cannot be automated. If the contaminant is eliminated, this work is wasted.

The second limitation is that the concentration toxicity screen compares only relative risk among contaminants in the same medium. While very efficient at selecting dominant contaminants in each medium, this method does not evaluate significance of total risk for the medium. Thus, the concentration toxicity screen can eliminate contaminants, but not routes of exposure.

RECOMMENDED METHODOLOGY

This guidance makes two changes intended to remove the limitations in existing guidance. These recommendations are intended for baseline risk assessments.

1. Re-ordering of steps. The eliminating screen is moved forward in the data evaluation process to a point immediately following data quality evaluation. The new process is shown in Table 2. Effort-intensive steps such as evaluation of quantitation limits and comparison with background now follow the eliminating screen. The steps are divided into four categories: data quality evaluation, initial data set reduction, re-inclusion of special cases, and optional final data set reduction.

The data quality evaluation steps (evaluating appropriateness of methods and qualifiers, significance of blank contamination, and need for special analyses) should be done as described in RAGS IA, Chapter 5. Next, the risk assessor should consult with the RPM to discuss the use of the risk-based concentration table (described in item [2] below) as a screening mechanism. With the RPM's approval, the risk assessor should reduce the data set and document the rationale for eliminating contaminants and routes of exposure from further analysis.

After the initial data set reduction, the risk assessor and RPM should consider re-including specific contaminants on the basis of historical data, toxicity, mobility, persistence, bioaccumulation, special exposure routes, special treatability problems, or exceedance of ARARs. These activities should proceed as described in Section 5.9 of RAGS IA.

Finally, optional further reductions in the data set may be justified, based on the status of a contaminant as an essential nutrient, low frequency of detection, or no statistical difference between site and background levels. These evaluations, the most complicated and contaminant-specific, are saved for last.

2. Screening by risk-based concentrations. The screening method is changed from the relative concentration toxicity screen of RAGS IA to an absolute comparison of risk. This is done by means of a table of risk-based concentrations (Appendix I). This table contains levels of nearly 600 contaminants in air, drinking water, fish tissue, and soil, which correspond to a systemic hazard quotient of 0.1 or a lifetime cancer risk of 10^{-6}. The risk-based concentrations were developed using protective default exposure scenarios suggested by EPA (1991) and the best available reference doses and carcinogenic potency slopes (see the table for sources), and represent relatively protective environmental concentrations at which EPA would typically not take action.

The risk-based concentration screen is used as follows:

(a) The risk assessor extracts the maximum concentration of each substance detected in each medium.

(b) If the maximum concentration exceeds the risk-based concentration for that medium, the contaminant is retained for risk assessment, for all routes of exposure involving that medium. Otherwise the contaminant is dropped for that medium.

(c) If a specific contaminant does not exceed its risk-based concentration for any medium, the contaminant is dropped from the risk assessment.

(d) If no contaminant in a specific medium exceeds its risk-based concentration, the medium is dropped from the risk assessment.

(e) All contaminants and exposure routes which are dropped are kept on a sub-list and considered for re-inclusion, based on special properties.

(f) If the risk assessor wants to include a route of exposure not covered in the risk-based concentration table, the equations provided in Appendix I can serve as the basis for new risk

based concentrations. Similarly, the risk assessor can use the same equations to calculate alternate risk levels (i.e., other than a systemic hazard quotient of 0.1 and lifetime cancer risk of 10^{-6}) to be the basis for screening.

SUMMARY

The process by which contaminants and exposure routes are selected in quantitative risk assessment can be made less effort-intensive by two simple changes. First, high-effort steps should be postponed until later in the selection process, because performing these operations on trivial contaminants and exposure routes is pointless. Second, changing from a relative concentration toxicity screen to an absolute risk-based concentration screen improves the risk assessor's ability to focus on dominant contaminants and exposure routes at an earlier stage.

REFERENCES

EPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors". OSWER Directive 9285.6-03, Office of Emergency and Remedial Response, March 25, 1991.

EPA, 1989. Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A). Office of Emergency and Remedial Response, December, 1989. EPA/540/1-89/002.

For additional information, call (215) 597-6682.

Approved by: _____

Thomas C. Voltaggio, Director
Hazardous Waste Management Division

Table 1. Summary of existing EPA guidance on selecting contaminants of concern (EPA, 1989, chapter 5)
Section 5.1: Combining data from site investigations
1. *Determine if methods are appropriate*
2. Evaluate quantitation limits
3. Determine if qualifiers are appropriate
4. Determine if significant blank contamination exists
5. Determine if special analyses for tentatively identified compounds are needed
6. Compare site samples to background
Section 5.9: Further reduction in the number of chemicals (optional)
7. Consult with RPM
8. Document rationale for eliminating chemicals
9. Examine historical information
10. Consider exceptional toxicity, mobility, persistence, or bioaccumulation
11. Consider special exposure routes
12. Consider special treatability problems
13. Determine if contaminants exceed ARARs
14. Group chemicals by class, evaluate toxicity equivalence
15. Evaluate frequency of detection
16. Evaluate essentiality
17. Use a concentration toxicity screen

Table 2. EPA Region III guidance on selecting contaminants and exposure routes of concern
A. Data quality evaluation
1. Determine if methods are appropriate
2. Determine if qualifiers are appropriate
3. Determine if significant blank contamination exists
4. Determine if special analyses for tentatively identified compounds are needed
B. Reduce data set using risk-based concentration screen
5. Consult with RPM
6. Use risk-based concentration table to screen contaminants and exposure routes of concern
7. Document rationale for eliminating chemicals and exposure routes
C. Consider re-including eliminated chemicals and routes, based on:
8. Historical information
9. Exceptional toxicity, mobility, persistence, or bioaccumulation
10. Special exposure routes
11. Special treatability problems
12. ARARs exceedance
13. Toxicity equivalence of chemical class (*e.g.*, CDD/CDFs, PAHs)
D. Make further specific reductions in data set (optional)
14. Evaluate essentiality
15. Evaluate frequency of detection
16. Compare site samples to background

Appendix I:
EPA Region III Risk-Based Screening Table
Background Information

General: Separate carcinogenic and non-carcinogenic risk-based concentrations were calculated for each compound for each pathway. The concentration in the table is the lower of the two, rounded to two significant figures. The following terms and values were used in the calculations:

VARIABLE	UNITS	VALUE	LABEL
1-General:			
Carcinogenic potency slope oral	kg-d/mg	*	CPSo
Carcinogenic potency slope inhaled	kg-d/mg	*	CPSi
Reference dose oral	mg/kg/d	*	RfDo
Reference dose inhaled	mg/kg/d	*	RfDi
Target cancer risk	unitless	1.00e-06	TR
Target hazard quotient	unitless	0.1	THQ
Body weight, adult	kg	70	BWa
Body weight, age 1-6	kg	15	BWc
Averaging time carcinogens	d	25550	ATc
Averaging time non-carcinogens	d	ED x 365	ATn
Inhalation, adult	m3/d	20	IRAa
Inhalation, child	m3/d	12	IRAc
Inhalation factor, age adjusted	m3-y/kg-d	11.66	IFAadj
Tap water ingestion, adult	L/d	2	IRWa
Tap water ingestion, child	L/d	1	IRWc
Tap water ingestion factor, age adjusted	L-y/kg-d	1.09	IFWadj
Fish ingestion	g/d	54	IRF
Soil ingestion, adult	mg/d	100	IRSa
Soil ingestion, child	mg/d	200	IRSc
Soil ingestion factor, age adjusted	mg-y/kg-d	114.29	IFSadj
2-Residential			
Exposure frequency, residential	d/y	350	EFr
Exposure duration, residential	y	30	EDtot

VARIABLE	UNITS	VALUE	LABEL
Exposure duration, age 1-6	y	6	EDc
Volatilization factor	L/m3	0.5	VF
3-Occupational			
Exposure frequency, occupational	d/y	250	EFo
Exposure duration, occupational	y	25	EDo
* = Contaminant-specific toxicity parameters			

The priority among sources of toxicological constants was as follows: (1) IRIS, (2) HEAST, (3) HEAST alternative method, (4) ECAO-Cincinnati, (5) withdrawn from IRIS, (6) withdrawn from HEAST, and (7) other EPA documents. Each source was used only if numbers from higher-priority sources were unavailable.

Algorithms:

1. Age-adjusted factors: Because contact rates with tap water, ambient air, and residential soil are different for children and adults, carcinogenic risks during the first 30 years of life were calculated using age-adjusted factors. These factors approximated the integrated exposure from birth until age 30 by combining contact rates, body weights, and exposure durations for two age groups - small children and adults. The age-adjusted factor for soil was obtained from RAGS IB; the others were developed by analogy.

a. Air inhalation ([m^3· y]/[kg· d]):

$$IFAadj = \frac{EDc \cdot IRAc}{BWc} + \frac{(EDtot - EDc) \cdot IRAa}{BWa}$$

b. Tap water ingestion ([L· y]/[kg· d]):

$$IFWadj = \frac{EDc \cdot IRWc}{BWc} + \frac{(EDtot - EDc) \cdot IRWa}{BWa}$$

c. Soil ingestion ([mg· y]/[kg· d]):

$$IFSadj = \frac{EDc \cdot IRSc}{BWc} + \frac{(EDtot - EDc) \cdot IRSa}{BWa}$$

2. Residential water use ($\mu g/L$). Volatilization terms were calculated only for compounds with "***" in the "VOC" column. Compounds having a Henry's Law constant greater than 10^{-5} were considered volatile. The list may be incomplete, but is unlikely to include false positives. The equations and the volatilization factor (VF, above) were obtained from RAGS IB. Oral potency slopes and reference doses were used for both oral and inhaled exposures for volatile compounds lacking inhalation values. Inhaled potency slopes were substituted for unavailable oral potency slopes only for volatile compounds; inhaled RfDs were substituted for unavailable oral RfDs for both volatile and non-volatile compounds.

a. Carcinogens: Calculations were based on combined childhood and adult exposure.

$$\frac{TR \cdot ATc \cdot 1000\frac{ug}{mg}}{EFr \cdot ([VF \cdot IFAadj \cdot CPSi] + [IFWadj \cdot CPSo])}$$

b. Non-carcinogens: Calculations were based on adult exposure.

$$\frac{THQ \cdot BWa \cdot ATn \cdot 1000\frac{ug}{mg}}{EFr \cdot EDtot \cdot \left(\frac{VF \cdot IRAa}{RfDi} + \frac{IRWa}{RfDo}\right)}$$

3. Air ($\mu g/m^3$). Oral potency slopes and references were used where inhalation values were not available.

a. Carcinogens: Calculations were based on combined childhood and adult exposure.

$$\frac{TR \cdot ATc \cdot 1000\frac{ug}{mg}}{EFr \cdot IFAadj \cdot CPSi}$$

b. Non-carcinogens: Calculations were based on adult exposure.

$$\frac{THQ \cdot RfDi \cdot BWa \cdot ATn \cdot 1000\frac{ug}{mg}}{EFr \cdot EDtot \cdot IRAa}$$

4. Fish (mg/kg):

a. Carcinogens: Calculations were based on adult exposure.

$$\frac{TR \cdot BWa \cdot ATc}{EFr \cdot EDtot \cdot \frac{IRF}{1000\frac{g}{kg}} \cdot CPSo}$$

b. Non-carcinogens: Calculations were based on adult exposure.

$$\frac{THQ \cdot RfDo \cdot BWa \cdot ATn}{EFr \cdot EDtot \cdot \frac{IRF}{1000\frac{g}{kg}}}$$

5. Soil commercial/industrial (mg/kg): The default exposure assumption that only 50% of incidental soil ingestion occurs at work has been omitted. Calculations were based on adult occupational exposure.

a. Carcinogens:

$$\frac{TR \cdot BWa \cdot ATc}{EFo \cdot EDo \cdot \frac{IRSa}{10^6\ \frac{mg}{kg}} \cdot CPSo}$$

b. Non-carcinogens:

$$\frac{THQ \cdot RfDo \cdot BWa \cdot ATn}{EFo \cdot EDo \cdot \frac{IRSa}{10^6\ \frac{mg}{kg}}}$$

6. Soil residential (mg/kg):

a. Carcinogens: Calculations were based on combined childhood and adult exposure.

$$\frac{TR \cdot ATc}{EFr \cdot \frac{IFSadj}{10^6\ \frac{mg}{kg}} \cdot CPSo}$$

b. Non-carcinogens: Calculations were based on childhood exposure only.

$$\frac{THQ \cdot RfDo \cdot BWc \cdot ATn}{EFr \cdot EDc \cdot \frac{IRSc}{10^6\ \frac{mg}{kg}}}$$

Sources: i=IRIS h=HEAST a=HEAST alt. w=Withdrawn from IRIS or HEAST e=EPA-ECAO o=Other EPA documents *F=final D=draft P=proposed T=tentative /c=carcinogen n=noncarcinogen*

Contaminant	CAS	RfDo mg/kg/d	RfDi mg/kg/d	CPSo kg•d/mg	CPSi kg•d/mg	VOC	MCL mg/L	Tap water µg/L	Ambient air µg/m3	Fish mg/kg	Industrial soil mg/kg	Residential soil mg/kg
Acephate	30560191	4.00E-03 *i*		8.70E-03 *i*				7.7 *c*	0.72 *c*	0.36 *c*	330 *c*	31 *n*
Acetaldehyde	75070		2.57E-03 *i*		7.70E-03 *i*			9.4 *n*	0.81 *c*			
Acetochlor	34256821	2.00E-02 *i*						73 *n*	7.3 *n*	2.7 *n*	2000 *n*	160 *n*
Acetone	67641	1.00E-01 *i*						370 *n*	37 *n*	14 *n*	10000 *n*	780 *n*
Acetone cyanohydrin	75865	7.00E-02 *h*	2.86E-03 *h*					260 *n*	1 *n*	9.5 *n*	7200 *n*	550 *n*
Acetonitrile	75078	6.00E-03 *i*	1.43E-02 *h*					22 *n*	5.2 *n*	0.81 *n*	610 *n*	47 *n*
Acetophenone	98862	1.00E-01 *i*	5.71E-06 *w*			•••		0.0042 *n*	0.0021 *n*	14 *n*	10000 *n*	780 *n*
Acifluorfen	62476599	1.30E-02 *i*						47 *n*	4.7 *n*	1.8 *n*	1300 *n*	100 *n*
Acrolein	107028	2.00E-02 *h*	5.71E-06 *i*					73 *n*	0.0021 *n*	2.7 *n*	2000 *n*	160 *n*
Acrylamide	79061	2.00E-04 *i*		4.50E+00 *i*	4.55E+00 *i*			0.015 *c*	0.0014 *c*	0.0007 *c*	0.64 *c*	0.14 *c*
Acrylic acid	79107	8.00E-02 *i*	8.57E-05 *i*					290 *n*	0.031 *n*	11 *n*	8200 *n*	630 *n*
Acrylonitrile	107131		5.71E-04 *i*	5.40E-01 *i*	2.38E-01 *i*			0.12 *c*	0.026 *c*	0.0058 *c*	5.3 *c*	1.2 *c*
Alachlor	15972608	1.00E-02 *i*		8.00E-02 *h*			0.002 *F*	0.84 *c*	0.078 *c*	0.039 *c*	36 *c*	8 *c*
Alar	1596845	1.50E-01 *i*						550 *n*	55 *n*	20 *n*	15000 *n*	1200 *n*
Aldicarb	116063	1.00E-03 *i*					0.007 *O*	3.7 *n*	0.37 *n*	0.14 *n*	100 *n*	7.8 *n*
Aldicarb sulfone	1646884	1.00E-03 *i*					0.007 *O*	3.7 *n*	0.37 *n*	0.14 *n*	100 *n*	7.8 *n*
Aldrin	309002	3.00E-05 *i*		1.70E+01 *i*	1.71E+01 *i*			0.004 *c*	0.00037 *c*	0.00019 *c*	0.17 *c*	0.038 *c*
Ally	74223646	2.50E-01 *i*						910 *n*	91 *n*	34 *n*	26000 *n*	2000 *n*
Allyl alcohol	107186	5.00E-03 *i*						18 *n*	1.8 *n*	0.68 *n*	510 *n*	39 *n*
Allyl chloride	107051	5.00E-02 *w*	2.86E-04 *i*					180 *n*	0.1 *n*	6.8 *n*	5100 *n*	390 *n*
Aluminum	7429905	2.90E+00 *o*						11000 *n*	1100 *n*	390 *n*	300000 *n*	23000 *n*
Aluminum phosphide	20859738	4.00E-04 *i*						1.5 *n*	0.15 *n*	0.054 *n*	41 *n*	3.1 *n*
Amdro	67485294	3.00E-04 *i*						1.1 *n*	0.11 *n*	0.041 *n*	31 *n*	2.3 *n*
Ametryn	834128	9.00E-03 *i*						33 *n*	3.3 *n*	1.2 *n*	920 *n*	70 *n*
m-Aminophenol	591275	7.00E-02 *h*						260 *n*	26 *n*	9.5 *n*	7200 *n*	550 *n*
4-Aminopyridine	504245	2.00E-05 *h*						0.073 *n*	0.0073 *n*	0.0027 *n*	2 *n*	0.16 *n*
Amitraz	33089611	2.50E-03 *i*						9.1 *n*	0.91 *n*	0.34 *n*	260 *n*	20 *n*
Ammonia	7664417		2.86E-02 *i*					100 *n*	10 *n*			
Ammonium sulfamate	7773060	2.00E-01 *i*						730 *n*	73 *n*	27 *n*	20000 *n*	1600 *n*
Aniline	62533		2.86E-04 *i*	5.70E-03 *i*				1 *n*	0.1 *n*	0.55 *c*	500 *c*	110 *c*
Antimony and compounds	7440360	4.00E-04 *i*					0.006 *F*	1.5 *n*	0.15 *n*	0.054 *n*	41 *n*	3.1 *n*
Antimony pentoxide	1314609	5.00E-04 *h*						1.8 *n*	0.18 *n*	0.068 *n*	51 *n*	3.9 *n*
Antimony potassium tartrate	304610	9.00E-04 *h*						3.3 *n*	0.33 *n*	0.12 *n*	92 *n*	7 *n*
Antimony tetroxide	1332316	4.00E-04 *h*						1.5 *n*	0.15 *n*	0.054 *n*	41 *n*	3.1 *n*
Antimony trioxide	1309644	4.00E-04 *h*						1.5 *n*	0.15 *n*	0.054 *n*	41 *n*	3.1 *n*
Apollo	74115245	1.30E-02 *i*						47 *n*	4.7 *n*	1.8 *n*	1300 *n*	100 *n*
Aramite	140578	5.00E-02 *h*		2.50E-02 *i*	2.49E-02 *i*			2.7 *c*	0.25 *c*	0.13 *c*	110 *c*	26 *c*
Arsenic	7440382	3.00E-04 *i*					0.05 •	1.1 *n*	0.11 *n*	0.041 *n*	31 *n*	2.3 *n*
Arsenic (as carcinogen)	744032	3.00E-04		1.75E+00 *i*	1.51E+01 *i*		0.05 •	0.038 *c*	0.00041 *c*	0.0018 *c*	[illegible]	0.37 *c*

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Contaminant	CAS	RfDo mg/kg/d	RfDi mg/kg/d	CPSo kg•d/mg	CPSi kg•d/mg	VOC	MCL mg/L	Tap water µg/L	Ambient air µg/m3	Fish mg/kg	Industrial soil mg/kg	Residential soil mg/kg
Assure	76578148	9.00E-03 *i*						33 *n*	3.3 *n*	1.2 *n*	920 *n*	70 *n*
Asulam	3337711	5.00E-02 *i*						180 *n*	18 *n*	6.8 *n*	5100 *n*	390 *n*
Atrazine	1912249	3.50E-02 *i*		2.22E-01 *h*			0.003 *F*	0.3 *c*	0.028 *c*	0.014 *c*	13 *c*	2.9 *c*
Avermectin B1	65195553	4.00E-04 *i*						1.5 *n*	0.15 *n*	0.054 *n*	41 *n*	3.1 *n*
Azobenzene	103333			1.10E-01 *i*	1.08E-01 *i*			0.61 *c*	0.058 *c*	0.029 *c*	26 *c*	5.8 *c*
Barium and compounds	7440393	7.00E-02 *i*	1.43E-04 *h*				2 *F*	260 *n*	0.052 *n*	9.5 *n*	7200 *n*	550 *n*
Baygon	114261	4.00E-03 *i*						15 *n*	1.5 *n*	0.54 *n*	410 *n*	31 *n*
Bayleton	43121433	3.00E-02 *i*						110 *n*	11 *n*	4.1 *n*	3100 *n*	230 *n*
Baythroid	68359375	2.50E-02 *i*						91 *n*	9.1 *n*	3.4 *n*	2600 *n*	200 *n*
Benefin	1861401	3.00E-01 *i*						1100 *n*	110 *n*	41 *n*	31000 *n*	2300 *n*
Benomyl	17804352	5.00E-02 *i*						180 *n*	18 *n*	6.8 *n*	5100 *n*	390 *n*
Bentazon	25057890	2.50E-03 *i*						9.1 *n*	0.91 *n*	0.34 *n*	260 *n*	20 *n*
Benzaldehyde	100527	1.00E-01 *i*				***		61 *n*	37 *n*	14 *n*	10000 *n*	780 *n*
Benzene	71432		1.43E-04 *e*	2.90E-02 *i*	2.90E-02 *i*	***	0.005 *F*	0.087 *n*	0.052 *n*	0.11 *c*	99 *c*	22 *c*
Benzidine	92875	3.00E-03 *i*		2.30E+02 *i*	2.35E+02 *i*			0.00029 *c*	0.00003 *c*	0.00001 *c*	0.012 *c*	0.0028 *c*
Benzoic acid	65850	4.00E+00 *i*						15000 *n*	1500 *n*	540 *n*	410000 *n*	31000 *n*
Benzotrichloride	98077			1.30E+01 *i*				0.0052 *c*	0.00048 *c*	0.00024 *c*	0.22 *c*	0.049 *c*
Benzyl alcohol	100516	3.00E-01 *h*						1100 *n*	110 *n*	41 *n*	31000 *n*	2300 *n*
Benzyl chloride	100447			1.70E-01 *i*		***		0.062 *c*	0.037 *c*	0.019 *c*	17 *c*	3.8 *c*
Beryllium and compounds	7440417	5.00E-03 *i*		4.30E+00 *i*	8.40E+00 *i*		0.004 *F*	0.016 *c*	0.00075 *c*	0.00073 *c*	0.67 *c*	0.15 *c*
Bidrin	141662	1.00E-04 *i*						0.37 *n*	0.037 *n*	0.014 *n*	10 *n*	0.78 *n*
Biphenthrin (Talstar)	82657043	1.50E-02 *i*						55 *n*	5.5 *n*	2 *n*	1500 *n*	120 *n*
1,1-Biphenyl	92524	5.00E-02 *i*						180 *n*	18 *n*	6.8 *n*	5100 *n*	390 *n*
Bis(2-chloroethyl)ether	111444			1.10E+00 *i*	1.16E+00 *i*	***		0.0092 *c*	0.0054 *c*	0.0029 *c*	2.6 *c*	0.58 *c*
Bis(2-chloroisopropyl)ether	39638329	4.00E-02 *i*		7.00E-02 *h*	3.50E-02 *h*	***		0.26 *c*	0.18 *c*	0.045 *c*	41 *c*	9.1 *c*
Bis(chloromethyl)ether	542881			2.20E+02 *i*	2.17E+02 *i*	***		0.00005 *c*	0.00003 *c*	0.00001 *c*	0.013 *c*	0.0029 *c*
Bis(2-chloro-1-methylethyl)ether				7.00E-02 *w*	7.00E-02 *w*			0.96 *c*	0.089 *c*	0.045 *c*	41 *c*	9.1 *c*
Bis(2-ethylhexyl)phthalate (DEHP)	117817	2.00E-02 *i*		1.40E-02 *i*			0.006 *F*	4.8 *c*	0.45 *c*	0.23 *c*	200 *c*	46 *c*
Bisphenol A	80057	5.00E-02 *i*						180 *n*	18 *n*	6.8 *n*	5100 *n*	390 *n*
Boron (and borates)	7440428	9.00E-02 *i*	5.71E-03 *h*					330 *n*	2.1 *n*	12 *n*	9200 *n*	700 *n*
Boron trifluoride	7637072		2.00E-04 *h*					0.73 *n*	0.073 *n*			
Bromodichloromethane	75274	2.00E-02 *i*		6.20E-02 *i*		***	0.1 *T*	0.17 *c*	0.1 *c*	0.051 *c*	46 *c*	10 *c*
Bromoethene	593602				1.10E-01 *h*	***		0.096 *c*	0.057 *c*			
Bromoform (tribromomethane)	75252	2.00E-02 *i*		7.90E-03 *i*	3.85E-03 *i*	***	0.1 *T*	2.4 *c*	1.6 *c*	0.4 *c*	360 *c*	81 *c*
Bromomethane	74839	1.40E-03 *i*	1.43E-03 *i*			***		0.87 *n*	0.52 *n*	0.19 *n*	140 *n*	11 *n*
4-Bromophenyl phenyl ether	101553	5.80E-02 *o*						210 *n*	21 *n*	7.8 *n*	5900 *n*	450 *n*
Bromophos	2104963	5.00E-03 *h*						18 *n*	1.8 *n*	0.68 *n*	510 *n*	39 *n*
Bromoxynil	1689845	2.00E-02 *i*						73 *n*	7.3 *n*	2.7 *n*	2000 *n*	160 *n*
Bromoxynil octanoate	1689992	2.00E-02 *i*						73 *n*	7.3 *n*	2.7 *n*	2000 *n*	160 *n*

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Contaminant	CAS	RfDo mg/kg/d	RfDi mg/kg/d	CPSo kg•d/mg	CPSi kg•d/mg	VOC	MCL mg/L	Tap water µg/L	Ambient air µg/m3	Fish mg/kg	Industrial soil mg/kg	Residential soil mg/kg
1,3-Butadiene	106990				9.80E-01 *i*	***		0.011 *c*	0.0064 *c*			
1-Butanol	71363	1.00E-01 *i*						370 *n*	37 *n*	14 *n*	10000 *n*	780 *n*
Butyl benzyl phthalate	85687	2.00E-01 *i*					0.1 *P*	730 *n*	73 *n*	27 *n*	20000 *n*	1600 *n*
Butylate	2008415	5.00E-02 *i*						180 *n*	18 *n*	6.8 *n*	5100 *n*	390 *n*
sec-Butylbenzene	135988	1.00E-02 *e*				***	0.002 *F*	6.1 *n*	3.7 *n*	1.4 *n*	1000 *n*	78 *n*
tert-Butylbenzene	104518	1.00E-02 *e*				***	0.002 *F*	6.1 *n*	3.7 *n*	1.4 *n*	1000 *n*	78 *n*
Butylphthalyl butylglycolate	85701	1.00E+00 *i*						3700 *n*	370 *n*	140 *n*	100000 *n*	7800 *n*
Cacodylic acid	75605	3.00E-03 *h*						11 *n*	1.1 *n*	0.41 *n*	310 *n*	23 *n*
Cadmium and compounds	7440439	5.00E-04 *i*			6.30E+00 *i*		0.005 *F*	1.8 *n*	0.00099 *c*	0.068 *n*	51 *n*	3.9 *n*
Caprolactam	105602	5.00E-01 *i*						1800 *n*	180 *n*	68 *n*	51000 *n*	3900 *n*
Captafol	2425061	2.00E-03 *i*		8.60E-03 *h*				7.3 *n*	0.73 *c*	0.27 *n*	200 *n*	16 *n*
Captan	133062	1.30E-01 *i*		3.50E-03 *h*				19 *c*	1.8 *c*	0.9 *c*	820 *c*	180 *c*
Carbaryl	63252	1.00E-01 *i*						370 *n*	37 *n*	14 *n*	10000 *n*	780 *n*
Carbazole	86748			2.00E-02 *h*				3.4 *c*	0.31 *c*	0.16 *c*	140 *c*	32 *c*
Carbofuran	1563662	5.00E-03 *i*					0.04 *F*	18 *n*	1.8 *n*	0.68 *n*	510 *n*	39 *n*
Carbon disulfide	75150	1.00E-01 *i*	2.86E-03 *h*			***		2.1 *n*	1 *n*	14 *n*	10000 *n*	780 *n*
Carbon tetrachloride	56235	7.00E-04 *i*	5.71E-04 *a*	1.30E-01 *i*	5.25E-02 *i*	***	0.005 *F*	0.16 *c*	0.12 *c*	0.024 *c*	22 *c*	4.9 *c*
Carbosulfan	55285148	1.00E-02 *i*						37 *n*	3.7 *n*	1.4 *n*	1000 *n*	78 *n*
Carboxin	5234684	1.00E-01 *i*						370 *n*	37 *n*	14 *n*	10000 *n*	780 *n*
Chloral	75876	2.00E-03 *i*						7.3 *n*	0.73 *n*	0.27 *n*	200 *n*	16 *n*
Chloramben	133904	1.50E-02 *i*						55 *n*	5.5 *n*	2 *n*	1500 *n*	120 *n*
Chloranil	118752			4.03E-01 *h*				0.17 *c*	0.016 *c*	0.0078 *c*	7.1 *c*	1.6 *c*
Chlordane	57749	6.00E-05 *i*		1.30E+00 *i*	1.29E+00 *i*		0.002 *F*	0.052 *c*	0.0049 *c*	0.0024 *c*	2.2 *c*	0.47 *n*
Chlorimuron-ethyl	90982324	2.00E-02 *i*						73 *n*	7.3 *n*	2.7 *n*	2000 *n*	160 *n*
Chlorine dioxide	10049044		5.71E-05 *i*					0.21 *n*	0.021 *n*			
Chloroacetaldehyde	107200	6.90E-03 *o*						25 *n*	2.5 *n*	0.93 *n*	710 *n*	54 *n*
Chloroacetic acid	79118	2.00E-03 *h*						7.3 *n*	0.73 *n*	0.27 *n*	200 *n*	16 *n*
2-Chloroacetophenone	532274		8.57E-06 *i*					0.031 *n*	0.0031 *n*			
4-Chloroaniline	106478	4.00E-03 *i*						15 *n*	1.5 *n*	0.54 *n*	410 *n*	31 *n*
Chlorobenzene	108907	2.00E-02 *i*	5.71E-03 *h*			***	0.1 *F*	3.9 *n*	2.1 *n*	2.7 *n*	2000 *n*	160 *n*
Chlorobenzilate	510156	2.00E-02 *i*		2.70E-01 *h*	2.70E-01 *h*			0.25 *c*	0.023 *c*	0.012 *c*	11 *c*	2.4 *c*
p-Chlorobenzoic acid	74113	2.00E-01 *h*						730 *n*	73 *n*	27 *n*	20000 *n*	1600 *n*
4-Chlorobenzotrifluoride	98566	2.00E-02 *h*						73 *n*	7.3 *n*	2.7 *n*	2000 *n*	160 *n*
2-Chloro-1,3-butadiene	126998	2.00E-02 *h*	2.00E-03 *h*			***		1.4 *n*	0.73 *n*	2.7 *n*	2000 *n*	160 *n*
1-Chlorobutane	109693	4.00E-01 *h*				***		240 *n*	150 *n*	54 *n*	41000 *n*	3100 *n*
Chlorodifluoromethane	75456		1.43e+01 *i*			***	0.002 *F*	8700 *n*	5200 *n*			
Chloroethane	75003	2.00E-02 *e*	2.86E+00 *i*			***		71 *n*	1000 *n*	2.7 *n*	2000 *n*	160 *n*
2-Chloroethyl vinyl ether	110758	2.50E-02 *o*				***		15 *n*	9.1 *n*	3.4 *n*	2600 *n*	200 *n*
Chloroform	67663	1.00E-02 *i*		6.10E-03 *i*	8.05E-02 *i*	***	0.1 *T*	0.15 *c*	0.078 *c*	0.52 *c*	470 *c*	78 *n*

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Contaminant	CAS	RfDo mg/kg/d	RfDi mg/kg/d	CPSo kg•d/mg	CPSi kg•d/mg	VOC	MCL mg/L	Tap water µg/L	Ambient air µg/m3	Fish mg/kg	Industrial soil mg/kg	Residential soil mg/kg
Chloromethane	74873			1.30E-02 *h*	6.30E-03 *h*	***		1.4 *c*	0.99 *c*	0.24 *c*	220 *c*	49 *c*
4-Chloro-2,2-methylaniline hydrochloride	3165933			4.60E-01 *h*				0.15 *c*	0.014 *c*	0.0069 *c*	6.2 *c*	1.4 *c*
4-Chloro-2-methylaniline	95692			5.80E-01 *h*				0.12 *c*	0.011 *c*	0.0054 *c*	4.9 *c*	1.1 *c*
beta-Chloronaphthalene	91587	8.00E-02 *i*						290 *n*	29 *n*	11 *n*	8200 *n*	630 *n*
o-Chloronitrobenzene	88733			2.50E-02 *h*		***		0.42 *c*	0.25 *c*	0.13 *c*	110 *c*	26 *c*
p-Chloronitrobenzene	121733			1.80E-02 *h*		***		0.59 *c*	0.35 *c*	0.18 *c*	160 *c*	35 *c*
2-Chlorophenol	95578	5.00E-03 *i*						18 *n*	1.8 *n*	0.68 *n*	510 *n*	39 *n*
2-Chloropropane	75296		2.86E-02 *h*			***		17 *n*	10 *n*			
Chlorothalonil	1897456	1.50E-02 *i*		1.10E-02 *h*				6.1 *c*	0.57 *c*	0.29 *c*	260 *c*	58 *c*
o-Chlorotoluene	95498	2.00E-02 *i*				***		12 *n*	7.3 *n*	2.7 *n*	2000 *n*	160 *n*
Chlorpropham	101213	2.00E-01 *i*						730 *n*	73 *n*	27 *n*	20000 *n*	1600 *n*
Chlorpyrifos	2921882	3.00E-03 *i*						11 *n*	1.1 *n*	0.41 *n*	310 *n*	23 *n*
Chlorpyrifos-methyl	5598130	1.00E-02 *h*						37 *n*	3.7 *n*	1.4 *n*	1000 *n*	78 *n*
Chlorsulfuron	64902723	5.00E-02 *i*						180 *n*	18 *n*	6.8 *n*	5100 *n*	390 *n*
Chlorthiophos	60238564	8.00E-04 *h*						2.9 *n*	0.29 *n*	0.11 *n*	82 *n*	6.3 *n*
Chromium III and compounds	16065831	1.00E+00 *i*	5.71E-07 *w*				0.1 *F*	3700 *n*	0.00021 *n*	140 *n*	100000 *n*	7800 *n*
Chromium VI and compounds	7440473	5.00E-03 *i*			4.20E+01 *i*		0.1 *F*	18 *n*	0.00015 *c*	0.68 *n*	510 *n*	39 *n*
Coal tar	8001589				2.20E+00 *w*				0.0028 *c*			
Coke Oven Emissions	8007452				2.17E+00 *i*				0.0029 *c*			
Copper and compounds	7440508	3.71E-02 *h*						140 *n*	14 *n*	5 *n*	3800 *n*	290 *n*
Crotonaldehyde	123739	1.00E-02 *w*		1.90E+00 *h*	1.90E+00 *w*			0.035 *c*	0.0033 *c*	0.0017 *c*	1.5 *c*	0.34 *c*
Cumene	98828	4.00E-02 *i*	2.57E-03 *h*					150 *n*	0.94 *n*	5.4 *n*	4100 *n*	310 *n*
Cyanides:							0.2 *P*					
Barium cyanide	542621	1.00E-01 *h*						370 *n*	37 *n*	14 *n*	10000 *n*	780 *n*
Calcium cyanide	592018	4.00E-02 *i*						150 *n*	15 *n*	5.4 *n*	4100 *n*	310 *n*
Copper cyanide	544923	5.00E-03 *i*						18 *n*	1.8 *n*	0.68 *n*	510 *n*	39 *n*
Cyanazine	21725462	2.00E-03 *h*		8.40E-01 *h*				0.08 *c*	0.0075 *c*	0.0038 *c*	3.4 *c*	0.76 *c*
Cyanogen	460195	4.00E-02 *i*						150 *n*	15 *n*	5.4 *n*	4100 *n*	310 *n*
Cyanogen bromide	506683	9.00E-02 *i*						330 *n*	33 *n*	12 *n*	9200 *n*	700 *n*
Cyanogen chloride	506774	5.00E-02 *i*						180 *n*	18 *n*	6.8 *n*	5100 *n*	390 *n*
Free cyanide	57125	2.00E-02 *i*						73 *n*	7.3 *n*	2.7 *n*	2000 *n*	160 *n*
Hydrogen cyanide	74908	2.00E-02 *i*						73 *n*	7.3 *n*	2.7 *n*	2000 *n*	160 *n*
Potassium cyanide	151508	5.00E-02 *i*						180 *n*	18 *n*	6.8 *n*	5100 *n*	390 *n*
Potassium silver cyanide	506616	2.00E-01 *i*						730 *n*	73 *n*	27 *n*	20000 *n*	1600 *n*
Silver cyanide	506649	1.00E-01 *i*						370 *n*	37 *n*	14 *n*	10000 *n*	780 *n*
Sodium cyanide	143339	4.00E-02 *i*						150 *n*	15 *n*	5.4 *n*	4100 *n*	310 *n*
Zinc cyanide	557211	5.00E-02 *i*						180 *n*	18 *n*	6.8 *n*	5100 *n*	390 *n*
Cyclohexanone	108941	5.00E+00 *i*				***		3000 *n*	1800 *n*	680 *n*	510000 *n*	39000 *n*
Cyclohexlamine	108918	2.00E-01 *i*						730 *n*	73 *n*	27 *n*	20000 *n*	1600 *n*

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Cyhalothrin/Karate	68085858	5.00E-03 *i*						18 *n*	1.8 *n*	0.68 *n*	510 *n*	39 *n*
Cypermethrin	52315078	1.00E-02 *i*						37 *n*	3.7 *n*	1.4 *n*	1000 *n*	78 *n*
Cyromazine	66215278	7.50E-03 *i*						27 *n*	2.7 *n*	1 *n*	770 *n*	59 *n*
Dacthal	1861321	5.00E-01 *i*						1800 *n*	180 *n*	68 *n*	51000 *n*	3900 *n*
Dalapon	75990	3.00E-02 *i*					0.2 *F*	110 *n*	11 *n*	4.1 *n*	3100 *n*	230 *n*
Danitol	39515418	5.00E-04 *w*						1.8 *n*	0.18 *n*	0.068 *n*	51 *n*	3.9 *n*
DDD	72548			2.40E-01 *i*				0.28 *c*	0.026 *c*	0.013 *c*	12 *c*	2.7 *c*
DDE	72559			3.40E-01 *i*				0.2 *c*	0.018 *c*	0.0093 *c*	8.4 *c*	1.9 *c*
DDT	50293	5.00E-04 *i*		3.40E-01 *i*	3.40E-01 *i*			0.2 *c*	0.018 *c*	0.0093 *c*	8.4 *c*	1.9 *c*
Decabromodiphenyl ether	1163195	1.00E-02 *i*				***		6.1 *n*	3.7 *n*	1.4 *n*	1000 *n*	78 *n*
Demeton	8065483	4.00E-05 *i*						0.15 *n*	0.015 *n*	0.0054 *n*	4.1 *n*	0.31 *n*
Diallate	2303164			6.10E-02 *h*		***		0.17 *c*	0.1 *c*	0.052 *c*	47 *c*	10 *c*
Diazinon	333415	9.00E-04 *h*						3.3 *n*	0.33 *n*	0.12 *n*	92 *n*	7 *n*
1,4-Dibromobenzene	106376	1.00E-02 *i*				***		6.1 *n*	3.7 *n*	1.4 *n*	1000 *n*	78 *n*
Dibromochloromethane	124481	2.00E-02 *i*		8.40E-02 *i*		***	0.1 *T*	0.13 *c*	0.075 *c*	0.038 *c*	34 *c*	7.6 *c*
1,2-Dibromo-3-chloropropane	96128		5.71E-05 *i*	1.40E+00 *h*	6.90E-07 *h*	***	0.0002 *F*	0.035 *n*	0.021 *n*	0.0023 *c*	2 *c*	0.46 *c*
1,2-Dibromoethane	106934		5.71E-05 *h*	8.50E+01 *i*	7.70E-01 *i*	***	0.00005 *F*	0.00075 *c*	0.0081 *c*	0.00004 *c*	0.034 *c*	0.0075 *c*
Dibutyl phthalate	84742	1.00E-01 *i*						370 *n*	37 *n*	14 *n*	10000 *n*	780 *n*
Dicamba	1918009	3.00E-02 *i*						110 *n*	11 *n*	4.1 *n*	3100 *n*	230 *n*
1,2-Dichlorobenzene	95501	9.00E-02 *i*	5.71E-02 *h*			***	0.6 *F*	37 *n*	21 *n*	12 *n*	9200 *n*	700 *n*
1,3-Dichlorobenzene	541731	8.90E-02 *o*				***	0.6 *F*	54 *n*	32 *n*	12 *n*	9100 *n*	700 *n*
1,4-Dichlorobenzene	106467		2.29E-01 *i*	2.40E-02 *h*		***	0.075 *F*	0.44 *c*	0.26 *c*	0.13 *c*	120 *c*	27 *c*
3,3'-Dichlorobenzidine	91941			4.50E-01 *i*				0.15 *c*	0.014 *c*	0.007 *c*	6.4 *c*	1.4 *c*
1,4-Dichloro-2-butene	764410				9.30E+00 *h*	***		0.0011 *c*	0.00067 *c*			
Dichlorodifluoromethane	75718	2.00E-01 *i*	5.71E-02 *h*			***		39 *n*	21 *n*	27 *n*	20000 *n*	1600 *n*
1,1-Dichloroethane	75343	1.00E-01 *h*	1.43E-01 *h*			***		81 *n*	52 *n*	14 *n*	10000 *n*	780 *n*
1,2-Dichloroethane (EDC)	107062		2.86E-03 *e*	9.10E-02 *i*	9.10E-02 *i*	***	0.005 *F*	0.12 *c*	0.069 *c*	0.035 *c*	31 *c*	7 *c*
1,1-Dichloroethylene	75354	9.00E-03 *i*		6.00E-01 *i*	1.75E-01 *i*	***	0.007 *F*	0.044 *c*	0.036 *c*	0.0053 *c*	4.8 *c*	1.1 *c*
1,2-Dichloroethylene (cis)	156592	1.00E-02 *h*				***	0.07 *F*	6.1 *n*	3.7 *n*	1.4 *n*	1000 *n*	78 *n*
1,2-Dichloroethylene (trans)	156605	2.00E-02 *i*				***	0.1 *F*	12 *n*	7.3 *n*	2.7 *n*	2000 *n*	160 *n*
1,2-Dichloroethylene (mixture)	540590	9.00E-03 *h*				***		5.5 *n*	3.3 *n*	1.2 *n*	920 *n*	70 *n*
2,4-Dichlorophenol	120832	3.00E-03 *i*						11 *n*	1.1 *n*	0.41 *n*	310 *n*	23 *n*
2,4-Dichlorophenoxyacetic Acid (2,4-D)	94757	1.00E-02 *i*				***	0.07 *F*	6.1 *n*	3.7 *n*	1.4 *n*	1000 *n*	78 *n*
4-(2,4-Dichlorophenoxy)butyric Acid	94826	8.00E-03 *i*						29 *n*	2.9 *n*	1.1 *n*	820 *n*	63 *n*
1,2-Dichloropropane	78875		1.14E-03 *i*	6.80E-02 *h*		***	0.005 *F*	0.16 *c*	0.092 *c*	0.046 *c*	42 *c*	9.4 *c*
2,3-Dichloropropanol	616239	3.00E-03 *i*						11 *n*	1.1 *n*	0.41 *n*	310 *n*	23 *n*
1,3-Dichloropropene	542756	3.00E-04 *i*	5.71E-03 *i*	1.80E-01 *h*	1.30E-01 *h*	***		0.077 *c*	0.048 *c*	0.018 *c*	16 *c*	2.3 *c*
Dichlorvos	62737	5.00e-04 *i*		2.90E-01 *i*				0.23 *c*	0.022 *c*	0.011 *c*	9.9 *c*	2.2 *c*
Dicofol	115322			3.40E-01 *w*				0.15 *c*	0.014 *c*	0.0072 *c*	[illegible]	1.5 *c*

