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REVISION 2 OF THE FOCUSED RISK ASSESSMENT FOR OPERABLE UNIT 2 (OU 2) MCCOY ANNEX LANDFILL CONTAINING RECOMMENDED EXPOSURE DURATION FOR SITE MAINTENANCE WORKERS FROM 15 TO 25 YEARS FROM REGULATORS NTC ORLANDO FL

12/22/1998

TETRA TECH

03.09.02.0001

TETRA TECH NUS, INC.

FILE COPY

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Jackson Plaza, Suite A-600
Oak Ridge, TN 37830

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ID-00192

98-E446

December 22, 1998

Project Number 7457

Ms. Barbara Nwokike (Code 1873) (IRP RPM)
SOUTHNAVFACENCOM
2155 Eagle Drive
North Charleston, South Carolina 29419-9010

Reference: CLEAN Contract No. N62467-94-D-0888
Contract Task Order No. 0024

Subject: Revision 2 of the Focused Risk Assessment for Operable Unit 2, McCoy Annex Landfill, Naval Training Center, Orlando, Florida

Dear Ms. Nwokike:

Enclosed are the Revision 2 changes to the Focused Risk Assessment report for OU 2. The changes result from an increase in the exposure duration for the site maintenance worker from 15 to 25 years, as directed by the Florida Department of Environmental Protection. Despite the increase, the revision does not change the conclusion that the Excess Lifetime Cancer Risks for both the recreational user and the site maintenance worker are less than the FDEP level of concern (1.0×10^{-6}).

All of those on distribution for the revision have received insert sheets with the exception of Allan Aikens, who joined the Orlando Partnering Team after the report was issued. A complete copy of the report has been sent to Mr. Aikens.

Previous recipients of the report should replace the pages listed below:

Binder Cover and Spine
Title Page
Executive Summary
Pages 6-3 and 6-4
Page 9-1
App. B - Tables B-1 and B-2
App. C - Risk Calculation Sheet for the Site Maintenance Worker
App. D - Hand Calculations (10 pages)

Please call me at (423) 220-4730 if you have any questions.

Sincerely yours,

Steven B. McCoy

Steven B. McCoy, P.E.
Task Order Manager

SBM/smc

Enclosure

c: Ms. Nancy Rodriguez, USEPA Region IV (2 copies)
Mr. David Grabka, FDEP (2 copies)
Mr. Wayne Hansel, SOUTHDIV (3 copies) (NTC-Orlando address - Lt. Gary Whipple)
Lt. Gary Whipple, NTC-Orlando
Mr. Allan Aikens, CH2M Hill (complete report)
Mr. Bob Cohose, Bechtel
Ms. Debra Evans-Ripley, SOUTHNAVFACENGCOM (w/o enclosure)
Mr. Rick Allen, Harding Lawson Associates
Ms. Ruthann Baur, Tetra Tech NUS (w/o enclosure)
Mr. Mark Perry, Tetra Tech NUS
Ms. Debbie Wroblewski, Tetra Tech NUS (w/o enclosure)
Mr. Gary Braganza, Tetra Tech NUS
Ms. LeeAnn Sinagoga, Tetra Tech NUS (w/o enclosure)
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98-E331

September 25, 1998

Project Number 7457

Ms. Barbara Nwokike (Code 1873)
SOUTHNAVFACENCOM
Naval Training Center - Orlando
1350 Grace Hopper Avenue
Orlando, Florida 32813-8405

Reference: CLEAN Contract No. N62467-94-D-0888
Contract Task Order No. 0024

Subject: Final Focused Risk Assessment for Operable Unit 2, McCoy Annex Landfill, Naval Training Center, Orlando, Florida

Dear Ms. Nwokike:

Enclosed is the final Focused Risk Assessment report for OU2. The final version incorporates comments received from the US EPA and FDEP.

If you have any questions please call me at (423) 220-4730.

Sincerely yours,

Steven B. McCoy

Steven B. McCoy, P.E.
Task Order Manager

SBM/smc

Enclosure

c: Ms. Nancy Rodriguez, USEPA Region IV
Mr. David Grabka, FDEP (2 copies)
Mr. Wayne Hansel, SOUTHDIV (3 copies) (NTC-Orlando address - Lt. Gary Whipple)
Lt. Gary Whipple, NTC-Orlando
Mr. Bob Cohose, Bechtel
Ms. Debra Evans-Ripley, SOUTHNAVFACENGCOM (w/o enclosure)
Mr. Rick Allen, Harding Lawson Associates
Ms. Ruthann Baur, Tetra Tech NUS (w/o enclosure)
Mr. Mark Perry, Tetra Tech NUS
Ms. Debbie Wroblewski, Tetra Tech NUS(w/o enclosure)
Mr. Mike Campbell, Tetra Tech NUS
Mr. Gary Braganza, Tetra Tech NUS
Ms. LeeAnn Sinagoga, Tetra Tech NUS (w/o enclosure)

Rev. 2
12/14/98

FOCUSED RISK ASSESSMENT
for
OPERABLE UNIT 2
McCOY ANNEX LANDFILL

Naval Training Center
Orlando, Florida

Southern Division
Naval Facilities Engineering Command
Contract Number N62467-94-D-0888
Contract Task Order 0024

DECEMBER 1998

Rev. 2
12/14/98

FOCUSED RISK ASSESSMENT
FOR
OPERABLE UNIT 2
McCOY ANNEX LANDFILL

NAVAL TRAINING CENTER
ORLANDO, FLORIDA

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:

Department of the Navy, Southern Division
Naval Facilities Engineering Command
2155 Eagle Drive
North Charleston, South Carolina 29406

Submitted by:

Tetra Tech NUS
661 Andersen Drive
Foster Plaza
Pittsburgh, Pennsylvania 15220

CONTRACT NO. N62467-94-D-0888
CONTRACT TASK ORDER 0024

DECEMBER 1998

PREPARED BY:

Steven B. McCoy

STEVEN B. McCOY
TASK ORDER MANAGER
TETRA TECH NUS
OAK RIDGE, TENNESSEE

APPROVED FOR SUBMITTAL BY:

Debbie Wroblewski

DEBBIE WROBLEWSKI
PROGRAM MANAGER
TETRA TECH NUS
PITTSBURGH, PENNSYLVANIA

R4707982

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FIGURES

TABLES

ACRONYMS

bls	below land surface
CPC	chemical of potential concern
CRDL	contract-required detection limit
CRQL	contract-required quantitation limit
CSF	Cancer Slope Factor
DRO	Diesel Range Organics
ELCR	excess lifetime cancer risk
EPC	Exposure Point Concentration
ET	exposure time
FDEP	Florida Department of Environmental Protection
FRA	Focused Risk Assessment
GRO	Gasoline Range Organics
HEAST	Health Effects Assessment Summary Tables
HI	hazard index
HQ	Hazard Quotient
IRIS	Integrated Risk Information System
NCP	National Oil and Hazardous Substances Contingency Plan
NTC	Naval Training Center
OPT	Orlando Partnering Team
OU	operable unit
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
QA	quality assurance
QC	quality control
RAGS	Risk Assessment guidance for Superfund
RBC	Risk-Based Concentration
RfD	Reference Dose
RGO	Remedial Goal Option
RME	Reasonable Maximum Exposure
SCG	Soil Cleanup Goal
SVOC	semivolatile organic compound
TAL	Target Analyte List
TPH	total petroleum hydrocarbons
UCL	Upper Confidence Limit
USEPA	United States Environmental Protection Agency
VOC	volatile organic compound

EXECUTIVE SUMMARY

A Focused Risk Assessment was conducted by Tetra Tech NUS, Inc., for Operable Unit 2 (OU2) of the McCoy Annex Landfill. OU2 is located at the southern end of the McCoy Annex and contains a nine-hole golf course. This risk assessment evaluated the risk associated with the contamination of the surficial soil covering the landfill. The soil data used in the risk assessment were obtained from sampling and analysis of the soil performed from May to December 1997, and reported in the Remedial Investigation Technical Memorandum for Operable Unit 2, McCoy Annex Landfill (Brown & Root Environmental 1998).

Three different receptor types were evaluated for this site: a site maintenance worker, a recreational user, and a hypothetical resident. The site is expected to remain in use as a golf course; therefore, the resident was evaluated for comparison purposes only and risk management decisions are not necessary for this receptor.

The total estimated Excess Lifetime Cancer Risk (ELCR) was 6.1×10^{-7} for the recreational user and 8.3×10^{-7} for the site maintenance worker. These values are within the acceptable risk range of 1.0×10^{-6} to 1.0×10^{-4} as defined by the United States Environmental Protection Agency. These ELCR values are approximately equivalent to the Florida Department of Environmental Protection level of concern (1.0×10^{-6}). For reference, if the property were to be redeveloped for residential use, the total risk to the resident was calculated to be 7.4×10^{-6}. The hazard index for all receptors was less than 1.

