



64940

US EPA Contract No. 68-W9-0024

ARCS II

FINAL ENDANGERMENT ASSESSMENT
TUTU WELLS SITE
ST. THOMAS, VIRGIN ISLANDS
VOLUME I OF IV

**REMEDIAL PLANNING ACTIVITIES AT SELECTED
UNCONTROLLED HAZARDOUS SUBSTANCE
DISPOSAL SITES WITHIN EPA REGION II
(NY, NJ, PR, VI)**

CDM Federal Programs Corporation

TUT 006 2175

**FINAL ENDANGERMENT ASSESSMENT
TUTU WELLS SITE
ST. THOMAS, VIRGIN ISLANDS
VOLUME I OF IV**

**Prepared for
U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Waste Programs Enforcement
Washington, DC 20460**

EPA Work Assignment No.	:	073-2P1D
EPA Region	:	II
Site No.	:	VID982272569
Contract No.	:	68-W9-0024
Document Control No.	:	7720-073-RA-CFKJ
Prepared by	:	CDM Federal Programs Corporation
Work Assignment Project Manager	:	Sally Odland
Telephone Number	:	(212) 393-9634
EPA Work Assignment Manager	:	Caroline Kwan
Telephone Number	:	(212) 637-4275
Date Prepared	:	March 24, 1995

TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
VOLUME I:	
EXECUTIVE SUMMARY	
BASELINE HUMAN HEALTH RISK ASSESSMENT	1
1.0 INTRODUCTION	8
1.1 Overview	8
1.2 Site Background	9
1.2.1 Site Description	9
1.3 Scope of the Risk Assessment	10
1.4 Organization of the Risk Assessment	13
2.0 DATA COLLECTION AND EVALUATION	19
2.1 Summary of Sampling and Analysis Activities	22
2.1.1 Soil	22
2.1.2 Groundwater	26
2.1.3 Air	31
2.2 Summary of Sampling and Analysis Results	32
2.2.1 Data Quality	32
2.2.2 Chemicals Detected in Soil	34
2.2.3 Chemicals Detected in Groundwater	68
2.3 Criteria for the Selection of Chemicals of Potential Concern	74
2.3.1 Blank Concentrations	103

TABLE OF CONTENTS (Cont'd)

	<u>Page</u>
2.3.2 Background Concentrations	105
2.3.3 Physical and Chemical Properties	116
2.4 Evaluation of Tentatively Identified Compounds (TICs)	119
2.5 Selected Chemicals of Potential Concern	120
3.0 EXPOSURE ASSESSMENT	123
3.1 Potential Release and Transport Mechanisms	124
3.2 Identification of Exposure Pathways	124
3.2.1 Present-Use Scenarios	127
3.2.2 Future-Use Scenarios	136
3.3 Exposure Point Concentrations	141
3.3.1 Exposure Point Concentration Modeling	143
3.4 Calculation of Chronic and Subchronic Daily Intakes	146
3.5 Exposure Assumptions	148
3.5.1 Surface Soil	157
3.5.2 Subsurface Soil	163
3.5.3 Groundwater	165
4.0 TOXICITY ASSESSMENT	169
4.1 Health Effects Criteria for Carcinogens	170
4.2 Health Effects Criteria for Noncarcinogens	178

TABLE OF CONTENTS (Cont'd)

	<u>Page</u>
4.2.1 Toxicity Endpoints/Target Organs for Noncarcinogenic Chemicals of Potential Concern Quantitatively Evaluated in the Risk Assessment	181
4.3 Qualitative Discussion of Chemicals Not Quantitatively Evaluated in the Risk Assessment	185
5.0 RISK CHARACTERIZATION	190
5.1 Carcinogenic Risk Characterization	190
5.2 Noncarcinogenic Effects Characterization	191
5.3 Quantitative Results of Carcinogenic Risk and Noncarcinogenic Effects Evaluation	192
5.3.1 Surface Soil	193
5.3.2 Subsurface Soil	201
5.3.3 Groundwater	206
5.4 Combining Cancer Risks and Noncancer Hazard Index Values Across Exposure Pathways	209
5.5 Applicable or Relevant and Appropriate Requirements (ARARs) .	216
6.0 UNCERTAINTIES IN RISK ASSESSMENT	220
6.1 Central Tendency Calculations	223
6.1.1 Surface Soil	225
6.1.2 Groundwater	227

TABLE OF CONTENTS (Cont'd)

	<u>Page</u>
7.0 PRELIMINARY REMEDIATION GOALS	229
7.1 Residential Land Use: Soil Ingestion and Inhalation	230
7.1.1 Noncarcinogens	232
7.2 Commercial/Industrial Land Use: Soil Ingestion and Inhalation . .	235
7.2.1 Noncarcinogens	235
7.3 Residential Land Use: Groundwater Ingestion and Inhalation . . .	237
7.3.1 Noncarcinogens	238
8.0 SUMMARY OF THE BASELINE RISK ASSESSMENT	242

VOLUME II:

Baseline Risk Assessment Appendices

APPENDIX A:	95 Percent Upper Confidence Limit Calculations
APPENDIX B:	Toxicological Profiles
APPENDIX C:	Spreadsheet Calculations
APPENDIX D:	Central Tendency Calculations
APPENDIX E:	Site Data

VOLUME III:

Baseline Risk Assessment Appendices (Cont'd)

APPENDIX E (Cont'd):	Site Data
----------------------	-----------

VOLUME IV:

ECOLOGICAL ASSESSMENT

Ecological Assessment Appendices

- APPENDIX A: Contacts made for Ecological Information on the Site
- APPENDIX B: Threatened and Endangered Species/Significant Habitats
- APPENDIX C: Ecological Exposure and Toxicity

LIST OF TABLES

Table 2-1	Groundwater Monitoring Program (February 1991 - March/April 1993)
Table 2-2	Summary of Chemicals in Surface Soil - Tillett Gardens and Art Center
Table 2-3	Summary of Chemicals in Surface Soil - Fire Department/Texaco Gas Station/Antilles Auto Parts/Ramsay Motor Company
Table 2-4	Summary of Chemicals in Surface Soil - Curriculum Center Building (Present)
Table 2-5	Summary of Chemicals in Surface Soil - Curriculum Center Building (Future)
Table 2-6	Summary of Chemicals in Surface Soil - O'Henry Dry Cleaners and Liquor Barn
Table 2-7	Summary of Chemicals in Subsurface Soil - Tillett Gardens and Art Center
Table 2-8	Summary of Chemicals in Subsurface Soil - Fire Department/Texaco Gas Station/Antilles Auto Parts/Ramsay Motor Company
Table 2-9	Summary of Chemicals in Subsurface Soil - Curriculum Center Building
Table 2-10	Summary of Chemicals in Subsurface Soil - Esso Gas Station and Splash and Dash Car Wash
Table 2-11	Summary of Chemicals in Subsurface Soil - O'Henry Dry Cleaners and Liquor Barn
Table 2-12	Summary of Chemicals in Groundwater (Site-Wide)
Table 2-13	Chemical Concentration - Toxicity Screen for Surface Soil - Tillett Gardens and Art Center
Table 2-14	Chemical Concentration - Toxicity Screen for Surface Soil - Fire Department/Texaco Gas Station/Antilles Auto Parts/Ramsay Motor Company
Table 2-15	Chemical Concentration - Toxicity Screen for Surface Soil - Curriculum Center Building (Present)
Table 2-16	Chemical Concentration - Toxicity Screen for Surface Soil - Curriculum Center Building (Future)
Table 2-17	Chemical Concentration - Toxicity Screen for Surface Soil - O'Henry Dry Cleaners and Liquor Barn

LIST OF TABLES (Cont'd)

Table 2-18	Chemical Concentration - Toxicity Screen for Subsurface Soil - Tillett Gardens and Art Center
Table 2-19	Chemical Concentration - Toxicity Screen for Subsurface Soil - Fire Department/Texaco Gas Station/Antilles Auto Parts/Ramsay Motor Company
Table 2-20	Chemical Concentration - Toxicity Screen for Subsurface Soil - Curriculum Center Building (Future)
Table 2-21	Chemical Concentration - Toxicity Screen for Subsurface Soil - Esso Gas Station and Splash and Dash Car Wash
Table 2-22	Chemical Concentration - Toxicity Screen for Subsurface Soil - O'Henry Dry Cleaners and Liquor Barn
Table 2-23	Chemical Concentration - Toxicity Screen for Groundwater (Site-Wide)
Table 2-24	Polycyclic Aromatic Hydrocarbon Compound Classification
Table 2-25	Soil Background Samples: Analytical Data - Detections Only
Table 2-26	Chemical Concentrations in Site Surface Soil versus Surface Soil Background Concentrations
Table 2-27	Chemical Concentrations in Site Subsurface Soil versus Subsurface Soil Background Concentrations
Table 2-28	Summary of Chemicals of Potential Concern in Site Matrices by Area of Concern
Table 3-1	Potential Exposure Pathways
Table 3-2	Inhalation of Airborne Chemicals (Shower Scenario)
Table 3-3	Ingestion of Chemicals in Soil
Table 3-4	Dermal Contact with Chemicals in Soil
Table 3-5	Inhalation of Indoor and Outdoor Particulates
Table 3-6	Inhalation of VOCs from Surface Soil
Table 3-7	Ingestion of Chemicals in Drinking Water

LIST OF TABLES (Cont'd)

Table 3-8	Dermal Contact with Chemicals in Groundwater While Showering
Table 3-9	Variables Used for Chronic and Subchronic Daily Intake Calculations
Table 4-1	Toxicity Values for Potential Carcinogenic Health Effects - Dose - Response Relationship
Table 4-2	Chronic Toxicity Values for Potential Noncarcinogenic Health Effects - Dose - Response Relationship
Table 4-3	Subchronic Toxicity Values for Potential Noncarcinogenic Health Effects - Dose - Response Relationship
Table 4-4	Toxicity Endpoints/Target Organs for Noncarcinogenic Chemicals of Potential Concern Quantitatively Evaluated in the Risk Assessment
Table 5-1	Combining Carcinogenic Risks Across Pathways
Table 5-2	Combining Noncarcinogenic Hazard Index Values Across Pathways
Table 5-3	Detected Concentrations versus Maximum Contaminant Levels (MCLs) for Chemicals of Potential Concern in Groundwater
Table 6-1	Variables Used for Chronic and Subchronic Daily Intake Calculations for Central Tendency Evaluation (50 th Percentile)
Table 7-1	Soil Risk-Based Preliminary Remediation Goals (PRGs) for Noncarcinogens - Residential and Commercial/Industrial Ingestion and Inhalation
Table 7-2	Groundwater Risk-Based Preliminary Remediation Goals (PRGs) for Noncarcinogens - Residential Ingestion

LIST OF FIGURES

Figure

1-1 Site Location Map

2-1 Site Map (Areas of Concern)

LIST OF ABBREVIATIONS

ABS	-	Absorption Factor
AF	-	Soil-to-Skin Adherence Factor
ARARs	-	Applicable or Relevant and Appropriate Requirements
ARCS	-	Alternative Remedial Contracting Strategy
AT	-	Averaging Time
BW	-	Body Weight
CA	-	Chemical Concentration in Air
CDI	-	Chronic Daily Intake
CERCLA	-	Comprehensive Environmental Response, Compensation, and Liability Act
CF	-	Conversion Factor
CS	-	Chemical Concentration in Soil
CW	-	Chemical Concentration in Water
CAG	-	Carcinogen Assessment Group
CDM Federal	-	CDM Federal Programs Corporation
CLP	-	Contract Laboratory Program
CRAVE	-	Carcinogen Risk Assessment Verification Endeavor
DPNR	-	Department of Planning and Natural Resources
ED	-	Exposure Duration
EF	-	Exposure Frequency
ET	-	Exposure Time
FI	-	Fraction Ingested
FS	-	Feasibility Study
HEAST	-	Health Effects Assessment Summary Tables
IR	-	Ingestion Rate; Inhalation Rate
IRIS	-	Integrated Risk Information System
K _{oc}	-	Organic Carbon Partitioning Coefficient
K _{ow}	-	Octanol-Water Partition Coefficient
LOAEL	-	Lowest-Observed-Adverse-Effect-Level
MCL	-	Maximum Contaminant Level
MF	-	Modifying Factor
NCP	-	National Oil and Hazardous Substances Pollution Contingency Plan
NOAEL	-	No-Observed-Adverse-Effect-Level
NPL	-	National Priority List
PAH	-	Polycyclic Aromatic Hydrocarbon
PC	-	Chemical-Specific Dermal Permeability Constant
PCB	-	Polychlorinated Biphenyl
PRG	-	Preliminary Remediation Goal
PRP	-	Potentially Responsible Party
RAGS-HHEM	-	Risk Assessment Guidance for Superfund - Human Health Evaluation Manual
RAS	-	Routine Analytical Services
RCRA	-	Resource Conservation and Recovery Act

LIST OF ABBREVIATIONS (Cont'd)

RF	-	Respirable Fraction
RfC	-	Reference Concentration
RfD	-	Reference Dose
RME	-	Reasonable Maximum Exposure
RI	-	Remedial Investigation
ROD	-	Record of Decision
RPM	-	Remedial Project Manager
SA	-	Skin Surface Area
SF	-	Slope Factor
SQL	-	Sample Quantitation Limit
SSC	-	Suspended Soil Concentration
SVOC	-	Semivolatile Organic Compound
TAL	-	Target Analyte List
TBC	-	To Be Considered
TCL	-	Target Compound List
TES	-	Technical Enforcement Support
TIC	-	Tentatively Identified Compound
TPH	-	Total Petroleum Hydrocarbon
UCL	-	Upper Confidence Limit
UF	-	Uncertainty Factor
USEPA	-	United States Environmental Protection Agency
VF	-	Soil-to-Air Volatilization Factor
VIHA	-	Virgin Islands Housing Authority
VOC	-	Volatile Organic Compound
WA	-	Work Assignment
WAPA	-	Water and Power Authority

EXECUTIVE SUMMARY

BASELINE HUMAN HEALTH RISK ASSESSMENT

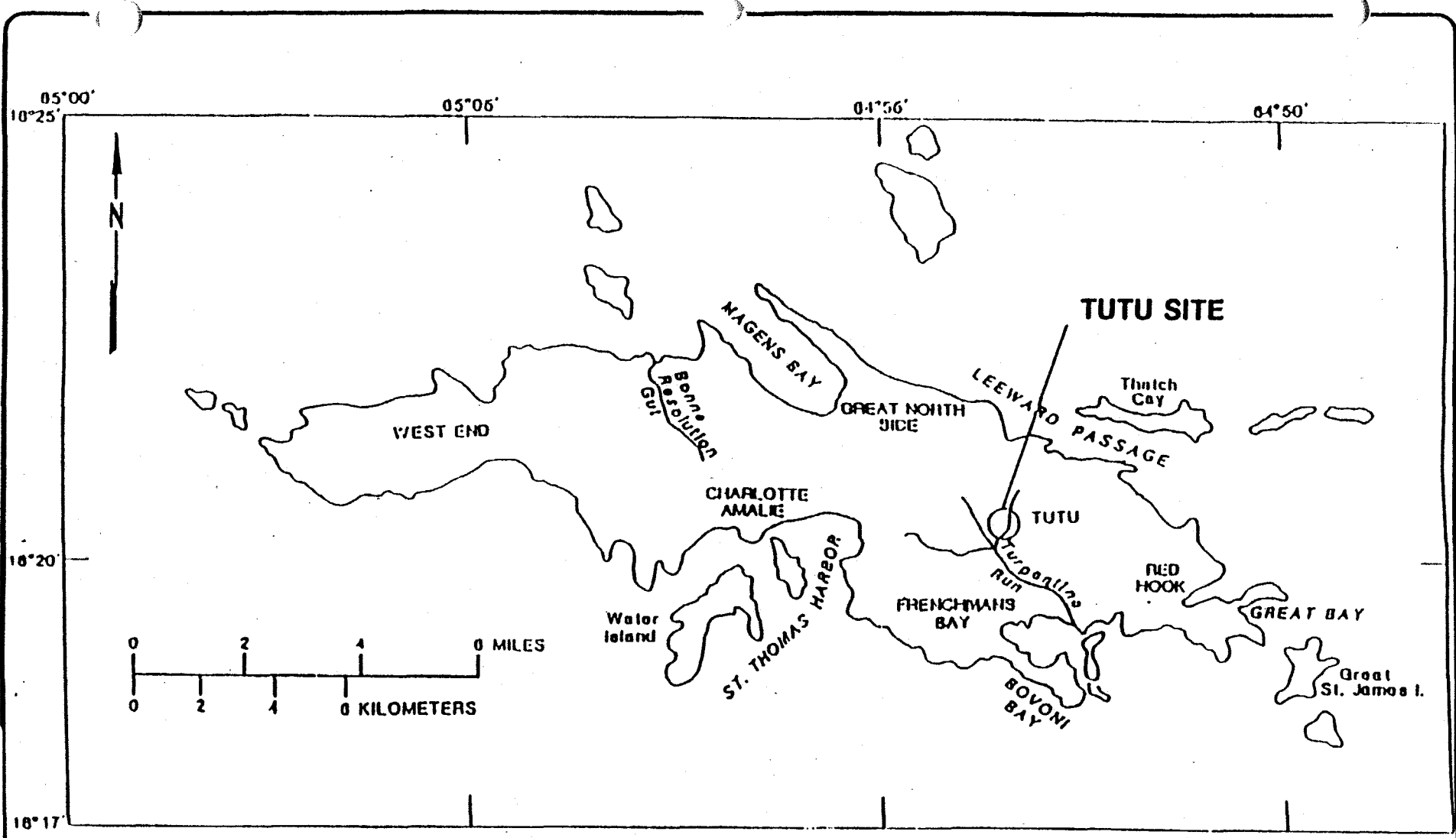
The Tutu Wells site is located on the eastern end of St. Thomas, U.S. Virgin Islands, at the Anna's Retreat Section (Figure 1-1). Many commercial businesses as well as private residences and the Virgin Islands Housing Authority (VIHA) multiple family units are located along the main road (Route 38) running through the site. Numerous water supply wells located at and in the vicinity of the site are utilized for a public drinking water supply. In July 1987, the Department of Planning and Natural Resources (DPNR) received a report of an odor emanating from a well on private property located at Anna's Retreat. The DPNR contacted the USEPA which determined, based on sampling, that drinking water wells at Tutu were contaminated with hazardous chemicals and petroleum products coming from two gas stations in the Tutu area. As a result, four wells were closed down by the DPNR due to high volatile organic compound (VOC) contamination. Under USEPA direction, cisterns served by the contaminated wells were disinfected, home plumbing was modified, contaminated wells were disconnected, and a local water hauler was contracted to deliver uncontaminated drinking water. A water sampling program to monitor the wells was also established by the USEPA.

The USEPA issued a Unilateral Administrative Order to Esso Standard Oil Company, Texaco Caribbean, Inc., and O'Henry dry cleaners in March 1990 to conduct groundwater monitoring of the drinking water wells in the Tutu aquifer, and to provide water to affected homes until the respondents connected to the water main. Esso and Texaco entered into a RCRA 7003/9003 Order of Consent with the USEPA to conduct a Remedial Investigation/Feasibility Study (RI/FS)

2

TUT 006 2189

513191



SCALE: SHOWN

SITE LOCATION

**TUTU SERVICE STATION INVESTIGATION
ST. THOMAS, U.S. VIRGIN ISLANDS**

FIGURE

1-1

Source: Technical Memorandum II - Results of the Field Program - Tutu Service Station Investigation by Geraghty & Miller (May 1993).

at the site in February 1992. The site was proposed for the NPL in February 1992.

This baseline human health risk assessment document for the Tutu Wells site provides quantitative estimates, in accordance with current USEPA policy and guidance, of the carcinogenic risks and noncarcinogenic health effects from human exposure to chemical contaminants in site environmental matrices in the absence of any site remediation and assuming no further institutional controls are put into place. This risk assessment process included data evaluation, exposure assessment, toxicity assessment, risk characterization, and uncertainty evaluation.

The data used in this report were obtained from:

- Geraghty & Miller's Draft Phase II RI Report (October 1994).
- Seven quarterly groundwater sampling reports produced by Geraghty & Miller (February 1991 through March/April 1993).
- Technical Memorandum II - Results of the Field Program Tutu Service Station Investigation produced by Geraghty & Miller (May 1993).
- CDM Federal Programs Corporation (CDM Federal's) 1993 Data Comparison and Evaluation Report for Groundwater and Soil Split Samples of the Tutu Wells Site (June 1993).
- CDM Federal's CLP Sample Analysis Data Summary of the 104(e) Letter Response Sampling Tutu Wellfield Area (September 8 through 15, 1988).
- CDM Federal's Final CLP Sample Analysis Data Summary of Soils and Waters Sampled in 1989, Tutu Wellfield Site, St. Thomas, U.S. Virgin Islands (June 5 through 10, 1989).

- Five groundwater samples collected from four monitoring wells at O'Henry dry cleaners by the O'Henry PRP in March 1993.

Chemicals of potential concern were selected for each sampled matrix for quantitative evaluation in the risk assessment. The selected chemicals are expected to be most representative of site conditions and the greatest contributors to potential human health impacts. The chemicals of potential concern selected for each sampled matrix are presented in Table 2-28.

Exposure scenarios (i.e., receptor groups and routes of exposure) were developed for both present and future land uses, as appropriate. The exposure point concentration for each chemical to which a person may be exposed was estimated by using the 95 percent Upper Confidence Limit (UCL) on the mean calculation as defined by USEPA guidance. Potential chemical intakes were then calculated using 95 percent UCL concentrations and reasonable maximum exposure (RME) variables.

The toxicity assessment presents general toxicological properties and identifies health effects criteria of selected chemicals of potential concern using the most current toxicological human health effects data. Chemicals with insufficient toxicological data were qualitatively addressed.

Carcinogenic risks and noncarcinogenic health effects were then characterized by integrating these exposure and toxicity assessments into quantitative expressions of carcinogenic risk and noncarcinogenic hazard index values. The quantitative results of this risk assessment should not be construed as absolute values, but instead as estimates of potential human health impacts. By

using RME variables, conservative estimates of health risks/effects within the range of possible exposures were obtained. These estimates were then compared to the acceptable USEPA target risk range of 10^{-4} to 10^{-6} for carcinogens and target level of one for noncarcinogens. The 10^{-4} to 10^{-6} target risk range may be interpreted as meaning carcinogenic risks should not be greater than approximately 1 in 10,000 to 1 in 1,000,000. Based on consultation with the USEPA, a carcinogenic risk greater than 1 in 10,000 or $1.0\text{E-}04$ is considered in exceedance of the target risk range.

Carcinogenic risks for present and potential future residential (adult and child) exposure to surface soil in the Tillett Gardens and Art Center via ingestion and dermal contact, and to groundwater via ingestion (adults and children), were in exceedance of the upper-bound of the USEPA's target risk range of 10^{-4} to 10^{-6} (i.e., greater than $1.0\text{E-}04$). Present and potential future site worker (employee) exposure to groundwater via ingestion also showed a carcinogenic risk which was in exceedance of the upper-bound of the target risk range. While soil exceedances were due mainly to Aroclor 1242, groundwater exceedances were due mainly to the combined tetrachloroethene and vinyl chloride risks.

Hazard index values for present and potential future residential (child only) exposure to surface soil in the Tillett Gardens and Art Center via ingestion and inhalation of particulates, as well as present and potential future resident (adult and child), site worker (employee), and construction worker (future-use only) exposures to groundwater via ingestion, were in exceedance of the USEPA's target level of one. The soil exceedances were due mainly to manganese while the

groundwater exceedances were due mainly to 1,2-dichloroethene (total), tetrachloroethene, antimony, manganese, and vanadium. The range of detections for the chemicals of potential concern selected in groundwater were compared to Applicable or Relevant and Appropriate Requirements (ARARs), which include federal maximum contaminant levels (MCLs).

In accordance with standard risk assessment practice, uncertainty in risk assessment is evaluated both qualitatively and quantitatively. A quantitative evaluation, involving the calculation of central tendencies, was performed for those exposure scenarios showing carcinogenic risks or noncarcinogenic hazard index values above the USEPA target levels.

Risk-based preliminary remediation goals (PRGs), as defined by USEPA guidance, were developed for the residential groundwater exposure scenario for chemicals not having established MCLs. Soil PRGs were developed for manganese for residential and commercial/industrial combined ingestion and inhalation exposures (1,360 mg/kg and 9,900 mg/kg, respectively). These PRGs are presented in Table 7-1. Groundwater PRGs of 0.33 mg/l and 0.18 mg/l were developed for the noncarcinogens 1,2-dichloroethene (total) and manganese and are presented in Table 7-2. Available MCLs for chemicals of potential concern in groundwater are presented in Table 5-3.

Finally, a summary of the results of the quantitative evaluation of potential carcinogenic risks and noncarcinogenic health effects was presented, with special note given to those results in

exceedance of the USEPA target levels. Risks and hazards are discussed in detail in Section 5.0 and are summarized in Table 5-1 and 5-2.

1.0 INTRODUCTION

1.1 Overview

CDM Federal Programs Corporation (CDM Federal) originally received Work Assignment (WA) No. C02116 from the U.S. Environmental Protection Agency (USEPA) under the Technical Enforcement Support (TES) V Contract which expired on April 30, 1994. When the WA was transferred and reactivated as WA 073-2P1D under the Alternative Remedial Contracting Strategy (ARCS II) contract, CDM Federal completed the endangerment assessment. The purpose of this WA is for CDM Federal to provide technical assistance by conducting an endangerment assessment relating to the Remedial Investigation/Feasibility Study (RI/FS) currently being performed for the Tutu Wells site in St. Thomas, Virgin Islands.

The specific objectives of this risk assessment are to evaluate appropriate site environmental matrices for potential human exposure routes to determine if adverse human health impacts are occurring at present and/or may occur in the future. This risk assessment was performed under the assumption that no additional corrective action will occur in the future. Presently, an order exists which states that site groundwater should not be used for drinking or bathing, but may be used for secondary purposes such as lawn watering and clothes laundering.

This report was prepared in accordance with USEPA Region II and federal guidance documents and the on-line data base listed below. Additional references are listed in the reference section at the end of the report.

- Risk Assessment Guidance for Superfund: Human Health Evaluation Manual (USEPA, 1989a).
- Exposure Factors Handbook (USEPA, 1989b).
- Guidance for Data Useability in Risk Assessment (USEPA, 1992a).
- Dermal Exposure Assessment: Principles and Applications - Interim Report (USEPA, 1992c).
- Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors (USEPA, 1991a).
- Health Effects Assessment Summary Tables FY 1994-Annual (USEPA, 1994).
- Integrated Risk Information System On-line Data Base of Toxicity Measures (IRIS, 1994).

1.2 Site Background

1.2.1 Site Description

The Tutu Wells site is located near the eastern end of St. Thomas, an island covering 32 square miles. As reported by Geraghty & Miller (1993a), the site is located within the Turpentine Run surface drainage basin which covers approximately 3.4 square miles. Turpentine Run is an intermittent stream which flows from northwest to southeast. The Turpentine Run basin is

separated into upper and lower basins; the upper consists of 2.3 square miles upstream of the historical stream gaging station located near Mt. Zion and the lower consists of 1.1 square miles downstream of this station (Jordan and Cosner, 1973). The major highway routes running through the site are lined with both single and multiple family residences as well as commercial establishments. Public drinking water supply wells are located throughout the site and surrounding area, although at present, clean water is delivered to the area by truck for primary usage (i.e., drinking). The groundwater from some of these wells is currently used for secondary (i.e., non-potable) purposes only, such as clothes laundering and lawn watering.

1.3 Scope of the Risk Assessment

Human health risk assessments have been utilized by regulatory agencies for the development of regulatory guidelines and criteria for environmental pollutants. Guidelines and criteria impact large numbers of potential receptors, therefore, worst-case (conservative) assumptions have typically been used by the regulatory agencies to ensure adequate protection of public health.

In the last few years, the USEPA has adopted these same risk assessment techniques to assist in resolving site-specific contamination problems. For these assessments, the goals are quite distinct. The first step is to evaluate the ways in which site contaminants might pose specific health threats to the public. For the sites where the estimated baseline risks are unacceptably high, a second step is taken. This step includes the identification and evaluation of potential

engineering remedies, including the extent to which each alternative remedy might reduce the baseline risks to an acceptable level.

As part of the effort to streamline the process and reduce the cost and time required to conduct the RI/FS and implement a clean up remedy if necessary, the Superfund human health evaluation focuses on providing information to justify action at the site and to select the best remedy for the site (USEPA, 1989a). For remedy decisions, utilizing worst-case approaches to evaluate baseline risks and hazards is clearly inconsistent with those goals. The use of chemicals that are not site-related and the application of overly conservative assumptions to determine potential exposure levels typically results in risk estimates that are one or more orders of magnitude greater than the risks likely to be posed by actual site conditions. Once worst-case risk conclusions have been reached, it becomes difficult to clearly evaluate which receptors are most significantly impacted, which medium poses the highest risks, and whether there are any imminent or substantial health risks posed. A more reasonable approach, and one recommended in the USEPA's Risk Assessment Guidance for Superfund (RAGS) Part A Human Health Evaluation Manual (HHEM) (USEPA, 1989a), involves estimating the reasonable maximum exposure (RME). The RME is the highest exposure that is reasonably expected to occur at a site. The risks and hazard index values estimated in this risk assessment are based on the RME.

This baseline risk assessment presents an evaluation of the potential risks and hazards to human health that may exist at the site currently and in the future in the absence of any further remediation (i.e., no further action). The soil and groundwater samples collected by Geraghty

& Miller between March and July 1994 as part of their Phase II RI, seven quarterly groundwater sampling reports completed by Geraghty & Miller between February 1991 and March/April 1993, Technical Memorandum II - Results of the Field Program Tutu Service Station Investigation completed by Geraghty & Miller in May 1993, CDM Federal's 1993 Data Comparison and Evaluation Report for Groundwater and Soil Split Samples of the Tutu Wells site, CDM Federal's September 8 through 15, 1988 and June 5 through 10, 1989 sampling reports, and five groundwater samples collected from four monitoring wells located on the O'Henry dry cleaners property by the O'Henry PRP in March 1993, serve as the main sources of the data used in this risk assessment.

This baseline risk assessment was prepared utilizing, to the maximum extent possible, site-specific data to define sources, pathways, receptors, chemical concentrations, and exposure input terms. Where specific data were not available, professional judgement was used to select input terms that are assumed to reflect actual site conditions. By having an adequate data base, the need for using conservative sources, pathways, chemical concentrations, and exposure input terms has been minimized.

1.4 Organization of the Risk Assessment

Data Evaluation

In the first step of the assessment, Data Evaluation, a subset of the various chemicals identified at the site was selected for detailed analysis. The primary selection criteria for these chemicals included 1) chemical concentrations in various media; 2) a chemical concentration-toxicity screen; 3) frequency of detection; 4) the physical/chemical parameters; 5) the degree of toxicity, mobility, and persistence of each chemical in the environment; and 6) historical information about site activities and the chemicals reliably associated with these activities. This procedure is described in detail in Data Collection and Evaluation (Section 2.0) of this risk assessment. Appendix E contains the site data utilized in the risk assessment which were collected during the various field investigations.

Exposure Assessment

In the second step, Exposure Assessment, qualitative or quantitative estimates of the magnitude, frequency, duration, and routes of exposure were made. Numerous pathways through which chemical contaminants could possibly migrate from potential sources to existing receptors were identified. Receptor groups (i.e., human populations) that might potentially be exposed as a result of the presence of one or more chemicals in the environment were also identified. Typically, these receptor populations include persons who might be exposed via ingestion of,

dermal contact with, or inhalation of chemicals in or released from media such as soil and water. Receptors who might be exposed under present or potential future land or water use scenarios were evaluated, as appropriate.

Exposure point concentrations for chemicals of potential concern were estimated based on the 95 percent Upper Confidence Limit (UCL) on the arithmetic mean (Appendix A). However, if the maximum site detection for a chemical was lower than the calculated 95 percent UCL concentration, the actual maximum site detection was utilized in the estimation of chemical intakes to prevent potential overestimation of human health impacts. In the cases where only one sample was collected, the single detected concentration was utilized in the estimation of chemical intakes.

Daily chemical intakes via ingestion, dermal contact, and/or inhalation routes were estimated based on the 95 percent UCL estimate and site-specific, medium-specific, and receptor-specific intake variables. Both chronic (seven years to lifetime) and subchronic (two weeks to seven years) daily intakes were estimated in this risk assessment depending on the specific receptor population being evaluated. Exposures were estimated for the RME which employs the 95 percent UCL (exposure point) concentration and RME assumptions (i.e., 90th and 95th percentile parameters except for skin surface area which utilizes 50th percentile parameters). The RME is the highest exposure that is reasonably expected to occur at a site.

It should be noted that this risk assessment assumes that no reduction in exposure concentrations occurs due to natural physical/chemical processes, site remediation or institutional controls. The results of the exposure assessment evaluation are provided in the Exposure Assessment (Section 3.0) of this risk assessment.

Toxicity Assessment

The third step of the risk assessment consisted of the Toxicity Assessment. The purpose of the toxicity assessment was to weigh available toxicological evidence regarding the potential for a particular chemical contaminant to cause adverse health effects in exposed individuals and to provide, where possible, an estimate of the relationship between the extent of exposure to a chemical contaminant and the increased likelihood and/or severity of adverse effects (USEPA, 1989a).

The USEPA has performed the toxicity assessment step for numerous chemicals and has made available the resulting toxicity information and toxicity values, which have undergone extensive peer review; however, data analysis and interpretation are still required when applying these values to a site. These established toxicity values were obtained from the Integrated Risk Information System (IRIS) data base (June 22 and 30, July 1, August 4, and October 25, 1994) which is updated monthly, or from the Health Effects Assessment Summary Tables (HEAST) FY 1994-Annual, if no value was present IRIS. The Superfund Health Risk Technical Support

Center was consulted for numerous specific chemical toxicity values (i.e., subchronic toxicity values), as directed by HEAST, when no value was presented.

A toxicological profile for each of the chemicals of potential concern was developed using the USEPA toxicity assessments and accompanying values. The toxicity data were evaluated to determine if they were appropriate for use in the risk assessment, or if they needed to be modified. When toxicity values were not available for a specific chemical, the chemical was qualitatively discussed. The toxicity values and the limitations of use of the toxicity values are described in the Toxicity Assessment (Section 4.0) of this risk assessment. Toxicological profiles are presented in Appendix B of this report.

Risk Characterization

In the last step of the risk assessment, Risk Characterization, the chronic or subchronic daily intake for each chemical to which a given receptor group might be exposed was compared to a concentration known or suspected to present some health risk or hazard. Quantitative estimates of the carcinogenic risks and noncarcinogenic health effects (hazard index values) associated with each exposure pathway are presented along with total estimated risks and hazard index values for present and potential future uses of the site.

The risks resulting from exposures to carcinogens were estimated based on the following assumptions.

- a linear relationship exists between the intake of a carcinogenic substance over a lifetime and the probability of cancer (the linearized multistage model of carcinogenesis) and;
- cancer risks from exposures to all carcinogens via all intake routes are additive.

The potential for noncarcinogenic effects was evaluated by comparing an exposure level over a specified time period with a reference dose derived for a similar exposure period. Section 5.0 of this risk assessment presents Risk Characterization. Spreadsheet calculations are presented in Appendix C of this risk assessment.

Due to the number of assumptions that are required during the risk assessment process, there will inevitably be some degree of uncertainty associated with the baseline risk and hazard estimates. These uncertainties are addressed both qualitatively and quantitatively (i.e., central tendency calculations) in Section 6.0 Uncertainties in Risk Assessment. Central tendency calculations are presented in Appendix D of this report.

Risk-based preliminary remediation goals (PRGs) are initial concentration goals for individual chemicals for specific medium and land use combinations. Whether PRGs are required for a site depends on the calculated site risks and hazard estimates, the existence of Applicable or Relevant and Appropriate Requirements (ARARs), and the existence of superseding USEPA guidance on action levels. PRGs for this site were calculated for residential and commercial/industrial exposure to site soil as well as for residential exposure to groundwater and are presented and discussed in Section 7.0 Preliminary Remediation Goals (PRGs).

A summary of the results of the baseline human health risk assessment is presented in Section 8.0.

2.0 DATA COLLECTION AND EVALUATION

Field investigations conducted by Geraghty & Miller, CDM Federal, and the O'Henry PRP from 1988 to 1994 serve as the sources of information for site characterization and analytical data for this risk assessment. The investigations include:

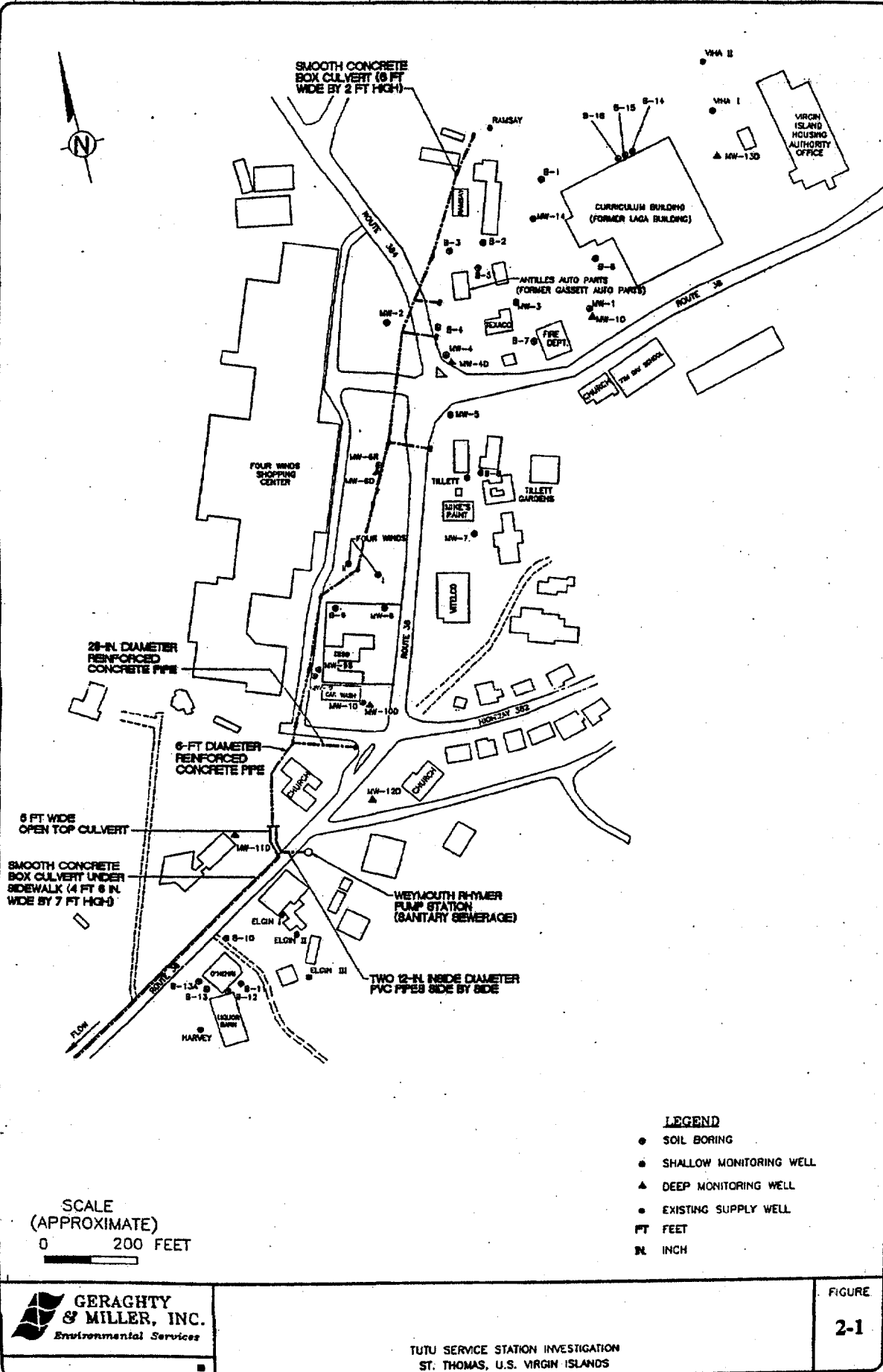
- Geraghty & Miller's Draft Phase II RI field investigation data (soil and groundwater) - (Geraghty & Miller, 1994).
- Technical Memorandum II - Results of the Field Program Tutu Service Station Investigation (soil and groundwater) - (Geraghty & Miller, 1993a).
- Seven quarterly groundwater sampling reports (Geraghty & Miller, 1991a, b, 1992a - February, June, and October, Geraghty & Miller, 1992c, d, e - February, May, and September, and Geraghty & Miller, 1993b March/April).
- CDM Federal's Data Comparison and Evaluation Report for Groundwater and Soil Split Samples at the Tutu Wells site (CDM Federal, 1993).
- CDM Federal's CLP Sample Analysis Data Summary of the 104(e) Letter Response Sampling Tutu Wellfield Area (September 8 through September 15, 1988) (CDM Federal, 1989a, b).
- CDM Federal's Final CLP Sample Analysis Data Summary of Soils and Waters Sampled in 1989, Tutu Wellfield, St. Thomas, U.S. Virgin Islands (June 5 through June 10, 1989) (CDM Federal, 1990).
- O'Henry dry cleaners PRP groundwater sampling of four monitoring wells located on the dry cleaning establishment property (March 1993).

This section presents a summary of the results of the sampling and analysis activities conducted to characterize conditions at the Tutu Wells site. The results of these activities are presented along with the criteria used to identify chemicals of potential concern and a list of chemicals of potential concern selected on the basis of these criteria.

All site environmental data, including Tentatively Identified Compounds (TICs), which were evaluated and/or utilized in this risk assessment are presented in Appendix E. The sampling results have been summarized in tabular form by area of concern for surface soil, subsurface soil, and groundwater and are presented in Section 2.2. The five areas of concern quantitatively evaluated in this risk assessment include the Tillett Gardens and Art Center, the Curriculum Center Building, the Fire Department/Texaco gas station/Antilles auto parts/Ramsay motor company, Esso gas station and Splash and Dash car wash, and O'Henry dry cleaners and Liquor Barn. The locations of these areas are presented in Figure 2-1. Each data summary table presents all chemicals detected, the associated frequencies and ranges of detections, the locations of the maximum detected concentrations, and the range of non-detect concentrations. Data are segregated by locations considered to be potentially impacted by the site (i.e., on-site and downgradient) and by locations that may be representative of "background" (i.e., upgradient).

All analytical data generated during the Geraghty & Miller, CDM Federal, and O'Henry PRP field investigations and which were utilized in this risk assessment, including TICs, were validated in accordance with USEPA Region II protocols. Accordingly, all data qualifiers have been included in the data summary tables for completeness.

Data collected from media to which exposure was considered likely and where exposure pathways were considered complete (i.e., soil and groundwater) formed the basis of the quantitative risk assessment. These data were used to estimate exposure point concentrations as discussed in Section 3.3 and carcinogenic risk and noncarcinogenic hazard estimates as presented in Section 5.0.



2.1 Summary of Sampling and Analysis Activities

The environmental media that were sampled and that were quantitatively evaluated in this risk assessment included surface soil, subsurface soil, and groundwater. The following is a summary of specific data sets for soil and groundwater used in the evaluation of potential human health risks and hazards and a discussion of data for air which was quantitatively evaluated for the O'Henry dry cleaners and Liquor Barn area in the risk assessment.

2.1.1 Soil

As part of Geraghty & Miller's Phase II RI field investigation, eight monitoring wells (MW-13, MW-15, MW-16 (a duplicate sample was collected)), MW-17, MW-18, MW-19, MW-24, and MW-25) were installed in March and April 1994. Nine samples were collected from these wells. The only surface soil samples collected were from monitoring well location MW-16 (including a duplicate). Subsurface soil samples were collected from the remaining seven monitoring wells. The locations of these wells were obtained from Geraghty & Miller's study area map showing supply well, monitoring well, and soil sampling locations and which is included in their Draft Phase II RI report. As part of Geraghty & Miller's Technical Memorandum II (Phase I) (Geraghty & Miller, 1993a), seventeen borings, including B-1 through B-13, B-13A, B-14, B-15, and B-16 and eighteen monitoring wells, including MW-1 through MW-10, MW-14, MW-1D, MW-4D, MW-6D, MW-10D, MW-11D, MW-12D, and MW-13D were drilled. Soil samples were collected from June to August 1992 (see Figures 1-3 and 1-4

of Technical Memorandum II-May 1993) for locations.

Eight surface soil samples, SS-1 through SS-6 (and SS-6FR) and SS-8, were collected from seven locations in August 1992 (see Figure 1-3 of Technical Memorandum II - May 1993). Surface soil samples SS-1, SS-2, and SS-8, located north of the Curriculum Center Building, are considered background samples and were analyzed for Target Analyte List (TAL) metals and cyanide only. Surface soil samples SS-3 through SS-6 (SS-6FR is a duplicate sample of SS-6) were analyzed for Target Compound List (TCL) VOCs, 1,2-dibromomethane, n-propylbenzene, methyl-tertiary-butyl-ether, TCL SVOCs, TAL metals and cyanide, and total petroleum hydrocarbons (TPHs). SS-7 data, as received by CDM Federal from Geraghty & Miller, is a field rinsate blank sample. Surface soil samples were collected at intervals ranging from one to seven inches below land surface after removing the top one inch layer of soil and vegetation.

Overall, thirty-nine samples, including four replicates, were collected from thirty-five soil boring and monitoring well locations during the Technical Memorandum II (Geraghty & Miller, 1993a) investigation. These samples were analyzed for TCL VOCs, 1,2-dibromomethane, n-propylbenzene, methyl-tertiary-butyl-ether, TCL SVOCs, TAL metals and cyanide, and TPHs.

Soil samples were collected at depth intervals ranging from zero to sixteen feet. Of these, eighteen soil samples were collected at depths ranging from zero to two feet, while twenty-one soil samples were collected at depths ranging from two to twelve feet (with the exception of sample MW-1D which was collected from one to two and one half feet). Of the eighteen soil

samples collected from zero to two feet, only six are considered surface soil samples since twelve were collected from beneath paved surfaces. Three of the six surface soil sample locations (B-14, B-15, and B-16) will likely be paved over in the near future. Based on this expected activity, these samples were considered surface soils in the present-use scenario, but were considered subsurface soil samples in the future-use scenario. Surface soil samples collected from zero to two feet below unpaved surfaces, and subsurface soil samples collected from under paved surfaces and from two (and one and one half feet - sample MW-1D) to approximately fourteen feet were used to produce data summary tables and calculate chemical concentration-toxicity screens and exposure point concentrations. Subsurface soil data down to approximately fourteen feet were used in the risk assessment, as this is the zone of soils which might be accessed during any potential excavation activities, and, in addition, this approach maximizes use of the available site sample data.

Split samples were collected by CDM Federal in August 1992 for each of seven surface soil samples (SS-1 through SS-6 and SS-8) taken by Geraghty & Miller. In July and August 1992, seven subsurface soil samples were split with Geraghty & Miller including MW-8, MW-6D, MW-9, B-6, B-1, MW-5, and B-12. These samples were analyzed for TCL VOCs and SVOCs, TAL metals, and cyanide. Subsurface soil samples were also analyzed for methyl-tertiary-butyl-ether, 1,2-dibromomethane, n-propylbenzene, and TPHs.

Prior to Geraghty & Miller's 1992 soil sampling as part of the Technical Memorandum II investigation (Geraghty & Miller, 1993a), CDM Federal collected hand augured surface soil

samples at the Tutu Wells site during September 8 through 15, 1988 and during June 5 through 10, 1989 in an effort to identify potentially contaminated areas of the site. The locations of the samples were obtained from field logbooks, CDM personnel, and from CDM Federal documents (CDM Federal Programs Corporation, 1989a, 1990). Per the USEPA Remedial Project Manager's (RPM's) request, these data have been included in the endangerment assessment.

During the September 1988 sampling event, one surface soil sample (e-01) was collected at O'Henry dry cleaners, two surface soil samples (eR-07s and eR-08s) were collected at the Ramsay motor company, two surface soil samples (eC-09s and eC-10s) were collected at Antilles auto parts, and two surface soil samples (eTT-14s and eTT-15s) were collected at the Tillett Gardens and Art Center. Samples were analyzed for various combinations of analytes including TCL VOCs, SVOCs, and pesticides/PCBs, TAL metals, and TPHs, and were collected at intervals ranging from zero to twelve inches below land surface. Two samples collected at the Texaco gas station (eT-02s and eT-02sd) were originally identified as surface soil samples. However, based on a recent site visit, the Texaco gas station area was observed to be completely paved. Therefore, these samples will be considered subsurface soil samples in the risk assessment.

During the June 1989 sampling event, three surface soil samples (e0-02-01, e0-02-02, and e0-02-03) were collected at O'Henry dry cleaners, three surface soil samples (eL-02-01s, eL-02-02s, and eL-02-03s) were collected behind the Curriculum Center Building, and one surface soil samples (eR-02-02s) was collected at the Ramsay motor company. Samples were analyzed for

various analyte combinations including TCL VOCs, SVOCs, and pesticides/PCBs, TAL metals, and TPHs, and were collected at intervals ranging from zero to two feet below land surface.

2.1.2 Groundwater

As part of their Phase I RI field investigation, Geraghty & Miller has been monitoring approximately twenty-five residential and commercial water supply wells at and in the vicinity of the site since September 1990 and has produced eight quarterly sampling reports including the most recent March/April 1993 sampling event results. The seven most recent sampling reports (reports two through eight) have been utilized in the production of the Tutu Wells site risk assessment per the direction of the USEPA RPM. In addition to these reports, Geraghty & Miller has also produced, as part of the Phase I RI, the Technical Memorandum II Tutu Service Station Investigation report (Geraghty & Miller, 1993a) which evaluated fourteen monitoring wells located at the site. During the Phase II RI field investigation, Geraghty & Miller conducted additional monitoring well installation and sampling. O'Henry dry cleaners has independently installed and sampled four monitoring wells from which two rounds of groundwater samples were collected (March and May 1993). Five samples were collected and analyzed for TCL VOC and low detection limit analyte lists in March 1993. These data have been validated by the USEPA so that they can be incorporated into the endangerment assessment. The May 1993 sample data were not utilized due to the closeness of the sampling dates, general similarity of the results, and the fact that the wells are more cross-gradient than representative downgradient wells under current nonpumping conditions.

Table 2-1 presents the wells sampled and parameters analyzed for the second through eighth groundwater sampling events.

As part of the second quarterly sampling event in February 1991, twenty-three wells were sampled for TCL VOCs and at least two of the following metals: antimony, mercury, selenium, and thallium. The Four Winds I and VIHA I wells were not sampled due to inoperable pumps. The remaining wells listed on Table 2-1 were not scheduled to be sampled during this event.

As part of the third quarterly sampling event in June 1991, fourteen wells were sampled for TCL VOCs only. The Four Winds II and VIHA I wells were not sampled due to inoperable pumps. The remaining wells listed on Table 2-1 were not scheduled to be sampled during this event.

As part of the fourth quarterly sampling event in October 1991, fourteen wells were sampled for TCL VOCs only. The Four Winds II and VIHA I wells were not sampled due to inoperable pumps. The remaining wells listed on Table 2-1 were not scheduled to be sampled during this event.

As part of the fifth quarterly sampling event in February 1992, eighteen wells were sampled for TCL VOCs and SVOCs, TAL metals, and cyanide. A Water and Power Authority (WAPA) sample was collected from the standpipe at the Virgin Island Housing Authority property on Route 38. The VIHA I, II, and III wells were not sampled due to inoperable pumps. The remaining wells listed on Table 2-1 were not scheduled to be sampled during this event.