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Contaminant	CAS	RfDo mg/kg/d	RfDi mg/kg/d	CPSo kg•d/mg	CPSi kg•d/mg	VOC	MCL mg/L	Tap water µg/L	Ambient air µg/m3	Fish mg/kg	Industrial soil mg/kg	Residential soil mg/kg
Dicyclopentadiene	77736	3.00E-02 *h*	5.71E-05 *h*			***		0.042 *n*	0.021 *n*	4.1 *n*	3100 *n*	230 *n*
Dieldrin	60571	5.00E-05 *i*		1.60E+01 *i*	1.61E+01 *i*			0.0042 *c*	0.00039 *c*	0.0002 *c*	0.18 *c*	0.04 *c*
Diesel emissions			1.43E-03 *i*					5.2 *n*	0.52 *n*			
Diethyl phthalate	84662	8.00E-01 *i*						2900 *n*	290 *n*	110 *n*	82000 *n*	6300 *n*
Diethylene glycol, monobutyl ether	112345		5.71E-03 *h*					21 *n*	2.1 *n*			
Diethylene glycol, monoethyl ether	111900	2.00E+00 *h*						7300 *n*	730 *n*	270 *n*	200000 *n*	16000 *n*
Diethylforamide	617845	1.10E-02 *h*						40 *n*	4 *n*	1.5 *n*	1100 *n*	86 *n*
Di(2-ethylhexyl)adipate	103231	6.00E-01 *i*		1.20E-03 *i*			0.4 *F*	56 *c*	5.2 *c*	2.6 *c*	2400 *c*	530 *c*
Diethylstilbestrol	56531			4.70E+03 *h*				0.00001 *c*	1E-06 *c*	7E-07 *c*	0.00061 *c*	0.00014 *c*
Difenzoquat (Avenge)	43222486	8.00E-02 *i*						290 *n*	29 *n*	11 *n*	8200 *n*	630 *n*
Diflubenzuron	35367385	2.00E-02 *i*						73 *n*	7.3 *n*	2.7 *n*	2000 *n*	160 *n*
Diisopropyl methylphosphonate (DIMP)	1445756	8.00E-02 *i*						290 *n*	29 *n*	11 *n*	8200 *n*	630 *n*
Dimethipin	55290647	2.00E-02 *i*						73 *n*	7.3 *n*	2.7 *n*	2000 *n*	160 *n*
Dimethoate	60515	2.00E-04 *i*						0.73 *n*	0.073 *n*	0.027 *n*	20 *n*	1.6 *n*
3,3'-Dimethoxybenzidine	119904			1.40E-02 *h*				4.8 *c*	0.45 *c*	0.23 *c*	200 *c*	46 *c*
Dimethyl phthalate	131113	1.00E+01 *h*						37000 *n*	3700 *n*	1400 *n*	1000000 *n*	78000 *n*
Dimethyl terephthalate	120616	1.00E-01 *i*						370 *n*	37 *n*	14 *n*	10000 *n*	780 *n*
Dimethylamine	124403		5.71E-06 *w*					0.021 *n*	0.0021 *n*			
2,4-Dimethylaniline hydrochloride	21436964			5.80E-01 *h*				0.12 *c*	0.011 *c*	0.0054 *c*	4.9 *c*	1.1 *c*
2,4-Dimethylaniline	95681			7.50E-01 *h*				0.09 *c*	0.0083 *c*	0.0042 *c*	3.8 *c*	0.85 *c*
N-N-Dimethylaniline	121697	2.00E-03 *i*						7.3 *n*	0.73 *n*	0.27 *n*	200 *n*	16 *n*
3,3'-Dimethylbenzidine	119937			9.20E+00 *h*				0.0073 *c*	0.00068 *c*	0.00034 *c*	0.31 *c*	0.069 *c*
N,N-Dimethylformamide	68122	1.00E-01 *h*	8.57E-03 *i*					370 *n*	3.1 *n*	14 *n*	10000 *n*	780 *n*
1,1-Dimethylhydrazine	57147			2.60E+00 *h*	3.50E+00 *h*			0.026 *c*	0.0018 *c*	0.0012 *c*	1.1 *c*	0.25 *c*
1,2-Dimethylhydrazine	540738			3.70E+01 *w*	3.70E+01 *w*			0.0018 *c*	0.00017 *c*	0.00009 *c*	0.077 *c*	0.017 *c*
2,4-Dimethylphenol	105679	2.00E-02 *i*						73 *n*	7.3 *n*	2.7 *n*	2000 *n*	160 *n*
2,6-Dimethylphenol	576261	6.00E-04 *i*						2.2 *n*	0.22 *n*	0.081 *n*	61 *n*	4.7 *n*
3,4-Dimethylphenol	95658	1.00E-03 *i*						3.7 *n*	0.37 *n*	0.14 *n*	100 *n*	7.8 *n*
1,2-Dinitrobenzene	528290	4.00E-04 *h*						1.5 *n*	0.15 *n*	0.054 *n*	41 *n*	3.1 *n*
1,3-Dinitrobenzene	99650	1.00E-04 *i*						0.37 *n*	0.037 *n*	0.014 *n*	10 *n*	0.78 *n*
1,4-Dinitrobenzene	100254	4.00E-04 *h*						1.5 *n*	0.15 *n*	0.054 *n*	41 *n*	3.1 *n*
4,6-Dinitro-o-cyclohexyl phenol	131895	2.00E-03 *i*						7.3 *n*	0.73 *n*	0.27 *n*	200 *n*	16 *n*
2,4-Dinitrophenol	51285	2.00E-03 *i*						7.3 *n*	0.73 *n*	0.27 *n*	200 *n*	16 *n*
Dinitrotoluene mixture				6.80E-01 *i*				0.099 *c*	0.0092 *c*	0.0046 *c*	4.2 *c*	0.94 *c*
2,4-Dinitrotoluene	121142	2.00E-03 *i*						7.3 *n*	0.73 *n*	0.27 *n*	200 *n*	16 *n*
2,6-Dinitrotoluene	606202	1.00E-03 *h*						3.7 *n*	0.37 *n*	0.14 *n*	100 *n*	7.8 *n*
Dinoseb	88857	1.00E-03 *i*					0.007 *F*	3.7 *n*	0.37 *n*	0.14 *n*	100 *n*	7.8 *n*
di-n-Octyl phthalate	117840	2.00E-02 *h*						73 *n*	7.3 *n*	2.7 *n*	2000 *n*	160 *n*
1,4-Dioxane	123911			1.10E-02 *i*				6.1 *c*	0.57 *c*	0.29 *c*	260 *c*	58 *c*

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Contaminant	CAS	RfDo mg/kg/d	RfDi mg/kg/d	CPSo kg•d/mg	CPSi kg•d/mg	VOC	MCL mg/L	Tap water µg/L	Ambient air µg/m3	Fish mg/kg	Industrial soil mg/kg	Residential soil mg/kg
Diphenamid	957517	3.00E-02 *i*						110 *n*	11 *n*	4.1 *n*	3100 *n*	230 *n*
Diphenylamine	122394	2.50E-02 *i*						91 *n*	9.1 *n*	3.4 *n*	2600 *n*	200 *n*
1,2-Diphenylhydrazine	122667			8.00E-01 *i*	7.70E-01 *i*			0.084 *c*	0.0081 *c*	0.0039 *c*	3.6 *c*	0.8 *c*
Diquat	85007	2.20E-03 *i*					0.02 *F*	8 *n*	0.8 *n*	0.3 *n*	220 *n*	17 *n*
Direct black 38	1937377			8.60E+00 *h*				0.0078 *c*	0.00073 *c*	0.00037 *c*	0.33 *c*	0.074 *c*
Direct blue 6	2602462			8.10E+00 *h*				0.0083 *c*	0.00077 *c*	0.00039 *c*	0.35 *c*	0.079 *c*
Direct brown 95	16071866			9.30E+00 *h*				0.0072 *c*	0.00067 *c*	0.00034 *c*	0.31 *c*	0.069 *c*
Disulfoton	298044	4.00E-05 *i*						0.15 *n*	0.015 *n*	0.0054 *n*	4.1 *n*	0.31 *n*
1,4-Dithiane	505293	1.00E-02 *i*						37 *n*	3.7 *n*	1.4 *n*	1000 *n*	78 *n*
Diuron	330541	2.00E-03 *i*						7.3 *n*	0.73 *n*	0.27 *n*	200 *n*	16 *n*
Dodine	2439103	4.00E-03 *i*						15 *n*	1.5 *n*	0.54 *n*	410 *n*	31 *n*
Endosulfan	115297	6.00E-03 *h*						22 *n*	2.2 *n*	0.81 *n*	610 *n*	47 *n*
Endothall	145733	2.00E-02 *i*					0.1 *F*	73 *n*	7.3 *n*	2.7 *n*	2000 *n*	160 *n*
Endrin	72208	3.00E-04 *i*					0.002 *F*	1.1 *n*	0.11 *n*	0.041 *n*	31 *n*	2.3 *n*
Epichlorohydrin	106898	2.00E-03 *h*	2.86E-04 *i*	9.90E-03 *i*	4.20E-03 *i*			6.8 *c*	0.1 *n*	0.27 *n*	200 *n*	16 *n*
1,2-Epoxybutane	106887		5.71E-03 *i*					21 *n*	2.1 *n*			
Ethephon (2-chloroethyl phosphonic acid)	16672870	5.00E-03 *i*						18 *n*	1.8 *n*	0.68 *n*	510 *n*	39 *n*
Ethion	563122	5.00E-04 *i*						1.8 *n*	0.18 *n*	0.068 *n*	51 *n*	3.9 *n*
2-Ethoxyethanol acetate	111159	3.00E-01 *h*						1100 *n*	110 *n*	41 *n*	31000 *n*	2300 *n*
2-Ethoxyethanol	110805	4.00E-01 *h*	5.71E-02 *i*					1500 *n*	21 *n*	54 *n*	41000 *n*	3100 *n*
Ethyl acrylate	140885			4.80E-02 *h*				1.4 *c*	0.13 *c*	0.066 *c*	60 *c*	13 *c*
EPTC (S-Ethyl dipropylthiocarbamate)	759944	2.50E-02 *i*						91 *n*	9.1 *n*	3.4 *n*	2600 *n*	200 *n*
Ethyl ether	60297	2.00E-01 *i*				•••		120 *n*	73 *n*	27 *n*	20000 *n*	1600 *n*
Ethyl methacrylate	97632	9.00E-02 *h*						330 *n*	33 *n*	12 *n*	9200 *n*	700 *n*
Ethyl acetate	141786	9.00E-01 *i*						3300 *n*	330 *n*	120 *n*	92000 *n*	7000 *n*
Ethylbenzene	100414	1.00E-01 *i*	2.86E-01 *i*			•••	0.7 *F*	130 *n*	100 *n*	14 *n*	10000 *n*	780 *n*
Ethylene cyanohydrin	109784	3.00E-01 *h*						1100 *n*	110 *n*	41 *n*	31000 *n*	2300 *n*
Ethylene diamine	107153	2.00E-02 *h*						73 *n*	7.3 *n*	2.7 *n*	2000 *n*	160 *n*
Ethylene glycol	107211	2.00E+00 *i*						7300 *n*	730 *n*	270 *n*	200000 *n*	16000 *n*
Ethylene glycol, monobutyl ether	111762		5.71E-03 *h*					21 *n*	2.1 *n*			
Ethylene oxide	75218			1.02E+00 *h*	3.50E-01 *h*			0.066 *c*	0.018 *c*	0.0031 *c*	2.8 *c*	0.63 *c*
Ethylene thiourea (ETU)	96457	8.00E-05 *i*		6.00E-01 *h*				0.11 *c*	0.01 *c*	0.0053 *c*	4.8 *c*	0.63 *n*
Ethyl p-nitrophenyl phenylphosphorothioate	2104645	1.00E-05 *i*						0.037 *n*	0.0037 *n*	0.0014 *n*	1 *n*	0.078 *n*
Ethylnitrosourea	759739			1.40E+02 *w*				0.00048 *c*	0.00005 *c*	0.00002 *c*	0.02 *c*	0.0046 *c*
Ethylphthalyl ethyl glycolate	84720	3.00E+00 *i*						11000 *n*	1100 *n*	410 *n*	310000 *n*	23000 *n*
Express	10120	8.00E-03 *i*						29 *n*	2.9 *n*	1.1 *n*	820 *n*	63 *n*
Fenamiphos	22224926	2.50E-04 *i*						0.91 *n*	0.091 *n*	0.034 *n*	26 *n*	2 *n*
Fluometuron	2164172	1.30E-02 *i*						47 *n*	4.7 *n*	1.8 *n*	1300 *n*	100 *n*
Fluoride	7782414	6.00E-02 *i*						220 *n*	22 *n*	8.1 *n*	6[illegible] *n*	470 *n*

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Contaminant	CAS	RfDo mg/kg/d	RfDi mg/kg/d	CPSo kg•d/mg	CPSi kg•d/mg	VOC	MCL mg/L	Tap water µg/L	Ambient air µg/m3	Fish mg/kg	Industrial soil mg/kg	Residential soil mg/kg
Fluoridone	59756604	8.00E-02 *i*						290 *n*	29 *n*	11 *n*	8200 *n*	630 *n*
Flurprimidol	56425913	2.00E-02 *i*						73 *n*	7.3 *n*	2.7 *n*	2000 *n*	160 *n*
Flutolanil	66332965	6.00E-02 *i*						220 *n*	22 *n*	8.1 *n*	6100 *n*	470 *n*
Fluvalinate	69409945	1.00E-02 *i*						37 *n*	3.7 *n*	1.4 *n*	1000 *n*	78 *n*
Folpet	133073	1.00E-01 *i*		3.50E-03 *i*				19 *c*	1.8 *c*	0.9 *c*	820 *c*	180 *c*
Fomesafen	72178020			1.90E-01 *i*				0.35 *c*	0.033 *c*	0.017 *c*	15 *c*	3.4 *c*
Fonofos	944229	2.00E-03 *i*						7.3 *n*	0.73 *n*	0.27 *n*	200 *n*	16 *n*
Formaldehyde	50000	2.00E-01 *i*			4.55E-02 *i*			730 *n*	0.14 *c*	27 *n*	20000 *n*	1600 *n*
Formic Acid	64186	2.00E+00 *h*						7300 *n*	730 *n*	270 *n*	200000 *n*	16000 *n*
Fosetyl-al	39148248	3.00E+00 *i*						11000 *n*	1100 *n*	410 *n*	310000 *n*	23000 *n*
Furan	110009	1.00E-03 *i*						3.7 *n*	0.37 *n*	0.14 *n*	100 *n*	7.8 *n*
Furazolidone	67458			3.80E+00 *h*				0.018 *c*	0.0016 *c*	0.00083 *c*	0.75 *c*	0.17 *c*
Furfural	98011	3.00E-03 *i*	1.43E-02 *h*					11 *n*	5.2 *n*	0.41 *n*	310 *n*	23 *n*
Furium	531828			5.00E+01 *h*				0.0013 *c*	0.00013 *c*	0.00006 *c*	0.057 *c*	0.013 *c*
Furmecyclox	60568050			3.00E-02 *i*				2.2 *c*	0.21 *c*	0.11 *c*	95 *c*	21 *c*
Glufosinate-ammonium	77182822	4.00E-04 *i*						1.5 *n*	0.15 *n*	0.054 *n*	41 *n*	3.1 *n*
Glycidaldehyde	765344	4.00E-04 *i*	2.86E-04 *n*					1.5 *n*	0.1 *n*	0.054 *n*	41 *n*	3.1 *n*
Glyphosate	1071836	1.00E-01 *i*					0.7 *F*	370 *n*	37 *n*	14 *n*	10000 *n*	780 *n*
Haloxyfop-methyl	69806402	5.00E-05 *i*						0.18 *n*	0.018 *n*	0.0068 *n*	5.1 *n*	0.39 *n*
Harmony	79277273	1.30E-02 *i*						47 *n*	4.7 *n*	1.8 *n*	1300 *n*	100 *n*
HCH (alpha)	319846			6.30E+00 *i*	6.30E+00 *i*			0.011 *c*	0.00099 *c*	0.0005 *c*	0.45 *c*	0.1 *c*
HCH (beta)	319857			1.80E+00 *i*	1.80E+00 *i*			0.037 *c*	0.0035 *c*	0.0018 *c*	1.6 *c*	0.35 *c*
HCH (gamma) Lindane	58899	3.00E-04 *i*		1.30E+00 *h*			0.0002 *F*	0.052 *c*	0.0048 *c*	0.0024 *c*	2.2 *c*	0.49 *c*
HCH-technical	608731			1.80E+00 *i*	1.79E+00 *i*			0.037 *c*	0.0035 *c*	0.0018 *c*	1.6 *c*	0.35 *c*
Heptachlor	76448	5.00E-04 *i*		4.50E+00 *i*	4.55E+00 *i*	***	0.0004 *F*	0.0023 *c*	0.0014 *c*	0.0007 *c*	0.64 *c*	0.14 *c*
Heptachlor epoxide	1024573	1.30E-05 *i*		9.10E+00 *i*	9.10E+00 *i*	***	0.0002 *F*	0.0012 *c*	0.00069 *c*	0.00035 *c*	0.31 *c*	0.07 *c*
Hexabromobenzene	87821	2.00E-03 *i*				***		1.2 *n*	0.73 *n*	0.27 *n*	200 *n*	16 *n*
Hexachlorobenzene	118741	8.00E-04 *i*		1.60E+00 *i*	1.61E+00 *i*	***	0.001 *F*	0.0066 *c*	0.0039 *c*	0.002 *c*	1.8 *c*	0.4 *c*
Hexachlorobutadiene	87683	2.00E-04 *h*		7.80E-02 *i*	7.70E-02 *i*	***		0.12 *n*	0.073 *n*	0.027 *n*	20 *n*	1.6 *n*
Hexachlorocyclopentadiene	77474	7.00E-03 *i*	2.00E-05 *h*			***	0.05 *F*	0.015 *n*	0.0073 *n*	0.95 *n*	720 *n*	55 *n*
Hexachlorodibenzo-p-dioxin mixture	19408743			6.20E+03 *i*	4.55E+03 *i*			0.00001 *c*	1E-06 *c*	5E-07 *c*	0.00046 *c*	0.0001 *c*
Hexachloroethane	67721	1.00E-03 *i*		1.40E-02 *i*	1.40E-02 *i*	***		0.61 *n*	0.37 *n*	0.14 *n*	100 *n*	7.8 *n*
Hexachlorophene	70304	3.00E-04 *i*						1.1 *n*	0.11 *n*	0.041 *n*	31 *n*	2.3 *n*
Hexahydro-1,3,5-trinitro-1,3,5-triazine	121824	3.00E-03 *i*		1.10E-01 *i*				0.61 *c*	0.057 *c*	0.029 *c*	26 *c*	5.8 *c*
n-Hexane	110543	6.00E-02 *h*	5.71E-02 *i*			***		35 *n*	21 *n*	8.1 *n*	6100 *n*	470 *n*
Hexazinone	51235042	3.30E-02 *i*						120 *n*	12 *n*	4.5 *n*	3400 *n*	260 *n*
Hydrazine, hydrazine sulfate	302012			3.00E+00 *i*	1.71E+01 *i*			0.022 *c*	0.00037 *c*	0.0011 *c*	0.95 *c*	0.21 *c*
Hydrogen chloride	7647010		2.00E-03 *i*					7.3 *n*	0.73 *n*			
Hydrogen sulfide	7783064	3.00E-03 *i*	2.57E-04 *i*					11 *n*	0.094 *n*	0.41 *n*	310 *n*	23 *n*

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Hydroquinone	123319	4.00E-02 h						150 n	15 n	5.4 n	4100 n	310 n
Imazalil	35554440	1.30E-02 i						47 n	4.7 n	1.8 n	1300 n	100 n
Imazaquin	81335377	2.50E-01 i						910 n	91 n	34 n	26000 n	2000 n
Iprodione	36734197	4.00E-02 i						150 n	15 n	5.4 n	4100 n	310 n
Isobutanol	78831	3.00E-01 i				***		180 n	110 n	41 n	31000 n	2300 n
Isophorone	78591	2.00E-01 i		9.50E-04 i				71 c	6.6 c	3.3 c	3000 c	670 c
Isopropalin	33820530	1.50E-02 i						55 n	5.5 n	2 n	1500 n	120 n
Isopropyl methyl phosphonic acid	1832548	1.00E-01 i						370 n	37 n	14 n	10000 n	780 n
Isoxaben	82558507	5.00E-02 i						180 n	18 n	6.8 n	5100 n	390 n
Kepone	143500			1.80E+01 o				0.0037 c	0.00035 c	0.00018 c	0.16 c	0.035 c
Lactofen	77501634	2.00E-03 i						7.3 n	0.73 n	0.27 n	200 n	16 n
Lead (tetraethyl)	78002	1.00E-07 i						0.00037 n	0.00004 n	0.00001 n	0.01 n	0.00078 n
Linuron	330552	2.00E-03 i						7.3 n	0.73 n	0.27 n	200 n	16 n
Lithium	7439932	2.00E-02 •						73 n	7.3 n	2.7 n	2000 n	160 n
Londax	83056996	2.00E-01 i						730 n	73 n	27 n	20000 n	1600 n
Malathion	121755	2.00E-02 i						73 n	7.3 n	2.7 n	2000 n	160 n
Maleic anhydride	108316	1.00E-01 i						370 n	37 n	14 n	10000 n	780 n
Maleic hydrazide	123331	5.00E-01 i						1800 n	180 n	68 n	51000 n	3900 n
Malononitrile	109773	2.00E-05 h						0.073 n	0.0073 n	0.0027 n	2 n	0.16 n
Mancozeb	8018017	3.00E-02 h						110 n	11 n	4.1 n	3100 n	230 n
Maneb	12427382	5.00E-03 i						18 n	1.8 n	0.68 n	510 n	39 n
Manganese and compounds	7439965	5.00E-03 i	1.43e-05 i					18 n	0.0052 n	0.68 n	510 n	39 n
Mephosfolan	950107	9.00E-05 h						0.33 n	0.033 n	0.012 n	9.2 n	0.7 n
Mepiquat chloride	24307264	3.00E-02 i						110 n	11 n	4.1 n	3100 n	230 n
Mercury (inorganic)	7439976	3.00E-04 h	8.57E-05 h				0.002 F	1.1 n	0.031 n	0.041 n	31 n	2.3 n
Mercury (methyl)	22967926	3.00E-04 i					0.002 F	1.1 n	0.11 n	0.041 n	31 n	2.3 n
Merphos	150505	3.00E-05 i						0.11 n	0.011 n	0.0041 n	3.1 n	0.23 n
Merphos oxide	78488	3.00E-05 i						0.11 n	0.011 n	0.0041 n	3.1 n	0.23 n
Metalaxyl	57837191	6.00E-02 i						220 n	22 n	8.1 n	6100 n	470 n
Methacrylonitrile	126987	1.00E-04 i	2.00E-04 h					0.37 n	0.073 n	0.014 n	10 n	0.78 n
Methamidophos	10265926	5.00E-05 i						0.18 n	0.018 n	0.0068 n	5.1 n	0.39 n
Methanol	67561	5.00E-01 i						1800 n	180 n	68 n	51000 n	3900 n
Methidathion	950378	1.00E-03 i						3.7 n	0.37 n	0.14 n	100 n	7.8 n
Methomyl	16752775	2.50E-02 i						91 n	9.1 n	3.4 n	2600 n	200 n
Methoxychlor	72435	5.00E-03 i					0.04 F	18 n	1.8 n	0.68 n	510 n	39 n
2-Methoxyethanol acetate	110496	2.00E-03 h						7.3 n	0.73 n	0.27 n	200 n	16 n
2-Methoxyethanol	109864	1.00E-03 h	5.71E-03 i					3.7 n	2.1 n	0.14 n	100 n	7.8 n
2-Methoxy-5-nitroaniline	99592			4.60E-02 h				1.5 c	0.14 c	0.069 c	62 c	14 c
Methyl acetate	79209	1.00E+00 h						3700 n	370 n	140 n	10000 n	7800 n

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Methyl acrylate	96333	3.00E-02 *h*						110 *n*	11 *n*	4.1 *n*	3100 *n*	230 *n*
2-Methylaniline hydrochloride	636215			1.80E-01 *h*				0.37 *c*	0.035 *c*	0.018 *c*	16 *c*	3.5 *c*
2-Methylaniline	95534			2.40E-01 *h*				0.28 *c*	0.026 *c*	0.013 *c*	12 *c*	2.7 *c*
Methyl chlorocarbonate	79221	1.00E+00 *w*						3700 *n*	370 *n*	140 *n*	100000 *n*	7800 *n*
4-(2-Methyl-4-chlorophenoxy) butyric acid	94815	1.00E-02 *i*						37 *n*	3.7 *n*	1.4 *n*	1000 *n*	78 *n*
2-Methyl-4-chlorophenoxyacetic acid	94746	5.00E-04 *i*						1.8 *n*	0.18 *n*	0.068 *n*	51 *n*	3.9 *n*
2-(2-Methyl-14-chlorophenoxy)propionic acid	93652	1.00E-03 *i*						3.7 *n*	0.37 *n*	0.14 *n*	100 *n*	7.8 *n*
Methylcyclohexane	108872		8.57E-01 *h*					3100 *n*	310 *n*			
Methylene bromide	74953	1.00E-02 *h*				•••		6.1 *n*	3.7 *n*	1.4 *n*	1000 *n*	78 *n*
Methylene chloride	75092	6.00E-02 *i*	8.57E-01 *h*	7.50E-03 *i*	1.64E-03 *i*	•••	0.005 *F*	4.1 *c*	3.8 *c*	0.42 *c*	380 *c*	85 *c*
4,4'-Methylene bis(2-chloroaniline)	101144	7.00E-04 *h*		1.30E-01 *h*	1.30E-01 *h*			0.52 *c*	0.048 *c*	0.024 *c*	22 *c*	4.9 *c*
4,4'-Methylenebisbenzeneamine	101779			2.50E-01 *h*				0.27 *c*	0.025 *c*	0.013 *c*	11 *c*	2.6 *c*
4,4'-Methylene bis(N,N'-dimethyl)aniline	101611			4.60E-02 *i*				1.5 *c*	0.14 *c*	0.069 *c*	62 *c*	14 *c*
4,4'-Methylenediphenyl isocyanate	101688		5.71E-06 *h*			•••		0.0035 *n*	0.0021 *n*			
Methyl ethyl ketone	78933	6.00E-01 *i*	2.86E-01 *i*					2200 *n*	100 *n*	81 *n*	61000 *n*	4700 *n*
Methyl hydrazine	60344			1.10E+00 *h*				0.061 *c*	0.0057 *c*	0.0029 *c*	2.6 *c*	0.58 *c*
Methyl isobutyl ketone	108101	5.00E-02 *h*	2.29E-02 *h*					180 *n*	8.4 *n*	6.8 *n*	5100 *n*	390 *n*
Methyl methacrylate	80626	8.00E-02 *h*						290 *n*	29 *n*	11 *n*	8200 *n*	630 *n*
2-Methyl-5-nitroaniline	99558			3.30E-02 *h*				2 *c*	0.19 *c*	0.096 *c*	87 *c*	19 *c*
Methyl parathion	298000	2.50E-04 *i*						0.91 *n*	0.091 *n*	0.034 *n*	26 *n*	2 *n*
2-Methylphenol (o-cresol)	95487	5.00E-02 *i*						180 *n*	18 *n*	6.8 *n*	5100 *n*	390 *n*
3-Methylphenol (m-cresol)	103394	5.00E-02 *i*						180 *n*	18 *n*	6.8 *n*	5100 *n*	390 *n*
4-Methylphenol (p-cresol)	106445	5.00E-03 *h*						18 *n*	1.8 *n*	0.68 *n*	510 *n*	39 *n*
Methyl styrene (mixture)	25013154	6.00E-03 *h*	1.14E-02 *h*			•••		6 *n*	4.2 *n*	0.81 *n*	610 *n*	47 *n*
Methyl styrene (alpha)	98839	7.00E-02 *h*				•••		43 *n*	26 *n*	9.5 *n*	7200 *n*	550 *n*
Methyl tertbutyl ether (MTBE)	1634044	5.00E-03 *a*	8.57E-01 *i*			•••		18 *n*	310 *n*	0.68 *n*	510 *n*	39 *n*
Metolaclor (Dual)	51218452	1.50E-01 *i*						550 *n*	55 *n*	20 *n*	15000 *n*	1200 *n*
Metribuzin	21807649	2.50E-02 *i*						91 *n*	9.1 *n*	3.4 *n*	2600 *n*	200 *n*
Mirex	2385855	2.00E-04 *i*		1.80E+00 *h*				0.037 *c*	0.0035 *c*	0.0018 *c*	1.6 *c*	0.35 *c*
Molinate	2212671	2.00E-03 *i*						7.3 *n*	0.73 *n*	0.27 *n*	200 *n*	16 *n*
Molybdenum	7439987	5.00E-03 *i*						18 *n*	1.8 *n*	0.68 *n*	510 *n*	39 *n*
Monochloramine	10599903	1.00E-01 *i*						370 *n*	37 *n*	14 *n*	10000 *n*	780 *n*
Naled	300765	2.00E-03 *i*						7.3 *n*	0.73 *n*	0.27 *n*	200 *n*	16 *n*
Napropamide	15299997	1.00E-01 *i*						370 *n*	37 *n*	14 *n*	10000 *n*	780 *n*
Nickel refinery dust					8.40E-01 *i*				0.0075 *o*			
Nickel (soluble salts)	7440020	2.00E-02 *i*					0.1 *F*	73 *n*	7.3 *n*	2.7 *n*	2000 *n*	160 *n*
Nickel subsulfide	12035722				1.70E+00 *i*				0.0037 *c*			
Nitrapyrin	1929824	1.50E-03 *w*						5.5 *n*	0.55 *n*	0.2 *n*	150 *n*	12 *n*
Nitrate	14797558	1.60E+00 *i*					10 *F*	5800 *n*	580 *n*	220 *n*	160000 *n*	13000 *n*

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Nitric Oxide	10102439	1.00E-01 *i*						370 *n*	37 *n*	14 *n*	10000 *n*	780 *n*
Nitrite	14797650	1.00E-01 *i*					1 *F*	370 *n*	37 *n*	14 *n*	10000 *n*	780 *n*
2-Nitroaniline	88744	6.00E-05 *w*	5.71E-05 *h*					0.22 *n*	0.021 *n*	0.0081 *n*	6.1 *n*	0.47 *n*
3-Nitroaniline	99092	3.00E-03 *o*						11 *n*	1.1 *n*	0.41 *n*	310 *n*	23 *n*
4-Nitroaniline	100016	3.00E-03 *o*						11 *n*	1.1 *n*	0.41 *n*	310 *n*	23 *n*
Nitrobenzene	98953	5.00E-04 *i*	5.71E-04 *h*			***		0.34 *n*	0.21 *n*	0.068 *n*	51 *n*	3.9 *n*
Nitrofurantoin	67209	7.00E-02 *h*						260 *n*	26 *n*	9.5 *n*	7200 *n*	550 *n*
Nitrofurazone	59870			1.50E+00 *h*	9.40E+00 *h*			0.045 *c*	0.00067 *c*	0.0021 *c*	1.9 *c*	0.43 *c*
Nitrogen dioxide	10102440	1.00E+00 *i*						3700 *n*	370 *n*	140 *n*	100000 *n*	7800 *n*
Nitroguanidine	556887	1.00E-01 *i*						370 *n*	37 *n*	14 *n*	10000 *n*	780 *n*
4-Nitrophenol	100027	6.20E-02 *o*						230 *n*	23 *n*	8.4 *n*	6300 *n*	480 *n*
2-Nitropropane	79469		5.71E-03 *i*		9.40E+00 *h*			21 *n*	0.00067 *c*			
N-Nitrosodi-n-butylamine	924163			5.40E+00 *i*	5.60E+00 *i*			0.012 *c*	0.0011 *c*	0.00058 *c*	0.53 *c*	0.12 *c*
N-Nitrosodiethanolamine	1116547			2.80E+00 *i*				0.024 *c*	0.0022 *c*	0.0011 *c*	1 *c*	0.23 *c*
N-Nitrosodiethylamine	55185			1.50E+02 *i*	1.51E+02 *i*			0.00045 *c*	0.00004 *c*	0.00002 *c*	0.019 *c*	0.0043 *c*
N-Nitrosodimethylamine	62759			5.10E+01 *i*	4.90E+01 *i*			0.0013 *c*	0.00013 *c*	0.00006 *c*	0.056 *c*	0.013 *c*
N-Nitrosodiphenylamine	86306			4.90E-03 *i*				14 *c*	1.3 *c*	0.64 *c*	580 *c*	130 *c*
N-Nitroso di-n-propylamine	621647			7.00E+00 *i*				0.0096 *c*	0.00089 *c*	0.00045 *c*	0.41 *c*	0.091 *c*
N-Nitroso-N-methylethylamine	10595956			2.20E+01 *i*				0.0031 *c*	0.00028 *c*	0.00014 *c*	0.13 *c*	0.029 *c*
N-Nitrosopyrrolidine	930552			2.10E+00 *i*	2.13E+00 *i*			0.032 *c*	0.0029 *c*	0.0015 *c*	1.4 *c*	0.3 *c*
m-Nitrotoluene	99081	1.00E-02 *h*				***		6.1 *n*	3.7 *n*	1.4 *n*	1000 *n*	78 *n*
o-Nitrotoluene	88722	1.00E-02 *h*				***		6.1 *n*	3.7 *n*	1.4 *n*	1000 *n*	78 *n*
p-Nitrotoluene	99990	1.00E-02 *h*				***		6.1 *n*	3.7 *n*	1.4 *n*	1000 *n*	78 *n*
Norflurazon	27314132	4.00E-02 *i*						150 *n*	15 *n*	5.4 *n*	4100 *n*	310 *n*
NuStar	85509199	7.00E-04 *i*						2.6 *n*	0.26 *n*	0.095 *n*	72 *n*	5.5 *n*
Octabromodiphenyl ether	32536520	3.00E-03 *i*						11 *n*	1.1 *n*	0.41 *n*	310 *n*	23 *n*
Octahydro-1357-tetranitro-1357-tetrazocine	2691410	5.00E-02 *i*						180 *n*	18 *n*	6.8 *n*	5100 *n*	390 *n*
Octamethylpyrophosphoramide	152169	2.00E-03 *h*						7.3 *n*	0.73 *n*	0.27 *n*	200 *n*	16 *n*
Oryzalin	19044883	5.00E-02 *i*						180 *n*	18 *n*	6.8 *n*	5100 *n*	390 *n*
Oxadiazon	19666309	5.00E-03 *i*						18 *n*	1.8 *n*	0.68 *n*	510 *n*	39 *n*
Oxamyl	23135220	2.50E-02 *i*					0.2 *F*	91 *n*	9.1 *n*	3.4 *n*	2600 *n*	200 *n*
Oxyfluorfen	42874033	3.00E-03 *i*						11 *n*	1.1 *n*	0.41 *n*	310 *n*	23 *n*
Paclobutrazol	76738620	1.30E-02 *i*						47 *n*	4.7 *n*	1.8 *n*	1300 *n*	100 *n*
Paraquat	1910425	4.50E-03 *i*						16 *n*	1.6 *n*	0.61 *n*	460 *n*	35 *n*
Parathion	56382	6.00E-03 *h*						22 *n*	2.2 *n*	0.81 *n*	610 *n*	47 *n*
Pebulate	1114712	5.00E-02 *h*						180 *n*	18 *n*	6.8 *n*	5100 *n*	390 *n*
Pendimethalin	40487421	4.00E-02 *i*						150 *n*	15 *n*	5.4 *n*	4100 *n*	310 *n*
Pentabromo-6-chloro cyclohexane	87843			2.30E-02 *h*				2.9 *c*	0.27 *c*	0.14 *c*	120 *c*	28 *c*
Pentabromodiphenyl ether	32534819	2.00E-03 *i*						7.3 *n*	0.73 *n*	0.27 *n*		16 *n*

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Pentachlorobenzene	608935	8.00E-04 *i*				***		0.49 *n*	0.29 *n*	0.11 *n*	82 *n*	6.3 *n*
Pentachloronitrobenzene	82688	3.00E-03 *i*		2.60E-01 *h*		***		0.041 *c*	0.024 *c*	0.012 *c*	11 *c*	2.5 *c*
Pentachlorophenol	87865	3.00E-02 *i*		1.20E-01 *i*			0.001 *F*	0.56 *c*	0.052 *c*	0.026 *c*	24 *c*	5.3 *c*
Permethrin	52645531	5.00E-02 *i*						180 *n*	18 *n*	6.8 *n*	5100 *n*	390 *n*
Phenmedipham	13684634	2.50E-01 *i*						910 *n*	91 *n*	34 *n*	26000 *n*	2000 *n*
Phenol	108952	6.00E-01 *i*						2200 *n*	220 *n*	81 *n*	61000 *n*	4700 *n*
m-Phenylenediamine	108452	6.00E-03 *i*						22 *n*	2.2 *n*	0.81 *n*	610 *n*	47 *n*
o-Phenylenediamine	95545	6.00E-03 *h*						22 *n*	2.2 *n*	0.81 *n*	610 *n*	47 *n*
p-Phenylenediamine	106503	1.90E-01 *h*						690 *n*	69 *n*	26 *n*	19000 *n*	1500 *n*
Phenylmercuric acetate	62384	8.00E-05 *i*						0.29 *n*	0.029 *n*	0.011 *n*	8.2 *n*	0.63 *n*
2-Phenylphenol	90437			1.94E-03 *h*				35 *c*	3.2 *c*	1.6 *c*	1500 *c*	330 *c*
Phorate	298022	2.00E-04 *h*						0.73 *n*	0.073 *n*	0.027 *n*	20 *n*	1.6 *n*
Phosmet	732116	2.00E-02 *i*						73 *n*	7.3 *n*	2.7 *n*	2000 *n*	160 *n*
Phosphine	7803512	3.00E-04 *i*	8.57E-06 *h*					1.1 *n*	0.0031 *n*	0.041 *n*	31 *n*	2.3 *n*
Phosphorus (white)	7723140	2.00E-05 *i*						0.073 *n*	0.0073 *n*	0.0027 *n*	2 *n*	0.16 *n*
p-Phthalic acid	100210	1.00E+00 *h*						3700 *n*	370 *n*	140 *n*	100000 *n*	7800 *n*
Phthalic anhydride	85449	2.00E+00 *i*	3.43E-01 *h*					7300 *n*	130 *n*	270 *n*	200000 *n*	16000 *n*
Picloram	1918021	7.00E-02 *i*					0.5 *F*	260 *n*	26 *n*	9.5 *n*	7200 *n*	550 *n*
Pirimiphos-methyl	29232937	1.00E-02 *i*						37 *n*	3.7 *n*	1.4 *n*	1000 *n*	78 *n*
Polybrominated biphenyls		7.00E-06 *h*		8.90E+00 *h*				0.0076 *c*	0.0007 *c*	0.00035 *c*	0.32 *c*	0.055 *n*
Polychlorinated biphenyls (PCBs)	1336363			7.70E+00 *i*			0.0005 *F*	0.0087 *c*	0.00081 *c*	0.00041 *c*	0.37 *c*	0.083 *c*
Aroclor 1016	12674112	7.00E-05 *i*						0.26 *n*	0.026 *n*	0.0095 *n*	7.2 *n*	0.55 *n*
Polychlorinated terphenyls (PCTs)				4.50E+00 *e*				0.015 *c*	0.0014 *c*	0.0007 *c*	0.64 *c*	0.14 *c*
Polynuclear aromatic hydrocarbons												
Acenaphthene	83329	6.00E-02 *i*						220 *n*	22 *n*	8.1 *n*	6100 *n*	470 *n*
Anthracene	120127	3.00E-01 *i*						1100 *n*	110 *n*	41 *n*	31000 *n*	2300 *n*
Benzo[a]pyrene	50328			7.30E+00 *i*	6.10E+00 *h*		0.0002 *F*	0.0092 *c*	0.001 *c*	0.00043 *c*	0.39 *c*	0.088 *c*
Benzo[b]fluoranthene	205992			7.30E-01 *e*	6.10E-01 *e*		0.0002 *P*	0.092 *c*	0.01 *c*	0.0043 *c*	3.9 *c*	0.88 *c*
Benzo[k]fluoranthene	207089			7.30E-02 *e*	6.10E-02 *e*		0.0002 *P*	0.92 *c*	0.1 *c*	0.043 *c*	39 *c*	8.8 *c*
Benz[a]anthracene	56553			7.30E-01 *e*	6.10E-01 *e*		0.0001 *P*	0.092 *c*	0.01 *c*	0.0043 *c*	3.9 *c*	0.88 *c*
Chrysene	218019			7.30E-03 *e*	6.10E-03 *e*		0.0002 *P*	9.2 *c*	1 *c*	0.43 *c*	390 *c*	88 *c*
Dibenz[ah]anthracene	53703			7.30E+00 *e*	6.10E+00 *e*		0.0003 *P*	0.0092 *c*	0.001 *c*	0.00043 *c*	0.39 *c*	0.088 *c*
Fluoranthene	206440	4.00E-02 *i*						150 *n*	15 *n*	5.4 *n*	4100 *n*	310 *n*
Fluorene	86737	4.00E-02 *i*						150 *n*	15 *n*	5.4 *n*	4100 *n*	310 *n*
Indeno[1,2,3-cd]pyrene	193395			7.30E-01 *e*	6.10E-01 *e*		0.0004 *P*	0.092 *c*	0.01 *c*	0.0043 *c*	3.9 *c*	0.88 *c*
Naphthalene	91203	4.00E-02 *w*						150 *n*	15 *n*	5.4 *n*	4100 *n*	310 *n*
Pyrene	129000	3.00E-02 *i*						110 *n*	11 *n*	4.1 *n*	3100 *n*	230 *n*
Prochloraz	67747095	9.00E-03 *i*		1.50E-01 *i*				0.45 *c*	0.042 *c*	0.021 *c*	19 *c*	4.3 *c*
Profluralin	26399360	6.00E-03 *h*						22 *n*	2.2 *n*	0.81 *n*	610 *n*	47 *n*

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Contaminant	CAS	RfDo mg/kg/d	RfDi mg/kg/d	CPSo kg•d/mg	CPSi kg•d/mg	VOC	MCL mg/L	Tap water µg/L	Ambient air µg/m3	Fish mg/kg	Industrial soil mg/kg	Residential soil mg/kg
Prometon	1610180	1.50E-02 *i*						55 *n*	5.5 *n*	2 *n*	1500 *n*	120 *n*
Prometryn	7287196	4.00E-03 *i*						15 *n*	1.5 *n*	0.54 *n*	410 *n*	31 *n*
Pronamide	23950585	7.50E-02 *i*						270 *n*	27 *n*	10 *n*	7700 *n*	590 *n*
Propachlor	1918167	1.30E-02 *i*						47 *n*	4.7 *n*	1.8 *n*	1300 *n*	100 *n*
Propanil	709988	5.00E-03 *i*						18 *n*	1.8 *n*	0.68 *n*	510 *n*	39 *n*
Propargite	2312358	2.00E-02 *i*						73 *n*	7.3 *n*	2.7 *n*	2000 *n*	160 *n*
Propargyl alcohol	107197	2.00E-03 *i*						7.3 *n*	0.73 *n*	0.27 *n*	200 *n*	16 *n*
Propazine	139402	2.00E-02 *i*						73 *n*	7.3 *n*	2.7 *n*	2000 *n*	160 *n*
Propham	122429	2.00E-02 *i*						73 *n*	7.3 *n*	2.7 *n*	2000 *n*	160 *n*
Propiconazole	60207901	1.30E-02 *i*						47 *n*	4.7 *n*	1.8 *n*	1300 *n*	100 *n*
Propylene glycol	57556	2.00E+01 *h*						73000 *n*	7300 *n*	2700 *n*	1000000 *n*	160000 *n*
Propylene glycol, monoethyl ether	52125538	7.00E-01 *h*						2600 *n*	260 *n*	95 *n*	72000 *n*	5500 *n*
Propylene glycol, monomethyl ether	107982	7.00E-01 *h*	5.71E-01 *i*					2600 *n*	210 *n*	95 *n*	72000 *n*	5500 *n*
Propylene oxide	75569		8.57E-03 *i*	2.40E-01 *i*	1.29E-02 *i*			0.28 *c*	0.49 *c*	0.013 *c*	12 *c*	2.7 *c*
Pursuit	81335775	2.50E-01 *i*						910 *n*	91 *n*	34 *n*	26000 *n*	2000 *n*
Pydrin	51630581	2.50E-02 *i*						91 *n*	9.1 *n*	3.4 *n*	2600 *n*	200 *n*
Pyridine	110861	1.00E-03 *i*						3.7 *n*	0.37 *n*	0.14 *n*	100 *n*	7.8 *n*
Quinalphos	13593038	5.00E-04 *i*						1.8 *n*	0.18 *n*	0.068 *n*	51 *n*	3.9 *n*
Quinoline	91225			1.20E+01 *h*				0.0056 *c*	0.00052 *c*	0.00026 *c*	0.24 *c*	0.053 *c*
Resmethrin	10463868	3.00E-02 *i*						110 *n*	11 *n*	4.1 *n*	3100 *n*	230 *n*
Ronnel	299843	5.00E-02 *h*						180 *n*	18 *n*	6.8 *n*	5100 *n*	390 *n*
Rotenone	83794	4.00E-03 *i*						15 *n*	1.5 *n*	0.54 *n*	410 *n*	31 *n*
Savey	78587050	2.50E-02 *i*						91 *n*	9.1 *n*	3.4 *n*	2600 *n*	200 *n*
Selenious Acid	7783008	5.00E-03 *i*						18 *n*	1.8 *n*	0.68 *n*	510 *n*	39 *n*
Selenium	7782492	5.00E-03 *i*					0.05 *F*	18 *n*	1.8 *n*	0.68 *n*	510 *n*	39 *n*
Selenourea	630104	5.00E-03 *h*						18 *n*	1.8 *n*	0.68 *n*	510 *n*	39 *n*
Sethoxydim	74051802	9.00E-02 *i*						330 *n*	33 *n*	12 *n*	9200 *n*	700 *n*
Silver and compounds	7440224	5.00E-03 *i*						18 *n*	1.8 *n*	0.68 *n*	510 *n*	39 *n*
Simazine	122349	5.00E-03 *i*		1.20E-01 *h*			0.004 *F*	0.56 *c*	0.052 *c*	0.026 *c*	24 *c*	5.3 *c*
Sodium azide	26628228	4.00E-03 *i*						15 *n*	1.5 *n*	0.54 *n*	410 *n*	31 *n*
Sodium diethyldithiocarbamate	148185	3.00E-02 *i*		2.70E-01 *h*				0.25 *c*	0.023 *c*	0.012 *c*	11 *c*	2.4 *c*
Sodium fluoroacetate	62748	2.00E-05 *i*						0.073 *n*	0.0073 *n*	0.0027 *n*	2 *n*	0.16 *n*
Sodium metavanadate	13718268	1.00E-03 *h*						3.7 *n*	0.37 *n*	0.14 *n*	100 *n*	7.8 *n*
Strontium, stable	7440246	6.00E-01 *i*						2200 *n*	220 *n*	81 *n*	61000 *n*	4700 *n*
Strychnine	57249	3.00E-04 *i*						1.1 *n*	0.11 *n*	0.041 *n*	31 *n*	2.3 *n*
Styrene	100425	2.00E-01 *i*	2.86E-01 *i*			***	0.1 *F*	160 *n*	100 *n*	27 *n*	20000 *n*	1600 *n*
Systhane	88671890	2.50E-02 *i*						91 *n*	9.1 *n*	3.4 *n*	2600 *n*	200 *n*
2,3,7,8-TCDD (dioxin)	1746016			1.50E+05 *h*	1.50E+05 *h*		3E-08 *F*	5E-07 *c*	4E-08 *c*	2E-08 *c*	0.00002 *c*	4.30E-06 *c*
Tebuthiuron	34014181	7.00E-02 *i*						260 *n*	26 *n*	9.5 *n*	72[illegible]	550 *n*