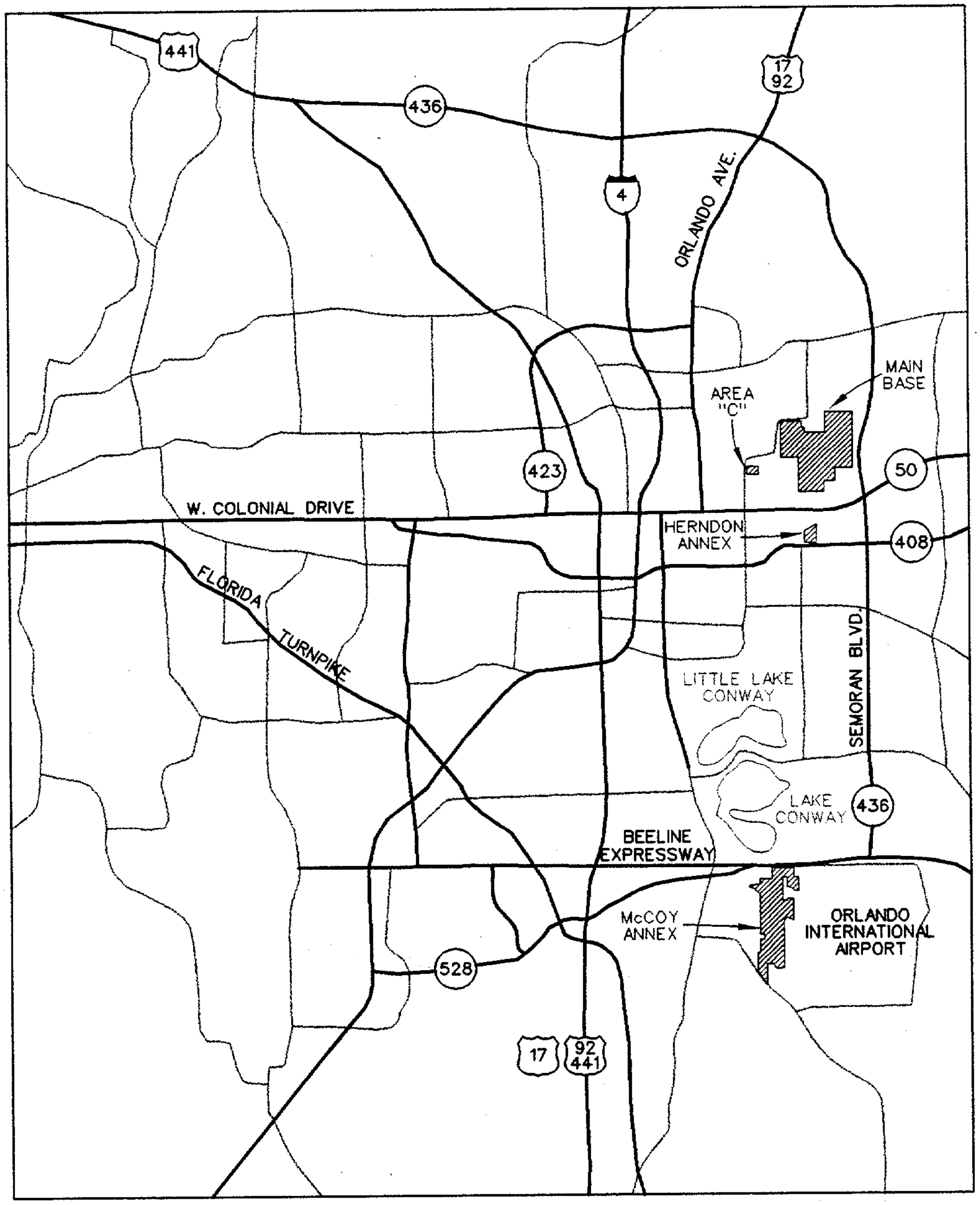
1.0 INTRODUCTION

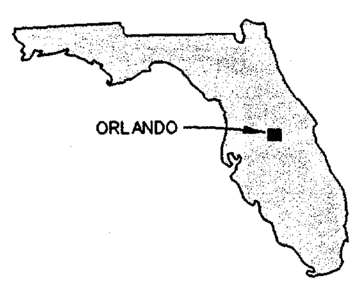
As directed by the Orlando Partnering Team (OPT), Tetra Tech NUS has completed a Focused Risk Assessment (FRA) for the Naval Training Center (NTC), Orlando, Operable Unit (OU) 2. OU2 is located in southern section of the McCoy Annex as shown Figures 1-1 and 1-2. The purpose of the FRA was to evaluate the risks from potential exposures to environmental contamination in surface soils at OU2. Contamination associated with groundwater at OU2 was not considered in this FRA, but it will be considered in the Remedial Investigation. This report summarizes the FRA methodology and presents the risk characterization results. This FRA was conducted in accordance with the following United States Environmental Protection Agency (USEPA) and Florida Department of Environmental Protection (FDEP) guidance:

- Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part A) (USEPA, 1989a).
- Guidance for Data Usability in Risk Assessment (Part A), Final (USEPA, 1992a).
- Region IV Risk Assessment Guidance (USEPA, 1995b).
- Soil Cleanup Goals for Florida (FDEP, 1995).
- Applicability of Soil Cleanup Goals for Florida (FDEP, 1996).

This FRA was conducted to assess whether exposure to chemicals in the surface soil at OU2 would result in potential health risks to individuals under the proposed reuse scenario – recreational use in the absence of remediation. A future residential scenario was also evaluated for informational purposes. This FRA was intended to assist decision-makers in evaluating land reuse alternatives and determining the need for remedial action prior to transfer of the property.

This FRA consists of nine Sections and four Appendices. Section 1.0 provides the introduction. Data evaluation is presented in Section 2.0. The identification of chemicals of potential concern (CPCs), is performed in Section 3.0. Exposure assessment, toxicity assessment, and risk characterization (including uncertainty analysis) (USEPA, 1989a) are presented in Sections 4.0, 5.0, and 6.0, respectively. Remedial goals options are provided in Section 7.0 and uncertainty is discussed in Section 8.0. The conclusions are presented in Section 9 Appendix A contains toxicity summaries. Exposure parameter are provided in Appendix B. Risk calculation sheets and hand calculations are presented in Appendices C and D, respectively. The FRA is used to identify site-related contaminants of concern and to estimate the potential magnitude of exposure and the risks resulting from the estimated exposure conditions.





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SCALE IN MILES

FIGURE 1-1

Tetra Tech NUS, Inc.

OAK RIDGE, TENNESSEE

FACILITY LOCATIONS

NAVAL TRAINING CENTER
ORLANDO, FLORIDA

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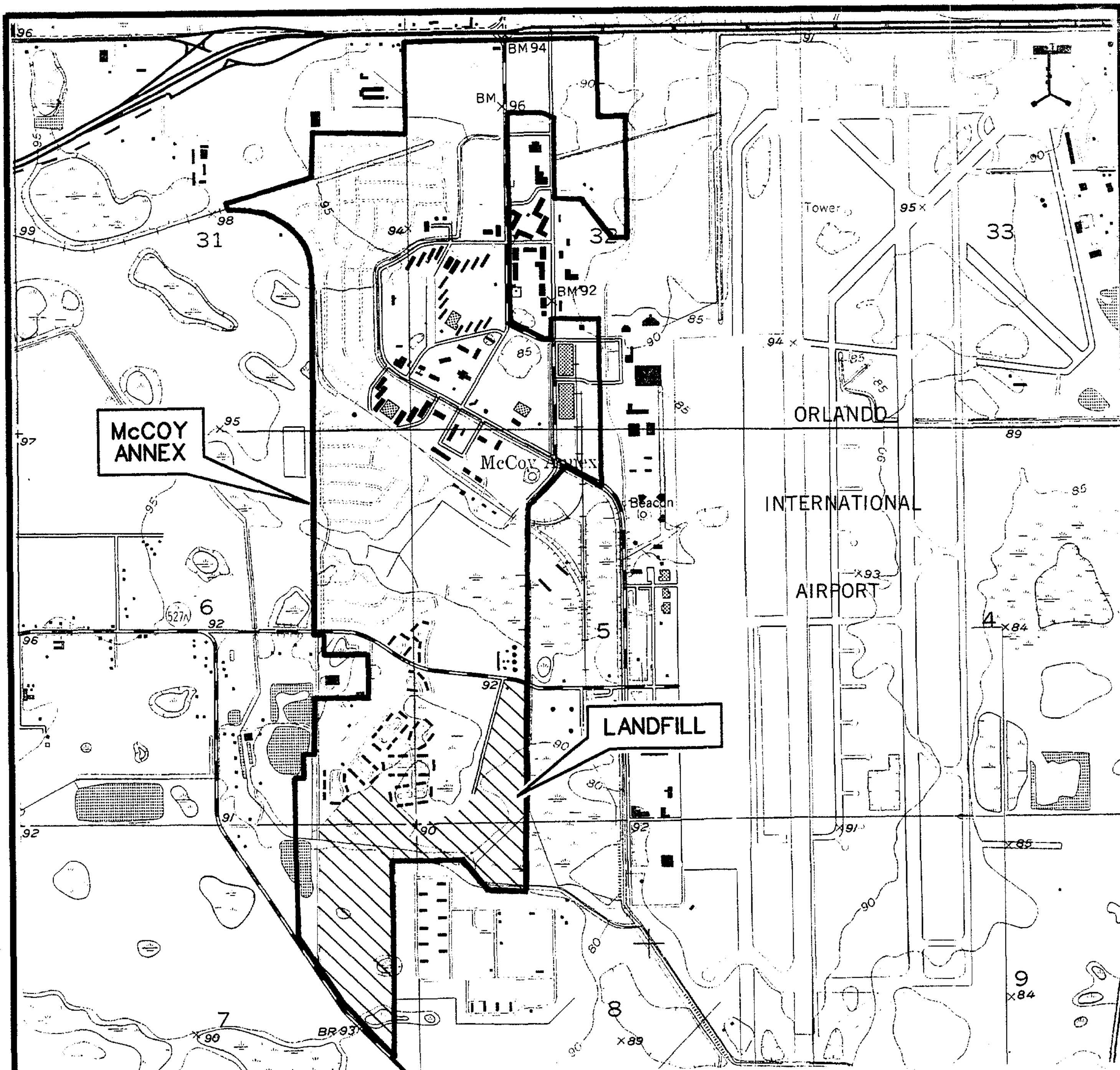