TUTU WELLS SITE
GROUNDWATER MONITORING PROGRAM (FEBRUARY 1991 - MARCH/APRIL 1993)*

Sampling Event: Date:	Second February 1991	Third June 1991	Fourth October 1991	Fifth February 1992	Sixth May 1992	Seventh September 1992	Eighth March/April 1993
ANALYTICAL PARAMETERS							
WELLS SAMPLED:							
(1) Bryan	VOCs, TI, Hg	-	-	-	-	-	-
(2) Dede	VOCs, Sb, TI	-	-	VOCs, SVOCs, Metals, CN	-	-	VOCs, SVOCs, Metals, CN
(1) Dimitri	VOCs, TI, Hg	-	-	-	-	-	-
(2) Dench	VOCs, Sb, TI	-	-	-	-	-	VOCs, SVOCs, Metals, CN
(2) Devcon I	VOCs, Sb, TI	-	-	-	-	-	-
(2) Devcon II	-	-	-	-	-	-	VOCs, SVOCs, Metals, CN
(2) Devcon III	VOCs, Sb, TI	-	-	-	-	-	-
Eglin I	VOCs, TI, Hg	VOCs	VOCs	VOCs, SVOCs, Metals, CN	VOCs	VOCs	VOCs, SVOCs, Metals, CN
Eglin II	VOCs, Sb, TI	VOCs	VOCs	VOCs, SVOCs, Metals, CN	VOCs	VOCs	-
Eglin III	VOCs, Sb, TI**	VOCs	VOCs	VOCs, SVOCs, Metals, CN	VOCs	VOCs	VOCs, SVOCs, Metals, CN
Four Winds I	-	VOCs	VOCs	VOCs, SVOCs, Metals, CN	-	VOCs	VOCs, SVOCs, Metals, CN
Four Winds II	VOCs, Sb, TI	-	VOCs	VOCs, SVOCs, Metals, CN	-	VOCs	-
Gassett	VOCs, TI, Hg	VOCs	VOCs	VOCs, SVOCs, Metals, CN**	VOCs	VOCs	VOCs, SVOCs, Metals, CN
Harthman II	VOCs, Sb, TI	VOCs	VOCs	VOCs, SVOCs, Metals, CN**	-	VOCs	-
Harthman III	VOCs, Sb, TI	VOCs	VOCs	VOCs, SVOCs, Metals, CN	-	-	-
Harvey	VOCs, Sb, TI	VOCs	VOCs	VOCs, SVOCs, Metals, CN	VOCs	VOCs	VOCs, SVOCs, Metals, CN**
LaPlace	VOCs, TI, Hg**	VOCs**	VOCs	VOCs, SVOCs, Metals, CN**	VOCs	VOCs	VOCs, SVOCs, Metals, CN
(1) Leonard	VOCs, Sb, TI	-	-	VOCs, SVOCs, Metals, CN	-	-	VOCs, SVOCs, Metals, CN
Matthias	VOCs, TI, Hg	VOCs	VOCs	VOCs, SVOCs, Metals, CN	-	-	-
Ramsay	VOCs, TI, Hg	VOCs	VOCs	VOCs, SVOCs, Metals, CN	VOCs	VOCs**	VOCs, SVOCs, Metals, CN
Rodriguez	VOCs, Sb, TI	-	-	VOCs, SVOCs, Metals, CN	-	-	VOCs, SVOCs, Metals, CN
Smith	VOCs, Sb, TI, Se	VOCs	VOCs	VOCs, SVOCs, Metals, CN	VOCs**	VOCs	VOCs, SVOCs, Metals, CN
Steele	VOCs, Sb, TI	VOCs	VOCs	VOCs, SVOCs, Metals, CN	VOCs	VOCs	VOCs, SVOCs, Metals, CN
Tillett	VOCs, TI, Hg	VOCs	VOCs**	VOCs, SVOCs, Metals, CN	VOCs	VOCs	VOCs, SVOCs, Metals, CN
VIHA I	-	-	-	-	-	-	-
VIHA II	-	-	-	-	-	-	-
(1) VIHA III	VOCs, Sb, TI	-	-	-	-	-	-
WAPA	-	-	-	VOCs, SVOCs, Metals, CN	-	-	-

Notes:

*The first sampling event from September/October 1990 was not included per direction of the USEPA RPM. All information on this table was obtained from seven Geraghty & Miller well sampling event reports (February 1991 through March/April 1993) (see reference section of risk assessment).

** A field replicate was also collected and analyzed.

Abbreviations:

- Not sampled.

VOCs - volatile organic compounds (TCL)

SVOCs - base neutral acid extractables (TCL)

Metals - TAL

CN - cyanide

Sb - antimony

Hg - mercury

Se - selenium

TI - thallium

(1) Upgradient and cross-gradient water supply wells.

(2) Downgradient water supply wells.

As part of the sixth quarterly sampling event in May 1992, ten wells were sampled for TCL VOCs only. The remaining wells listed on Table 2-1 were not scheduled to be sampled during this event.

As part of the seventh quarterly sampling event in September 1992, thirteen wells were sampled for TCL VOCs only. The remaining wells listed on Table 2-1 were not scheduled to be sampled during this event.

As part of the eighth quarterly sampling event in March and April 1993, fifteen wells were sampled for TCL VOCs and SVOC, TAL metals, and cyanide. A field replicate was collected from the Harvey well and analyzed for the same parameters. The VIHA I, VIHA II, Eglin II, Four Winds II, and Devcon II wells were not sampled due to inoperable pumps. The Matthias well was not sampled as the property owner would not allow access. The Harthman II and Harthman III wells were not sampled due to construction activities at the new Four Winds shopping plaza. The remaining wells listed on Table 2-1 were not scheduled to be sampled during this event.

As part of the Technical Memorandum II Tutu Service Station Investigation (Geraghty & Miller, 1993a), Geraghty & Miller installed twelve shallow monitoring wells (MW-1, MW-2, MW-3, MW-4, MW-5, MW-6R, MW-7, MW-8, MW-9, MW-9S, MW-10, and MW-14) and seven deep monitoring wells (MW-1D, MW-4D, MW-6D, MW-10D, MW-11D, MW-12D, and MW-13D).

Groundwater samples were collected from all shallow and deep wells in September and October 1992 and were analyzed for TCL VOCs and SVOCs, TAL metals, cyanide, 1,2-dibromomethane, n-propylbenzene, methyl-tertiary-butyl-ether, and TPHs.

CDM Federal collected split samples in September and October 1992 of five Geraghty & Miller aqueous samples (four groundwater samples and one field blank). The groundwater samples (MW-6R, MW-4, MW-5, and MW-14) were analyzed for TCL VOCs and SVOCs, TAL metals, (total only), cyanide, methyl-tertiary-butyl-ether, 1,2-dibromomethane, n-propylbenzene, and TPHs.

Geraghty & Miller recently conducted Phase II RI field activities to supplement the existing data in an effort to further characterize chemical contamination at the site (i.e., identify sources and potential migration pathways of chemical). As part of this groundwater investigation, Geraghty & Miller installed nine shallow monitoring wells (MW-13, MW-15, MW-16, MW-17, MW-18, MW-19, MW-20, MW-24, and MW-25), three very shallow monitoring wells (MW-17, MW-18, and MW-19), and three deep monitoring wells (MW-20D, MW-21D, and MW-22D).

Groundwater samples were collected from twelve supply wells and 51 monitoring wells from May to July 1994 and were analyzed for TCL VOCs (some low detection limit) and SVOCs, TAL metals, cyanide, 1,2-dibromomethane, n-propylbenzene, and methyl-tertiary-butyl-ether.

Groundwater results from each of the wells from each sampling round, including split samples,

as appropriate, have been used to produce a data summary table and to calculate a chemical concentration-toxicity screen and exposure point concentrations. Upgradient supply wells T3 and T4 (VIHA III and VIHA IV (alternate)) have not been included in the calculation of risk/health effects nor have the Bryan, Dimitri, Leonard, and Lockhart (alternate) cross-gradient wells which are impacted by pumping only in the residential area in the immediate vicinity and not by the site. All Harthman wells as well as the KFC-1 well are also considered cross-gradient wells and have not been included for quantitative evaluation in the risk assessment. The Dede, Dench, Devcon I, Devcon II (alternate), and Devcon III supply wells are clean wells downgradient of the contaminant plume, and therefore have not been utilized in quantitative calculations in the risk assessment. Shallow and deep groundwater samples have been grouped together for analysis since the fractured bedrock aquifer and the alluvial fill aquifer are in direct hydraulic communication with each other.

2.1.3 Air

No air monitoring data have been collected as part of the Geraghty & Miller, CDM Federal, or O'Henry PRP site investigations. However, air exposure point concentrations have been modelled as particulates released from surface and subsurface soils, and as VOCs released from surface soil and groundwater as part of the exposure assessment.

2.2 Summary of Sampling and Analysis Results

2.2.1 Data Quality

As part of the data evaluation process, the quality of all site data was evaluated. As stated previously, all data collected as part of the Geraghty & Miller, CDM Federal, and O'Henry PRP site investigations were validated in accordance with USEPA Region II data validation protocols. However, it should be noted that the data for certain samples and analytes that were not rejected during validation were qualified for the following reasons:

- The "*" qualifier indicates for inorganics that duplicate analysis was not within control limits.
- The "J" qualifier for all chemicals indicates that the reported concentration is estimated.
- The "B" qualifier indicates for organic chemicals that the reported concentration is estimated since it was detected in both the sample and in the associated blank; for inorganics, the "B" qualifier indicates that the reported concentration is less than the contract required detection limit and greater than the instrument detection limit.
- The "E" qualifier indicates for organics that the concentration exceeds the calibration range of the GC/MS instrument; for inorganics, the "E" qualifier indicates that the value is estimated due to matrix interferences.
- The "N" qualifier for organic chemicals indicates that there is only presumptive evidence for their presence; for inorganics the "N" qualifier indicates that the spiked sample recovery is not within control limits.
- The "D" qualifier for organics indicates that the chemical was identified in an analysis at a secondary dilution factor.
- The "P" qualifier for pesticides and PCBs indicates that the duplicate precision was not met.

2.2.2 Chemicals Detected in Soil

Surface Soil: Surface soil sample data summaries are presented in Tables 2-2 through 2-6 for the Tillett Gardens and Art Center, Fire Department/Texaco gas station/Antilles auto parts/Ramsay motor company, Curriculum Center Building (Present), Curriculum Center Building (Future), and O'Henry dry cleaners and Liquor Barn. The data used to evaluate exposures for the Curriculum Center Building present and potential future-use scenarios differ in that the sample groups evaluated are not the same. At present, samples B-14, B-15, and B-16 are considered surface soil samples and were collected at a depth range of zero to two feet. However, the area where these samples were collected is expected to be paved over in the near future. Therefore, these samples are considered subsurface soil samples in the future-use scenario. It should be noted that not all samples were analyzed for all chemical classes. In addition, soil samples collected during monitoring well installation were given the sample name prefix MWS (as opposed to MW for groundwater) so that the samples would be recognized properly in the computer data base. Samples having split or duplicate results were given the suffix AVS or AVD, respectively, to differentiate the components of the averaged result.

Tillett Gardens and Art Center

The results of the analysis of three surface soil samples collected at the Tillett Gardens and Art Center area presented in Table 2-2. Three volatile organic compounds (VOCs) were each detected in a single sample. Xylenes (total) were detected at the highest concentration, 11.0 J

TUTU WELLS SITE
SUMMARY OF CHEMICALS IN SURFACE SOIL
TILLET GARDENS AND ART CENTER

CONCENTRATION (ug/kg)

CHEMICALS	Frequency of Detection	Range of Detected Concentrations		Location of Maximum	Range of Non-Detect Concentrations	
		Minimum	Maximum		Minimum	Maximum
VOCs						
Methylene Chloride	1/2	9.00 J	9.00 J	SS-5-AVS	62.0 U	62.0 U
Chloroform	1/2	2.00 J	2.00 J	SS-5-AVS	7.00 U	7.00 U
Xylenes (Total)	1/3	11.0 J	11.0 J	eTT-14s	7.00 U	11.0 U
SVOCs						
Di-n-butylphthalate	1/1	55.0 J	55.0 J	SS-5-AVS	-	-
Fluoranthene	1/1	100 J	100 J	SS-5-AVS	-	-
Pyrene	1/1	76.0 J	76.0 J	SS-5-AVS	-	-
Butylbenzylphthalate	1/1	134 J	134 J	SS-5-AVS	-	-
Chrysene	1/1	59.0 J	59.0 J	SS-5-AVS	-	-
Benzo(b)fluoranthene	1/1	84.0 J	84.0 J	SS-5-AVS	-	-
Benzo(g,h,i)perylene	1/1	82.0 J	82.0 J	SS-5-AVS	-	-
PESTICIDES/PCBs						
Aroclor 1242	1/2	120000 J	120000 J	eTT-15s	580 UJ	580 UJ

Sample Group:
SS-5-AVS, eTT-14s, eTT-15s.

TABLE 2-2 (d)

TUTU WELLS SITE
SUMMARY OF CHEMICALS IN SURFACE SOIL
TILLET GARDEN AND ARTS CENTER

CONCENTRATION (mg/kg)

CHEMICALS	Frequency of Detection	Range of Detected Concentrations		Location of Maximum	Range of Non-Detect Concentrations	
		Minimum	Maximum		Minimum	Maximum
<u>INORGANICS</u>						
Aluminum	1/1	21300	21300	SS-5-AVS	-	-
Antimony	1/1	5.05 BNJ	5.05 BNJ	SS-5-AVS	-	-
Arsenic	1/1	10.0	10.0	SS-5-AVS	-	-
Barium	1/1	70.5	70.5	SS-5-AVS	-	-
Beryllium	1/1	0.20 B	0.20 B	SS-5-AVS	-	-
Calcium	1/1	35900	35900	SS-5-AVS	-	-
Chromium	1/1	25.3 NJ	25.3 NJ	SS-5-AVS	-	-
Cobalt	1/1	20.1 J	20.1 J	SS-5-AVS	-	-
Copper	1/1	79.7 NJ	79.7 NJ	SS-5-AVS	-	-
Iron	1/1	32750	32750	SS-5-AVS	-	-
Lead	1/1	86.4 SJ	86.4 SJ	SS-5-AVS	-	-
Magnesium	1/1	13250	13250	SS-5-AVS	-	-
Manganese	1/1	869	869	SS-5-AVS	-	-
Mercury	1/1	0.12	0.12	SS-5-AVS	-	-
Nickel	1/1	13.9	13.9	SS-5-AVS	-	-
Potassium	1/1	3390 J	3390 J	SS-5-AVS	-	-
Silver	1/1	2.15 B	2.15 B	SS-5-AVS	-	-
Sodium	1/1	328 B	328 B	SS-5-AVS	-	-
Vanadium	1/1	95.9 NJ	95.9 NJ	SS-5-AVS	-	-
Zinc	1/1	169	169	SS-5-AVS	-	-

Sample Group:

SS-5-AVS, eTT-14s, eTT-15s.

TUTU WELLS SITE
SUMMARY OF CHEMICALS IN SURFACE SOIL
FIRE DEPARTMENT / TEXACO GAS STATION / ANTILLES AUTO PARTS / RAMSAY MOTOR CO.

CONCENTRATION (ug/kg)

CHEMICALS	Frequency of Detection	Range of Detected Concentrations		Location of Maximum	Range of Non-Detect Concentrations	
		Minimum	Maximum		Minimum	Maximum
<u>VOCs</u>						
Methylene Chloride	2/6	17.0 J	200	eR-02-02s	26.0 U	12000 U
Acetone	1/6	14.0	14.0	B-2	17.0 UJ	2700 UJ
Benzene	2/6	6.00 J	45.0 J	eC-10s	6.00 U	880 U
4-Methyl-2-Pentanone	2/6	8.00 J	33.0 J	eC-10s	11.0 U	1800 UJ
2-Hexanone	1/6	55.0 J	55.0 J	eR-07s	11.0 U	1800 UJ
Toluene	3/6	2.00 J	1300	eC-10s	6.00 U	30.0 UJ
Ethylbenzene	3/6	18.0 B	2100	eC-10s	6.00 U	30.0 UJ
Xylenes (Total)	5/6	1.00 J	5600	eC-10s	11.0 U	11.0 U
<u>SVOCs</u>						
Naphthalene	1/2	4400	4400	eR-02-02s	1400 U	1400 U
2-Methylnaphthalene	1/2	6100	6100	eR-02-02s	1400 U	1400 U
Acenaphthene	1/2	190 J	190 J	eR-02-02s	1400 U	1400 U
Fluorene	1/2	420 J	420 J	eR-02-02s	1400 U	1400 U
Fluoranthene	1/2	740 J	740 J	eR-02-02s	1400 U	1400 U
Pyrene	2/2	220 J	2000	eR-02-02s	-	-
Bis(2-ethylhexyl)phthalate	1/2	5400	5400	eR-02-02s	1400 U	1400 U
Benzo(b)fluoranthene	1/2	870 J	870 J	eR-02-02s	1400 U	1400 U
Benzo(a)pyrene	2/2	270 J	770 J	eR-02-02s	-	-
Benzo(g,h,i)perylene	2/2	290 J	430 J	eR-02-02s	-	-
<u>PESTICIDES/PCBs</u>						
None Detected						

Sample Group:

B-2, eC-09s, eC-10s, eR-07s, eR-08s, eR-02-02s.

TABLE 2-1

TUTU WELLS SITE
SUMMARY OF CHEMICALS IN SURFACE SOIL
FIRE DEPARTMENT / TEXACO GAS STATION / ANTILLES AUTO PARTS / RAMSAY MOTOR CO.

CONCENTRATION (mg/kg)

	Frequency of Detection	Range of Detected Concentrations		Location of Maximum	Range of Non-Detect Concentrations	
		Minimum	Maximum		Minimum	Maximum
CHEMICALS						
<u>INORGANICS</u>						
Aluminum	1/1	26000	26000	B-2	-	-
Antimony	1/1	5.90 BJ	5.90 BJ	B-2	-	-
Barium	1/1	67.2	67.2	B-2	-	-
Beryllium	1/1	0.26 B	0.26 B	B-2	-	-
Calcium	1/1	47200	47200	B-2	-	-
Chromium	1/1	31.7	31.7	B-2	-	-
Cobalt	1/1	21.9	21.9	B-2	-	-
Copper	1/1	79.1	79.1	B-2	-	-
Iron	1/1	38400	38400	B-2	-	-
Lead	1/1	26.0 SJ	26.0 SJ	B-2	-	-
Magnesium	1/1	17100	17100	B-2	-	-
Manganese	1/1	834	834	B-2	-	-
Nickel	1/1	17.5	17.5	B-2	-	-
Potassium	1/1	1170	1170	B-2	-	-
Silver	1/1	2.20 J	2.20 J	B-2	-	-
Sodium	1/1	319 B	319 B	B-2	-	-
Vanadium	1/1	119	119	B-2	-	-
Zinc	1/1	108	108	B-2	-	-
Cyanide	1/1	1.10	1.10	B-2	-	-

Sample Group:

B-2, eC-09s, eC-10s, eR-07s, eR-08s, eR-02-02s.

TUTU WELLS SITE
SUMMARY OF CHEMICALS IN SURFACE SOIL
CURRICULUM CENTER BUILDING - PRESENT

CONCENTRATION (ug/kg)

CHEMICALS	Frequency of Detection	Range of Detected Concentrations		Location of Maximum	Range of Non-Detect Concentrations	
		Minimum	Maximum		Minimum	Maximum
<u>VOCs</u>						
Methylene Chloride	3/6	1.00 J	22.0	SS-3-AVS	11.0 U	12.0 U
Chloroform	2/9	2.00 J	6.75 J	SS-3-AVS	6.00 UJ	29.0 UJ
2-Butanone	1/9	44.5 J	44.5 J	SS-3-AVS	11.0 U	58.0 UJ
Trichloroethene	3/9	1.00 J	65.0 J	SS-3-AVS	6.00 UJ	29.0 UJ
Tetrachloroethene	4/9	23.0	170	B-15	6.00 UJ	39.0 U
Toluene	5/9	2.00 J	200 NJ	eL-02-01s	6.00 UJ	29.0 UJ
Ethylbenzene	2/9	3.00 J	420 J	eL-02-01s	6.00 UJ	29.0 UJ
Xylenes (Total)	3/9	19.0	1600 J	eL-02-02s	6.00 UJ	12.0 U
<u>SVOCs</u>						
Phenol	1/8	900000	900000	eL-02-01s	350 U	11000 UJ
2-Methylphenol	1/8	320000	320000	eL-02-01s	350 U	11000 UJ
4-Methylphenol	1/8	1300000 J	1300000 J	eL-02-01s	350 U	11000 UJ
2,4-Dimethylphenol	1/8	42000 J	42000 J	eL-02-01s	350 U	11000 UJ
Naphthalene	2/9	4100	7700 J	eL-02-01s	350 U	13000 UJ
2-Methylnaphthalene	1/9	750 J	750 J	eL-02-02s	350 U	78000 U
Di-n-butylphthalate	3/9	52.0 J	9400 J	SS-3-AVS	370 U	78000 U
Butylbenzylphthalate	2/9	58.0 J	120 J	eL-02-03s	350 U	78000 U
<u>PESTICIDES/PCBs</u>						
Endosulfan I	1/3	92.0	92.0	eL-02-01s	10.00 U	38.0 U

Sample Group:

SS-3-AVS, SS-4-AVS, B-14, B-15, B-16, MWS-16-AVD, eL-02-01s, eL-02-02s, eL-02-03s.

TABLE 2 (nd)

TUTU WELLS SITE
SUMMARY OF CHEMICALS IN SURFACE SOIL
CURRICULUM CENTER BUILDING - PRESENT

CONCENTRATION (mg/kg)

CHEMICALS	Frequency of Detection	Range of Detected Concentrations		Location of Maximum	Range of Non-Detect Concentrations	
		Minimum	Maximum		Minimum	Maximum
<u>INORGANICS</u>						
Aluminum	6/6	18900	27350	MWS-16-AVD	-	-
Antimony	5/6	4.08 BNJ	7.30 BNJ	B-14	5.10 UJ	5.10 UJ
Arsenic	5/6	1.30 B	11.6	B-16	0.46 U	0.46 U
Barium	6/6	32.1 B	96.3	SS-3-AVS	-	-
Beryllium	2/6	0.19 B	0.27 B	MWS-16-AVD	0.18 U	0.23 U
Cadmium	2/6	0.70 B	0.99 B	B-16	0.48 U	0.70 U
Calcium	6/6	38600	120000 *	B-14	-	-
Chromium	6/6	13.8 NJ	42.2 J	MWS-16-AVD	-	-
Cobalt	6/6	19.0	25.6 J	MWS-16-AVD	-	-
Copper	6/6	48.3 NJ	109	MWS-16-AVD	-	-
Iron	6/6	28000	48800	SS-3-AVS	-	-
Lead	6/6	2.90 J	45.6 N*J	B-16	-	-
Magnesium	6/6	16300	26200	B-14	-	-
Manganese	6/6	599	873	MWS-16-AVD	-	-
Mercury	1/6	0.57	0.57	B-16	0.05 U	0.09 U
Nickel	6/6	11.1	21.7	MWS-16-AVD	-	-
Potassium	6/6	125 B	7625 J	SS-3-AVS	-	-
Silver	5/6	0.93 B	1.90 B	SS-3-AVS	0.64 U	0.64 U
Sodium	5/6	181 B	489 B	SS-3-AVS	390 U	390 U
Vanadium	6/6	79.7 NJ	115	MWS-16-AVD	-	-
Zinc	6/6	50.9	459	B-16	-	-
Cyanide	2/6	0.64	0.75	B-15	0.53 U	0.58 U

Sample Group:

SS-3-AVS, SS-4-AVS, B-14, B-15, B-16, MWS-16-AVD, eL-02-01s, eL-02-02s, eL-02-03s.

TUTU WELLS SITE
SUMMARY OF CHEMICALS IN SURFACE SOIL
CURRICULUM CENTER BUILDING - FUTURE

CONCENTRATION (ug/kg)

CHEMICALS	Frequency of Detection	Range of Detected Concentrations		Location of Maximum	Range of Non-Detect Concentrations	
		Minimum	Maximum		Minimum	Maximum
VOCs						
Methylene Chloride	3/3	1.00 J	22.0	SS-3-AVS	-	-
Chloroform	2/6	2.00 J	6.75 J	SS-3-AVS	6.00 UJ	29.0 UJ
2-Butanone	1/6	44.5 J	44.5 J	SS-3-AVS	11.0 U	58.0 UJ
Trichloroethene	2/6	1.00 J	65.0 J	SS-3-AVS	6.00 UJ	29.0 UJ
Tetrachloroethene	1/6	53.5 J	53.5 J	MWS-16-AVD	6.00 UJ	39.0 U
Toluene	2/6	4.00 J	200 NJ	eL-02-01s	6.00 UJ	29.0 UJ
Ethylbenzene	2/6	3.00 J	420 J	eL-02-01s	6.00 UJ	29.0 UJ
Xylenes (Total)	3/6	19.0	1600 J	eL-02-02s	6.00 UJ	11.0 U
SVOCs						
Phenol	1/5	900000	900000	eL-02-01s	350 U	11000 UJ
2-Methylphenol	1/5	320000	320000	eL-02-01s	350 U	11000 UJ
4-Methylphenol	1/5	1300000 J	1300000 J	eL-02-01s	350 U	11000 UJ
2,4-Dimethylphenol	1/5	42000 J	42000 J	eL-02-01s	350 U	11000 UJ
Naphthalene	2/6	4100	7700 J	eL-02-01s	350 U	13000 UJ
2-Methylnaphthalene	1/6	750 J	750 J	eL-02-02s	350 U	78000 U
Di-n-butylphthalate	3/6	52.0 J	9400 J	SS-3-AVS	850 U	78000 U
Butylbenzylphthalate	1/6	120 J	120 J	eL-02-03s	350 U	78000 U
PESTICIDES/PCBs						
Endosulfan I	1/3	92.0	92.0	eL-02-01s	10.0 U	38.0 U

Sample Group:

SS-3-AVS, SS-4-AVS, MWS-16-AVD, eL-02-01s, eL-02-02s, eL-02-03s.

TABLE 2-1 (rd)

TUTU WELLS SITE
SUMMARY OF CHEMICALS IN SURFACE SOIL
CURRICULUM CENTER BUILDING - FUTURE

CONCENTRATION (mg/kg)

	Frequency of Detection	Range of Detected Concentrations		Location of Maximum	Range of Non-Detect Concentrations	
		Minimum	Maximum		Minimum	Maximum
CHEMICALS						
<u>INORGANICS</u>						
Aluminum	3/3	25000	27350	MWS-16-AVD	-	-
Antimony	2/3	4.08 BNJ	4.63 BNJ	SS-3-AVS	5.10 UJ	5.10 UJ
Arsenic	3/3	1.46 BWJ	2.30 B	SS-3-AVS	-	-
Barium	3/3	33.9 B	96.3	SS-3-AVS	-	-
Beryllium	2/3	0.19 B	0.27 B	MWS-16-AVD	0.18 U	0.18 U
Cadmium	1/3	0.70 B	0.70 B	MWS-16-AVD	0.48 U	0.57 U
Calcium	3/3	38600	56050	SS-4-AVS	-	-
Chromium	3/3	28.5 NJ	42.2 J	MWS-16-AVD	-	-
Cobalt	3/3	21.1 J	25.6 J	MWS-16-AVD	-	-
Copper	3/3	67.2 NJ	109	MWS-16-AVD	-	-
Iron	3/3	32450	48800	SS-3-AVS	-	-
Lead	3/3	3.10	20.0 J	SS-3-AVS	-	-
Magnesium	3/3	18700	23550	MWS-16-AVD	-	-
Manganese	3/3	677	873	MWS-16-AVD	-	-
Nickel	3/3	16.5	21.7	MWS-16-AVD	-	-
Potassium	3/3	125 B	7625 J	SS-3-AVS	-	-
Silver	2/3	1.17 B	1.90 B	SS-3-AVS	0.64 U	0.64 U
Sodium	2/3	403 B	489 B	SS-3-AVS	390 U	390 U
Vanadium	3/3	95.2 NJ	115	MWS-16-AVD	-	-
Zinc	3/3	52.0	318	SS-4-AVS	-	-
Cyanide	1/3	0.64	0.64	SS-3-AVS	0.53 U	0.54 U

Sample Group:

SS-3-AVS, SS-4-AVS, MWS-16-AVD, eL-02-01s, eL-02-02s, eL-02-03s.

TUTU WELLS SITE
SUMMARY OF CHEMICALS IN SURFACE SOIL
O'HENRY DRY CLEANERS AND LIQUOR BARN

CONCENTRATION (ug/kg)

CHEMICALS	Frequency of Detection	Range of Detected Concentrations		Location of Maximum	Range of Non-Detect Concentrations	
		Minimum	Maximum		Minimum	Maximum
<u>VOCs</u>						
Methylene Chloride	2/6	16.5	150 J	eO-02-02	11.0 UJ	14000 UB
Acetone	1/6	84.0 J	84.0 J	eO-02-02	11.0 UJ	27000 UB
1,2-Dichloroethene (Total)	1/6	20.0 J	20.0 J	eO-02-02	6.00 U	14000 U
Chloroform	2/6	2.00 J	12.0 J	eO-02-02	11.0 U	14000 U
Trichloroethene	1/6	75.0	75.0	eO-02-02	6.00 U	14000 U
Tetrachloroethene	5/6	15.0	440000	e-01	11.8 U	11.8 U
<u>SVOCs</u>						
Phenol	1/5	39.0 NJ	39.0 NJ	eO-02-03	350 U	420 U
Benzoic Acid	1/4	63.0 JN	63.0 JN	SS-6-AVS	1800 U	2000 U
Di-n-butylphthalate	1/5	62.0 J	62.0 J	SS-6-AVS	350 U	420 U
Butylbenzylphthalate	1/5	69.5 J	69.5 J	SS-6-AVS	350 U	420 U
Bis(2-ethylhexyl)phthalate	3/5	280 J	510	eO-02-01	350 U	380 UJ
<u>PESTICIDES/PCBs</u>						
None Detected						

Sample Group:

SS-6-AVS, B-13A, e-01, eO-02-01, eO-02-02, eO-02-03.

TABLE: (nt'd)

TUTU WELLS SITE
SUMMARY OF CHEMICALS IN SURFACE SOIL
O'HENRY DRY CLEANERS AND LIQUOR BARN

CONCENTRATION (mg/kg)

	Frequency of Detection	Range of Detected Concentrations		Location of Maximum	Range of Non-Detect Concentrations	
		Minimum	Maximum		Minimum	Maximum
CHEMICALS						
<u>INORGANICS</u>						
Aluminum	2/2	21100	22425 J	SS-6-AVS	-	-
Antimony	1/2	6.35 BNJ	6.35 BNJ	SS-6-AVS	4.30 UNJ	4.30 UNJ
Arsenic	2/2	13.7	18.7 J	SS-6-AVS	-	-
Barium	2/2	59.3	90.4 J	SS-6-AVS	-	-
Calcium	2/2	37825 J	73200 *	B-13A	-	-
Chromium	2/2	19.9 NJ	23.6	B-13A	-	-
Cobalt	2/2	13.9 J	16.3	B-13A	-	-
Copper	2/2	52.0	55.0 J	SS-6-AVS	-	-
Iron	2/2	27725 J	29400	B-13A	-	-
Lead	2/2	4.80 J	12.2 J	SS-6-AVS	-	-
Magnesium	2/2	9743 J	18300	B-13A	-	-
Manganese	2/2	670 J	870	B-13A	-	-
Nickel	2/2	11.5 J	14.7	B-13A	-	-
Potassium	2/2	841 B	2030 J	SS-6-AVS	-	-
Silver	2/2	0.75 BJ	1.60 BNJ	B-13A	-	-
Sodium	2/2	273 BJ	474 B	B-13A	-	-
Vanadium	2/2	72.7 NJ	83.1	B-13A	-	-
Zinc	2/2	63.1	95.8 J	SS-6-AVS	-	-
Cyanide	1/2	1.05	1.05	SS-6-AVS	0.54 U	0.54 U

Sample Group:

SS-6-AVS, B-13A, e-01, eO-02-01, eO-02-02, eO-02-03.

ug/kg in sample eTT-14s, while methylene chloride was detected at a maximum concentration of 9.0 J ug/kg in sample SS-5-AVS. Sample SS-5-AVS is an average of sample SS-5 (collected by Geraghty & Miller) and its split (collected by CDM Federal). Chloroform was detected in sample SS-5-AVS at a concentration of 2.0 J ug/kg.

Seven semivolatile organic compounds (SVOCs), which include polycyclic aromatic hydrocarbons (PAHs) and phthalates, were each detected in the single surface soil sample analyzed for SVOCs (SS-5-AVS). The highest concentrations were reported for butylbenzylphthalate (134 J ug/kg) and fluoranthene (100 J ug/kg).

One polychlorinated biphenyl (PCB), Aroclor 1242, was detected in only one of the two surface soil samples analyzed for PCBs. The detected concentration of 120000 J ug/kg was reported in sample eTT-15s.

Twenty inorganics were detected in the single Tillett Gardens and Art Center surface soil sample analyzed for inorganics. Aluminum, antimony, arsenic, barium, beryllium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, silver, sodium, vanadium, and zinc were all detected in sample SS-5-AVS. The highest concentrations were reported for calcium (35900 mg/kg), iron (32750 mg/kg), and aluminum (21300 mg/kg).

Fire Department/Texaco Gas Station/Antilles Auto Parts/Ramsay Motor Company

The results of the analysis of six surface soil samples collected at the Fire Department/Texaco gas station/Antilles auto parts/Ramsay motor company area are presented in Table 2-3. Eight VOCs, including primarily aromatics and ketones, were detected in at least one sample. The most frequently detected VOCs were xylenes (total) (5 of 6 samples), toluene (3 of 6 samples), and ethylbenzene (3 of 6 samples). The chemicals detected at the highest concentrations were xylenes (total) (5600 ug/kg), ethylbenzene (2100 ug/kg), and toluene (1300 ug/kg). These detections were all reported in sample eC-10s.

Ten SVOCs, which include PAHs and phthalates, were detected in at least one surface soil sample. The most frequently detected SVOCs were pyrene (2 of 2 samples), benzo(a)pyrene (2 of 2 samples), and benzo(g,h,i)perylene (2 of 2 samples). All other SVOCs were detected in only one of two samples. The highest SVOC detections occurred for 2-methylnaphthalene (6100 ug/kg), bis(2-ethylhexyl)phthalate (5400 ug/kg), and naphthalene (4400 ug/kg). These detections were all reported in sample eR-02-02s.

No pesticides or PCBs were detected in surface soil samples collected from the Fire Department/Texaco gas station/Antilles auto parts/Ramsay motor company area.

Nineteen inorganics were detected in the single surface soil sample analyzed for inorganics. Aluminum, antimony, barium, beryllium, calcium, chromium, cobalt, copper, iron, lead,

magnesium, manganese, nickel, potassium, silver, sodium, vanadium, zinc, and cyanide were all detected in sample B-2. The highest concentrations were reported for calcium (47200 mg/kg), iron (38400 mg/kg), and aluminum (26000 mg/kg).

Curriculum Center Building (Present)

The results of the analysis of nine surface soil samples collected at the present Curriculum Center Building area are presented in Table 2-4. Eight VOCs, including primarily aromatic and chlorinated chemicals, were detected in at least one sample. The most frequently detected VOCs were toluene (5 of 9 samples), tetrachloroethene (3 of 9 samples), and xylenes (total) (3 of 9 samples). The chemicals detected at the highest concentrations were xylenes (total) (1600 J ug/kg), ethylbenzene (420 J ug/kg), and toluene (200 NJ ug/kg). The toluene and ethylbenzene maximum detections were reported in sample eL-02-01s, while the xylenes (total) maximum detection was reported in sample eL-02-02s.

Eight SVOCs, including phenols, PAHs, and phthalates, were detected in at least one surface soil sample. The most frequently detected SVOCs were di-n-butylphthalate (3 of 9 samples), naphthalene (2 of 9 samples), and butylbenzylphthalate (2 of 9 samples). All other VOCs were detected in only one sample. The highest SVOC detections were reported for 4-methylphenol (1300000 J ug/kg), phenol (900000 ug/kg), and 2-methylphenol (320000 ug/kg). These detections were all reported in sample eL-02-01s.

One pesticide, endosulfan I, was detected in 1 of 3 samples analyzed for pesticides. The single detection, 92.0 ug/kg, was reported in sample eL-02-01s.

Twenty-two inorganics were detected in present Curriculum Center Building surface soil samples. Fourteen inorganics were detected in each of the six samples analyzed for inorganics, including aluminum, barium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, nickel, potassium, vanadium, and zinc. The highest concentrations were reported for calcium (120000 * mg/kg), iron (48800 mg/kg), aluminum (27350 mg/kg), and magnesium (26200 mg/kg). The calcium and magnesium maximum detections were reported in sample B-14, while the aluminum maximum detection was reported as the average of the sample and its associated duplicate (collected by Geraghty & Miller), MWS-16-AVD. The iron maximum detection was reported as the average of the sample (collected by Geraghty & Miller) and the split (collected by CDM Federal), SS-3-AVS.

Curriculum Center Building (Future)

The results of the analysis of six surface soil samples collected from the potential future Curriculum Center Building area are presented in Table 2-5. Eight VOCs, including primarily aromatic and chlorinated chemicals, were detected in at least one sample. The most frequently detected VOCs were methylene chloride (3 of 3 samples), xylenes (total) (3 of 6 samples), chloroform (2 of 6 samples), toluene (2 of 6 samples), and ethylbenzene (2 of 6 samples). All other VOCs were detected in only one sample. The chemicals detected at the highest

concentrations were xylenes (total) (1600 J ug/kg), ethylbenzene (420 J ug/kg), and toluene (200 NJ ug/kg). The toluene and ethylbenzene maximum detections were reported in sample eL-02-01s while the xylenes (total) maximum detection was reported in sample eL-02-02s.

Eight SVOCs, including phenols, PAHs, and phthalates, were detected in at least one surface soil sample. The most frequently detected SVOCs were di-n-butylphthalate (3 of 6 samples) and naphthalene (2 of 6 samples). All other SVOCs were detected in only one sample. The highest SVOC detections were reported for 4-methylphenol (1300000 J ug/kg), phenol (900000 ug/kg), and 2-methylphenol (320000 ug/kg). These detections were all reported in sample eL-02-01s.

One pesticide, endosulfan I, was detected in one of three samples analyzed for pesticides. The single detection, 92.0 ug/kg, was reported in sample eL-02-01s.

Twenty-one inorganics were detected in potential future Curriculum Center Building surface soil samples. Fifteen inorganics were detected in each of the three samples analyzed for inorganics, including aluminum, arsenic, barium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, nickel, potassium, vanadium, and zinc. The highest concentrations were reported for calcium (56050 mg/kg), iron (48800 mg/kg), aluminum (27350 mg/kg), and magnesium (23550 mg/kg). The calcium maximum detection was reported as the average of the sample (collected by Geraghty & Miller) and the split (collected by CDM Federal), SS-4-AVS, while the iron maximum detection was reported as the average of the sample (collected by

Geraghty & Miller) and the split (collected by CDM Federal), SS-3-AVS. The aluminum and magnesium maximum detections were reported as the average of the sample and its associated duplicate (both collected by Geraghty & Miller), MWS-16-AVD.

O'Henry Dry Cleaners and Liquor Barn

The results of the analysis of six surface soil samples collected at the O'Henry dry cleaners and Liquor Barn area are presented in Table 2-6. Six VOCs, including primarily chlorinated chemicals, were detected in at least one sample. The most frequently detected VOCs were tetrachloroethene (5 of 6 samples), methylene chloride (2 of 6 samples), and chloroform (2 of 6 samples). All other VOCs were detected in only one sample. The chemicals detected at the highest concentrations were tetrachloroethene (440000 ug/kg) and methylene chloride (150 J ug/kg). The tetrachlorethene maximum detection was reported in sample e-01, while the methylene chloride maximum detection was reported in sample e0-02-02.

Five SVOCs, including primarily phthalates, were detected in at least one surface soil sample. The most frequently detected SVOC was bis(2-ethylhexyl)phthalate (3 of 5 samples). All other SVOCs were detected in only one sample. The highest SVOC detection occurred for bis(2-ethylhexyl)phthalate (510 ug/kg) in sample e0-02-01. All other SVOC maximum detections were well below the bis(2-ethylhexyl)phthalate concentration.

No pesticides or PCBs were detected in surface soil samples collected from the O'Henry dry

cleaners and Liquor Barn area.

Nineteen inorganics were detected in the O'Henry dry cleaners and Liquor Barn surface soil samples. Seventeen inorganics were detected in each of the two samples analyzed for inorganics, including aluminum, arsenic, barium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, nickel, potassium, silver, sodium, vanadium, and zinc. The highest concentrations were reported for calcium (73200 * mg/kg), iron (29400 mg/kg), and aluminum (22425 J mg/kg). The calcium and iron maximum detections were reported in sample B-13A, while the aluminum maximum detection was reported as the average of the sample (collected by Geraghty & Miller) and the split (collected by CDM Federal), SS-6-AVS.

Subsurface Soil: Subsurface soil sample data are presented in Tables 2-7 through 2-11 for the Tillett Gardens and Art Center, Fire Department/Texaco gas station/Antilles auto parts/Ramsay motor company, Curriculum Center Building, Esso gas station and Splash and Dash car wash, and O'Henry dry cleaners and Liquor Barn. The Curriculum Center Building present and potential future-use scenarios differ in that the sample groups evaluated are not the same. At present, samples B-14, B-15, and B-16 are considered surface soil samples and were collected at a depth ranged zero to two feet. However, the area where these samples were collected is expected to be paved over in the near future. It should be noted that not all samples were analyzed for all chemical classes. In addition, soil samples collected during monitoring well installation were given the sample name prefix MWS (as opposed to MW for groundwater) so that the samples would be recognized as soil in the computer data base. Samples having split

TUTU WELLS SITE
SUMMARY OF CHEMICALS IN SUBSURFACE SOIL
TILLETT GARDENS AND ART CENTER

CONCENTRATION (ug/kg)

CHEMICALS	Frequency of Detection	Range of Detected Concentrations		Location of Maximum	Range of Non-Detect Concentrations	
		Minimum	Maximum		Minimum	Maximum
<u>VOCs</u>						
Tetrachloroethene	1/2	3.50 J	3.50 J	B-8-AVD	10.5 U	10.5 U
Toluene	1/2	4.00 J	4.00 J	B-8-AVD	10.5 U	10.5 U
Ethylbenzene	1/2	2.50 J	2.50 J	B-8-AVD	10.5 U	10.5 U
<u>SVOCs</u>						
Phenanthrene	1/2	160 J	168 J	B-8-AVD	345 UJ	345 UJ
Fluoranthene	1/2	233 J	233 J	B-8-AVD	345 UJ	345 UJ
Pyrene	1/2	238 J	238 J	B-8-AVD	345 UJ	345 UJ
Benzo(a)anthracene	1/2	178 J	178 J	B-8-AVD	345 UJ	345 UJ
Chrysene	1/2	193 J	193 J	B-8-AVD	345 UJ	345 UJ
Benzo(b)fluoranthene	1/2	213 J	213 J	B-8-AVD	345 UJ	345 UJ
Benzo(k)fluoranthene	1/2	96.0 J	96.0 J	B-8-AVD	345 UJ	345 UJ
Benzo(a)pyrene	1/2	188 J	188 J	B-8-AVD	345 UJ	345 UJ
Indeno(1,2,3-cd)pyrene	1/2	87.0 J	87.0 J	B-8-AVD	345 UJ	345 UJ
Benzo(g,h,i)perylene	1/2	84.0 J	84.0 J	B-8-AVD	345 UJ	345 UJ
<u>PESTICIDES/PCBs</u>						
Not Analyzed						

Sample Group:
B-8-AVD, MWS-5-AVS.

TABLE 2- (d)

TUTU WELLS SITE
SUMMARY OF CHEMICALS IN SUBSURFACE SOIL
TILLET GARDEN AND ART CENTER

CONCENTRATION (mg/kg)

CHEMICALS	Frequency of Detection	Range of Detected Concentrations		Location of Maximum	Range of Non-Detect Concentrations	
		Minimum	Maximum		Minimum	Maximum
<u>INORGANICS</u>						
Aluminum	2/2	21650	27400	MWS-5-AVS	-	-
Antimony	2/2	3.65 BNJ	5.10 BNJ	MWS-5-AVS	-	-
Arsenic	2/2	0.77 B	49.2 J	B-8-AVD	-	-
Barium	2/2	50.7	75.7	B-8-AVD	-	-
Beryllium	2/2	0.36 B	0.46 B	MWS-5-AVS	-	-
Calcium	2/2	54400 *	69000 *	B-8-AVD	-	-
Chromium	2/2	24.2	26.0	B-8-AVD	-	-
Cobalt	2/2	18.4	24.3	MWS-5-AVS	-	-
Copper	2/2	103 J	115	MWS-5-AVS	-	-
Iron	2/2	30300	37700	MWS-5-AVS	-	-
Lead	1/1	10.0 J	10.0 J	B-8-AVD	-	-
Magnesium	2/2	17050	26200	MWS-5-AVS	-	-
Manganese	2/2	746	763	MWS-5-AVS	-	-
Mercury	1/2	0.06	0.06	B-8-AVD	0.05 U	0.05 U
Nickel	2/2	14.5	15.3	MWS-5-AVS	-	-
Potassium	2/2	1180	2095 BJ	B-8-AVD	-	-
Silver	2/2	2.20 NJ	2.75 BNJ	B-8-AVD	-	-
Sodium	2/2	381 B	459 B	B-8-AVD	-	-
Vanadium	2/2	108	157	B-8-AVD	-	-
Zinc	2/2	106	164	MWS-5-AVS	-	-
Cyanide	1/2	1.50	1.50	B-8-AVD	0.52 U	0.52 U

Sample Group:
B-8-AVD, MWS-5-AVS.

TUTU WELLS SITE
SUMMARY OF CHEMICALS IN SUBSURFACE SOIL
FIRE DEPARTMENT / TEXACO GAS STATION / ANTILLES AUTO PARTS / RAMSAY MOTOR CO.

CONCENTRATION (ug/kg)

	Frequency of Detection	Range of Detected Concentrations		Location of Maximum	Range of Non-Detect Concentrations	
		Minimum	Maximum		Minimum	Maximum
CHEMICALS						
<u>VOCs</u>						
Bromomethane	1/9	2.00 J	2.00 J	eT-02s-AVD	10.0 U	13.0 U
Methylene Chloride	5/10	1.00 J	26.0 J	B-3	10.0 U	22.0 UBJ
Acetone	8/10	3.00 J	190 B	MWS-4	10.0 U	119 UJ
1,2-Dichloroethene (Total)	1/9	2.00 J	2.00 J	MWS-17	8.00 UJ	13.0 U
2-Butanone	3/9	18.0	75.0 J	eT-02s-AVD	10.0 U	12.0 U
Benzene	1/9	4.25 J	4.25 J	eT-02s-AVD	10.0 U	13.0 U
4-Methyl-2-Pentanone	1/9	17.0 J	17.0 J	eT-02s-AVD	10.0 U	13.0 U
Tetrachloroethene	4/9	1.00 J	6.00 J	B-3	8.00 UJ	12.0 U
Toluene	2/9	2.00 J	25.0 J	eT-02s-AVD	10.0 U	13.0 U
Ethylbenzene	1/9	9.00 J	9.00 J	eT-02s-AVD	10.0 U	13.0 U
Methyl-tert-butyl-ether	2/8	1.30 J	20.0 J	MWS-15	10.0 UJ	55.0 U
Xylenes (Total)	1/9	1700 J	1700 J	eT-02s-AVD	10.0 U	13.0 U
<u>SVOCs</u>						
Bis(2-chloroethyl)ether	1/9	13.0 J	13.0 J	MWS-4	340 U	410 U
Di-n-butylphthalate	1/9	170 J	170 J	MWS-3	340 U	1900 U
Benzo(a)pyrene	1/9	140 J	140 J	MWS-4	340 U	410 U
Bis(2-ethylhexyl)phthalate	1/9	370 J	370 J	MWS-17	340 U	420 U
<u>PESTICIDES/PCBs</u>						
None Detected						

Sample Group:

B-3, B-4, B-5, B-7, MWS-3, MWS-4, MWS-4D, MWS-15, MWS-17, eT-02s-AVD.

TABLE 2 (n'd)

TUTU WELLS SITE
SUMMARY OF CHEMICALS IN SUBSURFACE SOIL
FIRE DEPARTMENT / TEXACO GAS STATION / ANTILLES AUTO PARTS / RAMSAY MOTOR CO.

CONCENTRATION (mg/kg)

CHEMICALS	Frequency of Detection	Range of Detected Concentrations		Location of Maximum	Range of Non-Detect Concentrations	
		Minimum	Maximum		Minimum	Maximum
<u>INORGANICS</u>						
Aluminum	8/8	21100	32200 J	B-4	-	-
Antimony	4/8	3.50 BJ	7.90 BNJ	B-5	3.00 U	6.00 UJ
Arsenic	5/7	0.54 BWJ	1.80 BJ	MWS-4	0.46 U	0.46 U
Barium	8/8	36.9 B	184	B-3	-	-
Beryllium	3/8	0.27 BJ	0.42 B	B-3	0.21 U	0.24 U
Cadmium	2/8	0.73 BJ	1.10 B	MWS-15	0.62 U	0.70 U
Calcium	8/8	5730	67200 *	B-5	-	-
Chromium	8/8	27.0 J	38.0 EJ	MWS-4	-	-
Cobalt	8/8	18.9	32.7 J	MWS-4	-	-
Copper	8/8	47.3 NJ	104	B-3	-	-
Iron	8/8	29800	42500	B-3	-	-
Lead	8/8	1.50 J	19.8 J	B-7	-	-
Magnesium	8/8	11100	23600 J	B-4	-	-
Manganese	8/8	506	947 EJ	MWS-4	-	-
Mercury	2/8	0.08 B	0.12 BJ	B-4	0.05 U	0.06 U
Nickel	8/8	16.7 J	19.4	B-5	-	-
Potassium	8/8	386 B	1270 J	MWS-4	-	-
Selenium	2/8	0.53 BWJ	0.55 BWJ	MWS-4	0.41 UWJ	0.50 U
Silver	4/8	1.40 BJ	2.10 BJ	B-4	0.72 U	0.92 U
Sodium	8/8	217 BJ	2040	B-3	-	-
Vanadium	8/8	93.4 J	157	B-3	-	-
Zinc	8/8	42.6 J	62.4	B-7	-	-
Cyanide	1/8	0.65	0.65	MWS-4	0.52 U	0.79 U

Sample Group:

B-3, B-4, B-5, B-7, MWS-3, MWS-4, MWS-4D, MWS-15, MWS-17, eT-02s-AVD.

TUTU WELLS SITE
SUMMARY OF CHEMICALS IN SUBSURFACE SOIL
CURRICULUM CENTER BUILDING

CONCENTRATION (ug/kg)

CHEMICALS	Frequency of Detection	Range of Detected Concentrations		Location of Maximum	Range of Non-Detect Concentrations	
		Minimum	Maximum		Minimum	Maximum
<u>VOCs</u>						
Methylene Chloride	2/10	2.00 J	34.0 B	MWS-14	11.0 U	28.0 UJ
Acetone	3/10	10.8 J	370	B-6-AVS	11.0 UJ	16.0 U
2-Butanone	1/10	59.0	59.0	B-6-AVS	11.0 U	24.5 UJ
Trichloroethene	2/10	1.00 J	6.00 J	B-15	11.0 U	20.0 U
Tetrachloroethene	3/10	23.0	170	B-15	11.0 U	24.5 U
Toluene	4/10	2.00 J	12.0	B-15	11.0 U	24.5 U
Xylenes (Total)	1/10	1.00 J	1.00 J	MWS-14	11.0 U	24.5 U
<u>SVOCs</u>						
Diethylphthalate	1/10	40.0 J	40.0 J	MWS-14	350 U	825 U
Di-n-butylphthalate	1/10	890 B	890 B	MWS-14	350 U	825 U
Butylbenzylphthalate	1/10	58.0 J	58.0 J	B-16	350 U	825 UJ
Bis(2-ethylhexyl)phthalate	2/10	49.0 J	210 J	MWS-13	350 U	590 UJ
<u>PESTICIDES/PCBs</u>						
Not Analyzed						

Sample Group:

B-14-AVD, B-15, B-16, B-1-AVS, B-6-AVS, MWS-1, MWS-1D, MWS-13, MWS-13D, MWS-14.

TABLE 2 (n't'd)

TUTU WELLS SITE
SUMMARY OF CHEMICALS IN SUBSURFACE SOIL
CURRICULUM CENTER BUILDING

CONCENTRATION (mg/kg)

CHEMICALS	Frequency of Detection	Range of Detected Concentrations		Location of Maximum	Range of Non-Detect Concentrations	
		Minimum	Maximum		Minimum	Maximum
<u>INORGANICS</u>						
Aluminum	10/10	18900	37900	B-6-AVS	-	-
Antimony	9/10	3.40 BJ	19.0	B-6-AVS	5.20 UJ	5.20 UJ
Arsenic	8/10	0.45 BJ	11.6	B-16	0.46 U	0.46 U
Barium	10/10	17.9 BJ	59.1 J	MWS-1	-	-
Beryllium	2/10	0.22 B	0.23 BJ	MWS-1D	0.21 U	0.42 U
Cadmium	3/10	0.99 B	2.87	B-6-AVS	0.63 U	0.86 U
Calcium	10/10	6540	96500 *	B-14-AVD	-	-
Chromium	10/10	15.6 NJ	36.5	B-6-AVS	-	-
Cobalt	10/10	17.1	32.7	B-6-AVS	-	-
Copper	10/10	47.8 J	102 EJ	MWS-13D	-	-
Iron	10/10	25550	46400	B-6-AVS	-	-
Lead	10/10	2.45 J	45.6 N*J	B-16	-	-
Magnesium	10/10	16300	24600 J	MWS-1	-	-
Manganese	10/10	599	973	B-6-AVS	-	-
Mercury	1/10	0.57	0.57	B-16	0.05 U	0.13 U
Nickel	10/10	12.1	27.3	MWS-13	-	-
Potassium	10/10	181 B	806 B	B-6-AVS	-	-
Silver	5/10	0.70 B	2.30 J	MWS-1D	0.63 U	1.01 U
Sodium	9/10	186 B	632 B	MWS-1D	393 U	393 U
Vanadium	10/10	79.7 NJ	132 J	MWS-1	-	-
Zinc	10/10	52.1 J	585	MWS-13	-	-
Cyanide	2/10	0.75	0.88	MWS-1	0.52 U	5.29 U

Sample Group:

B-14-AVD, B-15, B-16, B-1-AVS, B-6-AVS, MWS-1, MWS-1D, MWS-13, MWS-13D, MWS-14.