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Contaminant	CAS	RfDo mg/kg/d	RfDi mg/kg/d	CPSo kg•d/mg	CPSi kg•d/mg	VOC	MCL mg/L	Tap water µg/L	Ambient air µg/m3	Fish mg/kg	Industrial soil mg/kg	Residential soil mg/kg
Temephos	3383968	2.00E-02 *h*						73 *n*	7.3 *n*	2.7 *n*	2000 *n*	160 *n*
Terbacil	5902512	1.30E-02 *i*						47 *n*	4.7 *n*	1.8 *n*	1300 *n*	100 *n*
Terbufos	13071799	2.50E-05 *h*						0.091 *n*	0.0091 *n*	0.0034 *n*	2.6 *n*	0.2 *n*
Terbutryn	886500	1.00E-03 *i*						3.7 *n*	0.37 *n*	0.14 *n*	100 *n*	7.8 *n*
1,2,4,5-Tetrachlorobenzene	95943	3.00E-04 *i*				***		0.18 *n*	0.11 *n*	0.041 *n*	31 *n*	2.3 *n*
1,1,1,2-Tetrachloroethane	630206	3.00E-02 *i*		2.60E-02 *i*	2.59E-02 *i*	***		0.41 *c*	0.24 *c*	0.12 *c*	110 *c*	25 *c*
1,1,2,2-Tetrachloroethane	630206			2.00E-01 *i*	2.03E-01 *i*	***		0.052 *c*	0.031 *c*	0.016 *c*	14 *c*	3.2 *c*
Tetrachloroethylene (PCE)	127184	1.00E-02 *i*		5.20E-02 *a*	2.03E-03 *a*	***	0.005 *F*	1.1 *c*	3.1 *c*	0.061 *c*	55 *c*	12 *c*
2,3,4,6-Tetrachlorophenol	58902	3.00E-02 *i*						110 *n*	11 *n*	4.1 *n*	3100 *n*	230 *n*
p,a,a,a-Tetrachlorotoluene	5216251			2.00E+01 *h*		***		0.00053 *c*	0.00031 *c*	0.00016 *c*	0.14 *c*	0.032 *c*
Tetrachlorovinphos	961115	3.00E-02 *i*		2.40E-02 *h*				2.8 *c*	0.26 *c*	0.13 *c*	120 *c*	27 *c*
Tetraethyldithiopyrophosphate	3689245	5.00E-04 *i*						1.8 *n*	0.18 *n*	0.068 *n*	51 *n*	3.9 *n*
Thallic oxide	1314325	7.00E-05 *h*						0.26 *n*	0.026 *n*	0.0095 *n*	7.2 *n*	0.55 *n*
Thallium							0.002 *F*					
Thallium acetate	563688	9.00E-05 *i*						0.33 *n*	0.033 *n*	0.012 *n*	9.2 *n*	0.7 *n*
Thallium carbonate	6533739	8.00E-05 *i*						0.29 *n*	0.029 *n*	0.011 *n*	8.2 *n*	0.63 *n*
Thallium chloride	7791120	8.00E-05 *i*						0.29 *n*	0.029 *n*	0.011 *n*	8.2 *n*	0.63 *n*
Thallium nitrate	10102451	9.00E-05 *i*						0.33 *n*	0.033 *n*	0.012 *n*	9.2 *n*	0.7 *n*
Thallium selenite	12039520	9.00E-05 *w*						0.33 *n*	0.033 *n*	0.012 *n*	9.2 *n*	0.7 *n*
Thallium sulfate	7446186	8.00E-05 *i*						0.29 *n*	0.029 *n*	0.011 *n*	8.2 *n*	0.63 *n*
Thiobencarb	28249776	1.00E-02 *i*						37 *n*	3.7 *n*	1.4 *n*	1000 *n*	78 *n*
2-(Thiocyanomethylthio)-benzothiazole	21564170	3.00E-02 *h*						110 *n*	11 *n*	4.1 *n*	3100 *n*	230 *n*
Thiofanox	39196184	3.00E-04 *h*						1.1 *n*	0.11 *n*	0.041 *n*	31 *n*	2.3 *n*
Thiophanate-methyl	23564058	8.00E-02 *i*						290 *n*	29 *n*	11 *n*	8200 *n*	630 *n*
Thiram	137268	5.00E-03 *i*						18 *n*	1.8 *n*	0.68 *n*	510 *n*	39 *n*
Tin and compounds		6.00E-01 *h*						2200 *n*	220 *n*	81 *n*	61000 *n*	4700 *n*
Toluene	108883	2.00E-01 *i*	1.14E-01 *w*			***	1 *F*	75 *n*	42 *n*	27 *n*	20000 *n*	1600 *n*
Toluene-2,4-diamine	95807			3.20E+00 *h*				0.021 *c*	0.002 *c*	0.00099 *c*	0.89 *c*	0.2 *c*
Toluene-2,5-diamine	95705	6.00E-01 *h*						2200 *n*	220 *n*	81 *n*	61000 *n*	4700 *n*
Toluene-2,6-diamine	823405	2.00E-01 *h*						730 *n*	73 *n*	27 *n*	20000 *n*	1600 *n*
p-Toluidine	106490			1.90E-01 *h*				0.35 *c*	0.033 *c*	0.017 *c*	15 *c*	3.4 *c*
Toxaphene	8001352			1.10E+00 *i*	1.12E+00 *i*		0.003 *F*	0.061 *c*	0.0056 *c*	0.0029 *c*	2.6 *c*	0.58 *c*
Tralomethrin	66841256	7.50E-03 *i*						27 *n*	2.7 *n*	1 *n*	770 *n*	59 *n*
Triallate	2303175	1.30E-02 *i*						47 *n*	4.7 *n*	1.8 *n*	1300 *n*	100 *n*
Triasulfuron	82097505	1.00E-02 *i*						37 *n*	3.7 *n*	1.4 *n*	1000 *n*	78 *n*
1,2,4-Tribromobenzene	615543	5.00E-03 *i*				***		3 *n*	1.8 *n*	0.68 *n*	510 *n*	39 *n*
Tributyltin oxide (TBTO)	56359	3.00E-05 *i*						0.11 *n*	0.011 *n*	0.0041 *n*	3.1 *n*	0.23 *n*
2,4,6-Trichloroaniline hydrochloride	33663502			2.90E-02 *h*				2.3 *c*	0.22 *c*	0.11 *c*	99 *c*	22 *c*
2,4,6-Trichloroaniline	634935			3.40E-02 *h*				2 *c*	0.18 *c*	0.093 *c*	84 *c*	19 *c*

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Contaminant	CAS	RfDo mg/kg/d	RfDi mg/kg/d	CPSo kg•d/mg	CPSi kg•d/mg	VOC	MCL mg/L	Tap water µg/L	Ambient air µg/m3	Fish mg/kg	Industrial soil mg/kg	Residential soil mg/kg
1,2,4-Trichlorobenzene	120821	1.00E-02 *i*	2.57E-03 *h*			***	0.07 *F*	1.8 *n*	0.94 *n*	1.4 *n*	1000 *n*	78 *n*
1,1,1-Trichloroethane	71556	9.00E-02 *w*	2.86E-01 *w*			***	0.2 *F*	130 *n*	100 *n*	12 *n*	9200 *n*	700 *n*
1,1,2-Trichloroethane	79005	4.00E-03 *i*		5.70E-02 *i*	5.60E-02 *i*	***	0.005 *F*	0.19 *c*	0.11 *c*	0.055 *c*	50 *c*	11 *c*
Trichloroethylene (TCE)	79016	6.00E-03 *e*		1.10E-02 *w*	6.00E-03 *e*	***	0.005 *F*	1.6 *c*	1 *c*	0.29 *c*	260 *c*	47 *n*
Trichlorofluoromethane	75694	3.00E-01 *i*	2.00E-01 *h*			***		130 *n*	73 *n*	41 *n*	31000 *n*	2300 *n*
2,4,5-Trichlorophenol	95954	1.00E-01 *i*						370 *n*	37 *n*	14 *n*	10000 *n*	780 *n*
2,4,6-Trichlorophenol	88062			1.10E-02 *i*	1.09E-02 *i*			6.1 *c*	0.57 *c*	0.29 *c*	260 *c*	58 *c*
2,4,5-Trichlorophenoxyacetic acid	93765	1.00E-02 *i*					0.05 *F*	37 *n*	3.7 *n*	1.4 *n*	1000 *n*	78 *n*
2-(2,4,5-Trichlorophenoxy)propionic acid	93721	8.00E-03 *i*						29 *n*	2.9 *n*	1.1 *n*	820 *n*	63 *n*
1,1,2-Trichloropropane	598776	5.00E-03 *i*				***		3 *n*	1.8 *n*	0.68 *n*	510 *n*	39 *n*
1,2,3-Trichloropropane	96184	6.00E-03 *i*				***		3.7 *n*	2.2 *n*	0.81 *n*	610 *n*	47 *n*
1,2,3-TCP as carcinogen	96184			2.70E+00 *e*		***		0.0039 *c*	0.0023 *c*	0.0012 *c*	1.1 *c*	0.24 *c*
1,2,3-Trichloropropene	96195	5.00E-03 *h*				***		3 *n*	1.8 *n*	0.68 *n*	510 *n*	39 *n*
1,1,2-Trichloro-1,2,2- trifluoroethane	76131	3.00E+01 *i*	8.57E+00 *h*			***		5900 *n*	3100 *n*	4100 *n*	1000000 *n*	230000 *n*
Tridiphane	58138082	3.00E-03 *i*						11 *n*	1.1 *n*	0.41 *n*	310 *n*	23 *n*
Triethylamine	121448		2.00E-03 *i*					7.3 *n*	0.73 *n*			
Trifluralin	1582098	7.50E-03 *i*		7.70E-03 *i*				8.7 *c*	0.81 *c*	0.41 *c*	370 *c*	59 *n*
1,2,4-Trimethylbenzene	95636	5.00e-04 *e*				***	0.002 *F*	0.3 *n*	0.18 *n*	0.068 *n*	51 *n*	3.9 *n*
1,3,5-Trimethylbenzene	108678	4.00e-04 *e*				***	0.002 *F*	0.24 *n*	0.15 *n*	0.054 *n*	41 *n*	3.1 *n*
Trimethyl phosphate	512561			3.70E-02 *h*				1.8 *c*	0.17 *c*	0.085 *c*	77 *c*	17 *c*
1,3,5-Trinitrobenzene	99354	5.00E-05 *i*						0.18 *n*	0.018 *n*	0.0068 *n*	5.1 *n*	0.39 *n*
Trinitrophenylmethylnitramine	479458	1.00E-02 *h*						37 *n*	3.7 *n*	1.4 *n*	1000 *n*	78 *n*
2,4,6-Trinitrotoluene	118967	5.00E-04 *i*		3.00E-02 *i*				1.8 *n*	0.18 *n*	0.068 *n*	51 *n*	3.9 *n*
Uranium (soluble salts)	7440611	3.00E-03 *i*						11 *n*	1.1 *n*	0.41 *n*	310 *n*	23 *n*
Vanadium	7440622	7.00E-03 *h*						26 *n*	2.6 *n*	0.95 *n*	720 *n*	55 *n*
Vanadium pentoxide	1314621	9.00E-03 *i*						33 *n*	3.3 *n*	1.2 *n*	920 *n*	70 *n*
Vanadium sulfate	36907423	2.00E-02 *h*						73 *n*	7.3 *n*	2.7 *n*	2000 *n*	160 *n*
Vernam	1929777	1.00E-03 *i*						3.7 *n*	0.37 *n*	0.14 *n*	100 *n*	7.8 *n*
Vinclozolin	50471448	2.50E-02 *i*						91 *n*	9.1 *n*	3.4 *n*	2600 *n*	200 *n*
Vinyl acetate	108054	1.00E+00 *h*	5.71E-02 *i*					3700 *n*	21 *n*	140 *n*	100000 *n*	7800 *n*
Vinyl bromide	593602		8.57E-04 *i*			***		0.52 *n*	0.31 *n*			
Vinyl chloride	75014			1.90E+00 *h*	3.00E-01 *h*	***	0.002 *F*	0.019 *c*	0.021 *c*	0.0017 *c*	1.5 *c*	0.34 *c*
Warfarin	81812	3.00E-04 *i*						1.1 *n*	0.11 *n*	0.041 *n*	31 *n*	2.3 *n*
m-Xylene	108323	2.00E+00 *h*	2.00E-01 *w*			***	10 *F*	140 *n*	73 *n*	270 *n*	200000 *n*	16000 *n*
o-Xylene	95476	2.00E+00 *h*	2.00E-01 *w*			***	10 *F*	140 *n*	73 *n*	270 *n*	200000 *n*	16000 *n*
p-Xylene	106423		8.57E-02 *w*			***	10 *F*	52 *n*	31 *n*			
Xylene (mixed)	1330207	2.00E+00 *i*				***	10 *F*	1200 *n*	730 *n*	270 *n*	200000 *n*	16000 *n*
Zinc	7440666	3.00E-01 *i*						1100 *n*	110 *n*	41 *n*	31000 *n*	2300 *n*
Zinc phosp	1314847	3.00E-04 *i*						1.1 *n*	0.11 *n*	0.041 *n*		2.3 *n*

Sources: i=IRIS h=HEAST a=HEAST alt. w=Withdrawn from IRIS or HEAST e=EPA-ECAO o=Other EPA documents *F=final D=draft P=proposed T=tentative | c=carcinogen n=noncarcinogen*

Contaminant	CAS	RfDo mg/kg/d	RfDi mg/kg/d	CPSo kg•d/mg	CPSi kg•d/mg	VOC	MCL mg/L	Tap water µg/L	Ambient air µg/m3	Fish mg/kg	Industrial soil mg/kg	Residential soil mg/kg
Zineb	12122677	5.00E-02 *i*						180 *n*	18 *n*	6.8 *n*	5100 *n*	390 *n*

APPENDIX C

RISK-BASED CONCENTRATION TABLE, FOURTH QUARTER 1994

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Region III
841 Chestnut Street
Philadelphia, Pennsylvania 19107

November 8, 1994

SUBJECT: Risk-Based Concentration Table, Fourth Quarter 1994

FROM: Roy L. Smith, Ph.D., Senior Toxicologist
Technical Support Section (3HW13)

TO: RBC Table mailing list

Attached is the EPA Region III risk-based concentration (RBC) table, which we have distributed quarterly to all interested parties since 1991. If you are not currently on the mailing list, but would like to be, please contact Anna Poulton (phone: 215-597-3179, fax: 215-597-9890) and give her your name, address, and phone and fax numbers. (This is the only information she needs; faxing parts of the table or cover memo is not necessary.)

IMPORTANT MESSAGE: It's once again time to re-register for the RBC table mailing list. We need to hear from you periodically to ensure that you still have an interest in the table, and that we have your correct address. If you have been on the mailing list since before October 1993, and would like to continue receiving the RBC table, please fax your request to re-register (or register for the first time) to Anna Poulton, along with any needed address or phone number changes. You need not respond if you were placed on the mailing list after October 1993, or if you are a Region III staff member. Please don't phone to re-register; we need hard copy to help justify continued funding. Thanks for your cooperation.

The table contains reference doses and carcinogenic potency slopes (obtained from IRIS through October 1, 1994, HEAST through March 1994, the Superfund Health Risk Technical Support Center, and other EPA sources) for nearly 600 chemicals. These toxicity constants have been combined with "standard" exposure scenarios to calculate RBCs - chemical concentrations corresponding to fixed levels of risk (*i.e.*, a hazard quotient of 1, or lifetime cancer risk of 10^{-6}, whichever occurs at a lower concentration) in water, air, fish tissue, and soil.

The Region III toxicologists use the table to screen sites not yet on the NPL, respond rapidly to citizen inquiries, and spot-check formal baseline risk assessments. The background materials provide the complete basis for all the calculations, with the intent of showing users exactly how the RBCs were developed. Simply put, RBCs are risk assessments run in reverse. For a single contaminant in a single medium, under standard default exposure assumptions, the RBC corresponds to the target risk or hazard quotient.

The calculations also have several important limitations. Specifically excluded from consideration are (1) transfers from soil to air and groundwater, and (2) cumulative risk from multiple contaminants or media. Also, the toxicity information in the table has been assembled by hand, and (despite extensive checking and years of use) may contain errors. It's advisable to cross-check before relying on any RfDs or CPSs in the table. If you find any errors, please

send me a note.

Lately, many callers have asked whether the risk-based concentrations can be used as valid no-action levels or cleanup levels, especially for soils.. The answer is a bit complex. First, it is important to realize that the RBC table does not constitute regulation or guidance, and should not be viewed as a substitute for a site-specific risk assessment. For sites where:

1. A single medium is contaminated;

2. A single contaminant contributes nearly all of the health risk;

3. Volatilization or leaching of that contaminant from soil is expected not to be significant;

4. The exposure scenarios used in the RBC table are appropriate for the site;

5. The fixed risk levels used in the RBC table are appropriate for the site; and

6. Risk to ecological receptors is expected not to be significant;

the risk-based concentrations would probably be protective as no-action levels or cleanup goals. However, to the extent that a site deviates from this description, as most do, the RBCs would not necessarily be appropriate.

To summarize, the table should generally not be used to (1) set cleanup or no-action levels at CERCLA or RCRA Corrective Action sites, (2) substitute for EPA guidance for preparing baseline risk assessments, or (3) determine if a waste is hazardous under RCRA.

This issue of the RBC table includes new toxicity constants and media concentrations, which are marked on the table in underlined boldface print.

I get many calls about the RBC table, but I'm often unavailable to answer the phone. Many of you have the same problem, so we play a lot of "phone tag". It's usually easier and more effective to fax me (at 215-597-9890) with your technical questions and concerns, and for me to respond by return fax. Of course, if you don't have access to a fax machine, I will also continue to respond to voice mail messages.

Attachment

Risk-Based Concentration Table
Background Information

General: Separate carcinogenic and non-carcinogenic risk-based concentrations were calculated for each compound for each pathway. The concentration in the table is the lower of the two, rounded to two significant figures. The following terms and values were used in the calculations:

Exposure variables	Value	Name
1-General:		
Carcinogenic potency slope oral (risk per mg/kg/d):	*	CPSo
Carcinogenic potency slope inhaled (risk per mg/kg/d):	*	CPSi
Reference dose oral (mg/kg/d):	*	RfDo
Reference dose inhaled (mg/kg/d):	*	RfDi
Target cancer risk:	1e-06	TR
Target hazard quotient:	1	THQ
Body weight, adult (kg):	70	BWa
Body weight, age 1-6 (kg):	15	BWc
Averaging time carcinogens (d):	25550	ATc
Averaging time non-carcinogens (d):	ED*365	ATn
Inhalation, adult (m3/d):	20	IRAa
Inhalation, child (m3/d):	12	IRAc
Inhalation factor, age-adjusted (m3-y/kg-d):	11.66	IFAadj
Tap water ingestion, adult (L/d):	2	IRWa
Tap water ingestion, age 1-6 (L/d):	1	IRWc
Tap water ingestion factor, age-adjusted (L-y/kg-d):	1.09	IFWadj
Fish ingestion (g/d):	54	IRF
Soil ingestion, adult (mg/d):	100	IRSa
Soil ingestion, age 1-6 (mg/d):	200	IRSc
Soil ingestion factor, age adjusted (mg-y/kg-d):	114.29	IFSadj
2-Residential:		
Exposure frequency (d/y):	350	EFr
Exposure duration, total (y):	30	EDtot

Exposure variables	Value	Name
Exposure duration, age 1-6 (y):	6	EDc
Volatilization factor (L/m3):	0.5	VF
3-Occupational:		
Exposure frequency (d/y):	250	EFo
Exposure duration (y):	25	EDo
* = Contaminant-specific toxicity parameters		

The priority among sources of toxicological constants was as follows: (1) IRIS, (2) HEAST, (3) HEAST alternative method, (4) EPA Superfund Health Risk Technical Support Center, (5) withdrawn from IRIS or HEAST, and (6) other EPA documents. Each source was used only if numbers from higher-priority sources were unavailable. The EPA Superfund Health Risk Technical Support Center, part of the Chemical Mixtures Branch of ECAO-Cincinnati, develops provisional RfDs and CPSs on request for contaminants not in IRIS or HEAST. These provisional values are labeled "e = EPA-ECAO provisional" in the table. It is possible they may be obsolete. If one of the "e" constants is important to a Superfund risk assessment, consider requesting, through a Regional risk assessor, a new provisional value.

Algorithms:

1. Age-adjusted factors: Because contact rates with tap water, ambient air, and residential soil are different for children and adults, carcinogenic risks during the first 30 years of life were calculated using age-adjusted factors. These factors approximated the integrated exposure from birth until age 30 by combining contact rates, body weights, and exposure durations for two age groups - small children and adults. The age-adjusted factor for soil was obtained from RAGS IB; the others were developed by analogy.

a. Air inhalation ($[m^3 \cdot y]/[kg \cdot d]$):

$$IFAadj = \frac{EDc \cdot IRAc}{BWc} + \frac{(EDtot - EDc) \cdot IRAa}{BWa}$$

b. Tap water ingestion ($[L \cdot y]/[kg \cdot d]$):

$$IFWadj = \frac{EDc \cdot IRWc}{BWc} + \frac{(EDtot - EDc) \cdot IRWa}{BWa}$$

c. Soil ingestion ([mg· y]/[kg· d]):

$$IFSadj = \frac{EDc \cdot IRSc}{BWc} + \frac{(EDtot - EDc) \cdot IRSa}{BWa}$$

2. Residential water use (μg/L). Volatilization terms were calculated only for compounds with "****" in the "VOC" column. Compounds having a Henry's Law constant greater than 10^{-5} were considered volatile. The list may be incomplete, but is unlikely to include false positives. The equations and the volatilization factor (VF, above) were obtained from RAGS IB. Oral potency slopes and reference doses were used for both oral and inhaled exposures for volatile compounds lacking inhalation values. Inhaled potency slopes were substituted for unavailable oral potency slopes only for volatile compounds; inhaled RfDs were substituted for unavailable oral RfDs for both volatile and non-volatile compounds.

a. Carcinogens: Calculations were based on combined childhood and adult exposure.

$$\frac{TR \cdot ATc \cdot 1000 \frac{\mu g}{mg}}{EFr \cdot ([VF \cdot IFAadj \cdot CPSi] + [IFWadj \cdot CPSo])}$$

b. Non-carcinogens: Calculations were based on adult exposure.

$$\frac{THQ \cdot BWa \cdot ATn \cdot 1000 \frac{\mu g}{mg}}{EFr \cdot EDtot \cdot \left(\frac{VF \cdot IRAa}{RfDi} + \frac{IRWa}{RfDo}\right)}$$

3. Air (μg/m^3). Oral potency slopes and references were used where inhalation values were not available.

a. Carcinogens: Calculations were based on combined childhood and adult exposure.

$$\frac{TR \cdot ATc \cdot 1000 \frac{\mu g}{mg}}{EFr \cdot IFAadj \cdot CPSi}$$

b. Non-carcinogens: Calculations were based on adult exposure.

$$\frac{THQ \cdot RfDi \cdot BWa \cdot ATn \cdot 1000 \frac{\mu g}{mg}}{EFr \cdot EDtot \cdot IRAa}$$

4. Fish (mg/kg):

a. Carcinogens: Calculations were based on adult exposure.

$$\frac{TR \cdot BWa \cdot ATc}{EFr \cdot EDtot \cdot \frac{IRF}{1000 \frac{g}{kg}} \cdot CPSo}$$

b. Non-carcinogens: Calculations were based on adult exposure.

$$\frac{THQ \cdot RfDo \cdot BWa \cdot ATn}{EFr \cdot EDtot \cdot \frac{IRF}{1000 \frac{g}{kg}}}$$

5. Soil commercial/industrial (mg/kg): The default exposure assumption that only 50% of incidental soil ingestion occurs at work has been omitted. Calculations were based on adult occupational exposure.

a. Carcinogens:

$$\frac{TR \cdot BWa \cdot ATc}{EFo \cdot EDo \cdot \frac{IRSa}{10^6 \frac{mg}{kg}} \cdot CPSo}$$

b. Non-carcinogens:

$$\frac{THQ \cdot RfDo \cdot BWa \cdot ATn}{EFo \cdot EDo \cdot \frac{IRSa}{10^6 \frac{mg}{kg}}}$$

6. Soil residential (mg/kg):

a. Carcinogens: Calculations were based on combined childhood and adult exposure.

$$\frac{TR \cdot ATc}{EFr \cdot \frac{IFSadj}{10^6 \frac{mg}{kg}} \cdot CPSo}$$

b. Non-carcinogens: Calculations were based on childhood exposure only.

$$\frac{THQ \cdot RfDo \cdot BWc \cdot ATn}{EFr \cdot EDc \cdot \frac{IRSc}{10^6 \frac{mg}{kg}}}$$

Sources: i=IRIS h=HEAST a=HEAST alt. w=Withdrawn from IRIS or HEAST e=EPA-ECAO provisional o=Other EPA documents *Basis of RBC: c=carcinogenic effects n=noncarcinogenic effects.*

Contaminant	CAS	RfDo mg/kg/d	RfDi mg/kg/d	CPSo kg-d/mg	CPSi kg-d/mg	VOC	Tap water µg/L	Ambient air µg/m3	Fish mg/kg	Industrial soil mg/kg	Residential soil mg/kg
Acephate	30560191	4.00E-03 i		8.70E-03 i			7.7 o	0.72 o	0.36 o	330 o	73 o
Acetaldehyde	75070		2.57E-03 i		7.70E-03 i		94 n	0.81 o			
Acetochlor	34256821	2.00E-02 i					730 n	73 n	27 n	20000 n	1600 n
Acetone	67641	1.00E-01 i					3700 n	370 n	140 n	100000 n	7800 n
Acetone cyanohydrin	75865	7.00E-02 h	2.86E-03 a				2600 n	10 n	95 n	72000 n	5500 n
Acetonitrile	75078	6.00E-03 i	1.43E-02 a				220 n	52 n	8.1 n	6100 n	470 n
Acetophenone	98862	1.00E-01 i	5.71E-06 w			***	0.042 n	0.021 n	140 n	100000 n	7800 n
Acifluorfen	62476599	1.30E-02 i					470 n	47 n	18 n	13000 n	1000 n
Acrolein	107028	2.00E-02 h	5.71E-06 i				730 n	0.021 n	27 n	20000 n	1600 n
Acrylamide	79061	2.00E-04 i		4.50E+00 i	4.55E+00 i		0.015 c	0.0014 c	0.0007 c	0.64 c	0.14 c
Acrylic acid	79107	5.00E-01 i	1.00E-03 i				18000 n	3.7 n	680 n	510000 n	39000 n
Acrylonitrile	107131	1.00E-03 h	5.71E-04 i	5.40E-01 i	2.38E-01 i		0.12 c	0.026 c	0.0058 c	5.3 c	1.2 c
Alachlor	15972608	1.00E-02 i		8.00E-02 h			0.84 c	0.078 c	0.039 c	36 c	8 c
Alar	1596845	1.50E-01 i					5500 n	550 n	200 n	150000 n	12000 n
Aldicarb	116063	1.00E-03 i					37 n	3.7 n	1.4 n	1000 n	78 n
Aldicarb sulfone	1646884	1.00E-03 i					37 n	3.7 n	1.4 n	1000 n	78 n
Aldrin	309002	3.00E-05 i		1.70E+01 i	1.71E+01 i		0.004 c	0.00037 c	0.00019 c	0.17 c	0.038 c
Ally	74223646	2.50E-01 i					9100 n	910 n	340 n	260000 n	20000 n
Allyl alcohol	107186	5.00E-03 i					180 n	18 n	6.8 n	5100 n	390 n
Allyl chloride	107051	5.00E-02 w	2.86E-04 i				1800 n	1 n	68 n	51000 n	3900 n
Aluminum	7429905	1.00E+00 a					37000 n	3700 n	1400 n	1000000 n	78000 n
Aluminum phosphide	20859738	4.00E-04 i					15 n	1.5 n	0.54 n	410 n	31 n
Amdro	67485294	3.00E-04 i					11 n	1.1 n	0.41 n	310 n	23 n
Ametryn	834128	9.00E-03 i					330 n	33 n	12 n	9200 n	700 n
m-Aminophenol	591275	7.00E-02 h					2600 n	260 n	95 n	72000 n	5500 n
4-Aminopyridine	504245	2.00E-05 h					0.73 n	0.073 n	0.027 n	20 n	1.6 n
Amitraz	33089611	2.50E-03 i					91 n	9.1 n	3.4 n	2600 n	200 n
Ammonia	7664417		2.86E-02 i				1000 n	100 n			
Ammonium sulfamate	7773060	2.00E-01 i					7300 n	730 n	270 n	200000 n	16000 n
Aniline	62533		2.86E-04 i	5.70E-03 i			10 n	1 n	0.55 o	500 o	110 o
Antimony and compounds	7440360	4.00E-04 i					15 n	1.5 n	0.54 n	410 n	31 n
Antimony pentoxide	1314609	5.00E-04 h					18 n	1.8 n	0.68 n	510 n	39 n
Antimony potassium tartrate	304610	9.00E-04 h					33 n	3.3 n	1.2 n	920 n	70 n
Antimony tetroxide	1332316	4.00E-04 h					15 n	1.5 n	0.54 n	410 n	31 n
Antimony trioxide	1309644	4.00E-04 h					15 n	1.5 n	0.54 n	410 n	31 n
Apollo	74115245	1.30E-02 i					470 n	47 n	18 n	13000 n	1000 n
Aramite	140578	5.00E-02 h		2.50E-02 i	2.49E-02 i		2.7 c	0.25 c	0.13 c	110 c	26 c
Arsenic	7440382	3.00E-04 i					11 n	1.1 n	0.41 n	310 n	23 n
Arsenic (as carcinogen)	7440382			1.75E+00 i	1.51E+01 i		0.038 c	0.00041 c	0.0018 c	1.6 c	0.37 c
Arsine	7784421		1.43E-05 i				0.52 n	0.052 n			
Assure	76578148	9.00E-03 i					330 n	33 n	12 n	9200 n	700 n
Asulam	3337711	5.00E-02 i					1800 n	180 n	68 n	51000 n	3900 n

Sources: I=IRIS h=HEAST a=HEAST alt. w=Withdrawn from IRIS or HEAST e=EPA-ECAO provisional o=Other EPA documents *Basis of RBC: c=carcinogenic effects n=noncarcinogenic effects.*

Contaminant	CAS	RfDo mg/kg/d	RfDi mg/kg/d	CPSo kg-d/mg	CPSi kg-d/mg	VOC	Tap water µg/L	Ambient air µg/m3	Fish mg/kg	Industrial soil mg/kg	Residential soil mg/kg
Atrazine	1912249	3.50E-02 *I*		2.22E-01 *h*			0.3 *c*	0.028 *c*	0.014 *c*	13 *c*	2.9 *c*
Avermectin B1	65195553	4.00E-04 *I*					15 *n*	1.5 *n*	0.54 *n*	410 *n*	31 *n*
Azobenzene	103333			1.10E-01 *I*	1.08E-01 *I*		0.61 *c*	0.058 *c*	0.029 *c*	26 *c*	5.8 *c*
Barium and compounds	7440393	7.00E-02 *I*	1.43E-04 *a*				2600 *n*	0.52 *n*	95 *n*	72000 *n*	5500 *n*
Baygon	114261	4.00E-03 *I*					150 *n*	15 *n*	5.4 *n*	4100 *n*	310 *n*
Bayleton	43121439	3.00E-02 *I*					1100 *n*	110 *n*	41 *n*	31000 *n*	2300 *n*
Baythroid	68359375	2.50E-02 *I*					910 *n*	91 *n*	34 *n*	26000 *n*	2000 *n*
Benefin	1861401	3.00E-01 *I*					11000 *n*	1100 *n*	410 *n*	310000 *n*	23000 *n*
Benomyl	17804352	5.00E-02 *I*					1800 *n*	180 *n*	68 *n*	51000 *n*	3900 *n*
Bentazon	25057890	2.50E-03 *I*					91 *n*	9.1 *n*	3.4 *n*	2600 *n*	200 *n*
Benzaldehyde	100527	1.00E-01 *I*				***	610 *n*	370 *n*	140 *n*	100000 *n*	7800 *n*
Benzene	71432		1.71E-03 *e*	2.90E-02 *I*	2.90E-02 *I*	***	0.36 *c*	0.22 *c*	0.11 *c*	99 *c*	22 *c*
Benzenethiol	108985	1.00E-05 *h*					0.37 *n*	0.037 *n*	0.014 *n*	10 *n*	0.78 *n*
Benzidine	92875	3.00E-03 *I*		2.30E+02 *I*	2.35E+02 *I*		0.00029 *c*	0.000027 *c*	0.000014 *c*	0.012 *c*	0.0028 *c*
Benzoic acid	65850	4.00E+00 *I*					150000 *n*	15000 *n*	5400 *n*	1000000 *n*	310000 *n*
Benzotrichloride	98077			1.30E+01 *I*			0.0052 *c*	0.00048 *c*	0.00024 *c*	0.22 *c*	0.049 *c*
Benzyl alcohol	100516	3.00E-01 *h*					11000 *n*	1100 *n*	410 *n*	310000 *n*	23000 *n*
Benzyl chloride	100447			1.70E-01 *I*		***	0.062 *c*	0.037 *c*	0.019 *c*	17 *c*	3.8 *c*
Beryllium and compounds	7440417	5.00E-03 *I*		4.30E+00 *I*	8.40E+00 *I*		0.016 *c*	0.00075 *c*	0.00073 *c*	0.67 *c*	0.15 *c*
Bidrin	141662	1.00E-04 *I*					3.7 *n*	0.37 *n*	0.14 *n*	100 *n*	7.8 *n*
Biphenthrin (Talstar)	82657043	1.50E-02 *I*					550 *n*	55 *n*	20 *n*	15000 *n*	1200 *n*
1,1-Biphenyl	92524	5.00E-02 *I*					1800 *n*	180 *n*	68 *n*	51000 *n*	3900 *n*
Bis(2-chloroisopropyl)ether	39638329	4.00E-02 *I*		7.00E-02 *h*	3.50E-02 *h*	***	0.26 *c*	0.18 *c*	0.045 *c*	41 *c*	9.1 *c*
Bis(chloromethyl)ether	542881			2.20E+02 *I*	2.17E+02 *I*	***	0.000049 *c*	0.000029 *c*	0.000014 *c*	0.013 *c*	0.0029 *c*
Bis(2-chloro-1-methylethyl)ether				7.00E-02 *w*	7.00E-02 *w*		0.96 *c*	0.089 *c*	0.045 *c*	41 *c*	9.1 *c*
Bis(2-ethylhexyl)phthalate (DEHP)	117817	2.00E-02 *I*		1.40E-02 *I*			4.8 *c*	0.45 *c*	0.23 *c*	200 *c*	46 *c*
Bis(chloroethyl)ether	111444			1.10E+00 *I*	1.16E+00 *I*	***	0.0092 *c*	0.0054 *c*	0.0029 *c*	2.6 *c*	0.58 *c*
Bisphenol A	80057	5.00E-02 *I*					1800 *n*	180 *n*	68 *n*	51000 *n*	3900 *n*
Boron (and borates)	7440428	9.00E-02 *I*	5.71E-03 *h*				3300 *n*	21 *n*	120 *n*	92000 *n*	7000 *n*
Boron trifluoride	7637072		2.00E-04 *h*				7.3 *n*	0.73 *n*			
Bromodichloromethane	75274	2.00E-02 *I*		6.20E-02 *I*		***	0.17 *c*	0.1 *c*	0.051 *c*	46 *c*	10 *c*
Bromoethene	593602				1.10E-01 *h*	***	0.096 *c*	0.057 *c*			
Bromoform (tribromomethane)	75252	2.00E-02 *I*		7.90E-03 *I*	3.85E-03 *I*	***	2.4 *c*	1.6 *c*	0.4 *c*	360 *c*	81 *c*
Bromomethane	74839	1.40E-03 *I*	1.43E-03 *I*			***	8.7 *n*	5.2 *n*	1.9 *n*	1400 *n*	110 *n*
4-Bromophenyl phenyl ether	101553	5.80E-02 *o*					2100 *n*	210 *n*	78 *n*	59000 *n*	4500 *n*
Bromophos	2104963	5.00E-03 *h*					180 *n*	18 *n*	6.8 *n*	5100 *n*	390 *n*
Bromoxynil	1689845	2.00E-02 *I*					730 *n*	73 *n*	27 *n*	20000 *n*	1600 *n*
Bromoxynil octanoate	1689992	2.00E-02 *I*					730 *n*	73 *n*	27 *n*	20000 *n*	1600 *n*
1,3-Butadiene	106990				9.80E-01 *I*	***	0.011 *c*	0.0064 *c*			
1-Butanol	71363	1.00E-01 *I*					3700 *n*	370 *n*	140 *n*	100000 *n*	7800 *n*
Butyl benzyl phthalate	85687	2.00E-01 *I*					7300 *n*	730 *n*	270 *n*	200000 *n*	16000 *n*
Butylate	2008415	5.00E-02 *I*					1800 *n*	180 *n*	68 *n*	51	3900 *n*

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Contaminant	CAS	RfDo mg/kg/d	RfDi mg/kg/d	CPSo kg·d/mg	CPSi kg·d/mg	V O C	Tap water µg/L	Ambient air µg/m3	Fish mg/kg	Industrial soil mg/kg	Residential soil mg/kg
sec-Butylbenzene	135988	1.00E-02 e				***	61 n	37 n	14 n	10000 n	780 n
tert-Butylbenzene	104518	1.00E-02 e				***	61 n	37 n	14 n	10000 n	780 n
Butylphthalyl butylglycolate	85701	1.00E+00 i					37000 n	3700 n	1400 n	1000000 n	78000 n
Cacodylic acid	75605	3.00E-03 h					110 n	11 n	4.1 n	3100 n	230 n
Cadmium and compounds	7440439	5.00E-04 i			6.30E+00 i		18 n	0.00099 c	0.68 n	510 n	39 n
Caprolactam	105602	5.00E-01 i					18000 n	1800 n	680 n	510000 n	39000 n
Captafol	2425061	2.00E-03 i		8.60E-03 h			7.8 c	0.73 c	0.37 c	330 c	74 c
Captan	133062	1.30E-01 i		3.50E-03 h			19 c	1.8 c	0.9 c	820 c	180 c
Carbaryl	63252	1.00E-01 i					3700 n	370 n	140 n	100000 n	7800 n
Carbazole	86748			2.00E-02 h			3.4 c	0.31 c	0.16 c	140 c	32 c
Carbofuran	1563662	5.00E-03 i					180 n	18 n	6.8 n	5100 n	390 n
Carbon disulfide	75150	1.00E-01 i	2.86E-03 h			***	21 n	10 n	140 n	100000 n	7800 n
Carbon tetrachloride	56235	7.00E-04 i	5.71E-04 e	1.30E-01 i	5.25E-02 i	***	0.16 c	0.12 c	0.024 c	22 c	4.9 c
Carbosulfan	55285148	1.00E-02 i					370 n	37 n	14 n	10000 n	780 n
Carboxin	5234684	1.00E-01 i					3700 n	370 n	140 n	100000 n	7800 n
Chloral	75876	2.00E-03 i					73 n	7.3 n	2.7 n	2000 n	160 n
Chloramben	133904	1.50E-02 i					550 n	55 n	20 n	15000 n	1200 n
Chloranil	118752			4.03E-01 h			0.17 c	0.016 c	0.0078 c	7.1 c	1.6 c
Chlordane	57749	6.00E-05 i		1.30E+00 i	1.29E+00 i		0.052 c	0.0049 c	0.0024 c	2.2 c	0.49 c
Chlorimuron-ethyl	90982324	2.00E-02 i					730 n	73 n	27 n	20000 n	1600 n
Chlorine	7782505	1.00E-01 i					3700 n	370 n	140 n	100000 n	7800 n
Chlorine dioxide	10049044		5.71E-05 i				2.1 n	0.21 n			
Chloroacetaldehyde	107200	6.90E-03 o					250 n	25 n	9.3 n	7100 n	540 n
Chloroacetic acid	79118	2.00E-03 h					73 n	7.3 n	2.7 n	2000 n	160 n
2-Chloroacetophenone	532274		8.57E-06 i				0.31 n	0.031 n			
4-Chloroaniline	106478	4.00E-03 i					150 n	15 n	5.4 n	4100 n	310 n
Chlorobenzene	108907	2.00E-02 i	5.71E-03 e			***	39 n	21 n	27 n	20000 n	1600 n
Chlorobenzilate	510156	2.00E-02 i		2.70E-01 h	2.70E-01 h		0.25 c	0.023 c	0.012 c	11 c	2.4 c
p-Chlorobenzoic acid	74113	2.00E-01 h					7300 n	730 n	270 n	200000 n	16000 n
4-Chlorobenzotrifluoride	98566	2.00E-02 h					730 n	73 n	27 n	20000 n	1600 n
2-Chloro-1,3-butadiene	126998	2.00E-02 e	2.00E-03 h			***	14 n	7.3 n	27 n	20000 n	1600 n
1-Chlorobutane	109693	4.00E-01 h				***	2400 n	1500 n	540 n	410000 n	31000 n
Chlorodifluoromethane	75456		1.43E+01 i			***	87000 n	52000 n			
Chloroethane	75003	4.00E-01 e	2.86E+00 i			***	8600 n	10000 n	540 n	410000 n	31000 n
2-Chloroethyl vinyl ether	110758	2.50E-02 o				***	150 n	91 n	34 n	26000 n	2000 n
Chloroform	67663	1.00E-02 i		6.10E-03 i	8.05E-02 i	***	0.15 c	0.078 c	0.52 c	470 c	100 c
Chloromethane	74873			1.30E-02 h	6.30E-03 h	***	1.4 c	0.99 c	0.24 c	220 c	49 c
4-Chloro-2,2-methylaniline hydrochloride	3165933			4.60E-01 h			0.15 c	0.014 c	0.0069 c	6.2 c	1.4 c
4-Chloro-2-methylaniline	95692			5.80E-01 h			0.12 c	0.011 c	0.0054 c	4.9 c	1.1 c
beta-Chloronaphthalene	91587	8.00E-02 i					2900 n	290 n	110 n	82000 n	6300 n
o-Chloronitrobenzene	88733			2.50E-02 h		***	0.42 c	0.25 c	0.13 c	110 c	26 c
p-Chloronitrobenzene	100005			1.80E-02 h		***	0.59 c	0.35 c	0.18 c	160 c	35 c