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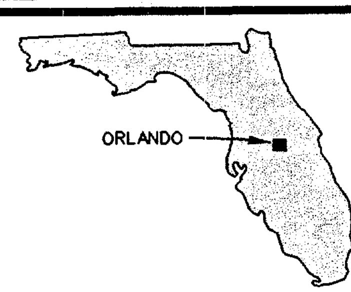

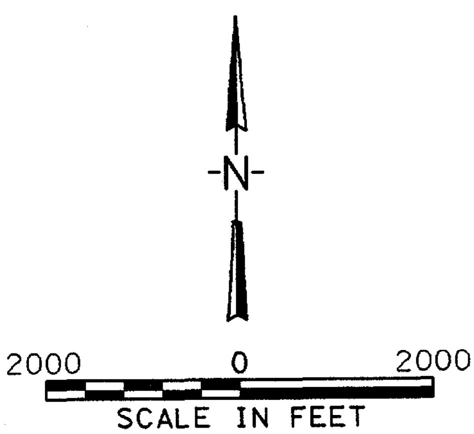

FIGURE 1-2

Tetra Tech NUS, Inc. OAK RIDGE, TENNESSEE	SITE LOCATION MAP McCOY ANNEX LANDFILL NAVAL TRAINING CENTER ORLANDO, FLORIDA

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2.0 DATA EVALUATION

The data evaluation involves numerous activities, including evaluating analytical methods, evaluating quantitation limits, evaluating quality of data with respect to qualifiers and codes, and developing a data set for use in risk assessment. A description of each of these activities is provided below.

2.1 AVAILABLE DATA

Analytical results for 116 surface soil sample locations (Figure 2-1) are evaluated in this FRA. Samples were collected 2 feet or less below land surface (bls) during the first phase of the Remedial Investigation. The samples were analyzed for Target Compound List volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), pesticides, Target Analyte List (TAL) inorganics, total petroleum hydrocarbons (TPH), and gross alpha/beta. The samples evaluated in this FRA and detected analytes are presented in Tables 2-1 and 2-2.

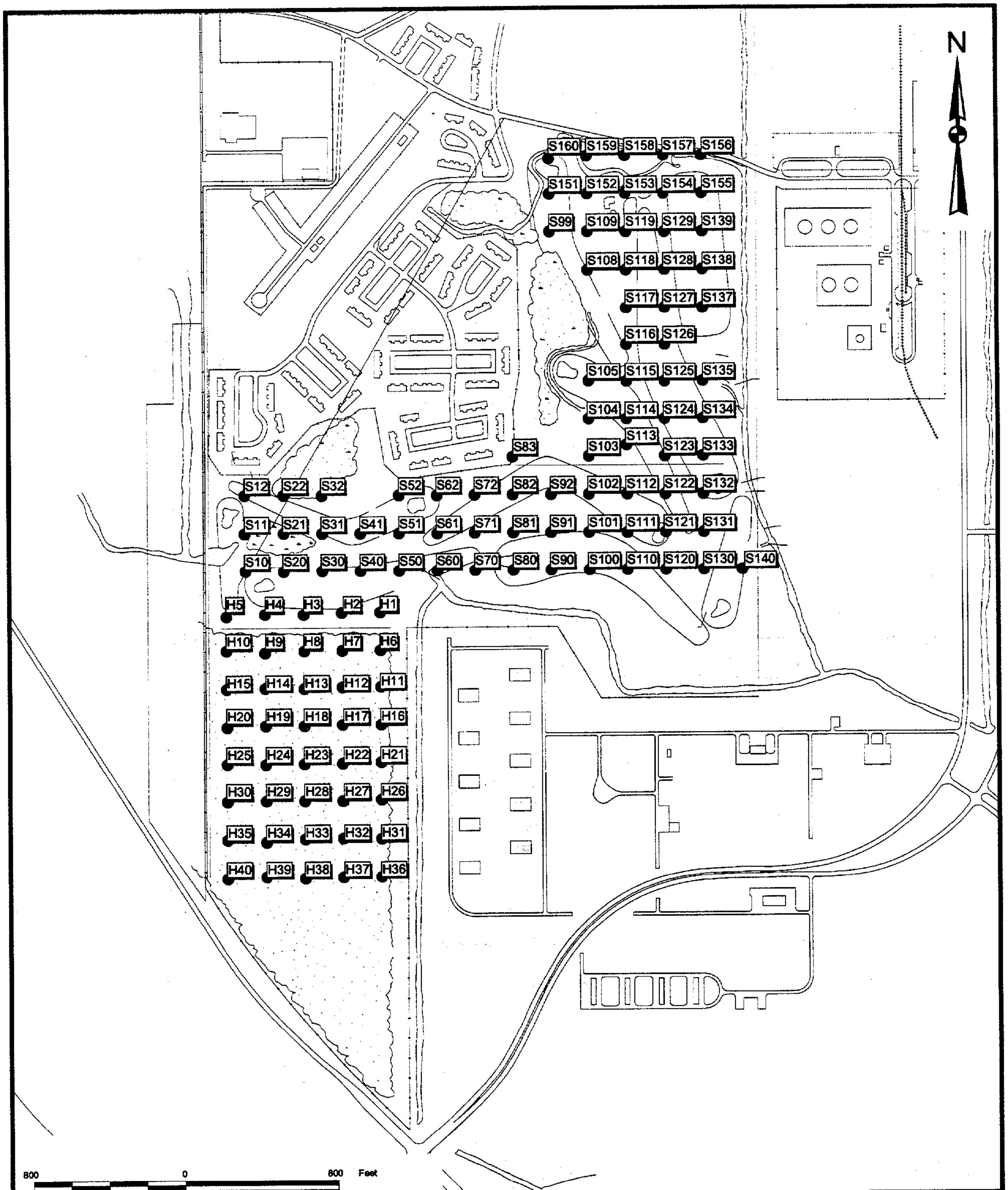
2.2 EVALUATION OF THE ANALYTICAL METHODS

The data used in this FRA were collected using documented quality assurance (QA)/quality control (QC) procedures. The analytical data were evaluated for usability in this FRA by evaluating quantitation limits and by evaluation of the qualifiers applied to the data.

The validated data (positive detections only) with qualifiers are presented in Tables 2-1 and 2-2. All unqualified positive detections and "J" qualified data were considered detected concentrations for this FRA. All nondetects (qualified with a "U" qualifier) were retained in the FRA data set as samples without positive detections. If all sample results for a given analyte in a given medium were nondetects, that analyte was not retained as a detected analyte for the purposes of this FRA. Any sample results with an "R" validation qualifier were eliminated from this FRA data set because QC indicated that the result was unusable. Several different analytes did have data that were qualified with an "R" but none of these analytes was determined to be drivers in the risk assessment, and it was decided that these rejected data did not impact the results.

2.3 DEVELOPMENT OF DATA SET FOR USE IN RISK ASSESSMENT

Data management concludes with the summarization of data and statistics generation for each data set. Table 2-3 provides the chemical name, the frequency of detection, the arithmetic mean, maximum of the detected concentrations, lognormal 95 percent Upper Confidence Limit (UCL), and the representative concentration. The mean and the UCL were calculated using one-half the reporting limit for all nondetects, and the representative concentration was determined as the lesser of the maximum or the UCL.



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SCALE AS NOTED	

SURFACE SOIL SAMPLE LOCATIONS
MCCOY ANNEX LANDFILL
NTC ORLANDO
ORLANDO, FLORIDA

CONTRACT NUMBER	
APPROVED BY	DATE
APPROVED BY	DATE
DRAWING NO. FIGURE 2-1	REV 0

P:\GIS\ORLANDO\7457TAG.APR 1-SEP-98 DNP SURFACE SOIL SAMPLE LOCATIONS SDV_AV LAYOUT

TABLE 2-1

SURFACE SOIL—DETECTED ORGANICS
OU2 McCOY ANNEX LANDFILL, NAVAL TRAINING CENTER, ORLANDO, FLORIDA
PAGE 1 OF 8

SAMPLE LOCATION[a]	S10	S10-D	S11	S12	S20	S21	S22	S30	S31	S32	S40	S41	S50	S51	S52	S60	S61
Volatiles (μg/kg)																	
Acetone										18500 J*					99 J		
Carbon Disulfide																	
Chloromethane																	
Methylene Chloride																	
Tetrachloroethene																	
Toluene					7.4												
Xylenes, Total					7.8												
Semivolatiles (μg/kg)																	
Anthracene																	
Benzo(a)anthracene																	
Benzo(a)pyrene												142		227	112		
Benzo(b)fluoranthene																	
Benzo(g,h,i)perylene																	
Benzo(k)fluoranthene																	
Chrysene																	
Dibenzo(a,h)anthracene																	
Fluoranthene																	
Indeno(1,2,3-cd)pyrene																	
Phenanthrene																	
Pyrene																	
Pesticides/PCBs (μg/kg)																	
4,4'-DDD								5.3									
4,4'-DDE					5.2		4.4	41			2.9		3.5	13		14	
4,4'-DDT														9.8		9.0	
Alpha-Chlordane														1.3			
Aroclor-1254	(b)		(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
Dieldrin																	
Endosulfan II														2.2			
Endrin																	
Endrin Ketone																	
Gamma-Chlordane														1.3			
Heptachlor												1.4		1.1			
Heptachlor Epoxide																	
Methoxychlor																	
Herbicides (μg/kg)																	
Pentachlorophenol																	
TPH[c] (mg/kg)																	
Diesel - Range Organics	8.34		9.97 J	12.7	8.16 J			11.5	9.6			9.76		31.6	9.28 J		
Gasoline - Range Organics																	
Dioxins (μg/kg)																	
OCDD																	