TUTU WELLS SITE
SUMMARY OF CHEMICALS IN SUBSURFACE SOIL
ESSO GAS STATION AND SPLASH AND DASH CAR WASH

CONCENTRATION (ug/kg)

CHEMICALS	Frequency of Detection	Range of Detected Concentrations		Location of Maximum	Range of Non-Detect Concentrations	
		Minimum	Maximum		Minimum	Maximum
<u>VOCS</u>						
Methylene Chloride	4/7	3.00 J	20.0 J	MWS-10D	11.0 U	21.5 UJ
Acetone	3/7	33.0 J	50.0 BJ	MWS-18	11.0 U	40.5 UJ
2-Butanone	2/7	5.00 J	13.0 BJ	MWS-18	10.5 U	12.0 U
Trichloroethene	1/7	7.75 J	7.75 J	MWS-9-AVS	11.0 U	12.0 UJ
Tetrachloroethene	1/7	2.00 J	2.00 J	MWS-8-AVS	10.5 U	12.0 UJ
Toluene	2/7	1.00 J	1.00 J	MWS-8-AVS	10.5 U	12.0 UJ
<u>SVOCs</u>						
Di-n-butylphthalate	1/7	458 B	458 B	MWS-8-AVS	345 U	750 U
Bis(2-ethylhexyl)phthalate	3/7	130 J	220 J	B-9	345 UJ	370 UJ
<u>PESTICIDES/PCBs</u>						
Not Analyzed						

Sample Group:
B-9, MWS-8-AVS, MWS-9-AVS, MWS-10, MWS-10D, MWS-18, MWS-25.

TABLE 2- (cont'd)

TUTU WELLS SITE
SUMMARY OF CHEMICALS IN SUBSURFACE SOIL
ESSO GAS STATION AND SPLASH AND DASH CAR WASH

CONCENTRATION (mg/kg)

CHEMICALS	Frequency of Detection	Range of Detected Concentrations		Location of Maximum	Range of Non-Detect Concentrations	
		Minimum	Maximum		Minimum	Maximum
<u>INORGANICS</u>						
Aluminum	7/7	14100	28000 J	MWS-9-AVS	-	-
Antimony	3/7	3.85 BJ	4.40 BJ	B-9	4.30 UJ	5.60 UJ
Arsenic	4/7	0.47 BJ	1.60 BJ	B-9	0.45 UJ	2.40 U
Barium	7/7	21.9 BJ	199	MWS-10D	-	-
Beryllium	6/7	0.16 B	0.35 B	MWS-25	0.18 U	0.18 U
Cadmium	1/7	0.95 B	0.95 B	MWS-25	0.48 U	0.91 U
Calcium	7/7	2340	37750 J	MWS-9-AVS	-	-
Chromium	7/7	4.50	35.2 J	B-9	-	-
Cobalt	7/7	7.90 B	23.7 J	B-9	-	-
Copper	7/7	40.2	105 J	B-9	-	-
Iron	7/7	30000	39300	MWS-25	-	-
Lead	7/7	1.19 BJ	11.7	MWS-25	-	-
Magnesium	7/7	5770	18550 J	MWS-9-AVS	-	-
Manganese	7/7	435	1250	MWS-25	-	-
Nickel	7/7	3.20 B	21.8 J	B-9	-	-
Potassium	7/7	203 B	1440	MWS-18	-	-
Selenium	1/7	1.10 B	1.10 B	MWS-25	0.43 U	0.47 U
Silver	5/7	0.82 B	4.12 B	MWS-9-AVS	0.68 U	0.85 U
Sodium	6/7	248 B	832 B	MWS-9-AVS	430 U	430 U
Vanadium	7/7	57.9	130	MWS-18	-	-
Zinc	7/7	38.5 J	87.2	MWS-25	-	-
Cyanide	1/7	0.41	0.41	MWS-8-AVS	0.53 U	0.59 U

Sample Group:

B-9, MWS-8-AVS, MWS-9-AVS, MWS-10, MWS-10D, MWS-18, MWS-25.

TUTU WELLS SITE
SUMMARY OF CHEMICALS IN SUBSURFACE SOIL
O'HENRY DRY CLEANERS AND LIQUOR BARN

CONCENTRATION (ug/kg)

	Frequency of Detection	Range of Detected Concentrations		Location of Maximum	Range of Non-Detect Concentrations	
		Minimum	Maximum		Minimum	Maximum
CHEMICALS						
<u>VOCs</u>						
Methylene Chloride	1/4	3.00 J	3.00 J	B-11	11.0 UJ	19.5 UJ
Tetrachloroethene	2/4	29.00	200 D	B-13	11.5 U	12.0 U
Toluene	1/4	3.00 J	3.00 J	B-11	11.0 U	12.0 U
<u>SVOCs</u>						
Di-n-butylphthalate	1/4	160 J	160 J	B-10	380 U	400 U
Fluoranthene	1/4	42.0 J	42.0 J	B-13	385 U	400 U
Butylbenzylphthalate	1/4	220 J	220 J	B-10	380 U	400 U
<u>PESTICIDES/PCBs</u>						
Not Analyzed						

Sample Group:
B-10, B-11, B-12-AVS, B-13.

TABLE 2-1 (continued)

TUTU WELLS SITE
SUMMARY OF CHEMICALS IN SUBSURFACE SOIL
O'HENRY DRY CLEANERS AND LIQUOR BARN

CONCENTRATION (mg/kg)

CHEMICALS	Frequency of Detection	Range of Detected Concentrations		Location of Maximum	Range of Non-Detect Concentrations	
		Minimum	Maximum		Minimum	Maximum
<u>INORGANICS</u>						
Aluminum	4/4	14300	19200	B-11	-	-
Antimony	2/4	4.90 BJ	5.20 BJ	B-10	4.40 UJ	4.70 UJ
Arsenic	3/4	5.00	185 J	B-13	2.20 U	2.20 U
Barium	4/4	29.0 B	498	B-10	-	-
Beryllium	2/4	0.29 B	0.33 B	B-11	0.22 U	0.22 U
Calcium	4/4	5150	14400	B-10	-	-
Chromium	4/4	13.0	21.2	B-12-AVS	-	-
Cobalt	4/4	15.1	18.2	B-12-AVS	-	-
Copper	4/4	48.4	88.7	B-10	-	-
Iron	4/4	26800 EJ	34100 EJ	B-11	-	-
Lead	4/4	1.20 J	6.90 SJ	B-11	-	-
Magnesium	4/4	5570	14600	B-13	-	-
Manganese	4/4	430	2200	B-10	-	-
Mercury	1/4	0.08 B	0.08 B	B-11	0.05 U	0.06 U
Nickel	4/4	4.70 B	16.4	B-12-AVS	-	-
Potassium	4/4	591 B	2830	B-11	-	-
Silver	4/4	1.60 BJ	2.00 BJ	B-10	-	-
Sodium	4/4	133 B	352 B	B-10	-	-
Vanadium	4/4	83.9	119	B-10	-	-
Zinc	4/4	45.7 EJ	99.5 EJ	B-11	-	-

Sample Group:

B-10, B-11, B-12-AVS, B-13.

or duplicate results were given the suffix AVS or AVD, respectively to differentiate the components of the averaged results.

Tillett Gardens and Art Center

The results of the analysis of two subsurface soil samples collected at the Tillett Gardens and Art Center are presented in Table 2-7. Three VOCs, tetrachloroethene, toluene, and ethylbenzene, were each detected in one of the two samples analyzed for VOCs. The chemical detected at the highest concentration was toluene at 4.0 J ug/kg in sample B-8-AVD. Sample B-8-AVD is an average of sample B-8 and its duplicate, both of which were collected by Geraghty & Miller.

Ten SVOCs, which include PAHs, were detected in one of the two samples analyzed for SVOCs. The chemicals detected at the highest concentrations were pyrene (238 J ug/kg), fluoranthene (233 J ug/kg), and benzo(b)fluoranthene (213 J ug/kg). These detections were all reported in sample B-8-AVD.

Pesticides and PCBs were not analyzed for in subsurface soil samples collected from the Tillett Gardens and Art Center.

Twenty-one inorganics were detected in subsurface soil samples collected from the Tillett Gardens and Art Center area. Nineteen inorganics were detected in each of the two samples

analyzed for inorganics, except for lead which was analyzed for and detected in only one sample. The inorganics detected in each of two samples include aluminum, antimony, arsenic, barium, beryllium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, nickel, potassium, silver, sodium, vanadium, and zinc. The highest concentrations were reported for calcium (69000 * mg/kg), iron (37700 mg/kg), aluminum (27400 mg/kg), and magnesium (26200 mg/kg). The calcium maximum detection was reported in sample B-8-AVD, while the iron, aluminum, and magnesium maximum detections were reported as the average of the sample (collected by Geraghty & Miller) and the split (collected by CDM Federal), MWS-5-AVS.

Fire Department/Texaco Gas Station/Antilles Auto Parts/Ramsay Motor Company

The results of the analysis of ten subsurface soil samples collected at the Fire Department/Texaco gas station/Antilles auto parts/Ramsay motor company area are presented in Table 2-8. Twelve VOCs, including primarily ketones and aromatics, were detected in at least one sample. The most frequently detected VOCs were acetone (8 of 10 samples), methylene chloride (5 of 10 samples), tetrachloroethene (4 of 9 samples), and 2-butanone (3 of 9 samples). The chemicals detected at the highest concentrations were xylenes (total) (1700 J ug/kg) and acetone (190 B ug/kg). The maximum xylenes (total) detection was reported as the average of the sample and its associated duplicate (both collected by CDM Federal), eT-02s-AVD. The maximum acetone detection was reported in sample MWS-4.

Four SVOCs, including an ether, two phthalates, and a PAH were each detected in one of nine

samples analyzed for SVOCs. The highest concentrations were reported for bis(2-ethylhexyl)phthalate (370 J ug/kg) and di-n-butylphthalate (170 J ug/kg). The bis(2-ethylhexyl)phthalate detection was reported in sample MWS-17, while the di-n-butylphthalate detection was reported in sample MWS-3.

No pesticides or PCBs were detected in subsurface soil samples collected from the Fire Department/Texaco gas station/Antilles auto parts/Ramsay motor company area.

Twenty-three inorganics were detected in Fire Department/Texaco gas station/Antilles auto parts/Ramsay motor company subsurface soil samples. Fifteen inorganics were detected in each of the seven samples analyzed for inorganics, including aluminum, barium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, nickel, potassium, sodium, vanadium, and zinc. The highest concentrations were reported for calcium (67200 * mg/kg), iron (42500 mg/kg), aluminum (32200 J mg/kg), and magnesium (23600 J mg/kg). The maximum detection of calcium was reported in sample B-5, while the maximum aluminum and magnesium detections were reported in sample B-4. The maximum iron detection was reported in sample B-3.

Curriculum Center Building (Future)

The results of the analysis of ten subsurface soil samples collected at the Curriculum Center Building area are presented in Table 2-9. Seven VOCs, including ketones, and chlorinated aliphatic and aromatic chemicals, were detected in at least one sample. The most frequently

detected VOCs were toluene (4 of 10 samples), acetone (3 of 10 samples), and tetrachloroethene (3 of 10 samples). The chemicals detected at the highest concentrations were acetone (370 ug/kg) and tetrachloroethene (170 ug/kg). The acetone maximum concentration was reported as the average of the sample (collected by Geraghty & Miller) and the split (collected by CDM Federal), B-6-AVS. The maximum iron detection was reported in sample B-15.

Four SVOCs, all phthalates, were detected in at least one subsurface soil sample. The most frequently detected SVOC was bis(2-ethylhexyl)phthalate (2 of 10 samples). All other SVOCs were detected in only one sample. The highest SVOC detections were reported for di-n-butylphthalate (890 B ug/kg) and bis(2-ethylhexyl)phthalate (210 J ug/kg). The di-n-butylphthalate maximum detection was reported in sample MWS-14 while the bis(2-ethylhexyl)phthalate maximum detection was reported in sample MWS-13.

Pesticides and PCBs were not analyzed for in subsurface soil samples collected at the Curriculum Center Building area.

Twenty-two inorganics were detected in Curriculum Center Building subsurface soil samples. Fourteen inorganics were detected in each of the ten samples analyzed for inorganics, including aluminum, barium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, nickel, potassium, vanadium, and zinc. The highest concentrations were reported for calcium (96500 * mg/kg), iron (46400 mg/kg), aluminum (37900 mg/kg), and magnesium (24600 J mg/kg). The calcium maximum detection was reported as the average of the sample and its

associated duplicate (collected by Geraghty & Miller), B-14-AVD, while the iron and aluminum maximum detections were reported as the average of the samples (collected by Geraghty & Miller) and their respective splits (collected by CDM Federal), B-6-AVS. The magnesium maximum detection was reported in sample MWS-1.

Esso Gas Station and Splash and Dash Car Wash

The results of the analysis of seven subsurface soil samples collected from the Esso gas station and Splash and Dash car wash area are presented in Table 2-10. Six VOCs, including primarily ketones and chlorinated aliphatics, were detected in at least one sample. The most frequently detected VOCs were methylene chloride (4 of 7 samples) and acetone (3 of 7 samples). The chemicals detected at the highest concentrations were acetone (50.0 BJ ug/kg) and methylene chloride (20.0 J ug/kg). These concentrations were reported in samples MWS-18 and MWS-10D, respectively.

Two SVOCs, both phthalates, were detected in at least one of seven samples analyzed for SVOCs. Di-n-butylphthalate was detected at 458 B ug/kg while the highest bis(2-ethylhexyl)phthalate detection was reported as 220 J ug/kg. The di-n-butylphthalate detection was reported as the average of the sample (collected by Geraghty & Miller) and the split (collected by CDM Federal), MWS-8-AVS, while the bis(2-ethylhexyl)phthalate detection was reported in sample B-9.

Pesticides and PCBs were not analyzed for in subsurface soil samples collected from the Esso gas station and Splash and Dash car wash.

Twenty-two inorganics were detected in subsurface soil samples collected from the Esso gas station and Splash and Dash car wash. Fourteen inorganics were detected in each of the seven samples analyzed for inorganics, including aluminum, barium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, nickel, potassium, vanadium, and zinc. The highest concentrations were reported for iron (39300 mg/kg), calcium (37750 J mg/kg), aluminum (28000 J mg/kg), and magnesium (18550 J mg/kg). The calcium, aluminum, and magnesium maximum detections were reported as the average of the sample (collected by Geraghty & Miller) and the split (collected by CDM Federal), MWS-9-AVS. The iron maximum detection was reported in sample MWS-25D.

O'Henry Dry Cleaners and Liquor Barn

The results of the analysis of four subsurface soil samples collected at O'Henry dry cleaners and Liquor Barn are presented in Table 2-11. Three VOCs, methylene chloride, tetrachloroethene, and toluene were each detected in at least one sample. Tetrachloroethene was detected at the highest concentration of the three chemicals, 200 D ug/kg. This detection was reported in sample B-13.

Three SVOCs, including PAHs and phthalates, were each detected once in the four samples

analyzed for SVOCs. Butylbenzylphthalate was reported at 220 J ug/kg, di-n-butylphthalate at 160 J ug/kg, and fluoranthene at 42.0 J ug/kg. Butylbenzylphthalate and di-n-butylphthalate were reported in sample B-10 while the fluoranthene detection was reported in sample B-13.

Pesticides and PCBs were not analyzed for in subsurface soil samples collected from the O'Henry dry cleaners and Liquor Barn area.

Twenty inorganics were detected in the O'Henry dry cleaners and Liquor Barn subsurface soil samples. Sixteen inorganics were detected in each of the four samples analyzed for inorganics, including aluminum, barium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, nickel, potassium, silver, sodium, vanadium, and zinc. The highest concentrations were reported for iron (34100 EJ mg/kg), aluminum (19200 mg/kg), magnesium (14600 mg/kg), and calcium (14400 mg/kg). The maximum iron and aluminum detections were reported in sample B-11, while the maximum magnesium detection was reported in sample B-13. The maximum calcium detection was reported in sample B-10.

2.2.3 Chemicals Detected in Groundwater

A single site groundwater data summary is presented in Table 2-12. Upgradient, cross-gradient, and downgradient groundwater samples have not been included in this table, but are discussed separately in Section 2.3.2. Since multiple groundwater results exist for many wells sampled during the seven quarterly monitoring events conducted by Geraghty & Miller from 1991 to

TUTU WELLS SITE
SUMMARY OF CHEMICALS IN
GROUNDWATER (SITE-WIDE)
CONCENTRATION (ug/l)

CHEMICALS	Frequency of Detection	Range of Detected Concentrations		Location of Maximum	Range of Non-Detect Concentrations	
		Minimum	Maximum		Minimum	Maximum
VOCs						
Chloromethane	1/169	0.62	0.62	Gassett-5-AVD	0.50 U	5000 U
Vinyl Chloride	21/164	0.22 J	1300	MW-16-9	0.50 U	5000 U
Methylene Chloride	18/168	0.18 BJ	64.0 J	MW-5-AVS	0.50 UJ	5000 U
Acetone	13/146	3.90 JB	2700 J	SW-3-9	2.00 UJ	5000 U
Carbon Disulfide	4/168	0.15 J	3.00 J	MW-14-AVS	0.50 UJ	5000 U
1,1-Dichloroethene	2/168	0.06 J	0.12 J	Steele-4	0.50 UJ	5000 U
1,1-Dichloroethane	5/168	0.05 J	0.11 J	Steele-4	0.50 UJ	5000 U
1,2-Dichloroethene (Total)	142/169	0.11 J	2100	MW-16-9	0.50 UJ	5000 U
Chloroform	82/170	0.05 J	150 J	SW-3-9	0.50 UJ	5000 U
1,2-Dichloroethane	1/169	290	290	TT-1-9	0.50 UJ	5000 U
2-Butanone	9/145	2.00 J	620 J	SW-2-9	2.00 U	5000 U
1,1,1-Trichloroethane	2/168	2.00 J	3.00 J	Harvey-9	0.50 UJ	5000 U
Bromodichloromethane	11/169	0.09 J	30.0	MW-12D	0.50 UJ	5000 U
Trichloroethene	142/172	0.06 J	190	MW-1	0.50 UJ	5000 U
Dibromochloromethane	4/169	6.00 J	36.0	MW-11D	0.50 UJ	5000 U
1,1,2-Trichloroethane	5/169	1.00 J	5.00	Smith-2	0.50 U	5000 U
Benzene	34/168	0.05 J	21000 D	TT-1-9	0.50 UJ	200 U
Bromoform	5/167	4.50 J	29.0	MW-11D	0.50 UJ	5000 U
Tetrachloroethene	143/173	1.00 J	1500	Harvey-2	0.50 UJ	5000 U
Toluene	32/168	0.05 J	17000	TT-4-9	0.50 UJ	200 U
Chlorobenzene	2/168	0.13 J	0.20 J	Tillet-4-AVD	0.50 UJ	5000 U
Ethylbenzene	13/168	1.00	4100 J	SW-3-9	0.50 UJ	1000 UJ
Xylenes (Total)	17/168	0.40 J	22000 J	SW-3-9	0.50 UJ	200 U
Methyl-tert-butyl-ether	57/89	1.00 JN	89000 DJ	SW-3-9	10.0 U	1000 UJ
n-Propylbenzene	10/78	4.20 J	3800 J	SW-3-9	5.00 UJ	5000 UJ
cis-1,2-Dichloroethene	4/4	11.5	37.0 D	MW02	-	-

Sample Group:

MW-1, MW-1D, MW-2, MW-3, MW-4-AVS, MW-4D, MW-5-AVS, MW-6D, MW-6R-AVS, MW-7-AVD, MW-8, MW-9-AVD, MW-9S, MW-10, MW-10D, MW-11D, MW-12D, MW-13D, MW-14-AVS, Eglin I-2, Eglin II-2, Eglin III-2-AVD, FourWindsI-2, Gassett-2, Harvey-2, LaPlace-2-AVD, Matthias-2, Ramsay-2, Rodriguez-2, Smith-2, Steele-2, Tillet-2, Eglin I-3, Eglin II-3, Eglin III-3, FourWindsI-3, Gassett-3, Harvey-3, LaPlace-3-AVD, Matthias-3, Ramsay-3, Smith-3, Steele-3, Tillet-3, Eglin I-4, Eglin II-4, Eglin III-4, FourWindsI-4, FourWindsII-4, Gassett-4, Harvey-4, LaPlace-4, Matthias-4, Ramsay-4, Smith-4, Steele-4, Tillet-4-AVD, Eglin I-5, Eglin II-5, Eglin III-5, FourWindsI-5, FourWindsII-5, Gassett-5-AVD, Harvey-5, LaPlace-5-AVD, Matthias-5, Ramsay-5, Rodriguez-5, Smith-5, Steele-5, Tillet-5, Eglin I-6, Eglin II-6, Eglin III-6, Gassett-6, Harvey-6, LaPlace-6, Ramsay-6, Smith-6-AVD, Steele-6, Tillet-6, Eglin I-7, Eglin II-7, Eglin III-7, FourWindsI-7, FourWindsII-7, Gassett-7, Harvey-7, LaPlace-7, Ramsay-7-AVD, Smith-7, Steele-7, Tillet-7, Eglin I-8, Eglin III-8, FourWindsI-8, Gassett-8, Harvey-8-AVD, LaPlace-8, Ramsay-8, Rodriguez-8, Smith-8, Steele-8, Tillet-8, MW01, MW02, MW03-AVD, MW04, CHT-3-9, CHT-6D-9, CHT-7D-9, Deleagarde-9, Deleagarde-9*, DW-1-9, DW-2-9, Eglin I-9, Eglin III-9, FourWindsI-9, FourWindsII-9AV, Gassett-9, Harvey-9, LaPlace-9, Matthias-9, MW-1-9, MW-1D-9, MW-2-9, MW-3-9, MW-4-9, MW-4D-9, MW-5-9, MW-6D-9, MW-6R-9, MW-7-9, MW-8-9, MW-9S-9, MW-10-9, MW-10D-9, MW-11D-9-AVD, MW-12D-9, MW-13-9, MW-13D-9, MW-15-9, MW-16-9, MW-17-9, MW-18-9, MW-18R-9, MW-19-9, MW-20-9, MW-20D-9, MW-21D-9, MW-22D-9, MW-24-9, MW-25-9, OHMW-1-9, OHMW-2-9, OHMW-3-9, OHMW-4-9, Ramsay-9, Smith-9, Steele-9, SW-2-9, SW-3-9, SW-4-9, SW-5-9, SW-6-9, SW-7-9-AVD, Tillet-9, TT-1-9, TT-1D-9, TT-2-9-AVD, TT-3D-9, TT-4-9, TT-5-9, VIHA I-9.

TABLE 2- (cont'd)

TUTU WELLS SITE
SUMMARY OF CHEMICALS IN
GROUNDWATER (SITE-WIDE)

CONCENTRATION (ug/l)

CHEMICALS	Frequency of Detection	Range of Detected Concentrations		Location of Maximum	Range of Non-Detect Concentrations	
		Minimum	Maximum		Minimum	Maximum
SVOCs						
Phenol	6/108	3.00 J	67.0 J	TT-1-9	8.00 UJ	50.0 UJ
1,4-Dichlorobenzene	1/112	2.00 J	2.00 J	MW-16-9	1.00 U	50.0 UJ
1,2-Dichlorobenzene	4/112	1.00 J	6.50 J	SW-7-9-AVD	1.00 U	50.0 UJ
2-Methylphenol	3/108	4.00 J	27.0 J	TT-1-9	8.00 U	50.0 UJ
4-Methylphenol	4/108	3.00 J	72.0 J	TT-1-9	8.00 UJ	50.0 UJ
2-Nitrophenol	1/108	3.00 J	3.00 J	MW-13D-9	8.00 U	100 U
2,4-Dimethylphenol	2/107	13.0 J	32.5 J	SW-7-9-AVD	8.00 U	100 U
Benzoic Acid	3/3	2.00 JN	60.0 J	Gassett-9	-	-
1,2,4-Trichlorobenzene	1/108	3.00 J	3.00 J	MW-16-9	8.00 U	50.0 UJ
Naphthalene	10/108	2.00 J	1000 DJ	SW-3-9	8.00 U	10.0 U
2-Methylnaphthalene	10/108	1.00 J	450 DJ	SW-3-9	8.00 U	10.0 U
Dimethylphthalate	2/108	3.00 J	8.00 J	MW-4D	8.00 U	50.0 UJ
Acenaphthylene	2/108	1.00 J	1.00 J	MW-9S-9	8.00 U	50.0 UJ
Acenaphthene	1/108	2.00 J	2.00 J	SW-7-9-AVD	8.00 U	50.0 UJ
Dibenzofuran	1/108	1.50 J	1.50 J	MW-14-AVS	8.00 U	50.0 UJ
Diethylphthalate	1/108	60.0 J	60.0 J	MW-10D-9	8.00 U	50.0 UJ
Fluorene	7/108	2.00 J	40.0 J	SW-3-9	8.00 U	25.0 U
Phenanthrene	7/108	1.50 J	32.0 J	SW-3-9	8.00 U	25.0 U
Anthracene	1/108	1.00 J	1.00 J	SW-7-9-AVD	8.00 U	50.0 UJ
Carbazole	1/108	1.00 J	1.00 J	MW-9S-9	8.00 U	50.0 UJ
Fluoranthene	2/108	1.00 J	1.00 J	MW-9S-9	8.00 U	50.0 UJ

Sample Group:

MW-1, MW-1D, MW-2, MW-3, MW-4-AVS, MW-4D, MW-5-AVS, MW-6D, MW-6R-AVS, MW-7-AVD, MW-8, MW-9-AVD, MW-9S, MW-10, MW-10D, MW-11D, MW-12D, MW-13D, MW-14-AVS, Eglin I-2, Eglin II-2, Eglin III-2-AVD, FourWindsII-2, Gassett-2, Harvey-2, LaPlace-2-AVD, Matthias-2, Ramsay-2, Rodriguez-2, Smith-2, Steele-2, Tillett-2, Eglin I-3, Eglin II-3, Eglin III-3, FourWindsI-3, Gassett-3, Harvey-3, LaPlace-3-AVD, Matthias-3, Ramsay-3, Smith-3, Steele-3, Tillett-3, Eglin I-4, Eglin II-4, Eglin III-4, FourWindsI-4, FourWindsII-4, Gassett-4, Harvey-4, LaPlace-4, Matthias-4, Ramsay-4, Smith-4, Steele-4, Tillett-4-AVD, Eglin I-5, Eglin II-5, Eglin III-5, FourWindsI-5, FourWindsII-5, Gassett-5-AVD, Harvey-5, LaPlace-5-AVD, Matthias-5, Ramsay-5, Rodriguez-5, Smith-5, Steele-5, Tillett-5, Eglin I-6, Eglin II-6, Eglin III-6, Gassett-6, Harvey-6, LaPlace-6, Ramsay-6, Smith-6-AVD, Steele-6, Tillett-6, Eglin I-7, Eglin II-7, Eglin III-7, FourWindsI-7, FourWindsII-7, Gassett-7, Harvey-7, LaPlace-7, Ramsay-7-AVD, Smith-7, Steele-7, Tillett-7, Eglin I-8, Eglin III-8, FourWindsI-8, Gassett-8, Harvey-8-AVD, LaPlace-8, Ramsay-8, Rodriguez-8, Smith-8, Steele-8, Tillett-8, MW01, MW02, MW03-AVD, MW04, CHT-3-9, CHT-6D-9, CHT-7D-9, Delegarde-9, Delegarde-9*, DW-1-9, DW-2-9, Eglin I-9, Eglin III-9, FourWindsI-9, FourWindsII-9-AV, Gassett-9, Harvey-9, LaPlace-9, Matthias-9, MW-1-9, MW-1D-9, MW-2-9, MW-3-9, MW-4-9, MW-4D-9, MW-5-9, MW-6D-9, MW-6R-9, MW-7-9, MW-8-9, MW-9S-9, MW-10-9, MW-10D-9, MW-11D-9-AVD, MW-12D-9, MW-13-9, MW-13D-9, MW-15-9, MW-16-9, MW-17-9, MW-18-9, MW-18R-9, MW-19-9, MW-20-9, MW-20D-9, MW-21D-9, MW-22D-9, MW-24-9, MW-25-9, OHMW-1-9, OHMW-2-9, OHMW-3-9, OHMW-4-9, Ramsay-9, Smith-9, Steele-9, SW-2-9, SW-3-9, SW-4-9, SW-5-9, SW-6-9, SW-7-9-AVD, Tillett-9, TT-1-9, TT-1D-9, TT-2-9-AVD, TT-3D-9, TT-4-9, TT-5-9, VIHA I-9.

TABLE 2- (nt'd)

TUTU WELLS SITE
SUMMARY OF CHEMICALS IN
GROUNDWATER (SITE-WIDE)

CONCENTRATION (ug/l)

CHEMICALS	Frequency of Detection	Range of Detected Concentrations		Location of Maximum	Range of Non-Detect Concentrations	
		Minimum	Maximum		Minimum	Maximum
<u>SVOCs (Cont'd)</u>						
Pyrene	3/108	2.50 J	8.00 J	SW-3-9	8.00 U	25.0 U
Butylbenzylphthalate	2/108	1.00 J	2.00 J	Tillett-9	8.00 U	50.0 UJ
Benzo(a)anthracene	1/108	1.00 J	1.00 J	SW-7-9-AVD	8.00 U	50.0 UJ
Chrysene	3/108	1.00 J	9.00 J	SW-3-9	8.00 U	25.0 U
Bis(2-ethylhexyl)phthalate	13/108	1.00 BJ	690 D	LaPlace-5-AVD	8.00 U	55.0 U
Di-n-octylphthalate	2/108	1.00 J	1.00 J	MW-6R-AVS	8.00 U	50.0 UJ
Benzo(b)fluoranthene	1/108	1.00 J	1.00 J	MW-9S-9	8.00 U	50.0 UJ
Benzo(g,h,i)perylene	2/108	1.00 J	1.00 J	MW-9S-9	8.00 U	50.0 UJ
<u>PESTICIDES/PCBS</u>						
Not Analyzed						
<u>INORGANICS</u>						
Aluminum	73/88	39.5 B	356000 J	OHMW-4-9	35.5 U	9420 UJ
Antimony	22/115	14.8 B	424 B	MW-13D-9	15.0 U	300 U
Arsenic	24/107	1.00 B	80.8 J	OHMW-2-9	1.00 U	2.50 UJ
Barium	107/107	1.10 B	4400 B	MW-13D-9	-	-
Beryllium	8/108	0.75 B	40.8 B	MW-13D-9	0.25 U	20.0 U
Cadmium	2/108	2.10 B	2.45 B	Gassett-5-AVD	2.00 U	75.0 U
Calcium	106/107	6870	11600000	Delegarde-9	17600 UJ	17600 UJ
Chromium	63/107	3.00 B	4610	OHMW-3-9	3.00 U	60.0 U
Cobalt	48/107	3.20 B	362 B	MW-13D-9	3.00 U	60.0 U
Copper	92/107	2.70 BJ	1730 J	MW-13D-9	2.00 U	60.0 U
Iron	105/106	7.00 BJ	572000 J	OHMW-4-9	3000 UJ	3000 UJ
Lead	69/107	1.40 BJ	201	OHMW-2-9	1.00 UJ	43.4 UJ

Sample Group:

MW-1, MW-1D, MW-2, MW-3, MW-4-AVS, MW-4D, MW-5-AVS, MW-6D, MW-6R-AVS, MW-7-AVD, MW-8, MW-9-AVD, MW-9S, MW-10, MW-10D, MW-11D, MW-12D, MW-13D, MW-14-AVS, Eglin I-2, Eglin II-2, Eglin III-2-AVD, FourWindsI-2, Gassett-2, Harvey-2, LaPlace-2-AVD, Matthias-2, Ramsay-2, Rodriguez-2, Smith-2, Steele-2, Tillett-2, Eglin I-3, Eglin II-3, Eglin III-3, FourWindsI-3, Gassett-3, Harvey-3, LaPlace-3-AVD, Matthias-3, Ramsay-3, Smith-3, Steele-3, Tillett-3, Eglin I-4, Eglin II-4, Eglin III-4, FourWindsI-4, Gassett-4, Harvey-4, LaPlace-4, Matthias-4, Ramsay-4, Smith-4, Steele-4, Tillett-4-AVD, Eglin I-5, Eglin II-5, Eglin III-5, FourWindsI-5, FourWindsII-5, Gassett-5-AVD, Harvey-5, LaPlace-5-AVD, Matthias-5, Ramsay-5, Rodriguez-5, Smith-5, Steele-5, Tillett-5, Eglin I-6, Eglin II-6, Eglin III-6, Gassett-6, Harvey-6, LaPlace-6, Ramsay-6, Smith-6-AVD, Steele-6, Tillett-6, Eglin I-7, Eglin II-7, Eglin III-7, FourWindsI-7, FourWindsII-7, Gassett-7, Harvey-7, LaPlace-7, Ramsay-7-AVD, Smith-7, Steele-7, Tillett-7, Eglin I-8, Eglin III-8, FourWindsI-8, Gassett-8, Harvey-8-AVD, LaPlace-8, Ramsay-8, Rodriguez-8, Smith-8, Steele-8, Tillett-8, MW01, MW02, MW03-AVD, MW04, CHT-3-9, CHT-6D-9, CHT-7D-9, Delegarde-9, Delegarde-9*, DW-1-9, DW-2-9, Eglin I-9, Eglin III-9, FourWindsI-9, FourWindsII-9, Gassett-9, Harvey-9, LaPlace-9, Matthias-9, MW-1-9, MW-1D-9, MW-2-9, MW-3-9, MW-4-9, MW-4D-9, MW-5-9, MW-6D-9, MW-6R-9, MW-7-9, MW-8-9, MW-9S-9, MW-10-9, MW-10D-9, MW-11D-9-AVD, MW-12D-9, MW-13-9, MW-13D-9, MW-15-9, MW-16-9, MW-17-9, MW-18-9, MW-18R-9, MW-19-9, MW-20-9, MW-20D-9, MW-21D-9, MW-22D-9, MW-24-9, MW-25-9, OHMW-1-9, OHMW-2-9, OHMW-3-9, OHMW-4-9, Ramsay-9, Smith-9, Steele-9, SW-2-9, SW-3-9, SW-4-9, SW-5-9, SW-6-9, SW-7-9-AVD, Tillett-9, TT-1-9, TT-1D-9, TT-2-9-AVD, TT-3D-9, TT-4-9, TT-5-9, VIHA I-9.

TABLE 2-12 (Cont'd)

TUTU WELLS SITE
SUMMARY OF CHEMICALS IN
GROUNDWATER (SITE-WIDE)

CONCENTRATION (ug/l)

	Frequency of Detection	Range of Detected Concentrations		Location of Maximum	Range of Non-Detect Concentrations	
		Minimum	Maximum		Minimum	Maximum
CHEMICALS						
INORGANICS (Cont'd)						
Magnesium	106/107	654 B	858000	Delegarde-9	27900 UJ	27900 UJ
Manganese	104/107	1.40 B	20400	MW-13D-9	1.00 U	71.6 UJ
Mercury	27/113	0.08 B	3.10 J	OHMW-1-9	0.10 U	1.60 UJ
Nickel	50/107	8.70 B	2050	MW-13D-9	7.10 U	200 U
Potassium	103/107	610 B	119000 J	OHMW-4-9	490 U	33300 UJ
Selenium	27/109	1.55 B	11.7 J	Smith-2	1.50 UJ	10.0 UJ
Silver	2/108	7.00 BJ	47.2	Rodriguez-5	2.00 UJ	75.0 U
Sodium	106/108	11300 J	9870000	Delegarde-9	372000 U	662000 UJ
Thallium	3/121	2.10 B	3.60 BJ	Tillett-8	1.00 UJ	20.0 UJ
Vanadium	101/107	4.90 B	1000 J	OHMW-4-9	4.00 U	10.0 U
Zinc	106/107	4.10 B	2510 J	OHMW-4-9	80.7 UJ	80.7 UJ
Cyanide (Total)	1/100	11.0	11.0	LaPlace-8	5.00 U	10.0 UJ

Sample Group:

MW-1, MW-1D, MW-2, MW-3, MW-4-AVS, MW-4D, MW-5-AVS, MW-6D, MW-6R-AVS, MW-7-AVD, MW-8, MW-9-AVD, MW-9S, MW-10, MW-10D, MW-11D, MW-12D, MW-13D, MW-14-AVS, Eglin I-2, Eglin II-2, Eglin III-2-AVD, FourWindsII-2, Gassett-2, Harvey-2, LaPlace-2-AVD, Matthias-2, Ramsay-2, Rodriguez-2, Smith-2, Steele-2, Tillett-2, Eglin I-3, Eglin II-3, Eglin III-3, FourWindsI-3, Gassett-3, Harvey-3, LaPlace-3-AVD, Matthias-3, Ramsay-3, Smith-3, Steele-3, Tillett-3, Eglin I-4, Eglin II-4, Eglin III-4, FourWindsI-4, FourWindsII-4, Gassett-4, Harvey-4, LaPlace-4, Matthias-4, Ramsay-4, Smith-4, Steele-4, Tillett-4-AVD, Eglin I-5, Eglin II-5, Eglin III-5, FourWindsI-5, FourWindsII-5, Gassett-5-AVD, Harvey-5, LaPlace-5-AVD, Matthias-5, Ramsay-5, Rodriguez-5, Smith-5, Steele-5, Tillett-5, Eglin I-6, Eglin II-6, Eglin III-6, Gassett-6, Harvey-6, LaPlace-6, Ramsay-6, Smith-6-AVD, Steele-6, Tillett-6, Eglin I-7, Eglin II-7, Eglin III-7, FourWindsI-7, FourWindsII-7, Gassett-7, Harvey-7, LaPlace-7, Ramsay-7-AVD, Smith-7, Steele-7, Tillett-7, Eglin I-8, Eglin III-8, FourWindsI-8, Gassett-8, Harvey-8-AVD, LaPlace-8, Ramsay-8, Rodriguez-8, Smith-8, Steele-8, Tillett-8, MW01, MW02, MW03-AVD, MW04, CHT-3-9, CHT-6D-9, CHT-7D-9, Delegarde-9, Delegarde-9*, DW-1-9, DW-2-9, Eglin I-9, Eglin III-9, FourWinds I-9, FourWindsII9AV, Gassett-9, Harvey-9, LaPlace-9, Matthias-9, MW-1-9, MW-1D-9, MW-2-9, MW-3-9, MW-4-9, MW-4D-9, MW-5-9, MW-6D-9, MW-6R-9, MW-7-9, MW-8-9, MW-9S-9, MW-10-9, MW-10D-9, MW-11D-9-AVD, MW-12D-9, MW-13-9, MW-13D-9, MW-15-9, MW-16-9, MW-17-9, MW-18-9, MW-18R-9, MW-19-9, MW-20-9, MW-20D-9, MW-21D-9, MW-22D-9, MW-24-9, MW-25-9, OHMW-1-9, OHMW-2-9, OHMW-3-9, OHMW-4-9, Ramsay-9, Smith-9, Steele-9, SW-2-9, SW-3-9, SW-4-9, SW-5-9, SW-6-9, SW-7-9-AVD, Tillett-9, TT-1-9, TT-1D-9, TT-2-9-AVD, TT-3D-9, TT-4-9, TT-5-9, VIHA I-9.

1993, a number denoting the sampling event has been added to the end of the well designation (i.e., Harvey-2). This quarterly sampling event designation has been added so that the samples would be recognized as groundwater in the computer data base. For the Geraghty & Miller Phase II groundwater samples, a "9" has been added to the end of the well designation only for the purpose of differentiating them from samples collected during previous sampling events. Samples having split or duplicate results, as for the soils, were given the suffix AVS or AVD, respectively, to differentiate the components of the averaged result.

The results of the analysis of 174 groundwater samples collected at and in the vicinity of the Tutu Wells site are presented in Table 2-12. Twenty-six VOCs, including primarily chlorinated aliphatic and aromatic chemicals, were detected in at least one sample. The most frequently detected VOCs were tetrachloroethene (143 of 173 samples), 1,2-dichloroethene (total) (142 of 169 samples), and trichloroethene (142 of 172 samples). The chemicals detected at the highest concentrations were methyl-tertiary-butyl-ether (89000 DJ ug/l), xylenes (total) (22000 J ug/l), and benzene (21000 D ug/l). The maximum methyl-tertiary-butyl-ether and xylenes (total) detections were reported in sample SW-3-9, while the maximum benzene detection was reported in sample TT-1-9.

Twenty-nine SVOCs, including primarily phenols, PAHs, and phthalates, were detected in at least one groundwater sample. The most frequently detected SVOC was bis(2-ethylhexyl)phthalate (13 of 108 samples). The highest SVOC detections were reported for naphthalene (1000 DJ ug/l) and bis(2-ethylhexyl)phthalate (690 D ug/l). The maximum

naphthalene detection was reported in sample SW-3-9, while the maximum bis(2-ethylhexyl)phthalate detection was reported as the average of the sample and its associated duplicate (both collected by Geraghty & Miller), LaPlace-5-AVD.

Pesticides and PCBs were not analyzed for in groundwater samples collected at the site.

Twenty-four inorganics were detected in site groundwater samples. Only one inorganic, barium, was detected in each of the samples analyzed for inorganics. The highest concentrations were reported calcium (11600000 ug/l) and sodium (9870000 ug/l). The maximum detections were reported in sample Delegarde-9.

2.3 Criteria for the Selection of Chemicals of Potential Concern

Due to the large number of chemicals detected at the Tutu Wells site, the number of chemicals retained for quantitative analysis in this risk assessment was reduced to the most significant (i.e., greatest contributors to risk/hazards). If all chemicals were retained for analysis, the resulting document would be unduly complex and could obscure the dominant risks/hazards associated with the site. Therefore, chemicals of potential concern were selected based on procedures specified in RAGS Part A (USEPA, 1989a) and on professional judgement. The primary considerations for selection or elimination were as follows:

- frequency of detection in analyzed medium (i.e., surface soil)

- historical site information/activities (i.e., site-relatedness)
- chemical concentration - toxicity screen
- sample chemical detections relative to blank chemical detections
- chemical concentrations relative to upgradient concentrations
- chemical toxicity (potential carcinogenic and noncarcinogenic effects, weight-of-evidence for potential carcinogenicity)
- chemical properties (i.e., mobility, persistence, and bioaccumulation)
- significant exposure routes

The frequency of detection is defined as the number of detections (hits) divided by the total number of valid sample analyses. For all chemicals detected in a given environmental medium, a frequency of detection of five (5) percent was utilized as the minimum cutoff point. A number of metals were detected in nearly all soil (surface and subsurface) and groundwater samples analyzed for metals, including the essential nutrients calcium, magnesium, potassium, and sodium. The potential toxicity of the essential nutrients is significantly lower than other inorganics detected at the site. In general, more data are available for these minerals with regard to identifying dietary intake rather than toxicity. These minerals are also typically obtained via food, mineral supplements, etc. and are homeostatically regulated to maintain appropriate body functions. Therefore, these minerals were not selected as chemicals of potential concern in the risk assessment. An additional metal detected at a high frequency, aluminum, which is ubiquitous in soil, air, and water (Klaassen et al., 1986), is not believed to be site-related. In addition, other chemicals not having established toxicity values (i.e., cobalt, copper, dibenzofuran) are qualitatively addressed in Section 4.3.

The potential health impact of a chemical is related to the relationship of concentration and toxicity. A chemical detected at a high concentration that may exhibit low noncarcinogenic toxicity may have less impact on human health than a potential carcinogen detected at a relatively low concentration. Therefore, a chemical concentration - toxicity screening procedure was performed for all chemicals detected in the specific areas of concern for surface soil, subsurface soil, and groundwater to aid in the determination of which chemicals were likely to contribute significantly to potential risks and hazards (see Tables 2-13 through 2-23). Individual chemical scores (or risk factors) were calculated for each medium as follows:

$$R_{ij} = (C_{ij})(T_{ij})$$

Where:

R_{ij} = risk factor for chemical i in medium j;

C_{ij} = concentration of chemical i in medium j; and

T_{ij} = toxicity value for chemical i in medium j;

(i.e., slope factor or 1/oral reference dose)

In accordance with RAGS and for conservatism, the maximum detected concentration of each chemical was used in the calculation (USEPA, 1989a). However, for samples having a duplicate analysis, the two values were averaged except when one-half of the sample quantitation limit (SQL) for a non-detect was higher than the actual detection. When this occurred, the SQL was ignored and the actual detection was utilized as the sample result. Chemicals other than essential

10/25/94

TOXSCRNSSTGA.XLS

TABLE 2-13

TUTU WELLS SITE
CHEMICAL CONCENTRATION - TOXICITY SCREEN
TILLET GARDENS AND ART CENTER - SURFACE SOIL

CARCINOGENS:

CHEMICAL	Chemical of Potential Concern (Contributes >1%)	Maximum Detected Concentration (mg/kg)	Slope Factor (mg/kg-day) ⁻¹	Risk Factor (unitless)	Contribution to Total Risk for Matrix (Percent)
Methylene Chloride	no	9.0E-03	7.5E-03	6.8E-05	0.00%
Chloroform	no	2.0E-03	6.1E-03	1.2E-05	0.00%
Chrysene	no	5.9E-02	7.3E-03	4.3E-04	0.00%
Benzo(b)fluoranthene	no	8.4E-02	7.3E-01	6.1E-02	0.01%
Aroclor 1242	YES	1.2E+02	7.7E+00	9.2E+02	98.05%
Arsenic	YES	1.0E+01	1.75E+00	1.8E+01	1.86%
Beryllium	no	2.0E-01	4.3E+00	8.6E-01	0.09%
TOTAL RISK FACTOR =				9.4E+02	100%

77

TUT 006 2263

TUTU WELLS SITE
CHEMICAL CONCENTRATION - TOXICITY SCREEN
TILLET GARDENS AND ART CENTER - SURFACE SOIL

NONCARCINOGENS:

CHEMICAL	Chemical of Potential Concern (Contributes >1%)	Maximum Detected Concentration (mg/kg)	Reference Dose (mg/kg-day)	Risk Factor (unitless)	Contribution to Total Risk for Matrix (Percent)
Methylene Chloride	no	9.0E-03	6.0E-02	1.5E-01	0.00%
Chloroform	no	2.0E-03	1.0E-02	2.0E-01	0.00%
Xylenes (Total)	no	1.1E-02	2.0E+00	5.5E-03	0.00%
Di-n-butylphthalate	no	5.5E-02	1.0E-01	5.5E-01	0.00%
Fluoranthene	no	1.0E-01	4.0E-02	2.5E+00	0.00%
Pyrene	no	7.6E-02	3.0E-02	2.5E+00	0.00%
Butylbenzylphthalate	no	1.3E-01	2.0E-01	6.7E-01	0.00%
Antimony	YES	5.1E+00	4.0E-04	1.3E+04	5.32%
Arsenic	YES	1.0E+01	3.0E-04	3.3E+04	14.04%
Barium	no	7.1E+01	7.0E-02	1.0E+03	0.42%
Beryllium	no	2.0E-01	5.0E-03	4.0E+01	0.02%
Chromium III	no	2.2E+01	1.0E+00	2.2E+01	0.01%
Chromium VI	no	3.6E+00	5.0E-03	7.2E+02	0.30%
Manganese	YES	8.7E+02	5.0E-03	1.7E+05	73.23%
Mercury	no	1.2E-01	3.0E-04	4.0E+02	0.17%
Nickel	no	1.4E+01	2.0E-02	7.0E+02	0.29%
Silver	no	2.2E+00	5.0E-03	4.3E+02	0.18%
Vanadium	YES	9.6E+01	7.0E-03	1.4E+04	5.77%
Zinc	no	1.7E+02	3.0E-01	5.6E+02	0.24%

TOTAL RISK FACTOR = 2.4E+05 100%

TUTU WELLS SITE
CHEMICAL CONCENTRATION - TOXICITY SCREEN
FIRE DEPARTMENT / TEXACO GAS STATION / ANTILLES AUTO PARTS / RAMSAY MOTOR CO. - SURFACE SOIL

CARCINOGENS:

CHEMICAL	Chemical of Potential Concern (Contributes >1%)	Maximum Detected Concentration (mg/kg)	Slope Factor (mg/kg-day) ⁻¹	Risk Factor (unitless)	Contribution to Total Risk for Matrix (Percent)
Methylene Chloride	no	2.0E-01	7.5E-03	1.5E-03	0.02%
Benzene	no	4.5E-02	2.9E-02	1.3E-03	0.02%
Benzo(b)fluoranthene	YES	8.7E-01	7.3E-01	6.4E-01	8.61%
Benzo(a)pyrene	YES	7.7E-01	7.3E+00	5.6E+00	76.20%
Beryllium	YES	2.6E-01	4.3E+00	1.1E+00	15.16%
TOTAL RISK FACTOR =				7.4E+00	100%

TUTU WELLS SITE
CHEMICAL CONCENTRATION - TOXICITY SCREEN
FIRE DEPARTMENT / TEXACO GAS STATION / ANTILLES AUTO PARTS / RAMSAY MOTOR CO. - SURFACE SOIL

NONCARCINOGENS:

CHEMICAL	Chemical of Potential Concern (Contributes >1%)	Maximum Detected Concentration (mg/kg)	Reference Dose (mg/kg-day)	Risk Factor (unitless)	Contribution to Total Risk for Matrix (Percent)
Methylene Chloride	no	2.0E-01	6.0E-02	3.3E+00	0.00%
Acetone	no	1.4E-02	1.0E-01	1.4E-01	0.00%
4-Methyl-2-Pentanone	no	3.3E-02	8.0E-02	4.1E-01	0.00%
Toluene	no	1.3E+00	2.0E-01	6.5E+00	0.00%
Ethylbenzene	no	2.1E+00	1.0E-01	2.1E+01	0.01%
Xylenes (Total)	no	5.6E+00	2.0E+00	2.8E+00	0.00%
Naphthalene	no	4.4E+00	4.0E-02	1.1E+02	0.05%
Acenaphthene	no	1.9E-01	6.0E-02	3.2E+00	0.00%
Fluorene	no	4.2E-01	4.0E-02	1.1E+01	0.01%
Fluoranthene	no	7.4E-01	4.0E-02	1.9E+01	0.01%
Pyrene	no	2.0E+00	3.0E-02	6.7E+01	0.03%
Bis(2-ethylhexyl)phthalate	no	5.4E+00	2.0E-02	2.7E+02	0.13%
Antimony	YES	5.9E+00	4.0E-04	1.5E+04	7.28%
Barium	no	6.7E+01	7.0E-02	9.6E+02	0.47%
Beryllium	no	2.6E-01	5.0E-03	5.2E+01	0.03%
Chromium III	no	2.7E+01	1.0E+00	2.7E+01	0.01%
Chromium VI	no	4.5E+00	5.0E-03	9.0E+02	0.44%
Manganese	YES	8.3E+02	5.0E-03	1.7E+05	82.28%
Nickel	no	1.8E+01	2.0E-02	8.8E+02	0.43%
Silver	no	2.2E+00	5.0E-03	4.4E+02	0.22%
Vanadium	YES	1.2E+02	7.0E-03	1.7E+04	8.39%
Zinc	no	1.1E+02	3.0E-01	3.6E+02	0.18%
Cyanide	no	1.1E+00	2.0E-02	5.5E+01	0.03%
TOTAL RISK FACTOR =				2.0E+05	100%

80

TUTU WELLS SITE
CHEMICAL CONCENTRATION - TOXICITY SCREEN
CURRICULUM CENTER BUILDING (PRESENT) - SURFACE SOIL

CARCINOGENS:

CHEMICAL	Chemical of Potential Concern (Contributes >1%)	Maximum Detected Concentration (mg/kg)	Slope Factor (mg/kg-day) ⁻¹	Risk Factor (unitless)	Contribution to Total Risk for Matrix (Percent)
Methylene Chloride	no	2.2E-02	7.5E-03	1.7E-04	0.00%
Chloroform	no	6.8E-03	6.1E-03	4.1E-05	0.00%
Trichloroethene	no	6.5E-02	1.1E-02	7.2E-04	0.00%
Tetrachloroethene	no	1.7E-01	5.2E-02	8.8E-03	0.04%
Arsenic	YES	1.2E+01	1.75E+00	2.0E+01	94.55%
Beryllium	YES	2.7E-01	4.3E+00	1.2E+00	5.41%
TOTAL RISK FACTOR =				2.1E+01	100%

TUTU WELLS SITE
CHEMICAL CONCENTRATION - TOXICITY SCREEN
CURRICULUM CENTER BUILDING (PRESENT) - SURFACE SOIL

NONCARCINOGENS:

CHEMICAL	Chemical of Potential Concern (Contributes >1%)	Maximum Detected Concentration (mg/kg)	Reference Dose (mg/kg-day)	Risk Factor (unitless)	Contribution to Total Risk for Matrix (Percent)
Methylene Chloride	no	2.2E-02	6.0E-02	3.7E-01	0.00%
Chloroform	no	6.8E-03	1.0E-02	6.8E-01	0.00%
2-Butanone	no	4.5E-02	6.0E-01	7.4E-02	0.00%
Trichloroethene	no	6.5E-02	6.0E-03	1.1E+01	0.00%
Tetrachloroethene	no	1.7E-01	1.0E-02	1.7E+01	0.00%
Toluene	no	2.0E-01	2.0E-01	1.0E+00	0.00%
Ethylbenzene	no	4.2E-01	1.0E-01	4.2E+00	0.00%
Xylenes (Total)	no	1.6E+00	2.0E+00	8.0E-01	0.00%
Phenol	no	9.0E+02	6.0E-01	1.5E+03	0.28%
2-Methylphenol	YES	3.2E+02	5.0E-02	6.4E+03	1.21%
4-Methylphenol	YES	1.3E+03	5.0E-03	2.6E+05	49.35%
2,4-Dimethylphenol	no	4.2E+01	2.0E-02	2.1E+03	0.40%
Naphthalene	no	7.7E+00	4.0E-02	1.9E+02	0.04%
Di-n-butylphthalate	no	9.4E+00	1.0E-01	9.4E+01	0.02%
Butylbenzylphthalate	no	1.2E-01	2.0E-01	6.0E-01	0.00%
Endosulfan I	no	9.2E-02	6.0E-03	1.5E+01	0.00%
Antimony	YES	7.3E+00	4.0E-04	1.8E+04	3.46%
Arsenic	YES	1.2E+01	3.0E-04	3.9E+04	7.34%
Barium	no	9.6E+01	7.0E-02	1.4E+03	0.26%
Beryllium	no	2.7E-01	5.0E-03	5.4E+01	0.01%
Cadmium	no	9.9E-01	1.0E-03	9.9E+02	0.19%
Chromium III	no	3.6E+01	1.0E+00	3.6E+01	0.01%
Chromium VI	no	6.0E+00	5.0E-03	1.2E+03	0.23%
Manganese	YES	8.7E+02	5.0E-03	1.7E+05	33.14%
Mercury	no	5.7E-01	3.0E-04	1.9E+03	0.36%
Nickel	no	2.2E+01	2.0E-02	1.1E+03	0.21%
Silver	no	1.9E+00	5.0E-03	3.8E+02	0.07%
Vanadium	YES	1.2E+02	7.0E-03	1.6E+04	3.12%
Zinc	no	4.6E+02	3.0E-01	1.5E+03	0.29%
Cyanide	no	7.5E-01	2.0E-02	3.8E+01	0.01%