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Contaminant	CAS	RfDo mg/kg/d	RfDi mg/kg/d	CPSo kg·d/mg	CPSi kg·d/mg	V O C	Tap water µg/L	Ambient air µg/m3	Fish mg/kg	Industrial soil mg/kg	Residential soil mg/kg
2-Chlorophenol	95578	5.00E-03 *I*					180 *n*	18 *n*	6.8 *n*	5100 *n*	390 *n*
2-Chloropropane	75296		2.86E-02 *h*			•••	170 *n*	100 *n*			
Chlorothalonil	1897456	1.50E-02 *I*		1.10E-02 *h*			6.1 *c*	0.57 *c*	0.29 *c*	260 *c*	58 *c*
o-Chlorotoluene	95498	2.00E-02 *I*				•••	120 *n*	73 *n*	27 *n*	20000 *n*	1600 *n*
Chlorpropham	101213	2.00E-01 *I*					7300 *n*	730 *n*	270 *n*	200000 *n*	16000 *n*
Chlorpyrifos	2921882	3.00E-03 *I*					110 *n*	11 *n*	4.1 *n*	3100 *n*	230 *n*
Chlorpyrifos-methyl	5598130	1.00E-02 *h*					370 *n*	37 *n*	14 *n*	10000 *n*	780 *n*
Chlorsulfuron	64902723	5.00E-02 *I*					1800 *n*	180 *n*	68 *n*	51000 *n*	3900 *n*
Chlorthiophos	60238564	8.00E-04 *h*					29 *n*	2.9 *n*	1.1 *n*	820 *n*	63 *n*
Chromium III and compounds	16065831	1.00E+00 *I*	5.71E-07 *w*				37000 *n*	0.0021 *n*	1400 *n*	1000000 *n*	78000 *n*
Chromium VI and compounds	7440473	5.00E-03 *I*			4.20E+01 *I*		180 *n*	0.00015 *c*	6.8 *n*	5100 *n*	390 *n*
Coal tar	8001589				2.20E+00 *w*			0.0028 *c*			
Cobalt	7440484	6.00E-02 •					2200 *n*	220 *n*	81 *n*	61000 *n*	4700 *n*
Coke Oven Emissions	8007452				2.17E+00 *I*			0.0029 *c*			
Copper and compounds	7440508	3.71E-02 *h*					1400 *n*	140 *n*	50 *n*	38000 *n*	2900 *n*
Crotonaldehyde	123739	1.00E-02 *w*		1.90E+00 *h*	1.90E+00 *w*		0.035 *c*	0.0033 *c*	0.0017 *c*	1.5 *c*	0.34 *c*
Cumene	98828	4.00E-02 *I*	2.57E-03 *h*				1500 *n*	9.4 *n*	54 *n*	41000 *n*	3100 *n*
Cyanides:											
Barium cyanide	542621	1.00E-01 *w*					3700 *n*	370 *n*	140 *n*	100000 *n*	7800 *n*
Calcium cyanide	592018	4.00E-02 *I*					1500 *n*	150 *n*	54 *n*	41000 *n*	3100 *n*
Copper cyanide	544923	5.00E-03 *I*					180 *n*	18 *n*	6.8 *n*	5100 *n*	390 *n*
Cyanazine	21725462	2.00E-03 *h*		8.40E-01 *h*			0.08 *c*	0.0075 *c*	0.0038 *c*	3.4 *c*	0.76 *c*
Cyanogen	460195	4.00E-02 *I*					1500 *n*	150 *n*	54 *n*	41000 *n*	3100 *n*
Cyanogen bromide	506683	9.00E-02 *I*					3300 *n*	330 *n*	120 *n*	92000 *n*	7000 *n*
Cyanogen chloride	506774	5.00E-02 *I*					1800 *n*	180 *n*	68 *n*	51000 *n*	3900 *n*
Free cyanide	57125	2.00E-02 *I*					730 *n*	73 *n*	27 *n*	20000 *n*	1600 *n*
Hydrogen cyanide	74908	2.00E-02 *I*	8.57E-04 *I*				730 *n*	3.1 *n*	27 *n*	20000 *n*	1600 *n*
Potassium cyanide	151508	5.00E-02 *I*					1800 *n*	180 *n*	68 *n*	51000 *n*	3900 *n*
Potassium silver cyanide	506616	2.00E-01 *I*					7300 *n*	730 *n*	270 *n*	200000 *n*	16000 *n*
Silver cyanide	506649	1.00E-01 *I*					3700 *n*	370 *n*	140 *n*	100000 *n*	7800 *n*
Sodium cyanide	143339	4.00E-02 *I*					1500 *n*	150 *n*	54 *n*	41000 *n*	3100 *n*
Zinc cyanide	557211	5.00E-02 *I*					1800 *n*	180 *n*	68 *n*	51000 *n*	3900 *n*
Cyclohexanone	108941	5.00E+00 *I*				•••	30000 *n*	18000 *n*	6800 *n*	1000000 *n*	390000 *n*
Cyclohexlamine	108918	2.00E-01 *I*					7300 *n*	730 *n*	270 *n*	200000 *n*	16000 *n*
Cyhalothrin/Karate	68085858	5.00E-03 *I*					180 *n*	18 *n*	6.8 *n*	5100 *n*	390 *n*
Cypermethrin	52315078	1.00E-02 *I*					370 *n*	37 *n*	14 *n*	10000 *n*	780 *n*
Cyromazine	66215278	7.50E-03 *I*					270 *n*	27 *n*	10 *n*	7700 *n*	590 *n*
Dacthal	1861321	1.00E-02 *I*					370 *n*	37 *n*	14 *n*	10000 *n*	780 *n*
Dalapon	75990	3.00E-02 *I*					1100 *n*	110 *n*	41 *n*	31000 *n*	2300 *n*
Danitol	39515418	2.50E-02 *I*					910 *n*	91 *n*	34 *n*	26000 *n*	2000 *n*
DDD	72548			2.40E-01 *I*			0.28 *c*	0.026 *c*	0.013 *c*	12 *c*	2.7 *c*
DDE	72559			3.40E-01 *I*			0.2 *c*	0.018 *c*	0.0093 *c*		1.9 *c*

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Contaminant	CAS	RfDo mg/kg/d	RfDi mg/kg/d	CPSo kg·d/mg	CPSi kg·d/mg	VOC	Tap water µg/L	Ambient air µg/m3	Fish mg/kg	Industrial soil mg/kg	Residential soil mg/kg
DDT	50293	5.00E-04 i		3.40E-01 i	3.40E-01 i		0.2 c	0.018 c	0.0093 c	8.4 c	1.9 c
Decabromodiphenyl ether	1163195	1.00E-02 i				•••	61 n	37 n	14 n	10000 n	780 n
Demeton	8065483	4.00E-05 i					1.5 n	0.15 n	0.054 n	41 n	3.1 n
Diallate	2303164			6.10E-02 h		•••	0.17 c	0.1 c	0.052 c	47 c	10 c
Diazinon	333415	9.00E-04 h					33 n	3.3 n	1.2 n	920 n	70 n
Dibenzofuran	132649	4.00E-03 a					150 n	15 n	5.4 n	4100 n	310 n
1,4-Dibromobenzene	106376	1.00E-02 i				•••	61 n	37 n	14 n	10000 n	780 n
Dibromochloromethane	124481	2.00E-02 i		8.40E-02 i		•••	0.13 c	0.075 c	0.038 c	34 c	7.6 c
1,2-Dibromo-3-chloropropane	96128		5.71E-05 i	1.40E+00 h	2.42E-03 h	•••	0.048 c	0.21 n	0.0023 c	2 c	0.46 c
1,2-Dibromoethane	106934		5.71E-05 h	8.50E+01 i	7.70E-01 i	•••	0.00075 c	0.0081 c	0.000037 c	0.034 c	0.0075 c
Dibutyl phthalate	84742	1.00E-01 i					3700 n	370 n	140 n	100000 n	7800 n
Dicamba	1918009	3.00E-02 i					1100 n	110 n	41 n	31000 n	2300 n
1,2-Dichlorobenzene	95501	9.00E-02 i	5.71E-02 a			•••	370 n	210 n	120 n	92000 n	7000 n
1,3-Dichlorobenzene	541731	8.90E-02 o				•••	540 n	320 n	120 n	91000 n	7000 n
1,4-Dichlorobenzene	106467		2.29E-01 i	2.40E-02 h		•••	0.44 c	0.26 c	0.13 c	120 c	27 c
3,3'-Dichlorobenzidine	91941			4.50E-01 i			0.15 c	0.014 c	0.007 c	6.4 c	1.4 c
1,4-Dichloro-2-butene	764410				9.30E+00 h	•••	0.0011 c	0.00067 c			
Dichlorodifluoromethane	75718	2.00E-01 i	5.71E-02 a			•••	390 n	210 n	270 n	200000 n	16000 n
1,1-Dichloroethane	75343	1.00E-01 h	1.43E-01 a			•••	810 n	520 n	140 n	100000 n	7800 n
1,2-Dichloroethane (EDC)	107062		2.86E-03 a	9.10E-02 i	9.10E-02 i	•••	0.12 c	0.069 c	0.035 c	31 c	7 c
1,1-Dichloroethylene	75354	9.00E-03 i		6.00E-01 i	1.75E-01 i	•••	0.044 c	0.036 c	0.0053 c	4.8 c	1.1 c
1,2-Dichloroethylene (cis)	156592	1.00E-02 h				•••	61 n	37 n	14 n	10000 n	780 n
1,2-Dichloroethylene (trans)	156605	2.00E-02 i				•••	120 n	73 n	27 n	20000 n	1600 n
1,2-Dichloroethylene (mixture)	540590	9.00E-03 h				•••	55 n	33 n	12 n	9200 n	700 n
2,4-Dichlorophenol	120832	3.00E-03 i					110 n	11 n	4.1 n	3100 n	230 n
2,4-Dichlorophenoxyacetic Acid (2,4-D)	94757	1.00E-02 i				•••	61 n	37 n	14 n	10000 n	780 n
4-(2,4-Dichlorophenoxy)butyric Acid	94826	8.00E-03 i					290 n	29 n	11 n	8200 n	630 n
1,2-Dichloropropane	78875		1.14E-03 i	6.80E-02 h		•••	0.16 c	0.092 c	0.046 c	42 c	9.4 c
2,3-Dichloropropanol	616239	3.00E-03 i					110 n	11 n	4.1 n	3100 n	230 n
1,3-Dichloropropene	542756	3.00E-04 i	5.71E-03 i	1.75E-01 h	1.30E-01 h	•••	0.077 c	0.048 c	0.018 c	16 c	3.7 c
Dichlorvos	62737	5.00E-04 i	1.43E-04 i	2.90E-01 i			0.23 c	0.022 c	0.011 c	9.9 c	2.2 c
Dicofol	115322			4.40E-01 w			0.15 c	0.014 c	0.0072 c	6.5 c	1.5 c
Dicyclopentadiene	77736	3.00E-02 h	5.71E-05 a			•••	0.42 n	0.21 n	41 n	31000 n	2300 n
Dieldrin	60571	5.00E-05 i		1.60E+01 i	1.61E+01 i		0.0042 c	0.00039 c	0.0002 c	0.18 c	0.04 c
Diesel emissions			1.43E-03 i				52 n	5.2 n			
Diethyl phthalate	84662	8.00E-01 i					29000 n	2900 n	1100 n	820000 n	63000 n
Diethylene glycol, monobutyl ether	112345		5.71E-03 h				210 n	21 n			
Diethylene glycol, monoethyl ether	111900	2.00E+00 h					73000 n	7300 n	2700 n	1000000 n	160000 n
Diethylformamide	617845	1.10E-02 h					400 n	40 n	15 n	11000 n	860 n
Di(2-ethylhexyl)adipate	103231	6.00E-01 i		1.20E-03 i			56 c	5.2 c	2.6 c	2400 c	530 c
Diethylstilbestrol	56531			4.70E+03 h			0.000014 c	1.30E-06 c	6.70E-07 c	0.00061 c	0.00014 c
Difenzoquat (Avenge)	43222486	8.00E-02 i					2900 n	290 n	110 n	82000 n	6300 n

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Diflubenzuron	35367385	2.00E-02 *I*					730 *n*	73 *n*	27 *n*	20000 *n*	1600 *n*
1,1-Difluoroethane	75376		1.14E+01 *I*			***	69000 *n*	42000 *n*			
Diisopropyl methylphosphonate (DIMP)	1445756	8.00E-02 *I*					2900 *n*	290 *n*	110 *n*	82000 *n*	6300 *n*
Dimethipin	55290647	2.00E-02 *I*					730 *n*	73 *n*	27 *n*	20000 *n*	1600 *n*
Dimethoate	60515	2.00E-04 *I*					7.3 *n*	0.73 *n*	0.27 *n*	200 *n*	16 *n*
3,3'-Dimethoxybenzidine	119904			1.40E-02 *h*			4.8 *c*	0.45 *c*	0.23 *c*	200 *c*	46 *c*
Dimethyl phthalate	131113	1.00E+01 *h*					370000 *n*	37000 *n*	14000 *n*	1000000 *n*	780000 *n*
Dimethyl terephthalate	120616	1.00E-01 *I*					3700 *n*	370 *n*	140 *n*	100000 *n*	7800 *n*
Dimethylamine	124403		5.71E-06 *w*				0.21 *n*	0.021 *n*			
2,4-Dimethylaniline hydrochloride	21436964			5.80E-01 *h*			0.12 *c*	0.011 *c*	0.0054 *c*	4.9 *c*	1.1 *c*
2,4-Dimethylaniline	95681			7.50E-01 *h*			0.09 *c*	0.0083 *c*	0.0042 *c*	3.8 *c*	0.85 *c*
N-N-Dimethylaniline	121697	2.00E-03 *I*					73 *n*	7.3 *n*	2.7 *n*	2000 *n*	160 *n*
3,3'-Dimethylbenzidine	119937			9.20E+00 *h*			0.0073 *c*	0.00068 *c*	0.00034 *c*	0.31 *c*	0.069 *c*
N,N-Dimethylformamide	68122	1.00E-01 *h*	8.57E-03 *I*				3700 *n*	31 *n*	140 *n*	100000 *n*	7800 *n*
1,1-Dimethylhydrazine	57147			2.60E+00 *w*	3.50E+00 *w*		0.026 *c*	0.0018 *c*	0.0012 *c*	1.1 *c*	0.25 *c*
1,2-Dimethylhydrazine	540738			3.70E+01 *w*	3.70E+01 *w*		0.0018 *c*	0.00017 *c*	0.000085 *c*	0.077 *c*	0.017 *c*
2,4-Dimethylphenol	105679	2.00E-02 *I*					730 *n*	73 *n*	27 *n*	20000 *n*	1600 *n*
2,6-Dimethylphenol	576261	6.00E-04 *I*					22 *n*	2.2 *n*	0.81 *n*	610 *n*	47 *n*
3,4-Dimethylphenol	95658	1.00E-03 *I*					37 *n*	3.7 *n*	1.4 *n*	1000 *n*	78 *n*
1,2-Dinitrobenzene	528290	4.00E-04 *h*					15 *n*	1.5 *n*	0.54 *n*	410 *n*	31 *n*
1,3-Dinitrobenzene	99650	1.00E-04 *I*					3.7 *n*	0.37 *n*	0.14 *n*	100 *n*	7.8 *n*
1,4-Dinitrobenzene	100254	4.00E-04 *h*					15 *n*	1.5 *n*	0.54 *n*	410 *n*	31 *n*
4,6-Dinitro-o-cyclohexyl phenol	131895	2.00E-03 *I*					73 *n*	7.3 *n*	2.7 *n*	2000 *n*	160 *n*
2,4-Dinitrophenol	51285	2.00E-03 *I*					73 *n*	7.3 *n*	2.7 *n*	2000 *n*	160 *n*
Dinitrotoluene mixture				6.80E-01 *I*			0.099 *c*	0.0092 *c*	0.0046 *c*	4.2 *c*	0.94 *c*
2,4-Dinitrotoluene	121142	2.00E-03 *I*					73 *n*	7.3 *n*	2.7 *n*	2000 *n*	160 *n*
2,6-Dinitrotoluene	606202	1.00E-03 *h*					37 *n*	3.7 *n*	1.4 *n*	1000 *n*	78 *n*
Dinoseb	88857	1.00E-03 *I*					37 *n*	3.7 *n*	1.4 *n*	1000 *n*	78 *n*
di-n-Octyl phthalate	117840	2.00E-02 *h*					730 *n*	73 *n*	27 *n*	20000 *n*	1600 *n*
1,4-Dioxane	123911			1.10E-02 *I*			6.1 *c*	0.57 *c*	0.29 *c*	260 *c*	58 *c*
Diphenamid	957517	3.00E-02 *I*					1100 *n*	110 *n*	41 *n*	31000 *n*	2300 *n*
Diphenylamine	122394	2.50E-02 *I*					910 *n*	91 *n*	34 *n*	26000 *n*	2000 *n*
1,2-Diphenylhydrazine	122667			8.00E-01 *I*	7.70E-01 *I*		0.084 *c*	0.0081 *c*	0.0039 *c*	3.6 *c*	0.8 *c*
Diquat	85007	2.20E-03 *I*					80 *n*	8 *n*	3 *n*	2200 *n*	170 *n*
Direct black 38	1937377			8.60E+00 *h*			0.0078 *c*	0.00073 *c*	0.00037 *c*	0.33 *c*	0.074 *c*
Direct blue 6	2602462			8.10E+00 *h*			0.0083 *c*	0.00077 *c*	0.00039 *c*	0.35 *c*	0.079 *c*
Direct brown 95	16071866			9.30E+00 *h*			0.0072 *c*	0.00067 *c*	0.00034 *c*	0.31 *c*	0.069 *c*
Disulfoton	298044	4.00E-05 *I*					1.5 *n*	0.15 *n*	0.054 *n*	41 *n*	3.1 *n*
1,4-Dithiane	505293	1.00E-02 *I*					370 *n*	37 *n*	14 *n*	10000 *n*	780 *n*
Diuron	330541	2.00E-03 *I*					73 *n*	7.3 *n*	2.7 *n*	2000 *n*	160 *n*
Dodine	2439103	4.00E-03 *I*					150 *n*	15 *n*	5.4 *n*	4100 *n*	310 *n*
Endosulfan	115297	6.00E-03 *I*					220 *n*	22 *n*	8.1 *n*	6100 *n*	470 *n*

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Contaminant	CAS	RfDo mg/kg/d	RfDi mg/kg/d	CPSo kg·d/mg	CPSi kg·d/mg	VOC	Tap water µg/L	Ambient air µg/m3	Fish mg/kg	Industrial soil mg/kg	Residential soil mg/kg
Endothall	145733	2.00E-02 i					730 n	73 n	27 n	20000 n	1600 n
Endrin	72208	3.00E-04 i					11 n	1.1 n	0.41 n	310 n	23 n
Epichlorohydrin	106898	2.00E-03 h	2.86E-04 i	9.90E-03 i	4.20E-03 i		6.8 c	1 n	0.32 c	290 c	65 c
1,2-Epoxybutane	106887		5.71E-03 i				210 n	21 n			
Ethephon (2-chloroethyl phosphonic acid)	16672870	5.00E-03 i					180 n	18 n	6.8 n	5100 n	390 n
Ethion	563122	5.00E-04 i					18 n	1.8 n	0.68 n	510 n	39 n
2-Ethoxyethanol acetate	111159	3.00E-01 a					11000 n	1100 n	410 n	310000 n	23000 n
2-Ethoxyethanol	110805	4.00E-01 h	5.71E-02 i				15000 n	210 n	540 n	410000 n	31000 n
Ethyl acrylate	140885			4.80E-02 h			1.4 c	0.13 c	0.066 c	60 c	13 c
EPTC (S-Ethyl dipropylthiocarbamate)	759944	2.50E-02 i					910 n	91 n	34 n	26000 n	2000 n
Ethyl ether	60297	2.00E-01 i				***	1200 n	730 n	270 n	200000 n	16000 n
Ethyl methacrylate	97632	9.00E-02 h					3300 n	330 n	120 n	92000 n	7000 n
Ethyl acetate	141786	9.00E-01 i					33000 n	3300 n	1200 n	920000 n	70000 n
Ethylbenzene	100414	1.00E-01 i	2.86E-01 i			***	1300 n	1000 n	140 n	100000 n	7800 n
Ethylene cyanohydrin	109784	3.00E-01 h					11000 n	1100 n	410 n	310000 n	23000 n
Ethylene diamine	107153	2.00E-02 h					730 n	73 n	27 n	20000 n	1600 n
Ethylene glycol	107211	2.00E+00 i					73000 n	7300 n	2700 n	1000000 n	160000 n
Ethylene glycol, monobutyl ether	111762		5.71E-03 h				210 n	21 n			
Ethylene oxide	75218			1.02E+00 h	3.50E-01 h		0.066 c	0.018 c	0.0031 c	2.8 c	0.63 c
Ethylene thiourea (ETU)	96457	8.00E-05 i		1.19E-01 h			0.57 c	0.053 c	0.027 c	24 c	5.4 c
Ethyl p-nitrophenyl phenylphosphorothioate	2104645	1.00E-05 i					0.37 n	0.037 n	0.014 n	10 n	0.78 n
Ethylnitrosourea	759739			1.40E+02 w			0.00048 c	0.000045 c	0.000023 c	0.02 c	0.0046 c
Ethylphthalyl ethyl glycolate	84720	3.00E+00 i					110000 n	11000 n	4100 n	1000000 n	230000 n
Express	10120	8.00E-03 i					290 n	29 n	11 n	8200 n	630 n
Fenamiphos	22224926	2.50E-04 i					9.1 n	0.91 n	0.34 n	260 n	20 n
Fluometuron	2164172	1.30E-02 i					470 n	47 n	18 n	13000 n	1000 n
Fluoride	7782414	6.00E-02 i					2200 n	220 n	81 n	61000 n	4700 n
Fluoridone	59756604	8.00E-02 i					2900 n	290 n	110 n	82000 n	6300 n
Flurprimidol	56425913	2.00E-02 i					730 n	73 n	27 n	20000 n	1600 n
Flutolanil	66332965	6.00E-02 i					2200 n	220 n	81 n	61000 n	4700 n
Fluvalinate	69409945	1.00E-02 i					370 n	37 n	14 n	10000 n	780 n
Folpet	133073	1.00E-01 i		3.50E-03 i			19 c	1.8 c	0.9 c	820 c	180 c
Fomesafen	72178020			1.90E-01 i			0.35 c	0.033 c	0.017 c	15 c	3.4 c
Fonofos	944229	2.00E-03 i					73 n	7.3 n	2.7 n	2000 n	160 n
Formaldehyde	50000	2.00E-01 i			4.55E-02 i		7300 n	0.14 c	270 n	200000 n	16000 n
Formic Acid	64186	2.00E+00 h					73000 n	7300 n	2700 n	1000000 n	160000 n
Fosetyl-al	39148248	3.00E+00 i					110000 n	11000 n	4100 n	1000000 n	230000 n
Furan	110009	1.00E-03 i					37 n	3.7 n	1.4 n	1000 n	78 n
Furazolidone	67458			3.80E+00 h			0.018 c	0.0016 c	0.00083 c	0.75 c	0.17 c
Furfural	98011	3.00E-03 i	1.43E-02 a				110 n	52 n	4.1 n	3100 n	230 n
Furium	531828			5.00E+01 h			0.0013 c	0.00013 c	0.000063 c	0.057 c	0.013 c
Furmecyclox	60568050			3.00E-02 i			2.2 c	0.21 c	0.11 c	95 c	21 c

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Glufosinate-ammonium	77182822	4.00E-04 i					15 n	1.5 n	0.54 n	410 n	31 n
Glycidaldehyde	765344	4.00E-04 i	2.86E-04 h				15 n	1 n	0.54 n	410 n	31 n
Glyphosate	1071836	1.00E-01 i					3700 n	370 n	140 n	100000 n	7800 n
Haloxyfop-methyl	69806402	5.00E-05 i					1.8 n	0.18 n	0.068 n	51 n	3.9 n
Harmony	79277273	1.30E-02 i					470 n	47 n	18 n	13000 n	1000 n
HCH (alpha)	319846			6.30E+00 i	6.30E+00 i		0.011 c	0.00099 c	0.0005 c	0.45 c	0.1 c
HCH (beta)	319857			1.80E+00 i	1.80E+00 i		0.037 c	0.0035 c	0.0018 c	1.6 c	0.35 c
HCH (gamma) Lindane	58899	3.00E-04 i		1.30E+00 h			0.052 c	0.0048 c	0.0024 c	2.2 c	0.49 c
HCH-technical	608731			1.80E+00 i	1.79E+00 i		0.037 c	0.0035 c	0.0018 c	1.6 c	0.35 c
Heptachlor	76448	5.00E-04 i		4.50E+00 i	4.55E+00 i	***	0.0023 c	0.0014 c	0.0007 c	0.64 c	0.14 c
Heptachlor epoxide	1024573	1.30E-05 i		9.10E+00 i	9.10E+00 i	***	0.0012 c	0.00069 c	0.00035 c	0.31 c	0.07 c
Hexabromobenzene	87821	2.00E-03 i				***	12 n	7.3 n	2.7 n	2000 n	160 n
Hexachlorobenzene	118741	8.00E-04 i		1.60E+00 i	1.61E+00 i	***	0.0066 c	0.0039 c	0.002 c	1.8 c	0.4 c
Hexachlorobutadiene	87683	2.00E-04 h		7.80E-02 i	7.70E-02 i	***	0.14 c	0.081 c	0.04 c	37 c	8.2 c
Hexachlorocyclopentadiene	77474	7.00E-03 i	2.00E-05 h			***	0.15 n	0.073 n	9.5 n	7200 n	550 n
Hexachlorodibenzo-p-dioxin mixture	19408743			6.20E+03 i	4.55E+03 i		0.000011 c	1.40E-06 c	5.10E-07 c	0.00046 c	0.0001 c
Hexachloroethane	67721	1.00E-03 i		1.40E-02 i	1.40E-02 i	***	0.75 c	0.45 c	0.23 c	200 c	46 c
Hexachlorophene	70304	3.00E-04 i					11 n	1.1 n	0.41 n	310 n	23 n
Hexahydro-1,3,5-trinitro-1,3,5-triazine	121824	3.00E-03 i		1.10E-01 i			0.61 c	0.057 c	0.029 c	26 c	5.8 c
1,6-Hexamethylene diisocyanate	822060		2.86E-06 i				0.1 a	0.01 a			
n-Hexane	110543	6.00E-02 h	5.71E-02 i			***	350 n	210 n	81 n	61000 n	4700 n
Hexazinone	51235042	3.30E-02 i					1200 n	120 n	45 n	34000 n	2600 n
Hydrazine, hydrazine sulfate	302012			3.00E+00 i	1.71E+01 i		0.022 c	0.00037 c	0.0011 c	0.95 c	0.21 c
Hydrogen chloride	7647010		2.00E-03 i				73 n	7.3 n			
Hydrogen sulfide	7783064	3.00E-03 i	2.57E-04 i				110 n	0.94 n	4.1 n	3100 n	230 n
Hydroquinone	123319	4.00E-02 h					1500 n	150 n	54 n	41000 n	3100 n
Imazalil	35554440	1.30E-02 i					470 n	47 n	18 n	13000 n	1000 n
Imazaquin	81335377	2.50E-01 i					9100 n	910 n	340 n	260000 n	20000 n
Iprodione	36734197	4.00E-02 i					1500 n	150 n	54 n	41000 n	3100 n
Isobutanol	78831	3.00E-01 i				***	1800 n	1100 n	410 n	310000 n	23000 n
Isophorone	78591	2.00E-01 i		9.50E-04 i			71 c	6.6 c	3.3 c	3000 c	670 c
Isopropalin	33820530	1.50E-02 i					550 n	55 n	20 n	15000 n	1200 n
Isopropyl methyl phosphonic acid	1832548	1.00E-01 i					3700 n	370 n	140 n	100000 n	7800 n
Isoxaben	82558507	5.00E-02 i					1800 n	180 n	68 n	51000 n	3900 n
Kepone	143500			1.80E+01 e			0.0037 c	0.00035 c	0.00018 c	0.16 c	0.035 c
Lactofen	77501634	2.00E-03 i					73 n	7.3 n	2.7 n	2000 n	160 n
Lead (tetraethyl)	78002	1.00E-07 i					0.0037 n	0.00037 n	0.00014 n	0.1 n	0.0078 n
Linuron	330552	2.00E-03 i					73 n	7.3 n	2.7 n	2000 n	160 n
Lithium	7439932	2.00E-02 e					730 n	73 n	27 n	20000 n	1600 n
Londax	83056996	2.00E-01 i					7300 n	730 n	270 n	200000 n	16000 n
Malathion	121755	2.00E-02 i					730 n	73 n	27 n	20000 n	1600 n
Maleic anhydride	108316	1.00E-01 i					3700 n	370 n	140 n	10( )	7800 n

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Maleic hydrazide	123331	5.00E-01 i					18000 n	1800 n	680 n	510000 n	39000 n
Malononitrile	109773	2.00E-05 h					0.73 n	0.073 n	0.027 n	20 n	1.6 n
Mancozeb	8018017	3.00E-02 h					1100 n	110 n	41 n	31000 n	2300 n
Maneb	12427382	5.00E-03 i					180 n	18 n	6.8 n	5100 n	390 n
Manganese and compounds	7439965	5.00E-03 i	1.43E-05 i				180 n	0.052 n	6.8 n	5100 n	390 n
Mephosfolan	950107	9.00E-05 h					3.3 n	0.33 n	0.12 n	92 n	7 n
Mepiquat chloride	24307264	3.00E-02 i					1100 n	110 n	41 n	31000 n	2300 n
Mercury (inorganic)	7439976	3.00E-04 h	8.57E-05 h				11 n	0.31 n	0.41 n	310 n	23 n
Mercury (methyl)	22967926	3.00E-04 i					11 n	1.1 n	0.41 n	310 n	23 n
Merphos	150505	3.00E-05 i					1.1 n	0.11 n	0.041 n	31 n	2.3 n
Merphos oxide	78488	3.00E-05 i					1.1 n	0.11 n	0.041 n	31 n	2.3 n
Metalaxyl	57837191	6.00E-02 i					2200 n	220 n	81 n	61000 n	4700 n
Methacrylonitrile	126987	1.00E-04 i	2.00E-04 a				3.7 n	0.73 n	0.14 n	100 n	7.8 n
Methamidophos	10265926	5.00E-05 i					1.8 n	0.18 n	0.068 n	51 n	3.9 n
Methanol	67561	5.00E-01 i					18000 n	1800 n	680 n	510000 n	39000 n
Methidathion	950378	1.00E-03 i					37 n	3.7 n	1.4 n	1000 n	78 n
Methomyl	16752775	2.50E-02 i					910 n	91 n	34 n	26000 n	2000 n
Methoxychlor	72435	5.00E-03 i					180 n	18 n	6.8 n	5100 n	390 n
2-Methoxyethanol acetate	110496	2.00E-03 a					73 n	7.3 n	2.7 n	2000 n	160 n
2-Methoxyethanol	109864	1.00E-03 h	5.71E-03 i				37 n	21 n	1.4 n	1000 n	78 n
2-Methoxy-5-nitroaniline	99592			4.60E-02 h			1.5 c	0.14 c	0.069 c	62 c	14 c
Methyl acetate	79209	1.00E+00 h					37000 n	3700 n	1400 n	1000000 n	78000 n
Methyl acrylate	96333	3.00E-02 a					1100 n	110 n	41 n	31000 n	2300 n
2-Methylaniline hydrochloride	636215			1.80E-01 h			0.37 c	0.035 c	0.018 c	16 c	3.5 c
2-Methylaniline	95534			2.40E-01 h			0.28 c	0.026 c	0.013 c	12 c	2.7 c
Methyl chlorocarbonate	79221	1.00E+00 w					37000 n	3700 n	1400 n	1000000 n	78000 n
4-(2-Methyl-4-chlorophenoxy) butyric acid	94815	1.00E-02 i					370 n	37 n	14 n	10000 n	780 n
2-Methyl-4-chlorophenoxyacetic acid	94746	5.00E-04 i					18 n	1.8 n	0.68 n	510 n	39 n
2-(2-Methyl-14-chlorophenoxy)propionic acid	93652	1.00E-03 i					37 n	3.7 n	1.4 n	1000 n	78 n
Methylcyclohexane	108872		8.57E-01 h				31000 n	3100 n			
Methylene bromide	74953	1.00E-02 a				***	61 n	37 n	14 n	10000 n	780 n
Methylene chloride	75092	6.00E-02 i	8.57E-01 h	7.50E-03 i	1.64E-03 i	***	4.1 c	3.8 c	0.42 c	380 c	85 c
4,4'-Methylene bis(2-chloroaniline)	101144	7.00E-04 h		1.30E-01 h	1.30E-01 h		0.52 c	0.048 c	0.024 c	22 c	4.9 c
4,4'-Methylenebisbenzeneamine	101779			2.50E-01 w			0.27 c	0.025 c	0.013 c	11 c	2.6 c
4,4'-Methylene bis(N,N'-dimethyl)aniline	101611			4.60E-02 i			1.5 c	0.14 c	0.069 c	62 c	14 c
4,4'-Methylenediphenyl isocyanate	101688		5.71E-06 i			***	0.035 n	0.021 n			
Methyl ethyl ketone	78933	6.00E-01 i	2.86E-01 i			***	1900 n	1000 n	810 n	610000 n	47000 n
Methyl hydrazine	60344			1.10E+00 w			0.061 c	0.0057 c	0.0029 c	2.6 c	0.58 c
Methyl isobutyl ketone	108101	8.00E-02 h	2.29E-02 a				2900 n	84 n	110 n	82000 n	6300 n
Methyl methacrylate	80626	8.00E-02 h					2900 n	290 n	110 n	82000 n	6300 n
2-Methyl-5-nitroaniline	99558			3.30E-02 h			2 c	0.19 c	0.096 c	87 c	19 c
Methyl parathion	298000	2.50E-04 i					9.1 n	0.91 n	0.34 n	260 n	20 n

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2-Methylphenol (o-cresol)	95487	5.00E-02 I					1800 n	180 n	68 n	51000 n	3900 n
3-Methylphenol (m-cresol)	103394	5.00E-02 I					1800 n	180 n	68 n	51000 n	3900 n
4-Methylphenol (p-cresol)	106445	5.00E-03 h					180 n	18 n	6.8 n	5100 n	390 n
Methyl styrene (mixture)	25013154	6.00E-03 a	1.14E-02 a			***	60 n	42 n	8.1 n	6100 n	470 n
Methyl styrene (alpha)	98839	7.00E-02 a				***	430 n	260 n	95 n	72000 n	5500 n
Methyl tertbutyl ether (MTBE)	1634044	5.00E-03 e	8.57E-01 I			***	180 n	3100 n	6.8 n	5100 n	390 n
Metolaclor (Dual)	51218452	1.50E-01 h					5500 n	550 n	200 n	150000 n	12000 n
Metribuzin	21807649	2.50E-02 I					910 n	91 n	34 n	26000 n	2000 n
Mirex	2385855	2.00E-04 I		1.80E+00 w			0.037 c	0.0035 c	0.0018 c	1.6 c	0.35 c
Molinate	2212671	2.00E-03 I					73 n	7.3 n	2.7 n	2000 n	160 n
Molybdenum	7439987	5.00E-03 I					180 n	18 n	6.8 n	5100 n	390 n
Monochloramine	10599903	1.00E-01 I					3700 n	370 n	140 n	100000 n	7800 n
Naled	300765	2.00E-03 I					73 n	7.3 n	2.7 n	2000 n	160 n
2-Naphthylamine	91598			1.30E+02 e			0.00052 c	0.000048 c	0.000024 c	0.022 c	0.0049 c
Napropamide	15299997	1.00E-01 I					3700 n	370 n	140 n	100000 n	7800 n
Nickel refinery dust					8.40E-01 I			0.0075 c			
Nickel (soluble salts)	7440020	2.00E-02 I					730 n	73 n	27 n	20000 n	1600 n
Nickel subsulfide	12035722				1.70E+00 I			0.0037 c			
Nitrapyrin	1929824	1.50E-03 w					55 n	5.5 n	2 n	1500 n	120 n
Nitrate	14797558	1.60E+00 I					58000 n	5800 n	2200 n	1000000 n	130000 n
Nitric Oxide	10102439	1.00E-01 w					3700 n	370 n	140 n	100000 n	7800 n
Nitrite	14797650	1.00E-01 I					3700 n	370 n	140 n	100000 n	7800 n
2-Nitroaniline	88744	6.00E-05 w	5.71E-05 h				2.2 n	0.21 n	0.081 n	61 n	4.7 n
3-Nitroaniline	99092	3.00E-03 o					110 n	11 n	4.1 n	3100 n	230 n
4-Nitroaniline	100016	3.00E-03 o					110 n	11 n	4.1 n	3100 n	230 n
Nitrobenzene	98953	5.00E-04 I	5.71E-04 a			***	3.4 n	2.1 n	0.68 n	510 n	39 n
Nitrofurantoin	67209	7.00E-02 h					2600 n	260 n	95 n	72000 n	5500 n
Nitrofurazone	59870			1.50E+00 h	9.40E+00 h		0.045 c	0.00067 c	0.0021 c	1.9 c	0.43 c
Nitrogen dioxide	10102440	1.00E+00 w					37000 n	3700 n	1400 n	1000000 n	78000 n
Nitroguanidine	556887	1.00E-01 I					3700 n	370 n	140 n	100000 n	7800 n
4-Nitrophenol	100027	6.20E-02 o					2300 n	230 n	84 n	63000 n	4800 n
2-Nitropropane	79469		5.71E-03 I		9.40E+00 h		210 n	0.00067 c			
N-Nitrosodi-n-butylamine	924163			5.40E+00 I	5.60E+00 I		0.012 c	0.0011 c	0.00058 c	0.53 c	0.12 c
N-Nitrosodiethanolamine	1116547			2.80E+00 I			0.024 c	0.0022 c	0.0011 c	1 c	0.23 c
N-Nitrosodiethylamine	55185			1.50E+02 I	1.51E+02 I		0.00045 c	0.000041 c	0.000021 c	0.019 c	0.0043 c
N-Nitrosodimethylamine	62759			5.10E+01 I	4.90E+01 I		0.0013 c	0.00013 c	0.000062 c	0.056 c	0.013 c
N-Nitrosodiphenylamine	86306			4.90E-03 I			14 c	1.3 c	0.64 c	580 c	130 c
N-Nitroso di-n-propylamine	621647			7.00E+00 I			0.0096 c	0.00089 c	0.00045 c	0.41 c	0.091 c
N-Nitroso-N-methylethylamine	10595956			2.20E+01 I			0.0031 c	0.00028 c	0.00014 c	0.13 c	0.029 c
N-Nitrosopyrrolidine	930552			2.10E+00 I	2.13E+00 I		0.032 c	0.0029 c	0.0015 c	1.4 c	0.3 c
m-Nitrotoluene	99081	1.00E-02 h				***	61 n	37 n	14 n	10000 n	780 n
o-Nitrotoluene	88722	1.00E-02 h				***	61 n	37 n	14 n	1(e	780 n

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Contaminant	CAS	RfDo mg/kg/d	RfDi mg/kg/d	CPSo kg·d/mg	CPSi kg·d/mg	VOC	Tap water µg/L	Ambient air µg/m3	Fish mg/kg	Industrial soil mg/kg	Residential soil mg/kg
p-Nitrotoluene	99990	1.00E-02 *h*				•••	61 *n*	37 *n*	14 *n*	10000 *n*	780 *n*
Norflurazon	27314132	4.00E-02 *I*					1500 *n*	150 *n*	54 *n*	41000 *n*	3100 *n*
NuStar	85509199	7.00E-04 *I*					26 *n*	2.6 *n*	0.95 *n*	720 *n*	55 *n*
Octabromodiphenyl ether	32536520	3.00E-03 *I*					110 *n*	11 *n*	4.1 *n*	3100 *n*	230 *n*
Octahydro-1357-tetranitro-1357-tetrazocine	2691410	5.00E-02 *I*					1800 *n*	180 *n*	68 *n*	51000 *n*	3900 *n*
Octamethylpyrophosphoramide	152169	2.00E-03 *h*					73 *n*	7.3 *n*	2.7 *n*	2000 *n*	160 *n*
Oryzalin	19044883	5.00E-02 *I*					1800 *n*	180 *n*	68 *n*	51000 *n*	3900 *n*
Oxadiazon	19666309	5.00E-03 *I*					180 *n*	18 *n*	6.8 *n*	5100 *n*	390 *n*
Oxamyl	23135220	2.50E-02 *I*					910 *n*	91 *n*	34 *n*	26000 *n*	2000 *n*
Oxyfluorfen	42874033	3.00E-03 *I*					110 *n*	11 *n*	4.1 *n*	3100 *n*	230 *n*
Paclobutrazol	76738620	1.30E-02 *I*					470 *n*	47 *n*	18 *n*	13000 *n*	1000 *n*
Paraquat	1910425	4.50E-03 *I*					160 *n*	16 *n*	6.1 *n*	4600 *n*	350 *n*
Parathion	56382	6.00E-03 *h*					220 *n*	22 *n*	8.1 *n*	6100 *n*	470 *n*
Pebulate	1114712	5.00E-02 *h*					1800 *n*	180 *n*	68 *n*	51000 *n*	3900 *n*
Pendimethalin	40487421	4.00E-02 *I*					1500 *n*	150 *n*	54 *n*	41000 *n*	3100 *n*
Pentabromo-6-chloro cyclohexane	87843			2.30E-02 *h*			2.9 *c*	0.27 *c*	0.14 *c*	120 *c*	28 *c*
Pentabromodiphenyl ether	32534819	2.00E-03 *I*					73 *n*	7.3 *n*	2.7 *n*	2000 *n*	160 *n*
Pentachlorobenzene	608935	8.00E-04 *I*				•••	4.9 *n*	2.9 *n*	1.1 *n*	820 *n*	63 *n*
Pentachloronitrobenzene	82688	3.00E-03 *I*		2.60E-01 *h*		•••	0.041 *c*	0.024 *c*	0.012 *c*	11 *c*	2.5 *c*
Pentachlorophenol	87865	3.00E-02 *I*		1.20E-01 *I*			0.56 *c*	0.052 *c*	0.026 *c*	24 *c*	5.3 *c*
Permethrin	52645531	5.00E-02 *I*					1800 *n*	180 *n*	68 *n*	51000 *n*	3900 *n*
Phenmedipham	13684634	2.50E-01 *I*					9100 *n*	910 *n*	340 *n*	260000 *n*	20000 *n*
Phenol	108952	6.00E-01 *I*					22000 *n*	2200 *n*	810 *n*	610000 *n*	47000 *n*
m-Phenylenediamine	108452	6.00E-03 *I*					220 *n*	22 *n*	8.1 *n*	6100 *n*	470 *n*
p-Phenylenediamine	106503	1.90E-01 *h*					6900 *n*	690 *n*	260 *n*	190000 *n*	15000 *n*
Phenylmercuric acetate	62384	8.00E-05 *I*					2.9 *n*	0.29 *n*	0.11 *n*	82 *n*	6.3 *n*
2-Phenylphenol	90437			1.94E-03 *h*			35 *c*	3.2 *c*	1.6 *c*	1500 *c*	330 *c*
Phorate	298022	2.00E-04 *h*					7.3 *n*	0.73 *n*	0.27 *n*	200 *n*	16 *n*
Phosmet	732116	2.00E-02 *I*					730 *n*	73 *n*	27 *n*	20000 *n*	1600 *n*
Phosphine	7803512	3.00E-04 *I*	8.57E-06 *h*				11 *n*	0.031 *n*	0.41 *n*	310 *n*	23 *n*
Phosphorus (white)	7723140	2.00E-05 *I*					0.73 *n*	0.073 *n*	0.027 *n*	20 *n*	1.6 *n*
p-Phthalic acid	100210	1.00E+00 *h*					37000 *n*	3700 *n*	1400 *n*	1000000 *n*	78000 *n*
Phthalic anhydride	85449	2.00E+00 *I*	3.43E-01 *h*				73000 *n*	1300 *n*	2700 *n*	1000000 *n*	160000 *n*
Picloram	1918021	7.00E-02 *I*					2600 *n*	260 *n*	95 *n*	72000 *n*	5500 *n*
Pirimiphos-methyl	29232937	1.00E-02 *I*					370 *n*	37 *n*	14 *n*	10000 *n*	780 *n*
Polybrominated biphenyls		7.00E-06 *h*		8.90E+00 *h*			0.0076 *c*	0.0007 *c*	0.00035 *c*	0.32 *c*	0.072 *c*
Polychlorinated biphenyls (PCBs)	1336363			7.70E+00 *I*			0.0087 *c*	0.00081 *c*	0.00041 *c*	0.37 *c*	0.083 *c*
Aroclor 1016	12674112	7.00E-05 *I*					2.6 *n*	0.26 *n*	0.095 *n*	72 *n*	5.5 *n*
Aroclor 1254	11097691	2.00E-05 *I*					0.73 *n*	0.073 *n*	0.027 *n*	20 *n*	1.6 *n*
Polychlorinated terphenyls (PCTs)				4.50E+00 *e*			0.015 *c*	0.0014 *c*	0.0007 *c*	0.64 *c*	0.14 *c*
Polynuclear aromatic hydrocarbons											
Acenaphthene	83329	6.00E-02 *I*					2200 *n*	220 *n*	81 *n*	61000 *n*	4700 *n*