TABLE 2-1

SURFACE SOIL—DETECTED ORGANICS
OU2 McCOY ANNEX LANDFILL, NAVAL TRAINING CENTER, ORLANDO, FLORIDA
PAGE 2 OF 8

SAMPLE LOCATION[a]	S62	S70	S71	S72	S80	S80-D	S81	S82	S83	S90	S91	S91-D	S92	S99	S100	S101	S102
Volatiles (µg/kg)																	
Acetone	212 J											4330 J*					
Carbon Disulfide																	
Chloromethane																	
Methylene Chloride																	
Tetrachloroethene													3.0				
Toluene			9.4 J							5.0							
Xylenes, Total			6.0 J														
Semivolatiles (µg/kg)																	
Anthracene																	
Benzo(a)anthracene	1050 J			497 J				900 J				2620					1060
Benzo(a)pyrene	**1030 J**	123		499 J				**923 J**			254	**2370**	286 J			285	**982**
Benzo(b)fluoranthene	1090 J							676 J				2660					829
Benzo(g,h,i)perylene	1390 J							876 J				1980					851
Benzo(k)fluoranthene	586 J							755 J				1640					680
Chrysene	1130 J			517 J				919 J				2770					1080
Dibenzo(a,h)anthracene	353 J			200 J				398 J				**654**				119	**294**
Fluoranthene	1670 J			789 J				1620 J			506	5970	692			513	1850
Indeno(1,2,3-cd)pyrene	1170 J							810 J				1770					797
Phenanthrene	571 J											3230*					1420
Pyrene	1240 J			562 J				1110 J			404	4700	509 J			383	1370
Pesticides/PCBs (µg/kg)																	
4,4'-DDD																	
4,4'-DDE										2.2	1.6	1.7			2.4	9.7	1.6
4,4'-DDT															7.8	6.1	
Alpha-Chlordane										3.1	2.3	3.5			1.7	1.7	
Aroclor-1254	(b)	(b)	(b)	(b)			(b)	(b)	(b)	(b)			(b)	(b)	(b)	(b)	
Dieldrin																1.0	
Endosulfan II													4.5				
Endrin																	
Endrin Ketone																	
Gamma-Chlordane										3.0	2.4	2.0			1.9	2.2	
Heptachlor			1.4													1.2	
Heptachlor Epoxide																	
Methoxychlor																	
Herbicides (µg/kg)																	
Pentachlorophenol		4.5															
TPH[c] (mg/kg)																	
Diesel - Range Organics	43.6	10.5	17.7	22			8.74 J	12.9	25.9	8.5 J	8.87 J	11.7			7.45 J		24.3
Gasoline - Range Organics																	
Dioxins (µg/kg)																	
OCDD																	

TABLE 2-1

SURFACE SOIL—DETECTED ORGANICS
OU2 McCOY ANNEX LANDFILL, NAVAL TRAINING CENTER, ORLANDO, FLORIDA

SAMPLE LOCATION[a]	S102-D	S103	S104	S105	S108	S109	S110	S111	S112	S113	S114	S115	S116	S117	S118	S119	S120
Volatiles (μg/kg)																	
Acetone		397 J	123 J	17000*							26700*		51400*	28200*		130 J	
Carbon Disulfide																	
Chloromethane																	
Methylene Chloride																	
Tetrachloroethene																	
Toluene																	
Xylenes, Total																	
Semivolatiles (μg/kg)																	
Anthracene		339															
Benzo(a)anthracene	465 J	1380															
Benzo(a)pyrene	396	2360 J							125			105 J					
Benzo(b)fluoranthene		937															
Benzo(g,h,i)perylene	380	805															
Benzo(k)fluoranthene		767															
Chrysene	486 J	1160															
Dibenzo(a,h)anthracene	116	560 J															
Fluoranthene	852 J	3000 J							427			509 J					
Indeno(1,2,3-cd)pyrene		753															
Phenanthrene	456	1380															
Pyrene	589 J	2080 J															
Pesticides/PCBs (μg/kg)																	
4,4'-DDD																	
4,4'-DDE	2.0	22 J						4.0				1.8 J					
4,4'-DDT																	
Alpha-Chlordane																	
Aroclor-1254		(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
Dieldrin																	
Endosulfan II																	
Endrin																	
Endrin Ketone		19 J															
Gamma-Chlordane												1.9 J					
Heptachlor																	
Heptachlor Epoxide																	
Methoxychlor																	
Herbicides (μg/kg)																	
Pentachlorophenol																	
TPH[c] (mg/kg)																	
Diesel - Range Organics	52.5	66.8	38.1					10.1									23.0
Gasoline - Range Organics																	
Dioxins (μg/kg)																	
OCDD																	

R4707982

TABLE 2-1

SURFACE SOIL—DETECTED ORGANICS
OU2 McCOY ANNEX LANDFILL, NAVAL TRAINING CENTER, ORLANDO, FLORIDA

SAMPLE LOCATION[a]	S121	S122	S123	S124	S124-D	S125	S126	S127	S128	S129	S130	S131	S132	S133	S134	S135	S137
Volatiles (μg/kg)																	
Acetone		7620 J*															
Carbon Disulfide																	
Chloromethane																	
Methylene Chloride	12.6 J*																
Tetrachloroethene																	
Toluene					9.6 J												
Xylenes, Total					7.4 J												
Semivolatiles (μg/kg)																	
Anthracene																	
Benzo(a)anthracene																	
Benzo(a)pyrene							48 J										
Benzo(b)fluoranthene																	
Benzo(g,h,i)perylene																	
Benzo(k)fluoranthene																	
Chrysene																	
Dibenzo(a,h)anthracene																	
Fluoranthene																	
Indeno(1,2,3-cd)pyrene																	
Phenanthrene																	
Pyrene																	
Pesticides/PCBs (μg/kg)																	
4,4'-DDD																	
4,4'-DDE		3.4	1.3 J							4.5 J							
4,4'-DDT									9.1 J								
Alpha-Chlordane																	
Aroclor-1254	(b)	(b)	(b)			(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	
Dieldrin																	
Endosulfan II																	
Endrin																	
Endrin Ketone																	
Gamma-Chlordane																	
Heptachlor		1.2										1.6				1.1 J	
Heptachlor Epoxide																	
Methoxychlor																	
Herbicides (μg/kg)																	
Pentachlorophenol																	
TPH[c] (mg/kg)																	
Diesel - Range Organics						10.5	10.4				8.09 J	9.48 J				47.8	
Gasoline - Range Organics																	
Dioxins (μg/kg)																	
OCDD																	

TABLE 2-1

SURFACE SOIL—DETECTED ORGANICS
OU2 McCOY ANNEX LANDFILL, NAVAL TRAINING CENTER, ORLANDO, FLORIDA
PAGE 5 OF 8

SAMPLE LOCATION[a]	S137-D	S138	S139	S140	S151	S151-D	S152	S153	S154	S155	S156	S157	S158	S159	S160	H1	H2
Volatiles (µg/kg)																	
Acetone																	
Carbon Disulfide																	
Chloromethane																	
Methylene Chloride																	
Tetrachloroethene																	
Toluene																8.7 J	
Xylenes, Total																	
Semivolatiles (µg/kg)																	
Anthracene																	
Benzo(a)anthracene																	
Benzo(a)pyrene																	
Benzo(b)fluoranthene																	
Benzo(g,h,i)perylene																	
Benzo(k)fluoranthene																	
Chrysene																	
Dibenzo(a,h)anthracene																	
Fluoranthene																	
Indeno(1,2,3-cd)pyrene																	
Phenanthrene																	
Pyrene																	
Pesticides/PCBs (µg/kg)																	
4,4'-DDD																	2.2
4,4'-DDE								2.1 J			3.0	3.1 J					2.2
4,4'-DDT																	
Alpha-Chlordane																	5.0
Aroclor-1254		(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
Dieldrin										3.0							
Endosulfan II																	
Endrin																	4.4
Endrin Ketone																	
Gamma-Chlordane																	3.9
Heptachlor	3.0																
Heptachlor Epoxide																	
Methoxychlor																	
Herbicides (µg/kg)																	
Pentachlorophenol																	
TPH[c] (mg/kg)																	
Diesel - Range Organics							9.92					9.66		30.7		11.1	
Gasoline - Range Organics																	
Dioxins (µg/kg)																	
OCDD																	