TOTAL RISK FACTOR = 5.3E+05 100%

TUTU WELLS SITE
CHEMICAL CONCENTRATION - TOXICITY SCREEN
CURRICULUM CENTER BUILDING (FUTURE) - SURFACE SOIL

CARCINOGENS:

CHEMICAL	Chemical of Potential Concern (Contributes >1%)	Maximum Detected Concentration (mg/kg)	Slope Factor (mg/kg-day) ⁻¹	Risk Factor (unitless)	Contribution to Total Risk for Matrix (Percent)
Methylene Chloride	no	2.2E-02	7.5E-03	1.7E-04	0.00%
Chloroform	no	6.8E-03	6.1E-03	4.1E-05	0.00%
Tetrachloroethene	no	5.4E-02	5.2E-02	2.8E-03	0.05%
Trichloroethene	no	6.5E-02	1.1E-02	7.2E-04	0.01%
Arsenic	YES	2.3E+00	1.75E+00	4.0E+00	77.56%
Beryllium	YES	2.7E-01	4.3E+00	1.2E+00	22.37%
TOTAL RISK FACTOR =				5.2E+00	100%

WELLS SITE

CHEMICAL CONCENTRATION - TOXICITY SCREEN
CURRICULUM CENTER BUILDING (FUTURE) - SURFACE SOIL

NONCARCINOGENS:

CHEMICAL	Chemical of Potential Concern (Contributes >1%)	Maximum Detected Concentration (mg/kg)	Reference Dose (mg/kg-day)	Risk Factor (unitless)	Contribution to Total Risk for Matrix (Percent)
Methylene Chloride	no	2.2E-02	6.0E-02	3.7E-01	0.00%
Chloroform	no	6.8E-03	1.0E-02	6.8E-01	0.00%
2-Butanone	no	4.5E-02	6.0E-01	7.4E-02	0.00%
Tetrachloroethene	no	5.4E-02	1.0E-02	5.4E+00	0.00%
Trichloroethene	no	6.5E-02	6.0E-03	1.1E+01	0.00%
Toluene	no	2.0E-01	2.0E-01	1.0E+00	0.00%
Ethylbenzene	no	4.2E-01	1.0E-01	4.2E+00	0.00%
Xylenes (Total)	no	1.6E+00	2.0E+00	8.0E-01	0.00%
Phenol	no	9.0E+02	6.0E-01	1.5E+03	0.31%
2-Methylphenol	YES	3.2E+02	5.0E-02	6.4E+03	1.32%
4-Methylphenol	YES	1.3E+03	5.0E-03	2.6E+05	53.44%
2,4-Dimethylphenol	no	4.2E+01	2.0E-02	2.1E+03	0.43%
Naphthalene	no	7.7E+00	4.0E-02	1.9E+02	0.04%
Di-n-butylphthalate	no	9.4E+00	1.0E-01	9.4E+01	0.02%
Butylbenzylphthalate	no	1.2E-01	2.0E-01	6.0E-01	0.00%
Endosulfan I	no	9.2E-02	6.0E-03	1.5E+01	0.00%
Antimony	YES	4.6E+00	4.0E-04	1.2E+04	2.38%
Arsenic	YES	2.3E+00	3.0E-04	7.7E+03	1.58%
Barium	no	9.6E+01	7.0E-02	1.4E+03	0.28%
Beryllium	no	2.7E-01	5.0E-03	5.4E+01	0.01%
Cadmium	no	7.0E-01	1.0E-03	7.0E+02	0.14%
Chromium III	no	3.6E+01	1.0E+00	3.6E+01	0.01%
Chromium VI	no	6.0E+00	5.0E-03	1.2E+03	0.25%
Manganese	YES	8.7E+02	5.0E-03	1.7E+05	35.89%
Nickel	no	2.2E+01	2.0E-02	1.1E+03	0.22%
Silver	no	1.9E+00	5.0E-03	3.8E+02	0.08%
Vanadium	YES	1.2E+02	7.0E-03	1.6E+04	3.38%
Zinc	no	3.2E+02	3.0E-01	1.1E+03	0.22%
Cyanide	no	6.4E-01	2.0E-02	3.2E+01	0.01%

TOTAL RISK FACTOR = 4.9E+05 100%

TUTU WELLS SITE
CHEMICAL CONCENTRATION - TOXICITY SCREEN
O'HENRY DRY CLEANERS AND LIQUOR BARN - SURFACE SOIL

CARCINOGENS:

CHEMICAL	Chemical of Potential Concern (Contributes >1%)	Maximum Detected Concentration (mg/kg)	Slope Factor (mg/kg-day) ⁻¹	Risk Factor (unitless)	Contribution to Total Risk for Matrix (Percent)
Methylene Chloride	no	1.5E-01	7.5E-03	1.1E-03	0.00%
Chloroform	no	1.2E-02	6.1E-03	7.3E-05	0.00%
Trichloroethene	no	7.5E-02	1.1E-02	8.3E-04	0.00%
Tetrachloroethene	YES	4.4E+02	5.2E-02	2.3E+01	41.21%
Bis(2-ethylhexyl)phthalate	no	5.1E-01	1.4E-02	7.1E-03	0.01%
Arsenic	YES	1.9E+01	1.75E+00	3.3E+01	58.78%
TOTAL RISK FACTOR =				5.6E+01	100%

TUTU WELLS SITE
CHEMICAL CONCENTRATION - TOXICITY SCREEN
O'HENRY DRY CLEANERS AND LIQUOR BARN - SURFACE SOIL

NONCARCINOGENS:

CHEMICAL	Chemical of Potential Concern (Contributes >1%)	Maximum Detected Concentration (mg/kg)	Reference Dose (mg/kg-day)	Risk Factor (unitless)	Contribution to Total Risk for Matrix (Percent)
Methylene Chloride	no	1.5E-01	6.0E-02	2.5E+00	0.00%
Acetone	no	8.4E-02	1.0E-01	8.4E-01	0.00%
1,2-Dichloroethene (Total)	no	2.0E-02	9.0E-03	2.2E+00	0.00%
Chloroform	no	1.2E-02	1.0E-02	1.2E+00	0.00%
Trichloroethene	no	7.5E-02	6.0E-03	1.3E+01	0.00%
Tetrachloroethene	YES	4.4E+02	1.0E-02	4.4E+04	14.13%
Phenol	no	3.9E-02	6.0E-01	6.5E-02	0.00%
Benzolic Acid	no	6.3E-02	4.0E+00	1.6E-02	0.00%
Di-n-butylphthalate	no	6.2E-02	1.0E-01	6.2E-01	0.00%
Butylbenzylphthalate	no	7.0E-02	2.0E-01	3.5E-01	0.00%
Bis(2-ethylhexyl)phthalate	no	5.1E-01	2.0E-02	2.6E+01	0.01%
Antimony	YES	6.4E+00	4.0E-04	1.6E+04	5.10%
Arsenic	YES	1.9E+01	3.0E-04	6.2E+04	19.97%
Barium	no	9.0E+01	7.0E-02	1.3E+03	0.41%
Chromium III	no	2.0E+01	1.0E+00	2.0E+01	0.01%
Chromium VI	no	3.4E+00	5.0E-03	6.7E+02	0.22%
Manganese	YES	8.7E+02	5.0E-03	1.7E+05	55.88%
Nickel	no	1.5E+01	2.0E-02	7.4E+02	0.24%
Silver	no	1.6E+00	5.0E-03	3.2E+02	0.10%
Vanadium	YES	8.3E+01	7.0E-03	1.2E+04	3.81%
Zinc	no	9.6E+01	3.0E-01	3.2E+02	0.10%
Cyanide	no	1.1E+00	2.0E-02	5.3E+01	0.02%
TOTAL RISK FACTOR =				3.1E+05	100%

86

TUT 006 2272

TUTU WELLS SITE
CHEMICAL CONCENTRATION - TOXICITY SCREEN
TILLET GARDENS AND ART CENTER - SUBSURFACE SOIL

CARCINOGENS:

CHEMICAL	Chemical of Potential Concern (Contributes >1%)	Maximum Detected Concentration (mg/kg)	Slope Factor (mg/kg-day) ⁻¹	Risk Factor (unitless)	Contribution to Total Risk for Matrix (Percent)
Tetrachloroethene	no	3.5E-03	5.2E-02	1.8E-04	0.00%
Benzo(a)anthracene	no	1.8E-01	7.3E-01	1.3E-01	0.14%
Chrysene	no	1.9E-01	7.3E-03	1.4E-03	0.00%
Benzo(b)fluoranthene	no	2.1E-01	7.3E-01	1.6E-01	0.17%
Benzo(k)fluoranthene	no	9.6E-02	7.3E-02	7.0E-03	0.01%
Benzo(a)pyrene	YES	1.9E-01	7.3E+00	1.4E+00	1.53%
Indeno(1,2,3-cd)pyrene	no	8.7E-02	7.3E-01	6.4E-02	0.07%
Arsenic	YES	4.9E+01	1.75E+00	8.6E+01	95.87%
Beryllium	YES	4.6E-01	4.3E+00	2.0E+00	2.20%
TOTAL RISK FACTOR =				9.0E+01	100%

TUTU WELLS SITE
CHEMICAL CONCENTRATION - TOXICITY SCREEN
TILLET GARDENS AND ART CENTER - SUBSURFACE SOIL

NONCARCINOGENS:

CHEMICAL	Chemical of Potential Concern (Contributes >1%)	Maximum Detected Concentration (mg/kg)	Reference Dose (mg/kg-day)	Risk Factor (unitless)	Contribution to Total Risk for Matrix (Percent)
Tetrachloroethene	no	3.5E-03	1.0E-02	3.5E-01	0.00%
Toluene	no	4.0E-03	2.0E-01	2.0E-02	0.00%
Ethylbenzene	no	2.5E-03	1.0E-01	2.5E-02	0.00%
Fluoranthene	no	2.3E-01	4.0E-02	5.8E+00	0.00%
Pyrene	no	2.4E-01	3.0E-02	7.9E+00	0.00%
Antimony	YES	5.1E+00	4.0E-04	1.3E+04	3.58%
Arsenic	YES	4.9E+01	3.0E-04	1.6E+05	46.08%
Barium	no	7.6E+01	7.0E-02	1.1E+03	0.30%
Beryllium	no	4.6E-01	5.0E-03	9.2E+01	0.03%
Chromium III	no	2.2E+01	1.0E+00	2.2E+01	0.01%
Chromium VI	no	3.7E+00	5.0E-03	7.4E+02	0.21%
Manganese	YES	7.6E+02	5.0E-03	1.5E+05	42.88%
Mercury	no	6.0E-02	3.0E-04	2.0E+02	0.06%
Nickel	no	1.5E+01	2.0E-02	7.7E+02	0.21%
Silver	no	2.8E+00	5.0E-03	5.5E+02	0.15%
Vanadium	YES	1.6E+02	7.0E-03	2.2E+04	6.30%
Zinc	no	1.6E+02	3.0E-01	5.5E+02	0.15%
Cyanide	no	1.5E+00	2.0E-02	7.5E+01	0.02%

TOTAL RISK FACTOR = 3.6E+05 100%

TUTU WELLS SITE
CHEMICAL CONCENTRATION - TOXICITY SCREEN
FIRE DEPARTMENT / TEXACO GAS STATION / ANTILLES AUTO PARTS / RAMSAY MOTOR CO. - SUBSURFACE SOIL

CARCINOGENS:

CHEMICAL	Chemical of Potential Concern (Contributes >1%)	Maximum Detected Concentration (mg/kg)	Slope Factor (mg/kg-day) ⁻¹	Risk Factor (unitless)	Contribution to Total Risk for Matrix (Percent)
Methylene Chloride	no	2.6E-02	7.5E-03	2.0E-04	0.00%
Benzene	no	4.3E-03	2.9E-02	1.2E-04	0.00%
Tetrachloroethene	no	6.0E-03	5.2E-02	3.1E-04	0.01%
Bis(2-chloroethyl)ether	no	1.3E-02	1.1E+00	1.4E-02	0.24%
Bis(2-ethylhexyl)phthalate	no	3.7E-01	1.4E-02	5.2E-03	0.09%
Benzo(a)pyrene	YES	1.4E-01	7.3E+00	1.0E+00	17.04%
Arsenic	YES	1.8E+00	1.75E+00	3.2E+00	52.52%
Beryllium	YES	4.2E-01	4.3E+00	1.8E+00	30.11%
TOTAL RISK FACTOR =				6.0E+00	100%

TUTU WELLS SITE
CHEMICAL CONCENTRATION - TOXICITY SCREEN
FIRE DEPARTMENT / TEXACO GAS STATION / ANTILLES AUTO PARTS / RAMSAY MOTOR CO. - SUBSURFACE SOIL

NONCARCINOGENS:

CHEMICAL	Chemical of Potential Concern (Contributes >1%)	Maximum Detected Concentration (mg/kg)	Reference Dose (mg/kg-day)	Risk Factor (unitless)	Contribution to Total Risk for Matrix (Percent)
Bromomethane	no	2.0E-03	1.4E-03	1.4E+00	0.00%
Methylene Chloride	no	2.6E-02	6.0E-02	4.3E-01	0.00%
Acetone	no	1.9E-01	1.0E-01	1.9E+00	0.00%
1,2-Dichloroethene	no	2.0E-03	9.0E-03	2.2E-01	0.00%
2-Butanone	no	7.5E-02	6.0E-01	1.3E-01	0.00%
4-Methyl-2-Pentanone	no	1.7E-02	8.0E-02	2.1E-01	0.00%
Tetrachloroethene	no	6.0E-03	1.0E-02	6.0E-01	0.00%
Toluene	no	2.5E-02	2.0E-01	1.3E-01	0.00%
Ethylbenzene	no	9.0E-03	1.0E-01	9.0E-02	0.00%
Xylenes (Total)	no	1.7E+00	2.0E+00	8.5E-01	0.00%
Bis(2-ethylhexyl)phthalate	no	3.7E-01	2.0E-02	1.9E+01	0.01%
Di-n-butylphthalate	no	1.7E-01	1.0E-01	1.7E+00	0.00%
Antimony	YES	7.9E+00	4.0E-04	2.0E+04	8.07%
Arsenic	YES	1.8E+00	3.0E-04	6.0E+03	2.45%
Barium	YES	1.8E+02	7.0E-02	2.6E+03	1.07%
Beryllium	no	4.2E-01	5.0E-03	8.4E+01	0.03%
Cadmium	no	1.1E+00	1.0E-03	1.1E+03	0.45%
Chromium III	no	3.3E+01	1.0E+00	3.3E+01	0.01%
Chromium VI	no	5.4E+00	5.0E-03	1.1E+03	0.44%
Manganese	YES	9.5E+02	5.0E-03	1.9E+05	77.41%
Mercury	no	1.2E-01	3.0E-04	4.0E+02	0.16%
Nickel	no	1.9E+01	2.0E-02	9.7E+02	0.40%
Selenium	no	5.5E-01	5.0E-03	1.1E+02	0.04%
Silver	no	2.1E+00	5.0E-03	4.2E+02	0.17%
Vanadium	YES	1.6E+02	7.0E-03	2.2E+04	9.17%
Zinc	no	6.2E+01	3.0E-01	2.1E+02	0.09%
Cyanide	no	6.5E-01	2.0E-02	3.3E+01	0.01%

TOTAL RISK FACTOR = 2.4E+05 100%

TUTU WELLS SITE
CHEMICAL CONCENTRATION - TOXICITY SCREEN
CURRICULUM CENTER BUILDING (FUTURE) - SUBSURFACE SOIL

CARCINOGENS:

CHEMICAL	Chemical of Potential Concern (Contributes >1%)	Maximum Detected Concentration (mg/kg)	Slope Factor (mg/kg-day) ⁻¹	Risk Factor (unitless)	Contribution to Total Risk for Matrix (Percent)
Methylene Chloride	no	3.4E-02	7.5E-03	2.6E-04	0.00%
Trichloroethene	no	6.0E-03	1.1E-02	6.6E-05	0.00%
Tetrachloroethene	no	1.7E-01	5.2E-02	8.8E-03	0.04%
Bis(2-ethylhexyl)phthalate	no	2.1E-01	1.4E-02	2.9E-03	0.01%
Arsenic	YES	1.2E+01	1.75E+00	2.0E+01	95.30%
Beryllium	YES	2.3E-01	4.3E+00	9.9E-01	4.64%
TOTAL RISK FACTOR =				2.1E+01	100%

TUTU WELLS SITE
CHEMICAL CONCENTRATION - TOXICITY SCREEN
CURRICULUM CENTER BUILDING (FUTURE) - SUBSURFACE SOIL

NONCARCINOGENS:

CHEMICAL	Chemical of Potential Concern (Contributes >1%)	Maximum Detected Concentration (mg/kg)	Reference Dose (mg/kg-day)	Risk Factor (unitless)	Contribution to Total Risk for Matrix (Percent)
Methylene Chloride	no	3.4E-02	6.0E-02	5.7E-01	0.00%
Acetone	no	3.7E-01	1.0E-01	3.7E+00	0.00%
2-Butanone	no	5.9E-02	6.0E-01	9.8E-02	0.00%
Trichloroethene	no	6.0E-03	6.0E-03	1.0E+00	0.00%
Tetrachloroethene	no	1.7E-01	1.0E-02	1.7E+01	0.01%
Toluene	no	1.2E-02	2.0E-01	6.0E-02	0.00%
Xylenes (Total)	no	1.0E-03	2.0E+00	5.0E-04	0.00%
Diethylphthalate	no	4.0E-02	8.0E-01	5.0E-02	0.00%
Di-n-butylphthalate	no	8.9E-01	1.0E-01	8.9E+00	0.00%
Butylbenzylphthalate	no	5.8E-02	2.0E-01	2.9E-01	0.00%
Bis(2-ethylhexyl)phthalate	no	2.1E-01	2.0E-02	1.1E+01	0.00%
Antimony	YES	1.9E+01	4.0E-04	4.8E+04	15.32%
Arsenic	YES	1.2E+01	3.0E-04	3.9E+04	12.47%
Barium	no	5.9E+01	7.0E-02	8.4E+02	0.27%
Beryllium	no	2.3E-01	5.0E-03	4.6E+01	0.01%
Cadmium	no	2.9E+00	1.0E-03	2.9E+03	0.93%
Chromium III	no	3.1E+01	1.0E+00	3.1E+01	0.01%
Chromium VI	no	5.2E+00	5.0E-03	1.0E+03	0.34%
Manganese	YES	9.7E+02	5.0E-03	1.9E+05	62.72%
Mercury	no	5.7E-01	3.0E-04	1.9E+03	0.61%
Nickel	no	2.7E+01	2.0E-02	1.4E+03	0.44%
Silver	no	2.3E+00	5.0E-03	4.6E+02	0.15%
Vanadium	YES	1.3E+02	7.0E-03	1.9E+04	6.08%
Zinc	no	5.9E+02	3.0E-01	2.0E+03	0.63%
Cyanide	no	8.8E-01	2.0E-02	4.4E+01	0.01%

TOTAL RISK FACTOR = 3.1E+05 100%

TUTU WELLS SITE
CHEMICAL CONCENTRATION - TOXICITY SCREEN
ESSO GAS STATION AND SPLASH AND DASH CAR WASH - SUBSURFACE SOIL

CARCINOGENS:

CHEMICAL	Chemical of Potential Concern (Contributes >1%)	Maximum Detected Concentration (mg/kg)	Slope Factor (mg/kg-day) ⁻¹	Risk Factor (unitless)	Contribution to Total Risk for Matrix (Percent)
Methylene Chloride	no	2.0E-02	7.5E-03	1.5E-04	0.00%
Trichloroethene	no	7.8E-03	1.1E-02	8.5E-05	0.00%
Tetrachloroethene	no	2.0E-03	5.2E-02	1.0E-04	0.00%
Bis(2-ethylhexyl)phthalate	no	2.2E-01	1.4E-02	3.1E-03	0.07%
Arsenic	YES	1.6E+00	1.75E+00	2.8E+00	64.99%
Beryllium	YES	3.5E-01	4.3E+00	1.5E+00	34.93%
TOTAL RISK FACTOR =				4.3E+00	100%

TUTU WELLS SITE
CHEMICAL CONCENTRATION - TOXICITY SCREEN
ESSO GAS STATION AND SPLASH AND DASH CAR WASH - SUBSURFACE SOIL

NONCARCINOGENS:

CHEMICAL	Chemical of Potential Concern (Contributes >1%)	Maximum Detected Concentration (mg/kg)	Reference Dose (mg/kg-day)	Risk Factor (unitless)	Contribution to Total Risk for Matrix (Percent)
Methylene Chloride	no	2.0E-02	6.0E-02	3.3E-01	0.00%
Acetone	no	5.0E-02	1.0E-01	5.0E-01	0.00%
2-Butanone	no	1.3E-02	6.0E-01	2.2E-02	0.00%
Trichloroethene	no	7.8E-03	6.0E-03	1.3E+00	0.00%
Tetrachloroethene	no	2.0E-03	1.0E-02	2.0E-01	0.00%
Toluene	no	1.0E-03	2.0E-01	5.0E-03	0.00%
Di-n-butylphthalate	no	4.6E-01	1.0E-01	4.6E+00	0.00%
Bis(2-ethylhexyl)phthalate	no	2.2E-01	2.0E-02	1.1E+01	0.00%
Antimony	YES	4.4E+00	4.0E-04	1.1E+04	3.76%
Arsenic	YES	1.6E+00	3.0E-04	5.3E+03	1.82%
Barium	no	2.0E+02	7.0E-02	2.8E+03	0.97%
Beryllium	no	3.5E-01	5.0E-03	7.0E+01	0.02%
Cadmium	no	9.5E-01	1.0E-03	9.5E+02	0.33%
Chromium III	no	3.0E+01	1.0E+00	3.0E+01	0.01%
Chromium VI	no	5.0E+00	5.0E-03	1.0E+03	0.34%
Manganese	YES	1.3E+03	5.0E-03	2.5E+05	85.54%
Nickel	no	2.2E+01	2.0E-02	1.1E+03	0.37%
Selenium	no	1.1E+00	5.0E-03	2.2E+02	0.08%
Silver	no	4.1E+00	5.0E-03	8.2E+02	0.28%
Vanadium	YES	1.3E+02	7.0E-03	1.9E+04	6.35%
Zinc	no	8.7E+01	3.0E-01	2.9E+02	0.10%
Cyanide	no	4.1E-01	2.0E-02	2.1E+01	0.01%
TOTAL RISK FACTOR =				2.9E+05	100%

TUTU WELLS SITE
CHEMICAL CONCENTRATION - TOXICITY SCREEN
O'HENRY DRY CLEANERS AND LIQUOR BARN - SUBSURFACE SOIL

CARCINOGENS:

CHEMICAL	Chemical of Potential Concern (Contributes >1%)	Maximum Detected Concentration (mg/kg)	Slope Factor (mg/kg-day) ⁻¹	Risk Factor (unitless)	Contribution to Total Risk for Matrix (Percent)
Methylene Chloride	no	3.0E-03	7.5E-03	2.3E-05	0.00%
Tetrachloroethene	no	2.0E-01	5.2E-02	1.0E-02	0.00%
Arsenic	YES	1.9E+02	1.75E+00	3.2E+02	99.56%
Beryllium	no	3.3E-01	4.3E+00	1.4E+00	0.44%
TOTAL RISK FACTOR =				3.3E+02	100%

TUTU WELLS SITE
CHEMICAL CONCENTRATION - TOXICITY SCREEN
O'HENRY DRY CLEANERS AND LIQUOR BARN - SUBSURFACE SOIL

NONCARCINOGENS:

CHEMICAL	Chemical of Potential Concern (Contributes >1%)	Maximum Detected Concentration (mg/kg)	Reference Dose (mg/kg-day)	Risk Factor (unitless)	Contribution to Total Risk for Matrix (Percent)
Methylene Chloride	no	3.0E-03	6.0E-02	5.0E-02	0.00%
Tetrachloroethene	no	2.0E-01	1.0E-02	2.0E+01	0.00%
Toluene	no	3.0E-03	2.0E-01	1.5E-02	0.00%
Di-n-butylphthalate	no	1.6E-01	1.0E-01	1.6E+00	0.00%
Fluoranthene	no	4.2E-02	4.0E-02	1.1E+00	0.00%
Butylbenzylphthalate	no	2.2E-01	2.0E-01	1.1E+00	0.00%
Antimony	YES	5.2E+00	4.0E-04	1.3E+04	1.19%
Arsenic	YES	1.9E+02	3.0E-04	6.2E+05	56.25%
Barium	no	5.0E+02	7.0E-02	7.1E+03	0.65%
Beryllium	no	3.3E-01	5.0E-03	6.6E+01	0.01%
Chromium III	no	1.8E+01	1.0E+00	1.8E+01	0.00%
Chromium VI	no	3.0E+00	5.0E-03	6.1E+02	0.06%
Manganese	YES	2.2E+03	5.0E-03	4.4E+05	40.13%
Mercury	no	8.0E-02	3.0E-04	2.7E+02	0.02%
Nickel	no	1.6E+01	2.0E-02	8.2E+02	0.07%
Silver	no	2.0E+00	5.0E-03	4.0E+02	0.04%
Vanadium	YES	1.2E+02	7.0E-03	1.7E+04	1.55%
Zinc	no	1.0E+02	3.0E-01	3.3E+02	0.03%

TOTAL RISK FACTOR = 1.1E+06 100%

TUTU WELLS SITE
CHEMICAL CONCENTRATION - TOXICITY SCREEN
GROUNDWATER (SITE-WIDE)

CARCINOGENS:

CHEMICAL	Chemical of Potential Concern (Contributes >1%)	Maximum Detected Concentration (mg/l)	Slope Factor (mg/kg-day) ⁻¹	Risk Factor (unitless)	Contribution to Total Risk for Matrix (Percent)
Chloromethane	no	6.2E-04	1.3E-02	8.1E-06	0.00%
Vinyl Chloride	YES	1.3E+00	1.9E+00	2.5E+00	70.16%
Methylene Chloride	no	6.4E-02	7.5E-03	4.8E-04	0.01%
1,1-Dichloroethene	no	1.2E-04	6.0E-01	7.2E-05	0.00%
Chloroform	no	1.5E-01	6.1E-03	9.2E-04	0.03%
1,2-Dichloroethane	no	2.9E-01	9.1E-02	2.6E-02	0.75%
Bromodichloromethane	no	3.0E-02	6.2E-02	1.9E-03	0.05%
Trichloroethene	no	1.9E-01	1.1E-02	2.1E-03	0.06%
Dibromochloromethane	no	3.6E-02	8.4E-02	3.0E-03	0.09%
1,1,2-Trichloroethane	no	5.0E-03	5.7E-02	2.9E-04	0.01%
Benzene	YES	2.1E+01	2.9E-02	6.1E-01	17.30%
Bromoform	no	2.9E-02	7.9E-03	2.3E-04	0.01%
Tetrachloroethene	YES	1.5E+00	5.2E-02	7.8E-02	2.22%
1,4-Dichlorobenzene	no	2.0E-03	2.4E-02	4.8E-05	0.00%
Carbazole	no	1.0E-03	2.0E-02	2.0E-05	0.00%
Benzo(a)anthracene	no	1.0E-03	7.3E-01	7.3E-04	0.02%
Chrysene	no	9.0E-03	7.3E-03	6.6E-05	0.00%
Bis(2-ethylhexyl)phthalate	no	6.9E-01	1.4E-02	9.7E-03	0.27%
Benzo(b)fluoranthene	no	1.0E-03	7.3E-01	7.3E-04	0.02%
Arsenic	YES	8.1E-02	1.75E+00	1.4E-01	4.02%
Beryllium	YES	4.1E-02	4.3E+00	1.8E-01	4.98%
TOTAL RISK FACTOR =				3.52E+00	100%

97

TUTU WELLS SITE
CHEMICAL CONCENTRATION - TOXICITY SCREEN
GROUNDWATER (SITE-WIDE)

NONCARCINOGENS:

CHEMICAL	Chemical of Potential Concern (Contributes >1%)	Maximum Detected Concentration (mg/l)	Reference Dose (mg/kg-day)	Risk Factor (unitless)	Contribution to Total Risk for Matrix (Percent)
Methylene Chloride	no	6.4E-02	6.0E-02	1.1E+00	0.02%
Acetone	no	2.7E+00	1.0E-01	2.7E+01	0.41%
Carbon Disulfide	no	3.0E-03	1.0E-01	3.0E-02	0.00%
1,1-Dichloroethene	no	1.2E-04	9.0E-03	1.3E-02	0.00%
1,1-Dichloroethane	no	1.1E-04	1.0E-01	1.1E-03	0.00%
1,2-Dichloroethene (Total)	YES	2.1E+00	9.0E-03	2.3E+02	3.52%
Chloroform	no	1.5E-01	1.0E-02	1.5E+01	0.23%
2-Butanone	no	6.2E-01	6.0E-01	1.0E+00	0.02%
Bromodichloromethane	no	3.0E-02	2.0E-02	1.5E+00	0.02%
Trichloroethene	no	1.9E-01	6.0E-03	3.2E+01	0.48%
Dibromochloromethane	no	3.6E-02	2.0E-02	1.8E+00	0.03%
1,1,2-Trichloroethane	no	5.0E-03	4.0E-03	1.3E+00	0.02%
Bromoform	no	2.9E-02	2.0E-02	1.5E+00	0.02%
Tetrachloroethene	YES	1.5E+00	1.0E-02	1.5E+02	2.26%
Toluene	YES	1.7E+01	2.0E-01	8.5E+01	1.28%
Chlorobenzene	no	2.0E-04	2.0E-02	1.0E-02	0.00%
Ethylbenzene	no	4.1E+00	1.0E-01	4.1E+01	0.62%
Xylenes(Total)	no	2.2E+01	2.0E+00	1.1E+01	0.17%
cis-1,2-Dichloroethene	no	3.7E-02	1.0E-02	3.7E+00	0.06%
Phenol	no	6.7E-02	6.0E-01	1.1E-01	0.00%
1,2-Dichlorobenzene	no	6.5E-03	9.0E-02	7.2E-02	0.00%
2-Methylphenol	no	2.7E-02	5.0E-02	5.4E-01	0.01%
4-Methylphenol	no	7.2E-02	5.0E-03	1.4E+01	0.22%
2,4-Dimethylphenol	no	3.3E-02	2.0E-02	1.6E+00	0.02%
Benzoic Acid	no	6.0E-02	4.0E+00	1.5E-02	0.00%
1,2,4-Trichlorobenzene	no	3.0E-03	1.0E-02	3.0E-01	0.00%
Naphthalene	no	1.0E+00	4.0E-02	2.5E+01	0.38%
Dimethylphthalate	no	8.0E-03	1.0E+01	8.0E-04	0.00%
Acenaphthene	no	2.0E-03	6.0E-02	3.3E-02	0.00%
Diethylphthalate	no	6.0E-02	8.0E-01	7.5E-02	0.00%
Fluorene	no	4.0E-02	4.0E-02	1.0E+00	0.02%
Anthracene	no	1.0E-03	3.0E-01	3.3E-03	0.00%
Fluoranthene	no	1.0E-03	4.0E-02	2.5E-02	0.00%
Pyrene	no	8.0E-03	3.0E-02	2.7E-01	0.00%
Butylbenzylphthalate	no	2.0E-03	2.0E-01	1.0E-02	0.00%
Bis(2-ethylhexyl)phthalate	no	6.9E-01	2.0E-02	3.5E+01	0.52%

TUTU WELLS SITE
CHEMICAL CONCENTRATION - TOXICITY SCREEN
GROUNDWATER (SITE-WIDE)

NONCARCINOGENS:

CHEMICAL	Chemical of Potential Concern (Contributes >1%)	Maximum Detected Concentration (mg/l)	Reference Dose (mg/kg-day)	Risk Factor (unitless)	Contribution to Total Risk for Matrix (Percent)
Di-n-octylphthalate	no	1.0E-03	2.0E-02	5.0E-02	0.00%
Phthalic Anhydride (TIC)	no	3.0E-03	2.0E+00	1.5E-03	0.00%
Antimony	YES	4.2E-01	4.0E-04	1.1E+03	16.00%
Arsenic	YES	8.1E-02	3.0E-04	2.7E+02	4.06%
Barium	no	4.4E+00	7.0E-02	6.3E+01	0.95%
Beryllium	no	4.1E-02	5.0E-03	8.2E+00	0.12%
Cadmium	no	2.5E-03	5.0E-04	4.9E+00	0.07%
Chromium III	no	4.0E+00	1.0E+00	4.0E+00	0.06%
Chromium VI	YES	6.6E-01	5.0E-03	1.3E+02	1.99%
Manganese	YES	2.0E+01	5.0E-03	4.1E+03	61.57%
Mercury	no	3.1E-03	3.0E-04	1.0E+01	0.16%
Nickel	YES	2.1E+00	2.0E-02	1.0E+02	1.55%
Selenium	no	1.2E-02	5.0E-03	2.3E+00	0.04%
Silver	no	4.7E-02	5.0E-03	9.4E+00	0.14%
Thallium	no	3.6E-03	8.0E-05	4.5E+01	0.68%
Vanadium	YES	1.0E+00	7.0E-03	1.4E+02	2.16%
Zinc	no	2.5E+00	3.0E-01	8.4E+00	0.13%
Cyanide	no	1.1E-02	2.0E-02	5.5E-01	0.01%
TOTAL RISK FACTOR =				6.63E+03	100%

nutrients, which do not have established toxicity values (i.e., aluminum, copper, lead) could not be screened; however, they were not eliminated as chemicals of potential concern from the risk assessment for this reason. These chemicals were evaluated qualitatively as part of Section 4.3 and/or Appendix B.

The chemical-specific risk factors per area of concern for surface soil, subsurface soil, and groundwater were summed to obtain a total risk factor for all chemicals for each area of concern. Separate total risk factors were calculated for carcinogens (using the appropriate slope factors) and noncarcinogens (using the appropriate oral reference doses). The ratio of the risk factor for each chemical in each area of concern in a medium to the total risk factor for each area of concern in a medium provided the relative contribution from each chemical in each area of concern in a medium. A contribution of one percent was used as a lower limit so that the chemicals contributing at least 94 percent to the total risk per area of concern per medium were retained.

The potential toxicity of each chemical to human health was qualitatively evaluated based on a review of acute and chronic noncarcinogenic effects, toxicity endpoint/target organ, potential carcinogenicity, and weight-of-evidence classification for potential carcinogenicity.

For the purposes of clarity, presented below is the USEPA's weight-of-evidence classification system for carcinogenicity (USEPA, 1989a).

Group A:	Human Carcinogen
Group B1 or B2:	Probable Human Carcinogen B1 indicates that limited human data are available indicates sufficient evidence in animals and inadequate or no evidence in humans
Group C:	Possible Human Carcinogen
Group D:	Not Classifiable as to human carcinogenicity
Group E:	Evidence of noncarcinogenicity in humans

Chemicals given a Group A weight-of-evidence classification were retained for conservatism even if they were detected at low concentrations. This was done based on the fact that the weight-of-evidence classification is an indication of the quality and quantity of data underlying a chemical's designation as a potential human carcinogen.

For the evaluation of chromium in this risk assessment, total chromium was speciated into its +3 and +6 valence states using a ratio of 6:1, respectively, per the IRIS data base (on-line June-October, 1994). This ratio was assumed, as laboratory analysis was not performed since hexavalent chromium in soil is very unstable and analysis is difficult. Hexavalent chromium analysis in groundwater is also difficult to perform. In addition, carcinogenic PAHs were evaluated using the slope factor for benzo(a)pyrene in conjunction with relative potency values from USEPA's Provisional Guidance for Risk Assessment of Polycyclic Aromatic Hydrocarbons (USEPA, 1993a). Only those noncarcinogenic PAHs having available toxicity values could be evaluated using the screening procedure. Table 2-24 presents a summary of PAH classification.

TUTU WELLS SITE

The following PAHs detected at the site were considered carcinogenic or noncarcinogenic:

Weight-of-Evidence Classification

Benzo(a)anthracene	-	B2
Benzo(b)fluoranthene	-	B2
Benzo(k)fluoranthene	-	B2
Benzo(a)pyrene	-	B2
Chrysene	-	B2
Indeno(1,2,3-cd)pyrene	-	B2

Weight-of-Evidence Classification

Acenaphthene	-	*
Acenaphthylene	-	D
Anthracene	-	D
Benzo(g,h,i)perylene	-	D
Fluoranthene	-	D
Fluorene	-	D
2-Methylnaphthalene	-	D
Naphthalene	-	D
Phenanthrene	-	D
Pyrene	-	D

*: No classification is specified in IRIS or HEAST

102

2.3.1 Blank Concentrations

As part of the data validation process, the chemicals detected in soil and groundwater samples collected at the site were compared with chemicals detected in field, trip, water, and equipment blanks to prevent the inclusion of non site-related chemicals in the risk assessment. Concentrations of the chemicals in soil could not be directly compared, however, as soil and water units are different. The organic chemicals acetone, 2-butanone (methyl ethyl ketone), methylene chloride, toluene, and the phthalate esters are considered by the USEPA to be common laboratory contaminants. It should be recognized, however, that toluene is a constituent of gasoline which has been found at the site.

Soil: One VOC, tetrachloroethene, was selected as a chemical of potential concern in O'Henry dry cleaners and Liquor Barn area surface soil. Tetrachloroethene was detected at a maximum concentration of 440000 ug/kg in sample e-01 and in one trip blank at a concentration of 0.10 J ug/l.

Of the four SVOCs selected as chemicals of potential concern in soil (benzo(b)fluoranthene, benzo(a)pyrene, 2-methylphenol, and 4-methylphenol), none were detected in any blank samples. Aroclor 1242, the only PCB selected as a chemical of potential concern in site soil, was detected in a single surface soil sample collected from the Tillett Gardens and Art Center at a concentration of 120000 J ug/kg. Aroclor 1242 was detected in field blank eC-12a (deionized water) at a concentration of 76.0 ug/l.

Several inorganics including antimony, arsenic, barium, manganese, and vanadium were retained as chemicals of potential concern in soil based on selection criteria, even though they were detected in some of the blank samples. Of these chemicals, only one was detected at concentrations resulting in exceedance of the target risk range or a hazard index value of one. Manganese showed hazard quotients above one for the surface soil ingestion and inhalation routes of exposure for children in the Tillett Gardens and Art Center. Manganese was detected in the single Tillett Gardens and Art Center surface soil sample analyzed for inorganics (SS-5-AVS) at a concentration of 869 mg/kg. While manganese was not detected in any water blanks, it was detected in an equipment blank at a concentration of 3.2 B ug/l. Manganese was also detected in twelve field blanks with a maximum reported concentration of 672 J ug/l. Due to the difference in reported soil and water concentration units, a direct comparison of concentrations cannot be made. The inorganic beryllium also selected as chemicals of potential concern, was not detected in any blank samples.

Groundwater: Of the volatile organic chemicals of potential concern selected in site groundwater (benzene, 1,2-dichloroethene (total), tetrachloroethene, toluene, and vinyl chloride), benzene, tetrachloroethene, and toluene were detected in blank samples. Benzene was detected in a single trip blank at 0.14 BJ ug/l. This chemical was detected in 34 of 168 site groundwater samples (a frequency of detection over 20 percent) with a maximum reported concentration of 21000 D ug/l. Tetrachloroethene was detected in a single trip blank at 0.10 J ug/l. This chemical was detected in 143 of 173 site groundwater samples (a frequency of detection of over 82 percent) with a maximum reported concentration of 1500 ug/l. Toluene was detected in one

field blank, two water blanks, and ten trip blanks at a maximum concentration of 2.0 ug/l. This chemical was detected in 32 of 168 site groundwater samples (a frequency of detection of 19 percent) with a maximum reported concentration of 17000 ug/l.

No SVOCs were selected as chemicals of potential concern in site groundwater.

Pesticides and PCBs were not analyzed for in site groundwater.

Seven inorganics, antimony, arsenic, beryllium, chromium VI, manganese, nickel, and vanadium, were selected as chemicals of potential concern in site groundwater. Of these, antimony, arsenic, chromium (total), manganese, nickel, and vanadium were detected in blank samples. The maximum site groundwater detections of these six chemicals exceeded the maximum blank concentrations by a minimum of four times (arsenic) to a maximum of 245 times (chromium). In addition, these chemicals combined contributed greater than 87 percent to the total risk for the matrix for noncarcinogens in the groundwater chemical concentration-toxicity screen.

2.3.2 Background Concentrations

Three background surface soil samples (SS-1, SS-2, and SS-8) were collected as part of Geraghty & Miller's Technical Memorandum II (Geraghty & Miller, 1993a) field activities (Table 2-25). According to this document, these samples were collected north of the Curriculum

Center Building from one to seven inches below the ground surface after removing the top one inch layer of soil and vegetation. CDM Federal collected splits of these samples which are also reported in Table 2-25. These samples were analyzed for TAL metals and cyanide only. Although a soil sample and duplicate from monitoring well MW-2 were collected from zero to two feet at the northern end of the Four Winds Shopping Center parking lot, they were collected from below the paved surface. According to Technical Memorandum II, this area is not a suspected source of chemical contamination. Monitoring well MW-2 laboratory results showed only the presence of three common laboratory contaminants, and inorganics at similar levels to Table 2-25 surface soil background samples SS-1, SS-2, and SS-8. It should be noted that no background samples were analyzed for pesticides and PCBs. Based on the above, monitoring well MW-2 results, as discussed with the USEPA RPM and Risk Assessment Specialist, are considered representative of subsurface soil background and are presented in Table 2-25.

Tables 2-26 and 2-27 present minimum and maximum site and background detections for chemicals of potential concern for the areas of concern at the site. Frequencies of detection for the chemicals of potential concern in site soils have also been included.

Surface soil background samples (SS-1, SS-2, and SS-8) were collected at the site by Geraghty & Miller during field activities relating to Technical Memorandum II (Geraghty & Miller, 1993a). Since split samples were collected for each of these samples by CDM Federal, the averaged result of the samples and their associated splits were used to determine minimum and maximum detections in Table 7-26. Several of the organic and inorganic maximum site surface

TUTU WELLS SITE
SOIL BACKGROUND SAMPLES
ANALYTICAL DATA - DETECTIONS ONLY

SURFACE SOIL							SUBSURFACE SOIL		
SAMPLE NAME	SS-1	SS-1-CDM	SS-2	SS-2-CDM	SS-8	SS-8-CDM	MWS-2	MWS-2-FR	
SAMPLE DATE	8/19/92	8/19/92	8/19/92	8/19/92	8/19/92	8/19/92	8/13/92	8/13/92	
SAMPLE TYPE	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	
SAMPLE DEPTH	0.08' - 0.58'	0.08' - 0.58'	0.08' - 0.58'	0.08' - 0.58'	0.08' - 0.58'	0.08' - 0.58'	0.0' - 2.0'	0.0' - 2.0'	
VOLATILE ORGANICS		ug/kg							
Methylene Chloride	NA	NA	NA	NA	NA	NA	10.0 J	10.0 J	
Acetone	NA	NA	NA	NA	NA	NA	58.0 J	130 J	
2-Butanone	NA	NA	NA	NA	NA	NA	ND	25.0	
SEMIVOLATILE ORGANICS		ug/kg							
NA	NA	NA	NA	NA	NA	NA	ND	ND	
PESTICIDES/PCBs		ug/kg							
NA	NA	NA	NA	NA	NA	NA	NA	NA	
INORGANIC ANALYTES									
Aluminum	mg/kg	23600	35600	16100	33100	21500 J	31000	13300	15700
Antimony	mg/kg	6.10 BNJ	ND	ND	ND	14.7 BNJ	ND	ND	ND
Arsenic	mg/kg	ND	1.20 B	ND	1.30 B	0.99 BJ	0.67 BJ	3.00	1.20 B
Barium	mg/kg	41.9 B	47.0	30.1 B	43.6	29.3 BJ	30.4 B	81.0	45.6 B
Beryllium	mg/kg	ND	0.20 B	ND	0.34 B	ND	0.27 B	ND	ND
Cadmium	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	mg/kg	75100	74700	9630	18700	144000 J	100000	68500 *J	8720 *J
Chromium	mg/kg	23.4 NJ	29.9	25.8 NJ	30.6	16.2 NJ	20.4	16.1 NJ	7.60 NJ
Cobalt	mg/kg	25.7 J	28.6	18.0 J	27.4	16.9 BJ	20.0	11.3	12.8
Copper	mg/kg	55.3 NJ	73.9	40.3 NJ	70.0	43.1 NJ	56.1	40.0 NJ	58.0 NJ
Iron	mg/kg	31300	43400	22600	40900	25400 J	33100	21700	30800
Lead	mg/kg	2.10 SJ	2.50	1.70 J	4.00	2.50 SJ	R	5.60 J	1.90 J
Magnesium	mg/kg	20500	22400	13200	19700	21400 J	23800	9160	9640
Manganese	mg/kg	763	814	535	810	888 J	911	582	1110
Mercury	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	mg/kg	18.9	19.6	15.5	18.8	12.9 BJ	10.3	12.7	5.60 B
Potassium	mg/kg	412 B	723 B	568 B	1090 J	325 BJ	520 B	557 B	299 B
Selenium	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND
Silver	mg/kg	0.98 B	1.90 B	0.99 B	2.20	ND	ND	ND	1.20 B
Sodium	mg/kg	557 B	577 B	157 B	257 B	187 BJ	184 B	717 B	536 B
Thallium	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	mg/kg	109 NJ	151	74.9 NJ	139	82.1 NJ	108	58.0 NJ	52.8 NJ
Zinc	mg/kg	50.6	54.8	40.1	56.8	43.8 J	51.3	66.2	119
Cyanide	mg/kg	1.20	ND	ND	ND	1.10	ND	ND	ND

Notes:

NA - Not Analyzed

ND - Not Detected

R - Rejected

TABLE L-26

TUTU WELLS SITE
CHEMICAL CONCENTRATIONS IN SITE SURFACE SOIL VS SURFACE SOIL BACKGROUND CONCENTRATIONS

	FREQUENCY OF DETECTION	MINIMUM DETECTION (mg/kg)	MINIMUM BACKGROUND* (mg/kg)	MAXIMUM DETECTION (mg/kg)	MAXIMUM BACKGROUND* (mg/kg)
CHEMICALS OF POTENTIAL CONCERN					
TILLET GARDENS AND ART CENTER					
Aroclor 1242	1/2	120000 J	NA	120000 J	NA
Antimony	1/1	5.05 BNJ	3.90 BNJ	5.05 BNJ	8.15 BNJ
Arsenic	1/1	10.0	0.71 B	10.0	0.83 BJ
Barium	1/1	70.5	29.9 BJ	70.5	44.5 B
Chromium (Total)	1/1	25.3 NJ	18.3 NJ	25.3 NJ	28.2 NJ
Manganese	1/1	869	673	869	900 J
Vanadium	1/1	95.9 NJ	95.1 NJ	95.9 NJ	130 NJ
FIRE DEPT./TEXACO GAS STATION / ANTILLES AUTO PARTS/ RAMSAY MOTOR CO.					
Benzo(b)fluoranthene	1/2	870 J	NA	870 J	NA
Benzo(a)pyrene	2/2	270 J	NA	770 J	NA
Antimony	1/1	5.90 BJ	3.90 BNJ	5.90 BJ	8.15 BNJ
Barium	1/1	67.2	29.9 BJ	67.2	44.5 B
Beryllium	1/1	0.26 B	0.16 B	0.26 B	0.24 B
Chromium (Total)	1/1	31.7	18.3 NJ	31.7	28.2 NJ
Manganese	1/1	834	673	834	900 J
Nickel	1/1	17.5	11.6 BJ	17.5	19.3
Silver	1/1	2.20 J	1.44 B	2.20 J	1.60 B
Vanadium	1/1	119	95.1 NJ	119	130 NJ
CURRICULUM CENTER BUILDING - PRESENT - USE					
2-Methylphenol	1/8	320000	NA	320000	NA
4-Methylphenol	1/8	1300000 J	NA	1300000 J	NA
Antimony	5/6	4.08 BNJ	3.90 BNJ	7.30 BNJ	8.15 BNJ
Arsenic	5/6	1.30 B	0.71 B	11.6	0.83 BJ
Beryllium	2/6	0.19 B	0.16 B	0.27 B	0.24 B
Manganese	6/6	599	673	873	900 J
Vanadium	6/6	79.7 NJ	95.1	115	130 NJ
CURRICULUM CENTER BUILDING - FUTURE - USE					
2-Methylphenol	1/5	320000	NA	320000	NA
4-Methylphenol	1/5	1300000 J	NA	1300000 J	NA
Antimony	2/3	4.08 BNJ	3.90 BNJ	4.63 BNJ	8.15 BNJ
Arsenic	3/3	1.46 BWJ	0.71 B	2.30 B	0.83 BJ
Beryllium	2/3	0.19 B	0.16 B	0.27 B	0.24 B
Manganese	3/3	677	673	873	900 J
Vanadium	3/3	95.2 NJ	95.1 NJ	115	130 NJ

TUTU WELLS SITE
CHEMICAL CONCENTRATIONS IN SITE SURFACE SOIL VS SURFACE SOIL BACKGROUND CONCENTRATIONS

	FREQUENCY OF DETECTION	MINIMUM DETECTION (mg/kg)	MINIMUM BACKGROUND* (mg/kg)	MAXIMUM DETECTION (mg/kg)	MAXIMUM BACKGROUND* (mg/kg)
CHEMICALS OF POTENTIAL CONCERN					
O'HENRY DRY CLEANERS AND LIQUOR BARN					
Tetrachloroethene	5/6	15.0	NA	440000	NA
Antimony	1/2	6.35 BNJ	3.90 BNJ	6.35 BNJ	8.15 BNJ
Arsenic	2/2	13.7	0.71 B	18.7 J	0.83 BJ
Manganese	2/2	670 J	673	870	900 J
Vanadium	2/2	72.7 NJ	95.1 NJ	83.1	130 NJ

Notes:

*Three surface soil background samples (SS-1, SS-2, and SS-8) and a split of each were collected at the site. The averaged results for these samples were used to determine minimum and maximum concentrations.