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Contaminant	CAS	RfDo mg/kg/d	RfDi mg/kg/d	CPSo kg·d/mg	CPSi kg·d/mg	V O C	Tap water µg/L	Ambient air µg/m3	Fish mg/kg	Industrial soil mg/kg	Residential soil mg/kg
Anthracene	120127	3.00E-01 i					11000 n	1100 n	410 n	310000 n	23000 n
Benzo[a]pyrene	50328			7.30E+00 i	6.10E+00 h		0.0092 c	0.001 c	0.00043 c	0.39 c	0.088 c
Benzo[b]fluoranthene	205992			7.30E-01 e	6.10E-01 e		0.092 c	0.01 c	0.0043 c	3.9 c	0.88 c
Benzo[k]fluoranthene	207089			7.30E-02 e	6.10E-02 e		0.92 c	0.1 c	0.043 c	39 c	8.8 c
Benz[a]anthracene.	56553			7.30E-01 e	6.10E-01 e		0.092 c	0.01 c	0.0043 c	3.9 c	0.88 c
Chrysene	218019			7.30E-03 e	6.10E-03 e		9.2 c	1 c	0.43 c	390 c	88 c
Dibenz[ah]anthracene	53703			7.30E+00 e	6.10E+00 e		0.0092 c	0.001 c	0.00043 c	0.39 c	0.088 c
Fluoranthene	206440	4.00E-02 i					1500 n	150 n	54 n	41000 n	3100 n
Fluorene	86737	4.00E-02 i					1500 n	150 n	54 n	41000 n	3100 n
Indeno[1,2,3-cd]pyrene	193395			7.30E-01 e	6.10E-01 e		0.092 c	0.01 c	0.0043 c	3.9 c	0.88 c
Naphthalene	91203	4.00E-02 w					1500 n	150 n	54 n	41000 n	3100 n
Pyrene	129000	3.00E-02 i					1100 n	110 n	41 n	31000 n	2300 n
Prochloraz	67747095	9.00E-03 i		1.50E-01 i			0.45 c	0.042 c	0.021 c	19 c	4.3 c
Profluralin	26399360	6.00E-03 h					220 n	22 n	8.1 n	6100 n	470 n
Prometon	1610180	1.50E-02 i					550 n	55 n	20 n	15000 n	1200 n
Prometryn	7287196	4.00E-03 i					150 n	15 n	5.4 n	4100 n	310 n
Pronamide	23950585	7.50E-02 i					2700 n	270 n	100 n	77000 n	5900 n
Propachlor	1918167	1.30E-02 i					470 n	47 n	18 n	13000 n	1000 n
Propanil	709988	5.00E-03 i					180 n	18 n	6.8 n	5100 n	390 n
Propargite	2312358	2.00E-02 i					730 n	73 n	27 n	20000 n	1600 n
Propargyl alcohol	107197	2.00E-03 i					73 n	7.3 n	2.7 n	2000 n	160 n
Propazine	139402	2.00E-02 i					730 n	73 n	27 n	20000 n	1600 n
Propham	122429	2.00E-02 i					730 n	73 n	27 n	20000 n	1600 n
Propiconazole	60207901	1.30E-02 i					470 n	47 n	18 n	13000 n	1000 n
Propylene glycol	57556	2.00E+01 h					730000 n	73000 n	27000 n	1000000 n	1000000 n
Propylene glycol, monoethyl ether	52125538	7.00E-01 h					26000 n	2600 n	950 n	720000 n	55000 n
Propylene glycol, monomethyl ether	107982	7.00E-01 h	5.71E-01 i				26000 n	2100 n	950 n	720000 n	55000 n
Propylene oxide	75569		8.57E-03 i	2.40E-01 i	1.29E-02 i		0.28 c	0.49 c	0.013 c	12 c	2.7 c
Pursuit	81335775	2.50E-01 i					9100 n	910 n	340 n	260000 n	20000 n
Pydrin	51630581	2.50E-02 i					910 n	91 n	34 n	26000 n	2000 n
Pyridine	110861	1.00E-03 i					37 n	3.7 n	1.4 n	1000 n	78 n
Quinalphos	13593038	5.00E-04 i					18 n	1.8 n	0.68 n	510 n	39 n
Quinoline	91225			1.20E+01 h			0.0056 c	0.00052 c	0.00026 c	0.24 c	0.053 c
Resmethrin	10463868	3.00E-02 i					1100 n	110 n	41 n	31000 n	2300 n
Ronnel	299843	5.00E-02 h					1800 n	180 n	68 n	51000 n	3900 n
Rotenone	83794	4.00E-03 i					150 n	15 n	5.4 n	4100 n	310 n
Savey	78587050	2.50E-02 i					910 n	91 n	34 n	26000 n	2000 n
Selenious Acid	7783008	5.00E-03 i					180 n	18 n	6.8 n	5100 n	390 n
Selenium	7782492	5.00E-03 i					180 n	18 n	6.8 n	5100 n	390 n
Selenourea	630104	5.00E-03 h					180 n	18 n	6.8 n	5100 n	390 n
Sethoxydim	74051802	9.00E-02 i					3300 n	330 n	120 n	92000 n	7000 n
Silver and compounds	7440224	5.00E-03 i					180 n	18 n	6.8 n	n	390 n

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Contaminant	CAS	RfDo mg/kg/d	RfDi mg/kg/d	CPSo kg-d/mg	CPSi kg-d/mg	VOC	Tap water µg/L	Ambient air µg/m3	Fish mg/kg	Industrial soil mg/kg	Residential soil mg/kg
Simazine	122349	5.00E-03 *I*		1.20E-01 *h*			0.56 *c*	0.052 *c*	0.026 *c*	24 *c*	5.3 *c*
Sodium azide	26628228	4.00E-03 *I*					150 *n*	15 *n*	5.4 *n*	4100 *n*	310 *n*
Sodium diethyldithiocarbamate	148185	3.00E-02 *I*		2.70E-01 *h*			0.25 *c*	0.023 *c*	0.012 *c*	11 *c*	2.4 *c*
Sodium fluoroacetate	62748	2.00E-05 *I*					0.73 *n*	0.073 *n*	0.027 *n*	20 *n*	1.6 *n*
Sodium metavanadate	13718268	1.00E-03 *h*					37 *n*	3.7 *n*	1.4 *n*	1000 *n*	78 *n*
Strontium, stable	7440246	6.00E-01 *I*					22000 *n*	2200 *n*	810 *n*	610000 *n*	47000 *n*
Strychnine	57249	3.00E-04 *I*					11 *n*	1.1 *n*	0.41 *n*	310 *n*	23 *n*
Styrene	100425	2.00E-01 *I*	2.86E-01 *I*			***	1600 *n*	1000 *n*	270 *n*	200000 *n*	16000 *n*
Systhane	88671890	2.50E-02 *I*					910 *n*	91 *n*	34 *n*	26000 *n*	2000 *n*
2,3,7,8-TCDD (dioxin)	1746016			1.56E+05 *h*	1.16E+05 *h*		4.30E-07 *c*	5.40E-08 *c*	2.00E-08 *c*	0.000018 *c*	4.10E-06 *c*
Tebuthiuron	34014181	7.00E-02 *I*					2600 *n*	260 *n*	95 *n*	72000 *n*	5500 *n*
Temephos	3383968	2.00E-02 *h*					730 *n*	73 *n*	27 *n*	20000 *n*	1600 *n*
Terbacil	5902512	1.30E-02 *I*					470 *n*	47 *n*	18 *n*	13000 *n*	1000 *n*
Terbufos	13071799	2.50E-05 *h*					0.91 *n*	0.091 *n*	0.034 *n*	26 *n*	2 *n*
Terbutryn	886500	1.00E-03 *I*					37 *n*	3.7 *n*	1.4 *n*	1000 *n*	78 *n*
1,2,4,5-Tetrachlorobenzene	95943	3.00E-04 *I*				***	1.8 *n*	1.1 *n*	0.41 *n*	310 *n*	23 *n*
1,1,1,2-Tetrachloroethane	630206	3.00E-02 *I*		2.60E-02 *I*	2.59E-02 *I*	***	0.41 *c*	0.24 *c*	0.12 *c*	110 *c*	25 *c*
1,1,2,2-Tetrachloroethane	79345			2.00E-01 *I*	2.03E-01 *I*	***	0.052 *c*	0.031 *c*	0.016 *c*	14 *c*	3.2 *c*
Tetrachloroethylene (PCE)	127184	1.00E-02 *I*		5.20E-02 *a*	2.03E-03 *a*	***	1.1 *c*	3.1 *c*	0.061 *c*	55 *c*	12 *c*
2,3,4,6-Tetrachlorophenol	58902	3.00E-02 *I*					1100 *n*	110 *n*	41 *n*	31000 *n*	2300 *n*
p,a,a,a-Tetrachlorotoluene	5216251			2.00E+01 *h*		***	0.00053 *c*	0.00031 *c*	0.00016 *c*	0.14 *c*	0.032 *c*
Tetrachlorovinphos	961115	3.00E-02 *I*		2.40E-02 *h*			2.8 *c*	0.26 *c*	0.13 *c*	120 *c*	27 *c*
Tetraethyldithiopyrophosphate	3689245	5.00E-04 *I*					18 *n*	1.8 *n*	0.68 *n*	510 *n*	39 *n*
Thallic oxide	1314325	7.00E-05 *w*					2.6 *n*	0.26 *n*	0.095 *n*	72 *n*	5.5 *n*
Thallium											
Thallium acetate	563688	9.00E-05 *I*					3.3 *n*	0.33 *n*	0.12 *n*	92 *n*	7 *n*
Thallium carbonate	6533739	8.00E-05 *I*					2.9 *n*	0.29 *n*	0.11 *n*	82 *n*	6.3 *n*
Thallium chloride	7791120	8.00E-05 *I*					2.9 *n*	0.29 *n*	0.11 *n*	82 *n*	6.3 *n*
Thallium nitrate	10102451	9.00E-05 *I*					3.3 *n*	0.33 *n*	0.12 *n*	92 *n*	7 *n*
Thallium selenite	12039520	9.00E-05 *w*					3.3 *n*	0.33 *n*	0.12 *n*	92 *n*	7 *n*
Thallium sulfate	7446186	8.00E-05 *I*					2.9 *n*	0.29 *n*	0.11 *n*	82 *n*	6.3 *n*
Thiobencarb	28249776	1.00E-02 *I*					370 *n*	37 *n*	14 *n*	10000 *n*	780 *n*
2-(Thiocyanomethylthio)-benzothiazole	21564170	3.00E-02 *h*					1100 *n*	110 *n*	41 *n*	31000 *n*	2300 *n*
Thiofanox	39196184	3.00E-04 *h*					11 *n*	1.1 *n*	0.41 *n*	310 *n*	23 *n*
Thiophanate-methyl	23564058	8.00E-02 *I*					2900 *n*	290 *n*	110 *n*	82000 *n*	6300 *n*
Thiram	137268	5.00E-03 *I*					180 *n*	18 *n*	6.8 *n*	5100 *n*	390 *n*
Tin and compounds		6.00E-01 *h*					22000 *n*	2200 *n*	810 *n*	610000 *n*	47000 *n*
Toluene	108883	2.00E-01 *I*	1.14E-01 *w*			***	750 *n*	420 *n*	270 *n*	200000 *n*	16000 *n*
Toluene-2,4-diamine	95807			3.20E+00 *h*			0.021 *c*	0.002 *c*	0.00099 *c*	0.89 *c*	0.2 *c*
Toluene-2,5-diamine	95705	6.00E-01 *h*					22000 *n*	2200 *n*	810 *n*	610000 *n*	47000 *n*
Toluene-2,6-diamine	823405	2.00E-01 *h*					7300 *n*	730 *n*	270 *n*	200000 *n*	16000 *n*
p-Toluidine	106490			1.90E-01 *h*			0.35 *c*	0.033 *c*	0.017 *c*	15 *c*	3.4 *c*

Sources: i=IRIS h=HEAST a=HEAST alt. w=Withdrawn from IRIS or HEAST e=EPA-ECAO provisional o=Other EPA documents *Basis of RBC: c=carcinogenic effects n=noncarcinogenic effects.*

Contaminant	CAS	RfDo mg/kg/d	RfDi mg/kg/d	CPSo kg·d/mg	CPSi kg·d/mg	VOC	Tap water µg/L	Ambient air µg/m3	Fish mg/kg	Industrial soil mg/kg	Residential soil mg/kg
Toxaphene	8001352			1.10E+00 i	1.12E+00 i		0.061 c	0.0056 c	0.0029 c	2.6 c	0.58 c
Tralomethrin	66841256	7.50E-03 i					270 n	27 n	10 n	7700 n	590 n
Triallate	2303175	1.30E-02 i					470 n	47 n	18 n	13000 n	1000 n
Triasulfuron	82097505	1.00E-02 i					370 n	37 n	14 n	10000 n	780 n
1,2,4-Tribromobenzene	615543	5.00E-03 i				***	30 n	18 n	6.8 n	5100 n	390 n
Tributyltin oxide (TBTO)	56359	3.00E-05 i					1.1 n	0.11 n	0.041 n	31 n	2.3 n
2,4,6-Trichloroaniline hydrochloride	33663502			2.90E-02 h			2.3 c	0.22 c	0.11 c	99 c	22 c
2,4,6-Trichloroaniline	634935			3.40E-02 h			2 c	0.18 c	0.093 c	84 c	19 c
1,2,4-Trichlorobenzene	120821	1.00E-02 i	5.71E-02 h			***	190 n	210 n	14 n	10000 n	780 n
1,1,1-Trichloroethane	71556	9.00E-02 w	2.86E-01 w			***	1300 n	1000 n	120 n	92000 n	7000 n
1,1,2-Trichloroethane	79005	4.00E-03 i		5.70E-02 i	5.60E-02 i	***	0.19 c	0.11 c	0.055 c	50 c	11 c
Trichloroethylene (TCE)	79016	6.00E-03 e		1.10E-02 w	6.00E-03 e	***	1.6 c	1 c	0.29 c	260 c	58 c
Trichlorofluoromethane	75694	3.00E-01 i	2.00E-01 a			***	1300 n	730 n	410 n	310000 n	23000 n
2,4,5-Trichlorophenol	95954	1.00E-01 i					3700 n	370 n	140 n	100000 n	7800 n
2,4,6-Trichlorophenol	88062			1.10E-02 i	1.09E-02 i		6.1 c	0.57 c	0.29 c	260 c	58 c
2,4,5-Trichlorophenoxyacetic acid	93765	1.00E-02 i					370 n	37 n	14 n	10000 n	780 n
2-(2,4,5-Trichlorophenoxy)propionic acid	93721	8.00E-03 i					290 n	29 n	11 n	8200 n	630 n
1,1,2-Trichloropropane	598776	5.00E-03 i				***	30 n	18 n	6.8 n	5100 n	390 n
1,2,3-Trichloropropane	96184	6.00E-03 i		7.00E+00 i		***	0.0015 c	0.00089 c	0.00045 c	0.41 c	0.091 c
1,2,3-Trichloropropene	96195	5.00E-03 h				***	30 n	18 n	6.8 n	5100 n	390 n
1,1,2-Trichloro-1,2,2- trifluoroethane	76131	3.00E+01 i	8.57E+00 h			***	59000 n	31000 n	41000 n	1000000 n	1000000 n
Tridiphane	58138082	3.00E-03 i					110 n	11 n	4.1 n	3100 n	230 n
Triethylamine	121448		2.00E-03 i				73 n	7.3 n			
Trifluralin	1582098	7.50E-03 i		7.70E-03 i			8.7 c	0.81 c	0.41 c	370 c	83 c
1,2,4-Trimethylbenzene	95636	5.00E-04 e				***	3 n	1.8 n	0.68 n	510 n	39 n
1,3,5-Trimethylbenzene	108678	4.00E-04 e				***	2.4 n	1.5 n	0.54 n	410 n	31 n
Trimethyl phosphate	512561			3.70E-02 h			1.8 c	0.17 c	0.085 c	77 c	17 c
1,3,5-Trinitrobenzene	99354	5.00E-05 i					1.8 n	0.18 n	0.068 n	51 n	3.9 n
Trinitrophenylmethylnitramine	479458	1.00E-02 h					370 n	37 n	14 n	10000 n	780 n
2,4,6-Trinitrotoluene	118967	5.00E-04 i		3.00E-02 i			2.2 c	0.21 c	0.11 c	95 c	21 c
Uranium (soluble salts)	7440611	3.00E-03 i					110 n	11 n	4.1 n	3100 n	230 n
Vanadium	7440622	7.00E-03 h					260 n	26 n	9.5 n	7200 n	550 n
Vanadium pentoxide	1314621	9.00E-03 i					330 n	33 n	12 n	9200 n	700 n
Vanadium sulfate	36907423	2.00E-02 h					730 n	73 n	27 n	20000 n	1600 n
Vernam	1929777	1.00E-03 i					37 n	3.7 n	1.4 n	1000 n	78 n
Vinclozolin	50471448	2.50E-02 i					910 n	91 n	34 n	26000 n	2000 n
Vinyl acetate	108054	1.00E+00 h	5.71E-02 i				37000 n	210 n	1400 n	1000000 n	78000 n
Vinyl bromide	593602		8.57E-04 i			***	5.2 n	3.1 n			
Vinyl chloride	75014			1.90E+00 h	3.00E-01 h	***	0.019 c	0.021 c	0.0017 c	1.5 c	0.34 c
Warfarin	81812	3.00E-04 i					11 n	1.1 n	0.41 n	310 n	23 n
m-Xylene	108323	2.00E+00 h	2.00E-01 w			***	1400 n	730 n	2700 n	1000000 n	160000 n
o-Xylene	95476	2.00E+00 h	2.00E-01 w			***	1400 n	730 n	2700 n	1000000 n	160000 n

Sources: I=IRIS h=HEAST a=HEAST alt. w=Withdrawn from IRIS or HEAST e=EPA-ECAO provisional o=Other EPA documents *Basis of RBC: c=carcinogenic effects n=noncarcinogenic effects*

Contaminant	CAS	RfDo mg/kg/d	RfDi mg/kg/d	CPSo kg·d/mg	CPSi kg·d/mg	V O C	Tap water µg/L	Ambient air µg/m3	Fish mg/kg	Industrial soil mg/kg	Residential soil mg/kg
p-Xylene	1.06E+05		8.57E-02 w			***	5.20E+02 n	3.10E+02 n			
Xylene (mixed)	1.33E+06	2.00E+00 I				***	12000 n	7300 n	2700 n	1000000 n	160000 n
Zinc	7.44E+06	3.00E-01 I					11000 n	1100 n	410 n	310000 n	23000 n
Zinc phosphide	1.31E+06	3.00E-04 I					11 n	1.1 n	0.41 n	310 n	23 n
Zineb	1.21E+07	5.00E-02 I					1800 n	180 n	68 n	51000 n	3900 n

APPENDIX D

ESTIMATION OF THE AREA AND VOLUME OF SOIL CONTAMINATION

APPENDIX D

ESTIMATION OF THE AREA AND VOLUME OF SOIL CONTAMINATION

D.1 JUSTIFICATION

Very low levels of volatile compounds were detected in the surface and subsurface soil samples, due to their highly mobile nature. Volatiles present in the soil may have gone undetected due to evaporation into the atmosphere during sampling. As a result, soil gas sample results have been used to approximate the total soil concentrations. This method of estimation is outlined in *"Accelerated Superfund Site Remediation Using the U.S. EPA Superfund Accelerated Clean Up Model (SACM): A Case Study Application."*

The soil gas data is used as the gas phase concentration (C_g) in the following relation (Zachary, et. al., 1994):

$$C_T = \frac{(K_D\ (\rho_b\ +\ \Theta_W)\ /\ k_H) + (\Theta_T - \Theta_W)}{\rho_b} * C_g$$

where, C_T = Total Soil Concentration (µg/kg)

C_g = Gas Phase Concentration (µg/l, chemical specific)

k_H = Henry's Coefficient (dimensionless, chemical specific)

k_D = Partition Coefficient (ml/g , chemical specific)

and using values from the geotechnical survey (Table 2-4)

ρ_b = Dry Bulk Density of Soil (g/cm^3) = 1.485 g/cm^3

θ_T = Total Porosity of Soil (dimensionless) = 0.447

θ_W = Water Filled Porosity of Soil (dimensionless) = 0.116

Ave. moisture content of soil = 24.97%

D.2 CONVERSION FROM SOIL GAS DATA

The initial soil gas data (Table 2-2) was used along with the chemical properties in Table 5-1 to determine the total soil concentration of the chemicals of concern. The resulting data is shown in Table D-1.

TABLE D-1 CONVERSION FROM SOIL GAS DATA

	Benzene				Toluene				cis-1,2-Dichloroethene	
Sample Number	Henry's Law Constant (dimensionless)	Soil Gas Concentration (µg/l)	Partition Coefficient (ml/g)	Total Soil Concentration C_T (µg/kg)	Henry's Law Constant (dimensionless)	Soil Gas Concentration (µg/l)	Partition Coefficient (ml/g)	Total Soil Concentration C_T (µg/kg)	Henry's Law Constant (dimensionless)	Soil Gas Concentration (µg/l)
SG-1	0.22917	0.0	4.7E+00	0.0	0.27009	65.0	1.4E+01	3637.1	0.16779	12.0
SG-2	0.22917	0.0	4.7E+00	0.0	0.27009	0.0	1.4E+01	0.0	0.16779	0.0
SG-3	0.22917	0.0	4.7E+00	0.0	0.27009	0.0	1.4E+01	0.0	0.16779	7.0
SG-4	0.22917	0.0	4.7E+00	0.0	0.27009	0.0	1.4E+01	0.0	0.16779	0.0
SG-5	0.22917	0.0	4.7E+00	0.0	0.27009	0.0	1.4E+01	0.0	0.16779	0.0
SG-6	0.22917	0.0	4.7E+00	0.0	0.27009	0.0	1.4E+01	0.0	0.16779	0.0
SG-8	0.22917	0.0	4.7E+00	0.0	0.27009	0.0	1.4E+01	0.0	0.16779	0.0
SG-9-6	0.22917	0.0	4.7E+00	0.0	0.27009	0.0	1.4E+01	0.0	0.16779	0.0
SG-9-6R	0.22917	0.0	4.7E+00	0.0	0.27009	0.0	1.4E+01	0.0	0.16779	0.0
SG-9-12	0.22917	0.0	4.7E+00	0.0	0.27009	0.0	1.4E+01	0.0	0.16779	0.0
SG-10	0.22917	0.0	4.7E+00	0.0	0.27009	26.0	1.4E+01	1454.9	0.16779	148.0
SG-11	0.22917	0.0	4.7E+00	0.0	0.27009	0.0	1.4E+01	0.0	0.16779	6.2
SG-12	0.22917	0.0	4.7E+00	0.0	0.27009	0.0	1.4E+01	0.0	0.16779	0.0
SG-13	0.22917	0.0	4.7E+00	0.0	0.27009	4.5	1.4E+01	251.8	0.16779	0.0
SG-14	0.22917	11.0	4.7E+00	245.0	0.27009	707.0	1.4E+01	39560.8	0.16779	243.0
SG-15	0.22917	0.0	4.7E+00	0.0	0.27009	0.0	1.4E+01	0.0	0.16779	0.0
SG-16	0.22917	0.0	4.7E+00	0.0	0.27009	0.0	1.4E+01	0.0	0.16779	0.0
SG-17	0.22917	0.0	4.7E+00	0.0	0.27009	0.0	1.4E+01	0.0	0.16779	0.0
SG-18	0.22917	0.0	4.7E+00	0.0	0.27009	0.0	1.4E+01	0.0	0.16779	0.0
SG-19	0.22917	0.0	4.7E+00	0.0	0.27009	0.0	1.4E+01	0.0	0.16779	0.0
SG-20	0.22917	0.0	4.7E+00	0.0	0.27009	0.0	1.4E+01	0.0	0.16779	0.0
SG-21	0.22917	0.0	4.7E+00	0.0	0.27009	0.0	1.4E+01	0.0	0.16779	0.0
SG-22R	0.22917	0.0	4.7E+00	0.0	0.27009	0.0	1.4E+01	0.0	0.16779	0.0
SG-22	0.22917	0.0	4.7E+00	0.0	0.27009	0.0	1.4E+01	0.0	0.16779	0.0
SG-23	0.22917	0.0	4.7E+00	0.0	0.27009	0.0	1.4E+01	0.0	0.16779	0.0
SG-25	0.22917	0.0	4.7E+00	0.0	0.27009	0.0	1.4E+01	0.0	0.16779	0.0
SG-27	0.22917	0.0	4.7E+00	0.0	0.27009	0.0	1.4E+01	0.0	0.16779	0.0
SG-29	0.22917	0.0	4.7E+00	0.0	0.27009	0.0	1.4E+01	0.0	0.16779	0.0
SG-30	0.22917	0.0	4.7E+00	0.0	0.27009	0.0	1.4E+01	0.0	0.16779	0.0
SG-38	0.22917	0.0	4.7E+00	0.0	0.27009	0.0	1.4E+01	0.0	0.16779	0.0
SG-41	0.22917	0.0	4.7E+00	0.0	0.27009	0.0	1.4E+01	0.0	0.16779	0.0
SG-44	0.22917	0.0	4.7E+00	0.0	0.27009	0.0	1.4E+01	0.0	0.16779	0.0
SG-46	0.22917	0.0	4.7E+00	0.0	0.27009	0.0	1.4E+01	0.0	0.16779	0.0
SG-47	0.22917	0.0	4.7E+00	0.0	0.27009	0.0	1.4E+01	0.0	0.16779	0.0
SG-49-6	0.22917	0.0	4.7E+00	0.0	0.27009	0.0	1.4E+01	0.0	0.16779	0.0
SG-49-12	0.22917	0.0	4.7E+00	0.0	0.27009	0.0	1.4E+01	0.0	0.16779	0.0
SG-50-6	0.22917	0.0	4.7E+00	0.0	0.27009	0.0	1.4E+01	0.0	0.16779	4.7
SG-50-12	0.22917	0.0	4.7E+00	0.0	0.27009	0.0	1.4E+01	0.0	0.16779	1.6
SG-50-12R	0.22917	0.0	4.7E+00	0.0	0.27009	0.0	1.4E+01	0.0	0.16779	1.9
SG-51-6	0.22917	0.0	4.7E+00	0.0	0.27009	0.0	1.4E+01	0.0	0.16779	8.3
SG-51-12	0.22917	0.0	4.7E+00	0.0	0.27009	5.0	1.4E+01	279.8	0.16779	18.0
SG-52-6	0.22917	0.0	4.7E+00	0.0	0.27009	3.9	1.4E+01	218.2	0.16779	0.0
SG-52-12	0.22917	0.0	4.7E+00	0.0	0.27009	1.3	1.4E+01	72.7	0.16779	0.0
SG-54	0.22917	0.0	4.7E+00	0.0	0.27009	0.0	1.4E+01	0.0	0.16779	0.0
SG-55	0.22917	0.0	4.7E+00	0.0	0.27009	2.2	1.4E+01	123.1	0.16779	0.0
SG-56	0.22917	0.0	4.7E+00	0.0	0.27009	0.0	1.4E+01	0.0	0.16779	0.0
SG-57	0.22917	0.0	4.7E+00	0.0	0.27009	0.0	1.4E+01	0.0	0.16779	0.0
SG-58	0.22917	0.0	4.7E+00	0.0	0.27009	0.0	1.4E+01	0.0	0.16779	0.0

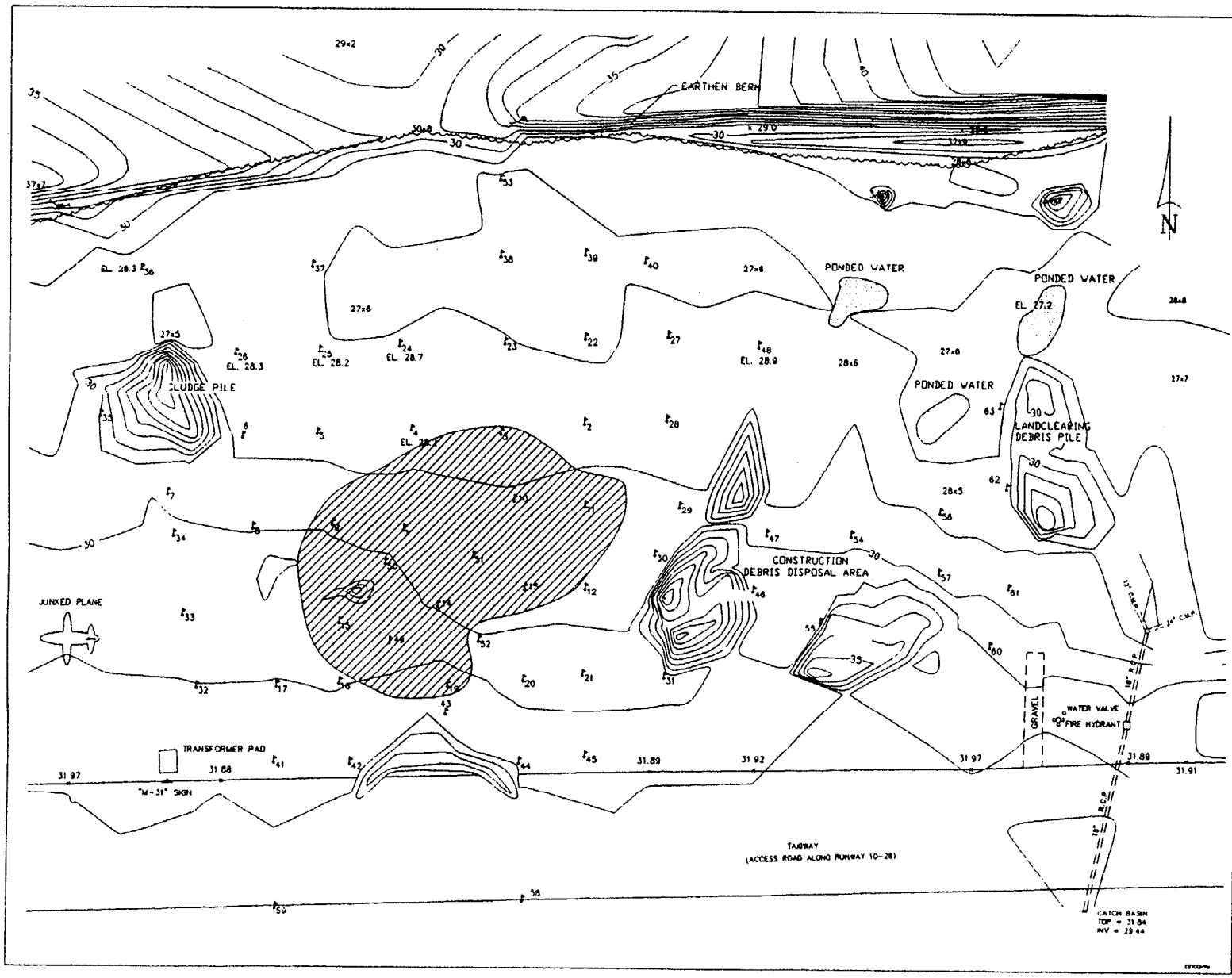
TABLE D-1 CONVERSION FROM SOIL GAS DATA (Continued)

	cis-1,2-Dichloroethene		Tetrachloroethene				1,1-Dichloroethene			
Sample Number	Partition Coefficient (ml/g)	Total Soil Concentration C_T (µg/kg)	Henry's Law Constant (dimensionless)	Soil Gas Concentration (µg/l)	Partition Coefficient (ml/g)	Total Soil Concentration C_T (µg/kg)	Henry's Law Constant (dimensionless)	Soil Gas Concentration (µg/l)	Partition Coefficient (ml/g)	Total Soil Concentration C_T (µg/kg)
SG-1	7.6E+00	587.1	0.73171	31.0	3.6E+01	1646.8	0.1678	209.0	5.2E+01	69686.3
SG-2	7.6E+00	0.0	0.73171	2.0	3.6E+01	106.2	0.1678	6.0	5.2E+01	2000.6
SG-3	7.6E+00	342.5	0.73171	42.0	3.6E+01	2231.2	0.1678	30.0	5.2E+01	10002.8
SG-4	7.6E+00	0.0	0.73171	0.0	3.6E+01	0.0	0.1678	2.0	5.2E+01	666.9
SG-5	7.6E+00	0.0	0.73171	1.7	3.6E+01	90.3	0.1678	12.0	5.2E+01	4001.1
SG-6	7.6E+00	0.0	0.73171	0.0	3.6E+01	0.0	0.1678	1.1	5.2E+01	366.8
SG-8	7.6E+00	0.0	0.73171	0.0	3.6E+01	0.0	0.1678	3.4	5.2E+01	1133.7
SG-9-6	7.6E+00	0.0	0.73171	1.6	3.6E+01	85.0	0.1678	24.0	5.2E+01	8002.3
SG-9-6R	7.6E+00	0.0	0.73171	1.5	3.6E+01	79.7	0.1678	23.0	5.2E+01	7668.8
SG-9-12	7.6E+00	0.0	0.73171	2.2	3.6E+01	116.9	0.1678	30.0	5.2E+01	10002.8
SG-10	7.6E+00	7240.8	0.73171	87.0	3.6E+01	4621.7	0.1678	129.0	5.2E+01	43012.1
SG-11	7.6E+00	303.3	0.73171	8.6	3.6E+01	456.9	0.1678	16.0	5.2E+01	5334.8
SG-12	7.6E+00	0.0	0.73171	1.6	3.6E+01	85.0	0.1678	11.0	5.2E+01	3667.7
SG-13	7.6E+00	0.0	0.73171	2.6	3.6E+01	138.1	0.1678	97.0	5.2E+01	32342.5
SG-14	7.6E+00	11888.7	0.73171	1.6	3.6E+01	85.0	0.1678	209.0	5.2E+01	69686.3
SG-15	7.6E+00	0.0	0.73171	1.2	3.6E+01	63.7	0.1678	43.0	5.2E+01	14337.4
SG-16	7.6E+00	0.0	0.73171	0.0	3.6E+01	0.0	0.1678	6.6	5.2E+01	2200.6
SG-17	7.6E+00	0.0	0.73171	0.0	3.6E+01	0.0	0.1678	1.6	5.2E+01	533.5
SG-18	7.6E+00	0.0	0.73171	0.0	3.6E+01	0.0	0.1678	7.5	5.2E+01	2500.7
SG-19	7.6E+00	0.0	0.73171	0.0	3.6E+01	0.0	0.1678	21.0	5.2E+01	7002.0
SG-20	7.6E+00	0.0	0.73171	0.0	3.6E+01	0.0	0.1678	11.0	5.2E+01	3667.7
SG-21	7.6E+00	0.0	0.73171	0.0	3.6E+01	0.0	0.1678	4.5	5.2E+01	1500.4
SG-22R	7.6E+00	0.0	0.73171	0.0	3.6E+01	0.0	0.1678	4.8	5.2E+01	1600.5
SG-22	7.6E+00	0.0	0.73171	0.0	3.6E+01	0.0	0.1678	4.9	5.2E+01	1633.8
SG-23	7.6E+00	0.0	0.73171	0.0	3.6E+01	0.0	0.1678	2.6	5.2E+01	866.9
SG-25	7.6E+00	0.0	0.73171	0.0	3.6E+01	0.0	0.1678	4.3	5.2E+01	1433.7
SG-27	7.6E+00	0.0	0.73171	0.0	3.6E+01	0.0	0.1678	1.4	5.2E+01	466.8
SG-29	7.6E+00	0.0	0.73171	1.1	3.6E+01	58.4	0.1678	2.3	5.2E+01	766.9
SG-30	7.6E+00	0.0	0.73171	0.0	3.6E+01	0.0	0.1678	3.7	5.2E+01	1233.7
SG-38	7.6E+00	0.0	0.73171	0.0	3.6E+01	0.0	0.1678	2.5	5.2E+01	833.6
SG-41	7.6E+00	0.0	0.73171	0.0	3.6E+01	0.0	0.1678	0.0	5.2E+01	0.0
SG-44	7.6E+00	0.0	0.73171	0.0	3.6E+01	0.0	0.1678	0.0	5.2E+01	0.0
SG-46	7.6E+00	0.0	0.73171	0.0	3.6E+01	0.0	0.1678	0.0	5.2E+01	0.0
SG-47	7.6E+00	0.0	0.73171	0.0	3.6E+01	0.0	0.1678	0.0	5.2E+01	0.0
SG-49-6	7.6E+00	0.0	0.73171	0.0	3.6E+01	0.0	0.1678	45.0	5.2E+01	15004.2
SG-49-12	7.6E+00	0.0	0.73171	2.2	3.6E+01	116.9	0.1678	68.0	5.2E+01	22673.1
SG-50-6	7.6E+00	229.9	0.73171	4.0	3.6E+01	212.5	0.1678	85.0	5.2E+01	28341.3
SG-50-12	7.6E+00	78.3	0.73171	1.1	3.6E+01	58.4	0.1678	18.0	5.2E+01	6001.7
SG-50-12R	7.6E+00	93.0	0.73171	1.2	3.6E+01	63.7	0.1678	21.0	5.2E+01	7002.0
SG-51-6	7.6E+00	406.1	0.73171	2.2	3.6E+01	116.9	0.1678	33.0	5.2E+01	11003.1
SG-51-12	7.6E+00	880.6	0.73171	2.6	3.6E+01	138.1	0.1678	56.0	5.2E+01	18671.9
SG-52-6	7.6E+00	0.0	0.73171	0.0	3.6E+01	0.0	0.1678	2.4	5.2E+01	800.2
SG-52-12	7.6E+00	0.0	0.73171	0.0	3.6E+01	0.0	0.1678	10.0	5.2E+01	3334.3
SG-54	7.6E+00	0.0	0.73171	0.0	3.6E+01	0.0	0.1678	0.0	5.2E+01	0.0
SG-55	7.6E+00	0.0	0.73171	0.0	3.6E+01	0.0	0.1678	0.0	5.2E+01	0.0
SG-56	7.6E+00	0.0	0.73171	0.0	3.6E+01	0.0	0.1678	0.0	5.2E+01	0.0
SG-57	7.6E+00	0.0	0.73171	0.0	3.6E+01	0.0	0.1678	0.0	5.2E+01	0.0
SG-58	7.6E+00	0.0	0.73171	0.0	3.6E+01	0.0	0.1678	0.0	5.2E+01	0.0

Based on these calculations, the data from 1,1-dichloroethene was chosen to represent the most extensive contamination. The estimated area of contamination was determined by creating an concentration map, including all values which exceeded the RBC for 1,1-dichloroethene in industrial soil (4.8 mg/kg). This area is shown on Figure D-1.

D.3 CALCULATION OF AREA AND VOLUME

The area of soil contamination was estimated using a planimeter. Five measurements were used to determine an average value of 556, which resulted in an area of 22,240 ft^2 when converted based on the scale of the map and the length of the tracer arm. The volume of contaminated soil was 324,704 ft^3 (12,026 yd^3), using an average depth to groundwater equal to 14.6 feet.