TABLE 2-1

SURFACE SOIL—DETECTED ORGANICS
OU2 McCOY ANNEX LANDFILL, NAVAL TRAINING CENTER, ORLANDO, FLORIDA

SAMPLE LOCATION[a]	H3	H4	H5	H5-D	H6	H7	H8	H9	H10	H11	H12	H13	H14	H15	H15-D	H16	H17
Volatiles (µg/kg)																	
Acetone																	
Carbon Disulfide																	
Chloromethane																	
Methylene Chloride																	
Tetrachloroethene																	
Toluene																	
Xylenes, Total																	
Semivolatiles (µg/kg)																	
Anthracene															716		
Benzo(a)anthracene														5750	1600		
Benzo(a)pyrene							166		100			197 J		5500*	1490 J		
Benzo(b)fluoranthene														4410	1220 J		
Benzo(g,h,i)perylene														4420	1100 J		
Benzo(k)fluoranthene														2600	802 J		
Chrysene														6680	1730		
Dibenzo(a,h)anthracene												152 J		1580	392 J		
Fluoranthene												792		22300	3740		
Indeno(1,2,3-cd)pyrene														3930	1060 J		
Phenanthrene												532		11400*	2890*		
Pyrene												579 J		14700	2700		
Pesticides/PCBs (µg/kg)																	
4,4'-DDD						23							2.7				
4,4'-DDE						39.4									5.2		
4,4'-DDT						234											
Alpha-Chlordane						36			60 J								
Aroclor-1254	(b)	(b)	39	22	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)			(b)	(b)
Dieldrin								4.1	9.0 J								
Endosulfan II																	
Endrin																	
Endrin Ketone																	
Gamma-Chlordane						46			66 J			2.3					
Heptachlor						4.2									2.8		
Heptachlor Epoxide									6.3 J								
Methoxychlor																	
Herbicides (µg/kg)																	
Pentachlorophenol									13.5*					2.5			
TPH[c] (mg/kg)																	
Diesel - Range Organics			11.1			11			11.5	24.3		13.4		32.1	52.9		
Gasoline - Range Organics																	
Dioxins (µg/kg)																	
OCDD			0.18J	0.13J													

TABLE 2-1

SURFACE SOIL—DETECTED ORGANICS
OU2 McCOY ANNEX LANDFILL, NAVAL TRAINING CENTER, ORLANDO, FLORIDA

SAMPLE LOCATION[a]	H18	H19	H20	H21	H22	H23	H24	H25	H25-D	H26	H27	H28	H29	H30	H31	H32	H33
Volatiles (μg/kg)																	
Acetone							24 J										
Carbon Disulfide							3.6 J										
Chloromethane					7.4												
Methylene Chloride																	
Tetrachloroethene																	
Toluene					4.5												4.0
Xylenes, Total																	
Semivolatiles (μg/kg)																	
Anthracene												515					
Benzo(a)anthracene												1730	603				
Benzo(a)pyrene					127	311						1780	565			403	
Benzo(b)fluoranthene												1280	505				
Benzo(g,h,i)perylene												1240	420				
Benzo(k)fluoranthene												1080	399				
Chrysene												1800	717				
Dibenzo(a,h)anthracene						194						769	262			248	
Fluoranthene						527						5380	1560			1200	
Indeno(1,2,3-cd)pyrene												1210	417				
Phenanthrene												2040	994			734	
Pyrene						430						3740	991			793	
Pesticides/PCBs (μg/kg)																	
4,4'-DDD					13							18				3.0	
4,4'-DDE					8.6							26	3.9			1.8	1.9
4,4'-DDT					188							47				21	
Alpha-Chlordane					14							20				2.3	15
Aroclor-1254	(b)	(b)	(b)	(b)	(b)	(b)	(b)		(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
Dieldrin																	
Endosulfan II																	
Endrin																	
Endrin Ketone												7.5					
Gamma-Chlordane					12							19				3.0	13
Heptachlor	1.8														2.7		
Heptachlor Epoxide												1.4					
Methoxychlor												27					
Herbicides (μg/kg)																	
Pentachlorophenol																	
TPH[c] (mg/kg)																	
Diesel - Range Organics	9.59					13.0	12.2		7.26 J			35.7	19.0		14.2	27.7	10.1
Gasoline - Range Organics																	
Dioxins (μg/kg)																	
OCDD																	

TABLE 2-1

SURFACE SOIL—DETECTED ORGANICS
OU2 McCOY ANNEX LANDFILL, NAVAL TRAINING CENTER, ORLANDO, FLORIDA
PAGE 8 OF 8

SAMPLE LOCATION[a]	H34	H35	H35-D	H36	H37	H38	H39	H40
Volatiles (μg/kg)								
Acetone		1560*	33	39.5 J				
Carbon Disulfide								
Chloromethane								
Methylene Chloride					3.6		4.4	
Tetrachloroethene								
Toluene	3.8	4.8			10.4		3.8	
Xylenes, Total	2.2	3.7			5.7		2.8	
Semivolatiles (μg/kg)								
Anthracene								
Benzo(a)anthracene								
Benzo(a)pyrene	166							
Benzo(b)fluoranthene								
Benzo(g,h,i)perylene								
Benzo(k)fluoranthene								
Chrysene								
Dibenzo(a,h)anthracene	89.9							
Fluoranthene	416							
Indeno(1,2,3-cd)pyrene								
Phenanthrene								
Pyrene								
Pesticides/PCBs (μg/kg)								
4,4'-DDD								
4,4'-DDE	6.3							
4,4'-DDT	4.8							
Alpha-Chlordane	2.7							
Aroclor-1254	(b)			(b)	(b)	(b)	(b)	(b)
Dieldrin								
Endosulfan II								
Endrin								
Endrin Ketone								
Gamma-Chlordane	4.7							
Heptachlor								
Heptachlor Epoxide								
Methoxychlor								
Herbicides (μg/kg)								
Pentachlorophenol								
TPH[c] (mg/kg)								
Diesel - Range Organics	11.1	43.1	11.5	36.2		11.9	12.9	
Gasoline - Range Organics		0.128						
Dioxins (μg/kg)								
OCDD								

Notes:

"J" qualifier on analytical data indicates an estimated value.

No entry indicates chemical not detected.

Only chemicals detected in at least one sample are shown.

The complete list of samples, analytical results, and screening criteria (Table A-3) is presented in Appendix A of this report.

Shaded entry indicates chemical detected at a concentration exceeding residential screening criterion.

Bold entry indicates chemical detected at a concentration exceeding industrial screening criterion.

Entry with an asterisk (*) indicates chemical detected at a concentration exceeding leaching screening criterion.

[a] "D" in sample location indicates a duplicate sample.

[b] Not analyzed for PCBs.

[c] Total petroleum hydrocarbons

TABLE 2-2

SURFACE SOIL—DETECTED INORGANICS
OU2 McCOY ANNEX LANDFILL, NAVAL TRAINING CENTER, ORLANDO, FLORIDA
PAGE 1 OF 10

SAMPLE LOCATION[a]	S10	S10-D	S11	S12	S20	S21	S22	S30	S31	S32	S40	S41	S50
Metals (mg/kg)													
Aluminum	2980	2080	3430	1210	3510	2030	2800	4340	2760	1560	3590	1970	3380
Arsenic	0.98	0.65		1.3	2.5	3.8	2.1	2.5	2.4	0.61	2.3	3.8	3.2
Barium			10.0	3.8			7.3	13.3	13.7	5.0	15.9		16.7
Cadmium							0.23	0.13		0.16			
Calcium	668	670	773	431	553	472	684	1460	480	536	825	620	942
Chromium	3.9	2.6	3.9	2.4	3.5	2.5	4.8	4.7	3.3	2.5	4.3	2.9	4.0
Cobalt			0.24				0.27	0.26	0.23			0.25	0.21
Copper	0.78	0.77	1.2		0.82	1.2	4.5	4.6	1.7		1.0	1.8	1.4
Iron	538	467	837	694 J	589	878	955 J	1130	1220	1240 J	374	1020	836
Lead	4.3	3.3	5.6	2.4	3.7	3.9	13.5	6.5	4.7	9.2	4.1	4.6	5.0
Magnesium	83.1	75.4	84.5	37.1	67.0	52.4	54.9	127	63.7	39.9	116	59.4	113
Manganese	2.3	2.1	4.1	2.2	4.4	3.5	6.9	7.6	2.5	4.2	2.7	4.3	4.7
Mercury	0.10												
Nickel	0.96	0.68	1.7	0.57	1.4	1.2	1.4	1.9	2.3	0.88	0.77	0.96	1.1
Potassium	40.4	33.5	47.2	28.7	30.4	37.2	54.8	44.4	53.9	26.1	63.0	51.9	52.4
Selenium													
Silver													
Sodium													
Thallium													
Vanadium	2.2		4.8	1.9	3.5	2.8	3.0	4.7	4.2	2.2	3.1	2.6	4.3
Zinc			6.1			5.7	16.5	8.9	5.8	12.8		5.3	9.6
Radiological (pCi/g)													
Gross Alpha	1.61	0.855	2.33	0.785	1.63	0.936	1.10	1.95	2.37	0.669	2.01	1.27	1.81
Gross Beta	0.733	0.406	1.11		0.609	0.478	0.731	0.951	0.674	0.387	0.934	0.558	0.699