NA: Not Analyzed

TUTU WELLS SITE

CHEMICAL CONCENTRATIONS IN SITE SUBSURFACE SOIL VS SUBSURFACE SOIL BACKGROUND CONCENTRATIONS

	FREQUENCY OF DETECTION	MINIMUM DETECTION (mg/kg)	MINIMUM BACKGROUND* (mg/kg)	MAXIMUM DETECTION (mg/kg)	MAXIMUM BACKGROUND* (mg/kg)
CHEMICALS OF POTENTIAL CONCERN					
TILLET GARDENS AND ART CENTER					
Benzo(a)pyrene	1/2	188 J	ND	188 J	ND
Antimony	2/2	3.65 BNJ	ND	5.10 BNJ	ND
Arsenic	2/2	0.77 B	2.10 B	49.2 J	2.10 B
Beryllium	2/2	0.36 B	ND	0.46 B	ND
Manganese	2/2	746	846	763	846
Vanadium	2/2	108	55.4 NJ	157	55.4 NJ
FIRE DEPT./TEXACO GAS STATION / ANTILLES AUTO PARTS/ RAMSAY MOTOR CO.					
Benzo(a)pyrene	1/9	140 J	ND	140 J	ND
Antimony	4/8	3.50 BJ	ND	7.90 BNJ	ND
Arsenic	5/7	0.54 BWJ	2.10 B	1.80 BJ	2.10 B
Barium	8/8	36.9 B	63.3	184	63.3
Beryllium	3/8	0.27 BJ	ND	0.42 B	ND
Cadmium	2/8	0.73 BJ	ND	1.10 B	ND
Chromium (Total)	8/8	27.0 J	11.9 NJ	38.0 EJ	11.9 NJ
Manganese	8/8	506	846	947 EJ	846
Nickel	8/8	16.7 J	9.15 B	19.4	9.15 B
Vanadium	8/8	93.4 J	55.4 NJ	157	55.4 NJ
CURRICULUM CENTER BUILDING					
Antimony	9/10	3.40 BJ	ND	19.0	ND
Arsenic	8/10	0.45 BJ	2.10 B	11.6	2.10 B
Beryllium	2/10	0.22 B	ND	0.23 BJ	ND
Cadmium	3/10	0.99 B	ND	2.87	ND
Manganese	10/10	599	846	973	846
Mercury	1/10	0.57	ND	0.57	ND
Nickel	10/10	12.1	9.15 B	27.3	9.15 B
Vanadium	10/10	79.7 NJ	55.4 NJ	132 J	55.4 NJ
Zinc	10/10	52.1 J	92.6	585	92.6

TABLE 2-27 (Cont'd)

TUTU WELLS SITE
CHEMICAL CONCENTRATIONS IN SITE SUBSURFACE SOIL VS SUBSURFACE SOIL BACKGROUND CONCENTRATIONS

	FREQUENCY OF DETECTION	MINIMUM DETECTION (mg/kg)	MINIMUM BACKGROUND* (mg/kg)	MAXIMUM DETECTION (mg/kg)	MAXIMUM BACKGROUND* (mg/kg)
CHEMICALS OF POTENTIAL CONCERN					
ESSO GAS STATION AND SPLASH AND DASH CAR WASH					
Antimony	3/7	3.65 BJ	ND	4.40 BJ	ND
Arsenic	4/7	0.47 BJ	2.10 B	1.60 BJ	2.10 B
Barium	7/7	21.9 BJ	63.3	199	63.3
Beryllium	6/7	0.16 B	ND	0.35 B	ND
Cadmium	1/7	0.95 B	ND	0.95 B	ND
Chromium (Total)	7/7	4.50	11.9 NJ	35.2 J	11.9 NJ
Manganese	7/7	435	846	1250	846
Nickel	7/7	3.20 B	9.15 B	21.8 J	9.15 B
Silver	5/7	0.82 B	0.82 B	4.12 B	0.82 B
Vanadium	7/7	57.9	55.4 NJ	130	55.4 NJ
O'HENRY DRY CLEANERS AND LIQUOR BARN					
Antimony	2/4	4.90 BJ	ND	5.20 BJ	ND
Arsenic	3/4	5.00	2.10 B	185 J	2.10 B
Barium	4/4	29.0 B	63.3	498	63.3
Manganese	4/4	430	846	2200	846
Vanadium	4/4	83.9	55.4 NJ	119	55.4 NJ

Notes:

*MWS-2 was the only subsurface soil background sample collected at the site. Since this sample has a duplicate result, the averaged result is reported as both the minimum and maximum background concentration.

ND: Not Detected

soil detections in the areas of concern exceeded surface soil background detections. Although inorganics are common constituents of volcanic rocks which underly the site, inorganics were included in this risk assessment as a group; any significant contributions to total risk by inorganics at the site will be addressed as part of a risk management decision.

One site subsurface soil background sample, MWS-2 was collected by Geraghty & Miller during field activities relating to Technical Memorandum II (Geraghty & Miller, 1993a). A split sample was collected by CDM Federal, and the averaged result is presented in Table 7-27 as both the minimum and maximum background concentrations. Due to the limited subsurface soil background results, the background comparison criterion has not been used to select or eliminate chemicals of potential concern in subsurface soil. However, in general, maximum site detections of the chemicals of potential concern in subsurface soil exceeded the background detection. Any significant contributions to total risk by inorganics at the site will be addressed as part of a risk management decision.

As stated in Section 2.1.2, supply wells VIHA III and VIHA IV (alternate) are considered upgradient of or not influenced by the site while the Bryan, Demitri, Leonard, Lockhart (alternate), Harthman (all three), and KFC-1-9 supply wells are considered to be cross-gradient of the site. It should be noted that no samples have been collected from the VIHA IV (alternate) or Lockhart (alternate) wells. Dede, Dench, Devcon I, Devcon II (alternate), and Devcon III are clean supply wells downgradient of the contaminant plume. Therefore, a qualitative review of the data from these wells versus the site wells has been performed.

Of the twelve chemicals contributing at least one percent to the total risk in the groundwater chemical concentration - toxicity screen, none were detected in the single upgradient well sampled (VIHA III) and nine were detected in cross-gradient wells (four VOCs and five inorganics). Of the seven cross-gradient wells sampled for VOCs, benzene was detected in only one well (KFC-1-9) at a concentration of 110 J ug/l. This benzene concentration at KFC-1 is part of a separate groundwater plume related to a release from a former leaking tank at this location. This concentration is well below the maximum detected concentration of benzene in site groundwater (21000 D ug/l) but is approximately 2200 times greater than the minimum detected concentration (0.05 J ug/l) in site groundwater.

1,2-Dichloroethene (total) was detected in seven samples collected from two wells. A maximum concentration of 11.0 ug/l was reported in sample Harthman II-7. This concentration is well below the maximum detected concentration in site groundwater (2100 ug/l) but is 100 times greater than the minimum detected concentration (0.11 J ug/l) in site groundwater. Tetrachloroethene was detected in ten samples collected from four wells. A maximum concentration of 10.0 ug/l was reported in sample Harthman II-7. This concentration is well below the maximum detected concentration in site groundwater (1500 ug/l) but is ten times greater than the minimum detected concentration (1.0 J ug/l) in site groundwater. Toluene was detected in one well (KFC-1-9) at a concentration of 2.0 J ug/l. This concentration is well below the maximum detected concentration of toluene in site groundwater (17000 ug/l) but is 40 times greater than the minimum detected concentration (0.05 J ug/l) in site groundwater.

Antimony was detected in two groundwater samples collected from two cross-gradient wells. A maximum concentration of 30.0 BJ ug/l was reported in sample Harthman II-2. This concentration is well below the maximum detected concentration in site groundwater (424 B ug/l) but is approximately two times greater than the minimum detected concentration (14.8 B ug/l) in site groundwater. Chromium was detected in one well (KFC-1-9) at a concentration of 14.3 J ug/l. One seventh of this concentration or 2.0 J ug/l would be considered hexavalent chromium according to the speciation presented in IRIS (1994). This concentration is well below the maximum detected concentration in site groundwater (4610 ug/l for total chromium and approximately 659 ug/l from chromium VI) and is greater than four times the minimum detected concentration (0.43 B ug/l) in site groundwater. Manganese was detected in three groundwater samples collected from three cross-gradient wells. A maximum concentration of 1030 J ug/l was reported in sample KFC-1-9. This concentration is well below the maximum detected concentration in site groundwater (20400 ug/l) but is greater than 700 times the minimum detected concentration (1.40 B ug/l) in site groundwater. Nickel was detected in one well (KFC-1-9) at a concentration of 12.1 BJ ug/l. This concentration is well below the maximum detected concentration of nickel in site groundwater (2050 ug/l) but is only slightly greater than the minimum detected concentration (8.7 B ug/l) in site groundwater. Vanadium was detected in six groundwater samples collected from five cross-gradient wells. A maximum concentration of 313 J ug/l was reported in sample KFC-1-9. This concentration is approximately three times less than the maximum detected concentration in site groundwater (1000 J ug/l) but is more than 60 times greater than the minimum detected concentration (4.90 B ug/l) in site groundwater.

Of the twelve chemicals contributing at least one percent to the total risk in the groundwater chemical concentration-toxicity screen, only three chemicals, chromium (total), manganese, and vanadium were detected in downgradient wells. A total of eight downgradient samples plus one field replicate were collected, although all samples were not analyzed for all chemical classes. Chromium was detected in two of four downgradient groundwater samples analyzed for inorganics. A maximum concentration of 6.6 B ug/l (one seventh of this concentration or 0.94 B ug/l is assumed to be chromium VI per IRIS (1994)) was reported in sample Dede-5. This concentration is well below the maximum detected concentration of chromium VI in site groundwater (659 ug/l) and is approximately twice the minimum detected concentration (0.43 B ug/l) in site groundwater. Manganese was detected in all four downgradient groundwater samples analyzed for inorganics. The maximum downgradient manganese concentration (538 ug/l) is nearly 38 times less than the maximum site groundwater concentration of 20400 ug/l. The minimum downgradient manganese concentration (45.9 ug/l) is approximately 33 times greater than the minimum site groundwater concentration of 1.4 B ug/l. Vanadium was detected in three of four downgradient groundwater samples analyzed for inorganics. The maximum downgradient vanadium concentration (9.6 B ug/l) is well below the maximum site groundwater concentration of 1000 J ug/l. The minimum downgradient vanadium concentration (5.9 B ug/l) is slightly greater than the minimum site groundwater concentration of 4.9 B ug/l.

The upgradient and cross-gradient as well as the downgradient groundwater data are presented in Appendix E.

2.3.3 Physical and Chemical Properties

The chemicals detected in surface soil, subsurface soil, and groundwater samples collected from the site can be classified into categories according to their similarity in chemical structure and/or physicochemical properties (factors which would influence mobility in the environment). The chemical categories and examples of chemicals detected at the site within each category are listed below:

- chlorinated aliphatic compounds: 1,1-dichloroethane, 1,1-dichloroethene, 1,2-dichloroethene, methylene chloride, chloroform, trichloroethene, tetrachloroethene, vinyl chloride
- Simple aromatic compounds: benzene, ethylbenzene, toluene, xylenes (total), n-propylbenzene
- Ethers: bis(2-chloroethyl)ether, methyl-tert-butyl-ether
- Ketones: acetone, 2-hexanone, 2-butanone, 4-methyl-2-pentanone
- Organic acids: benzoic acid
- Phenolic compounds: phenol, 2-methylphenol, 4-methylphenol, 2,4-dimethylphenol
- Phthalate esters: bis(2-ethylhexyl)phthalate, di-n-butylphthalate, butylbenzylphthalate
- Polycyclic aromatic hydrocarbons: carcinogenic and noncarcinogenic PAHs
- Chlorinated pesticides: endosulfan I
- Polychlorinated biphenyls: Aroclor 1242
- Inorganics (behaving as cations in water): aluminum, barium, cadmium, trivalent chromium, copper, iron, lead, manganese, mercury, nickel, zinc
- Inorganics (behaving as anions in water): arsenic, vanadium

- Inorganics (behaving as neutral molecules in water): cyanide

The physical and chemical properties that are important in determining a chemical contaminant's persistence and mobility in the environment were evaluated. The main properties that were reviewed were water solubility, K_{oc} (organic carbon partitioning coefficient), K_{ow} (octanol-water partitioning coefficient), volatilization, vapor pressure, vaporization, and Henry's law constant. This information is more difficult to evaluate for the inorganic chemicals because the migration of inorganics depends upon several site-specific factors such as the following:

- The presence of other cations and anions which can enhance or limit mobility by forming complexes
- pH differences between infiltrating precipitation, soil pore water, and aquifer materials
- the ability of the soil to retain metals through cation or anion exchange
- the presence of oxidizing or reducing agents
- the presence of humic materials or other organic chelating agents

The mobility of metals is therefore greatly dependent upon external factors which are seldom measured and cannot be easily determined based upon chemical-specific properties such as vapor pressure, solubility, and sorption to organic carbon. Moreover, physicochemical properties depend upon the identity of the metal complex which is almost never known (i.e., the analysis provides only information on total metal concentration, not on the metal complex or valence state).

The water solubility of a chemical is a critical property affecting its environmental fate. Chemicals with high water solubility can be rapidly leached from contaminated soil and are generally mobile in the groundwater. Solubilities can range from less than one mg/liter to totally miscible with most common organic chemicals falling between one mg/liter to 10^6 mg/liter (Lyman et al., 1982). The solubility of a chemical which is not readily soluble in water can become enhanced in the presence of other organic solvents which in and of themselves are more soluble in water.

The organic carbon partitioning coefficient (K_{oc}) is used to reflect the potential of a chemical to sorb to the organic matter found in soil. The normal range of K_{oc} is one to 10^7 , with higher values indicating greater sorption potential and lower values indicating limited retardation of a chemical. The octanol-water partition coefficient (K_{ow}) is used to estimate the extent to which a chemical will partition from water into lipophilic parts of organisms (i.e., animal fat). The greater the K_{ow} , the more likely a chemical is to partition to octanol (considered a surrogate for lipids).

Volatilization of a chemical is dependent on its vapor pressure, water solubility, and diffusion coefficients. Vapor pressure is a measure of the volatility of a chemical in its pure state. Vapor pressures typically range from 10^{-3} to 760 mm Hg for liquids, with solids ranging to less than 10^{-10} . Highly water soluble compounds generally have lower volatilization rates from water unless they also have high vapor pressures. Vaporization is also a major transport process. The rate of vaporization depends on temperature, degree of adsorption, soil properties, and soil water

content. Airflow over the evaporating surface also affects the rate of vaporization.

Henry's law constant, which combines vapor pressure with solubility and molecular weight, is more appropriate for estimating releases from water to air than the vapor pressure. Chemicals with Henry's law constants in the range of 10^{-3} and larger can be expected to be readily released to the atmosphere through volatilization. Chemicals with values ranging from 10^{-3} to 10^{-5} are associated with moderate volatilization, while chemicals with values less than 10^{-5} will only volatilize to a limited extent.

2.4 Evaluation of Tentatively Identified Compounds (TICs)

The RAGS document (USEPA, 1989a) specifies that both the identity and reported concentration of a TIC are questionable. The USEPA's Contract Laboratory Program (CLP) Routine Analytical Services (RAS) requires the contracted laboratory to analyze samples for organic chemicals on the Target Compound List (TCL) and for inorganic chemicals on the Target Analyte List (TAL). Chemicals on the TCL and TAL, however, may be a limited subset of the chemicals which may actually be encountered at the site. The analysis of VOCs and SVOCs may indicate the presence of additional organics not on the TCL. These additional chemicals appear as peaks on a chromatogram. A chromatogram is a paper representation of the response of the analytical instrument to the presence of a chemical. The laboratory attempts to identify the thirty highest peaks (ten VOCs and twenty SVOCs) using computerized searches of a library containing mass spectra (essentially "fingerprints" for particular chemicals). When the mass

spectra match to a certain degree, the chemical or chemical class is named; however, the assigned identity is highly uncertain in most cases. These chemicals are therefore called TICs (USEPA, 1989a). Site Data (Appendix E) presents the TIC results. All results are listed as "Unknown" or with the prefix "Unknown" (i.e., Unknown Amide Record), or as "TID Compound" followed by a number (i.e., TID Compound 5) except for the new 1994 Geraghty & Miller groundwater data in which one TIC, phthalic anhydride, was identified for evaluation in the risk assessment. Phthalic anhydride has an established toxicological value and was included in the chemical concentration-toxicity screening procedure for groundwater. This TIC, however, was not selected as a chemical of potential concern to be evaluated in the risk assessment.

2.5 Selected Chemicals of Potential Concern

Using the criteria discussed in Section 2.3, chemicals of potential concern were selected for surface soil, subsurface soil, and groundwater. Table 2-28 presents the chemicals selected for quantitative evaluation in this risk assessment.

TABLE 2-28

TUTU WELLS SITE
SUMMARY OF CHEMICALS OF POTENTIAL CONCERN IN SITE MATRICES BY AREA OF CONCERN

SURFACE SOIL				
Tillett Gardens and Art Center	Fire Dept./Texaco Gas Station/Antilles Auto Parts/Ramsay Motor Co.	Curriculum Center Building (Present)	Curriculum Center Building (Future)	O'Henry Dry Cleaners and Liquor Barn
<u>VOCs:</u>	<u>VOCs:</u>	<u>VOCs:</u>	<u>VOCs:</u>	<u>VOCs:</u>
None Selected	None Selected	None Selected	None Selected	Tetrachloroethane
<u>SVOCs:</u>	<u>SVOCs:</u>	<u>SVOCs:</u>	<u>SVOCs:</u>	<u>SVOCs:</u>
None Selected	Benzo(b)fluoranthene Benzo(a)pyrene	2-Methylphenol 4-Methylphenol	2-Methylphenol 4-Methylphenol	None Selected
<u>Pesticides/PCBs:</u>	<u>Pesticides/PCBs:</u>	<u>Pesticides/PCBs:</u>	<u>Pesticides/PCBs:</u>	<u>Pesticides/PCBs:</u>
Aroclor 1242	None Selected	None Selected	None Selected	None Selected
<u>Inorganics:</u>	<u>Inorganics:</u>	<u>Inorganics:</u>	<u>Inorganics:</u>	<u>Inorganics:</u>
Antimony Arsenic Manganese Vanadium	Antimony Beryllium Manganese Vanadium	Antimony Arsenic Beryllium Manganese Vanadium	Antimony Arsenic Beryllium Manganese Vanadium	Antimony Arsenic Manganese Vanadium

TABLE 2-28 (Cont'd)

TUTU WELLS SITE
SUMMARY OF CHEMICALS OF POTENTIAL CONCERN IN SITE MATRICES BY AREA OF CONCERN

SUBSURFACE SOIL					GROUNDWATER
Tillett Gardens and Art Center	Fire Dept./Texaco Gas Station/Antilles Auto Parts/Ramsay Motor Co.	Curriculum Center Building (Future)	Eso Gas Station and Splash and Dash Car Wash	O'Henry Dry Cleaners and Liquor Barn	Site-Wide
<u>VOCs:</u>	<u>VOCs:</u>	<u>VOCs:</u>	<u>VOCs:</u>	<u>VOCs:</u>	<u>VOCs:</u>
None Selected	None Selected	None Selected	None Selected	None Selected	Benzene 1,2 Dichloroethene (Total) Tetrachloroethene Toluene Vinyl Chloride
<u>SVOCs:</u>	<u>SVOCs:</u>	<u>SVOCs:</u>	<u>SVOCs:</u>	<u>SVOCs:</u>	<u>SVOCs:</u>
Benzo(a)pyrene	Benzo(a)pyrene	None Selected	None Selected	None Selected	None Selected
<u>Pesticides/PCBs:</u>	<u>Pesticides/PCBs:</u>	<u>Pesticides/PCBs:</u>	<u>Pesticides/PCBs:</u>	<u>Pesticides/PCBs:</u>	<u>Pesticides/PCBs:</u>
Not Analyzed	None Selected	Not Analyzed	Not Analyzed	Not Analyzed	Not Analyzed
<u>Inorganics:</u>	<u>Inorganics:</u>	<u>Inorganics:</u>	<u>Inorganics:</u>	<u>Inorganics:</u>	<u>Inorganics:</u>
Antimony Arsenic Beryllium Manganese Vanadium	Antimony Arsenic Barium Beryllium Manganese Vanadium	Antimony Arsenic Beryllium Manganese Vanadium	Antimony Arsenic Beryllium Manganese Vanadium	Antimony Arsenic Manganese Vanadium	Antimony Arsenic Beryllium Chromium VI Manganese Nickel Vanadium

3.0 EXPOSURE ASSESSMENT

This section of the risk assessment presents the approach used for identifying the potential human exposure pathways at the Tutu Wells site for present and potential future land use scenarios. The exposure pathways identified in this section are combined with chemical-specific toxicity data in Section 4.0 to characterize potential risks and health effects. All plausible exposures to receptor populations (i.e., residents, site workers, and construction workers) associated with current and potential future conditions have been evaluated. Present conditions are as they exist today and future conditions are based on potential future land uses of the site assuming no additional institutional controls are put in place and no remediation has occurred.

For present and potential future-use conditions, exposure scenarios which identify plausible routes of exposure to site-related chemical contaminants were developed. Exposure pathways were identified by assessing the various ways in which people living in the area and workers at the site could be exposed to chemicals originating from the site. The exposure point concentration of each chemical to which a person may be exposed via each pathway was estimated using the 95 percent UCL calculation. From the estimated exposure point concentrations, potential chemical intakes were calculated in terms of the mass of a substance in contact with the body per unit body weight per unit time, expressed as milligrams of a chemical per kilogram of body weight per day. Variables such as contact rate, exposure frequency, and exposure duration were considered in the calculation of the chemical intakes.

3.1 Potential Release and Transport Mechanisms

Chemical contaminants present in waste materials and contaminated source media may migrate through a number of release and transport mechanisms. In general, potential release and transport mechanisms may include:

- The leaching of chemical contaminants from subsurface soil into underlying groundwater due to infiltration of precipitation.
- The migration of chemical contaminants in soil via surface runoff.
- The adsorption of chemical contaminants onto soil.
- The volatilization of chemical contaminants present in soil and groundwater into the ambient air.
- The generation of fugitive dust from contaminated soils into the ambient air via wind erosion or mechanical disturbances of soil.
- The transport of VOCs and dust to ambient air downwind locations.
- The uptake of chemical contaminants present in soil and surface water by biota.

3.2 Identification of Exposure Pathways

The objective of the exposure assessment is to estimate the types and magnitudes of exposures to chemicals of potential concern at or migrating from the site. The results of the exposure assessment are then combined with chemical-specific toxicity data to determine site-specific carcinogenic risks and noncarcinogenic hazards.

In accordance with RAGS (USEPA, 1989a), when determining the exposure pathways for a site two steps are followed. The initial step consists of characterizing the exposure setting. This step includes consideration of the physical characteristics of the site and the human receptors at or in the vicinity of the site (i.e., residents). Site characteristics, which are noted during the site visit, may include climate, soil type (i.e., sandy), vegetation (i.e., grassy or bare), presence of paved surfaces, and presence of surface water. Potential human receptors such as on-site residents or workers may be observed with respect to activity patterns, presence of sensitive receptors (i.e., children, occupationally exposed individuals), and location. Potentially exposed off site receptors (i.e., local residents - trespassers, downgradient public water supply consumers, downwind receptors) must also be considered. This step must also take into account the presence of potential future receptors under an alternate land use condition (i.e., zoning changes, currently unused water that is of potable quality for future use).

The second step of exposure assessment involves identifying the appropriate exposure pathways for the site. As described in RAGS (USEPA, 1989a), an exposure pathway describes the course a chemical or physical agent takes from the source to the exposed individual. An exposure pathway analysis links the sources, locations, types of environmental releases, and environmental fate with receptor locations and activity patterns. An exposure pathway generally consists of four elements.

- Source and mechanism of release
- A transport medium

- An exposure point (point of potential contact with a contaminated medium)
- An exposure route (i.e., ingestion) at the exposure point

The following presents the basic analytical process for identifying and selecting exposure pathways in the risk assessment. An environmental medium contaminated by a previous release can be a contaminant source for other media. The identification of potential release mechanisms and receiving media may be determined utilizing site histories and data from existing reports. Examples of typical release sources, mechanisms of release, and receiving media include the following:

- Volatilization of chemicals from surface soil, surface water, lagoons or spills into the air
- Leaching from surface or buried wastes into soil; surface runoff from contaminated surface soil; episodic overland flow resulting from lagoon overflow, spills or leaking containers; and fugitive dust generation/deposition from contaminated surface soil or waste piles
- Leaching from surface or buried wastes and contaminated soil into groundwater

The fate and transport of the chemicals from release media are then considered in order to identify media that are receiving or may receive site-related chemicals. Points of potential contact with contaminated media (or sources) by human receptors are then considered. After exposure points are identified, potential exposure routes (i.e., ingestion, dermal contact, inhalation) may be selected.

By integrating the information presented above, complete exposure pathways at a site may be selected. Based on additional considerations such as the potential magnitude of exposure from the pathway or probability of exposure occurring, the complete exposure pathways may be retained for quantitative evaluation in the risk assessment or eliminated from further analysis.

3.2.1 Present - Use Scenarios

Since residents currently live at the Tutu Wells site and workers are employed at commercial establishments at the site, numerous potential present exposure scenarios were selected for quantitative evaluation in this risk assessment. Table 3-1 presents the environmental media, receptors, and scenarios considered for analysis with a "yes" next to those selected and justification for the pathway's elimination from or retention for quantitative analysis. Justifications are based on visual observations made during a March 23rd through March 25th, 1994 site visit, conversations with the USEPA RPM and Risk Assessment Specialist, and review of the sample data for each area of concern.

Surface Soil: During the March 1994 site visit, a residence was observed to be located at the Tillett Gardens and Art Center. Residents may inadvertently ingest and/or dermally contact surface soil in the vicinity of their home during their daily activities. The inhalation of suspended surface soil particulates route was not selected for quantitative evaluation as the areas from which the soil samples were collected consist of hard packed soil or are covered by vegetation.

TABLE 3-1

TUTU WELLS SITE
POTENTIAL EXPOSURE PATHWAYS

Matrix	Receptor Population(s)	Exposure Route(s)	Retained for Quantitative Analysis	Justification
PRESENT - USE SCENARIOS:				
<i>Surface Soil</i>				
	Site Residents (Adults and Children) (Tillett Gardens and Art Center)	Ingestion Dermal Contact* Inhalation of Particulates Inhalation of VOCs	Yes Yes No No	Site residents are expected to come into direct contact with surface soil in the vicinity of their home and Tillett Gardens and Art Center. The inhalation of particulates from surface soil is assumed to be negligible, as the areas where samples were collected either consist of hard packed soil or are covered by vegetation. The inhalation of VOCs is also assumed to be negligible, as no VOCs were selected as chemicals of potential concern. The inhalation pathways were therefore not selected for further evaluation.
	Site Workers 1- (Employees of the Fire Dept., Texaco gas station, Antilles auto parts, and Ramsay motor company)**	Ingestion Dermal Contact* Inhalation of Particulates Inhalation of VOCs	Yes Yes No No	
	2- (Employees of the Curriculum Center Building)	Ingestion Dermal Contact* Inhalation of Particulates Inhalation of VOCs	Yes Yes No No	
	3- (Employees of the Esso gas station and the Splash and Dash car wash)	Ingestion Dermal Contact* Inhalation of Particulates Inhalation of VOCs	No No No No	
	4- (Employees of O'Henry dry cleaners and Liquor Barn)	Ingestion Dermal Contact* Inhalation of Particulates Inhalation of VOCs	Yes Yes No Yes	Site workers may come into direct contact with surface soil during the course of a normal work day (i.e., outdoor work, lunch hour). The inhalation of particulates from surface soil is assumed to be negligible, as the area where samples were collected is covered to a large extent by dense vegetation. Since a VOC was selected as a chemical of potential concern for this area, the inhalation of VOCs pathway was retained for further evaluation.

TUTU WELLS SITE
POTENTIAL EXPOSURE PATHWAYS

Matrix	Receptor Population(s)	Exposure Route(s)	Retained for Quantitative Analysis	Justification
PRESENT - USE SCENARIOS CONT'D:				
Surface Soil (Cont'd)				
	Construction Workers (Site-Wide)	Ingestion	No	No construction work is currently in progress in any areas of concern at the site.
		Dermal Contact*	No	
		Inhalation of Particulates	No	
		Inhalation of VOCs	No	
Subsurface Soil				
	Site Residents (Adults and Children) (Tillett Gardens and Art Center)	Ingestion	No	No construction work (i.e., excavation activity) is currently in progress in this area of the site.
		Dermal Contact*	No	
		Inhalation of Particulates	No	
		Inhalation of VOCs	No	
	Site Workers	Ingestion	No	No construction work (i.e., excavation activity) is currently in progress in this area of the site.
1-	(Employees of the Fire Dept., Texaco gas station, Antilles auto parts, and Ramsay motor company)	Dermal Contact*	No	
		Inhalation of Particulates	No	
		Inhalation of VOCs	No	
2-	(Employees of the Curriculum Center Building)	Ingestion	No	No construction work (i.e., excavation activity) is currently in progress in this area of the site.
		Dermal Contact*	No	
		Inhalation of Particulates	No	
		Inhalation of VOCs	No	
3-	(Employees of the Esso gas station and the Splash and Dash car wash)	Ingestion	No	No construction work (i.e., excavation activity) is currently in progress in this area of the site.
		Dermal Contact*	No	
		Inhalation of Particulates	No	
		Inhalation of VOCs	No	
4-	(Employees of O'Henry dry cleaners and Liquor Barn)	Ingestion	No	No construction work (i.e., excavation activity) is currently in progress in this area of the site.
		Dermal Contact*	No	
		Inhalation of Particulates	No	
		Inhalation of VOCs	No	
	Construction Workers (Site-Wide)	Ingestion	No	No construction work (i.e., excavation activity) is currently in progress in any areas of concern at the site.
		Dermal Contact*	No	
		Inhalation of Particulates	No	

TABLE 3-1

TUTU WELLS SITE
POTENTIAL EXPOSURE PATHWAYS

Matrix	Receptor Population(s)	Exposure Route(s)	Retained for Quantitative Analysis	Justification
PRESENT - USE SCENARIOS CONT'D:				
<i>Groundwater</i>				
	Site Residents (Adults and Children)	Ingestion Dermal Contact (Shower) Inhalation of VOCs (Shower)	Yes Yes Yes	Currently, an order against drinking and bathing in groundwater at the site has been issued. However, since evidence of pumping exists at the Ramsay well, residents may be using the groundwater for these purposes in addition to secondary purposes such as clothes washing, lawn watering, etc.
	Site Workers (All)	Ingestion Dermal Contact (Shower) Inhalation of VOCs (Shower)	Yes No No	Currently, an order against drinking and bathing in groundwater at the site has been issued. However, since evidence of pumping exists at the Ramsay well, site workers may be using the groundwater for drinking. Site workers are not expected to shower on-site.
	Construction Workers (Site-Wide)	Ingestion Dermal Contact (Shower) Inhalation of VOCs (Shower)	No No No	No construction work (i.e., excavation activity) is currently in progress in any areas of concern at the site.
FUTURE - USE SCENARIOS:				
<i>Surface Soil</i>				
	Residents (Adults and Children) (Tillett Gardens and Art Center)	Ingestion Dermal Contact* Inhalation of Particulates Inhalation of VOCs	Yes Yes Yes No	Site residents are expected to come into direct contact with surface soil in the vicinity of their home and Tillett Gardens and Art Center. The inhalation of particulates exposure route may be of concern due to the potential for future construction work (i.e., excavation activity) in this area. The inhalation of VOCs is assumed to be negligible, as no VOCs were selected as chemicals of potential concern. The inhalation of VOCs pathway was therefore not selected for further evaluation.
	Site Workers 1- (Employees of the Fire Dept., Texaco gas station, Antilles auto parts, and Ramsay motor company)**	Ingestion Dermal Contact* Inhalation of Particulates Inhalation of VOCs	Yes Yes Yes No	Site workers may come into direct contact with surface soil during the course of a normal work day (i.e., outdoor work, lunch hour). The inhalation of particulates exposure route may be of concern due to the potential for future construction work (i.e., excavation activity) in this area. The inhalation of VOCs is assumed to be negligible, as no VOCs were selected as chemicals of potential concern. The inhalation of VOCs pathway was therefore not selected for further evaluation.

130

TUT 006 2316

TUTU WELLS SITE
POTENTIAL EXPOSURE PATHWAYS

Matrix	Receptor Population(s)	Exposure Route(s)	Retained for Quantitative Analysis	Justification
FUTURE - USE SCENARIOS CONT'D:				
Surface Soil (Cont'd)				
2- (Employees of the Curriculum Center Building)		Ingestion	Yes	Site workers may come into direct contact with surface soil during the course of a normal work day (i.e., outdoor work, lunch hour). The inhalation of particulates exposure route may be of concern due to the potential for future construction work (i.e., excavation activity) in this area. The inhalation of VOCs is assumed to be negligible, as no VOCs were selected as chemicals of potential concern. The inhalation of VOCs pathway was therefore not selected for further evaluation.
		Dermal Contact*	Yes	
		Inhalation of Particulates	Yes	
		Inhalation of VOCs	No	
3- (Employees of the Esso gas station and the Splash and Dash car wash)		Ingestion	No	Since the Esso gas station and Splash and Dash car wash properties are completely paved, no surface soil would be available for contact. Therefore, no surface soil exposure can occur.
		Dermal Contact*	No	
		Inhalation of Particulates	No	
		Inhalation of VOCs	No	
4- (Employees of O'Henry dry cleaners and Liquor Barn)		Ingestion	Yes	Site workers may come into direct contact with surface soil during the course of a normal work day (i.e., outdoor work, lunch hour). The inhalation of particulates exposure route may be of concern due to the potential for future construction work (i.e., excavation activity) in this area. Since a VOC was selected as a chemical of potential concern for this area, the inhalation of VOCs pathway was retained for further evaluation.
		Dermal Contact*	Yes	
		Inhalation of Particulates	Yes	
		Inhalation of VOCs	Yes	
Construction Workers (Tillett Gardens and Art Center)		Ingestion	Yes	The potential exists for further commercial or residential development of the Tillett Gardens and Art Center area of concern. Construction workers would be expected to routinely contact surface soil during excavation activities. The inhalation of particulates exposure route may also be of concern as a result of this activity. The inhalation of VOCs is assumed to be negligible as no VOCs were selected as chemicals of potential concern. The inhalation of VOCs pathway was therefore not selected for further evaluation.
		Dermal Contact*	Yes	
		Inhalation of Particulates	Yes	
		Inhalation of VOCs	No	
Subsurface Soil				
Residents (Adults and Children) (Tillett Gardens and Art Center)		Ingestion	No	During potential future construction work (i.e., excavation activity), residents may come into direct contact with exposed subsurface soil. However, they are assumed to ingest a negligible amount of excavated subsurface soil. The inhalation of VOCs is also assumed to be negligible, as no VOCs were selected as chemicals of potential concern. The inhalation of VOCs pathway was therefore not selected for further evaluation.
		Dermal Contact*	Yes	
		Inhalation of Particulates	Yes	
		Inhalation of VOCs	No	

TABLE 3-1

TUTU WELLS SITE
POTENTIAL EXPOSURE PATHWAYS

Matrix	Receptor Population(s)	Exposure Route(s)	Retained for Quantitative Analysis	Justification
FUTURE - USE SCENARIOS CONT'D:				
<i>Subsurface Soil (Cont'd)</i>				
	Site Workers	Ingestion	No	During potential future construction work (i.e., excavation activity), site workers may come into direct contact with exposed subsurface soil. However, they are assumed to ingest a negligible amount of excavated subsurface soil. The inhalation of VOCs is also assumed to be negligible, as no VOCs were selected as chemicals of potential concern. The inhalation of VOCs pathway was therefore not selected for further evaluation.
1-	(Employees of the Fire Dept., Texaco gas station, Antilles auto parts, and Ramsay motor company)	Dermal Contact*	Yes	
		Inhalation of Particulates	Yes	
		Inhalation of VOCs	No	
2-	(Employees of the Curriculum Center Building)	Ingestion	No	During potential future construction work (i.e., excavation activity), site workers may come into direct contact with exposed subsurface soil. However, they are assumed to ingest a negligible amount of excavated subsurface soil. The inhalation of VOCs is also assumed to be negligible, as no VOCs were selected as chemicals of potential concern. The inhalation of VOCs pathway was therefore not selected for further evaluation.
		Dermal Contact*	Yes	
		Inhalation of Particulates	Yes	
		Inhalation of VOCs	No	
3-	(Employees of the Esso gas station and the Splash and Dash car wash)	Ingestion	No	During potential future construction work (i.e., excavation activity), site workers may come into direct contact with exposed subsurface soil. However, they are assumed to ingest a negligible amount of excavated subsurface soil. The inhalation of VOCs is also assumed to be negligible, as no VOCs were selected as chemicals of potential concern. The inhalation of VOCs pathway was therefore not selected for further evaluation.
		Dermal Contact*	Yes	
		Inhalation of Particulates	Yes	
		Inhalation of VOCs	No	
4-	(Employees of O'Henry dry cleaners and Liquor Barn)	Ingestion	No	During potential future construction work (i.e., excavation activity), site workers may come into direct contact with exposed subsurface soil. However, they are assumed to ingest a negligible amount of excavated subsurface soil. The inhalation of VOCs is also assumed to be negligible, as no VOCs were selected as chemicals of potential concern. The inhalation of VOCs pathway was therefore not selected for further evaluation.
		Dermal Contact*	Yes	
		Inhalation of Particulates	Yes	
		Inhalation of VOCs	No	
	Construction Workers (Tillett Gardens and Art Center)	Ingestion	Yes	The potential exists for further commercial or residential development of the Tillett Gardens and Art Center area of concern. Construction workers would be expected to routinely contact subsurface soil during excavation activities. The inhalation of particulates exposure route may also be of concern as a result of this activity. The inhalation of VOCs is assumed to be negligible, as no VOCs were selected as chemicals of potential concern. The inhalation of VOCs pathway was therefore not selected for further evaluation.
		Dermal Contact*	Yes	
		Inhalation of Particulates	Yes	
		Inhalation of VOCs	No	

TUTU WELLS SITE
POTENTIAL EXPOSURE PATHWAYS

Matrix	Receptor Population(s)	Exposure Route(s)	Retained for Quantitative Analysis	Justification
FUTURE - USE SCENARIOS CONT'D:				
Groundwater	Site Residents (Adults and Children)	Ingestion	Yes	Currently, an order against drinking and bathing in groundwater at the site has been issued. However, since evidence of pumping exists at the Ramsay well, residents may continue to use the groundwater in the future for these purposes in addition to secondary purposes such as clothes washing, lawn watering,
		Dermal Contact (Shower)	Yes	
		Inhalation of VOCs (Shower)	Yes	
	Site Workers (All)	Ingestion	Yes	Currently, an order against drinking and bathing in groundwater at the site has been issued. However, since evidence of pumping exists at the Ramsay well, site workers may continue to use the groundwater in the future for drinking. Site workers are not expected to shower on-site.
		Dermal Contact (Shower)	No	
		Inhalation of VOCs (Shower)	No	
	Construction Workers	Ingestion	Yes	Currently, an order against drinking and bathing in groundwater at the site has been issued. However, since evidence of pumping exists at the Ramsay well, construction workers may continue to use the groundwater in the future for drinking. Construction workers are not expected to shower on-site.
		Dermal Contact (Shower)	No	
		Inhalation of VOCs (Shower)	No	

*The dermal contact pathway can only be quantitatively evaluated for PCBs and cadmium as only these chemicals have established dermal absorption factors (PCBs = 6% and cadmium = 1%). All other chemicals will be qualitatively discussed.

**It should be noted that present and potential future site workers at the Fire Department and Texaco gas station were not considered receptors for surface soil since no surface soil samples were collected at the Fire Department, and the Texaco gas station is completely paved (all soil samples would be subsurface). However, all individual areas in the area of concern are listed to be consistent with those listed for the subsurface soil area of concern.

The inhalation of VOCs exposure route was assumed to be negligible as no VOCs were selected as chemicals of potential concern. The inhalation of VOCs pathway was therefore not selected for further evaluation.

Site workers currently employed at the Fire Department/Texaco gas station/Antilles auto parts/Ramsay motor company may inadvertently ingest and/or dermally contact surface soil while performing their daily job activities or during lunch hour. The inhalation of suspended surface soil particulates route was not selected for quantitative evaluation as the areas from which the samples were collected consist of hard packed soil or are largely covered by vegetation. The inhalation of VOCs exposure route was assumed to be negligible, as no VOCs were selected as chemicals of potential concern. The inhalation of VOCs pathway was therefore not selected for further evaluation.

Site workers currently employed at the Curriculum Center Building may inadvertently ingest and/or dermally contact surface soil while performing their daily job responsibilities or during their lunch hour. The inhalation of suspended surface soil particulates route was not selected for quantitative evaluation as the areas from which the samples were collected consist of hard packed soil or are largely covered by vegetation. The inhalation of VOCs exposure route was assumed to be negligible, as no VOCs were selected as chemicals of potential concern. The inhalation of VOCs pathway was therefore not selected for further evaluation.

Site workers currently employed at the Esso gas station and Splash and Dash car wash are not exposed to surface soil, as the entire area was observed to be paved during the site visit.

Site workers currently employed at O'Henry dry cleaners and Liquor Barn may inadvertently ingest and/or dermally contact surface soil while performing their daily job activities or during lunch hour. The inhalation of suspended surface soil particulates route was not selected for quantitative evaluation as the area where the samples were collected is covered to a large extent by dense vegetation. The inhalation of VOCs exposure route was selected for quantitative evaluation, as one VOC, tetrachloroethene, was selected as a chemical of potential concern.

Based on observations made during the March 1994 site visit, no construction work is currently in progress in any of the areas of concern at the site. Therefore, no construction worker exposure to surface soil is occurring.

Subsurface Soil: Based on observations made during the March 1994 site visit, no construction work involving excavation activity is currently in progress in any of the areas of concern. Therefore, no exposure to subsurface soil by any of the potential receptors (i.e., residents, site workers, and construction workers) is occurring at present.

Groundwater: Event though an order against drinking and bathing in groundwater at the site has been issued, evidence of pumping at the Ramsay well exists. Therefore, current residents of the site may be ingesting groundwater and/or using the water for showering in addition to

secondary purposes such as clothes laundering and lawn watering. The showering scenario, which has been selected for quantitative evaluation, includes dermal contact with SVOCs, and inorganics and the inhalation pathway which addresses VOCs only. Pesticides and PCBs were not analyzed for in groundwater. Dermal contact with volatilized VOCs is assumed to be negligible.

Based on the fact that the Ramsay well has undergone pumping in the recent past, it is reasonably assumed that site workers may be ingesting this water (i.e., Ramsay motor company employees). Site workers, however, are not assumed to shower while at work. Therefore, the dermal contact and the inhalation of VOCs routes of exposure associated with the showering scenario have not been selected for quantitative evaluation.

3.2.2 Future Use-Scenarios

The potential exists, in the future, for further commercial or residential development of the Tutu Wells site. Based on visual observations made during the site visit, site history, discussions with the USEPA RPM and Risk Assessment Specialist, and professional judgement, potential future-use exposure scenarios and human receptors were selected for quantitative evaluation. Table 3-1 presents the media, receptors, and scenarios considered for analysis with a "yes" next to those selected and justification for the pathway's elimination from or retention for quantitative analysis.

Surface Soil: As discussed for the present-use scenario, during the March 1994 site visit a residence was observed to be located at the Tillett Gardens and Art Center. Residents may continue to come into direct contact with surface soil via the ingestion and dermal contact routes of exposure during the course of their daily activities. The inhalation of suspended surface soil particulates may be of concern due to the potential for future construction activity in this area of concern. Therefore, this route of exposure has been selected for quantitative evaluation in the risk assessment. The inhalation of VOCs is assumed to be negligible, as no VOCs were selected as chemicals of potential concern. The inhalation of VOCs pathway was therefore not selected for further evaluation.

Site workers at the Fire Department/Texaco gas station/Antilles auto parts/Ramsay motor company are assumed to remain in their respective areas while performing their various daily activities in the future. The ingestion and dermal contact routes of exposure were therefore selected for quantitative evaluation. The inhalation of suspended surface soil particulates exposure pathway may be of concern due to the potential for future construction activity in the areas. The inhalation of VOCs is assumed to be negligible, as no VOCs were selected as chemicals of potential concern. The inhalation of VOCs pathway was therefore not selected for further evaluation.

Site workers at the Curriculum Center Building are assumed to remain in that area while performing their various daily activities in the future. The ingestion and dermal contact routes of exposure were therefore selected for quantitative evaluation. The inhalation of suspended

surface soil particulates exposure pathway may be of concern due to the potential for future construction activity in the area. Therefore, this route of exposure has been selected for quantitative evaluation in the risk assessment. The inhalation of VOCs exposure route is assumed to be negligible, as no VOCs were selected as chemicals of potential concern. The inhalation of VOCs pathway was therefore not selected for further evaluation.

Since the Esso gas station and Splash and Dash car wash areas are completely paved at present, any future excavation activity would result in the exposure of subsurface soil. Therefore, no site worker exposure to surface soil in this area of concern may occur in the future.

Site workers at O'Henry dry cleaners and the Liquor Barn are assumed to remain in their respective areas while performing their various daily activities. The ingestion and dermal contact routes of exposure were selected for quantitative evaluation. The inhalation of suspended surface soil particulates may also be of concern due to the potential for future construction activities in this area. The inhalation of VOCs exposure route was selected for quantitative evaluation in the risk assessment, as one VOC, tetrachloroethene, was selected as a chemical of potential concern.

Construction worker exposure to surface soil in the Tillett Gardens and Art Center area of concern were selected for quantitative evaluation, as this area may be further developed in the future, is the most chemically contaminated (for soil), and presents the highest risks/hazards to future residents. The ingestion and dermal contact routes of exposure were selected for

quantitative evaluation. The inhalation of suspended surface soil particulates was also selected due to the potential for future excavation activities in this area.

Subsurface Soil: The possibility exists for the Tillett Gardens and Art Center area to be further developed either commercially or residentially in the future. Residents may dermally contact exposed subsurface soil during recreational activity. However, they are assumed to ingest only a negligible amount of the exposed subsurface soil during such activity. The inhalation of suspended subsurface soil particulates from soil piles and/or excavated holes may be of concern. The inhalation of VOCs exposure route is assumed to be negligible, as no VOCs were selected as chemicals of potential concern. The inhalation of VOCs pathway was therefore not selected for further evaluation.

Since the potential exists for future construction work involving excavation activity at the Fire Department/Texaco gas station/Antilles auto parts/Ramsay motor company, potential future site workers in these areas may inadvertently come into direct contact (i.e., dermal contact) with exposed subsurface soil during the course of a normal workday. However, workers are assumed to ingest only a negligible amount of this exposed subsurface soil. The inhalation of suspended subsurface soil particulates from soil piles and/or excavated holes may be of concern. The inhalation of VOCs is assumed to be negligible, as no VOCs were selected as chemicals of potential concern. The inhalation of VOCs pathway was therefore not selected for further evaluation.

The potential exists for future construction work involving excavation activity at the Curriculum Center Building. Potential future site workers may inadvertently come into direct contact (i.e., dermal contact) with exposed subsurface soil during the course of a normal workday. However, workers are assumed to ingest only a negligible amount of this exposed subsurface soil. The inhalation of suspended subsurface soil particulates from soil piles and/or excavated holes may be of concern. The inhalation of VOCs exposure route is assumed to be negligible, as no VOCs were selected as chemicals of potential concern. The inhalation of VOCs pathway was therefore not selected for further evaluation.

Since the potential exists for future construction work involving excavation activity at the Esso gas station and Splash and Dash car wash, potential future site workers may inadvertently come into direct contact (i.e., dermal contact) with exposed subsurface soil during the course of a normal workday. However, workers are assumed to ingest only a negligible amount of this exposed subsurface soil. The inhalation of suspended subsurface soil particulates from soil piles and/or excavated holes may be of concern. The inhalation of VOCs exposure route is assumed to be negligible, as no VOCs were selected as chemicals of potential concern. The inhalation of VOCs pathway was therefore not selected for further evaluation.

The potential exists for future construction work involving excavation activity at the O'Henry dry cleaners and Liquor Barn. Potential future site workers may inadvertently come into direct contact (i.e., dermal contact) with exposed subsurface soil during the course of a normal workday. However, workers are assumed to ingest only a negligible amount of this exposed

subsurface soil. The inhalation of suspended subsurface soil particulates from soil piles and/or excavated holes may be of concern. The inhalation of VOCs exposure route is assumed to be negligible, as no VOCs were selected as chemicals of potential concern. The inhalation of VOCs pathway was therefore not selected for further evaluation.

Groundwater: Even though an order against drinking and bathing in groundwater at the site has currently been issued, evidence of pumping at the Ramsay well exists. Residents at the site may continue to use the groundwater indefinitely into the future for ingestion and/or showering (dermal contact with SVOCs and inorganics, and inhalation of VOCs) as well as for secondary purposes such as clothes washing and lawn watering.

3.3 Exposure Point Concentrations

Concentrations at potential exposure points (any point of potential contact with a contaminated medium) were developed individually for chemicals of potential concern in the selected areas of concern for appropriate site media for use in calculation of the chronic and subchronic daily intakes. This concentration is the 95 percent UCL on the arithmetic mean of the concentration that is contacted over the exposure period. Although this concentration does not reflect the maximum concentration that could be contacted at any one time, it is considered a reasonable estimate of the concentration likely to be contacted over time, since long-term contact with the maximum concentration is not a reasonable assumption.

Due to the uncertainty associated with an estimate of exposure concentration, the 95 percent UCL on the arithmetic mean is used for this variable. If there is a large variability in measured or modeled concentrations, the 95 percent UCL may exceed the maximum measured or modeled values, in which case, the maximum detected or modeled value is used. The formula used to calculate the 95 percent UCL for a lognormal distribution is as follows:

$$UCL = e^{(\bar{x} + 0.5s^2 + sH\sqrt{n-1})}$$

Where:

UCL	=	upper confidence limit
e	=	constant (base of the natural log, equal to 2.718)
$\bar{x}$	=	mean of the transformed data
s	=	standard deviation of the transformed data
H	=	H-statistic (i.e., from table published in Gilbert, 1987)
n	=	number of samples

The lognormal distribution formula was selected based on the limited number of surface and subsurface soil samples collected in each area of concern and on the plotting of groundwater data. In calculating this 95 percent UCL value, non-detects were accounted for by using one-half the SQL as the proxy concentration. In some cases, one-half the SQL exceeded the maximum (or only detected) value. If, in a group of samples, only one (one-half the) SQL exceeded the maximum detection, the SQL was eliminated from the calculation; if all (one-half the) SQLs exceeded the maximum detection, the maximum detection was utilized as the default value. Appendix A presents the calculated 95 percent UCL concentrations used to estimate carcinogenic risks and noncarcinogenic hazards.

3.3.1 Exposure Point Concentration Modeling

In performing this risk assessment, modeling was required for the evaluation of inhalation exposure to VOCs in groundwater while showering. In this scenario, potential future human receptors were assumed to inhale VOCs while showering and during time spent in the bathroom after showering. Dermal contact with volatilized VOCs was assumed to be negligible although dermal contact with SVOCs and inorganics is evaluated in Section 3.5. A chapter entitled *Estimating Dermal and Inhalation Exposure to Volatile Chemicals in Domestic Water* by J. Schaum et al. (1994) which appears as Chapter 13 in the recently published book entitled *Water Contamination and Health: Integration of Exposure Assessment, Toxicology, and Risk Assessment* was utilized to perform the shower modeling. This Chapter presents a methodology for estimating exposure to VOCs in domestic water supplies for the inhalation and dermal contact exposure routes. The dermal contact methodology was not utilized, as the dermal permeability coefficient for all but one chemical evaluated was the default value for water, (i.e., chemical-specific values are not available). The procedure for estimating exposure to VOCs was based on research performed by Julian Andelman (Andelman, 1990).

This model treats the bathroom as one compartment and yields an air concentration averaged over the time of the actual shower and the time spent in the bathroom after the shower. The model was derived by assuming that the chemical contaminant volatilizes at a constant rate, instantly mixes uniformly with the bathroom air, and that ventilation with clean air does not occur. This implies that contaminant concentration in the air increases linearly from zero to a

maximum at the end of the shower, and then remains constant during the time an individual spends in the bathroom immediately after the shower.

$$C(a) = \frac{[(C(aMAX)/2)] t1 + C(aMAX) t2}{t1 + t2}$$

Where:

C(a)	=	concentration of chemical contaminant in air (mg/m ³)
C(aMAX)	=	maximum concentration of chemical contaminant in air (mg/m ³)
t1	=	time of shower (hr)
t2	=	time after shower (hr)

C(aMAX) is estimated as follows:

$$C(aMAX) = \frac{C(w) f F(w) t1}{V(a)}$$

Where:

C(aMAX)	=	maximum air concentration in bathroom (mg/m ³)
C(w)	=	water concentration (mg/l)
f	=	fraction volatilized (unitless)
F(w)	=	water flow rate (l/hr)
V(a)	=	bathroom volume (m ³)

The water concentration, C(w), is a site-specific value that refers to the concentration of a chemical in water as it enters the shower. The 95 percent UCL value, or the maximum detected value, was utilized as the water concentration.

The fraction volatilized, f , is a chemical-specific value that refers to the mass fraction of chemical in water that volatilizes over the course of the shower. Volatilization rates depend on properties such as Henry's law constants and molecular weights, although the relationship is not well established. Andelman (1990) has reported volatilization factors of 0.5 to 0.9 based on experiments with chloroform and trichloroethene. These chemicals have Henry's law constants of $2.87\text{E-}03 \text{ atm-m}^3/\text{mol}$ and $9.10\text{E-}03 \text{ atm-m}^3/\text{mol}$, respectively, and are assumed to be representative of other VOCs (i.e., those having Henry's law constants that are similar or greater). A review of the Henry's law constants for the VOCs modeled showed all to be similar to or greater than those for chloroform and trichloroethene. The fraction volatilized for all chemicals in the shower model was assumed to be 75 percent, based on the assumptions used in the model.

The water flow rate, $F(w)$, refers to the rate at which water flows into the shower. A value of 750 l/hr was assumed in the model.

The bathroom volume, $V(a)$, refers to the volume of the bathroom including the shower stall. A value of 12 m^3 was assumed in the model.

The shower time, t_1 , refers to the actual time of the shower. A 90th percentile value of 12 minutes (0.2 hr) (USEPA, 1989a) was assumed in the model.

The time spent in the bathroom after showering, t_2 , was assumed to be 20 minutes (0.3 hr). The variables selected for input into the shower model generally represent average values in an attempt to reduce over conservatism inherent in the model.

The model is very conservative in nature due to the following assumptions,

- constant volatilization
- no ventilation
- the concentration of the chemical contaminant is assumed to be zero at the start of the shower (i.e., no residual chemical concentrations)
- the exchange between air in the shower chamber and bathroom air is so rapid that the combined volume of the two compartments can be treated as a single chamber with a single concentration of volatilized chemical
- the model does not account for the exchange rate that occurs when an exhaust fan is turned on

Since groundwater at the site has been found to contain VOC contamination and the potential exists in the future for the groundwater to again be used as a potable source, it has been evaluated for potential health impacts.

Table 3-2 presents the daily intake equation for VOC inhalation during and after showering.

3.4 Calculation of Chronic and Subchronic Daily Intakes

To quantitatively assess the potential carcinogenic risks and health hazards to human populations based on the present and potential future-use scenarios discuss in Section 3.2, daily intakes were.