NOTES.
1. Horizontal Datum: Virginia State Plane Coordinate System.
2. Vertical Datum: N.G.V.D.
3. Horizontal and vertical data based on control information provided by N.A.S.A.
4. This plan represents a field survey taken by Ramesh C. Batta Associates, P.A. FEBRUARY 1994

1,1-Dichloroethene	
Sample Number	Total Soil Concentration (mg/kg)
SG-1	69.7
SG-2	2.0
SG-3	10.0
SG-4	0.7
SG-5	4.0
SG-6	0.4
SG-8	1.1
SG-9	10.0
SG-10	43.0
SG-11	5.3
SG-12	3.7
SG-13	32.3
SG-14	69.7
SG-15	14.3
SG-16	2.2
SG-17	0.5
SG-18	2.5
SG-19	7.0
SG-20	3.7
SG-21	1.5
SG-22	1.6
SG-23	0.9
SG-25	1.4
SG-27	0.5
SG-29	0.6
SG-30	1.2
SG-36	0.8
SG-49	22.7
SG-50	28.3
SG-51	18.7
SG-52	3.3

LEGEND

EXISTING CONTOUR
EXISTING SPOT ELEVATION · 27x2
SOIL GAS SAMPLE LOCATION t_{23}
ESTIMATED AREA OF CONTAMINATION CONCENTRATIONS OF 1,1-DICHLOROETHENE IN PPM

50 25 0 50

METCALF & EDDY INC.
14502 GREENVIEW DRIVE
SUITE 500
LAUREL, MARYLAND
20708

FIGURE D-1
ESTIMATED AREA OF CONTAMINATED SOIL
FORMER FIRE TRAINING AREA
NASA/GODDARD SPACE FLIGHT CENTER
WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA

APPENDIX E

WORKSHEETS FOR DOSE ESTIMATION

TABLE E-1
DOSE ESTIMATES: INGESTION OF SOIL FOR CURRENT LAND USE

Chemical Name	MAX CS (μg/kg)	AVE CS (μg/kg)	CF ($1kg/10^9 \mu g$)	IR (mg/day)	FI (unitless)	EF (days/365days)	ED (years)	BW (kg)	AT (years) Non-carcinogenic	MAX CDI (mg/kg/day)	AVE CDI (mg/kg/day)
Benzo(a)pyrene	130	84.5	1.00E-09	50	1	250/365	25	70	25	6.36E-08	4.13E-08
Benzo(g,h,i)perylene	91	91	1.00E-09	50	1	250/365	25	70	25	4.45E-08	4.45E-08
Arsenic	6,300	2,580	1.00E-09	50	1	250/365	25	70	25	3.08E-06	1.26E-06
Lead	33,800	12,900	1.00E-09	50	1	250/365	25	70	25	1.65E-05	6.31E-06

Chemical Name	MAX CS (μg/kg)	AVE CS (μg/kg)	CF ($1kg/10^9 \mu g$)	IR (mg/day)	FI (unitless)	EF (days/365days)	ED (years)	BW (kg)	AT (years) Carcinogenic	MAX CDI (mg/kg/day)	AVE CDI (mg/kg/day)
Benzo(a)pyrene	130	84.5	1.00E-09	50	1	250/365	25	70	70	2.27E-08	1.48E-08
Benzo(g,h,i)perylene	91	91	1.00E-09	50	1	250/365	25	70	70	1.59E-08	1.59E-08
Arsenic	6,300	2,580	1.00E-09	50	1	250/365	25	70	70	1.10E-06	4.51E-07
Lead	33,800	12,900	1.00E-09	50	1	250/365	25	70	70	5.91E-06	2.25E-06

KEY: CDI = Chronic Daily Chemical Intake (mg/kg/day) [Formula: CDI=(CS*CF*IR*FI*EF*ED)/(BW*AT)]
CS = Chemical Concentration in Soil (μg/kg)
EF = Exposure Frequency (#days/365days)
CF = Conversion Factor ($1kg/10^9 \mu g$)
ED = Exposure Duration (years)
IR = Ingestion Rate (mg/day)
BW = Body Weight (kg)
FI= Fraction Ingested from Source (unitless)
AT = Averaging Time: Exposure Duration Value for Non-carcinogens and 70 for Carcinogens (years)

TABLE E-2
DOSE ESTIMATES: DERMAL ABSORPTION OF SOIL FOR CURRENT LAND USE

Chemical Name	MAX CS (μg/kg)	AVE CS (μg/kg)	CF ($1kg/10^9\mu g$)	SA (cm^2)	AF (mg/cm^2)	ABS (unitless)	EF (days/365days)	ED (years)	BW (kg)	AT (years) Non-carcinogenic	MAX AD (mg/kg/day)	AVE AD (mg/kg/day)
Benzo(a)pyrene	130	84.5	1.00E-09	1,890	1.45	0.10	250/365	25	70	25	3.49E-07	2.27E-07
Benzo(g,h,i)perylene	91	91	1.00E-09	1,890	1.45	0.10	250/365	25	70	25	2.44E-07	2.44E-07
Arsenic	6,300	2,580	1.00E-09	1,890	1.45	0.03	250/365	25	70	25	5.07E-06	2.08E-06
Lead	33,800	12,900	1.00E-09	1,890	1.45	0.01	250/365	25	70	25	9.06E-06	3.46E-06

Chemical Name	MAX CS (μg/kg)	AVE CS (μg/kg)	CF ($1kg/10^9\mu g$)	SA (cm^2)	AF (mg/cm^2)	ABS (unitless)	EF (days/365days)	ED (years)	BW (kg)	AT (years) Carcinogenic	MAX AD (mg/kg/day)	AVE AD (mg/kg/day)
Benzo(a)pyrene	130	84.5	1.00E-09	1,890	1.45	0.10	250/365	25	70	70	1.24E-07	8.09E-08
Benzo(g,h,i)perylene	91	91	1.00E-09	1,890	1.45	0.10	250/365	25	70	70	8.71E-08	8.71E-08
Arsenic	6,300	2,580	1.00E-09	1,890	1.45	0.03	250/365	25	70	70	1.81E-06	7.41E-07
Lead	33,800	12,900	1.00E-09	1,890	1.45	0.01	250/365	25	70	70	3.24E-06	1.24E-06

KEY: AD = Absorbed Dose (mg/kg/day) [Formula: AD=(CS*CF*SA*AF*ABS*EF*ED)/(BW*AT)]
CS = Chemical Concentration in Soil (μg/kg)
CF = Conversion Factor ($1kg/10^9\mu g$)
SA = Skin Surface Area Exposed (cm^2)
AF = Soil to Skin Adherence Factor (mg/cm^2)
EF = Exposure Frequency (#days/365days)
ED = Exposure Duration (years)
BW = Body Weight (kg)
AT = Averaging Time: Exposure Duration Value for Non-carcinogens and 70 for Carcinogens (years)
ABS = Dermal Absorption Factor (unitless) [(Volatiles=0.25), (Semi-Volatiles=0.10), (Pesticides other than DDT=0.10), (Arsenic=0.03, other inorganics=0.01)]

TABLE E-3
DOSE ESTIMATES: INGESTION OF SEDIMENT FOR CURRENT LAND USE

Chemical Name	MAX CS (µg/kg)	AVE CS (µg/kg)	CF (1kg/10^9µg)	IR (mg/day)	FI (unitless)	EF (days/365days)	ED (years)	BW (kg)	AT (years) Non-carcinogenic	MAX CDI (mg/kg/day)	AVE CDI (mg/kg/day)
Benzo(b)fluoranthene	1,600	583	1.00E-09	50	1	250/365	25	70	25	7.83E-07	2.85E-07
Phenanthrene	140	140	1.00E-09	50	1	250/365	25	70	25	6.85E-08	6.85E-08
Benzo(a)pyrene	550	550	1.00E-09	50	1	250/365	25	70	25	2.69E-07	2.69E-07
Dibenz(a,h)anthracene	240	240	1.00E-09	50	1	250/365	25	70	25	1.17E-07	1.17E-07
Benzo(g,h,i)perylene	340	340	1.00E-09	50	1	250/365	25	70	25	1.66E-07	1.66E-07
Arsenic	9,000	5,400	1.00E-09	50	1	250/365	25	70	25	4.40E-06	2.64E-06
Lead	67,500	40,000	1.00E-09	50	1	250/365	25	70	25	3.30E-05	1.96E-05

Chemical Name	MAX CS (µg/kg)	AVE CS (µg/kg)	CF (1kg/10^9µg)	IR (mg/day)	FI (unitless)	EF (days/365days)	ED (years)	BW (kg)	AT (years) Carcinogenic	CDI (mg/kg/day)	AVE CDI (mg/kg/day)
Benzo(b)fluoranthene	1,600	583	1.00E-09	50	1	250/365	25	70	70	2.80E-07	1.02E-07
Phenanthrene	140	140	1.00E-09	50	1	250/365	25	70	70	2.45E-08	2.45E-08
Benzo(a)pyrene	550	550	1.00E-09	50	1	250/365	25	70	70	9.61E-08	9.61E-08
Dibenz(a,h)anthracene	240	240	1.00E-09	50	1	250/365	25	70	70	4.19E-08	4.19E-08
Benzo(g,h,i)perylene	340	340	1.00E-09	50	1	250/365	25	70	70	5.94E-08	5.94E-08
Arsenic	9,000	5,400	1.00E-09	50	1	250/365	25	70	70	1.57E-06	9.44E-07
Lead	67,500	40,000	1.00E-09	50	1	250/365	25	70	70	1.18E-05	6.99E-06

KEY: CDI = Chronic Daily Chemical Intake (mg/kg/day) [Formula: CDI=(CS*CF*IR*FI*EF*ED)/(BW*AT)]
CS = Chemical Concentration in Sediment (µg/kg) EF = Exposure Frequency (#days/365days)
CF = Conversion Factor (1kg/10^9µg) ED = Exposure Duration (years)
IR = Ingestion Rate (mg/day) BW = Body Weight (kg)
FI= Fraction Ingested from Source (unitless)
AT = Averaging Time: Exposure Duration Value for Non-carcinogens and 70 for Carcinogens (years)

TABLE E-4
DOSE ESTIMATES: DERMAL ABSORPTION OF SEDIMENT FOR CURRENT LAND USE

Chemical Name	MAX CS (μg/kg)	AVE CS (μg/kg)	CF (1kg/10^9μg)	SA (cm^2)	AF (mg/cm^2)	ABS (unitless)	EF (days/365days)	ED (years)	BW (kg)	AT (years) Non-carcinogenic	MAX AD (mg/kg/day)	AVE AD (mg/kg/day)
Benzo(b)fluoranthene	1,600	583	1.00E-09	1,890	1.45	0.10	250/365	25	70	25	4.29E-06	1.56E-06
Phenanthrene	140	140	1.00E-09	1,890	1.45	0.10	250/365	25	70	25	3.75E-07	3.75E-07
Benzo(a)pyrene	550	550	1.00E-09	1,890	1.45	0.10	250/365	25	70	25	1.47E-06	1.47E-06
Dibenz(a,h)anthracene	240	240	1.00E-09	1,890	1.45	0.10	250/365	25	70	25	6.44E-07	6.44E-07
Benzo(g,h,i)perylene	340	340	1.00E-09	1,890	1.45	0.10	250/365	25	70	25	9.12E-07	9.12E-07
Arsenic	9,000	5,400	1.00E-09	1,890	1.45	0.03	250/365	25	70	25	7.24E-06	4.34E-06
Lead	67,500	40,000	1.00E-09	1,890	1.45	0.01	250/365	25	70	25	1.81E-05	1.07E-05

Chemical Name	MAX CS (μg/kg)	AVE CS (μg/kg)	CF (1kg/10^9μg)	SA (cm^2)	AF (mg/cm^2)	ABS (unitless)	EF (days/365days)	ED (years)	BW (kg)	AT (years) Carcinogenic	MAX AD (mg/kg/day)	AVE AD (mg/kg/day)
Benzo(b)fluoranthene	1,600	583	1.00E-09	1,890	1.45	0.10	250/365	25	70	70	1.53E-06	5.58E-07
Phenanthrene	140	140	1.00E-09	1,890	1.45	0.10	250/365	25	70	70	1.34E-07	1.34E-07
Benzo(a)pyrene	550	550	1.00E-09	1,890	1.45	0.10	250/365	25	70	70	5.27E-07	5.27E-07
Dibenz(a,h)anthracene	240	240	1.00E-09	1,890	1.45	0.10	250/365	25	70	70	2.30E-07	2.30E-07
Benzo(g,h,i)perylene	340	340	1.00E-09	1,890	1.45	0.10	250/365	25	70	70	3.26E-07	3.26E-07
Arsenic	9,000	5,400	1.00E-09	1,890	1.45	0.03	250/365	25	70	70	2.59E-06	1.55E-06
Lead	67,500	40,000	1.00E-09	1,890	1.45	0.01	250/365	25	70	70	6.46E-06	3.83E-06

KEY: AD = Absorbed Dose (mg/kg/day) [Formula: AD=(CS*CF*SA*AF*ABS*EF*ED)/(BW*AT)]
CS = Chemical Concentration in Sediment (μg/kg)
CF = Conversion Factor (1kg/10^9μg)
SA = Skin Surface Area Exposed (cm^2)
AF = Sediment to Skin Adherence Factor (mg/cm^2)
EF = Exposure Frequency (#days/365days)
ED = Exposure Duration (years)
BW = Body Weight (kg)
AT = Averaging Time: Exposure Duration Value for Non-carcinogens and 70 for Carcinogens (years)
ABS = Dermal Absorption Factor (unitless) [(Volatiles=0.25), (Semi-Volatiles=0.10), (Pesticides other than DDT=0.10), (Arsenic=0.03, other inorganics=0.01)]

TABLE E-5
DOSE ESTIMATES: DERMAL ABSORPTION OF SURFACE WATER FOR CURRENT LAND USE

Chemical Name	MAX CW (µg/l)	AVE CW (µg/l)	SA (cm^2)	PC (cm/hr)	ET (hrs/day)	CF (l/cm^3)	EF (days/365days)	ED (years)	BW (kg)	AT (years) Non-carcinogenic	AD (mg/kg/day)	AVE AD (mg/kg/day)
Arsenic	5.30	3.90	3190	1.0E-03	2	1.00E-03	50/365	25	70	25	6.62E-08	4.87E-08
Lead	7.00	1.85	3190	1.0E-03	2	1.00E-03	50/365	25	70	25	8.74E-08	2.31E-08

Chemical Name	MAX CW (µg/l)	AVE CW (µg/l)	SA (cm^2)	PC (cm/hr)	ET (hrs/day)	CF (l/cm^3)	EF (days/365days)	ED (years)	BW (kg)	AT (years) Carcinogenic	AD (mg/kg/day)	AVE AD (mg/kg/day)
Arsenic	5.30	3.90	3190	1.0E-03	2	1.00E-03	50/365	25	70	70	2.36E-08	1.74E-08
Lead	7.00	1.85	3190	1.0E-03	2	1.00E-03	50/365	25	70	70	3.12E-08	8.25E-09

KEY: AD = Absorbed Dose (mg/kg/day) [Formula: AD=(CW*SA*PC*ET*CF*EF*ED)/(BW*AT)]
CW = Chemical Concentration in Surface Water (µg/l)
CF = Volumetric Conversion Factor ($1l/cm^3$)
SA = Skin Surface Area Exposed - Lower Legs and Feet (cm^2)
EF = Exposure Frequency (#days/365days)
PC = Chemical Specific Dermal Permeability Constant (cm/hr)
ED = Exposure Duration (years)
ET = Exposure Time (hrs/day)
BW = Body Weight (kg)
AT = Averaging Time: Exposure Duration Value for Non-carcinogens and 70 for Carcinogens (years)

TABLE E-6
DOSE ESTIMATES: INGESTION OF SOIL FOR FUTURE LAND USE AND CHRONIC EXPOSURE (ADULT)

Chemical Name	MAX CS (µg/kg)	AVE CS (µg/kg)	CF (1kg/10^9µg)	IR (mg/day)	FI (unitless)	EF (days/365days)	ED (years)	BW (kg)	AT (years) Non-carcinogenic	MAX CDI (mg/kg/day)	AVE CDI (mg/kg/day)
Phenanthrene	610	332	1.00E-09	50	1	350/365	24	70	24	4.18E-07	2.27E-07
Benzo(a)anthracene	6,200	460	1.00E-09	50	1	350/365	24	70	24	4.25E-06	3.15E-07
Benzo(b)fluoranthene	6,900	583	1.00E-09	50	1	350/365	24	70	24	4.73E-06	3.99E-07
Benzo(a)pyrene	3,300	392	1.00E-09	50	1	350/365	24	70	24	2.26E-06	2.68E-07
Benzo(g,h,i)perylene	2,300	2,300	1.00E-09	50	1	350/365	24	70	24	1.58E-06	1.58E-06
Dibenz(a,h)anthracene	630	630	1.00E-09	50	1	350/365	24	70	24	4.32E-07	4.32E-07
Arsenic	9,000	5,400	1.00E-09	50	1	350/365	24	70	24	6.16E-06	3.70E-06
Lead	67,500	40,000	1.00E-09	50	1	350/365	24	70	24	4.62E-05	2.74E-05

Chemical Name	MAX CS (µg/kg)	AVE CS (µg/kg)	CF (1kg/10^9µg)	IR (mg/day)	FI (unitless)	EF (days/365days)	ED (years)	BW (kg)	AT (years) Carcinogenic	MAX CDI (mg/kg/day)	AVE CDI (mg/kg/day)
Phenanthrene	610	332	1.00E-09	50	1	350/365	24	70	70	1.43E-07	7.80E-08
Benzo(a)anthracene	6,200	460	1.00E-09	50	1	350/365	24	70	70	1.46E-06	1.08E-07
Benzo(b)fluoranthene	6,900	583	1.00E-09	50	1	350/365	24	70	70	1.62E-06	1.37E-07
Benzo(a)pyrene	3,300	392	1.00E-09	50	1	350/365	24	70	70	7.75E-07	9.21E-08
Benzo(g,h,i)perylene	2,300	2,300	1.00E-09	50	1	350/365	24	70	70	5.40E-07	5.40E-07
Dibenz(a,h)anthracene	630	630	1.00E-09	50	1	350/365	24	70	70	1.48E-07	1.48E-07
Arsenic	9,000	5,400	1.00E-09	50	1	350/365	24	70	70	2.11E-06	1.27E-06
Lead	67,500	40,000	1.00E-09	50	1	350/365	24	70	70	1.59E-05	9.39E-06

KEY: CDI = Chronic Daily Chemical Intake (mg/kg/day) [Formula: CDI=(CS*CF*IR*FI*EF*ED)/(BW*AT)]
CS = Chemical Concentration in Soil (µg/kg) EF = Exposure Frequency (#days/365days)
CF = Conversion Factor (1kg/10^9µg) ED = Exposure Duration (years)
IR = Ingestion Rate (mg/day) BW = Body Weight (kg)
FI= Fraction Ingested from Source (unitless)
AT = Averaging Time: Exposure Duration Value for Non-carcinogens and 70 for Carcinogens (years)

TABLE E-7
DOSE ESTIMATES: INGESTION OF SOIL FOR FUTURE LAND USE AND CHRONIC EXPOSURE (CHILD)

Chemical Name	MAX CS (µg/kg)	AVE CS (µg/kg)	CF (1kg/10^9µg)	IR (mg/day)	FI (unitless)	EF (days/365days)	ED (years)	BW (kg)	AT (years) Non-carcinogenic	MAX CDI (mg/kg/day)	AVE CDI (mg/kg/day)
Phenanthrene	610	332	1.00E-09	100	1	350/365	6	15	6	3.90E-06	2.12E-06
Benzo(a)anthracene	6,200	460	1.00E-09	100	1	350/365	6	15	6	3.96E-05	2.94E-06
Benzo(b)fluoranthene	6,900	583	1.00E-09	100	1	350/365	6	15	6	4.41E-05	3.73E-06
Benzo(a)pyrene	3,300	392	1.00E-09	100	1	350/365	6	15	6	2.11E-05	2.51E-06
Benzo(g,h,i)perylene	2,300	2,300	1.00E-09	100	1	350/365	6	15	6	1.47E-05	1.47E-05
Dibenz(a,h)anthracene	630	630	1.00E-09	100	1	350/365	6	15	6	4.03E-06	4.03E-06
Arsenic	9,000	5,400	1.00E-09	100	1	350/365	6	15	6	5.75E-05	3.45E-05
Lead	67,500	40,000	1.00E-09	100	1	350/365	6	15	6	4.32E-04	2.56E-04

Chemical Name	MAX CS (µg/kg)	AVE CS (µg/kg)	CF (1kg/10^9µg)	IR (mg/day)	FI (unitless)	EF (days/365days)	ED (years)	BW (kg)	AT (years) Carcinogenic	MAX CDI (mg/kg/day)	AVE CDI (mg/kg/day)
Phenanthrene	610	332	1.00E-09	100	1	350/365	6	15	70	3.34E-07	1.82E-07
Benzo(a)anthracene	6,200	460	1.00E-09	100	1	350/365	6	15	70	3.40E-06	2.52E-07
Benzo(b)fluoranthene	6,900	583	1.00E-09	100	1	350/365	6	15	70	3.78E-06	3.19E-07
Benzo(a)pyrene	3,300	392	1.00E-09	100	1	350/365	6	15	70	1.81E-06	2.15E-07
Benzo(g,h,i)perylene	2,300	2,300	1.00E-09	100	1	350/365	6	15	70	1.26E-06	1.26E-06
Dibenz(a,h)anthracene	630	630	1.00E-09	100	1	350/365	6	15	70	3.45E-07	3.45E-07
Arsenic	9,000	5,400	1.00E-09	100	1	350/365	6	15	70	4.93E-06	2.96E-06
Lead	67,500	40,000	1.00E-09	100	1	350/365	6	15	70	3.70E-05	2.19E-05

KEY: CDI = Chronic Daily Chemical Intake (mg/kg/day) [Formula: CDI=(CS*CF*IR*FI*EF*ED)/(BW*AT)]
CS = Chemical Concentration in Soil (µg/kg)
CF = Conversion Factor (1kg/10^9µg)
IR = Ingestion Rate (mg/day)
FI= Fraction Ingested from Source (unitless)
EF = Exposure Frequency (#days/365days)
ED = Exposure Duration (years)
BW = Body Weight (kg)
AT = Averaging Time: Exposure Duration Value for Non-carcinogens and 70 for Carcinogens (years)

TABLE E-8
DOSE ESTIMATES: DERMAL ABSORPTION OF SOIL FOR FUTURE LAND USE AND CHRONIC EXPOSURE (ADULT)

Chemical Name	MAX CS (µg/kg)	AVE CS (µg/kg)	CF (1kg/10^9µg)	SA (cm^2)	AF (mg/cm^2)	ABS (unitless)	EF (days/365days)	ED (years)	BW (kg)	AT (years) Non-carcinogenic	MAX AD (mg/kg/day)	AVE AD (mg/kg/day)
Phenanthrene	610	332	1.00E-09	1,890	1.45	0.10	350/365	24	70	24	2.29E-06	1.25E-06
Benzo(a)anthracene	6,200	460	1.00E-09	1,890	1.45	0.10	350/365	24	70	24	2.33E-05	1.73E-06
Benzo(b)fluoranthene	6,900	583	1.00E-09	1,890	1.45	0.10	350/365	24	70	24	2.59E-05	2.19E-06
Benzo(a)pyrene	3,300	392	1.00E-09	1,890	1.45	0.10	350/365	24	70	24	1.24E-05	1.47E-06
Benzo(g,h,i)perylene	2,300	2,300	1.00E-09	1,890	1.45	0.10	350/365	24	70	24	8.63E-06	8.63E-06
Dibenz(a,h)anthracene	630	630	1.00E-09	1,890	1.45	0.10	350/365	24	70	24	2.37E-06	2.37E-06
Arsenic	9,000	5,400	1.00E-09	1,890	1.45	0.03	350/365	24	70	24	1.01E-05	6.08E-06
Lead	67,500	40,000	1.00E-09	1,890	1.45	0.01	350/365	24	70	24	2.53E-05	1.50E-05

Chemical Name	MAX CS (µg/kg)	AVE CS (µg/kg)	CF (1kg/10^9µg)	SA (cm^2)	AF (mg/cm^2)	ABS (unitless)	EF (days/365days)	ED (years)	BW (kg)	AT (years) Carcinogenic	MAX AD (mg/kg/day)	AVE AD (mg/kg/day)
Phenanthrene	610	332	1.00E-09	1,890	1.45	0.10	350/365	24	70	70	7.85E-07	4.27E-07
Benzo(a)anthracene	6,200	460	1.00E-09	1,890	1.45	0.10	350/365	24	70	70	7.98E-06	5.92E-07
Benzo(b)fluoranthene	6,900	583	1.00E-09	1,890	1.45	0.10	350/365	24	70	70	8.88E-06	7.50E-07
Benzo(a)pyrene	3,300	392	1.00E-09	1,890	1.45	0.10	350/365	24	70	70	4.25E-06	5.05E-07
Benzo(g,h,i)perylene	2,300	2,300	1.00E-09	1,890	1.45	0.10	350/365	24	70	70	2.96E-06	2.96E-06
Dibenz(a,h)anthracene	630	630	1.00E-09	1,890	1.45	0.10	350/365	24	70	70	8.11E-07	8.11E-07
Arsenic	9,000	5,400	1.00E-09	1,890	1.45	0.03	350/365	24	70	70	3.48E-06	2.09E-06
Lead	67,500	40,000	1.00E-09	1,890	1.45	0.01	350/365	24	70	70	8.69E-06	5.15E-06

KEY: AD = Absorbed Dose (mg/kg/day)] [Formula: AD=(CS*CF*SA*AF*ABS*EF*ED)/(BW*AT)

CS = Chemical Concentration in Soil (µg/kg)

CF = Conversion Factor (1kg/10^9µg)

SA = Skin Surface Area Exposed (cm^2)

AF = Soil to Skin Adherence Factor (mg/cm^2)

EF = Exposure Frequency (#days/365days)

ED = Exposure Duration (years)

BW = Body Weight (kg)

AT = Averaging Time: Exposure Duration Value for Non-carcinogens and 70 for Carcinogens (years)

ABS = Dermal Absorption Factor (unitless) [(Volatiles=0.25), (Semi-Volatiles=0.10), (Pesticides other than DDT=0.10), (Arsenic=0.03, other inorganics=0.01)]

TABLE E-9
DOSE ESTIMATES: DERMAL ABSORPTION OF SOIL FOR FUTURE LAND USE AND CHRONIC EXPOSURE (CHILD)

Chemical Name	MAX CS (µg/kg)	AVE CS (µg/kg)	CF (1kg/10^9µg)	SA (cm^2)	AF (mg/cm^2)	ABS (unitless)	EF (days/365days)	ED (years)	BW (kg)	AT (years) Non-carcinogenic	MAX AD (mg/kg/day)	AVE AD (mg/kg/day)
Phenanthrene	610	332	1.00E-09	830	1.45	0.10	350/365	6	15	6	4.69E-06	2.55E-06
Benzo(a)anthracene	6,200	460	1.00E-09	830	1.45	0.10	350/365	6	15	6	4.77E-05	3.54E-06
Benzo(b)fluoranthene	6,900	583	1.00E-09	830	1.45	0.10	350/365	6	15	6	5.31E-05	4.49E-06
Benzo(a)pyrene	3,300	392	1.00E-09	830	1.45	0.10	350/365	6	15	6	2.54E-05	3.02E-06
Benzo(g,h,i)perylene	2,300	2,300	1.00E-09	830	1.45	0.10	350/365	6	15	6	1.77E-05	1.77E-05
Dibenz(a,h)anthracene	630	630	1.00E-09	830	1.45	0.10	350/365	6	15	6	4.85E-06	4.85E-06
Arsenic	9,000	5,400	1.00E-09	830	1.45	0.03	350/365	6	15	6	2.08E-05	1.25E-05
Lead	67,500	40,000	1.00E-09	830	1.45	0.01	350/365	6	15	6	5.19E-05	3.08E-05

Chemical Name	MAX CS (µg/kg)	AVE CS (µg/kg)	CF (1kg/10^9µg)	SA (cm^2)	AF (mg/cm^2)	ABS (unitless)	EF (days/365days)	ED (years)	BW (kg)	AT (years) Carcinogenic	MAX AD (mg/kg/day)	AVE AD (mg/kg/day)
Phenanthrene	610	332	1.00E-09	830	1.45	0.10	350/365	6	15	70	4.02E-07	2.19E-07
Benzo(a)anthracene	6,200	460	1.00E-09	830	1.45	0.10	350/365	6	15	70	4.09E-06	3.03E-07
Benzo(b)fluoranthene	6,900	583	1.00E-09	830	1.45	0.10	350/365	6	15	70	4.55E-06	3.84E-07
Benzo(a)pyrene	3,300	392	1.00E-09	830	1.45	0.10	350/365	6	15	70	2.18E-06	2.59E-07
Benzo(g,h,i)perylene	2,300	2,300	1.00E-09	830	1.45	0.10	350/365	6	15	70	1.52E-06	1.52E-06
Dibenz(a,h)anthracene	630	630	1.00E-09	830	1.45	0.10	350/365	6	15	70	4.15E-07	4.15E-07
Arsenic	9,000	5,400	1.00E-09	830	1.45	0.03	350/365	6	15	70	1.78E-06	1.07E-06
Lead	67,500	40,000	1.00E-09	830	1.45	0.01	350/365	6	15	70	4.45E-06	2.64E-06

KEY: AD = Absorbed Dose (mg/kg/day) [Formula: AD=(CS*CF*SA*AF*ABS*EF*ED)/(BW*AT)]
CS = Chemical Concentration in Soil (µg/kg)
CF = Conversion Factor (1kg/10^9µg)
SA = Skin Surface Area Exposed (cm^2)
AF = Soil to Skin Adherence Factor (mg/cm^2)
EF = Exposure Frequency (#days/365days)
ED = Exposure Duration (years)
BW = Body Weight (kg)
AT = Averaging Time: Exposure Duration Value for Non-carcinogens and 70 for Carcinogens (years)
ABS = Dermal Absorption Factor (unitless) [(Volatiles=0.25), (Semi-Volatiles=0.10), (Pesticides other than DDT=0.10), (Arsenic=0.03, other inorganics=0.01)]

TABLE E-10

DOSE ESTIMATES: INGESTION OF GROUNDWATER FROM CHRONIC EXPOSURE UNDER FUTURE LAND USE (CHILD)

Chemical Name	MAX CW (µg/l)	AVE CW (µg/l)	CF (µg/mg)	IR (l/day)	EF (days/365days)	ED (years)	BW (kg)	AT (years) Non-carcinogenic	MAX CDI (mg/kg/day)	AVE CDI (mg/kg/day)
1,1-Dichloroethene	18	2.04	1000	1	350/365	6	15	6	1.15E-03	1.30E-04
cis-1,2-Dichloroethene	3,000	509	1000	1	350/365	6	15	6	1.92E-01	3.25E-02
Methylene Chloride	730	93.1	1000	1	350/365	6	15	6	4.67E-02	5.95E-03
Chloroform	5	1.24	1000	1	350/365	6	15	6	3.20E-04	7.93E-05
Benzene	120	15.1	1000	1	350/365	6	15	6	7.67E-03	9.65E-04
Tetrachloroethene	64	6.06	1000	1	350/365	6	15	6	4.09E-03	3.87E-04
Toluene	1,800	115	1000	1	350/365	6	15	6	1.15E-01	7.35E-03
Trimethylbenzene	700	269	1000	1	350/365	6	15	6	4.47E-02	1.72E-02
Tetramethylbenzene	36	32	1000	1	350/365	6	15	6	2.30E-03	2.05E-03
Phenanthrene	82	16.5	1000	1	350/365	6	15	6	5.24E-03	1.05E-03
2-Methylnaphthalene	3,000	260	1000	1	350/365	6	15	6	1.92E-01	1.66E-02
Naphthalene	2,000	18	1000	1	350/365	6	15	6	1.28E-01	1.15E-03
alpha-BHC	0.049	0.047	1000	1	350/365	6	15	6	3.13E-06	3.00E-06
Heptachlor epoxide	0.016	0.010	1000	1	350/365	6	15	6	1.02E-06	6.39E-07
gamma-Chlordane	0.055	0.021	1000	1	350/365	6	15	6	3.52E-06	1.34E-06
Arsenic	11.1	4.43	1000	1	350/365	6	15	6	7.10E-04	2.83E-04
Lead	10.5	3.33	1000	1	350/365	6	15	6	6.71E-04	2.13E-04

DOSE ESTIMATES: INGESTION OF GROUNDWATER FROM CHRONIC EXPOSURE UNDER FUTURE LAND USE (CHILD)

Chemical Name	MAX CW (µg/l)	AVE CW (µg/l)	CF (µg/mg)	IR (l/day)	EF (days/365days)	ED (years)	BW (kg)	AT (years) Carcinogenic	MAX CDI (mg/kg/day)	AVE CDI (mg/kg/day)
1,1-Dichloroethene	18	2.04	1000	1	350/365	6	15	70	9.86E-05	1.12E-05
cis-1,2-Dichloroethene	3,000	509	1000	1	350/365	6	15	70	1.64E-02	2.79E-03
Methylene Chloride	730	93.1	1000	1	350/365	6	15	70	4.00E-03	5.10E-04
Chloroform	5	1.24	1000	1	350/365	6	15	70	2.74E-05	6.79E-06
Benzene	120	15.1	1000	1	350/365	6	15	70	6.58E-04	8.27E-05
Tetrachloroethene	64	6.06	1000	1	350/365	6	15	70	3.51E-04	3.32E-05
Toluene	1,800	115	1000	1	350/365	6	15	70	9.86E-03	6.30E-04
Trimethylbenzene	700	269	1000	1	350/365	6	15	70	3.84E-03	1.47E-03
Tetramethylbenzene	36	32	1000	1	350/365	6	15	70	1.97E-04	1.75E-04
Phenanthrene	82	16.5	1000	1	350/365	6	15	70	4.49E-04	9.04E-05
2-Methylnaphthalene	3,000	260	1000	1	350/365	6	15	70	1.64E-02	1.42E-03
Naphthalene	2,000	18	1000	1	350/365	6	15	70	1.10E-02	9.86E-05
alpha-BHC	0.049	0.047	1000	1	350/365	6	15	70	2.68E-07	2.58E-07
Heptachlor epoxide	0.016	0.010	1000	1	350/365	6	15	70	8.77E-08	5.48E-08
gamma-Chlordane	0.055	0.021	1000	1	350/365	6	15	70	3.01E-07	1.15E-07
Arsenic	11.1	4.43	1000	1	350/365	6	15	70	6.08E-05	2.43E-05
Lead	10.5	3.33	1000	1	350/365	6	15	70	5.75E-05	1.82E-05

KEY: CDI = Chronic Daily Chemical Intake (mg/kg/day) [Formula: CDI=(CW*IR*EF*ED)/(BW*AT*CF)]
CW = Chemical Concentration in Water (µg/l)
CF = Conversion factor from µg/l to mg/l
IR = Ingestion Rate (l/day)
ED = Exposure Duration (years)
EF = Exposure Frequency (#days/365days)
BW = Body Weight (kg)
AT = Averaging Time: Exposure Duration Value for Non-carcinogens and 70 for Carcinogens (years)

TABLE E-11
DOSE ESTIMATES: INGESTION OF GROUNDWATER FROM CHRONIC EXPOSURE UNDER FUTURE LAND USE (ADULT)

Chemical Name	MAX CW (µg/l)	AVE CW (µg/l)	CF (µg/mg)	IR (l/day)	EF (days/365days)	ED (years)	BW (kg)	AT (years) Non-carcinogenic	MAX CDI (mg/kg/day)	AVE CDI (mg/kg/day)
1,1-Dichloroethene	18	2.04	1000	2	350/365	24	70	24	4.93E-04	5.59E-05
cis-1,2-Dichloroethene	3,000	509	1000	2	350/365	24	70	24	8.22E-02	1.39E-02
Methylene Chloride	730	93.1	1000	2	350/365	24	70	24	2.00E-02	2.55E-03
Chloroform	5	1.24	1000	2	350/365	24	70	24	1.37E-04	3.40E-05
Benzene	120	15.1	1000	2	350/365	24	70	24	3.29E-03	4.14E-04
Tetrachloroethene	64	6.06	1000	2	350/365	24	70	24	1.75E-03	1.66E-04
Toluene	1,800	115	1000	2	350/365	24	70	24	4.93E-02	3.15E-03
Trimethylbenzene	700	269	1000	2	350/365	24	70	24	1.92E-02	7.37E-03
Tetramethylbenzene	36	32	1000	2	350/365	24	70	24	9.86E-04	8.77E-04
Phenanthrene	82	16.5	1000	2	350/365	24	70	24	2.25E-03	4.52E-04
2-Methylnaphthalene	3,000	260	1000	2	350/365	24	70	24	8.22E-02	7.12E-03
Naphthalene	2,000	18	1000	2	350/365	24	70	24	5.48E-02	4.93E-04
alpha-BHC	0.049	0.047	1000	2	350/365	24	70	24	1.34E-06	1.29E-06
Heptachlor epoxide	0.016	0.010	1000	2	350/365	24	70	24	4.38E-07	2.74E-07
gamma-Chlordane	0.055	0.021	1000	2	350/365	24	70	24	1.51E-06	5.75E-07
Arsenic	11.1	4.43	1000	2	350/365	24	70	24	3.04E-04	1.21E-04
Lead	10.5	3.33	1000	2	350/365	24	70	24	2.88E-04	9.12E-05

DOSE ESTIMATES: INGESTION OF GROUNDWATER FROM CHRONIC EXPOSURE UNDER FUTURE LAND USE (ADULT)

Chemical Name	MAX CW (µg/l)	AVE CW (µg/l)	CF (µg/mg)	IR (l/day)	EF (days/365days)	ED (years)	BW (kg)	AT (years) Carcinogenic	MAX CDI (mg/kg/day)	AVE CDI (mg/kg/day)
1,1-Dichloroethene	18	2.04	1000	2	350/365	24	70	70	1.69E-04	1.92E-05
cis-1,2-Dichloroethene	3,000	509	1000	2	350/365	24	70	70	2.82E-02	4.78E-03
Methylene Chloride	730	93.1	1000	2	350/365	24	70	70	6.86E-03	8.75E-04
Chloroform	5	1.24	1000	2	350/365	24	70	70	4.70E-05	1.16E-05
Benzene	120	15.1	1000	2	350/365	24	70	70	1.13E-03	1.42E-04
Tetrachloroethene	64	6.06	1000	2	350/365	24	70	70	6.01E-04	5.69E-05
Toluene	1,800	115	1000	2	350/365	24	70	70	1.69E-02	1.08E-03
Trimethylbenzene	700	269	1000	2	350/365	24	70	70	6.58E-03	2.53E-03
Tetramethylbenzene	36	32	1000	2	350/365	24	70	70	3.38E-04	3.01E-04
Phenanthrene	82	16.5	1000	2	350/365	24	70	70	7.70E-04	1.55E-04
2-Methylnaphthalene	3,000	260	1000	2	350/365	24	70	70	2.82E-02	2.44E-03
Naphthalene	2,000	18	1000	2	350/365	24	70	70	1.88E-02	1.69E-04
alpha-BHC	0.049	0.047	1000	2	350/365	24	70	70	4.60E-07	4.41E-07
Heptachlor epoxide	0.016	0.010	1000	2	350/365	24	70	70	1.50E-07	9.39E-08
gamma-Chlordane	0.055	0.021	1000	2	350/365	24	70	70	5.17E-07	1.97E-07
Arsenic	11.1	4.43	1000	2	350/365	24	70	70	1.04E-04	4.16E-05
Lead	10.5	3.33	1000	2	350/365	24	70	70	9.86E-05	3.13E-05

KEY: CDI = Chronic Daily Chemical Intake (mg/kg/day) [Formula: CDI=(CW*IR*EF*ED)/(BW*AT*CF)]
CW = Chemical Concentration in Water (µg/l)
CF = Conversion factor from µg/l to mg/l
IR = Ingestion Rate (l/day)
ED = Exposure Duration (years)
EF = Exposure Frequency (#days/365days)
BW = Body Weight (kg)
AT = Averaging Time: Exposure Duration Value for Non-carcinogens and 70 for Carcinogens (years)

TABLE E-12
DOSE ESTIMATES: DERMAL ABSORPTION OF GROUNDWATER DUE TO CHRONIC EXPOSURE FOR FUTURE LAND USE (CHILD)

Chemical Name	MAX CW (µg/l)	AVE CW (µg/l)	CF (µg/mg)	SA (cm^2)	PC (cm/hr)	ET (hrs/day)	VCF (l/cm^3)	EF (days/365days)	ED (years)	BW (kg)	AT (years) Non-carcinogenic	MAX AD (mg/kg/day)	AVE AD (mg/kg/day)
1,1-Dichloroethene	18	2.04	1000	9400	1.6E-02	0.25	1.00E-03	350/365	6	15	6	4.33E-05	4.90E-06
cis-1,2-Dichloroethene	3,000	509	1000	9400	1.0E-02	0.25	1.00E-03	350/365	6	15	6	4.51E-03	7.65E-04
Methylene Chloride	730	93.1	1000	9400	4.5E-03	0.25	1.00E-03	350/365	6	15	6	4.94E-04	6.29E-05
Chloroform	5	1.24	1000	9400	8.9E-03	0.25	1.00E-03	350/365	6	15	6	6.69E-06	1.66E-06
Benzene	120	15.1	1000	9400	2.1E-02	0.25	1.00E-03	350/365	6	15	6	3.79E-04	4.76E-05
Tetrachloroethene	64	6.06	1000	9400	4.8E-02	0.25	1.00E-03	350/365	6	15	6	4.62E-04	4.37E-05
Toluene	1,800	115	1000	9400	4.5E-02	0.25	1.00E-03	350/365	6	15	6	1.22E-02	7.77E-04
Trimethylbenzene	700	269	1000	9400	7.4E-02	0.25	1.00E-03	350/365	6	15	6	7.78E-03	2.99E-03
Tetramethylbenzene	36	32	1000	9400	7.4E-02	0.25	1.00E-03	350/365	6	15	6	4.00E-04	3.56E-04
Phenanthrene	82	16.5	1000	18,150	0.0000	0.25	1.00E-03	350/365	24	70	70	0.00E+00	0.00E+00
2-Methylnaphthalene	3,000	260	1000	9400	6.9E-02	0.25	1.00E-03	350/365	6	15	6	3.11E-02	2.70E-03
Naphthalene	2,000	18	1000	9400	6.9E-02	0.25	1.00E-03	350/365	6	15	6	2.07E-02	1.87E-04
alpha-BHC	0.049	0.047	1000	9400	1.4E-02	0.25	1.00E-03	350/365	6	15	6	1.03E-07	9.89E-08
Heptachlor epoxide	0.016	0.010	1000	9400	1.1E-02	0.25	1.00E-03	350/365	6	15	6	2.64E-08	1.65E-08
gamma-Chlordane	0.055	0.021	1000	9400	1.0E-03	0.25	1.00E-03	350/365	6	15	6	8.26E-09	3.15E-09
Arsenic	11.1	4.43	1000	9400	1.0E-03	0.25	1.00E-03	350/365	6	15	6	1.67E-06	6.66E-07
Lead	10.5	3.33	1000	9400	1.0E-03	0.25	1.00E-03	350/365	6	15	6	1.58E-06	5.00E-07

Chemical Name	MAX CW (µg/l)	AVE CW (µg/l)	CF (µg/mg)	SA (cm^2)	PC (cm/hr)	ET (hrs/day)	VCF (l/cm^3)	EF (days/365days)	ED (years)	BW (kg)	AT (years) Carcinogenic	MAX AD (mg/kg/day)	AVE AD (mg/kg/day)
1,1-Dichloroethene	18	2.04	1000	9400	1.6E-02	0.25	1.00E-03	350/365	6	15	70	3.71E-06	4.20E-07
cis-1,2-Dichloroethene	3,000	509	1000	9400	1.0E-02	0.25	1.00E-03	350/365	6	15	70	3.86E-04	6.55E-05
Methylene Chloride	730	93.1	1000	9400	4.5E-03	0.25	1.00E-03	350/365	6	15	70	4.23E-05	5.39E-06
Chloroform	5	1.24	1000	9400	8.9E-03	0.25	1.00E-03	350/365	6	15	70	5.73E-07	1.42E-07
Benzene	120	15.1	1000	9400	2.1E-02	0.25	1.00E-03	350/365	6	15	70	3.24E-05	4.08E-06
Tetrachloroethene	64	6.06	1000	9400	4.8E-02	0.25	1.00E-03	350/365	6	15	70	3.96E-05	3.75E-06
Toluene	1,800	115	1000	9400	4.5E-02	0.25	1.00E-03	350/365	6	15	70	1.04E-03	6.66E-05
Trimethylbenzene	700	269	1000	9400	7.4E-02	0.25	1.00E-03	350/365	6	15	70	6.67E-04	2.56E-04
Tetramethylbenzene	36	32	1000	9400	7.4E-02	0.25	1.00E-03	350/365	6	15	70	3.43E-05	3.05E-05
Phenanthrene	82	16.5	1000	9400	0.0E+00	0.25	1.00E-03	350/365	6	15	70	0.00E+00	0.00E+00
2-Methylnaphthalene	3,000	260	1000	9400	6.9E-02	0.25	1.00E-03	350/365	6	15	70	2.67E-03	2.31E-04
Naphthalene	2,000	18	1000	9400	6.9E-02	0.25	1.00E-03	350/365	6	15	70	1.78E-03	1.60E-05
alpha-BHC	0.049	0.047	1000	9400	1.4E-02	0.25	1.00E-03	350/365	6	15	70	8.83E-09	8.47E-09
Heptachlor epoxide	0.016	0.010	1000	9400	1.1E-02	0.25	1.00E-03	350/365	6	15	70	2.27E-09	1.42E-09
gamma-Chlordane	0.055	0.021	1000	9400	1.0E-03	0.25	1.00E-03	350/365	6	15	70	7.08E-10	2.70E-10
Arsenic	11.1	4.43	1000	9400	1.0E-03	0.25	1.00E-03	350/365	6	15	70	1.43E-07	5.70E-08
Lead	10.5	3.33	1000	9400	1.0E-03	0.25	1.00E-03	350/365	6	15	70	1.35E-07	4.29E-08

KEY: AD = Absorbed Dose (mg/kg/day)
CW = Chemical Concentration in Groundwater (µg/l)
CF = Conversion factor from µg/l to mg/l
SA = Skin Surface Area Exposed - Full Body During Bathing (cm^2)
PC = Chemical Specific Dermal Permeability Constant (cm/hr)
ET = Exposure Time-Bathing (hrs/day)
AT = Averaging Time: Exposure Duration Value for Non-carcinogens and 70 for Carcinogens (years)

[Formula: AD=(CW*SA*PC*ET*VCF*EF*ED)/(BW*AT*CF)]
VCF = Volumetric Conversion Factor ($1l/cm^3$)
EF = Exposure Frequency (#days/365days)
ED = Exposure Duration (years)
BW = Body Weight (kg)

TABLE E-13
DOSE ESTIMATES: DERMAL ABSORPTION OF GROUNDWATER DUE TO CHRONIC EXPOSURE FOR FUTURE LAND USE (ADULT)

Chemical Name	MAX CW (µg/l)	AVE CW (µg/l)	CF (µg/mg)	SA (cm^2)	PC (cm/hr)	ET (hrs/day)	VCF (l/cm^3)	EF (days/365days)	ED (years)	BW (kg)	AT (years) Non-carcinogenic	MAX AD (mg/kg/day)	AVE AD (mg/kg/day)
1,1-Dichloroethene	18	2.04	1000	18,150	1.6E-02	0.25	1.00E-03	350/365	24	70	24	1.79E-05	2.03E-06
cis-1,2-Dichloroethene	3,000	509	1000	18,150	1.0E-02	0.25	1.00E-03	350/365	24	70	24	1.86E-03	3.16E-04
Methylene Chloride	730	93.1	1000	18,150	4.5E-03	0.25	1.00E-03	350/365	24	70	24	2.04E-04	2.60E-05
Chloroform	5	1.24	1000	18,150	8.9E-03	0.25	1.00E-03	350/365	24	70	24	2.77E-06	6.86E-07
Benzene	120	15.1	1000	18,150	2.1E-02	0.25	1.00E-03	350/365	24	70	24	1.57E-04	1.97E-05
Tetrachloroethene	64	6.06	1000	18,150	4.8E-02	0.25	1.00E-03	350/365	24	70	24	1.91E-04	1.81E-05
Toluene	1,800	115	1000	18,150	4.5E-02	0.25	1.00E-03	350/365	24	70	24	5.03E-03	3.22E-04
Trimethylbenzene	700	269	1000	18,150	7.4E-02	0.25	1.00E-03	350/365	24	70	24	3.22E-03	1.24E-03
Tetramethylbenzene	36	32	1000	18,150	7.4E-02	0.25	1.00E-03	350/365	24	70	24	1.66E-04	1.47E-04
Phenanthrene	82	16.5	1000	18,150	0.0000	0.25	1.00E-03	350/365	24	70	70	0.00E+00	0.00E+00
2-Methylnaphthalene	3,000	260	1000	18,150	6.9E-02	0.25	1.00E-03	350/365	24	70	24	1.29E-02	1.12E-03
Naphthalene	2,000	18	1000	18,150	6.9E-02	0.25	1.00E-03	350/365	24	70	24	8.58E-03	7.72E-05
alpha-BHC	0.049	0.047	1000	18,150	1.4E-02	0.25	1.00E-03	350/365	24	70	24	4.26E-08	4.09E-08
Heptachlor epoxide	0.016	0.010	1000	18,150	1.1E-02	0.25	1.00E-03	350/365	24	70	24	1.09E-08	6.84E-09
gamma-Chlordane	0.055	0.021	1000	18,150	1.0E-03	0.25	1.00E-03	350/365	24	70	24	3.42E-09	1.31E-09
Arsenic	11.1	4.43	1000	18,150	1.0E-03	0.25	1.00E-03	350/365	24	70	24	6.90E-07	2.75E-07
Lead	10.5	3.33	1000	18,150	1.0E-03	0.25	1.00E-03	350/365	24	70	24	6.53E-07	2.07E-07