TABLE 2-2

SURFACE SOIL—DETECTED INORGANICS
OU2 McCOY ANNEX LANDFILL, NAVAL TRAINING CENTER, ORLANDO, FLORIDA
PAGE 2 OF 10

SAMPLE LOCATION[a]	S51	S52	S60	S61	S62	S70	S71	S72	S80	S80-D	S81	S82	S83
Metals (mg/kg)													
Aluminum	2720	2730	3880	2130	2650	4260	1670	2200	963	1090	2220	2060	2570
Arsenic	3.2	4.8	2.1	0.93	3.9	1.3	1.2	1.7	3.3	3.4		1.9	1.8
Barium	9.6	13.7	13.7		10.3			5.6			12.2	10.6	6.9
Cadmium						0.07			0.06				
Calcium	2980	564	868	2450	1370	656	666	3650	796	1160	12700	1680	946 J
Chromium	3.2	3.1	3.9	2.8	4.0	4.4	2.1	3.0	3.5	6.5	3.3	2.9	3.4
Cobalt						0.25							
Copper	2.5		1.6	2.0		1.5	1.6	2.4	2.3	3.0	2.7	3.0	
Iron	869	491 J	770	462	831 J	884	293	396 J	266	342	294	246 J	254 J
Lead	5.3	3.4	4.9	4.9	7.1	5.1	4.4	6.4	3.1	3.5	7.8	5.7	3.5 J
Magnesium	99.9	74.4	144	76.6	55.2	95.7	73.7	72.3	51.3	66.3	49.1	113	75.1
Manganese	6.4	4.5	3.9	5.3	8.0	3.5	2.3	3.7	17.1	21.2	3.2	4.8	3.0
Mercury									0.13				
Nickel	1.2	0.94	1.3	0.73	0.80	1.7	0.51	0.73	0.35	0.64	0.56	0.62	0.49
Potassium	47.8	43.9	61.8	40.0	41.4	35.0	43.9	30.3	15.3	18.1	28.2	43.8	49.8
Selenium													0.50
Silver									0.47	0.41	0.55	0.34	
Sodium											128		
Thallium													
Vanadium	3.0	2.3	4.3	1.9	2.8	5.8	1.1	1.7			1.5	1.6	1.7
Zinc	5.6			6.2	4.5	8.3		6.5	6.7	6.5	8.7	5.1	
Radiological (pCi/g)													
Gross Alpha	1.56	0.825	1.73	1.41	1.75	2.80	1.14	1.19	0.901	0.922	2.16	1.17	1.22
Gross Beta	0.501	0.669	0.830	0.840	0.852	1.53	0.599	0.804	0.360	0.483	0.549	0.512	0.516

TABLE 2-2

SURFACE SOIL—DETECTED INORGANICS
OU2 McCOY ANNEX LANDFILL, NAVAL TRAINING CENTER, ORLANDO, FLORIDA
PAGE 3 OF 10

SAMPLE LOCATION[a]	S90	S91	S91-D	S92	S99	S100	S101	S102	S102-D	S103	S104	S105	S108
Metals (mg/kg)													
Aluminum	3350	893	1030	938	2530	3680	2040	2070	1360	1410	2890	2680	2410
Arsenic	2.2	0.93	0.89		2.6	0.51	1.3	1.2	0.86	0.87		3.2	2.5
Barium	12.9			5.7	3.0	14.0	9.6	13.6	8.0	4.4	1.9	2.7	3.6
Cadmium									0.08				
Calcium	1340	529	601	593	682 J	1020	1110	860	686	1050 J	214 J	822 J	518 J
Chromium	4.0	2.9	3.8	2.2	3.3	4.3	3.8	3.7	2.4	2.1	3.1	3.4	3.0
Cobalt													
Copper	2.4	2.8	3.7			1.6	2.3	6.8	5.0	2.5			
Iron	291	117	140	252 J	486 J	335	294	616 J	321 J	346 J	330 J	323 J	282 J
Lead	9.5	11.2	13.1	6.5	1.7 J	6.5	9.4	4.9	4.1	4.4 J	2.6 J	2.3 J	1.7 J
Magnesium	165	41.1	45.5	43.6	59.8	112	84.1	107	65.9	63.3	27.6	62.1	47.2
Manganese	7.3	1.0	1.3	3.0	2.4	2.9	3.9	3.5	2.4	4.0	1.1	4.6	2.2
Mercury							0.09	0.10					
Nickel	0.71	0.30	0.31	0.38	0.63	0.91	0.95	1.0	0.60	0.49	0.81	0.70	0.72
Potassium	46.7	20.4	24.5	17.7	42.5	39.6	35.4	46.3	30.7	18.1	12.8	27.7	43.3
Selenium	0.43	0.41							0.48				
Silver							0.26	0.79	0.83				
Sodium													
Thallium													
Vanadium	2.1	0.72	0.97	0.62	3.1	2.3	1.3	2.1	1.2	0.96	1.8	1.9	1.8
Zinc	9.7	5.9	6.9	6.9		5.8	9.0	6.4	6.6	4.4			
Radiological (pCi/g)													
Gross Alpha	2.13	1.28	0.506	0.670	1.36	2.74	0.170	1.14	0.905	0.933	1.60	0.937	0.903
Gross Beta	1.13			0.196	0.701 J	1.21		0.573	0.479	0.485 J	0.640 J	0.339 J	0.586 J

TABLE 2-2

SURFACE SOIL—DETECTED INORGANICS
OU2 McCOY ANNEX LANDFILL, NAVAL TRAINING CENTER, ORLANDO, FLORIDA
PAGE 4 OF 10

SAMPLE LOCATION[(a)]	S109	S110	S111	S112	S113	S114	S115	S116	S117	S118	S119	S120	S121
Metals (mg/kg)													
Aluminum	980	4980	3050	1630	1780	2900	2410	1690	1120	1340	1540	3340	1360
Arsenic		3.2	1.5	2.8		1.2	3.8	1.6			0.86	1.1	2.1
Barium	3.0	21.5	17.8	5.5	3.0	6.2	7.5	3.8	2.7	3.3	3.2		
Cadmium													
Calcium	718 J	1850	760	858	372 J	3140 J	4440 J	980 J	3110 J	2490 J	852 J	879	1470
Chromium	3.5	6.4	5.5	2.6	3.3	3.6	3.3	2.5	1.6	2.2	2.4	3.9	2.5
Cobalt													
Copper		1.9	3.5	2.7								1.3	2.0
Iron	313 J	398	492	132 J	167 J	361 J	277 J	164 J	201 J	265 J	322 J	1040	165
Lead	2.5 J	5.2	7.0	6.6	2.8 J	4.5 J	6.5 J	2.8 J	4.6 J	1.8 J	1.8 J	5.1	3.7
Magnesium	59.8	188	81.0	63.9		87.7	87.6	42.3	46.8	60.7	69.7	89.0	116
Manganese	3.5	7.1	3.3	4.0	0.60	2.4	5.1	2.7	4.2	1.7	3.0	2.7	14.3
Mercury													
Nickel		0.93	0.96	0.34		0.63	0.61	0.47	0.34	0.41	0.44	0.93	0.36
Potassium	25.3	66.9	41.3	43.0		30.5	35.6	29.4	17.7	18.9	28.2	29.1	33.4
Selenium	0.53					0.47	0.45						
Silver				0.37		0.24							
Sodium													
Thallium													
Vanadium	0.87	2.8	2.5	0.59	1.2	1.8	2.0	1.2	0.93	1.8	1.5	3.3	0.68
Zinc												6.8	5.4
Radiological (pCi/g)													
Gross Alpha	0.584	2.65	2.80	1.19	0.808	0.912	1.61	0.632	0.641	1.16	0.556	1.13	0.687
Gross Beta	0.335 J	1.31	1.31	0.394	0.482	0.794	0.796	0.429	0.364	0.631	0.469	0.819	0.315

TABLE 2-2

SURFACE SOIL—DETECTED INORGANICS
OU2 McCOY ANNEX LANDFILL, NAVAL TRAINING CENTER, ORLANDO, FLORIDA
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SAMPLE LOCATION[a]	S122	S123	S124	S124-D	S125	S126	S127	S128	S129	S130	S131	S132	S133
Metals (mg/kg)													
Aluminum	928	1850	3400	3020	2740	1110	741	524	821	3540	1840	1680	1700
Arsenic	2.5	1.6	2.4	2.0	1.8	2.5	1.5	1.5	0.76	1.2	0.89	2.5	4.8
Barium	2.4	6.4	6.2	4.5	7.6	3.8	2.8	3.5	3.6	10.5		6.0	3.6
Cadmium	0.09											0.07	
Calcium	841	792 J	1430 J	1560 J	4130 J	16000 J	1040 J	8250 J	939 J	964	1720	794	731 J
Chromium	1.5	2.9	4.3	3.9	3.6	1.9				3.9	2.2	2.4	2.8
Cobalt													
Copper	3.0									1.3	1.4	4.1	
Iron	114 J	187 J	383 J	291 J	344 J	306 J	252 J	137 J	176 J	972	637	349 J	207 J
Lead	3.3	3.8 J	5.4 J	4.7 J	6.0 J	3.8 J	3.4 J	2.2 J	3.0 J	4.7	3.4	4.2	3.9 J
Magnesium	48.0	72.6	71.5	61.0	95.5	332	75.6	97.9	70.6	122	49.1	64.4	47.9
Manganese	2.7	1.6	2.7	3.2	3.9	10.2	2.8	3.9	3.3	4.0	2.8	3.5	5.9
Mercury												0.12	
Nickel		0.31	0.63	0.67	0.73	0.54				1.0	0.48	0.42	0.43
Potassium	27.7	37.9	47.2	34.6	28.6	40.7	25.2	40.7	29.5	46.1	27.8	38.8	32.5
Selenium						0.45							
Silver	0.24											0.53	
Sodium													
Thallium													
Vanadium		1.0	2.2	2.0	3.3	1.6	0.61	0.50	0.51	3.4	1.7	1.3	1.1
Zinc	8.2				4.5						6.3	7.7	5.8
Radiological (pCi/g)													
Gross Alpha	0.579	0.700	1.00	1.35	1.69	0.554	0.664	0.548	0.639	1.19	0.792	0.434	0.744
Gross Beta	0.265	0.403	0.380	0.698	1.22		0.599	0.339	0.558	0.765	0.449		0.377