TABLE 3-2
TUTU WELLS SITE
INHALATION OF AIRBORNE CHEMICALS
(SHOWER SCENARIO)*

Equation:

$$\text{Intake (mg/kg-day)} = \frac{\text{CA} \times \text{IR} \times \text{ET} \times \text{EF} \times \text{ED}}{\text{BW} \times \text{AT}}$$

Where:

CA	=	Chemical Concentration in Air (mg/m ³)
IR	=	Inhalation Rate (m ³ /hour)
ET	=	Exposure Time (hours/day)
EF	=	Exposure Frequency (days/year)
ED	=	Exposure Duration (years)
BW	=	Body Weight (kg)
AT	=	Averaging Time (period over which exposure is averaged - days)

*Schaum et al. (1994) based on the Andelman (1990) Shower Model

calculated. These daily intakes were evaluated for both chronic (approximately seven year to lifetime) and subchronic (two week to approximately seven year) exposures (USEPA, 1989a). For the chronic and subchronic daily intakes, intakes were averaged over a lifetime for carcinogenic chemicals and over the period of exposure for noncarcinogens. The daily intake was expressed in terms of the mass of the chemical per unit of body weight over the averaging time (mg chemical/kg body weight-day).

Equations presented and described in RAGS (USEPA, 1989a) were used to estimate daily intakes from ingestion and dermal contact exposures. The inhalation of particulates daily intake was calculated based on the equation presented in USEPA (1989b). The inhalation of VOCs daily intake was calculated based on the equation presented in USEPA (1991b). These equations are presented in Tables 3-3 through 3-8 and also appear at the top of the appropriate spreadsheets for clarity.

3.5 Exposure Assumptions

All exposure parameters selected for use in chronic and subchronic daily intake calculations are presented in Table 3-9. The following sections describe the reasoning behind their selection and the sources from which the values were obtained. Daily intakes were calculated for residents (adults and children), site workers, and construction workers. Children have been identified as a subpopulation that is potentially at higher risk from chemical exposure due to increased sensitivity and behavior patterns that may result in higher exposure (i.e., surface soil) than in

TABLE 3-3
TUTU WELLS SITE
INGESTION OF CHEMICALS IN SOIL

Equation:

$$\text{Intake (mg/kg-day)} = \frac{\text{CS} \times \text{IR} \times \text{CF} \times \text{FI} \times \text{EF} \times \text{ED}}{\text{BW} \times \text{AT}}$$

Where:

CS	=	Chemical Concentration in Soil (mg/kg)
IR	=	Ingestion Rate (mg soil/day)
CF	=	Conversion Factor (10^{-6} kg/mg)
FI	=	Fraction Ingested from Contaminated Source (unitless)
EF	=	Exposure Frequency (days/year)
ED	=	Exposure Duration (years)
BW	=	Body Weight (kg)
AT	=	Averaging Time (period over which exposure is averaged - days)

TABLE 3-4

TUTU WELLS SITE
DERMAL CONTACT WITH CHEMICALS IN SOIL

Equation:

$$\text{Absorbed Dose (mg/kg-day)} = \frac{\text{CS} \times \text{CF} \times \text{SA} \times \text{AF} \times \text{ABS} \times \text{EF} \times \text{ED}}{\text{BW} \times \text{AT}}$$

Where:

CS	=	Chemical Concentration in Soil (mg/kg)
CF	=	Conversion Factor (10 ⁻⁶ kg/mg)
SA	=	Skin Surface Area Available for Contact (cm ² /event)
AF	=	Soil-to-Skin Adherence Factor (mg/cm ²)
ABS	=	Absorption Factor (unitless)
EF	=	Exposure Frequency (events/year)
ED	=	Exposure Duration (years)
BW	=	Body Weight (kg)
AT	=	Averaging Time (period over which exposure is averaged - days)

TABLE 3-5

TUTU WELLS SITE
INHALATION OF INDOOR AND OUTDOOR PARTICULATES

Equation:

$$\text{Intake (mg/kg-day)} = \frac{\text{CS} \times \text{SSC} \times \text{RF} \times \text{IR} \times \text{ET} \times \text{EF} \times \text{ED} \times \text{CF}}{\text{BW} \times \text{AT}}$$

Where:

CS	=	Chemical Concentration in Soil (mg/kg)
SSC	=	Suspended Soil Concentration (mg/m ³)
RF	=	Respirable Fraction (unitless)
IR	=	Inhalation Rate (m ³ /hour)
ET	=	Exposure Time (hours/day)
EF	=	Exposure Frequency (days/year)
ED	=	Exposure Duration (years)
CF	=	Conversion Factor (10 ⁻⁶ kg/mg)
BW	=	Body Weight (kg)
AT	=	Averaging Time (period over which exposure is averaged - days)

TABLE 3-6

TUTU WELLS SITE
INHALATION OF VOCs FROM SURFACE SOIL

Equation:

$$\text{Intake (mg/kg-day)} = \frac{\text{CS} \times 1/\text{VF} \times \text{IR} \times \text{ET} \times \text{EF} \times \text{ED}}{\text{BW} \times \text{AT}}$$

Where:

CS	=	Chemical Concentration in Soil (mg/kg)
VF	=	Soil-to-Air Volatilization Factor (m ³ /kg)
IR	=	Inhalation Rate (m ³ /hour)
ET	=	Exposure Time (hours/day)
EF	=	Exposure Frequency (days/year)
ED	=	Exposure Duration (years)
BW	=	Body Weight (kg)
AT	=	Averaging Time (period over which exposure is averaged - days)

TABLE 3-7

TUTU WELLS SITE
INGESTION OF CHEMICALS IN DRINKING WATER

Equation:

$$\text{Intake (mg/kg-day)} = \frac{\text{CW} \times \text{IR} \times \text{EF} \times \text{ED}}{\text{BW} \times \text{AT}}$$

Where:

CW	=	Chemical Concentration in Water (mg/liter)
IR	=	Ingestion Rate (liters/day)
EF	=	Exposure Frequency (days/year)
ED	=	Exposure Duration (years)
BW	=	Body Weight (kg)
AT	=	Averaging Time (period over which exposure is averaged - days)

TABLE 3-8

TUTU WELLS SITE
DERMAL CONTACT WITH CHEMICALS IN GROUNDWATER
WHILE SHOWERING

Equation:

$$\text{Absorbed Dose (mg/kg-day)} = \frac{\text{CW} \times \text{SA} \times \text{PC} \times \text{ET} \times \text{EF} \times \text{ED} \times \text{CF}}{\text{BW} \times \text{AT}}$$

Where:

CW	=	Chemical Concentration in Water (mg/liter)
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/year)
ED	=	Exposure Duration (years)
CF	=	Volumetric Conversion Factor for Water (1 liter/1000 cm ³)
BW	=	Body Weight (kg)
AT	=	Averaging Time (period over which exposure is averaged - days)

TUTU WELLS SITE
VARIABLES USED FOR CHRONIC AND SUBCHRONIC DAILY INTAKE CALCULATIONS

Matrices and Receptor Populations	Exposure Route	CONCENTRATIONS				CONTACT PARAMETERS							TIME VARIABLES				CF (3) (variable)	BW (kg)
		CW (mg/l)	CA/SSC (mg/m3)	CS (mg/kg)	VF (m3/kg)	SA (cm2)	PC (cm/hr)	IR (1) (variable)	RF (unitless)	AF (mg/cm2)	ABS (unitless)	FI (unitless)	ET (hr/day)	EF (day/yr)	ED (yrs)	AT (2) (years)		
Surface Soil																		
Residents (Tillett Gardens and Art Center)																		
Adults	Ingestion	-	-	Site Data	-	-	-	100 mg/day	-	-	-	1	-	350	24	70(24)	1E-6 kg/mg	70
Children (0-6 years)	Ingestion	-	-	Site Data	-	-	-	200 mg/day	-	-	-	1	-	350	6	70(6)	1E-6 kg/mg	15
Adults	Dermal Contact	-	-	Site Data	-	5065	-	-	-	1	(5)	-	-	350 events/yr	24	70(24)	1E-6 kg/mg	70
Children (0-6 years)	Dermal Contact	-	-	Site Data	-	1270	-	-	-	1	(5)	-	-	350 events/yr	6	70(6)	1E-6 kg/mg	15
Adults	Inhalation of Particulates	-	0.070	Site Data	-	-	-	0.83 m3/hr	0.75	-	-	-	18	350	24	70(24)	1E-6 kg/mg	70
Children (0-6 years)	Inhalation of Particulates	-	0.070	Site Data	-	-	-	0.83 m3/hr	0.75	-	-	-	18	350	6	70(6)	1E-6 kg/mg	15
Site Workers																		
Adults	Ingestion	-	-	Site Data	-	-	-	50 mg/day	-	-	-	1	-	250	25	70(25)	1E-6 kg/mg	70
	Dermal Contact	-	-	Site Data	-	1940	-	-	-	1	(5)	-	-	250 events/yr	25	70(25)	1E-6 kg/mg	70
	Inhalation of Particulates	-	0.070	Site Data	-	-	-	0.83 m3/hr	0.75	-	-	-	8	250	25	70(25)	1E-6 kg/mg	70
	Inhalation of VOCs	-	-	Site Data	(4)	-	-	0.83 m3/hr	-	-	-	-	8	250	25	70(25)	-	70
Construction Workers																		
Adults	Ingestion	-	-	Site Data	-	-	-	480 mg/day	-	-	-	1	-	225	1	70(1)	1E-6 kg/mg	70
	Dermal Contact	-	-	Site Data	-	6125	-	-	-	1	(5)	-	-	225 events/yr	1	70(1)	1E-6 kg/mg	70
	Inhalation of Particulates	-	0.070	Site Data	-	-	-	0.83 m3/hr	0.75	-	-	-	8	225	1	70(1)	1E-6 kg/mg	70
Subsurface Soil																		
Residents (Tillett Gardens and Art Center)																		
Adults	Dermal Contact	-	-	Site Data	-	5065	-	-	-	1	(5)	-	-	91 events/yr	1	70(1)	1E-6 kg/mg	70
Children (0-6 years)	Dermal Contact	-	-	Site Data	-	1270	-	-	-	1	(5)	-	-	91 events/yr	1	70(1)	1E-6 kg/mg	15
Adults	Inhalation of Particulates	-	0.070	Site Data	-	-	-	0.83 m3/hr	0.75	-	-	-	18	91	1	70(1)	1E-6 kg/mg	70
Children (0-6 years)	Inhalation of Particulates	-	0.070	Site Data	-	-	-	0.83 m3/hr	0.75	-	-	-	18	91	1	70(1)	1E-6 kg/mg	15
Site Workers																		
Adults	Dermal Contact	-	-	Site Data	-	1940	-	-	-	1	(5)	-	-	65 events/yr	1	70(1)	1E-6 kg/mg	70
	Inhalation of Particulates	-	0.070	Site Data	-	-	-	0.83 m3/hr	0.75	-	-	-	8	65	1	70(1)	1E-6 kg/mg	70
Construction Workers																		
Adults	Ingestion	-	-	Site Data	-	-	-	480 mg/day	-	-	-	1	-	65	1	70(1)	1E-6 kg/mg	70
	Dermal Contact	-	-	Site Data	-	6125	-	-	-	1	(5)	-	-	65 events/yr	1	70(1)	1E-6 kg/mg	70
	Inhalation of Particulates	-	0.070	Site Data	-	-	-	0.83 m3/hr	0.75	-	-	-	8	65	1	70(1)	1E-6 kg/mg	70

TUTU WELLS SITE
VARIABLES USED FOR CHRONIC AND SUBCHRONIC DAILY INTAKE CALCULATIONS

		CONCENTRATIONS				CONTACT PARAMETERS								TIME VARIABLES					
Matrices and Receptor Populations	Exposure Route	CW (mg/l)	CA/SSC (mg/m3)	CS (mg/kg)	VF (m3/kg)	SA (cm2)	PC (cm/hr)	IR (1) (variable)	RF (unitless)	AF (mg/cm2)	ABS (unitless)	FI (unitless)	ET (hr/day)	EF (day/yr)	ED (yrs)	AT (2) (years)	CF (3) (variable)	BW (kg)	
Groundwater																			
Site Residents																			
Adults	Ingestion	Site Data	-	-	-	-	-	2 l/day	-	-	-	-	-	350	30	70(30)	-	70	
Children (0-6 years)	Ingestion	Site Data	-	-	-	-	-	1 l/day	-	-	-	-	-	350	6	70(6)	-	15	
Adults	Dermal Contact (Shower)	Site Data	-	-	-	18150	(7)	-	-	-	-	-	0.2	350	30	70(30)	1E-3 l/cm3	70	
Children (0-6 years)	Dermal Contact (Shower)	Site Data	-	-	-	5400	(7)	-	-	-	-	-	0.2	350	6	70(6)	1E-3 l/cm3	15	
Adults	Inhalation(Shower)	-	(6)	-	-	-	-	0.6 m3/hr	-	-	-	-	0.2	350	30	70(30)	-	70	
Children (0-6 years)	Inhalation(Shower)	-	(6)	-	-	-	-	0.6 m3/hr	-	-	-	-	0.2	350	6	70(6)	-	15	
Site Workers																			
Adults	Ingestion	Site Data	-	-	-	-	-	1 l/day	-	-	-	-	-	250	25	70(25)	-	70	
Construction Workers																			
Adults	Ingestion	Site Data	-	-	-	-	-	1 l/day	-	-	-	-	-	225	1	70(1)	-	70	

NOTES:

- (1) Ingestion or inhalation rate
- (2) 70 years for carcinogens, 30 years for noncarcinogens for adult residents, 25 years for noncarcinogens for site workers, 6 years for noncarcinogens for children and 1 year for all construction workers and subsurface soil (multiplied by 365 days).
- (3) Conversion Factor
- (4) The soil-to-air volatilization factor (VF) will be calculated individually for chemicals of potential concern as appropriate.
- (5) Soil dermal contact absorption factors: 6% = PCBs and 1% = cadmium.
- (6) This value was modeled from RI Data.
- (7) This value is the default value for water when no chemical-specific values were available in USEPA (1992c).

Other Abbreviations:

CW = Contaminant concentration in water
 CA = Contaminant concentration in air
 CS = Contaminant concentration in soil
 SA = Skin surface area available for dermal contact
 PC = Chemical-specific dermal permeability constant
 RF = Respirable fraction of particulates
 AF = Soil-to-skin adherence factor
 SSC = Suspended soil concentration
 FI = Fraction ingested from contaminant source
 ET = Exposure Time
 EF = Exposure Frequency
 ED = Exposure Duration
 BW = Body Weight
 AT = Averaging Time

adults. For soil, a 30 year exposure is separated into a six year exposure for children (age 0 - 6 years) and a 24 year exposure for older children and adults. The spreadsheet calculations present the individual as well as the combined estimates.

For all receptor populations, the chemical concentrations in the various matrices (except for groundwater chemical concentrations in the shower model) were based on actual site data from which 95 percent UCLs were calculated. In cases where the 95 percent UCL exceeded the maximum detected site concentration, the maximum site detection was used in the daily intake calculation.

It should be noted for subsurface soil that exposure is considered to be subchronic for the residential and worker receptor groups as the potential for exposure would only occur during excavation activities. All child exposures to noncarcinogens are considered chronic per USEPA direction since the exposure duration (6 years) is at the upper-bounds of subchronic exposure.

3.5.1 Surface Soil

Residents: For present and potential future adult and child residents in the Tillett Gardens and Art Center, surface soil data were used to calculate chemical concentrations for the intake equations.

For potential future adult and child residents, daily soil ingestion rates (IR) of 100 and 200 mg/day, respectively, were obtained from USEPA (1991a). The fraction ingested (FI) from contaminated surface soil was conservatively assumed to be one for both adults and children. An exposure frequency (EF) of 350 days/year was assumed for potential future residents (USEPA, 1991a). This value was based on the assumption that residents would be away on vacation two weeks per year. Exposure durations (ED) were assumed to be 24 years for adults and 6 years for children (USEPA, 1991a) for a 30 year total exposure which corresponds to the 90th percentile national upper-bound time spent at the same residence. The averaging time (AT) was calculated from USEPA (1989a) as the exposure duration (ED) multiplied by 365 days/year for noncarcinogens and 70 years (lifetime) multiplied by 365 days/year for carcinogens. An adult body weight (BW) of 70 kg and a child body weight (BW) of 15 kg were assumed (USEPA, 1991a).

For potential future residential dermal contact exposure, the skin surface area (SA) available for contact was calculated from information presented in USEPA (1989b, 1992c). For adult males and females, the skin surface areas (SA) for the head, hands, forearms, and lower legs were summed by sex, then averaged, resulting in a value of 5065 cm². For children (age 0 - 6 years), the average skin surface area (SA) was calculated as 25 percent of the average adult male and female skin surface area (SA = 5065 cm²), resulting in an exposed surface area of 1270 cm². An adherence factor (AF) of 1 mg/cm² for adults and children was obtained from USEPA (1992c). Soil dermal absorption factors (ABS) of six percent for PCBs and one percent for cadmium were obtained from USEPA (1992c). All other chemicals of potential concern were qualitatively

addressed in the risk assessment for dermal contact exposure since no other dermal absorption factors are currently established for USEPA Region II. The exposure frequency (EF), exposure duration (ED), averaging time (AT), and body weight (BW) values for adults and children are the same as ingestion exposure, except for the exposure frequency unit, which for dermal contact is reported in events/year instead of days/year.

For potential future residential inhalation exposures, an outdoor suspended soil concentration (SSC) of 70 ug/m³ (Hawley, 1985) was assumed to occur during construction activities. It was further assumed that 75 percent of the inhaled particulate mass is retained (respirable fraction - RF) (Hawley, 1985). An inhalation rate (IR) of 0.83 m³/hour was assumed based on an adult average rate of 20 m³/day as reported in USEPA (1989a). An exposure time (ET) of 18 hours was assumed to be the average combined amount of time spent both indoors and outdoors (i.e., at home) per day. The exposure frequency (EF), exposure duration (ED), averaging time (AT), and body weight (BW) values for adults and children are the same as ingestion exposure.

Site Worker (Employee): For present and/or potential future site worker (employee) surface soil exposures at the Fire Department/Texaco gas station/Antilles auto parts/Ramsay motor company, Curriculum Center Building, Esso gas station and Splash and Dash car wash, and O'Henry dry cleaners and Liquor Barn areas of concern, site data were used to calculate chemical concentrations for use in the intake equations. Workers (employees) at the Fire Department were not considered receptors for surface soil exposure, as no surface soil samples were collected from the Fire Department area. Workers (employees) at the Texaco gas station

were also not considered receptors for surface soil exposure as the entire gas station area is paved.

A daily ingestion rate (IR) of 50 mg/day was assumed for commercial land use scenarios (USEPA, 1991a). The fraction ingested (FI) from contaminated surface soil was conservatively assumed to be one. An exposure frequency (EF) of 250 days/year (five days/week for twelve months minus two weeks/year vacation) for 25 years (exposure duration (ED)) was assumed (USEPA, 1991a). The averaging time (AT) was calculated from USEPA (1989a) as the exposure duration (ED) multiplied by 365 days/year for noncarcinogens and 70 years (lifetime) multiplied by 365 days/year for carcinogens. An adult body weight (BW) of 70 kg was assumed (USEPA, 1991a).

For present and potential future site worker (employee) dermal contact exposure, a skin surface area (SA) of 1940 cm²/event was calculated based on information contained in USEPA (1989b, 1992c). For males and females, the average skin surface area (SA) for the head and hands were summed by sex, then averaged, resulting in the final value. An adherence factor (AF) of 1 mg/cm² was obtained from USEPA (1992c). Soil dermal absorption factors (ABS) of six percent for PCBs and one percent for cadmium were obtained from USEPA (1992c). All other chemicals of potential concern were qualitatively addressed in the risk assessment for dermal contact exposure since no other dermal absorption factors are currently established for USEPA Region II. The exposure frequency (EF), exposure duration (ED), averaging time (AT), and body weight (BW) are the same as site worker (employee) ingestion exposure except for the

exposure frequency unit, which for dermal contact is reported in events/year instead of days/year.

For present and potential future site worker (employee) inhalation of particulates exposure, an outdoor suspended soil concentration (SSC) of 70 ug/m^3 (Hawley, 1985) was assumed to occur during construction activities. It was further assumed that 75 percent of the inhaled particulate mass is retained (respirable fraction - RF) (Hawley, 1985). An inhalation rate (IR) of $0.83 \text{ m}^3/\text{hour}$ was assumed based on an adult average rate of $20 \text{ m}^3/\text{day}$ as reported in USEPA (1989a). An exposure time (ET) of eight hours was assumed, based on the length of a typical workday. The exposure frequency (EF), exposure duration (ED), averaging time (AT), and body weight (BW) are the same as site worker ingestion exposure.

For present and potential future site worker (employee) inhalation of VOCs exposure, a soil-to-air volatilization factor (VF) was calculated for the single VOC, tetrachloroethene, selected as a chemical of potential concern. The VF calculation was based on equations presented in USEPA (1991b). An inhalation rate (IR) of $0.83 \text{ m}^3/\text{hour}$ was assumed based on an adult average rate of $20 \text{ m}^3/\text{day}$ as reported in USEPA (1989a). An exposure time (ET) of eight hours was assumed, based on the length of a typical workday. The exposure frequency (EF), exposure duration (ED), averaging time (AT), and body weight (BW) are the same as site worker ingestion exposure.

Construction Worker:

For potential future construction worker site surface soil exposure, sample data were again used to calculate chemical concentrations for use in the intake equations.

For potential future construction workers, a surface soil ingestion rate (IR) of 480 mg/day was assumed based on information presented for the commercial/industrial setting (USEPA, 1991a). The fraction ingested (FI) from contaminated site surface soil was conservatively assumed to be one. An exposure frequency (EF) of 225 days/year based on eleven months of exposure/year, five days/week minus ten vacation days was assumed. Approximately one month's time was assumed to be spent on non-invasive activities such as planning, mobilization, and demobilization. A twelve month exposure duration (ED) was assumed to be the length of time a construction project would last. The averaging time (AT) was calculated by the same method described for site worker surface soil ingestion. A body weight (BW) of 70 kg was assumed (USEPA, 1991a).

For potential future construction worker dermal contact exposure, a skin surface area (SA) of 6125 cm²/event was calculated from information presented in USEPA (1989b, 1992c). For males and females, the average skin surface area (SA) for the head, upper extremities, and lower legs were summed by sex, then averaged, resulting in the final value. An adherence factor (AF) of 1 mg/cm² was obtained from USEPA (1992c). Soil dermal absorption factors (ABS) of six percent for PCBs and one percent for cadmium were obtained from USEPA (1992c). All other

chemicals of potential concern were qualitatively addressed in the risk assessment for dermal contact exposure since no other dermal absorption factors are currently established for USEPA Region II. The exposure frequency (EF), exposure duration (ED), averaging time (AT), and body weight (BW) are the same as ingestion exposure except for the exposure frequency unit, which for dermal contact is reported in events/year instead of days/year.

For present and potential future construction worker particulate inhalation exposure, an outdoor suspended soil concentration (SSC) of 70 ug/m^3 (Hawley, 1985) was assumed to occur during construction activities. Additionally, 75 percent of the inhaled particulate mass was assumed to be retained (respirable fraction-RF) (Hawley, 1985). An inhalation rate (IR) of $0.83 \text{ m}^3/\text{hour}$ was assumed as described for site worker (employee) inhalation exposure. An exposure time (ET) of eight hours/day was assumed to be the length of a normal workday. The exposure frequency (EF), exposure duration (ED), averaging time (AT), and body weight (BW) are the same as construction worker ingestion exposure.

3.5.2 Subsurface Soil

Potential future subsurface soil contact parameters for residents, site workers, and construction workers in the Tillett Gardens and Art Center, Fire Department/Texaco gas station/Antilles auto parts/Ramsay motor company, Curriculum Center Building, Esso gas station and Splash and Dash car wash, and O'Henry dry cleaners and Liquor Barn areas of concern are the same as

those selected for surface soil exposures for the same receptor groups. These contact parameters are presented in Table 3-9.

For all receptor groups, chemical concentrations for the intake equations were calculated based on site data. Differences between the surface soil and subsurface soil pathways, beside chemical concentrations, lie basically with the time variables, specifically the exposure frequency (EF), exposure duration (ED), and averaging time (AT). For subsurface soil, exposure is considered to be subchronic for all receptor groups, as the potential for exposure would only exist during construction (i.e., excavation) activities. The exposure duration (ED) for residents, site workers (employees), and construction workers was assumed to be one year, which corresponds to the assumed length of a construction project at the site. The exposure frequency (EF) for residents was assumed to be 91 days (or events) per year which corresponds to the assumed length of excavation activities (three months/year, seven days/week). For conservatism, no vacation away from home is assumed during the three months of excavation. The exposure frequency (EF) for site workers was assumed to be 65 days (or events) per year which also corresponds to the length of excavation activities (three months, five days/week) during the construction project. Again, no vacation time is assumed during the period of excavation. The exposure frequency (EF) for construction workers was also assumed to be 65 days (or events) per year corresponding to the length of the excavation activities (three months, five days/week) during a construction project. No vacation time is assumed during the period of excavation.

3.5.3 Groundwater

Residents: For present and potential future residential groundwater exposure, site sample data were used to calculate chemical concentrations for use in the intake equations.

Ingestion rates (IR) of two liters/day for adults and one liter/day for children living at the site at present and potentially in the future were assumed based on information presented in USEPA (1989b). The two liter/day adult ingestion rate represents an historical long-term average consumption rate and includes drinking water consumed in the form of beverages (i.e., juices containing tap water). The one liter/day child ingestion rate is assumed to be protective of the sensitive receptor, who is also expected to ingest beverages other than those containing water. An exposure frequency (EF) of 350 days/year was assumed based on the assumption that two weeks/year are spent away from home on vacation (USEPA, 1991a). The exposure duration (ED) was assumed to be 30 years for adults and six years for children (USEPA, 1989a). Thirty years corresponds to the national upper-bound (90th percentile) time spent at one residence. The averaging time (AT) was calculated in the same manner as soils where the exposure duration (30 years for adults and 6 years for children) was multiplied by 365 days/year for noncarcinogens, and 70 years (lifetime) for adults and was multiplied by 365 days/year for carcinogens. Body weights (BW) of 70 kg for adults and 15 kg for children were assumed (USEPA, 1991a).

For potential future residential dermal contact with groundwater during showering, the dermal absorption of SVOCs, pesticides/PCBs, and inorganics have been evaluated. The skin surface

areas available for contact was calculated from information presented in USEPA (1989a, 1989b, and 1992c). Whole body exposure was assumed to occur during showering. For adult males and females, the average total body surface areas were summed, then averaged, resulting in a value of 18150 cm². For children age 0-6 years, the average skin surface area (SA) was calculated as 75 percent of the average male and female total body surface area for 3 - 6 year olds (7195 cm²). The 3 - 6 year old age group was utilized as this is the closest age group for which data are available. Based on the fact that children grow (i.e., skin surface area increases) rapidly during the early years, a skin surface area (SA) of 5400 cm² is assumed to be a reasonable value for the 0 - 6 year old age group. Chemical-specific dermal permeability constants were obtained from USEPA (1992c). When a dermal permeability constant was not available for a specific chemical, the dermal permeability constant for water was utilized as a default value. An exposure time (ET) of 0.2 hours/day (12 minutes) was assumed to be the length of a typical shower and is the 90th percentile value specified in USEPA (1989a). An exposure frequency (EF) of 350 days/year was assumed for daily showering, taking into account two weeks/year spent away from home (USEPA, 1991a). The exposure duration (ED) was assumed to be 30 years for adults and six years for children corresponding to the national upper-bound (90th percentile) time spent at the same residence (USEPA, 1989a). The averaging time (AT) was calculated in the same manner as residential groundwater ingestion. An adult body weight (BW) of 70 kg and a child body weight (BW) of 15 kg were assumed (USEPA, 1991a).

For residential inhalation of VOCs during showering, the Andelman (1990) shower model was run utilizing the procedures discussed in Schaum et al. (1994). The details of the model are

presented in Section 3.3.1. Using the two equations presented, the average concentration of a volatile chemical in the shower air over the period of time spent in the shower was calculated. This value was then used in the intake calculation. An inhalation rate (IR) of 0.6 m³/hour was assumed based on information presented in USEPA (1989a). This value assumes that showering represents light activity and is representative of the entire exposed population (USEPA, 1989a, 1989b). The exposure time (ET), exposure frequency (EF), exposure duration (ED), averaging time (AT), and body weight (BW) are the same as residential dermal contact exposure.

Groundwater ingestion exposure may be occurring for present site workers since evidence of pumping exists at the Ramsay well. This ingestion exposure may continue indefinitely into the future. The concentrations of chemicals in groundwater used in the intake equation were determined based on actual site data. An ingestion rate (IR) of 1 liter/day was assumed for the commercial/industrial setting (USEPA, 1991a) since it is assumed that other beverages would be ingested besides water. An exposure frequency (EF) of 250 days/year (5 days/week for 12 months minus 2 weeks/year vacation) for 25 years (exposure duration (ED)) was assumed (USEPA, 1991a). The averaging time (AT) was calculated in the same manner as residential groundwater ingestion. A body weight (BW) of 70 kg was assumed (USEPA, 1991a). Site workers were assumed to have negligible dermal contact exposure with groundwater and were not assumed to shower on-site.

Construction workers may also be exposed to groundwater via the ingestion route, if the site is further developed in the future. The same exposure parameters selected for site workers were

assumed to apply to construction workers except for the time variables exposure frequency (EF), exposure duration (ED), and averaging time (AT). An exposure frequency (EF) of 225 days/year was assumed based on eleven months of exposure/year, five days/week minus ten days vacation. A twelve month exposure duration (ED) was assumed to be the length of time a construction project would last. The averaging time (AT) was calculated in the same manner as residential groundwater ingestion. Construction workers were assumed to have negligible dermal contact exposure with groundwater and were not assumed to shower on-site.

4.0 TOXICITY ASSESSMENT

The toxicity assessment presents the general toxicological properties of the selected chemicals of potential concern using the most current toxicological human health effects data. Toxicity profiles for each of the chemicals of potential concern are presented in Appendix B.

Each chemical can produce a wide variety of human health effects. While only certain chemicals can produce potentially carcinogenic effects, all chemicals have the potential to produce noncarcinogenic effects, depending on the type and duration of exposure. The USEPA has developed a qualitative weight-of-evidence classification system in which available data for a chemical are evaluated to determine the likelihood that the agent is a human carcinogen. Evidence is characterized separately for human and animal studies as sufficient, limited, or inadequate evidence, no data, or evidence of no effect. The characterizations of these two types of data are combined and the chemical is given a provisional weight-of-evidence classification based on the extent to which the agent has been shown to be carcinogenic in experimental animals, humans, or both. Supporting evidence of carcinogenicity may adjust the provisional weight-of-evidence classification up or down. The USEPA weight-of-evidence classification system for carcinogenicity, as discussed in Section 2.3, is described again below for the purposes of clarity.

<u>GROUP</u>	<u>DESCRIPTION</u>
A	Human Carcinogen.
B1	Probable Human Carcinogen. Limited human data are available.
B2	Probable Human Carcinogen. Sufficient evidence of carcinogenicity in animals and inadequate or no evidence in

C	humans.
D	Possible Human Carcinogen.
E	Not Classifiable as to human carcinogenicity.
	Evidence of noncarcinogenicity for humans.

Two measurements used to quantify the toxic effects of a chemical on human health include a chemical's carcinogenic slope factor (SF) and noncarcinogenic reference dose (RfD). Many of the carcinogenic slope factors and reference doses (including reference concentrations which are often converted to reference doses) used in this assessment were obtained from USEPA's IRIS data base. IRIS is an on-line data base which is updated monthly. It provides chemical-specific risk data that represent a USEPA scientific consensus. The quantitative risk values and supporting explanations in IRIS have been reviewed and agreed upon by scientists across the USEPA using available studies on a chemical. Slope factors and reference doses/concentrations not available on IRIS were obtained from the USEPA's second most current source of toxicity information, the Health Effects Assessment Summary Tables (HEAST) FY 1994-Annual (USEPA, 1994). Per HEAST direction, toxicity information for certain chemicals was obtained from the Superfund Health Risk Technical Support Center (See Tables 4-1 and 4-2).

4.1 Health Effects Criteria for Carcinogens

Generally, a slope factor is a plausible upper-bound estimate of the probability of a response per unit intake of a chemical over a lifetime. In risk assessment, a slope factor is used to estimate an upper-bound probability of an individual developing cancer as a result of a lifetime of exposure to a particular level of a potential carcinogen. Slope factors are calculated by the USEPA's Carcinogen Assessment Group (CAG) and are verified by the USEPA's Carcinogen

TUTU WELLS SITE
TOXICITY VALUES FOR POTENTIAL CARCINOGENIC HEALTH EFFECTS
DOSE - RESPONSE RELATIONSHIP (1)

CHEMICALS	CARCINOGENS: SLOPE FACTORS (SF)		
	Oral SF (mg/kg-day) ⁻¹	Inhalation SF (mg/kg-day) ⁻¹	Weight-of- Evidence
<i>Volatile Organics</i>			
Acetone	-	-	D
Benzene	2.9E-02	2.9E-02	A
Bromodichloromethane	6.2E-02	-	B2
Bromoform	7.9E-03	3.9E-03	B2
Bromomethane	-	-	D
2-Butanone	-	-	D
Carbon Disulfide	-	-	-
Chlorobenzene	-	-	D
Chloroform	6.1E-03	8.1E-02	B2
Chloromethane	1.3E-02 (2)	6.3E-03 (2)	C
Dibromochloromethane	8.4E-02	-	C
1,1-Dichloroethane	-	-	C
1,2-Dichloroethane	9.1E-02	9.1E-02	B2
1,1-Dichloroethene	6.0E-01	1.8E-01	C
cis 1,2-Dichloroethene	-	-	D
1,2-Dichloroethene (Total)	-	-	-
Ethylbenzene	-	-	-
2-Hexanone	-	-	-
Methyl-tert-Butyl-Ether	-	-	-
4-Methyl-2-Pentanone	-	-	-
Methylene Chloride	7.5E-03	1.6E-03	B2
n-Propylbenzene	-	-	-
Tetrachloroethene	5.2E-02 (3)	2.0E-03 (3)	C-B2
Toluene	-	-	D
1,1,1-Trichloroethane	-	-	D
1,1,2-Trichloroethane	5.7E-02	5.6E-02	C
Trichloroethene	1.1E-02 (3)	6.0E-03 (3)	B2
Vinyl Chloride	1.9E+00 (2)	3.0E-01 (2)	A
Xylenes (Total)	-	-	D
<i>Semivolatile Organics</i>			
Acenaphthene	-	-	-
Acenaphthylene	-	-	D
Anthracene	-	-	D
Benzoic Acid	-	-	D
Benzo(a)anthracene	7.3E-01*	-	B2
Benzo(a)pyrene	7.3E+00	-	B2
Benzo(b)fluoranthene	7.3E-01*	-	B2
Benzo(g,h,i)perylene	-	-	D
Benzo(k)fluoranthene	7.3E-02*	-	B2
Bis(2-chloroethyl)ether	1.1E+00	1.1E+00	B2
Bis(2-ethylhexyl)phthalate	1.4E-02	-	B2
Butylbenzylphthalate	-	-	C

TUTU WELLS SITE
TOXICITY VALUES FOR POTENTIAL CARCINOGENIC HEALTH EFFECTS
DOSE - RESPONSE RELATIONSHIP (1)

CHEMICALS	CARCINOGENS: SLOPE FACTORS (SF)		
	Oral SF (mg/kg-day) ⁻¹	Inhalation SF (mg/kg-day) ⁻¹	Weight-of- Evidence
Semivolatile Organics (Cont'd)			
Carbazole	2.0E-02 (2)	-	B2
Chrysene	7.3E-03*	-	B2
Di-n-butylphthalate	-	-	D
Di-n-octylphthalate	-	-	-
Dibenzofuran	-	-	D
1,2-Dichlorobenzene	-	-	D
1,4-Dichlorobenzene	2.4E-02 (2)	-	B2
Diethylphthalate	-	-	D
2,4-Dimethylphenol	-	-	-
Dimethylphthalate	-	-	D
Fluoranthene	-	-	D
Fluorene	-	-	D
Indeno(1,2,3-cd)pyrene	7.3E-01*	-	B2
2-Methylnaphthalene	-	-	-
2-Methylphenol	-	-	C
4-Methylphenol	-	-	C
Naphthalene	-	-	D
2-Nitrophenol	-	-	-
Phenanthrene	-	-	D
Phenol	-	-	D
Phthalic Anhydride (TIC)	-	-	-
Pyrene	-	-	D
1,2,4-Trichlorobenzene	-	-	D
Pesticides/PCBs			
Chlordane	1.3E+00	1.3E+00	B2
Endosulfan (4)	-	-	-
PCBs (Aroclors)	7.7E+00	-	B2
Inorganics			
Aluminum	-	-	-
Antimony	-	-	-
Arsenic	1.75E+00	1.5E+01	A
Barium	-	-	-
Beryllium	4.3E+00	8.4E+00	B2
Cadmium	-	6.3E+00	B1
Chromium III	-	-	-
Chromium VI	-	4.2E+01	A
Cobalt	-	-	-
Copper**	-	-	D
Cyanide	-	-	D
Lead (and compounds-inorg.)	-	-	B2
Manganese (water)	-	-	D

TUTU WELLS SITE
TOXICITY VALUES FOR POTENTIAL CARCINOGENIC HEALTH EFFECTS
DOSE - RESPONSE RELATIONSHIP (1)

CHEMICALS	CARCINOGENS: SLOPE FACTORS (SF)		
	Oral SF (mg/kg-day) ⁻¹	Inhalation SF (mg/kg-day) ⁻¹	Weight-of- Evidence
<i>Inorganics (Cont'd)</i>			
Mercury	-	-	D
Nickel (sol. salt)	-	-	-
Selenium	-	-	D
Silver	-	-	D
Thallium (chloride)	-	-	D
Vanadium	-	-	-
Zinc (and compounds)	-	-	D

NOTES:

- Calcium, iron, magnesium, potassium, and sodium are considered essential nutrients and will not be quantitatively evaluated in the risk assessment.

*Relative Potency Values were used in conjunction with slope factors per USEPA Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons (July 1993).

**The current drinking water standard for copper is 1.3 mg/l. The DWCD (1987) concluded that toxicity data are inadequate for calculation of a reference dose for this chemical.

(1) All toxicity values obtained from IRIS (on-line June 22 and 30, 1994, July 1, 1994, August 4, 1994, and December 6, 1994) unless otherwise noted.

(2) Toxicity values obtained from HEAST Annual FY-1994.

(3) Toxicity values were originally obtained from the Superfund Health Risk Technical Support Center, September 27, 1993. These values were confirmed by the USEPA Risk Assessment Specialist.

(4) The endosulfan toxicity values are reported, as none are available for the endosulfan I isomer.

USEPA WEIGHT - OF - EVIDENCE:

A - Human Carcinogen.

B1 - Probable Human Carcinogen. Limited human data are available.

B2 - Probable Human Carcinogen. Sufficient evidence of carcinogenicity 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.

TABLE 4-2

TUTU WELLS SITE
CHRONIC TOXICITY VALUES FOR POTENTIAL NONCARCINOGENIC HEALTH EFFECTS
DOSE - RESPONSE RELATIONSHIP (1)

CHEMICALS	NONCARCINOGENS: REFERENCE DOSES (RID)			
	Oral RID (mg/kg-day)	Uncertainty Factor	Inhalation RID (mg/kg-day)	Uncertainty Factor
Volatile Organics				
Acetone	1.0E-01	1000	-	-
Benzene	-	-	-	-
Bromodichloromethane	2.0E-02	1000	-	-
Bromoform	2.0E-02	1000	-	-
Bromomethane	1.4E-03	1000	1.4E-03	100
2-Butanone	6.0E-01	3000	2.9E-01	1000
Carbon Disulfide	1.0E-01	100	2.9E-03 (2)	1000
Chlorobenzene	2.0E-02	1000	5.7E-03 (3)	10000
Chloroform	1.0E-02	1000	-	-
Chloromethane	-	-	-	-
Dibromochloromethane	2.0E-02	1000	-	-
1,1-Dichloroethane	1.0E-01 (2)	1000	1.4E-01 (3)	1000
1,2-Dichloroethane	-	-	-	-
1,1-Dichloroethene	9.0E-03	1000	-	-
cis 1,2-Dichloroethene	1.0E-02 (2)	3000	-	-
1,2-Dichloroethene (Total)	9.0E-03 (2)	1000	-	-
Ethylbenzene	1.0E-01	1000	2.9E-01	300
2-Hexanone	-	-	-	-
Methyl-tert-Butyl-Ether	-	-	9.0E-01	100
4-Methyl-2-Pentanone	8.0E-02 (2)	3000	2.3E-02 (3)	1000
Methylene Chloride	6.0E-02	100	8.6E-01 (2)	100
n-Propylbenzene	-	-	-	-
Tetrachloroethene	1.0E-02	1000	-	-
Toluene	2.0E-01	1000	1.1E-01	300
1,1,1-Trichloroethane	-	-	-	-
1,1,2-Trichloroethane	4.0E-03	1000	-	-
Trichloroethene	6.0E-03 (4)	3000	-	-
Vinyl Chloride	-	-	-	-
Xylenes (Total)	2.0E+00	100	-	-
Semivolatile Organics				
Acenaphthene	6.0E-02	3000	-	-
Acenaphthylene	-	-	-	-
Anthracene	3.0E-01	3000	-	-
Benzoic Acid	4.0E+00	1	-	-
Benzo(a)anthracene	-	-	-	-
Benzo(a)pyrene	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-
Benzo(g,h,i)perylene	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-
Bis(2-chloroethyl)ether	-	-	-	-
Bis(2-ethylhexyl)phthalate	2.0E-02	1000	-	-
Butylbenzylphthalate	2.0E-01	1000	-	-
Carbazole	-	-	-	-

TABLE 4-2

TUTU WELLS SITE
CHRONIC TOXICITY VALUES FOR POTENTIAL NONCARCINOGENIC HEALTH EFFECTS
DOSE - RESPONSE RELATIONSHIP (1)

CHEMICALS	NONCARCINOGENS: REFERENCE DOSES (RfD)			
	Oral RfD (mg/kg-day)	Uncertainty Factor	Inhalation RfD (mg/kg-day)	Uncertainty Factor
Semivolatile Organics (Cont'd)				
Chrysene	-	-	-	-
Di-n-butylphthalate	1.0E-01	1000	-	-
Di-n-octylphthalate	2.0E-02 (2)	1000	-	-
Dibenzofuran	-	-	-	-
1,2-Dichlorobenzene	9.0E-02	1000	5.7E-02 (3)	1000
1,4-Dichlorobenzene	-	-	2.3E-01	100
Diethylphthalate	8.0E-01	1000	-	-
2,4-Dimethylphenol	2.0E-02	3000	-	-
Dimethylphthalate	1.0E+01 (2)	100	-	-
Fluoranthene	4.0E-02	3000	-	-
Fluorene	4.0E-02	3000	-	-
Indeno(1,2,3-cd)pyrene	-	-	-	-
2-Methylnaphthalene	-	-	-	-
2-Methylphenol	5.0E-02 (4)	1000	-	-
4-Methylphenol	5.0E-03 (2)	1000	-	-
2-Nitrophenol	-	-	-	-
Naphthalene	4.0E-02 (4)	1000	-	-
Phenanthrene	-	-	-	-
Phenol	6.0E-01	100	-	-
Phthalic Anhydride (TIC)	2.0E+00	1000	3.4E-02 (2)	300
Pyrene	3.0E-02	3000	-	-
1,2,4-Trichlorobenzene	1.0E-02	1000	5.7E-02 (2)	1000
Pesticides/PCBs				
Chlordane	6.0E-05	1000	-	-
Endosulfan	6E-03 (2)	100	-	-
PCBs (Aroclors)	-	-	-	-
Inorganics				
Aluminum	-	-	-	-
Antimony	4.0E-04	1000	-	-
Arsenic	3.0E-04	3	-	-
Barium	7.0E-02	3	1.4E-04 (3)	1000
Beryllium	5.0E-03	100	-	-
Cadmium (food)	1.0E-03	10	-	-
Cadmium (water)	5.0E-04	10	-	-
Chromium III	1.0E+00	100	-	-
Chromium VI	5.0E-03	500	-	-
Cobalt	-	-	-	-
Copper*	-	-	-	-
Cyanide	2.0E-02	100	-	-
Lead (and compounds-inorg.)	-	-	-	-

TABLE 4-2

TUTU WELLS SITE
CHRONIC TOXICITY VALUES FOR POTENTIAL NONCARCINOGENIC HEALTH EFFECTS
DOSE - RESPONSE RELATIONSHIP (1)

CHEMICALS	NONCARCINOGENS: REFERENCE DOSES (RfD)			
	Oral RfD (mg/kg-day)	Uncertainty Factor	Inhalation RfD (mg/kg-day)	Uncertainty Factor
<i>Inorganics</i>				
Manganese (water)	5.0E-03	1	1.4E-05	1000
Mercury	3.0E-04 (2)	1000	8.6E-05 (2)	30
Nickel (sol. salt)	2.0E-02	300	-	-
Selenium	5.0E-03	3	-	-
Silver	5.0E-03	3	-	-
Thallium (chloride)	8.0E-05	3000	-	-
Vanadium	7.0E-03 (2)	100	-	-
Zinc (and compounds)	3.0E-01	3	-	-

NOTES:

- Calcium, iron, magnesium, potassium, and sodium are considered essential nutrients and will not be quantitatively evaluated in the risk assessment.

*The current drinking water standard for copper is 1.3 mg/l. The DWCD (1987) concluded that toxicity data are inadequate for calculation of a reference dose for this chemical.

(1) All toxicity values obtained from IRIS (on-line June 22 and 30, 1994, July 1, 1994, August 4, 1994, and December 6, 1994) unless otherwise noted.

(2) Toxicity values obtained from HEAST Annual FY-1994.

(3) Toxicity values obtained from HEAST Annual FY-1994: Toxicity values are found in USEPA documents but were calculated by alternative methods not currently practiced by the RfD Work Group.

(4) Toxicity values were originally obtained from the Superfund Health Risk Technical Support Center, September 27, 1993. These values were confirmed by the USEPA Risk Assessment Specialist.

(5) The endosulfan toxicity values are reported, as none are available for the endosulfan I isomer.

USEPA WEIGHT - OF - EVIDENCE:

A - Human Carcinogen

B1 - Probable Human Carcinogen. Limited human data are available.

B2 - Probable Human Carcinogen. Sufficient evidence of carcinogenicity 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.

Risk Assessment Verification Endeavor (CRAVE) Workgroup. Slope factors for the potential carcinogenic chemicals of concern are presented in Table 4-1. Oral and inhalation unit risk estimates were converted to slope factors, per HEAST and USEPA Region II guidance, by multiplying by 70 kg (assumed human body weight), dividing by 20 m³/day (assumed human inhalation rate) or by 2 liters/day (assumed human water consumption rate) and multiplying by 1000 ug/mg (conversion factor). The slope factor, which is usually the upper 95th percent confidence limit of the slope of the dose-response curve, is expressed in (mg/kg/day)⁻¹. It represents the probability of an individual developing cancer as a result of chronic exposure to a given carcinogenic chemical over a lifetime of 70 years. A risk of 10⁻⁶ indicates that the probability of an individual developing cancer from a given exposure is unlikely to exceed one in one million (10⁶).

In several instances, when slope factors were not available for specific chemicals, the slope factor for one isomer or chemical within a chemical class was used to represent the slope factor for all other isomers or chemicals in the same class (i.e., PAHs and PCBs). For several carcinogenic PAHs, the benzo(a)pyrene slope factor was used in conjunction with relative potency values to develop slope factors for benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, and indeno(1,2,3-cd)pyrene, in accordance with provisional CERCLA USEPA Region II guidance.

Although it is known that PCB congeners vary greatly as to their potency in producing biological effects, the USEPA has not developed slope factors for most of the PCB congeners. For the

purposes of this risk assessment, the oral slope factor for Aroclor 1260 was used to represent the oral toxicity of Aroclor 1242, the only PCB detected at the site. Since benzo(a)pyrene and Aroclor 1260 are more toxic than some of the other PAH and PCB congeners, these procedures may overestimate the risks and hazards generated as part of this assessment and are, therefore, a source of uncertainty in this risk assessment.

4.2 Health Effects Criteria for Noncarcinogens

The determination of the potential health hazards associated with exposure to noncarcinogens was made by comparing the estimated chronic or subchronic daily intake of a chemical with the reference dose. Various reference doses are available depending on the exposure route, the critical effect, and the length of exposure evaluated in the scenario. For this assessment, both chronic and subchronic oral and inhalation reference doses (RfDs) were used. It should be noted that inhalation RfDs were developed by converting a concentration in air (mg/m^3) to a corresponding inhaled dose ($\text{mg}/\text{kg}\cdot\text{day}$) by dividing by 70 kg (assumed human body weight) and multiplying by 20 m^3/day (assumed human inhalation rate) per HEAST and USEPA Region II direction. Tables 4-2 and 4-3 present these values along with their uncertainty factors. It should be noted for the chemicals benzene, vinyl chloride, bis(2-ethylhexyl)phthalate, and hexavalent chromium that the Superfund Health Risk Technical Support Center was contacted directly per HEAST direction on August 5, 1994 for subchronic toxicity values. These values are reported in Table 4-3.

TUTU WELLS SITE
SUBCHRONIC TOXICITY VALUES FOR POTENTIAL NONCARCINOGENIC HEALTH EFFECTS
DOSE - RESPONSE RELATIONSHIP (1)

CHEMICALS	NONCARCINOGENS: SUBCHRONIC REFERENCE DOSES (RfD)			
	Oral RfD (mg/kg-day)	Uncertainty Factor	Inhalation RfD (mg/kg-day)	Uncertainty Factor
<i>Volatile Organics</i>				
Benzene	-	-	1.7E-02 (2)	100
1,2-Dichloroethene (Total)	9.0E-03	1000	-	-
Tetrachloroethene	1.0E-01	100	-	-
Toluene	2.0E+00	100	2.9E-01 (2)	300
Vinyl Chloride	- (2)	-	- (2)	-
<i>Semivolatile Organics</i>				
Benzo(a)pyrene	-	-	-	-
<i>Pesticides/PCBs</i>				
PCBs (Aroclors)	-	-	-	-
<i>Inorganics</i>				
Antimony	4.0E-04	1000	-	-
Arsenic	3.0E-04	3	-	-
Beryllium	5.0E-03	100	-	-
Chromium VI (insol. salt)	2.0E-02	100	1.1E-06 (2)	100
Manganese (water)	5.0E-03	1	1.1E-04	900
Nickel (sol. salt)	2.0E-02	300	-	-
Vanadium	7.0E-03	100	-	-

NOTES:

- Calcium, iron, magnesium, potassium, and sodium are considered essential nutrients and are not quantitatively evaluated in the risk assessment.

(1) Toxicity values were obtained from HEAST Annual FY-1994.

(2) Toxicity values were obtained from the Superfund Health Risk Technical Support Center - June 9, 1994 and August 9, 1994.

USEPA WEIGHT - OF - EVIDENCE:

A - Human Carcinogen

B1 - Probable Human Carcinogen. Limited human data are available.

B2 - Probable Human Carcinogen. Sufficient evidence of carcinogenicity 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.

A chronic reference dose is defined as an estimate (with uncertainty spanning possibly an order of magnitude or greater) of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime. The chronic reference doses derived by the USEPA's Reference Dose Workgroup are specifically developed to be protective for long-term exposure to a chemical. In general, chronic reference doses are used to evaluate the potential noncarcinogenic effects associated with exposure periods between seven years (approximately ten percent of a human lifetime) and a lifetime. Subchronic reference doses, which are useful in characterizing potential noncarcinogenic effects associated with shorter-term exposures, may generally be used to evaluate the potential noncarcinogenic effects of exposure periods between two weeks and approximately seven years. In this risk assessment, exposures of six years and greater were considered chronic while exposures of less than six years were considered subchronic. Per USEPA direction, a six year exposure is at the upper-bounds of subchronic exposure and therefore chronic toxicity values are more appropriately used.

For many noncarcinogenic effects, it is believed that protective mechanisms exist which must be overcome before an adverse effect is manifested. For example, when a large number of cells perform the same or similar function, a significant number of the cells may have to be depleted before an effect is seen. Therefore, there is a range of exposures between zero and some finite value that can be tolerated by the organism with essentially no chance of expression of adverse effects.

Oral and inhalation chronic reference doses are derived from the no-observed-adverse-effect-level (NOAEL) or the lowest-observed-adverse-effect-level (LOAEL) for the critical toxic effect by application of uncertainty factors (UFs) and a modifying factor (MF-oral only). Subchronic reference doses are derived from subchronic NOAELs by application of UFs and MFs as done for chronic reference doses. The distinction between the two RfDs lies with exposure duration which is shorter for subchronic studies.

Uncertainty related to toxicity information will be discussed in Section 6.0 Uncertainties in Risk Assessment.