Chemical Name	MAX CW (µg/l)	AVE CW (µg/l)	CF (µg/mg)	SA (cm^2)	PC (cm/hr)	ET (hrs/day)	CF (l/cm^3)	EF (days/365days)	ED (years)	BW (kg)	AT (years) Carcinogenic	MAX AD (mg/kg/day)	AVE AD (mg/kg/day)
1,1-Dichloroethene	18	2.04	1000	18,150	1.6E-02	0.25	1.00E-03	350/365	24	70	70	6.14E-06	6.96E-07
cis-1,2-Dichloroethene	3,000	509	1000	18,150	1.0E-02	0.25	1.00E-03	350/365	24	70	70	6.39E-04	1.08E-04
Methylene Chloride	730	93.1	1000	18,150	4.5E-03	0.25	1.00E-03	350/365	24	70	70	7.00E-05	8.93E-06
Chloroform	5	1.24	1000	18,150	8.9E-03	0.25	1.00E-03	350/365	24	70	70	9.48E-07	2.35E-07
Benzene	120	15.1	1000	18,150	2.1E-02	0.25	1.00E-03	350/365	24	70	70	5.37E-05	6.76E-06
Tetrachloroethene	64	6.06	1000	18,150	4.8E-02	0.25	1.00E-03	350/365	24	70	70	6.55E-05	6.20E-06
Toluene	1,800	115	1000	18,150	4.5E-02	0.25	1.00E-03	350/365	24	70	70	1.73E-03	1.10E-04
Trimethylbenzene	700	269	1000	18,150	7.4E-02	0.25	1.00E-03	350/365	24	70	70	1.10E-03	4.24E-04
Tetramethylbenzene	36	32	1000	18,150	7.4E-02	0.25	1.00E-03	350/365	24	70	70	5.68E-05	5.05E-05
Phenanthrene	82	16.5	1000	18,150	0.0E+00	0.25	1.00E-03	350/365	24	70	70	0.00E+00	0.00E+00
2-Methylnaphthalene	3,000	260	1000	18,150	6.9E-02	0.25	1.00E-03	350/365	24	70	70	4.41E-03	3.82E-04
Naphthalene	2,000	18	1000	18,150	6.9E-02	0.25	1.00E-03	350/365	24	70	70	2.94E-03	2.65E-05
alpha-BHC	0.049	0.047	1000	18,150	1.4E-02	0.25	1.00E-03	350/365	24	70	70	1.46E-08	1.40E-08
Heptachlor epoxide	0.016	0.010	1000	18,150	1.1E-02	0.25	1.00E-03	350/365	24	70	70	3.75E-09	2.34E-09
gamma-Chlordane	0.055	0.021	1000	18,150	1.0E-03	0.25	1.00E-03	350/365	24	70	70	1.17E-09	4.48E-10
Arsenic	11.1	4.43	1000	18,150	1.0E-03	0.25	1.00E-03	350/365	24	70	70	2.37E-07	9.44E-08
Lead	10.5	3.33	1000	18,150	1.0E-03	0.25	1.00E-03	350/365	24	70	70	2.24E-07	7.10E-08

KEY: AD = Absorbed Dose (mg/kg/day)
CW = Chemical Concentration in Groundwater (µg/l)
CF = Conversion factor from µg/l to mg/l
SA = Skin Surface Area Exposed - Full Body During Bathing (cm^2)
PC = Chemical Specific Dermal Permeability Constant (cm/hr)
ET = Exposure Time-Bathing (hrs/day)
AT = Averaging Time: Exposure Duration Value for Non-carcinogens and 70 for Carcinogens (years)

[Formula: AD=(CW*SA*PC*ET*VCF*EF*ED)/(BW*AT*CF)]
CF = Volumetric Conversion Factor ($1l/cm^3$)
EF = Exposure Frequency (#days/365days)
ED = Exposure Duration (years)
BW = Body Weight (kg)

TABLE E-14

DOSE ESTIMATES: INHALATION OF GROUNDWATER DUE TO CHRONIC EXPOSURE FOR FUTURE LAND USE (CHILD)

Chemical Name	MAX CW (µg/l)	AVE CW (µg/l)	CF (µg/mg)	K (L/m^3)	IRa (m^3/day)	EF (unitless)	ED (years)	BW (kg)	AT (years) Non-carcinogenic	MAX CDI (mg/kg/day)	AVE CDI (mg/kg/day)
1,1-Dichloroethene	18	2.04	1000	0.5	15	0.95890411	6	15	6	2.36E-05	2.68E-06
cis-1,2-Dichloroethene	3000	509	1000	0.5	15	0.95890411	6	15	6	3.94E-03	6.69E-04
Methylene Chloride	730	93.1	1000	0.5	15	0.95890411	6	15	6	9.59E-04	1.22E-04
Chloroform	5	1.24	1000	0.5	15	0.95890411	6	15	6	6.57E-06	1.63E-06
Benzene	120	15.1	1000	0.5	15	0.95890411	6	15	6	1.58E-04	1.98E-05
Tetrachloroethene	64	6.06	1000	0.5	15	0.95890411	6	15	6	8.41E-05	7.96E-06
Toluene	1800	115	1000	0.5	15	0.95890411	6	15	6	2.36E-03	1.51E-04
Trimethylbenzene	700	269	1000	0.5	15	0.95890411	6	15	6	9.19E-04	3.53E-04
Tetramethylbenzene	36	32	1000	0.5	15	0.95890411	6	15	6	4.73E-05	4.20E-05

DOSE ESTIMATES: INHALATION OF GROUNDWATER DUE TO CHRONIC EXPOSURE FOR FUTURE LAND USE (CHILD)

Chemical Name	MAX CW (µg/l)	AVE CW (µg/l)	CF (µg/mg)	K (L/m^3)	IRa (m^3/day)	EF (unitless)	ED (years)	BW (kg)	AT (years) Carcinogenic	MAX CDI (mg/kg/day)	AVE CDI (mg/kg/day)
1,1-Dichloroethene	18	2.04	1000	0.5	15	0.95890411	6	15	70	2.03E-06	2.30E-07
cis-1,2-Dichloroethene	3000	509	1000	0.5	15	0.95890411	6	15	70	3.38E-04	5.73E-05
Methylene Chloride	730	93.1	1000	0.5	15	0.95890411	6	15	70	8.22E-05	1.05E-05
Chloroform	5	1.24	1000	0.5	15	0.95890411	6	15	70	5.63E-07	1.40E-07
Benzene	120	15.1	1000	0.5	15	0.95890411	6	15	70	1.35E-05	1.70E-06
Tetrachloroethene	64	6.06	1000	0.5	15	0.95890411	6	15	70	7.21E-06	6.82E-07
Toluene	1800	115	1000	0.5	15	0.95890411	6	15	70	2.03E-04	1.29E-05
Trimethylbenzene	700	269	1000	0.5	15	0.95890411	6	15	70	7.88E-05	3.03E-05
Tetramethylbenzene	36	32	1000	0.5	15	0.95890411	6	15	70	4.05E-06	3.60E-06

KEY: CDI = Cronic Daily Chemical Intake (mg/kg/day)
CW = Chemical Concentration in Water (µg/L)
CF = Conversion Factor = 1000 µg/mg
K = Volatilization Factor (L/m^3) = 0.0005 x 1000 L/m^3
IRa = Daily Indoor Inhalation Rate = 15 m^3/day
AT = Averaging Time: Exposure Duration Value for Non-Carcinogens and 70 for Carcinogens (years)

[Formula: CDI = (CWx K x IRa x EF x ED)/ (CF x BW x AT x 365 days/yr)]
EF = Exposure Frequency = 350 days/365 days
ED = Exposure Duration = 6 years
BW = Body Weight = 15 kg

(Note: Inhalation of volatiles in groundwater is considered only if the Henry's Law Constant is 1 x 10^{-5} atm-m^3/mole or greater and the molecular weight is less than 200 g/mol.)

TABLE E-15
DOSE ESTIMATES: INHALATION OF GROUNDWATER DUE TO CHRONIC EXPOSURE FOR FUTURE LAND USE (ADULT)

Chemical Name	MAX CW (µg/l)	AVE CW (µg/l)	CF (µg/mg)	K (L/m^3)	IRa (m^3/day)	EF (unitless)	ED (years)	BW (kg)	AT (years) Non-carcinogenic	MAX CDI (mg/kg/day)	AVE CDI (mg/kg/day)
1,1-Dichloroethene	18	2.04	1000	0.5	15	0.95890411	30	70	24	6.33E-06	7.18E-07
cis-1,2-Dichloroethene	3000	509	1000	0.5	15	0.95890411	30	70	24	1.06E-03	1.79E-04
Methylene Chloride	730	93.1	1000	0.5	15	0.95890411	30	70	24	2.57E-04	3.28E-05
Chloroform	5	1.24	1000	0.5	15	0.95890411	30	70	24	1.76E-06	4.36E-07
Benzene	120	15.1	1000	0.5	15	0.95890411	30	70	24	4.22E-05	5.31E-06
Tetrachloroethene	64	6.06	1000	0.5	15	0.95890411	30	70	24	2.25E-05	2.13E-06
Toluene	1800	115	1000	0.5	15	0.95890411	30	70	24	6.33E-04	4.05E-05
Trimethylbenzene	700	269	1000	0.5	15	0.95890411	30	70	24	2.46E-04	9.46E-05
Tetramethylbenzene	36	32	1000	0.5	15	0.95890411	30	70	24	1.27E-05	1.13E-05

DOSE ESTIMATES: INHALATION OF GROUNDWATER DUE TO CHRONIC EXPOSURE FOR FUTURE LAND USE (ADULT)

Chemical Name	MAX CW (µg/l)	AVE CW (µg/l)	CF (µg/mg)	K (L/m^3)	IRa (m^3/day)	EF (unitless)	ED (years)	BW (kg)	AT (years) Carcinogenic	MAX CDI (mg/kg/day)	AVE CDI (mg/kg/day)
1,1-Dichloroethene	18	2.04	1000	0.5	15	0.95890411	30	70	70	2.17E-06	2.46E-07
cis-1,2-Dichloroethene	3000	509	1000	0.5	15	0.95890411	30	70	70	3.62E-04	6.14E-05
Methylene Chloride	730	93.1	1000	0.5	15	0.95890411	30	70	70	8.81E-05	1.12E-05
Chloroform	5	1.24	1000	0.5	15	0.95890411	30	70	70	6.03E-07	1.50E-07
Benzene	120	15.1	1000	0.5	15	0.95890411	30	70	70	1.45E-05	1.82E-06
Tetrachloroethene	64	6.06	1000	0.5	15	0.95890411	30	70	70	7.72E-06	7.31E-07
Toluene	1800	115	1000	0.5	15	0.95890411	30	70	70	2.17E-04	1.39E-05
Trimethylbenzene	700	269	1000	0.5	15	0.95890411	30	70	70	8.44E-05	3.25E-05
Tetramethylbenzene	36	32	1000	0.5	15	0.95890411	30	70	70	4.34E-06	3.86E-06

KEY: CDI = Cronic Daily Chemical Intake (mg/kg/day)
CW = Chemical Concentration in Water (µg/L)
CF = Conversion Factor = 1000 µg/mg
K = Volatilization Factor (L/m^3) = 0.0005 x 1000 L/m^3
IRa = Daily Indoor Inhalation Rate = 15 m^3/day
AT = Averaging Time: Exposure Duration Value for Non-Carcinogens and 70 for Carcinogens (years)

[Formula: CDI = (CWx K x IRa x EF x ED)/ (CF x BW x AT x 365 days/yr)]
EF = Exposure Frequency = 350 days /365 days
ED = Exposure Duration = 30 years
BW = Body Weight = 70 kg

(Note: Inhalation of volatiles in groundwater is considered only if the Henry's Law Constant is 1 x 10^{-5} atm-m^3/mole or greater and the molecular weight is less than 200 g/mol.)

APPENDIX F

RISK ASSOCIATED WITH EXPOSURE TO BACKGROUND SOILS

TABLE F-1. RISK LEVELS ASSOCIATED WITH EXPOSURE TO MAXIMUM BACKGROUND CONCENTRATIONS OF ARSENIC IN SOIL

	NONCARCINOGENIC EFFECTS				CARCINOGENIC EFFECTS			
EXPOSURE SCENARIO	Maximum Background Conc.* (µg/kg)	RME Chronic Dose (mg/kg/day)	Reference Dose (RfD) (mg/kg/day)	Hazard Quotient	Maximum Background Conc.* (µg/kg)	RME Chronic Dose (mg/kg/day)	Oral Slope Factor $(mg/kg/day)^{-1}$	Increased Lifetime Cancer Risk
Ingestion of Soil Current Land Use	Not Detected	NA	NA	NA	Not Detected	NA	NA	NA
Dermal Absorption from Soil Current Land Use	Not Detected	NA	NA	NA	Not Detected	NA	NA	NA
Ingestion of Soil by a Child Future Land Use	1100	7.03E-06	3.00E-04	2.34E-02	1100	6.03E-07	1.75E+00	1E-06
Ingestion of Soil by a Adult Future Land Use	1100	7.53E-07	3.00E-04	2.51E-03	1100	2.58E-07	1.75E+00	5E-07
Dermal Absorption from Soil by a Child Future Land Use	1100	2.54E-06	3.00E-04	8.47E-03	1100	2.18E-07	1.75E+00	4E-07
Dermal Absorption from Soil by an Adult Future Land Use	1100	1.23E-06	3.00E-04	4.10E-03	1100	4.25E-07	1.75E+00	7E-07

Note:

* Arsenic was not detected in background surface soil. Background for future conditions is based on blending of surface and subsurface soils.

APPENDIX G

LEAD UPTAKE/BIOKINETIC MODEL RESULTS

LEAD UPTAKE/BIOKINETIC MODEL RESULTS

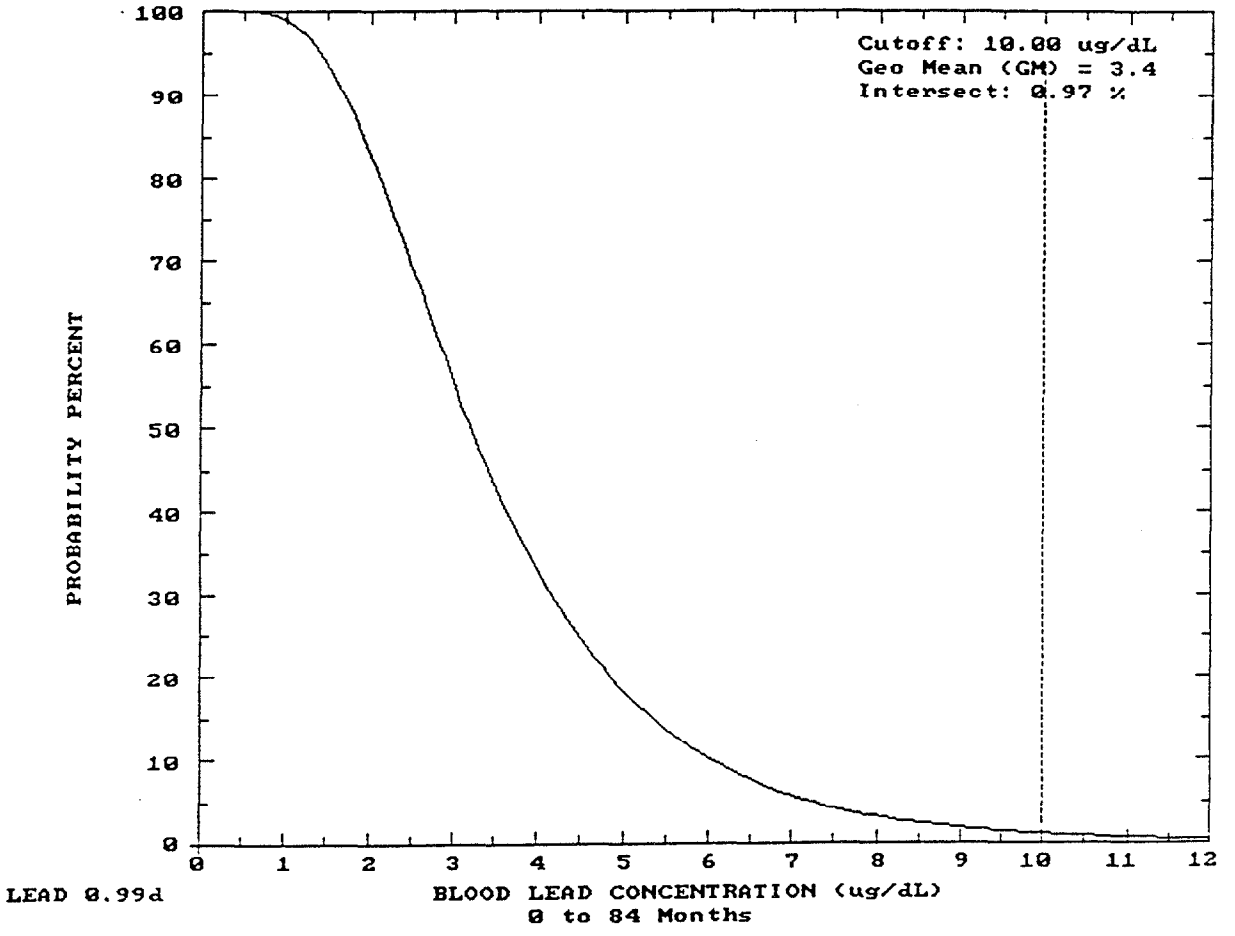
The U.S. EPA Integrated Exposure Uptake Biokinetic Model (U.S. EPA 1994) gives an estimate of blood lead levels predicted to be associated with media-specific chemical concentrations. The lead uptake biokinetic model provides an estimate of a child's total lead uptake from diet, ambient air (indoor/outdoor) drinking water, and soil. This can be employed to predict blood lead levels (μg lead/dl) based upon the total lead uptake across all media. The model provides blood lead level estimates specific to the child receptor (aged 0 to 6 years). Site-specific information was included in the model to reflect conditions relative to lead levels in the soil, sediment, and groundwater at the Wallops Field Facility (WFF). The Particulate Emission Factor method (PEF) detailed in RAGs/HHEM Part B was employed to estimate the lead concentration in air from fugitive dust emissions via surface soil contamination. The default parameter values were used to yield a default PEF of 4.63×10^9 m^3/kg. The surface soil concentration was then multiplied by the inverse PEF, giving an estimated air concentration (in mg/m^3) for direct use in the lead biokinetic/uptake model.

Site-specific surface soil and estimated maximum air concentrations along with both filtered and unfiltered groundwater maximum concentrations were substituted for default values in the model. Table 1 summarizes the maximum and average concentrations of lead detected in each medium. Likewise, site-specific sediment maximum concentrations were combined with filtered and unfiltered groundwater maximum concentrations for each model run. Maximum lead concentrations were chosen for evaluation rather than average lead concentrations since the average values were consistently lower (than the maximum lead concentrations). However, the average unfiltered groundwater lead concentration was also evaluated in the model using only default values since unfiltered groundwater is expected to contribute most to potential deleterious human health effects. Otherwise, default values were used in the model. The site-specific and default parameter values employed in the model are presented in Tables 2-8.

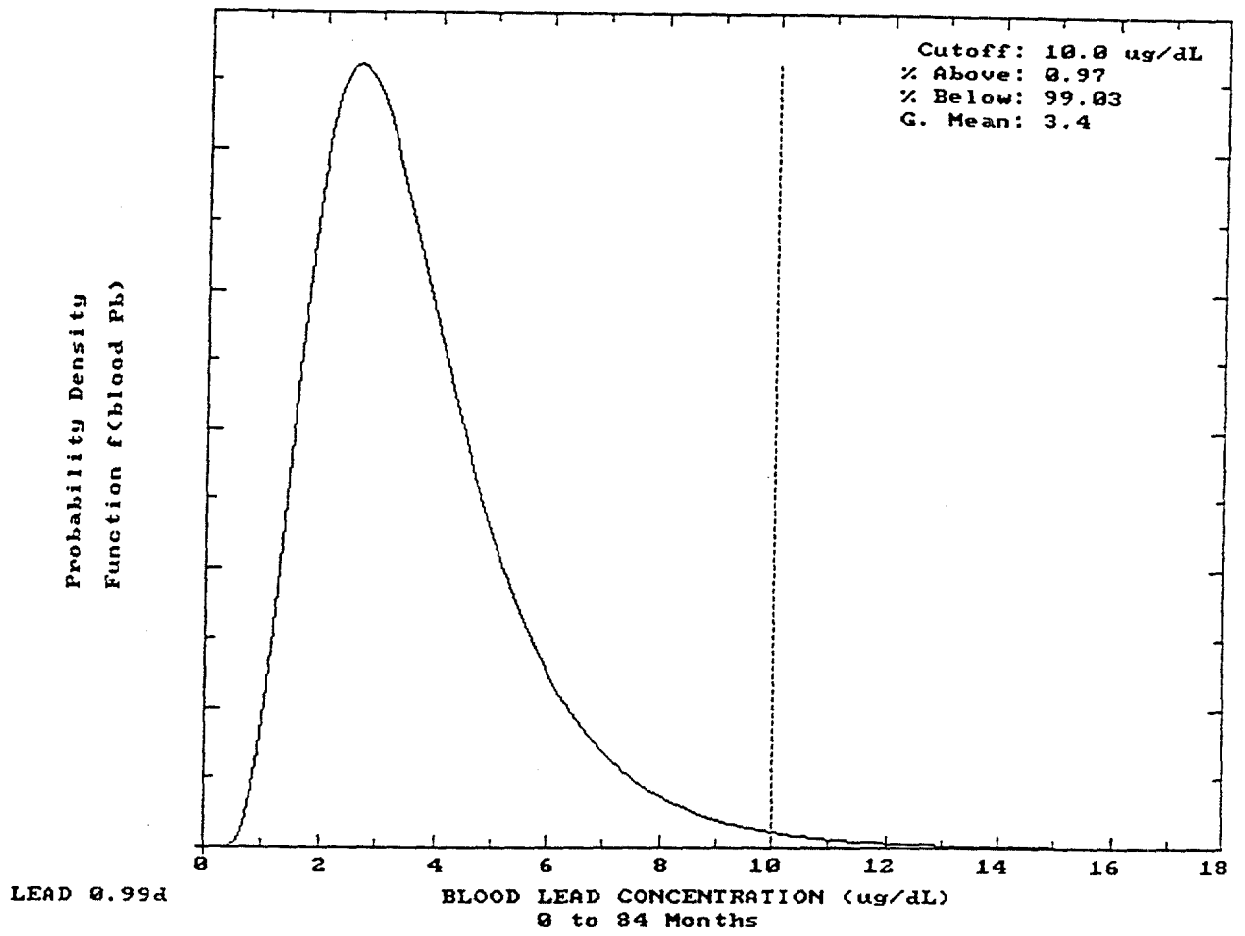
Figures 1, 3, 5, 7, 9, 11, and 13 present the probability plot relative to the geometric mean blood lead level predicted by the model and also show the geometric mean blood lead level concentrations associated with the site-specific conditions. Figures 2, 4, 6, 8,1 0, 12, and 14 present the probability density distribution about the geometric mean and standard deviation of the predicted blood lead levels. The model predicts the percentage of the exposed population which would be expected to have blood lead levels above 10 μg/dl.

Blood lead levels of 10-25 μg/dl are considered within a criterion or "cause for concern" range, being levels at which toxic effects might occur in children, therefore this range was used to evaluate potential health effects (U.S. EPA 1991d, 1994). Table 9 summarizes the geometric mean blood lead concentrations related to site-specific conditions at WWF for each combination of media. When the surface soil lead maximum concentrations (and resulting PEF estimated air concentration) were incorporated into the model along with the maximum filtered groundwater concentrations, the criterion volume of 10 μg lead/dl in more than five percent of the population was not exceeded. Likewise, the maximum sediment concentration combined with the maximum filtered groundwater concentration did not exceed the criterion value of 10 μg lead/dl. However, when unfiltered maximum groundwater concentrations along with surface soil (and air) and, in the same manner, sediment maximum concentrations were incorporated into the model, the criterion value for lead was exceeded in nearly 99 percent of the population for both media. The groundwater average lead concentration evaluated using the biokinetic uptake model did not predict blood lead levels which would exceed the criterion value. Clearly, lead in unfiltered groundwater poses the primary human health threat but only when incorporating the maximum groundwater lead concentrations and not the average groundwater lead levels.

TABLE 1 CONCENTRATIONS OF LEAD DETECTED BY MEDIUM		
MEDIUM	MAXIMUM DETECTED CONCENTRATION	AVERAGE DETECTED CONCENTRATION
SEDIMENT	67.5 mg/kg	40 mg/kg
SURFACE SOIL	33.8 mg/kg	12.9 mg/kg
GROUNDWATER - UNFILTERED	747 µg/L	70.2 µg/L
GROUNDWATER - FILTERED	10.5 µg/L	3.33 µg/L



M&E	PROBABILITY PLOT OF BLOOD LEAD LEVELS PREDICTED FOR CHILDREN FOR THE WFF (MAXIMUM FILTERED GROUNDWATER AND SURFACE SOIL CONCENTRATIONS)	Project Number #013516-0006 Figure 1



M&E	PROBABILITY DENSITY PLOT OF BLOOD LEAD LEVELS PREDICTED FOR CHILDREN FOR THE WFF (MAXIMUM FILTERED GROUNDWATER AND SURFACE SOIL CONCENTRATIONS)	Project Number #013516-0006 Figure 2

TABLE 2
PARAMETER VALUES FOR LEAD BIOKINETIC MODEL
USING MAXIMUM FILTERED GROUNDWATER AND SURFACE SOIL CONCENTRATIONS

LEAD MODEL Version 0.99d

AIR CONCENTRATION: 0.000 μg Pb/m3
Indoor AIR Pb Conc: 30.0 percent of outdoor.
Other AIR Parameters:

Age	Time Outdoors (hr)	Vent. Rate (m3/day)	Lung Abs. (%)
0-1	1.0	2.0	32.0
1-2	2.0	3.0	32.0
2-3	3.0	5.0	32.0
3-4	4.0	5.0	32.0
4-5	4.0	5.0	32.0
5-6	4.0	7.0	32.0
6-7	4.0	7.0	32.0

DIET: DEFAULT

DRINKING WATER Conc: 10.50 μg Pb/L
WATER Consumption: DEFAULT

SOIL & DUST:
Soil: user varied by year
Dust: constant conc.

Age	Soil (μg Pb/g)	House Dust (μg Pb/g)
0-1	33.8	0.0
1-2	33.8	0.0
2-3	33.8	0.0
3-4	33.8	0.0
4-5	33.8	0.0
5-6	33.8	0.0
6-7	33.8	0.0

Additional Dust Sources: None DEFAULT

PAINT Intake: 0.00 μg Pb/day DEFAULT

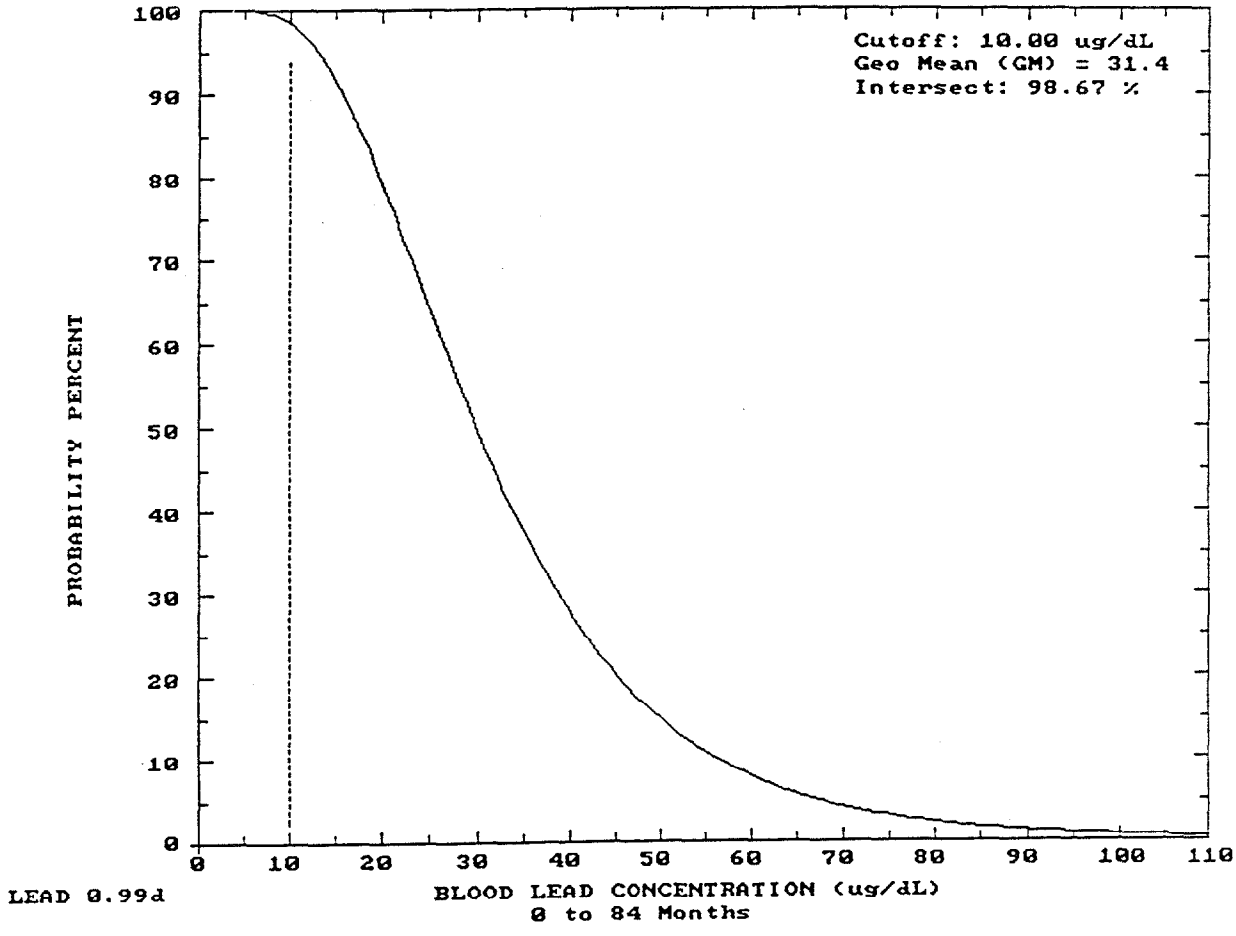
MATERNAL CONTRIBUTION: Infant Model
Maternal Blood Conc: 2.50 μg Pb/dL

TABLE 2 (Continued)

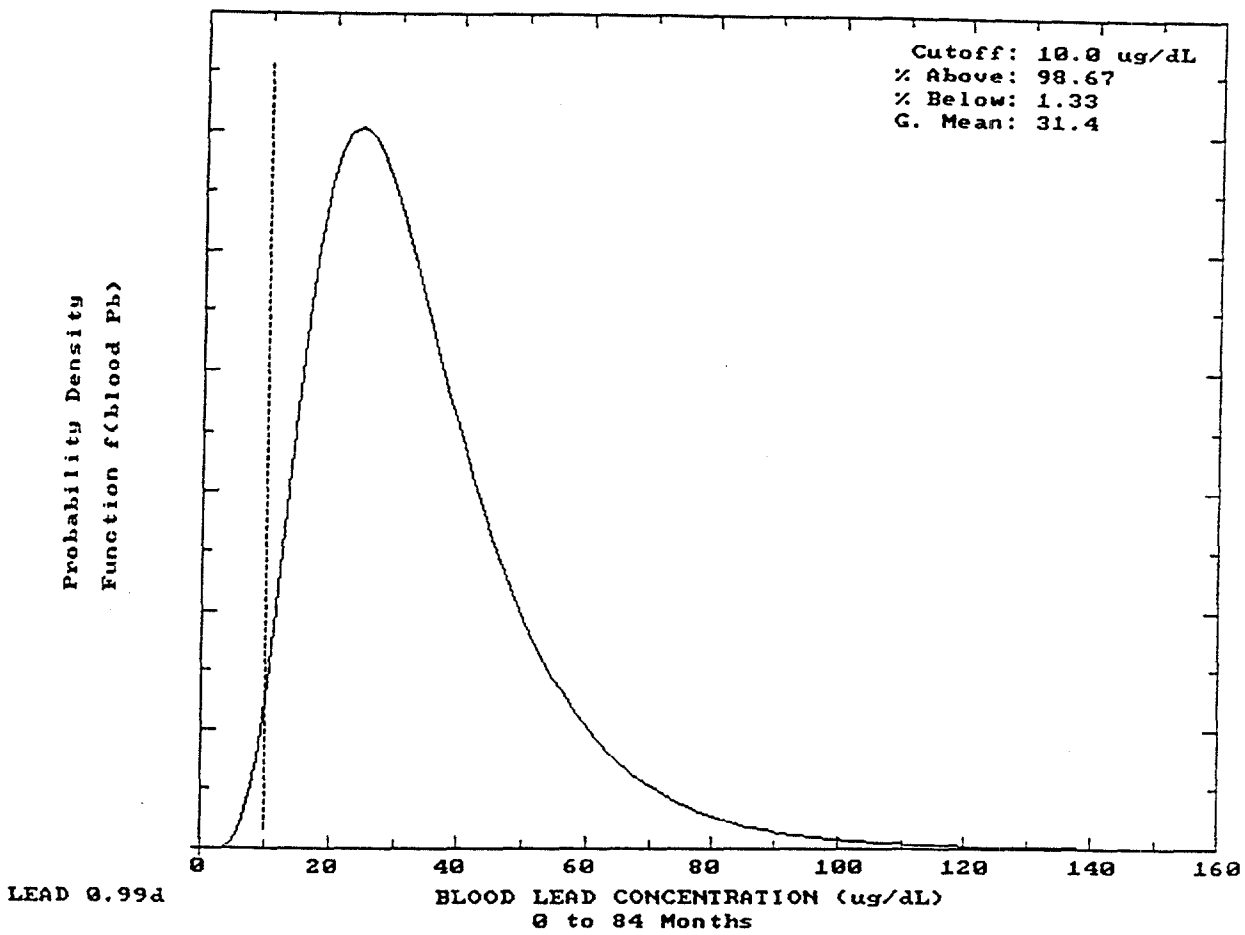
CALCULATED BLOOD Pb and Pb UPTAKES:

YEAR	Blood Level (μg/dL)	Total Uptake (μg/day)	Soil+Dust Uptake (μg/day)
0.5-1:	3.5	6.51	2.96
1-2:	4.0	9.72	4.66
2-3:	3.8	10.23	4.70
3-4:	3.6	10.28	4.75
4-5:	3.2	9.18	3.57
5-6:	2.9	9.18	3.23
6-7:	2.7	9.39	3.06

YEAR	Diet Uptake (μg/day)	Water Uptake (μg/day)	Paint Uptake (μg/day)	Air Uptake (μg/day)
0.5-1:	2.57	0.97	0.00	0.00
1-2:	2.65	2.41	0.00	0.00
2-3:	3.01	2.53	0.00	0.00
3-4:	2.92	2.61	0.00	0.00
4-5:	2.86	2.75	0.00	0.00
5-6:	3.03	2.91	0.00	0.00
6-7:	3.36	2.97	0.00	0.00



M&E	PROBABILITY PLOT OF BLOOD LEAD LEVELS PREDICTED FOR CHILDREN FOR THE WFF (MAXIMUM SURFACE SOIL AND UNFILTERED GROUNDWATER CONCENTRATIONS)	Project Number #013516-0006 Figure 3



M&E	PROBABILITY DENSITY PLOT OF BLOOD LEAD LEVELS PREDICTED FOR CHILDREN FOR THE WFF (MAXIMUM SURFACE SOIL AND UNFILTERED GROUNDWATER CONCENTRATIONS)	Project Number #013516-0006 Figure 4

TABLE 3
PARAMETER VALUES FOR LEAD BIOKINETIC MODEL
USING MAXIMUM SURFACE SOIL AND UNFILTERED GROUNDWATER

LEAD MODEL Version 0.99d

AIR CONCENTRATION: 0.000 μg Pb/m3
Indoor AIR Pb Conc: 30.0 percent of outdoor.
Other AIR Parameters:

Age	Time Outdoors (hr)	Vent. Rate (m3/day)	Lung Abs. (%)
0-1	1.0	2.0	32.0
1-2	2.0	3.0	32.0
2-3	3.0	5.0	32.0
3-4	4.0	5.0	32.0
4-5	4.0	5.0	32.0
5-6	4.0	7.0	32.0
6-7	4.0	7.0	32.0

DIET: DEFAULT

DRINKING WATER Conc: 747.00 μg Pb/L
WATER Consumption: DEFAULT

SOIL & DUST:
Soil: user varied by year
Dust: constant conc.

Age	Soil (μg Pb/g)	House Dust (μg Pb/g)
0-1	21.8	0.0
1-2	33.8	0.0
2-3	33.8	0.0
3-4	33.8	0.0
4-5	33.8	0.0
5-6	33.8	0.0
6-7	33.8	0.0

Additional Dust Sources: None DEFAULT

PAINT Intake: 0.00 μg Pb/day DEFAULT

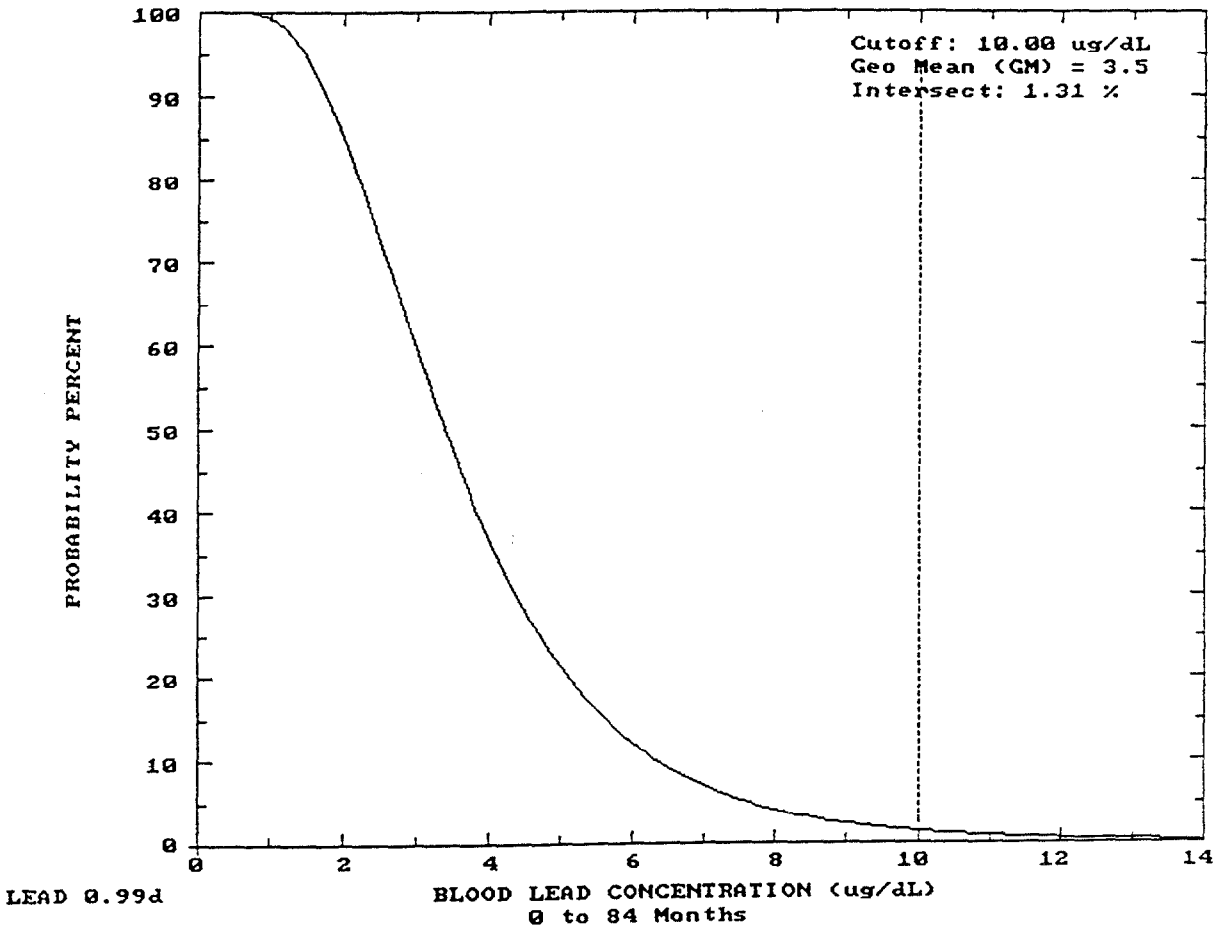
MATERNAL CONTRIBUTION: Infant Model
Maternal Blood Conc: 2.50 μg Pb/dL

TABLE 3 (continued)

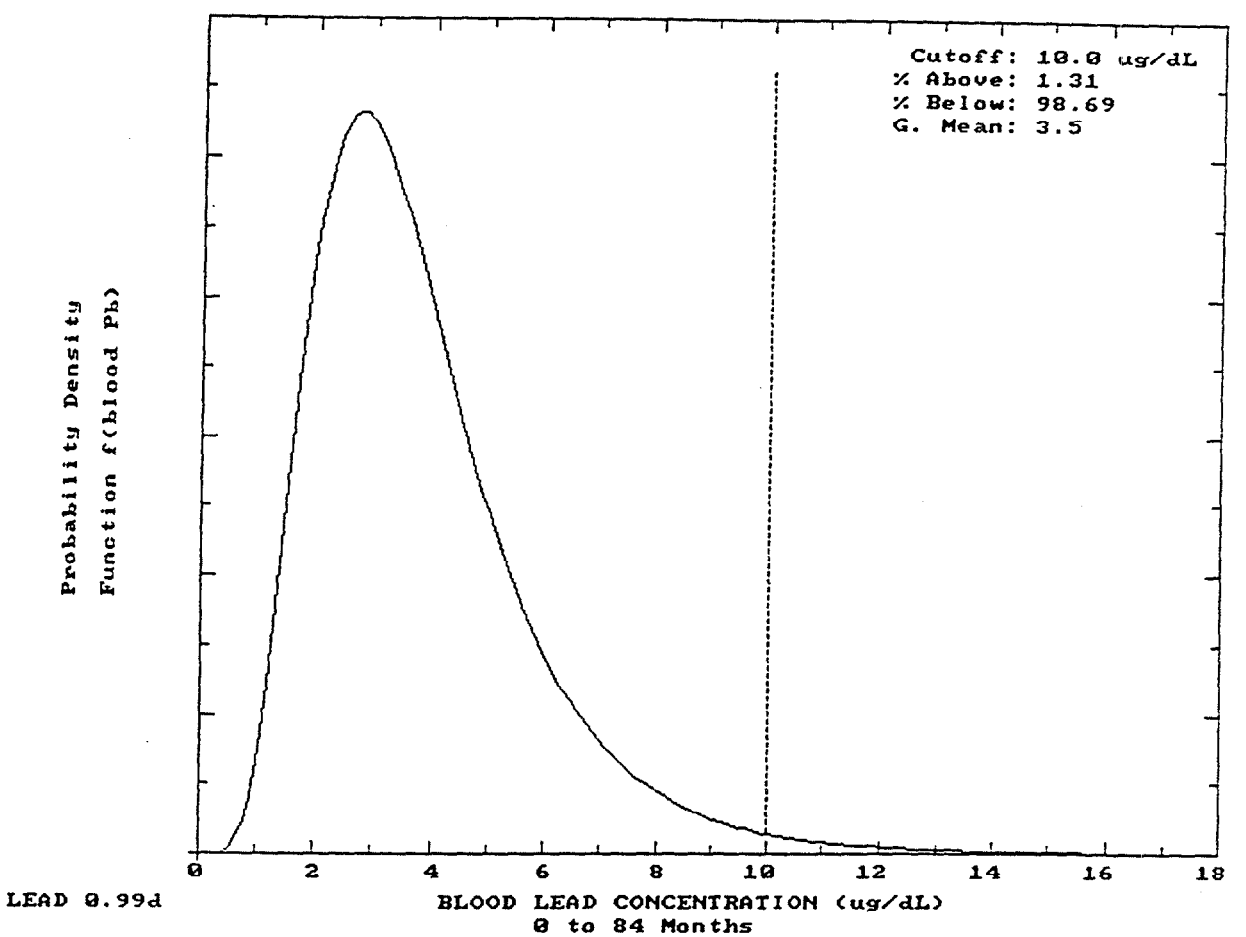
CALCULATED BLOOD Pb and Pb UPTAKES:

YEAR	Blood Level (μg/dL)	Total Uptake (μg/day)	Soil+Dust Uptake (μg/day)
0.5-1:	23.2	46.43	1.76
1-2:	33.1	89.23	2.32
2-3:	33.3	97.24	2.43
3-4:	33.5	104.30	2.57
4-5:	33.9	112.13	1.99
5-6:	33.9	120.91	1.83
6-7:	33.0	126.07	1.77

YEAR	Diet Uptake (μg/day)	Water Uptake (μg/day)	Paint Uptake (μg/day)	Air Uptake (μg/day)
0.5-1:	1.59	43.08	0.00	0.00
1-2:	1.32	85.58	0.00	0.00
2-3:	1.56	93.24	0.00	0.00
3-4:	1.58	100.16	0.00	0.00
4-5:	1.59	108.56	0.00	0.00
5-6:	1.72	117.37	0.00	0.00
6-7:	1.94	122.36	0.00	0.00



M&E	PROBABILITY PLOT OF BLOOD LEAD LEVELS PREDICTED FOR CHILDREN FOR THE WFF (MAXIMUM FILTERED GROUNDWATER AND SEDIMENT CONCENTRATIONS)	Project Number #013516-0006 Figure 5



M&E	PROBABILITY DENSITY PLOT OF BLOOD LEAD LEVELS PREDICTED FOR CHILDREN FOR THE WFF (MAXIMUM FILTERED GROUNDWATER AND SEDIMENT CONCENTRATIONS)	Project Number #013516-0006 Figure 6

TABLE 4
PARAMETER VALUES FOR LEAD BIOKINETIC MODEL
USING MAXIMUM SEDIMENT AND FILTERED GROUNDWATER

LEAD MODEL Version 0.99d

AIR CONCENTRATION: 0.100 μg Pb/m3 DEFAULT
Indoor AIR Pb Conc: 30.0 percent of outdoor.
Other AIR Parameters:

Age	Time Outdoors (hr)	Vent. Rate (m3/day)	Lung Abs. (%)
0-1	1.0	2.0	32.0
1-2	2.0	3.0	32.0
2-3	3.0	5.0	32.0
3-4	4.0	5.0	32.0
4-5	4.0	5.0	32.0
5-6	4.0	7.0	32.0
6-7	4.0	7.0	32.0

DIET: DEFAULT

DRINKING WATER Conc: 10.50 μg Pb/L
WATER Consumption: DEFAULT

SOIL & DUST:
Soil: user varied by year
Dust: constant conc.