TABLE 2-2

SURFACE SOIL—DETECTED INORGANICS
OU2 McCOY ANNEX LANDFILL, NAVAL TRAINING CENTER, ORLANDO, FLORIDA
PAGE 6 OF 10

SAMPLE LOCATION[a]	S134	S135	S137	S137-D	S138	S139	S140	S151	S151-D	S152	S153	S154	S155
Metals (mg/kg)													
Aluminum	1400	1650	1830	1450	815	3180	1690	4980	5090	1230	2170	2450	1240
Arsenic	1.3	1.2	0.92	0.58		1.4	1.2	2.5	3.3		0.73	1.9	0.78
Barium	2.0	3.2	2.9	2.4	2.4	4.2		18.7	14.8	3.6	6.3	4.7	4.2
Cadmium													
Calcium	811	452	730	1680	864	583	450	610 J	545 J	1790 J	12500 J	1060 J	4300
Chromium	1.4	1.8	2.3	2.0	1.4	4.2	2.1	6.0	5.8	2.5	3.6	3.6	2.3
Cobalt									0.22				
Copper							0.86			2.5	3.0	5.0	
Iron	219 J	258 J	622 J	576 J	298 J	925 J	431	584 J	734 J	312 J	458 J	362 J	552 J
Lead	2.5	2.6	2.4	1.7	2.3	1.6		3.0 J	3.7 J	11.6 J	3.7 J	2.2 J	5.3
Magnesium	71.0	42.5	63.7	59.2	55.9	63.2	60.6	79.0	83.0	58.5	143	68.0	86.7
Manganese	2.8	1.0	1.4	1.7	2.0	1.0	4.1	1.8	2.4	5.0	5.5	5.2	3.8
Mercury											0.22		
Nickel		0.47	0.54	0.28	0.26	0.93	5.4	1.2	1.4	0.34	0.65	0.68	0.47
Potassium	30.1	31.0	28.9	17.1	16.4	23.9	21.6	71.8	77.2	26.6	33.8	33.1	24.7
Selenium											0.47		
Silver											2.4		
Sodium													
Thallium													
Vanadium	0.62	1.6	2.2	2.0	1.3	5.7	2.2	6.3	6.6	0.81	2.2	2.2	2.7
Zinc											9.1		4.9
Radiological (pCi/g)													
Gross Alpha	0.460	0.601	0.695	0.697	0.509	0.995	0.981	2.57	2.72	0.720	1.19	1.06	0.826
Gross Beta		0.157		0.357	0.358	0.701	0.617	1.28 J	1.42	0.621 J	0.908	0.686	0.312

TABLE 2-2

SURFACE SOIL—DETECTED INORGANICS
OU2 McCOY ANNEX LANDFILL, NAVAL TRAINING CENTER, ORLANDO, FLORIDA
PAGE 7 OF 10

SAMPLE LOCATION[(a)]	S156	S157	S158	S159	S160	H1	H2	H3	H4	H5	H5-D	H6	H7
Metals (mg/kg)													
Aluminum	2700	3110	2930	1760	1280	2880	4660	6520	3870	2510	2880	614	2870
Arsenic	0.84	1.4			2.0			0.68	1.2	0.85	0.63		
Barium	6.5	8.7	5.4	10.5	4.6		9.7		11.5	10.1	11.4		
Cadmium													
Calcium	1230	3270 J	1840 J	1640 J	666 J	947	381	168	844	443	406	218	209
Chromium	3.5	4.8	2.8	1.9	5.7	3.4	4.6	5.4	4.6	3.2	3.4	0.93	3.0
Cobalt							0.20						
Copper		3.3	2.3	2.6	3.0	11.9	4.0	0.71				0.30	0.52
Iron	500 J	645 J	246 J	299 J	297 J	381	634	571	834 J	395 J	441 J	105	300
Lead	7.3	7.1 J	4.4 J	5.7 J	4.2 J	6.9	5.3	4.2	5.2	5.0	4.9	2.3	3.8
Magnesium	75.5	86.6	64.5	36.5	50.0	57.1	60.1	45.6	60.1	46.3	45.1		20.4
Manganese	5.1	8.9	2.6	2.7	35.5	2.3	2.0	0.78	4.3	2.2	2.0	0.58	2.1
Mercury		0.13											
Nickel	0.96	1.1	0.67	0.28	0.38	1.0	1.7	1.2	1.2	1.3	1.2		0.74
Potassium	30.3	43.0	28.8	15.3	34.6	27.3	33.4	20.5	36.8	40.5	39.8		15.0
Selenium		0.54					0.50						
Silver		1.9											
Sodium													
Thallium													
Vanadium	3.4	2.7	1.1	0.73	0.68	2.6	3.8	2.6	4.3	2.3	2.8	0.43	1.6
Zinc	7.7	9.6			4.7	6.2	6.8		5.3	4.4	4.0		
Radiological (pCi/g)													
Gross Alpha	0.741	2.09	0.806	1.51	1.28	1.03	1.32	1.45	1.18	1.11	0.937	0.625	1.06
Gross Beta	0.657	1.14	0.251	0.628 J	0.754 J	0.421	0.598	0.459	0.635	0.526	0.462	0.226	0.753

TABLE 2-2

SURFACE SOIL—DETECTED INORGANICS
OU2 McCOY ANNEX LANDFILL, NAVAL TRAINING CENTER, ORLANDO, FLORIDA
PAGE 8 OF 10

SAMPLE LOCATION[a]	H8	H9	H10	H11	H12	H13	H14	H15	H15-D	H16	H17	H18	H19
Metals (mg/kg)													
Aluminum	4070	3910	3400	200	1010	3590	4940	2520	2890	378	1260	2000	915
Arsenic			0.52										
Barium		4.3	8.2				177	7.3	7.3				
Cadmium													
Calcium	169	135	3160		199	116	209	467	411		262	225	1120
Chromium	3.8	4.4	3.6	0.49	1.5	3.3	4.9	3.3	4.0	0.94	1.7	3.0	1.7
Cobalt							0.33						
Copper	1.3				1.0	1.4	2.0	0.98	0.79	1.2	0.67	21.4	1.0
Iron	401	469 J	409 J	60.1	160	407	652	327	335	474	153	289	163
Lead	4.7	6.8	9.3	2.4	5.2	5.4	7.1	7.0	6.9	2.8	3.7	6.6	7.9
Magnesium	22.8		47.0		15.5	25.2	32.7	29.3	26.0	10.2	30.8	24.3	21.8
Manganese	1.3	1.6	2.9		1.6	2.1	3.8	7.7	4.8	2.0	1.5	3.5	1.8
Mercury													
Nickel	1.2	1.1	1.1		0.28	1.1	1.2	0.69	0.75		0.38	0.57	0.34
Potassium	16.5	15.0	19.5		11.2	14.9	13.3	16.1	19.6		16.5	12.0	10.8
Selenium	0.49						0.44						
Silver								0.27	0.23				
Sodium													
Thallium													
Vanadium	2.0	2.0	1.9	0.22	0.66	1.6	2.2	1.3	1.6	0.33	0.72	1.2	0.59
Zinc	21.6	4.8	6.0				45.8	5.2		11.9		7.2	
Radiological (pCi/g)													
Gross Alpha	1.50	1.48	1.84	0.171	0.445	1.18	1.45	1.53	0.940 J	0.229 J	0.483 J	0.835 J	0.492 J
Gross Beta		0.491	0.642		0.212	0.453	0.421	0.520	0.452		0.378	0.377	0.279

TABLE 2-2

SURFACE SOIL—DETECTED INORGANICS
OU2 McCOY ANNEX LANDFILL, NAVAL TRAINING CENTER, ORLANDO, FLORIDA
PAGE 9 OF 10

SAMPLE LOCATION[(a)]	H20	H21	H22	H23	H24	H25	H25-D	H26	H27	H28	H29	H30	H31
Metals (mg/kg)													
Aluminum	3490	585	2480	2640	1470	1380	899	300	1700	804	791	1490	1290
Arsenic				1.7									
Barium	26.2			12.0									
Cadmium			0.10	0.16								0.08	
Calcium	7470	121	351	1160	260	166	103	58.4	255	851	332	906	
Chromium	4.0	0.70	3.1	6.2	2.0	1.2	0.75	0.54	2.6	2.9	0.96	1.8	1.5
Cobalt	0.26												
Copper	11.3	0.42	0.83	3.4					0.30	0.93		0.93	
Iron	560	209	835	709	160	116	92.2	102	129	130	85.1	406	574
Lead	8.8	2.8	10.6	17.1	4.2	2.8			4.3	5.4		3.8	3.3
Magnesium	318			79.8	28.8					49.6	43.8	46.1	
Manganese	11.3	0.61	3.6	7.4	1.4	0.77			0.62	3.3	1.4	3.0	0.57
Mercury				0.15									
Nickel	3.7	0.24	0.64	0.86	0.54	0.36	0.47	0.35	0.53	0.45	0.24	0.58	0.29
Potassium	53.8			21.4	20.0						14.2	19.6	11.2
Selenium													
Silver													
Sodium													
Thallium													
Vanadium	1.9												
Zinc	21.5		10.4	24.6						11.3		6.8	
Radiological (pCi/g)													
Gross Alpha	1.41 J	0.271 J	0.680 J	1.29 J	0.370 J	0.282 J		0.280 J	0.433 J	0.853 J	0.423 J	1.40	0.542 J
Gross Beta	0.517		0.187	0.558	0.283			0.219	0.400	0.288	0.232	0.527	0.444