4.2.1 Toxicity Endpoints/Target Organs for Noncarcinogenic Chemicals of Potential Concern Quantitatively Evaluated in the Risk Assessment

Table 4-4 presents the available toxicity endpoints (i.e., target organs) for the noncarcinogenic chemicals of potential concern which have been quantitatively evaluated in this risk assessment, and show hazard quotients above 1. Per the RAGS (USEPA, 1989a) guidance, in the calculation of the hazard index (see Section 5.2 for a detailed discussion of hazard index), limitations exist which include the following: 1) the level of concern does not increase linearly as the reference dose is approached or exceeded since reference doses do not have equal accuracy or precision and are not based on the same severity of effect; 2) hazard quotients are often combined for substances with reference doses based on critical effects of varying toxicological significance; 3) reference doses of varying levels of confidence that include different uncertainty adjustments

TUTU WELLS SITE
TOXICITY ENDPOINTS/TARGET ORGANS FOR NONCARCINOGENIC CHEMICALS OF POTENTIAL CONCERN
QUANTITATIVELY EVALUATED IN THE RISK ASSESSMENT

CHEMICALS	TOXICITY ENDPOINT/TARGET ORGAN*
1,2-Dichloroethene (Total)	Liver
Tetrachloroethene	Liver
Antimony	Blood
Manganese	Central Nervous System
Vanadium	Respiratory Tract

MATRIX	EXPOSURE ROUTE	RECEPTOR	HAZARD INDEX	HAZARD INDEX BY TOXICITY ENDPOINT/TARGET ORGAN
<i>Surface Soil:</i> (Tillett Gardens and Art Center)	Ingestion	Residents: Children	3.0	Manganese - 2.2
	Inhalation of Particulates	Children	3.1	Manganese - 3.1
<i>Groundwater:</i> (Site-Wide)	Ingestion	Residents: Adults	29	1,2-Dichloroethene (Total) - 1.2 Manganese - 26
	Ingestion	Children	67	1,2-Dichloroethene (Total) - 2.8 Tetrachloroethene - 1.3 Antimony - 1.6 Manganese - 60 Vanadium - 1.0
	Ingestion	Site Workers	10	Manganese - 9.2
	Ingestion	Construction Workers	9.1	Manganese - 8.2

*Sources: Integrated Risk Information System (IRIS) on-line June-August 1994, HEAST FY 1994 - Annual, and Klaassen et al., (1986).

and modifying factors (i.e., extrapolation from animals to humans, from LOAELS to NOAELS, and from one exposure duration to another) and, 4) application of the hazard index equation to chemicals not expected to induce the same type of effects or that do not act by the same mechanism may overestimate the potential for adverse health effects.

If the hazard index is greater than one due to the summing of several hazard quotients of similar value, segregation of the hazard index by critical effect and mechanism of action is performed. Upon review of the hazard indices calculated in this risk assessment in Section 5.0 and presented in Appendix C, it was observed that six hazard index values exceeded one including surface soil ingestion and inhalation by children in the Tillett Gardens and Art Center, and groundwater ingestion by residents (adults and children), site workers (employees), and construction workers. Table 4-4 also presents the breakout of the hazard indices exceeding one by chemical. It should be noted that two chemicals in Table 4-4 have the same toxicity endpoint/target organ (liver), 1,2-dichloroethene (total) and tetrachloroethene. For surface soil ingestion by children in the Tillett Gardens and Art Center, the hazard index of 3.0 is due mainly to manganese with a smaller contribution from arsenic. While the manganese hazard quotient exceeds one (2.2), the arsenic hazard quotient (0.43) does not. The toxicity endpoint for manganese, as shown on Table 4-4, is the central nervous system while the toxicity endpoint for arsenic is the skin. For surface soil inhalation by children in the Tillett Gardens and Art Center, the hazard index of 3.1 is due entirely to manganese.

For groundwater ingestion by adults, the hazard index of 29 is due mainly to 1,2-dichloroethene (total) and manganese which have individual hazard quotients above one. Although the hazard quotient for 1,2-dichloroethene (total) only slightly exceeds one (1.2), the manganese hazard quotient of 26 is well above the target value. As shown in the table, 1,2-dichloroethene (total) and manganese have different toxicity endpoints. For groundwater ingestion by children, the hazard index of 67 is due in large part to 1,2-dichloroethene (total), tetrachloroethene, antimony, and manganese which have individual hazard quotients above one. Vanadium has an individual hazard quotient of one. As shown in the table, two of the five chemicals have the same toxicity endpoint (liver).

For groundwater ingestion by site workers, the hazard index of 10 is due in large part to manganese with a smaller contribution from 1,2-dichloroethene (total). While the manganese hazard quotient exceeds one (9.2), the 1,2-dichloroethene (total) hazard quotient (0.42) does not. Table 4-4 shows that these two chemicals have different toxicity endpoints.

For groundwater ingestion by construction workers, the hazard index of 9.1 is due mainly to manganese with a smaller contribution from 1,2-dichloroethene (total). While the manganese hazard quotient exceeds one (8.2), the 1,2-dichloroethene (total) hazard quotient (0.38) does not. As presented in the table, these two chemicals have different toxicity endpoints.

4.3 Qualitative Discussion of Chemicals Not Quantitatively Evaluated in the Risk Assessment

Numerous VOCs, SVOCs, and inorganics could not be quantitatively evaluated in this risk assessment due to the lack of established toxicity values. This section presents brief toxicological profiles for these chemicals.

benzo(g,h,i)perylene - This chemical is a PAH and is currently classified in Group D - Not Classifiable as to human carcinogenicity (USEPA, 1992b). PAHs are a ubiquitous class of chemicals formed during the combustion of fossil fuels (Klaassen et al., 1986). Little information is available regarding nonmalignant changes due to PAH exposure although liver and kidney effects may occur (Clement Associates, Inc., 1985).

2-hexanone - This chemical is an industrial solvent which causes neurotoxicity in chronically exposed workers. 2-Hexanone may also be involved in the potentiation of hepatotoxicity. (Klaassen et al., 1986).

dibenzofuran - Dibenzofurans may cause adverse health effects in man due to their high toxicity (Klaassen et al., 1986). This chemical has been given a Group D weight-of-evidence classification (IRIS, 1994).

2-nitrophenol - Little specific toxicity information for this chemical has been located in the literature. Nitrophenol may cause liver and kidney damage in experimental animals (Clement Associates, Inc., 1985).

1,1,1-trichloroethane - This chemical may induce liver tumors in female mice and may be mutagenic. Inhalation of high concentrations of 1,1,1-trichloroethane by animals and humans may depress the central nervous system, affect the cardiovascular system, and damage the lungs, liver and kidneys. Human exposure may also result in irritation of the skin and mucous membranes. (Clement Associates, Inc., 1985). This chemical has been given a Group D weight-of-evidence classification (IRIS, 1994).

n-propylbenzene - This chemical, also known as 1-phenylpropane, is used for dyeing and printing textiles (Merck Index, 1989). The primary effects resulting from exposure to alkylbenzenes include narcosis, central nervous system anomalies, and irritation, especially of the mucous membranes (Clement Associates, Inc., 1985).

total petroleum hydrocarbons (TPHs) - TPHs are components of gasoline. Human exposure to TPHs may result in a variety of health effects ranging from membrane irritation and vomiting to death. A full toxicological profile for TPHs is presented in Appendix B Toxicological Profiles.

methyl-tertiary-butyl-ether - Methyl-tertiary-butyl-ether may be mixed into gasoline to reduce air pollution. Human exposure to methyl-tertiary-butyl-ether may result in a variety of health effects including headaches, nausea, dizziness, and nose and throat irritation (ATSDR, 1994). A full toxicological profile for this chemical is presented in Appendix B Toxicological Profiles.

2-methylnaphthalene - This chemical is a PAH which has not currently been given a weight-of-evidence classification. No specific toxicity information for this chemical has been located in the literature.

acenaphthylene - This chemical is a PAH and is currently classified in Group D - Not Classifiable as to human carcinogenicity (IRIS, 1994). Little specific toxicity information for this chemical has been located in the literature, although it is thought to be a skin irritant (Clement Associates, Inc., 1985).

phenanthrene - This PAH has been given a Group D weight-of-evidence classification (IRIS, 1994). Although limited information is available regarding nonmalignant changes due to PAH exposure, generally, liver and kidney effects may occur (Clement Associates, Inc., 1985).

aluminum - This chemical is ubiquitous in the environment. It may affect the absorption of other elements in the gastrointestinal tract and may alter intestinal function. There has been increasing interest in the possible relationship of aluminum to dementia in humans. (Wills and Savory, 1983 and Klaassen et al., 1986).

cobalt - This chemical is a component of vitamin B₁₂ required for the production of red blood cells and prevention of pernicious anemia. Ingestion of excessive amounts of cobalt in humans may cause polycythemia. High levels of chronic oral administration may result in goiter. Occupational inhalation of cobalt salts may result in respiratory symptoms (Klaassen et al., 1986).

copper - This chemical is an essential element widely distributed in nature. Acute poisoning from ingestion of excessive amounts of oral copper salts may produce death. Symptoms include vomiting, hematemesis, hypotension, melena, coma, and jaundice. (Klaassen et al., 1986). This chemical has been given a Group D weight-of-evidence classification (IRIS, 1994). A full toxicological profile for this chemical is located in Appendix B Toxicological Profiles.

iron - This chemical is an essential element (Klaassen et al., 1986). The ingestion of excessive amounts of this chemical can irritate the gastrointestinal tract. Inhaling some iron containing dusts and fumes can cause siderosis, a type of benign pneumoconiosis (Clement Associates, Inc., 1985).

lead - A full toxicological profile for this chemical is located in Appendix B Toxicological Profiles due to the extensive amount of information available and its Group B2 weight-of-evidence classification.

The inability to quantitatively evaluate these chemicals (and other essential nutrients) is a source of uncertainty in this risk assessment as the potential of underestimation of risks or health impacts exists. Uncertainty related to chemical toxicity data is addressed further in Section 6.0 Uncertainties in Risk Assessment.

5.0 RISK CHARACTERIZATION

The characterization of potential carcinogenic risks and noncarcinogenic health effects estimates associated with the "no action" alternative are presented for the exposure pathways identified in Section 3.2. The spreadsheet calculations which present quantitative estimates of carcinogenic risks and noncarcinogenic health effects are presented in Appendix C. Applicable or Relevant and Appropriate Requirements (ARARs) are discussed for those chemicals contributing the greatest amount to carcinogenic risks and noncarcinogenic hazard indices in groundwater.

5.1 Carcinogenic Risk Characterization

For carcinogens, risks are estimated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to a potential carcinogen (i.e., incremental or excess individual lifetime cancer risk).

Per RAGS (USEPA, 1989a), the slope factor converts estimated daily intakes averaged over a lifetime of exposure directly to incremental risk of an individual developing cancer. Since the slope factor is often an upper 95th percentile confidence limit of the probability of response based on experimental animal data used in the multistage model, the carcinogenic risk estimate will generally be an upper-bound estimate. This means that the USEPA is reasonably confident that the "true risk" will not exceed the risk estimate derived through use of this model and is likely to be less than that predicted. Since relatively low intakes (in comparison to those experienced

by test animals) are most likely from environmental exposures at Superfund sites, the USEPA assumes that the dose-response relationship is linear in the low dose portion of the multistage model dose-response curve. Under this assumption, the slope factor is constant and risk will be directly related to intake. Therefore, the linear form of the carcinogenic risk equation, as presented below, was used to estimate risk.

$$\text{Risk} = \text{CDI} \times \text{SF}$$

Where:

Risk = a unitless probability of an individual developing cancer;

CDI = chronic daily intake averaged over 70 years (mg/kg-day);

SF = slope factor expressed in (mg/kg-day)⁻¹

5.2 Noncarcinogenic Effects Characterization

The potential for noncarcinogenic effects is evaluated by comparing an exposure level over a specified time period with a reference dose derived for a similar exposure period. This ratio of exposure to toxicity is referred to as a hazard quotient; the sum of the individual hazard quotients is referred to as a hazard index. The formula for the hazard index is presented below.

$$\text{Noncancer Hazard Index} = E_1/\text{RfD}_1 + E_2/\text{RfD}_2 = E_i/\text{RfD}_i$$

Where:

E_i = Exposure Intake (chronic or subchronic) for the i^{th} chemical

RfD = Reference Dose (chronic or subchronic) for the i^{th} chemical

The noncancer hazard quotient assumes that there is a level of exposure (i.e., RfD) below which it is unlikely even for sensitive populations to experience adverse health effects. If the exposure intake exceeds the threshold (i.e., the noncancer hazard quotient exceeds one), there may be concern for potential noncancer effects. Generally, the greater the value of the noncancer hazard quotient above one, the greater the level of concern. However, the ratio should not be interpreted as a statistical probability. It is important to note that the level of concern does not increase linearly as the RfD is approached or exceeded, as RfDs do not have equal accuracy or precision and are not based on the same severity of toxic effects.

If the hazard index exceeds one due to the summing of several hazard quotients, segregation of the hazard index by critical effect or mechanism is performed.

5.3 Quantitative Results of Carcinogenic Risk and Noncarcinogenic Effects Evaluation

In accordance with the National Oil and Hazardous Substance Pollution Contingency Plan (NCP) Section 300.430 (e)(2) for known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper-bound lifetime cancer risk to an individual in the range of 10^{-4} to 10^{-6} . Per RAGS Part B: Development of Risk-Based Preliminary Remediation Goals (USEPA, 1991b), for noncarcinogenic effects, the NCP does not specify a range, but it is generally appropriate to assume a hazard index equal to one.

In general, the USEPA recommends a target range and a target level (i.e., carcinogenic risk = 10^{-4} to 10^{-6} or noncarcinogenic hazard index = 1) as threshold values for potential human health impacts (USEPA, 1989a). The 10^{-4} to 10^{-6} target risk range may be interpreted as meaning

carcinogenic risks should not be greater than approximately 1 in 10,000 to 1 in 1,000,000. For this site, the upper-bound of the target risk range, as discussed with the USEPA, is $1.0E-04$. A risk greater than 1 in 10,000 or $1.0E-04$ is considered to be in exceedance of the USEPA's 10^{-4} to 10^{-6} target risk range. These values aid in determining the objectives of the baseline human health risk assessment which include determining whether additional response action is necessary at the site, by providing a basis for determining residual chemical levels that are adequately protective of human health, by providing a basis for comparing potential health impacts of various remedial alternatives, and to help support selection of the "no action" remedial alternative, where appropriate.

Tables C-1 through C-36 in Appendix C present the results of carcinogenic risk and noncarcinogenic health effects calculations for the environmental matrices and human receptors quantitatively evaluated in this risk assessment.

5.3.1 Surface Soil

The results of carcinogenic risk and noncarcinogenic hazard index calculations for present and potential future resident (adult and child) and site worker exposures and potential future construction worker exposure to surface soil for the Tillett Gardens and Art Center, Fire Department/Texaco gas station/Antilles auto parts/Ramsay motor co., Curriculum Center Building, and O'Henry dry cleaners and Liquor Barn areas of concern are presented in Tables C-1 through C-18. Surface soil exposure at the Esso gas station and Splash and Dash car wash area was not evaluated since the properties are completely paved (i.e., no exposure is occurring).

Residents (Tillett Gardens and Art Center): The results of carcinogenic risk and noncarcinogenic hazard index calculations for present and/or potential future residents in the Tillett Gardens and Art Center area are presented in Tables C-1 through C-3.

Table C-1, present and potential future residential surface soil ingestion in the Tillett Gardens and Art Center area, shows total carcinogenic risks for adults and children of $4.4\text{E-}04$ and $1.0\text{E-}03$, respectively. Both risks exceed the upper-bound of the USEPA's 10^{-4} to 10^{-6} target risk range. Aroclor 1242, which shows risks of $4.3\text{E-}04$ for adults and $1.0\text{E-}03$ for children, is responsible for nearly the entire risk in adults and the entire risk in children. The 30-year combined risk for adults and children, $1.5\text{E-}03$, also exceeds the upper-bound of the USEPA's target risk range for the site and is due almost entirely to Aroclor 1242.

The hazard index values for present and potential future adult and child surface soil ingestion in the Tillett Gardens and Art Center area are $3.2\text{E-}01$ and $3.0\text{E+}00$, respectively. The hazard index value for children only exceeds the USEPA's target level of one. Manganese shows a hazard quotient of $2.2\text{E+}00$ and contributes greater than 73 percent to the hazard. No other chemicals show hazard quotients in exceedance of one. The 30-year combined hazard index for adults and children, $3.3\text{E+}00$, also exceeds the USEPA's target level of one and is due largely to manganese.

Table C-2, present and potential future residential dermal contact with surface soil in the Tillett Gardens and Art Center area, shows total carcinogenic risks for adults and children of $1.3\text{E-}03$ and $3.9\text{E-}04$, respectively. Both risks exceed the upper-bound of the USEPA's 10^{-4} to 10^{-6} target risk range. Aroclor 1242 is responsible for the entire risk in both cases. The 30-year combined

risk for adults and children, $1.7\text{E-}03$, exceeds the upper-bound of the USEPA's target risk range and is due entirely to Aroclor 1242.

For present and potential future residential dermal contact with surface soil in the Tillett Gardens and Art Center area, neither adult nor child hazard index values could be calculated as no chronic oral reference dose is currently established for Aroclor 1242.

Table C-3, potential future residential indoor and outdoor surface soil inhalation in the Tillett Gardens and Art Center area, shows total carcinogenic risks for adults and children $5.5\text{E-}07$ and $6.4\text{E-}07$, respectively. These risks fall outside and below the USEPA's 10^{-4} to 10^{-6} target risk range. The 30-year combined risk for adults and children, $1.2\text{E-}06$, falls within the USEPA's target risk range.

The hazard index values for potential future adult and child indoor and outdoor surface soil inhalation in the Tillett Gardens and Art Center area are $6.7\text{E-}01$ and $3.1\text{E+}00$, respectively. While the adult hazard index falls below the USEPA's target level of one, the child hazard index exceeds this level. Manganese shows a hazard quotient of $3.1\text{E+}00$ for children and is responsible for the entire hazard index. The 30-year combined hazard index for adults and children, $3.8\text{E+}00$, exceeds the USEPA's target level of one and is due entirely to manganese.

Site Workers/Employees (Fire Department/Texaco Gas Station/Antilles Auto Parts/Ramsay Motor Co.): The results of carcinogenic risk and noncarcinogenic hazard index calculations for present and/or potential future site workers (employees) in the Fire Department/Texaco gas station/Antilles auto parts/Ramsay motor co. area are presented in Tables C-4 through C-6.

Table C-4, present and potential future site worker (employee) surface soil ingestion in the Fire Department/Texaco gas station/Antilles auto parts/Ramsay motor co. area, shows a total carcinogenic risk of $1.3\text{E-}06$. This risk falls within the USEPA's 10^{-4} to 10^{-6} target risk range.

The hazard index for present and potential future site worker (employee) surface soil ingestion in the Fire Department/Texaco gas station/Antilles auto parts/Ramsay motor co. area, $9.7\text{E-}02$, falls well below the USEPA's target level of one.

In Table C-5, present and potential future dermal contact with surface soil in the Fire Department/Texaco gas station/Antilles auto parts/Ramsay motor co. area by site workers (employees), neither a carcinogenic risk nor a noncarcinogenic hazard index could be calculated as no chemicals of potential concern have established dermal absorption factors.

Table C-6, potential future site worker (employees) surface soil inhalation in the Fire Department/Texaco gas station/Antilles auto parts/Ramsay motor co. area, shows a total carcinogenic risk of $2.7\text{E-}09$. This risk falls outside and below the USEPA's 10^{-4} to 10^{-6} target risk range.

The hazard index for potential future site worker (employee) surface soil inhalation in the Fire Department/Texaco gas station/Antilles auto parts/Ramsay motor co. area, $2.0\text{E-}01$, falls below the USEPA's target level of one.

Site Workers/Employees (Curriculum Center Building - Present): The results of carcinogenic risk and noncarcinogenic hazard index calculations for present site workers (employees) in the Curriculum Center Building area are presented in Tables C-7 and C-8.

Table C-7, present site worker (employee) surface soil ingestion in the Curriculum Center Building area, shows a total carcinogenic risk of $3.7\text{E-}06$. This risk falls within the USEPA's 10^{-4} to 10^{-6} target risk range.

The hazard index for present site worker (employee) surface soil ingestion in the Curriculum Center Building area, $2.5\text{E-}01$, falls below the USEPA's target level of one.

In Table C-8, present dermal contact with surface soil in the Curriculum Center Building area by site workers (employees), neither a carcinogenic risk nor a noncarcinogenic hazard index could be calculated as no chemicals of potential concern have established dermal absorption factors.

Site Workers/Employees (Curriculum Center Building - Future): The results of carcinogenic risks and noncarcinogenic hazard index calculations for potential future site workers (employees) in the Curriculum Center Building area are presented in Tables C-9 through C-11.

Table C-9, potential future site worker (employee) surface soil ingestion in the Curriculum Center Building area, shows a total carcinogenic risk of $9.1\text{E-}07$. This risk falls outside and below the USEPA's 10^{-4} to 10^{-6} target risk range.

The hazard index for potential future site worker (employee) surface soil ingestion in the Curriculum Center Building area, $2.3E-01$, falls below the USEPA's target level of one.

In Table C-10, potential future dermal contact with surface soil in the Curriculum Center Building area by site workers (employees), neither a carcinogenic risk nor a noncarcinogenic hazard index could be calculated as no chemicals of potential concern have established dermal absorption factors.

Table C-11, potential future site worker (employee) surface soil inhalation in the Curriculum Center Building area, shows a total carcinogenic risk of $4.5E-08$. This risk falls outside and below the USEPA's 10^{-4} to 10^{-6} target risk range.

The hazard index for potential future site worker (employee) surface soil inhalation in the Curriculum Center Building area, $2.1E-01$, falls below the USEPA's target level of one.

Site Workers/Employees (O'Henry Dry Cleaners and Liquor Barn): The results of carcinogenic risk and noncarcinogenic hazard index calculations for present and/or potential future site workers (employees) in the O'Henry dry cleaners and Liquor Barn area are presented in Tables C-12 through C-15.

Table C-12, present and potential future site worker (employee) surface soil ingestion in the O'Henry dry cleaners and Liquor Barn area, shows a total carcinogenic risk of $9.7E-06$. This risk falls within the USEPA's 10^{-4} to 10^{-6} target risk range.

The hazard index for present and potential future site worker (employee) surface soil ingestion in the O'Henry dry cleaners and Liquor Barn area, $1.5\text{E-}01$, falls below the USEPA's target level of one.

In Table C-13, present and potential future dermal contact with surface soil in the O'Henry dry cleaners and Liquor Barn area by site workers (employees), neither a carcinogenic risk nor a noncarcinogenic hazard index could be calculated as no chemicals of potential concern have established dermal absorption factors.

Table C-14, potential future site worker (employee) surface soil inhalation in the O'Henry dry cleaners and Liquor Barn area, shows a total carcinogenic risk of $3.4\text{E-}07$. This risk falls outside and below the USEPA's 10^{-4} to 10^{-6} target risk range.

The hazard index for potential future site worker (employee) surface soil inhalation in the O'Henry dry cleaners and Liquor Barn area, $2.1\text{E-}01$, falls below the USEPA's target level of one.

Table C-15, present and potential future site worker (employee) surface soil inhalation of VOCs in the O'Henry dry cleaners and Liquor Barn area, shows a total carcinogenic risk of $4.9\text{E-}07$. This risk falls outside and below the USEPA's 10^{-4} to 10^{-6} target risk range.

The hazard index for potential future site worker (employee) surface soil inhalation in the O'Henry dry cleaners and Liquor Barn area, $2.1\text{E-}01$, falls below the USEPA's target level of one.

Table C-15, present and potential future site worker (employee) surface soil inhalation of VOCs in the O'Henry dry cleaners and Liquor Barn area, shows a total carcinogenic risk of $4.9\text{E-}07$. This risk falls outside and below the USEPA's 10^{-4} to 10^{-6} target risk range.

A hazard index for present and potential future site worker (employee) surface soil inhalation of VOCs in the O'Henry dry cleaners and Liquor Barn area could not be calculated as tetrachloroethene does not currently have an established chronic inhalation reference dose.

Construction Workers (Tillett Gardens and Art Center): The results of carcinogenic risk and noncarcinogenic hazard index calculations of potential future construction workers in the Tillett Gardens and Art Center area are presented in Tables C-16 through C-18.

Table C-16, potential future construction worker surface soil ingestion in the Tillett Gardens and Art Center area, shows a total carcinogenic risk of $5.7\text{E-}05$. This risk falls within the USEPA's 10^{-4} to 10^{-6} target risk range.

The hazard index for potential future construction worker surface soil ingestion in the Tillett Gardens and Art Center area, $9.9\text{E-}01$, falls below the USEPA's target level of one.

Table C-17, potential future dermal contact with surface soil in the Tillett Gardens and Art Center area by construction workers, shows a total carcinogenic risk of $4.3\text{E-}05$. This risk falls within the USEPA's 10^{-4} to 10^{-6} target risk range.

A hazard index for potential future construction worker dermal contact with surface soil in the Tillett Gardens and Art Center area could not be calculated as a subchronic noncarcinogenic oral reference dose is not currently established for Aroclor 1242.

Table C-18, potential future construction worker surface soil inhalation in the Tillett Gardens and Art Center area, shows a total carcinogenic risk of $6.6E-09$. This risk falls outside and below the USEPA's 10^{-4} to 10^{-6} target risk range.

The hazard index for potential future construction worker surface soil inhalation in the Tillett Gardens and Art Center area, $2.4E-02$, falls well below the USEPA's target level of one.

5.3.2 Subsurface Soil

The results of carcinogenic risk and noncarcinogenic hazard index calculations for potential future resident (adult and child), site worker, and construction worker exposure to subsurface soil for the Tillett Gardens and Art Center, Fire Department/Texaco gas station/Antilles auto parts/Ramsay motor co., Curriculum Center building, Esso gas station and Splash and Dash car wash, and O'Henry dry cleaners and Liquor Barn areas of concern are presented in Tables C-19 through C-31.

Residents (Tillett Gardens and Art Center): The results of carcinogenic risk and noncarcinogenic hazard index calculations for potential future residents in the Tillett Gardens and Art Center area are presented in Tables C-19 and C-20.

In Table C-19, potential future dermal contact with subsurface soil in the Tillett Gardens and Art Center area by residents, neither carcinogenic risk nor noncarcinogenic hazard index values could be calculated as no chemicals of potential concern have established dermal absorption factors.

Table C-20, potential future residential indoor and outdoor subsurface soil inhalation in the Tillett Gardens and Art Center area, shows total carcinogenic risks for adults and children of $3.0\text{E-}08$ and $1.4\text{E-}07$, respectively. These risks fall outside and below the USEPA's 10^{-4} to 10^{-6} target risk range. The 30-year combined risk for adults and children, $1.7\text{E-}07$, also falls outside and below the USEPA's target risk range.

The hazard index values for potential future adult and child indoor and outdoor subsurface soil inhalation in the Tillett Gardens and Art Center area are, $1.9\text{E-}02$ and $9.0\text{E-}02$, respectively. These values fall well below the USEPA's target level of one. The 30-year combined hazard index for adults and children, $1.1\text{E-}01$, also falls below the USEPA's target level.

Site Workers/Employees (Fire Department/Texaco Gas Station/Antilles Auto Parts/Ramsay Motor Co.): The results of carcinogenic risk and noncarcinogenic hazard index calculations for potential future site workers (employees) in the Fire Department/Texaco gas station/Antilles auto parts/Ramsay motor co. area are presented in Tables C-21 and C-22.

In Table C-21, potential future dermal contact with subsurface soil in the Fire Department/Texaco gas station/Antilles auto parts/Ramsay motor co. area by site workers

(employees), neither a carcinogenic risk nor a noncarcinogenic hazard index could be calculated as no chemicals of potential concern have established dermal absorption factors.

Table C-22, potential future site worker (employee) subsurface soil inhalation in the Fire Department/Texaco gas station/Antilles auto parts/Ramsay motor co. area, shows a total carcinogenic risk of $3.8E-10$. This risk falls outside and below the USEPA's 10^{-4} to 10^{-6} target risk range.

The hazard index for potential future site worker (employee) subsurface soil inhalation in the Fire Department/Texaco gas station/Antilles auto parts/Ramsay motor co. area, $7.4E-03$, falls well below the USEPA's target level of one.

Site Workers/Employees (Curriculum Center Building - Future): The results of carcinogenic risk and noncarcinogenic hazard index calculations for potential future site workers (employees) in the Curriculum Center Building area are presented in Tables C-23 and C-24.

In Table C-23, potential future dermal contact with subsurface soil in the Curriculum Center Building area by site workers (employees), neither a carcinogenic risk nor a noncarcinogenic hazard index could be calculated as no chemicals of potential concern have established dermal absorption factors.

Table C-24, potential future site worker (employee) subsurface soil inhalation in the Curriculum Center Building area, shows a total carcinogenic risk of $1.1\text{E-}09$. This risk falls outside and below the USEPA's 10^{-4} to 10^{-6} target risk range.

The hazard index for potential future site worker (employee) subsurface soil inhalation in the Curriculum Center Building area, $6.9\text{E-}03$, falls well below the USEPA's target level of one.

Site Workers/Employees (Esso Gas Station and Splash and Dash Car Wash): The results of carcinogenic risk and noncarcinogenic hazard index calculations for potential future site workers (employees) in the Esso gas station and Splash and Dash Car Wash area are presented in Tables C-25 and C-26.

In Table C-25, potential future dermal contact with subsurface soil in the Esso gas station and Splash and Dash car wash by site workers (employees), neither a carcinogenic risk nor a noncarcinogenic hazard index could be calculated as no chemicals of potential concern have established dermal absorption factors.

Table C-26, potential future site worker (employee) subsurface soil inhalation in the Esso gas station and Splash and Dash car wash area, shows a total carcinogenic risk of $3.4\text{E-}10$. This risk falls outside and below the USEPA's 10^{-4} to 10^{-6} target risk range.

The hazard index for potential future site worker (employee) subsurface soil inhalation in the Esso gas station and Splash and Dash car wash area, $8.2\text{E-}03$, falls well below the USEPA's target level of one.

Site Workers/Employees (O'Henry Dry Cleaners and Liquor Barn): The results of carcinogenic risk and noncarcinogenic hazard index calculations for potential future site workers (employees) in the O'Henry dry cleaners and Liquor Barn area are presented in Tables C-27 and C-28.

In Table C-27, potential future dermal contact with subsurface soil in the O'Henry dry cleaners and Liquor Barn area by site workers (employees), neither a carcinogenic risk nor a noncarcinogenic hazard index could be calculated as no chemicals of potential concern have established dermal absorption factors.

Table C-28, potential future site worker (employee) subsurface soil inhalation in the O'Henry dry cleaners and Liquor Barn area, shows a total carcinogenic risk of $3.5\text{E-}08$. This risk falls outside and below the USEPA's 10^{-4} and 10^{-6} target risk range.

The hazard index for potential future site worker (employee) subsurface soil inhalation in the O'Henry dry cleaners and Liquor Barn area, $1.8\text{E-}02$, falls well below the USEPA's target level of one.

Table C-29, potential future construction worker subsurface soil ingestion in the Tillett Gardens and Art Center area, shows a total carcinogenic risk of $1.6\text{E-}06$. This risk falls within the USEPA's 10^{-4} to 10^{-6} target risk range.

The hazard index for potential future construction worker subsurface soil ingestion in the Tillett Gardens and Art Center area, $4.3\text{E-}01$, falls below the USEPA's target level of one.

In Table C-30, potential future dermal contact with subsurface soil in the Tillett Gardens and Art Center area by construction workers, neither carcinogenic risks nor hazard index values could be calculated as no chemicals of potential concern have established dermal absorption factors.

Table C-31, potential future construction worker subsurface soil inhalation in the Tillett Gardens and Art Center Area, shows a total carcinogenic risk of $9.4\text{E-}09$. This risk falls outside and below the USEPA's 10^{-4} to 10^{-6} target risk range.

The hazard index value for potential future construction worker subsurface soil inhalation in the Tillett Gardens and Art Center area, $6.2\text{E-}03$, falls well below the USEPA's target level of one.

5.3.3 Groundwater

The results of carcinogenic risk and noncarcinogenic hazard index calculations for present and potential future resident (adult and child) and site worker, and potential future construction worker exposures to groundwater are presented in Tables C-32 through C-36.

Residents (Site-Wide): The results of carcinogenic risk and noncarcinogenic hazard index calculations for present and potential future residential groundwater exposure are presented in Tables C-32 through C-34.

Table C-32, present and potential future residential groundwater ingestion across the site, shows total carcinogenic risks for adults and children of $6.6\text{E-}04$ and $3.1\text{E-}04$, respectively. Both risks

exceed the upper-bound of the USEPA's 10^{-4} to 10^{-6} target risk range. For adults, tetrachloroethene and vinyl chloride show individual risks of $1.2\text{E-}04$ and $4.5\text{E-}04$, respectively, which combined contribute greater than 86 percent to the total risk. For children, tetrachloroethene and vinyl chloride show individual risks of $5.7\text{E-}05$ and $2.1\text{E-}04$, respectively, which combined also contribute greater than 86 percent to the total risk.

The hazard index values for adult and child groundwater ingestion are $2.9\text{E+}01$ and $6.7\text{E+}01$, respectively. These values exceed the USEPA's target level of one. For adults, 1,2-dichloroethene (total) and manganese show hazard quotients of $1.2\text{E+}00$ and $2.6\text{E+}01$, respectively, which combined contribute nearly 94 percent to the hazard index. For children, 1,2-dichloroethene (total), tetrachloroethene, antimony, manganese, and vanadium show hazard quotients of $2.8\text{E+}00$, $1.3\text{E+}00$, $1.6\text{E+}00$, $6.0\text{E+}01$, and $1.0\text{E+}00$, respectively, which combined contribute greater than 99 percent to the hazard index.

Table C-33, present and potential future residential dermal contact with site-wide groundwater during showering, shows total carcinogenic risks for adults and children of $1.3\text{E-}07$ and $3.6\text{E-}08$, respectively. These risks fall outside and below the USEPA's 10^{-4} to 10^{-6} target risk range.

The hazard index values for present and potential future adult and child groundwater dermal contact are $4.9\text{E-}02$ and $6.8\text{E-}02$, respectively. These values fall well below the USEPA's target level of one.

Table C-34, present and potential future residential inhalation of VOCs in site-wide groundwater (shower model), shows total carcinogenic risks of $4.3\text{E-}05$ and $4.0\text{E-}05$, respectively. These risks fall within the USEPA's 10^{-4} to 10^{-6} target risk range.

The hazard index values for present and potential future adult and child inhalation of VOCs in site-wide groundwater (shower model) are $3.4\text{E-}03$ and $1.6\text{E-}02$, respectively. These values fall well below the USEPA's target level of one.

Site Workers/Employees (Site-Wide): The results of carcinogenic risk and noncarcinogenic hazard index calculations for present and potential future site workers (employees) site-wide are presented in Table C-35.

Table C-35, present and potential future site worker (employee) ingestion of site-wide groundwater, shows a total carcinogenic risk of $2.0\text{E-}04$. This risk exceeds the upper-bound of the USEPA's 10^{-4} to 10^{-6} target risk range. Tetrachloroethene and vinyl chloride show individual risks of $3.6\text{E-}05$ and $1.3\text{E-}04$, respectively, which combined contribute 83 percent to the total risk.

The hazard index for present and potential future site worker (employee) ingestion of site-wide groundwater is $1.0\text{E+}01$. This value exceeds the USEPA's target level of one. Manganese shows a hazard quotient of $9.2\text{E+}00$ and contributes approximately 92 percent to the hazard. No other chemicals have hazard quotients in exceedance of one.

Construction Workers (Site-Wide): The results of carcinogenic risk and noncarcinogenic hazard index calculations for potential future construction workers site-wide are presented in Table C-36.

Table C-36, potential future construction worker ingestion of site-wide groundwater, shows a total carcinogenic risk of $7.1\text{E-}06$. This risk falls within the USEPA's 10^{-4} to 10^{-6} target risk range.

The hazard index for potential future construction worker ingestion of site-wide groundwater is $9.1\text{E}+00$. This value exceeds the USEPA's target level of one. Manganese shows a hazard quotient of $8.2\text{E}+00$ and contributes greater than 90 percent to the hazard. No other chemicals have hazard quotients in exceedance of one.

5.4 Combining Cancer Risks and Noncancer Hazard Index Values Across Exposure Pathways

Multichemical cancer risk/noncancer hazard estimates may be combined across exposure pathways for exposed receptor group(s) provided that the same group(s) would consistently face the RME by more than one pathway. Cancer risks from various exposure pathways are assumed to be additive, as long as the risks are for the same individuals and time period. For noncarcinogens, the total hazard index for each exposure duration (i.e., chronic, subchronic) was calculated separately.

The summing of appropriate carcinogenic risks and noncarcinogenic hazard index values is presented in Tables 5-1 and 5-2, respectively.

TABLE 5-1

TUTU WELLS SITE
COMBINING CARCINOGENIC RISKS ACROSS PATHWAYS

MEDIA	RECEPTOR POPULATION	EXPOSURE ROUTE	INDIVIDUAL CANCER RISK	CHEMICALS CONTRIBUTING THE GREATEST AMOUNT TO RISK
SURFACE SOIL Tillett Gardens and Art Center Area	Residents: Adults	Ingestion Dermal Contact Inhalation of Particulates Total Carcinogenic Risk =	4.4E-04 1.3E-03 5.5E-07 1.7E-03	Aroclor 1242, Arsenic Aroclor 1242 -- Aroclor 1242, Arsenic
	Children (0-6 years)	Ingestion Dermal Contact Inhalation of Particulates Total Carcinogenic Risk =	1.0E-03 3.9E-04 6.4E-07 1.4E-03	Aroclor 1242, Arsenic Aroclor 1242 -- Aroclor 1242, Arsenic
Fire Dept./Texaco gas station/ Antilles auto parts/ Ramsay motor co. Area	Site Workers (Employees)	Ingestion Dermal Contact Inhalation of Particulates Total Carcinogenic Risk =	1.3E-06 NA 2.7E-09 1.3E-06	-- -- -- --
Curriculum Center Building Area (Present-Use)	Site Workers (Employees)	Ingestion Dermal Contact Total Carcinogenic Risk =	3.7E-06 NA 3.7E-06	-- -- --
Curriculum Center Building Area (Future-Use)	Site Workers (Employees)	Ingestion Dermal Contact Inhalation of Particulates Total Carcinogenic Risk =	9.1E-07 NA 4.5E-08 9.6E-07	-- -- -- --
O'Henry dry cleaners and Liquor Barn Area	Site Workers (Employees)	Ingestion Dermal Contact Inhalation of Particulates Inhalation of VOCs Total Carcinogenic Risk =	9.7E-06 NA 3.4E-07 4.9E-07 1.1E-05	-- -- -- -- --
Tillett Gardens and Art Center Area (Future-Use)	Construction Workers	Ingestion Dermal Contact Inhalation of Particulates Total Carcinogenic Risk =	5.7E-05 4.3E-05 6.6E-09 1.0E-04	-- -- -- --

TABLE 5-1

TUTU WELLS SITE
COMBINING CARCINOGENIC RISKS ACROSS PATHWAYS

MEDIA	RECEPTOR POPULATION	EXPOSURE ROUTE	INDIVIDUAL CANCER RISK	CHEMICALS CONTRIBUTING THE GREATEST AMOUNT TO RISK
SUBSURFACE SOIL				
Tillett Gardens and Art Center Area (Future-Use)	Residents: Adults	Dermal Contact	NA	--
		Inhalation of Particulates	3.0E-08	--
		Total Carcinogenic Risk =	3.0E-08	--
	Children (0-6 years)	Dermal Contact	NA	--
		Inhalation of Particulates	1.4E-07	--
		Total Carcinogenic Risk =	1.4E-07	--
Fire Dept./ Texaco gas station/ Antilles auto parts/ Ramsay motor co. Area (Future-Use)	Site Workers (Employees)	Dermal Contact	NA	--
		Inhalation of Particulates	3.8E-10	--
		Total Carcinogenic Risk =	3.8E-10	--
Curriculum Center Building Area (Future-Use)	Site Workers (Employees)	Dermal Contact	NA	--
		Inhalation of Particulates	1.1E-09	--
		Total Carcinogenic Risk =	1.1E-09	--
Esso gas station and Splash and Dash car wash Area (Future-Use)	Site Workers (Employees)	Dermal Contact	NA	--
		Inhalation of Particulates	3.4E-10	--
		Total Carcinogenic Risk =	3.4E-10	--
O'Henry dry cleaners and Liquor Barn Area	Site Workers (Employees)	Dermal Contact	NA	--
		Inhalation of Particulates	3.5E-08	--
		Total Carcinogenic Risk =	3.5E-08	--
Tillett Gardens and Art Center Area (Future-Use)	Construction Workers	Ingestion	1.6E-06	--
		Dermal Contact	NA	--
		Inhalation of Particulates	9.4E-09	--
		Total Carcinogenic Risk =	1.6E-06	--

TABLE 5.1

TUTU WELLS SITE
COMBINING CARCINOGENIC RISKS ACROSS PATHWAYS

MEDIA	RECEPTOR POPULATION	EXPOSURE ROUTE	INDIVIDUAL CANCER RISK	CHEMICALS CONTRIBUTING THE GREATEST AMOUNT TO RISK
GROUNDWATER (Site-Wide)	Residents: Adults	Ingestion	6.6E-04	Tetrachloroethene, Vinyl Chloride
		Dermal Contact (Shower)	1.3E-07	--
		Inhalation of VOCs (Shower)	4.3E-05	--
		Total Carcinogenic Risk =	7.0E-04	Tetrachloroethene, Vinyl Chloride
	Children(0-6 years)	Ingestion	3.1E-04	Tetrachloroethene, Vinyl Chloride
		Dermal Contact (Shower)	3.6E-08	--
		Inhalation of VOCs (Shower)	4.0E-05	--
		Total Carcinogenic Risk =	3.5E-04	Tetrachloroethene, Vinyl Chloride
	Site Workers (Employees)	Ingestion	2.0E-04	Tetrachloroethene, Vinyl Chloride
		Total Carcinogenic Risk =	2.0E-04	Tetrachloroethene, Vinyl Chloride
	Construction Workers	Ingestion	7.1E-06	--
		Total Carcinogenic Risk =	7.1E-06	--

COMBINING CARCINOGENIC RISKS ACROSS ENVIRONMENTAL MATRICES:

Residents: Surface soil exposure durations are different than subsurface soil exposure durations and therefore cannot be combined. The child (6 year) surface soil exposure duration is the same as the child groundwater exposure duration and therefore may be combined.

Children: Surface Soil + Groundwater (Site-Wide)

Tillett Gardens and Art Center Area: $1.4E-03 + 3.5E-04 = 1.8E-03$

Site Workers: Surface soil exposure durations are different than subsurface soil exposure durations and therefore cannot be combined. The site worker surface soil exposure duration is the same as the site worker groundwater exposure duration and therefore may be combined.

Site Workers: Surface Soil + Groundwater (Site-Wide):

Fire Department/Texaco gas station/ Antilles auto parts/ Ramsay motor co. : $1.3E-06 + 2.0E-04 = 2.0E-04$

Curriculum Center Building Area (Present-Use): $3.7E-06 + 2.0E-04 = 2.0E-04$

Curriculum Center Building Area (Future-Use): $9.6E-07 + 2.0E-04 = 2.0E-04$

O'Henry dry cleaners and Liquor Barn Area: $1.1E-05 + 2.0E-04 = 2.1E-04$

Construction Workers: Surface Soil + Subsurface Soil + Groundwater (Site-Wide)

Tillett Gardens and Art Center Area: $1.0E-04 + 1.6E-06 + 7.1E-06 = 1.1E-04$

Notes

-- Indicates that the carcinogenic risk does not exceed the target risk range or could not be calculated; therefore, no chemicals were selected as contributors.

NA: The carcinogenic risk for dermal contact with soil could not be calculated as carcinogenic chemicals of potential concern either do not have established dermal absorption factors or do not have established carcinogenic toxicity values.

TUTU WELLS SITE
COMBINING NONCARCINOGENIC HAZARD INDEX VALUES ACROSS PATHWAYS

MEDIA	RECEPTOR POPULATION	EXPOSURE ROUTE	INDIVIDUAL HAZARD INDEX	CHEMICALS CONTRIBUTING THE GREATEST AMOUNT TO HAZARD INDEX VALUES
SURFACE SOIL				
Tillett Gardens and Art Center Area	Residents: Adults	Ingestion Dermal Contact Inhalation of Particulates Total Hazard Index =	3.2E-01 NA 6.7E-01 9.9E-01	-- -- -- --
	Children (0-6 years)	Ingestion Dermal Contact Inhalation of Particulates Total Hazard Index =	3.0E+00 NA 3.1E+00 6.1E+00	Manganese -- Manganese Manganese
Fire Dept./ Texaco gas station/ Antilles auto parts/ Ramsay motor co. Area	Site Workers (Employees)	Ingestion Dermal Contact Inhalation of Particulates Total Hazard Index =	9.7E-02 NA 2.0E-01 3.0E-01	-- -- -- --
Curriculum Center Building Area (Present-Use)	Site Workers (Employees)	Ingestion Dermal Contact Total Hazard Index =	2.5E-01 NA 2.5E-01	-- -- --
Curriculum Center Building Area (Future-Use)	Site Workers (Employees)	Ingestion Dermal Contact Inhalation of Particulates Total Hazard Index =	2.3E-01 NA 2.1E-01 4.4E-01	-- -- -- --
O'Henry dry cleaners and Liquor Barn Area	Site Workers (Employees)	Ingestion Dermal Contact Inhalation of Particulates Inhalation of VOCs Total Hazard Index =	1.5E-01 NA 2.1E-01 NA 3.6E-01	-- -- -- -- --
Tillett Gardens and Art Center Area (Future-Use)	Construction Workers	Ingestion Dermal Contact Inhalation of Particulates Total Hazard Index =	9.9E-01 NA 2.4E-02 1.0E+00	-- -- -- --

TUTU WELLS SITE
COMBINING NONCARCINOGENIC HAZARD INDEX VALUES ACROSS PATHWAYS

MEDIA	RECEPTOR POPULATION	EXPOSURE ROUTE	INDIVIDUAL HAZARD INDEX	CHEMICALS CONTRIBUTING THE GREATEST AMOUNT TO HAZARD INDEX VALUES
SUBSURFACE SOIL				
Tillett Gardens and Art Center Area (Future-Use)	Residents: Adults	Dermal Contact	NA	--
		Inhalation of Particulates	1.9E-02	--
		Total Hazard Index =	1.9E-02	--
	Children (0-6 years)	Dermal Contact	NA	--
		Inhalation of Particulates	9.0E-02	--
		Total Hazard Index =	9.0E-02	--
Fire Dept./ Texaco gas station/ Antilles auto parts/ Ramsay motor co. Area (Future-Use)	Site Workers (Employees)	Dermal Contact	NA	--
		Inhalation of Particulates	7.4E-03	--
Curriculum Center Building Area (Future-Use)	Site Workers (Employees)	Dermal Contact	NA	--
		Inhalation of Particulates	6.9E-03	--
Esso gas station and Splash and Dash car wash Area (Future-Use)	Site Workers (Employees)	Dermal Contact	NA	--
		Inhalation of Particulates	8.2E-03	--
O'Henry dry cleaners and Liquor Barn Area	Site Workers (Employees)	Dermal Contact	NA	--
		Inhalation of Particulates	1.8E-02	--
Tillett Gardens and Art Center Area (Future-Use)	Construction Workers	Dermal Contact	4.3E-01	--
		Inhalation of Particulates	6.2E-03	--
		Total Hazard Index =	4.4E-01	--

TUTU WELLS SITE
COMBINING NONCARCINOGENIC HAZARD INDEX VALUES ACROSS PATHWAYS

MEDIA	RECEPTOR POPULATION	EXPOSURE ROUTE	INDIVIDUAL HAZARD INDEX	CHEMICALS CONTRIBUTING THE GREATEST AMOUNT TO HAZARD INDEX VALUES
GROUNDWATER (Site-Wide)	Residents: Adults	Ingestion	2.9E+01	1,2-Dichloroethene (Total), Manganese
		Dermal Contact (Shower)	4.9E-02	--
		Inhalation of VOCs (Shower)	3.4E-03	--
		Total Hazard Index =	2.9E+01	1,2-Dichloroethene (Total), Manganese
	Children (0-6 years)	Ingestion	6.7E+01	1,2-Dichloroethene (Total), Tetrachloroethene, Antimony, Manganese, Vanadium
		Dermal Contact (Shower)	6.8E-02	--
		Inhalation of VOCs (Shower)	1.6E-02	--
		Total Hazard Index =	6.7E+01	1,2-Dichloroethene (Total), Tetrachloroethene, Antimony, Manganese, Vanadium
	Site Workers (Employees)	Ingestion	1.0E+01	Manganese
		Total Hazard Index =	1.0E+01	Manganese
	Construction Workers	Ingestion	9.1E+00	Manganese
		Total Hazard Index =	9.1E+00	Manganese

COMBINING NONCARCINOGENIC HAZARD INDEX VALUES ACROSS ENVIRONMENTAL MATRICES:

Residents: Surface soil exposure durations are different than subsurface soil exposure durations and therefore cannot be combined. The child (6 year) surface soil exposure duration is the same as the child groundwater exposure duration and therefore may be combined.

Children: Surface Soil + Groundwater

Tillett Gardens and Art Center Area: $6.1E+00 + 6.7E+01 = 7.3E+01$

Site Workers: Surface soil exposure durations are different than subsurface soil exposure durations and therefore cannot be combined. The site worker surface soil exposure duration is the same as the site worker groundwater exposure duration and therefore may be combined.

Site Worker: Surface Soil + Groundwater (Site-Wide)

Fire Department/Texaco gas station/ Antilles auto parts/ Ramsay motor co. Area: $3.0E-01 + 1.0E+01 = 1.0E+01$

Curriculum Center Building Area (Present-Use): $2.5E-01 + 1.0E+01 = 1.0E+01$

Curriculum Center Building Area (Future-Use): $4.4E-01 + 1.0E+01 = 1.0E+01$

O'Henry dry cleaners and Liquor Barn Area: $3.6E-01 + 1.0E+01 = 1.0E+01$

Construction Workers: Surface Soil + Subsurface Soil + Groundwater (Site-Wide)

Tillett Gardens and Art Center Area: $1.0E+00 + 4.4E-01 + 9.1E+00 = 1.1E+01$

Notes

-- Indicates that the noncarcinogenic hazard index does not exceed the target level or could not be calculated; therefore no chemicals were selected as contributors.

NA: The noncarcinogenic hazard index for dermal contact with soil could not be calculated as noncarcinogenic chemicals of potential concern either do not have established dermal absorption factors or do not have noncarcinogenic toxicity values.

5.5 Applicable or Relevant and Appropriate Requirements (ARARs)

The National Contingency Plan (NCP) and Section 121(d) of CERCLA (cleanup standards) requires that the selected remedial actions at Superfund sites attain or exceed applicable or relevant and appropriate requirements (ARARs) of Federal laws and more stringent promulgated state laws.

ARARs are identified to determine media and chemical contaminants that may require remediation and regulations that may apply to remedial action.

A requirement under CERCLA and under other environmental laws may be either "applicable" or "relevant and appropriate" to a remedial action, but not both. A two-tiered approach may be applied: first, to determine whether a given requirement is applicable, then, if it is not applicable, to determine whether it is relevant and appropriate. These terms are defined in the NCP as follows:

- Applicable requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable. Examples of applicable requirements are Maximum Contaminant Levels (MCLs) promulgated under the Safe Drinking Water Act for contamination of a drinking water supply aquifer.

- Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive requirements, criteria or limitations described above, that, while not "applicable", address problems or situations sufficiently similar to those encountered at a CERCLA site that their use is well-suited to the particular site.
- Other requirements to be considered (TBCs) are non-promulgated federal and state advisories or guidance documents. These do not have status as potential ARARs; however, these advisories or guidance documents may be considered in determining the necessary level of cleanup for the protection of health or the environment.

The USEPA divides ARARs into three categories: chemical-specific, location-specific, and action-specific. This distinction is based on whether the requirement is triggered by the presence or emission of a chemical, by a sensitive or protected location, or by a particular remedial action, respectively.

Chemical-specific ARARs are useful in identifying chemicals that may pose a risk and require remediation, and may be selected as cleanup levels that must be achieved by a particular action. Chemical-specific requirements set concentration limits or ranges in various environmental media for specific hazardous substances, pollutants or contaminants. These requirements (i.e., MCLs) may represent protective levels for designated media.

USEPA Region II federal MCLs have been identified in this risk assessment for the selected chemicals of potential concern in site groundwater (See Table 2-28). These MCLs were obtained from the Region II Drinking and Groundwater Standards Update (USEPA, 1993b).

Table 5-3 presents the MCLs along with the range of detected concentrations of chemicals of potential concern for comparative purposes.

Preliminary remediation goals have been calculated for those chemicals of potential concern in groundwater not having established MCLs (i.e., 1,2-dichloroethene (total) and manganese), and are presented in Section 7.1. A preliminary remediation goal was not developed for vanadium since it did not result in a hazard quotient in exceedance of one (i.e., hazard quotient was equal to one). It should be noted that manganese does have a secondary MCL of 50 ug/l in drinking water; however, this level is an unenforceable federal guideline which is based on taste, odor, and non-aesthetic effects.

For VOCs in Table 5-3, all maximum detected concentrations far exceed established MCLs, except for 1,2-dichloroethene (total), which does not have an established MCL. For the inorganics in Table 5-3, all maximum detected concentrations exceed established MCLs except for manganese. Manganese does not currently have an established MCL, although as mentioned above, it does have a nonenforceable secondary MCL of 50 ug/l.