Age	Soil (μg Pb/g)	House Dust (μg Pb/g)
0-1	67.5	0.0
1-2	67.5	0.0
2-3	67.5	0.0
3-4	67.5	0.0
4-5	67.5	0.0
5-6	67.5	0.0
6-7	67.5	0.0

Additional Dust Sources: None DEFAULT

PAINT Intake: 0.00 μg Pb/day DEFAULT

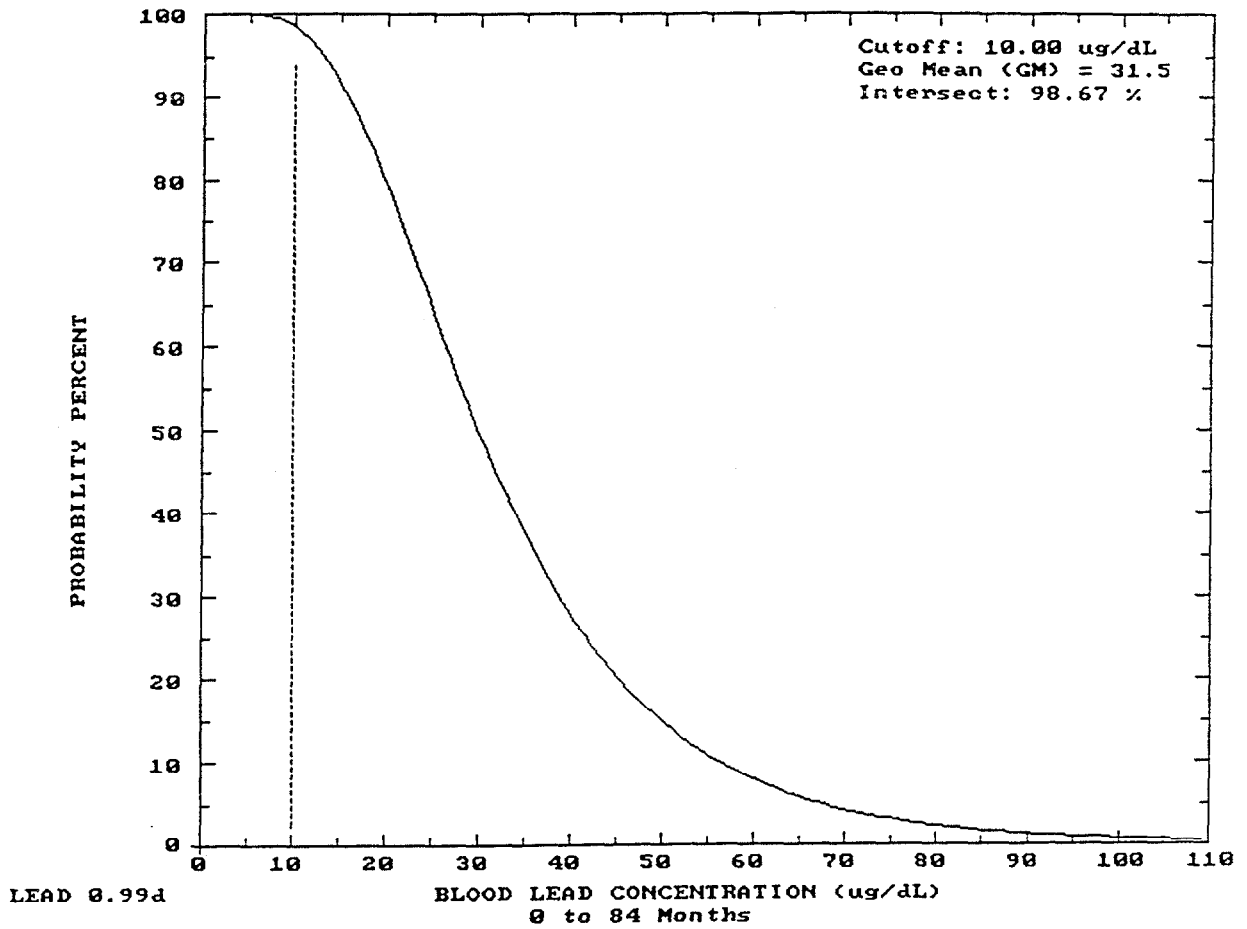
MATERNAL CONTRIBUTION: Infant Model
Maternal Blood Conc: 2.50 μg Pb/dL

TABLE 4 (continued)

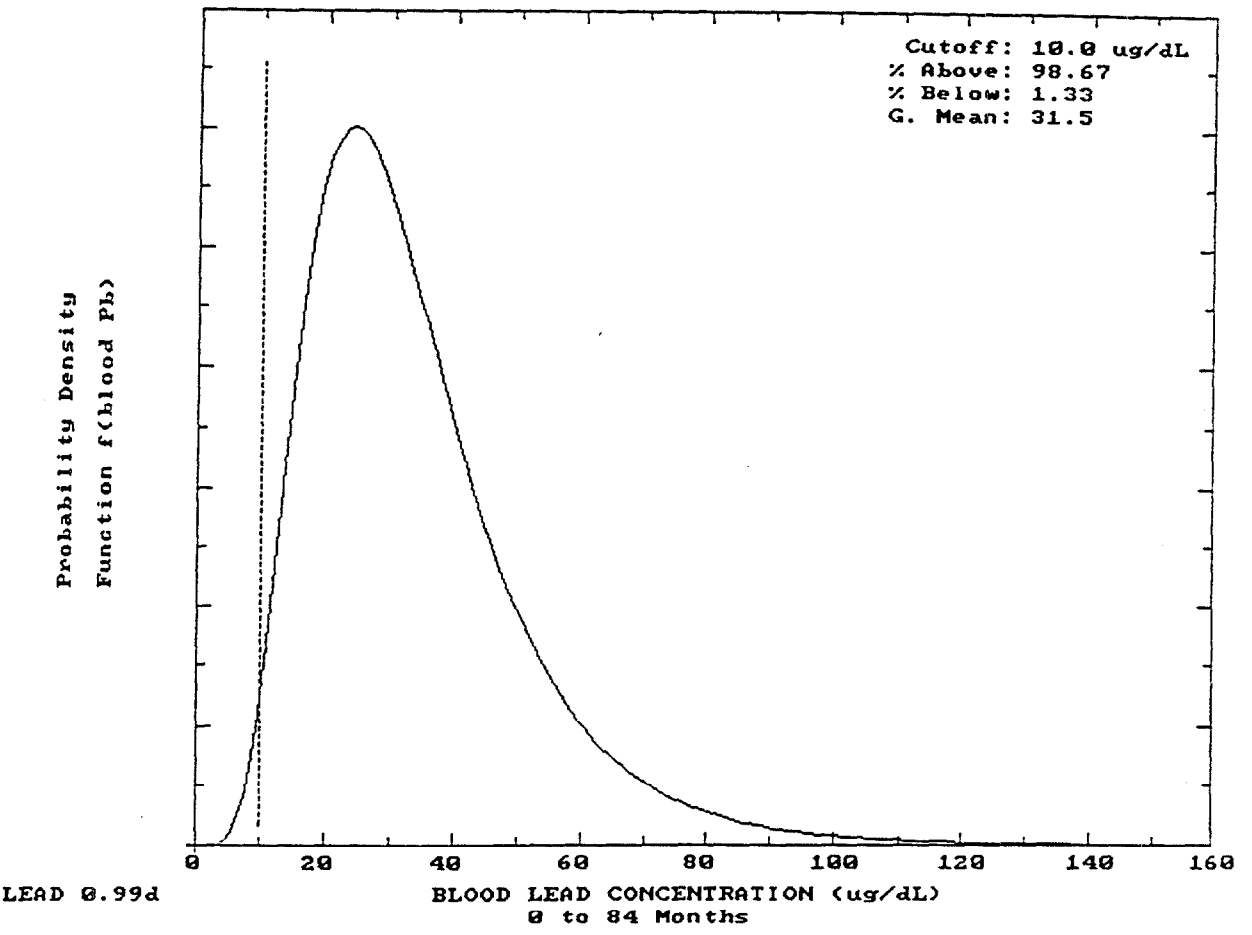
CALCULATED BLOOD Pb and Pb UPTAKES:

YEAR	Blood Level (μg/dL)	Total Uptake (μg/day)	Soil + Dust Uptake (μg/day)
0.5-1:	3.7	6.86	3.31
1-2:	4.2	10.27	5.19
2-3:	4.0	10.82	5.25
3-4:	3.8	10.88	5.31
4-5:	3.3	9.65	4.00
5-6:	3.0	9.64	3.62
6-7:	2.8	9.84	3.43

YEAR	Diet Uptake (μg/day)	Water Uptake (μg/day)	Paint Uptake (μg/day)	Air Uptake (μg/day)
0.5-1:	2.56	0.97	0.00	0.02
1-2:	2.64	2.40	0.00	0.03
2-3:	2.99	2.52	0.00	0.06
3-4:	2.91	2.60	0.00	0.07
4-5:	2.85	2.74	0.00	0.07
5-6:	3.03	2.91	0.00	0.09
6-7:	3.35	2.97	0.00	0.09



M&E	PROBABILITY PLOT OF BLOOD LEAD LEVELS PREDICTED FOR CHILDREN FOR THE WFF (MAXIMUM UNFILTERED GROUNDWATER AND SEDIMENT CONCENTRATIONS)	Project Number #013516-0006 Figure 7



M&E	PROBABILITY DENSITY PLOT OF BLOOD LEAD LEVELS PREDICTED FOR CHILDREN FOR THE WFF (MAXIMUM UNFILTERED GROUNDWATER AND SEDIMENT CONCENTRATIONS)	Project Number #013516-0006 Figure 8

TABLE 5
PARAMETER VALUES FOR LEAD BIOKINETIC MODEL
USING MAXIMUM SEDIMENT AND UNFILTERED GROUNDWATER

LEAD MODEL Version 0.99d

AIR CONCENTRATION: 0.100 μg Pb/m3 DEFAULT
Indoor AIR Pb Conc: 30.0 percent of outdoor.
Other AIR Parameters:

Age	Time Outdoors (hr)	Vent. Rate (m3/day)	Lung Abs. (%)
0-1	1.0	2.0	32.0
1-2	2.0	3.0	32.0
2-3	3.0	5.0	32.0
3-4	4.0	5.0	32.0
4-5	4.0	5.0	32.0
5-6	4.0	7.0	32.0
6-7	4.0	7.0	32.0

DIET: DEFAULT

DRINKING WATER Conc: 747.00 μg Pb/L
WATER Consumption: DEFAULT

SOIL & DUST:
Soil: user varied by year
Dust: constant conc.

Age	Soil (μg Pb/g)	House Dust (μg Pb/g)
0-1	67.5	0.0
1-2	67.5	0.0
2-3	67.5	0.0
3-4	67.5	0.0
4-5	67.5	0.0
5-6	67.5	0.0
6-7	67.5	0.0

Additional Dust Sources: None DEFAULT

PAINT Intake: 0.00 μg Pb/day DEFAULT

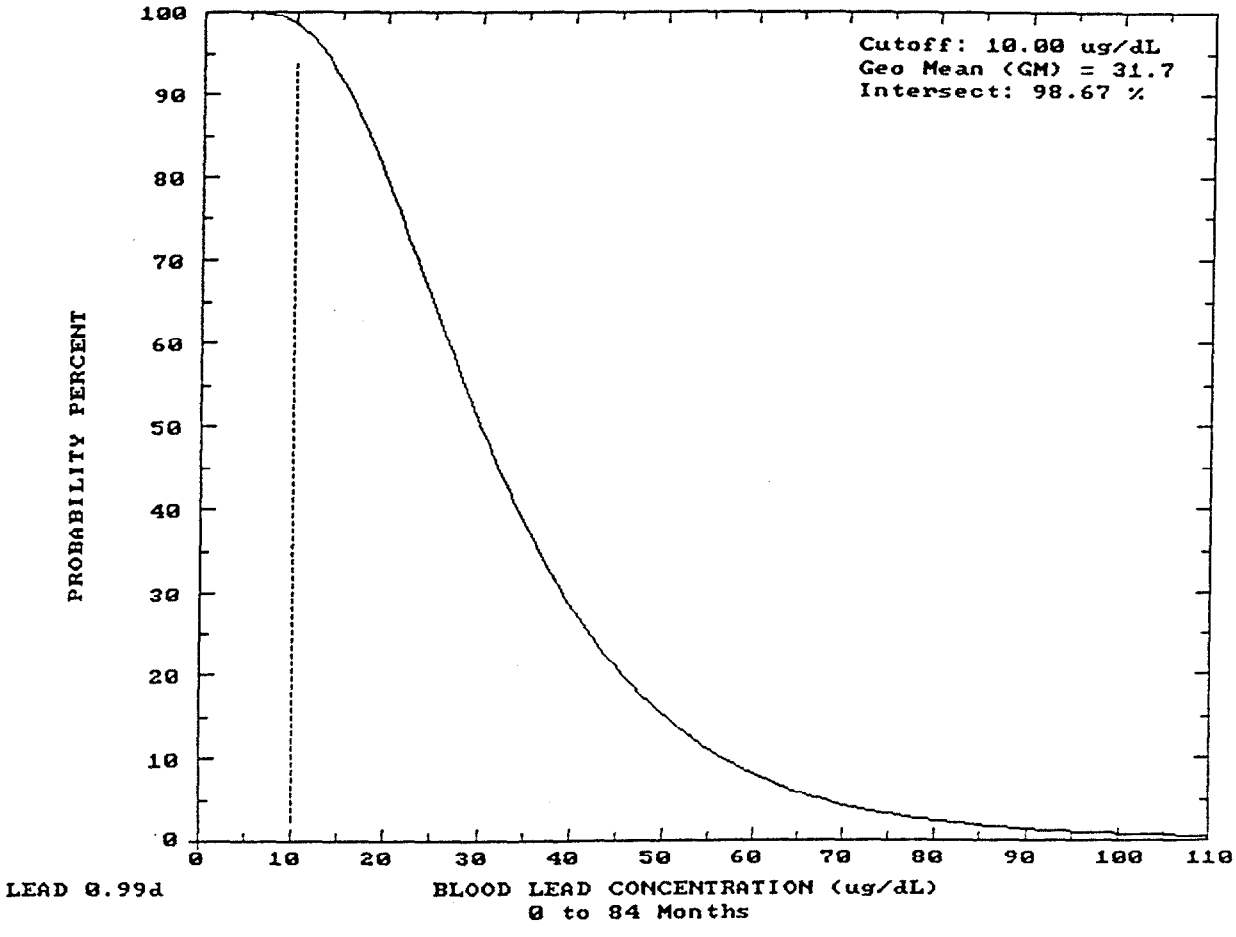
MATERNAL CONTRIBUTION: Infant Model
Maternal Blood Conc: 2.50 μg Pb/dL

TABLE 5 (continued)

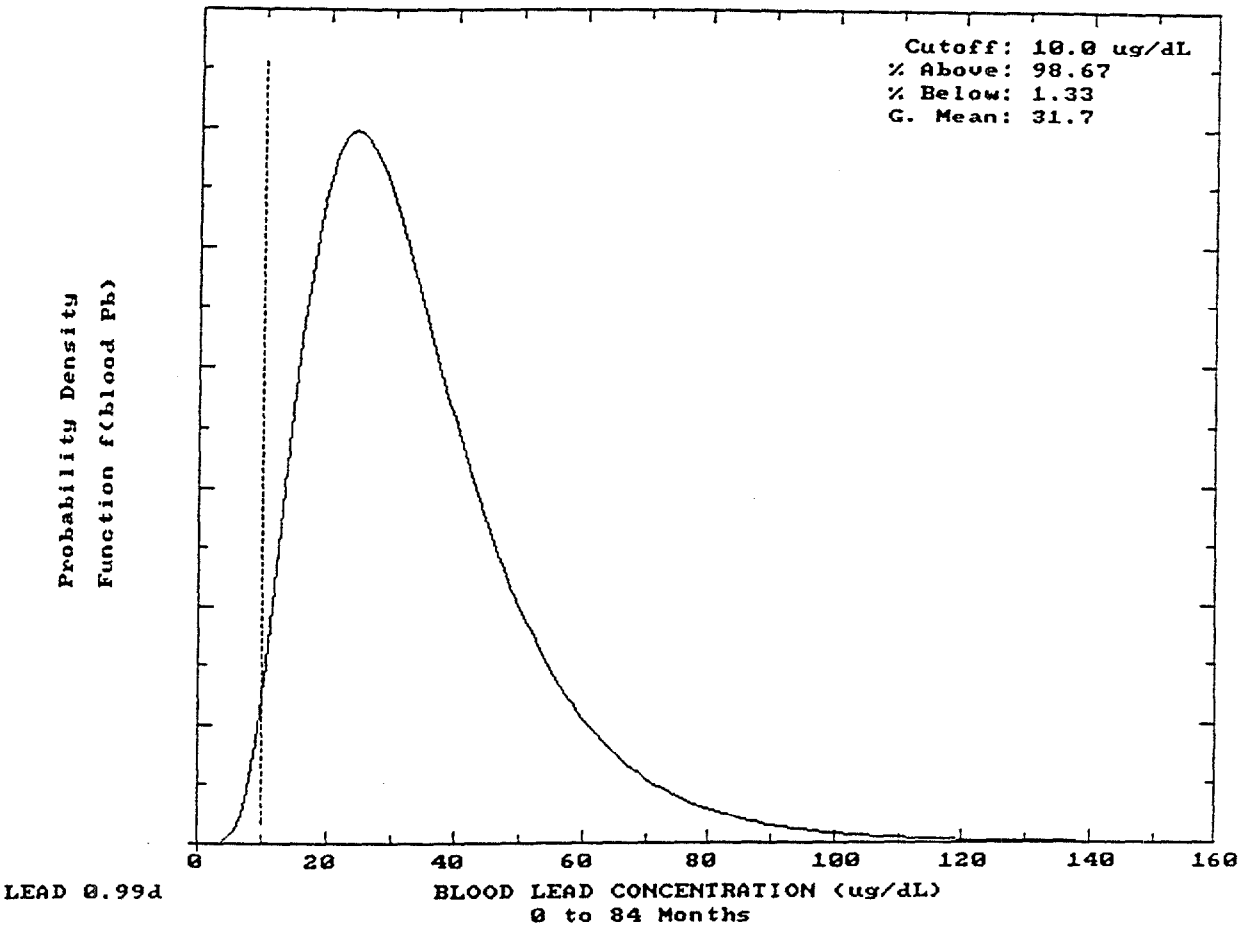
CALCULATED BLOOD Pb and Pb UPTAKES:

YEAR	Blood Level (μg/dL)	Total Uptake (μg/day)	Soil+Dust Uptake (μg/day)
0.5-1:	23.3	46.65	2.06
1-2:	33.2	89.43	2.60
2-3:	33.4	97.48	2.73
3-4:	33.6	104.56	2.87
4-5:	33.9	112.35	2.22
5-6:	34.0	121.15	2.05
6-7:	33.0	126.30	1.99

YEAR	Diet Uptake (μg/day)	Water Uptake (μg/day)	Paint Uptake (μg/day)	Air Uptake (μg/day)
0.5-1:	1.59	42.98	0.00	0.02
1-2:	1.32	85.48	0.00	0.03
2-3:	1.56	93.14	0.00	0.06
3-4:	1.58	100.05	0.00	0.07
4-5:	1.59	108.47	0.00	0.07
5-6:	1.72	117.29	0.00	0.09
6-7:	1.94	122.28	0.00	0.09



M&E	PROBABILITY PLOT OF BLOOD LEAD LEVELS PREDICTED FOR CHILDREN FOR THE WFF (MAXIMUM UNFILTERED GROUNDWATER CONCENTRATION)	Project Number #013516-0006 Figure 9



M&E	PROBABILITY DENSITY PLOT OF BLOOD LEAD LEVELS PREDICTED FOR CHILDREN FOR THE WFF (MAXIMUM UNFILTERED GROUNDWATER CONCENTRATION)	Project Number #013516-0006 Figure 10

TABLE 6
PARAMETER VALUES FOR LEAD BIOKINETIC MODEL
USING MAXIMUM UNFILTERED GROUNDWATER ONLY

LEAD MODEL Version 0.99d

AIR CONCENTRATION: 0.100 μg Pb/m3 DEFAULT
Indoor AIR Pb Conc: 30.0 percent of outdoor.
Other AIR Parameters:

Age	Time Outdoors (hr)	Vent. Rate (m3/day)	Lung Abs. (%)
0-1	1.0	2.0	32.0
1-2	2.0	3.0	32.0
2-3	3.0	5.0	32.0
3-4	4.0	5.0	32.0
4-5	4.0	5.0	32.0
5-6	4.0	7.0	32.0
6-7	4.0	7.0	32.0

DIET: DEFAULT

DRINKING WATER Conc: 747.00 μg Pb/L
WATER Consumption: DEFAULT

SOIL & DUST:
Soil: constant conc.
Dust: constant conc.

Age	Soil (μg Pb/g)	House Dust (μg Pb/g)
0-1	200.0	200.0
1-2	200.0	200.0
2-3	200.0	200.0
3-4	200.0	200.0
4-5	200.0	200.0
5-6	200.0	200.0
6-7	200.0	200.0

Additional Dust Sources: None DEFAULT

PAINT Intake: 0.00 μg Pb/day DEFAULT

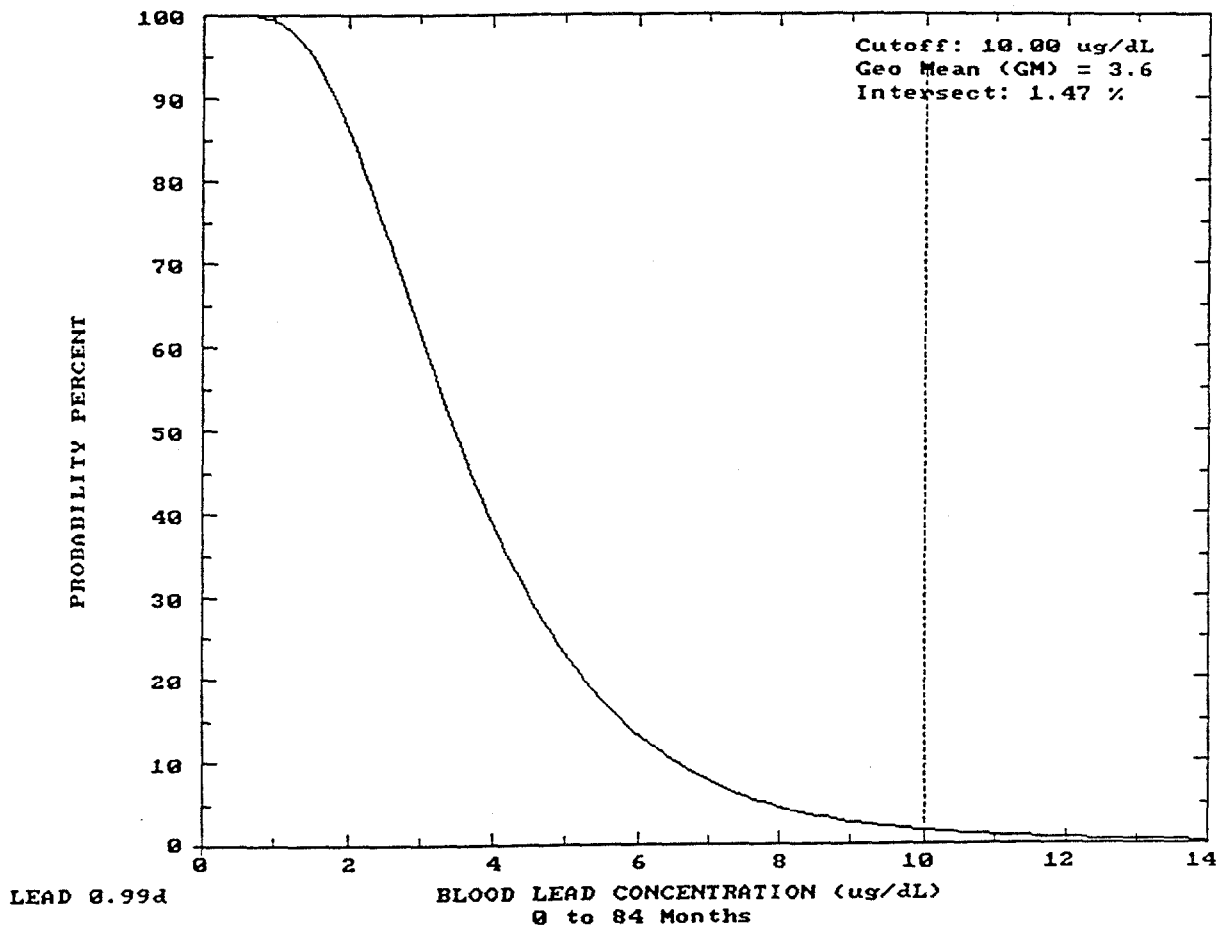
MATERNAL CONTRIBUTION: Infant Model
Maternal Blood Conc: 2.50 μg Pb/dL

TABLE 6 (continued)

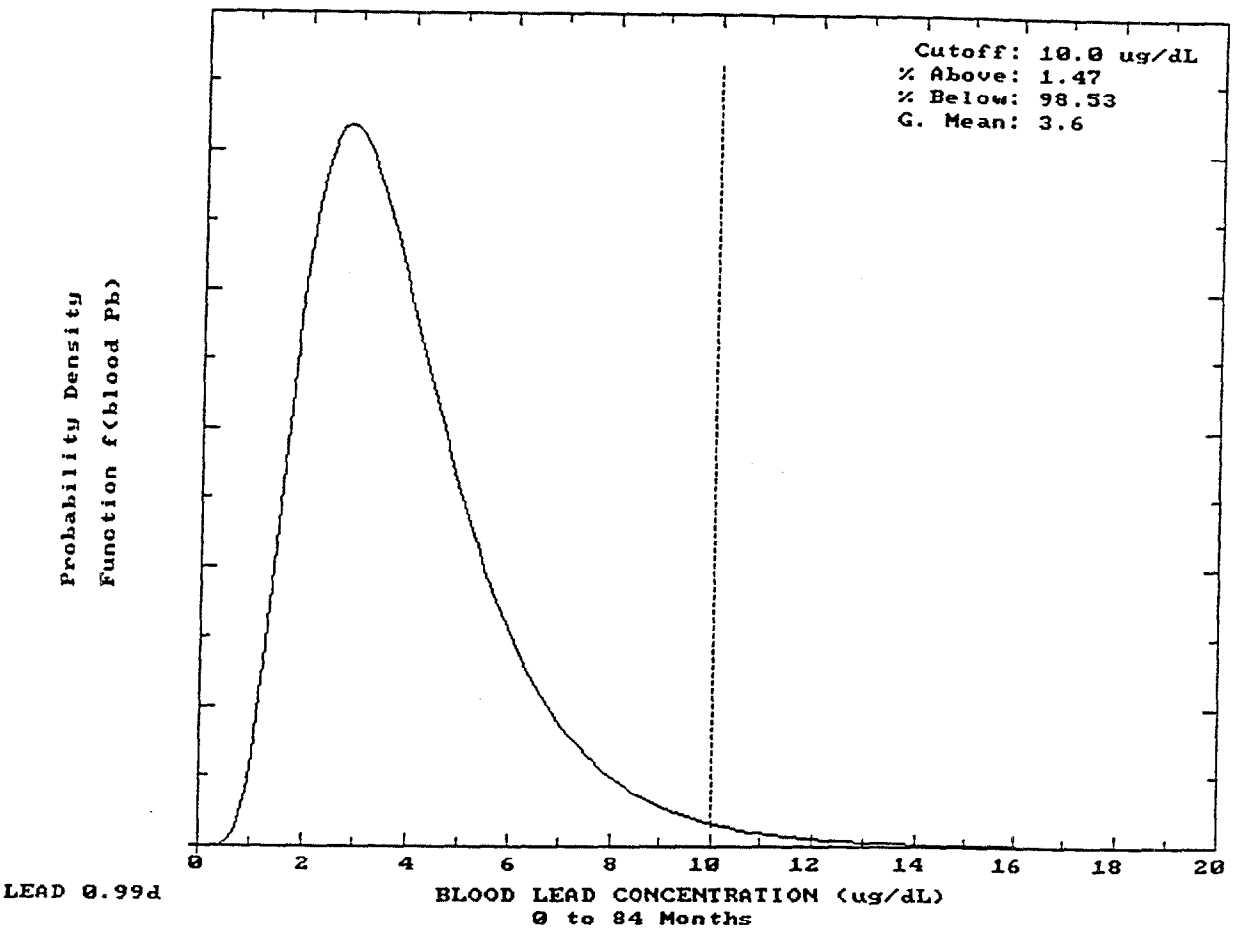
CALCULATED BLOOD Pb and Pb UPTAKES:

YEAR	Blood Level (μg/dL)	Total Uptake (μg/day)	Soil+Dust Uptake (μg/day)
0.5-1:	23.6	47.22	2.92
1-2:	33.4	90.12	3.69
2-3:	33.6	98.20	3.87
3-4:	33.8	105.32	4.08
4-5:	34.1	112.95	3.16
5-6:	34.1	121.71	2.92
6-7:	33.2	126.85	2.82

YEAR	Diet Uptake (μg/day)	Water Uptake (μg/day)	Paint Uptake (μg/day)	Air Uptake (μg/day)
0.5-1:	1.58	42.71	0.00	0.02
1-2:	1.32	85.08	0.00	0.03
2-3:	1.55	92.72	0.00	0.06
3-4:	1.57	99.61	0.00	0.07
4-5:	1.58	108.14	0.00	0.07
5-6:	1.71	116.98	0.00	0.09
6-7:	1.94	121.99	0.00	0.09



M&E	PROBABILITY PLOT OF BLOOD LEAD LEVELS PREDICTED FOR CHILDREN FOR THE WFF (AVERAGE FILTERED GROUNDWATER CONCENTRATION)	Project Number #013516-0006 Figure 11



M&E	PROBABILITY DENSITY PLOT OF BLOOD LEAD LEVELS PREDICTED FOR CHILDREN FOR THE WFF (AVERAGE FILTERED GROUNDWATER CONCENTRATION)	Project Number #013516-0006 Figure 12

TABLE 7
PARAMETER VALUES FOR LEAD BIOKINETIC MODEL USING MAXIMUM FILTERED GROUNDWATER ONLY

LEAD MODEL Version 0.99d

AIR CONCENTRATION: 0.100 μg Pb/m3 DEFAULT
Indoor AIR Pb Conc: 30.0 percent of outdoor.
Other AIR Parameters:

Age	Time Outdoors (hr)	Vent. Rate (m3/day)	Lung Abs. (%)
0-1	1.0	2.0	32.0
1-2	2.0	3.0	32.0
2-3	3.0	5.0	32.0
3-4	4.0	5.0	32.0
4-5	4.0	5.0	32.0
5-6	4.0	7.0	32.0
6-7	4.0	7.0	32.0

DIET: DEFAULT

DRINKING WATER Conc: 3.33 μg Pb/L
WATER Consumption: DEFAULT

SOIL & DUST:
Soil: constant conc.
Dust: constant conc.

Age	Soil (μg Pb/g)	House Dust (μg Pb/g)
0-1	200.0	200.0
1-2	200.0	200.0
2-3	200.0	200.0
3-4	200.0	200.0
4-5	200.0	200.0
5-6	200.0	200.0
6-7	200.0	200.0

Additional Dust Sources: None DEFAULT

PAINT Intake: 0.00 μg Pb/day DEFAULT

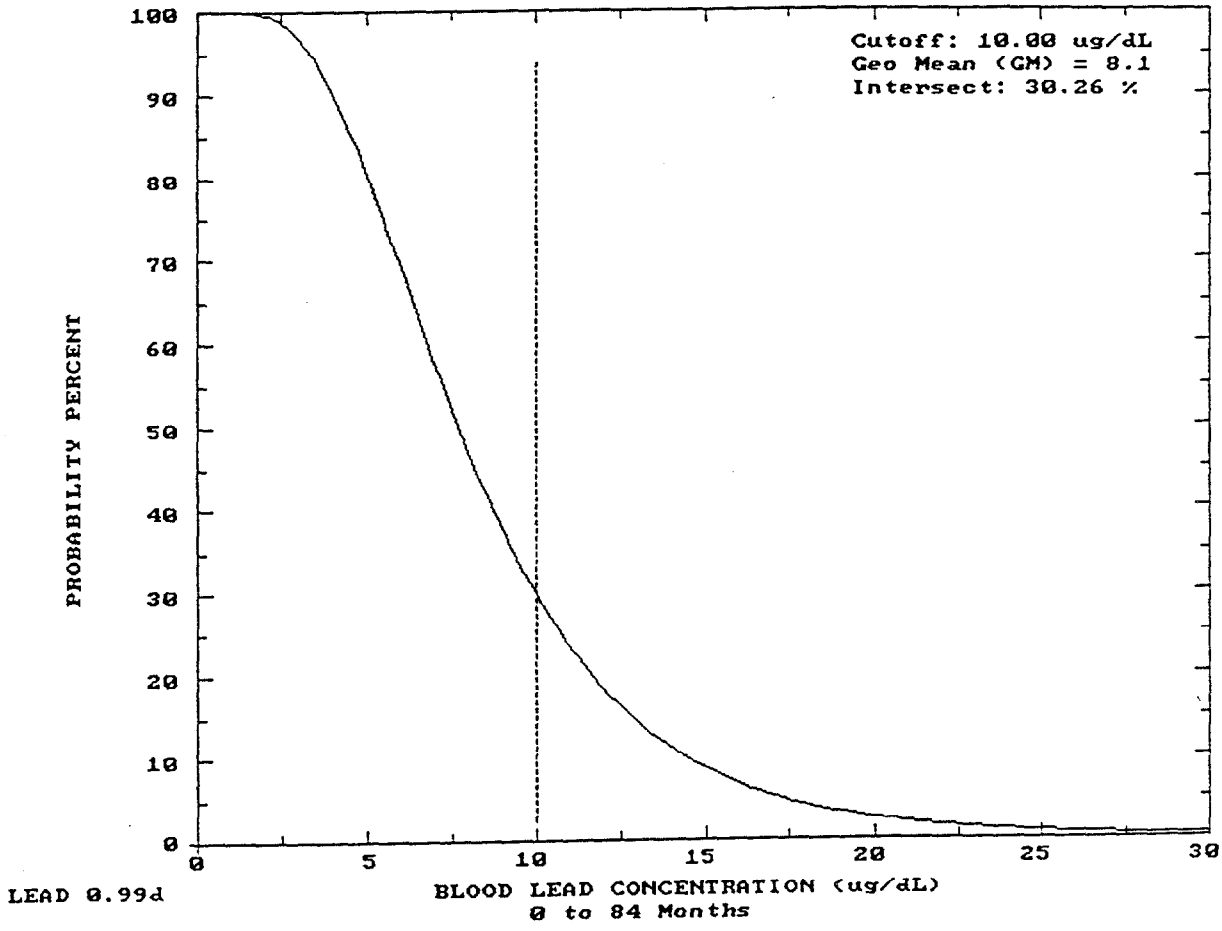
MATERNAL CONTRIBUTION: Infant Model
Maternal Blood Conc: 2.50 μg Pb/dL

TABLE 7 (continued)

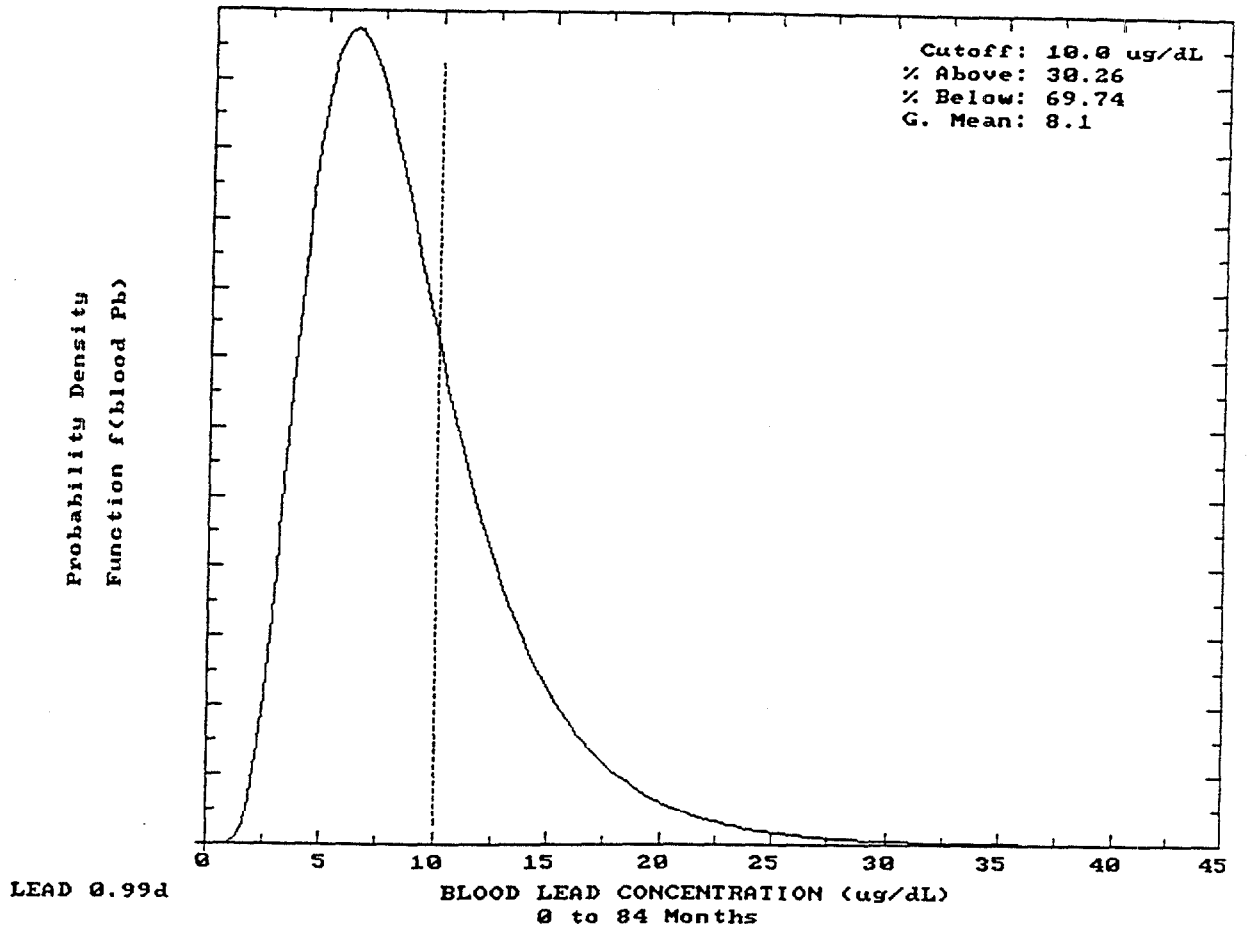
CALCULATED BLOOD Pb and Pb UPTAKES:

YEAR	Blood Level (μg/dL)	Total Uptake (μg/day)	Soil+Dust Uptake (μg/day)
0.5-1:	4.1	7.54	4.68
1-2:	4.5	10.79	7.37
2-3:	4.2	11.29	7.45
3-4:	4.0	11.33	7.54
4-5:	3.3	9.49	5.70
5-6:	2.9	9.22	5.17
6-7:	2.7	9.29	4.90

YEAR	Diet Uptake (μg/day)	Water Uptake (μg/day)	Paint Uptake (μg/day)	Air Uptake (μg/day)
0.5-1:	2.54	0.31	0.00	0.02
1-2:	2.63	0.76	0.00	0.03
2-3:	2.98	0.80	0.00	0.06
3-4:	2.90	0.82	0.00	0.07
4-5:	2.85	0.87	0.00	0.07
5-6:	3.03	0.92	0.00	0.09
6-7:	3.36	0.94	0.00	0.09



M&E	PROBABILITY PLOT OF BLOOD LEAD LEVELS PREDICTED FOR CHILDREN FOR THE WFF (AVERAGE UNFILTERED GROUNDWATER CONCENTRATION)	Project Number #013516-0006 Figure 13



M&E	PROBABILITY DENSITY PLOT OF BLOOD LEAD LEVELS PREDICTED FOR CHILDREN FOR THE WFF (AVERAGE UNFILTERED GROUNDWATER CONCENTRATION)	Project Number #013516-0006 Figure 14

TABLE 8
PARAMETER VALUES FOR LEAD BIOKINETIC MODEL USING AVERAGE UNFILTERED GROUNDWATER ONLY

LEAD MODEL Version 0.99d

AIR CONCENTRATION: 0.100 μg Pb/m3 DEFAULT
Indoor AIR Pb Conc: 30.0 percent of outdoor.
Other AIR Parameters:

Age	Time Outdoors (hr)	Vent. Rate (m3/day)	Lung Abs. (%)
0-1	1.0	2.0	32.0
1-2	2.0	3.0	32.0
2-3	3.0	5.0	32.0
3-4	4.0	5.0	32.0
4-5	4.0	5.0	32.0
5-6	4.0	7.0	32.0
6-7	4.0	7.0	32.0

DIET: DEFAULT

DRINKING WATER Conc: 70.20 μg Pb/L
WATER Consumption: DEFAULT

SOIL & DUST:
Soil: constant conc.
Dust: constant conc.

Age	Soil (μg Pb/g)	House Dust (μg Pb/g)
0-1	200.0	200.0
1-2	200.0	200.0
2-3	200.0	200.0
3-4	200.0	200.0
4-5	200.0	200.0
5-6	200.0	200.0
6-7	200.0	200.0

Additional Dust Sources: None DEFAULT

PAINT Intake: 0.00 μg Pb/day DEFAULT

MATERNAL CONTRIBUTION: Infant Model
Maternal Blood Conc: 2.50 μg Pb/dL

TABLE 8 (continued)

CALCULATED BLOOD Pb and Pb UPTAKES:

YEAR	Blood Level (μg/dL)	Total Uptake (μg/day)	Soil+Dust Uptake (μg/day)
0.5-1:	6.9	12.85	4.40
1-2:	9.2	23.20	6.57
2-3:	9.0	24.60	6.72
3-4:	8.7	25.37	6.87
4-5:	8.2	24.73	5.23
5-6:	7.8	25.59	4.76
6-7:	7.3	26.14	4.53

YEAR	Diet Uptake (μg/day)	Water Uptake (μg/day)	Paint Uptake (μg/day)	Air Uptake (μg/day)
0.5-1:	2.38	6.05	0.00	0.02
1-2:	2.35	14.24	0.00	0.03
2-3:	2.69	15.13	0.00	0.06
3-4:	2.65	15.78	0.00	0.07
4-5:	2.62	16.82	0.00	0.07
5-6:	2.79	17.95	0.00	0.09
6-7:	3.11	18.40	0.00	0.09

TABLE 9
RESULTING GEOMETRIC MEAN BLOOD LEAD LEVELS FOR VARYING COMBINATIONS OF SOIL, SEDIMENT AND GROUNDWATER AT THE WFF

	PARAMETER CONCENTRATION USED IN LEAD MODEL			
	MAXIMUM		AVERAGE	
	Unfiltered Groundwater	Filtered Groundwater	Unfiltered Groundwater	Filtered Groundwater
SEDIMENT (MAXIMUM)	31.5	3.5	NA	NA
SOIL (MAXIMUM)	31.4	3.4	NA	NA
	31.7	NA	8.1	3.6

All values are the geometric mean blood lead concentrations (μg lead/dl)
NA - Not available