TABLE 5-3

TUTU WELLS SITE
DETECTED CONCENTRATIONS VERSUS FEDERAL MAXIMUM CONTAMINANT LEVELS (MCLS) FOR
CHEMICALS OF POTENTIAL CONCERN IN SITE GROUNDWATER (ug/l)

CHEMICALS	Range of Detected Concentrations		MCL (1)
	Minimum	Maximum	
<u>VOCS:</u>			
Benzene	0.05 J	21000 D	5
1,2-Dichloroethene (Total)	0.11 J	2100	NA
Tetrachloroethene	1.00 J	1500	5
Toluene	0.05 J	17000	1000
Vinyl Chloride	0.22 J	1300	2
<u>Inorganics:</u>			
Antimony	14.8 B	424 B	6
Arsenic	1.00 B	80.8 J	50
Beryllium	0.75 B	40.8 B	4
Chromium VI	0.43 B	659	100 (Total)
Manganese	1.40 B	20400	NA
Nickel	8.70 B	2050	100
Vanadium	4.90 B	1000 J	NA

(1) Region II Drinking and Groundwater Standards Update (USEPA, 1993b).

NA: Not Available

6.0 UNCERTAINTIES IN RISK ASSESSMENT

As in any risk assessment, the estimates of potential health threats (carcinogenic risks and noncarcinogenic health effects) for the Tutu Wells site data have numerous associated uncertainties. In general, the primary areas of uncertainty include the following:

- Environmental data
- Exposure pathway assumptions
- Toxicological data
- Risk Characterization

Uncertainty is always involved in the estimation of chemical concentrations. Errors in the analytical data may stem from errors inherent in sampling and/or laboratory procedures. One of the most effective methods of minimizing procedural or systematic error is to subject the data to a strict quality control review. This quality control review procedure helps to eliminate many laboratory errors. However, even with all data vigorously validated, it must be realized that error is inherent in all laboratory procedures.

The lack of site-specific exposure measurements requires that estimates be made on the basis of literature values and/or professional judgement. These types of estimates were required in the evaluation of exposure scenario input parameters. For example, assumptions were made for the exposure time, frequency, and duration of potential chemical exposures, as well as for the

quantity of ingested and/or inhaled chemical contaminants. In general, assumptions were made based on reasonable maximum exposures.

Other standard assumptions used throughout this risk assessment (i.e., 70 kg average adult body weight) or upper-bounds of potential exposure (i.e., inhalation rate) have been used as appropriate.

Other sources of error in the risk assessment can stem from the use of estimated concentrations and can arise during the calculation of 95 percent UCLs. For example, one-half the SQL was used in the 95 percent UCL calculation as a proxy concentration for non-detect chemicals. An additional uncertainty involved in the calculation of 95 percent UCLs involved selection of the H-statistic when more than 101 samples are included (i.e., groundwater). In cases where the number of samples exceeded 101, the H-statistics for 101 samples were utilized for conservatism. While the use of these H-statistics may tend to overestimate the 95 percent UCL concentration, the amount would be slight since H-statistics decrease by small increments as the number of samples increases.

Toxicological data uncertainty is one of the largest sources of error in this risk assessment. Numerous uncertainties are associated with USEPA-derived toxicity values used in risk assessment. One source of uncertainty may include using dose-response information from effects observed at high doses in animals to predict adverse health effects from low level exposures to humans in contact with the chemical in the environment. Another source may be the use of dose-response information from short-term exposure studies to predict the effects of long-term exposure and vice versa. Uncertainties may also arise from using dose-response information in

animals to predict human health effects and from homogeneous animal and healthy human populations to predict effects likely to be observed in the general population which consists of individuals with varying sensitivities. In addition, the inability to quantitatively evaluate all chemicals detected at the site due to the lack of sufficient toxicological data may result in underestimation of risks and/or health effects. The potential toxicological effects of these chemicals have been discussed in Section 4.3 and in Appendix B Toxicological Profiles.

Other toxicological data uncertainty in this risk assessment includes the use of the established Aroclor 1260 oral slope factor to represent all Aroclors (i.e., Aroclor 1248); the use of the benzo(a)pyrene oral slope factor in conjunction with relative potency values to develop slope factors for numerous other carcinogenic PAHs; and the combining of carcinogens with different weights-of-evidence in the calculation of risk.

Uncertainty is also involved in the calculation of risk and hazard estimates via the dermal contact with soil pathway. Only cadmium and PCBs (as a class) could be quantitatively evaluated via this route since these are the only chemicals detected in site soil which have USEPA-established soil dermal absorption factors. The potential exists to underestimate risks/impacts via this pathway since all other chemicals detected in the soil could only be qualitatively addressed. An additional source of uncertainty may include the use of oral reference doses to evaluate dermal exposure (i.e., cadmium and PCBs in soil, and SVOCs and inorganics in groundwater). It should be noted for the dermal contact with groundwater during showering pathway, that a specific dermal permeability constant was available for only two chemicals and all others defaulted to the value for water. Considering that all of the chemicals in the spreadsheet are

inorganics and that inorganics generally have low dermal permeabilities, the use of the default value for water may overestimate risks/impacts via this pathway.

As a result of the uncertainties described above, this risk assessment should not be construed as presenting absolute risks or hazards. Rather, it is a conservative analysis intended to indicate the potential for adverse impacts to occur, based on a reasonable maximum exposure.

6.1 Central Tendency Calculations

Central tendency is a statistical measure that identifies the single most representative value for an entire distribution of values. As a quantitative measure of uncertainty in this risk assessment, central tendency calculations have been performed utilizing 50th percentile input parameters (i.e., exposure duration) in the risk and hazard index calculations as opposed to the 90th percentile parameters generally used in risk assessment calculations. Ninetieth percentile input parameters are used in the risk assessment for calculation of risk and hazard index values in a given pathway so that the combination of all intake variables results in an estimate of the RME for that pathway. The RME is the maximum exposure that is reasonably expected to occur at a site. The 50th percentile values used in the central tendency calculations are considered to be representative of the general receptor population, but may underestimate the true carcinogenic risk and/or noncarcinogenic health effects to sensitive receptors.

Table 6-1 presents the 50th percentile exposure parameters utilized in the calculation of central tendency for those exposure pathways which have results in exceedance of the upper-bounds of the 10^{-4} to 10^{-6} risk range, $1.0E-04$, for carcinogens and one for noncarcinogens. These

TUTU WELLS SITE
VARIABLES USED FOR CHRONIC AND SUBCHRONIC DAILY INTAKE CALCULATIONS FOR CENTRAL TENDENCY EVALUATION

Matrices and Receptor Populations	Exposure Route	CONCENTRATIONS				CONTACT PARAMETERS							TIME VARIABLES				CF (3) (variable)	BW (kg)
		CW (mg/l)	CA/SSC (mg/m3)	CS (mg/kg)	VF (m3/kg)	SA (cm2)	PC (cm/hr)	IR (1) (variable)	RF (unitless)	AF (mg/cm2)	ABS (unitless)	FI (unitless)	ET (hr/day)	EF (day/yr)	ED (yrs)	AT (2) (years)		
Surface Soil																		
Residents (Tillett Gardens and Art Center Area)																		
Adults	Ingestion	-	-	Site Data	-	-	-	50 mg/day	-	-	-	1	-	275	9	70(9)	1E-6 kg/mg	70
Children (0-6 years)	Ingestion	-	-	Site Data	-	-	-	100 mg/day	-	-	-	1	-	275	6	70(6)	1E-6 kg/mg	15
Adults	Dermal Contact	-	-	Site Data	-	5065	-	-	-	0.6	(4)	-	-	275 events/yr	9	70(9)	1E-6 kg/mg	70
Children (0-6 years)	Dermal Contact	-	-	Site Data	-	1270	-	-	-	0.6	(4)	-	-	275 events/yr	6	70(6)	1E-6 kg/mg	15
Children (0-6 years)	Inhalation of Particulates	-	7.0E-02	Site Data	-	-	-	0.83 m3/hr	0.75	-	-	-	12	275 events/yr	6	70(6)	1E-6 kg/mg	15
Groundwater																		
Site Residents																		
Adults	Ingestion	Site Data	-	-	-	-	-	1.4 l/day	-	-	-	-	-	275	9	70(9)	-	70
Children (0-6 years)	Ingestion	Site Data	-	-	-	-	-	0.7 l/day	-	-	-	-	-	275	6	70(6)	-	15
Site Workers																		
Adults	Ingestion	Site Data	-	-	-	-	-	1 l/day	-	-	-	-	-	185	25	70(25)	-	70
Construction Workers																		
Adults	Ingestion	Site Data	-	-	-	-	-	1 l/day	-	-	-	-	-	130	1	70(1)	-	70

NOTES:

- (1) Ingestion or inhalation rate
 (2) 70 years for carcinogens, 9 years for noncarcinogens for adult residents, and 6 years for noncarcinogens for children (multiplied by 365 days).
 (3) Conversion Factor
 (4) Soil dermal contact absorption factors: 3.3% = PCBs.

Other Abbreviations:

CW = Chemical concentration in water
 CA = Chemical concentration in air
 CS = Chemical concentration in soil
 SA = Skin surface area available for dermal contact
 PC = Chemical-specific dermal permeability constant
 RF = Respirable fraction of particulates
 AF = Soil-to-skin adherence factor
 SSC = Suspended soil concentration
 FI = Fraction ingested from chemical source
 ET = Exposure Time
 EF = Exposure Frequency
 ED = Exposure Duration
 BW = Body Weight
 AT = Averaging Time

parameters were obtained from several USEPA guidance documents including RAGS (USEPA, 1989a), Exposure Factors Handbook (USEPA, 1989b), and Dermal Exposure Assessment: Principles and Applications (USEPA, 1992c) as well as through discussion with the USEPA site Risk Assessment Specialist. The 95 percent UCL concentrations have been utilized in these calculations. Tables D-1 through D-6 in Appendix D present the results of the central tendency calculations.

6.1.1 Surface Soil

The results of central tendency calculations for residential exposure to carcinogens and noncarcinogens in surface soil of the Tillett Gardens and Art Center area via the ingestion (adults and children), dermal contact (adults and children), and inhalation (child only) routes are presented in Tables D-1 through D-3, respectively.

Table D-1, central tendency calculation for adult and child exposures to surface soil in the Tillett Gardens and Art Center area via ingestion, shows total carcinogenic risks of $6.5\text{E-}05$ and $4.1\text{E-}04$, respectively. The adult total risk of $6.5\text{E-}05$ is approximately 6.8 times less than the RME adult total risk of $4.4\text{E-}04$ (Table C-1, Appendix C) and falls within the USEPA's 10^{-4} to 10^{-6} target risk range. The child total risk of $4.1\text{E-}04$ is approximately 2.4 times less than the RME child total risk of $1.0\text{E-}03$ and still exceeds the upper-bound of the USEPA's 10^{-4} to 10^{-6} target risk range. The 30-year combined risk for central tendency, $4.7\text{E-}04$, is approximately 3.2 times less than the RME 30-year combined risk of $1.5\text{E-}03$ (Table C-1, Appendix C) and still exceeds the upper-bounds of the USEPA's 10^{-4} to 10^{-6} target risk range.

The central tendency calculation for child exposure to surface soil in the Tillett Gardens and Art Center area via ingestion shows a hazard index value of $1.2\text{E}+00$. This value is approximately 2.5 times less than the RME child hazard index of $3.0\text{E}+00$ (Table C-1, Appendix C) and still exceeds the USEPA's target level of one.

Table D-2, central tendency calculation for adult and child exposures to surface soil in the Tillett Gardens and Art Center area via dermal contact, shows total carcinogenic risks of $1.3\text{E}-04$ and $1.0\text{E}-04$, respectively. The adult total risk of $1.3\text{E}-04$ is ten times less than the RME adult total risk of $1.3\text{E}-03$ (Table C-2, Appendix C) and still exceeds the upper-bound of the USEPA's 10^{-4} to 10^{-6} target risk range. The child total risk of $1.0\text{E}-04$ is 3.9 times less than the RME child total risk of $3.9\text{E}-04$ and falls within the USEPA's 10^{-4} to 10^{-6} target risk range. The 30-year combined risk for central tendency, $2.3\text{E}-04$, is approximately 7.4 times less than the RME 30-year combined risk of $1.7\text{E}-03$ (Table C-2, Appendix C) and still exceeds the upper-bound of the USEPA's 10^{-4} to 10^{-6} target risk range.

Table D-3, central tendency calculation for child exposure to surface soil in the Tillett Gardens and Art Center area via inhalation, shows a hazard index value of $1.6\text{E}+00$. This value is approximately 1.9 times less than the RME child hazard index of $3.1\text{E}+00$ (Table C-3, Appendix C) and still exceeds the USEPA's target level of one.

6.1.2 Groundwater

The results of central tendency calculations for residential, site worker (employee), and construction worker exposures to carcinogens and noncarcinogens in site groundwater via the ingestion route are presented in Tables D-4 through D-6.

Table D-4, central tendency calculation for adult and child exposures to site groundwater via ingestion, shows total carcinogenic risks of $1.1\text{E-}04$ and $1.7\text{E-}04$, respectively. The adult total risk of $1.1\text{E-}04$ is six times less than RME adult total risk of $6.6\text{E-}04$ (Table C-32, Appendix C) and still exceeds the upper-bound of the USEPA's 10^{-4} to 10^{-6} target risk range. The child total risk of $1.7\text{E-}04$ is approximately 1.8 times less than the RME child total risk of $3.1\text{E-}04$ and still exceeds the upper-bound of the USEPA's 10^{-4} to 10^{-6} target risk range.

The central tendency calculations for adult and child exposures to site groundwater via ingestion show hazard index values of $1.6\text{E}+01$ and $3.7\text{E}+01$, respectively. The adult hazard index of $1.6\text{E}+01$ is approximately 1.8 times less than the RME adult hazard index of $2.9\text{E}+01$ (Table C-32, Appendix C) and still exceeds the USEPA's target level of one. The child hazard index of $3.7\text{E}+01$ is approximately 1.8 times less than the RME child hazard index of $6.7\text{E}+01$ (Table C-32, Appendix C) and still exceeds the USEPA's target level of one.

Table D-5, central tendency calculation for site worker (employee) exposure to site groundwater via ingestion, shows a total carcinogenic risk of $1.5\text{E-}04$. This total risk is approximately 1.3 times less than the RME site worker (employee) total risk of $2.0\text{E-}04$ (Table C-35, Appendix C) and still exceeds the upper-bound of the USEPA's 10^{-4} to 10^{-6} target risk range.

The central tendency calculation for site worker (employee) exposure to site groundwater via ingestion shows a hazard index value of $7.6E+00$. This value is approximately 1.3 times less than the RME site worker (employee) hazard index of $1.0E+01$ (Table C-35, Appendix C) and still exceeds the USEPA's target level of one.

Table D-6, central tendency calculation for construction worker exposure to site groundwater via ingestion, shows a hazard index value of $5.2E+00$. This value is approximately 1.8 times less than the RME construction worker hazard index of $9.1E+00$ (Table C-36, Appendix C) and still exceeds the USEPA's target level of one.

Residential carcinogenic risks for ingestion and dermal contact exposure decreased approximately 2.5 to ten times in the calculation of central tendency when compared to RME residential ingestion and dermal contact carcinogenic risks for surface soil in the Tillett Gardens and Art Center area. Child hazard index values for ingestion and inhalation decreased approximately two to 2.5 times in the calculation of central tendency when compared to RME child ingestion and inhalation hazards for surface soil in the Tillett Gardens and Art Center area. For groundwater, residential carcinogenic risks for ingestion decreased approximately 1.8 to six times in the calculation of central tendency when compared to RME residential ingestion risks for groundwater. Site worker (employee) carcinogenic risk for ingestion decreased approximately 1.3 times in the calculation of central tendency when compared to the RME site worker (employee) ingestion risk for groundwater. Noncarcinogenic hazard index values decreased by less than two times in the calculation of central tendency for residential, site worker (employee), and construction worker groundwater ingestion when compared to RME ingestion hazard index values for the same receptors.

7.0 PRELIMINARY REMEDIATION GOALS (PRGs)

Chemical - specific preliminary remediation goals (PRGs) are concentration goals for individual chemicals for specific medium and land use combinations at CERCLA sites. In this section, chemical-specific PRGs were developed based on the risk assessment (i.e., risk-based calculations). Site-specific parameter values were used in place of default parameters, where appropriate, to reflect site-specific conditions. Risk-based PRGs are initial guidelines only; they do not establish that cleanup to these goals is warranted. A risk-based concentration will be considered a final remediation level after analysis in the RI/FS and ROD.

For this risk assessment, risk-based PRGs were not needed for any chemicals in a medium with a cumulative cancer risk of less than $1.0E-04$, where a hazard index was less than or equal to one, where the PRGs were clearly defined by ARARs (i.e., MCLs), or where superseding USEPA guidance on action levels exists (i.e., PCBs in soil).

Upon review of the spreadsheet calculations for site soils, several exceedances of the USEPA's target levels were noted. For surface soil, Aroclor 1242 showed carcinogenic risks in exceedance of $1.0E-04$ while hazard index values for manganese exceeded the target level of one. Per the USEPA's direction, recommended soil action levels for PCBs at the Tutu Wells site were obtained from the USEPA's 1990 fact sheet entitled "A Guide on Remedial Actions at Superfund Sites With PCB Contamination" (USEPA, 1990). For residential land use, an action level of 1 ppm was specified for PCBs. For industrial land use, an action level range of 10 to 25 ppm was specified. These levels, according to the USEPA, supersede risk-based

PRGs. No risk-based PRGs have therefore been calculated for the PCB Aroclor 1242 in site soil.

Risk-based PRGs have been calculated for the noncarcinogen manganese in site soil. The risk-based equations used have been derived to reflect the potential risk from exposure to a chemical, given a specific pathway, medium, and land use combination. By setting the hazard index equal to one for a noncarcinogen, the concentration term (risk-based PRG) could be calculated. The formulas presented below have been obtained from the RAGS Human Health Evaluation Manual, Part B: Development of Risk-Based Preliminary Remediation Goals (USEPA, 1991b).

7.1 Residential Land Use: Soil Ingestion and Inhalation

Under residential land use, risk from the chemical in soil is generally assumed to be due to the direct ingestion route only. For this site, however, the inhalation of suspended soil particulates route has also been included since the hazard quotient for manganese via the inhalation route is slightly is greater than that calculated for the ingestion route and both exceed the USEPA's target level of one.

$$\begin{aligned} \text{Total risk from soil} &= \text{Risk from ingestion of soil (child to adult)} \\ &+ \text{Risk from inhalation of particulates from soil (child to adult)} \end{aligned}$$

Because the soil ingestion rate is different for children and adults, the risk due to direct ingestion of soil is calculated using an age-adjusted ingestion factor. The age-adjusted soil ingestion factor ($IF_{\text{soil/adj}}$) takes into account the difference in daily soil ingestion rates, body weights, and

exposure durations for two exposure groups - children (0 to 6 years) and others (7 to 30 years). Exposure frequency (EF) is assumed to be identical for the two exposure groups. For convenience, this ingestion factor has been calculated separately as a time-weighted soil intake, normalized to body weight, and then substituted in the total intake equations (see Equations (2) and (3)). This ingestion factor leads to a more protective risk-based concentration compared to an adult-only assumption. The ingestion factor is in units mg-yr/kg-day and therefore is not directly comparable to daily soil intake rate in units of mg/kg-day. Equation (1) presents the formula for calculation of the age-adjusted soil ingestion factor.

Age-Adjusted Soil Ingestion Factor

$$IF_{\text{soil/adj}} \text{ (mg-yr/kg-day)} = \frac{IR_{\text{soil/age 0-6}} \times ED_{\text{age 0-6}}}{BW_{\text{age 0-6}}} + \frac{(IR_{\text{soil/age 7-30}} \times ED_{\text{age 7-30}})}{BW_{\text{age 7-30}}} \quad (1)$$

<u>Parameters</u>	<u>Definitions (units)</u>	<u>Site-Specific Values</u>
$IF_{\text{soil/adj}}$	age-adjusted soil ingestion factor (mg-yr/kg-day)	114 mg-yr/kg-day
$BW_{\text{age 0-6}}$	average body weight from ages 0-6 (kg)	15 kg
$BW_{\text{age 7-30}}$	average body weight from ages 7-30 (kg)	70 kg
$ED_{\text{age 0-6}}$	exposure duration during ages 0-6 (yrs)	6 yrs
$ED_{\text{age 7-30}}$	exposure duration during ages 7-30 (yrs)	24 yrs
$IR_{\text{soil/age 0-6}}$	ingestion rate of soil for ages 0-6 (mg/day)	200 mg/day
$IR_{\text{soil/age 7-30}}$	ingestion rate of soil for all other ages (mg/day)	100 mg/day

7.1.1 Noncarcinogens

The total hazard index has been calculated by combining the appropriate oral and inhalation reference doses with the intakes from soil. These intakes were combined and a risk-based PRG was derived to be protective for both exposure pathways.

$$\text{Hazard Index} = \frac{\text{Intake from ingestion of soil}}{\text{RfD}_0} + \frac{\text{Intake from inhalation of soil particulates}}{\text{RfD}_i}$$

Adding appropriate parameters and solving for the concentration (C) results in Equation (2). Equation (3) is the reduced version of Equation (2), using site-specific input parameters where appropriate. This reduced equation was used for calculating the risk-based PRG at the target level of one. It combines the toxicity information of a specific chemical with site-specific exposure parameters for residential land use to generate a concentration for that chemical that corresponds to a hazard index of one. The risk-based PRGs calculated for site soil are presented in Table 7-1.

Residential Soil - Noncarcinogenic Effects

$$\text{THI} = \frac{C \times 10^{-6} \text{ kg/mg} \times \text{EF} \times \text{IF}_{\text{soil/adj}}}{\text{RfD}_0 \times \text{AT} \times 365 \text{ days/yr}} + \frac{C \times \text{ED} \times \text{EF} \times \text{IR}_{\text{air}} \times (1/\text{PEF})}{\text{RfD}_i \times \text{BW} \times \text{AT} \times 365 \text{ days/yr}} \quad (2)$$

$$\begin{aligned} C \text{ (mg/kg; risk based)} &= \frac{\text{THI} \times \text{AT} \times 365 \text{ days/yr}}{[(1/\text{RfD}_0 \times 10^{-6} \text{ kg/mg} \times \text{EF} \times \text{IF}_{\text{soil/adj}}) + (1/\text{RfD}_i \times \text{ED} \times \text{EF} \times \text{IR}_{\text{air}} \times 1/\text{BW} \times (1/\text{PEF}))]} \end{aligned}$$

where:

<u>Parameters</u>	<u>Definitions (units)</u>	<u>Site-Specific Values</u>
C	chemical concentration in soil (mg/kg)	-
THI	target hazard index (unitless)	1
RfD _o	chronic oral reference dose (mg/kg-day)	chemical-specific
RfD _i	chronic inhalation reference dose (mg/kg-day)	chemical-specific
BW	adult body weight (kg)	70 kg
AT	averaging time (yrs)	30 yrs (for noncarcinogens, equal to ED [which is incorporated in IF _{soil/adj}])
EF	exposure frequency (days/yr)	350 days/yr
ED	exposure duration (yrs)	30 yrs
IF _{soil/adj}	age-adjusted ingestion factor (mg-yr/kg-day)	114 mg-yr/kg-day (see Equation 1)
IR _{air}	inhalation rate (m ³ /day)	20 m ³ /day
PEF	particulate emission factor (m ³ /kg)	4.63 x 10 ⁹ m ³ /kg

Reduced Equation: Residential Soil - Noncarcinogenic Effects

$$\text{Risk-based PRG (mg/kg; THI = 1)} = \frac{1.095\text{E}+04}{[(4.0\text{E}-02/\text{RfD}_o) + (6.5\text{E}-07/\text{RfD}_i)]} \quad (3)$$

where:

RfD_o = chronic oral reference dose in mg/kg-day

RfD_i = chronic inhalation reference dose in mg/kg-day

TABLE 7-1

TUTU WELLS SITE
SOIL RISK-BASED PRELIMINARY REMEDIATION GOALS (PRGs)
FOR NONCARCINOGENS (mg/kg)

RESIDENTIAL INGESTION AND INHALATION:

<u>Chemical</u>	<u>Risk-Based PRGs</u>
Manganese	1,360

COMMERCIAL/INDUSTRIAL INGESTION AND INHALATION:

<u>Chemical</u>	<u>Risk-Based PRGs</u>
Manganese	9,900

7.2 Commercial/Industrial Land Use : Soil Ingestion and Inhalation

Under commercial/industrial land use, risk from the chemical in soil was also assumed to be due to direct ingestion and inhalation of particulates from the soil, and was calculated for an adult worker only. For this type of land use, it was assumed in calculating risk-based PRGs that the potential exists for use of heavy equipment and related traffic in and around contaminated soils and thus for soils to be disturbed and produce particulate emissions.

Intakes from the two exposure pathways were combined and the risk-based PRG was derived to be protective for exposures from both pathways.

$$\begin{aligned} \text{Total risk from soil} &= \text{Risk from ingestion of soil (worker)} \\ &\quad + \text{Risk from inhalation of particulates} \\ &\quad \text{from soil (worker)} \end{aligned}$$

7.2.1 Noncarcinogens

The total hazard index has been calculated by combining the appropriate oral and inhalation reference doses with the two intakes from soil:

$$\text{Hazard Index} = \frac{\text{Intake from ingestion of soil}}{\text{RfD}_0} + \frac{\text{Intake from inhalation of particulates}}{\text{RfD}_i}$$

Adding appropriate parameters and solving for the concentration (C) results in Equation (4). Equation (5) is the reduced version of Equation (4), using site-specific input parameters where appropriate. This reduced equation was used for calculating the risk-based PRG at the target level of one. It combines the toxicity information of a specific chemical with site-specific

exposure parameters for commercial/industrial land use to generate a concentration for that chemical that corresponds to a hazard index of one. The risk-based PRG calculated for commercial/industrial soil land use is presented in Table 7-1 along with the residential soil land use risk-based PRG.

Commercial Industrial Soil - Noncarcinogenic Effects

$$THI = \frac{C \times 10^{-6} \text{ kg/mg} \times EF \times ED \times IR_{\text{soil}}}{RfD_0 \times BW \times AT \times 365 \text{ days/yr}} + \frac{C \times EF \times ED \times IR_{\text{air}} \times (1/VF + 1/PEF)}{RfD_i \times BW \times AT \times 365 \text{ days/yr}} \quad (4)$$

$$C \text{ (mg/kg; risk based)} = \frac{THI \times BW \times AT \times 365 \text{ days/yr}}{ED \times EF \times [(1/RfD_0) \times 10^{-6} \text{ kg/mg} \times IR_{\text{soil}}] + [(1/RfD_i) \times IR_{\text{air}} \times 1/VF + 1/PEF]}$$

where:

<u>Parameters</u>	<u>Definitions (units)</u>	<u>Site-Specific Values</u>
C	chemical concentration in soil (mg/kg)	-
THI	target hazard index (unitless)	1
RfD ₀	chronic oral reference dose (mg/kg-day)	chemical-specific
RfD _i	chronic inhalation reference dose (mg/kg-day)	chemical-specific
BW	adult body weight (kg)	70 kg
AT	averaging time (yrs)	25 yrs (always equal to ED)
EF	exposure frequency (days/yr)	250 days/yr (site worker)
ED	exposure duration (yrs)	25 yrs (site worker)
IR _{soil}	soil ingestion rate (mg/day)	50 mg/day (site worker)
IR _{air}	workday inhalation rate (m ³ /day)	20 m ³ /day
VF	soil-to-air volatilization factor (m ³ /kg)	not applicable
PEF	particulate emission factor (m ³ /kg)	4.63 x 10 ⁹ m ³ /kg

Reduced Equation: Commercial Industrial Soil - Noncarcinogenic Effects

$$\begin{array}{l} \text{Risk-based} = \frac{102}{[(5\text{E-}5/\text{RfD}_0) + ((4.3\text{E-}9/\text{RfD}_i)]} \quad (5) \\ \text{PRG (mg/kg;} \\ \text{THI} = 1) \\ \text{(Site worker)} \end{array}$$

where:

RfD_0 = chronic oral reference dose in mg/kg-day

RfD_i = chronic inhalation reference dose in mg/kg-day

7.3 Residential Land Use: Groundwater Ingestion and Inhalation

In reviewing the spreadsheet calculations for site groundwater, tetrachloroethene and vinyl chloride showed carcinogenic risks in exceedance of $1.0\text{E-}04$. However, since these chemicals have established MCLs of 5 and 2 ug/l, respectively, PRG calculations were not necessary per direction from the USEPA. The chemicals 1,2-dichloroethene (total), tetrachloroethene, antimony, and manganese were found to individually exceed a hazard index of one in site groundwater. Vanadium showed a hazard index of $1.0\text{E+}00$ for child ingestion of groundwater which is equal to the target level. Of these chemicals, only tetrachloroethene and antimony have established MCLs. PRGs were therefore calculated for 1,2-dichorethene (total) and manganese.

For the calculation of risk-based PRGs, risk-based equations have been derived to reflect the potential risk from exposure to a chemical, given a specific pathway, medium, and land use combination. By setting the total risk for carcinogenic effects at a target level of 10^{-6} , (the NCP's point of departure for analysis of remedial alternatives) or the hazard index equal to one for noncarcinogens, the concentration terms (risk-based PRGs) can be calculated. The formulas

presented below have been obtained from the RAGS HHEM, Part B: Development of Risk-based Preliminary Remediation Goals (USEPA, 1991b).

Under residential land use, risk from chemicals in groundwater was assumed to be due primarily to direct ingestion and to inhalation of VOCs while showering, and was calculated for an adult.

Intakes from the two exposure pathways were combined and the risk-based PRGs were derived to be protective for exposures from both pathways.

Total risk from water = Risk from ingestion of water (adult)
+ Risk from inhalation of VOCs while showering (adult)

Risk from indoor inhalation of VOCs is assumed to be relevant only for VOCs that easily volatilize.

7.3.1 Noncarcinogens

The total hazard index has been calculated by combining the appropriate oral reference doses with the groundwater ingestion intakes (the inhalation of VOCs has not been evaluated as no inhalation reference dose is available for 1,2-dichloroethene (total), the only VOC for which a PRG is being calculated).

$$\text{Hazard Index} = \frac{\text{Intake from ingestion of groundwater}}{\text{RfD}_o}$$

Adding appropriate parameters and solving for the concentration (C) results in Equation (6). Equation (7) is the reduced version of Equation (6), using site-specific input parameters, where appropriate. This reduced equation was used for calculating the risk-based PRG at the target level of one. It combines the toxicity information of a specific chemical with site-specific exposure parameters for residential land use to generate a concentration for that chemical that corresponds to a hazard index of one.

The risk-based PRGs calculated for the residential groundwater scenario for this site are presented in Table 7-2.

Residential Groundwater - Noncarcinogenic Effects

$$\text{THI} = \frac{C \times \text{IR}_w \times \text{EF} \times \text{ED}}{\text{RfD}_o \times \text{BW} \times \text{AT} \times 365 \text{ days/yr}}$$

$$C \text{ (mg/l; risk based)} = \frac{\text{THI} \times \text{BW} \times \text{AT} \times 365 \text{ days/yr}}{\text{EF} \times \text{ED} \times 1/\text{RfD}_o \times \text{IR}_w} \quad (6)$$

<u>Parameters</u>	<u>Definitions (units)</u>	<u>Site-Specific Values</u>
C	chemical concentration in water (mg/l)	-
THI	target hazard index (unitless)	1
RfD _o	chronic oral reference dose (mg/kg/day)	chemical-specific
BW	adult body weight (kg)	70 kg
AT	averaging time (yrs)	30 yrs (for noncarcinogens, equal to ED)
EF	exposure frequency (days/yr)	350 days/yr
ED	exposure duration (yrs)	30 yrs
IR _w	daily water ingestion rate (l/day)	2 l/day

Reduced Equation: Residential Groundwater - Noncarcinogenic Effects

$$\text{Risk-based PRG} = \frac{73}{2/\text{RfD}_0} \quad (7)$$

(mg/l; THI = 1)

where:

RfD_0 = chronic oral reference dose in mg/kg-day

Although the Tutu Wells site may continue to be commercially developed, the site will likely remain residential, at least in part, indefinitely into the future.

Since the NCP encourages protection of groundwater to its maximum beneficial use, once the groundwater is determined to be suitable for drinking, risk-based PRGs should be based on residential exposure (USEPA, 1991b). Therefore, risk-based PRGs have been developed for residential groundwater use only, to be protective of human health.

TABLE 7-2

TUTU WELLS SITE
GROUNDWATER RISK-BASED PRELIMINARY REMEDIATION GOALS (PRGs)
FOR NONCARCINOGENS (mg/l)

RESIDENTIAL INGESTION:

<u>Chemicals</u>	<u>Risk-Based PRGs</u>
1,2-Dichloroethene (Total)	0.33
Manganese	0.18

8.0 SUMMARY OF THE BASELINE RISK ASSESSMENT

In this baseline human health risk assessment, the site matrices surface soil, subsurface soil, and groundwater were quantitatively evaluated for potential health threats to human receptors via the ingestion, dermal contact, and inhalation routes of exposure. Receptors including residents (adults and children), site workers (employees), and construction workers were evaluated under present and potential future land use conditions, as appropriate. The results of the risk and hazard index calculations and the greatest chemical contributors to these estimates have been presented and discussed.

Chemicals of potential concern were selected for each matrix based on criteria outlined in RAGS (USEPA, 1989a) and presented in Section 2.3. The chemicals of potential concern included VOCs, SVOCs, a PCB, and inorganics. The chemicals 2-hexanone, n-propylbenzene, 1,1,1-trichloroethane, benzo(g,h,i)perylene, dibenzofuran, 2-nitrophenol, acenaphthylene, methyl-tertiary-butyl-ether, 2-methylnaphthalene, phenanthrene, TPH, aluminum, cobalt, copper, iron, and lead could not be quantitatively evaluated in this risk assessment due to their lack of established toxicity values. The essential nutrients (i.e., calcium, magnesium, potassium, and sodium) were not quantitatively evaluated as their potential toxicity is significantly lower than other inorganics at the site, and most existing toxicological data pertain to dietary intake.

Exposure routes and receptor groups were identified and quantitative estimates of the magnitude, frequency, and duration of exposure were made. Exposure points were estimated using the 95 percent UCL calculation, as appropriate. Chronic and subchronic daily intakes for ingestion,

dermal contact, and inhalation routes were calculated for the reasonable maximum exposure (i.e., using 95 percent UCL concentrations and 90th and 95th percentile exposure parameters).

In the toxicity assessment, current toxicological human health data (i.e., reference doses, reference concentrations, and slope factors) were obtained from various sources and were utilized in the order specified by RAGS (USEPA, 1989a). Brief toxicological profiles for chemicals which could not be quantitatively evaluated in the risk assessment have been included in this section (4.0). Toxicological profiles for the chemicals of potential concern have been developed and are presented in Appendix B.

Risk characterization involved integrating the exposure and toxicity assessments into quantitative expressions of risks/health effects. Specifically, chronic and subchronic daily intakes were compared with concentrations known or suspected to present health risks or hazards. The carcinogenic risks and noncarcinogenic hazard index values calculated at the site are based on the reasonable maximum exposure (the highest exposure reasonably expected to occur at a site). The intent is to estimate a conservative exposure case that is still within the range of possible exposures.

In accordance with the National Oil and Hazardous Substance Pollution Contingency Plan (NCP) Section 300.430 (e)(2) for known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper-bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6} . Per the RAGS Part B: Development of Risk-Based Preliminary Remediation Goals (USEPA, 1991b), for noncarcinogenic effects, the NCP does not specify a range, but it is generally appropriate to assume a hazard index equal to one.

In general, the USEPA recommends a target range and a target level (i.e., carcinogenic risk of 10^{-4} to 10^{-6} or noncarcinogenic hazard index of one) as threshold values for potential human health impacts (USEPA, 1989a). The 10^{-4} to 10^{-6} target risk range may be interpreted as meaning carcinogenic risks should not be greater than approximately 1 in 10,000 to 1 in 1,000,000. For this risk assessment, the upper-bound of the target risk range is $1.0\text{E-}04$. A risk greater than 1 in 10,000 or $1.0\text{E-}04$ is considered to be in exceedance of the USEPA's 10^{-4} to 10^{-6} target risk range. These target values aid in determining the objectives of the baseline human health risk assessment which include determining whether additional response action is necessary at the site, by providing a basis for determining residual chemical levels that are adequately protective of human health, by providing a basis for comparing potential health impacts of various remedial alternatives, and to help support selection of the "no action" remedial alternative, where appropriate. In addition, the chemicals of potential concern in site groundwater were compared to federal MCLs (Table 5-3). All VOC maximum detections, except for 1,2-dichloroethene (total) which does not have an established MCL, far exceed their respective established MCLs. The maximum concentrations of all of the inorganics except for manganese exceed their respective MCLs. Manganese does not currently have an established primary MCL, although it does have a nonenforceable secondary MCL of 50 ug/l. Vanadium, which also does not have an established MCL, did not result in any hazard quotients above one.

Human Health Risks and Hazards Identified

The following discussion presents by receptor group carcinogenic risks and noncarcinogenic hazard index values in exceedance of the USEPA's target values for the matrices evaluated in

this risk assessment. Brief mention of those risks and hazards not exceeding any target values are also included for completeness.

Residents

Surface Soil: Present and potential future residents in the Tillett Gardens and Art Center area were quantitatively evaluated for surface soil exposure via the ingestion, dermal contact, and inhalation of particulates (future-use only) routes. The ingestion and dermal contact routes of exposure showed carcinogenic risks in exceedance of the upper-bound of the target risk range (i.e., greater than $1.0\text{E-}04$). These risks ranged from $4.4\text{E-}04$ (ingestion) to $1.3\text{E-}03$ (dermal contact) for adults and from $3.9\text{E-}04$ (dermal contact) to $1.0\text{E-}03$ (ingestion) for children. These risks were due largely to Aroclor 1242. The child ingestion and inhalation of surface soil routes of exposure showed hazard index values in exceedance of one. The child ingestion hazard index ($3.0\text{E}+00$) and the child inhalation hazard index ($3.1\text{E}+00$) combined resulted in a total hazard index of $6.1\text{E}+00$ which was due largely to manganese. No adult hazard index values exceeded one.

Subsurface Soil: Potential future residents in the Tillett Gardens and Art Center area were quantitatively evaluated for subsurface soil exposure via the dermal contact and inhalation of particulates routes. Neither of these routes of exposure (the dermal contact route could not be quantitatively evaluated) resulted in carcinogenic risks or hazard index values in exceedance of the upper-bound of the USEPA's 10^{-4} to 10^{-6} target risk range for carcinogens or target level of one for noncarcinogens.

Groundwater: Present and potential future residents at the site were quantitatively evaluated for site-wide groundwater exposure via the ingestion, dermal contact (during showering), and inhalation of VOCs (during and after showering) routes. Only the ingestion route of exposure showed carcinogenic risks in exceedance of the upper-bounds of the target risk range (i.e., greater than $1.0\text{E-}04$). These risks, $6.6\text{E-}04$ for adults and $3.1\text{E-}04$ for children, were due largely to tetrachlorethene and vinyl chloride.

The ingestion of groundwater by adults and children showed hazard index values in exceedance of one. The adult hazard index of $2.9\text{E+}01$ was due largely to 1,2-dichloroethene (total) and manganese, while the child hazard index of $6.7\text{E+}01$ was due largely to 1,2-dichloroethene (total), tetrachloroethene, antimony, manganese, and vanadium.

Site Workers (Employees)

Surface Soil: Present and potential future site workers (employees) in the Fire Department/Texaco gas station/Antilles auto parts/Ramsay motor co., Curriculum Center Building, and O'Henry dry cleaners and Liquor Barn were quantitatively evaluated for surface soil exposure via the ingestion, dermal contact, inhalation of particulates (future-use only), and inhalation of VOCs (O'Henry dry cleaners and Liquor Barn only) routes. None of these routes of exposure (the dermal contact route could not be quantitatively evaluated) resulted in carcinogenic risk or hazard index values in exceedance of the upper-bound of the USEPA's 10^{-4} to 10^{-6} target risk range for carcinogens or target level of one for noncarcinogens.

Subsurface Soil: Potential future site workers (employees) in the Fire Department/Texaco gas station/Antilles auto parts/Ramsay motor co., Curriculum Center Building, Esso gas station and Splash and Dash car wash, and O'Henry dry cleaners and Liquor Barn areas of concern were quantitatively evaluated for subsurface soil exposure via the dermal contact and inhalation of particulates routes. None of these routes of exposure (the dermal contact route could not be quantitatively evaluated) resulted in carcinogenic risks or hazard index values in exceedance of the upper-bound of the USEPA's 10^{-4} to 10^{-6} target risk range for carcinogens or target level of one for noncarcinogens.

Groundwater: Present and potential future site workers (employees) were quantitatively evaluated for site groundwater exposure via the ingestion route. The carcinogenic risk of $2.0E-04$ is in exceedance of the upper-bound of the USEPA's 10^{-4} to 10^{-6} target risk range and is due largely to tetrachloroethene and vinyl chloride. The hazard index of $1.0E+01$ exceeds the target level of one and is largely due to manganese.

Construction Workers

Surface and Subsurface Soil: Potential future construction workers in the Tillett Gardens and Art Center area were quantitatively evaluated for surface soil and subsurface soil exposure via the ingestion, dermal contact, and inhalation of particulates routes. None of these routes of exposure resulted in carcinogenic risks or hazard index values in exceedance of the upper-bound of the USEPA's 10^{-4} to 10^{-6} target risk range for carcinogens or target level of one for noncarcinogens.

Groundwater: Potential future site construction workers were quantitatively evaluated for site groundwater exposure via the ingestion route. The carcinogenic risk of $7.1\text{E}-06$ is not in exceedance of the upper-bound of the USEPA's 10^{-4} to 10^{-6} target risk range. The hazard index of $9.1\text{E}+00$ exceeds the target level of one and is due largely to manganese.

Summary of Risks and Hazards

A review of the carcinogenic risks for the various matrices and receptor populations showed that present and potential future residential exposure to surface soil in the Tillett Gardens and Art Center via ingestion and dermal contact, and to groundwater via ingestion were in exceedance of the upper-bound of the USEPA's target risk range of 10^{-4} to 10^{-6} . Site worker (employee) and construction worker carcinogenic risks from exposure to groundwater were also in exceedance of the upper-bound of the USEPA's 10^{-4} to 10^{-6} target risk range. A review of the noncarcinogenic hazard index values for the site matrices and receptors showed that present and/or potential future child exposures to surface soil in the Tillett Gardens and Art Center via ingestion and inhalation and present and potential future resident, site worker (employee), and construction worker (future-use only) exposures to groundwater via ingestion were in exceedance of USEPA's target level of one.

MCLs for the chemicals of potential concern in groundwater have been presented in Table 5-3 for comparison to site detections. The maximum detected site concentrations of benzene, tetrachloroethene, toluene, vinyl chloride, antimony, arsenic, beryllium, chromium VI, and nickel were found to exceed current Federal drinking water standards.

Site-specific uncertainties relating to the risk assessment were qualitatively and quantitatively addressed in Section 6.0.

In accordance with standard risk assessment practice, central tendency calculations were performed as a quantitative measure of uncertainty in the risk assessment and are presented in Tables D-1 through D-6 in Appendix D. The 50th percentile parameters used in these calculations and presented in Table 6-1 were assumed to be representative of the general population. These central tendency calculations, however, have the potential to underestimate true risks/hazard index values for sensitive receptors.

Finally, risk-based PRGs were calculated for residential and commercial/industrial land use and for residential groundwater use for risks greater than $1.0E-04$ and hazard indices greater than one and are presented in Tables 7-1 and 7-2. Per USEPA direction, PRGs were not calculated for chemicals of potential concern in soil where superseding USEPA guidance on action levels exists or in groundwater if MCLs exist. Risk-based PRGs are initial guidelines only and do not establish that cleanup to these goals is required. A risk-based concentration is considered a final remediation level only after analysis in the RI/FS and ROD.

REFERENCES

Agency for Toxic Substances and Disease Registry (ATSDR). 1994. Toxicological Profile for Methyl-t-Butyl Ether (Draft). U.S. Public Health Service, August 1994.

Andelman, J. 1990. Total Exposure to Volatile Organic Compounds in Potable Water, Chapter 20. In: Significance and Treatment of Volatile Organic Compounds in Water Supplies. Editors, Cantor, K., Christman., N. Lewis Publishers, Michigan. Pages 485-504.

CDM Federal Programs Corporation. 1989a. CLP Sample Analysis Data Summary of the 104(e) Letter Response Sampling. Tutu Wellfield Area. March 31, 1989.

CDM Federal Programs Corporation. 1989b. CLP Sample Analysis Data Summary of the 104(e) Letter Response Sampling. Tutu Wellfield Area. (TPH results). April 14, 1989.

CDM Federal Programs Corporation. 1990. Final CLP Sample Analysis Data Summary of Soils and Waters Sampled in 1989. Tutu Wellfield, St. Thomas, U.S. Virgin Islands. May 31, 1990.

CDM Federal Programs Corporation. 1993. Data Comparison and Evaluation Report for Groundwater and Soil Split Samples at the Tutu Wellfield Site, St. Thomas, U.S. Virgin Islands. June 8, 1993.

Clement Associates, Inc. 1985. Chemical, Physical, and Biological Properties of Compounds Present at Hazardous Waste Sites. Final Report. Prepared for the U.S. Environmental Protection Agency. September 27, 1985.

Conway, R. ed. 1982. Environmental Risk Analysis for Chemicals. New York: Van Nostrand Reinhold Company.

Friberg. 1986. Handbook of Toxicity of Metals. 2nd edition. Volumes I and II 1986 V2 86. In Hazardous Substance Data Bank. On-line April 14, 1993.

Geraghty & Miller, Inc. 1991a. Second Quarter Sampling Report - February 1991. Tutu Wells Site Quarterly Sampling, St. Thomas, U.S. Virgin Islands. Prepared for Tutu Environmental Investigation Committee. May 13, 1991.

Geraghty & Miller, Inc. 1991b. Third Sampling Report - June 1991. Tutu Wells Site, St. Thomas, U.S. Virgin Islands. Prepared for L'Henri, Inc. and Tutu Environmental Investigation Committee. September 6, 1991.

REFERENCES (Continued)

Geraghty & Miller, Inc. 1992a. Fourth Sampling Report - October 1991. Tutu Wells Site, St. Thomas, U.S. Virgin Islands. Prepared for Tutu Environmental Investigation Committee. January 1992.

Geraghty & Miller, Inc. 1992b. Tutu Service Station Investigation Work Plan. St. Thomas, U.S. Virgin Islands. Submitted to Tutu Environmental Investigation Committee. March 20, 1992.

Geraghty & Miller, Inc. 1992c. Fifth Sampling Report - February 1992. Tutu Wells Site, St. Thomas, U.S. Virgin Islands. Prepared for Tutu Environmental Investigation Committee. May 15, 1992.

Geraghty & Miller, Inc. 1992d. Sixth Sampling Report - May 1992. Tutu Wells Site, St. Thomas, U.S. Virgin Islands. Prepared for Tutu Environmental Investigation Committee. August 1992.

Geraghty & Miller, Inc. 1992e. Seventh Sampling Report - September 1992. Tutu Wells Site, St. Thomas, U.S. Virgin Islands. Prepared for Tutu Environmental Investigation Committee. December 18, 1992.

Geraghty & Miller, Inc. 1993a. Technical Memorandum II - Results of the Field Program Tutu Service Station Investigation. St. Thomas, U.S. Virgin Islands, Volumes 1 and 2, Prepared for Tutu Environmental Investigation Committee. May 1993.

Geraghty & Miller, Inc. 1993b. Eighth Sampling Report - March/April 1993. Tutu Wells Site, St. Thomas, U.S. Virgin Islands. Prepared for Tutu Environmental Investigation Committee. July 1993.

Geraghty & Miller, Inc. 1993c. Phase II Remedial Investigation Work Plan. Tutu Wells Site, St. Thomas, U.S. Virgin Islands. Volume 1 of 2. Prepared for Tutu Environmental Investigation Committee. December 1993.

Geraghty & Miller, Inc. 1994. Draft Phase II Remedial Investigation. Tutu Wells Site, St. Thomas, U.S. Virgin Islands. Volumes I and II. Prepared for Tutu Environmental Investigation Committee. October 1994.

Gilbert, R.O. 1987. Statistical Methods for Environmental Pollution Monitoring, Van Nostrand Reinhold, New York, New York.

Hawley, J., 1985. Assessment of Health Risk from Exposure to Contaminated Soil. Risk Analysis Vol. 5, No. 4 pp. 289-302.

REFERENCES (Continued)

Integrated Risk Information System (IRIS). 1994. U.S. Environmental Protection Agency on-line data base of toxicity measures. Office of Research and Development, Environmental Criteria and Assessment Office, Cincinnati, OH. On-line June 22 and 30, 1994, July 1, 1994, August 4, 1994, and October 25, 1994.

Jordan, D., and Cosner, O. 1973. A survey of the Water Resources of St. Thomas, Virgin Islands, U.S. Geological Survey Open-File Report, 55 pp.

Klaassen, C., Amdur, M., and Doull, J. eds. 1986. In: Casarett and Doull's Toxicology: The Basic Science of Poisons, 3rd ed. Macmillan Publishing Co., New York, Toronto and London.

Lyman, W., Reehl, W., and Rosenblatt, D. 1982. Handbook of Chemical Property Estimation Methods: Environmental Behavior of Organic Compounds. New York: McGraw-Hill Book Company, Inc.

The Merck Index, 1989. An Encyclopedia of Chemicals, Drugs, and Biologicals. Eleventh edition. Ed. S. Budavari. Merck and Co., Inc. Rahway, NJ.

National Contingency Plan (NCP). Volume 40 Code of Federal Regulations (CFR) Part 300.

Schaum, J., Hoang, K., Kinerson, R., Moya, J., and Wang, R. 1994. Estimating Dermal and Inhalation Exposure to Volatile Chemicals in Domestic Water. In: Water Contamination and Health-Integration of Exposure Assessment, Toxicology, and Risk Assessment, R. Wang, Human Risk Assessment Branch, USEPA, ed. Marcel Dekker, Inc., New York, Basel, Hong Kong.

USEPA, 1984. Health Assessment Document for Manganese. Final Draft. U.S. Environmental Protection Agency. Office of Research and Development, Cincinnati, OH. EPA/600/8-83-013F.

USEPA, 1985. Ambient Water Quality Criteria for Cyanide - 1984. U.S. Environmental Protection Agency. Regulations and Standards. Criteria and Standards Division, Washington, D.C. January 1985.

USEPA, 1986. Superfund Public Health Evaluation Manual. U.S. Environmental Protection Agency. Office of Emergency and Remedial Response. Washington, D.C. OSWER Directive 9285.4-1. EPA 540 1-86-060. October 1986.

USEPA, 1988a. Superfund Exposure Assessment Manual. Office of Remedial Response, U.S. Environmental Protection Agency, Washington, DC. EPA/540/1-88/001.

REFERENCES (Continued)

USEPA, 1989a. Risk Assessment Guidance for Superfund: Human Health Evaluation Manual Part A. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency and Remedial Response. OSWER Directive 9285.701A.

USEPA, 1989b. Exposure Factors Handbook. Exposure Assessment Group, Office of Health and Environmental Assessment, U.S. Environmental Protection Agency, Washington, DC. EPA/600/8-89/043.

USEPA, 1990. A Guide on Remedial Actions at Superfund Sites with PCB Contamination-Fact Sheet. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response. OSWER Directive 9355.4-01 FS. August.

USEPA, 1991a. Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. OSWER Directive 9285.6-03

USEPA, 1991b. Human Health Evaluation Manual Part B: Development of Risk-Based Preliminary Remediation Goals. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response. OSWER Directive 9285.7-01B.

USEPA, 1992a. Guidance for Data Useability in Risk Assessment - Final. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, D.C. OSWER Directive 9285.7-09A. April.

USEPA, 1992b. Risk Assessment Issue Paper for: Status of Polyaromatic Hydrocarbons. U.S. Environmental Protection Agency, Office of Research and Development, Cincinnati, Ohio.

USEPA, 1992c. Dermal Exposure Assessment: Principles and Applications - Interim Report. U.S. Environmental Protection Agency, Office of Research and Development, Washington, DC. EPA/600/8-91/011B. January.

USEPA, 1992d. Provisional RfD and Carcinogenicity Information for Trichloroethene. U.S. Environmental Protection Agency, Office Research and Development, Environmental Assessment Office, Cincinnati, OH. Received December 7, 1992.

USEPA, 1993a. Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons. U.S. Environmental Protection Agency, Office of Research and Development, Washington, D.C. EPA/600/R-93/089. July.

REFERENCES (Continued)

USEPA, 1993b. Region II Drinking and Groundwater Standards Update. Groundwater Management Section. U.S. Environmental Protection Agency. Tables 1 and 2 National Primary Drinking Water Regulations (Title 40 CFR - Part 141, 1992) and Table 5 National Secondary Drinking Water Regulations (Title 40 CFR - Part 143, 1992). July 20, 1993.

USEPA, 1994. Health Effects Assessment Summary Tables (HEAST) FY 1994-Annual U.S. Environmental Protection Agency, Office of Research and Development. OERR 9200.6-303 (94-1)(March).

Wills, M. and Savory, J. 1983. Aluminum poisoning: Dialysis encephalopathy, osteomalacia, and anemia. Lancet 2:29-33. In Casarett and Doull's Toxicology: The Basic Science of Poisons, 3rd ed. Klaassen, C., Amdur, M., and Doull, J. eds. Macmillan Publishing Co., New York, Toronto and London.