TABLE 2-2

SURFACE SOIL—DETECTED INORGANICS
OU2 McCOY ANNEX LANDFILL, NAVAL TRAINING CENTER, ORLANDO, FLORIDA
PAGE 10 OF 10

SAMPLE LOCATION[(a)]	H32	H33	H34	H35	H35-D	H36	H37	H38	H39	H40
Metals (mg/kg)										
Aluminum	761	873	515	998	956	1500	1390	548	230	58.4
Arsenic							0.54			
Barium										
Cadmium		0.10								
Calcium	2340	515	360	208	192	286		213	58.4	78.2
Chromium	1.6	1.9	2.6	1.3	1.2	1.8	2.0	1.0	0.73	0.21
Cobalt										
Copper	0.31	8.7	1.3			4.4				
Iron	217	116	439	92.5	84.0	600	718	101	23.1	19.7
Lead	6.8	7.0	9.4	3.0	3.0	12.3		2.6		
Magnesium	39.9	29.5				73.0				
Manganese	1.4	2.4	2.2	0.53		1.1	0.86			
Mercury			0.12							
Nickel	0.31	0.26	0.41	0.26		0.93	0.33	0.34		
Potassium			10.7			44.4				
Selenium						0.56				
Silver										
Sodium										
Thallium							0.45			
Vanadium	2.2									
Zinc		14.5	17.2							
Radiological (pCi/g)										
Gross Alpha	0.674 J	0.158 J	0.557 J	0.286 J		0.386	0.438	0.417	0.153	0.111
Gross Beta				0.215		0.581	0.211	0.257		0.469

Notes:

"J" qualifier on analytical data indicates an estimated value.

No entry indicates chemical not detected.

Only chemicals detected in at least one sample are shown.

The complete list of samples, analytical results, and screening criteria (Table A-3) is presented in Appendix A of this report.

Shaded entry indicates chemical detected at a concentration exceeding residential screening criterion.

Bold entry indicates chemical detected at a concentration exceeding industrial screening criterion.

Entry with an asterisk (*) indicates chemical detected at a concentration exceeding leaching screening criterion.

[(a)] "D" in sample location indicates a duplicate sample.

TABLE 2-3

SELECTION OF HUMAN HEALTH CHEMICALS OF POTENTIAL CONCERN
OU2 McCOY ANNEX LANDFILL, NAVAL TRAINING CENTER, ORLANDO, FLORIDA

Chemical Name	Frequency of Detection(1)	Mean(2)	Maximum	Lognormal 95% UCL(2)	EPC(3)	Background Screening Conc.(4)	Florida Residential SCG(5)	USEPA Region III Residential RBC(6)	Exceeded Background Screening Conc.?	Selected as CPC?(7)
Volatiles (µg/kg)										
Acetone	15/43	3,621.6	51,400.0	43,810.9	43,810.9	NA	770,000	780,000	NA	NO
Carbon Disulfide	1/116	21.2	3.6	7.8	3.6	NA	200,000	780,000	NA	NO
Chloromethane	1/116	42.0	7.4	15.5	7.4	NA	1,700	49,000	NA	NO
Methylene Chloride	3/116	21.3	12.6	8.0	8.0	NA	16,000	85,000	NA	NO
Tetrachloroethene	1/116	21.1	3.0	7.9	3.0	NA	10,000	12,000	NA	NO
Toluene	11/116	21.5	10.4	8.5	8.5	NA	300,000	1,600,000	NA	NO
Xylenes, Total	7/116	21.3	7.8	8.0	7.8	NA	290,000	16,000,000	NA	NO
Semivolatiles (µg/kg)										
Anthracene	3/116	241.4	716.0	252.0	252.0	NA	19,000,000	2,300,000	NA	NO
Benzo(a)pyrene (equivalent) (8)	25/116	267.4	5,401.0	211.4	211.4	NA	100	88	NA	YES
Fluoranthene	17/116	490.9	13,020.0	414.5	414.5	NA	2,800,000	310,000	NA	NO
Pentachlorophenol	3/116	1.3	13.5	1.3	1.3	NA	8,600	5,300	NA	NO
Phenanthrene	9/116	354.6	7145.0	328.2	328.2	NA	1,900,000	NA	NA	NO
Pyrene	14/116	391.8	8,700.0	351.4	351.4	NA	2,200,000	230,000	NA	NO

TABLE 2-3

SELECTION OF HUMAN HEALTH CHEMICALS OF POTENTIAL CONCERN
OU2 McCOY ANNEX LANDFILL, NAVAL TRAINING CENTER, ORLANDO, FLORIDA
PAGE 2 OF 5

Chemical Name	Frequency of Detection[1]	Mean[2]	Maximum	Lognormal 95% UCL[2]	EPC[3]	Background Screening Conc.[4]	Florida Residential SCG[5]	USEPA Region III Residential RBC[6]	Exceeded Background Screening Conc.?	Selected as CPC?[7]
Pesticides (μg/kg)										
4,4'-DDD	7/116	1.6	23.0	1.5	1.5	NA	4,500	2,700	NA	NO
4,4'-DDE	30/116	2.5	41.0	2.2	2.2	NA	3,200	1,900	NA	NO
4,4'-DDT	10/116	6.8	234.0	4.3	4.3	NA	3,200	1,900	NA	NO
Alpha-Chlordane	13/116	1.8	60.0	1.1	1.1	NA	3,000	1,800	NA	NO
Aroclor-1254	1/9	8.8	30.5	13.2	13.2	NA	600	160	NA	NO
Dieldrin	4/116	0.6	9.0	0.6	0.6	NA	70	40	NA	NO
Endosulfan II	2/116	0.7	4.5	0.7	0.7	NA	410,000	47,000	NA	NO
Endrin	1/116	0.9	4.4	0.9	0.9	NA	21,000	2,300	NA	NO
Endrin Ketone	2/116	4.1	19.0	4.2	4.2	NA	21,000[9]	2,300[9]	NA	NO
Gamma-Chlordane	15/116	2.0	66.0	1.3	1.3	NA	3,000	1,800	NA	NO
Heptachlor	12/116	0.7	4.2	0.7	0.7	NA	10	140	NA	NO
Heptachlor Epoxide	2/116	0.6	6.3	0.6	0.6	NA	100	70	NA	NO
Methoxychlor	1/116	3.8	27.0	3.8	3.8	NA	380,000	39,000	NA	NO
Other (μg/kg)										
OCDD	1/1	0.2	0.2	NA	0.2	NA	NA	4.3[10]	NA	NO
Diesel Range Organics	53/116	10.8	66.8	12.8	12.8	NA	1,000,000[11]	310,000[11]	NA	NO
Gasoline Range Organics	1/116	0.1	0.1	0.1	0.1	NA	420,000[12]	470,000[12]	NA	NO
Total Organic Carbon	24/24	14,534.2	30,000.0	341,818.5	30,000.0	NA	NA	NA	NA	NO

TABLE 2-3

SELECTION OF HUMAN HEALTH CHEMICALS OF POTENTIAL CONCERN
OU2 McCOY ANNEX LANDFILL, NAVAL TRAINING CENTER, ORLANDO, FLORIDA
PAGE 3 OF 5

Chemical Name	Frequency of Detection[1]	Mean[2]	Maximum	Lognormal 95% UCL[2]	EPC[3]	Background Screening Conc.[4]	Florida Residential SCG[5]	USEPA Region III Residential RBC[6]	Exceeded Background Screening Conc.?	Selected as CPC?[7]
Radioactive Materials (pCi/g)										
Gross Alpha	116/116	1.1	2.8	1.2	1.2	NA	NA	NA	NA	YES
Gross Beta	101/110	0.5	1.5	0.7	0.7	NA	NA	NA	NA	YES
Metals (mg/kg)										
Aluminum	116/116	2,141.7	6,520.0	2,672.1	2,672.1	2,088.0	72,000	7,800	YES	NO
Arsenic	70/116	1.2	4.8	1.6	1.6	1.0	0.8	0.43	YES	YES
Barium	72/116	7.0	177.0	7.7	7.7	8.7	105	550	YES	YES
Cadmium	12/116	0.04	0.23	0.04	0.04	1.0	1.5	3.9	NO	NO
Calcium	112/116	1,420.5	16,000.0	2,048.0	2,048.0	25,295.0	NA	NA	NO	NO
Chromium	113/116	2.9	6.4	3.4	3.4	4.6	290	39	YES	NO
Cobalt	11/116	0.1	0.3	0.1	0.1	NA	4,700	470	NO	NO
Copper	67/116	1.8	21.4	2.3	2.3	4.1	105	NA	YES	NO
Iron	116/116	420.8	1,240.0	520.4	520.4	712.0	23,000	2,300	YES	NO
Lead	110/116	4.9	17.1	5.7	5.7	14.5	500	400	YES	NO
Magnesium	100/116	63.0	332.0	86.5	86.5	328.0	NA	NA	YES	NO
Manganese	111/116	3.7	35.5	4.8	4.8	8.1	1,600	180	YES	NO
Mercury	9/116	0.1	0.2	0.1	0.1	0.1	3.7	2.3	YES	NO

TABLE 2-3

SELECTION OF HUMAN HEALTH CHEMICALS OF POTENTIAL CONCERN
OU2 McCOY ANNEX LANDFILL, NAVAL TRAINING CENTER, ORLANDO, FLORIDA
PAGE 4 OF 5

Chemical Name	Frequency of Detection[1]	Mean[2]	Maximum	Lognormal 95% UCL[2]	EPC[3]	Background Screening Conc.[4]	Florida Residential SCG[5]	USEPA Region III Residential RBC[6]	Exceeded Background Screening Conc.?	Selected as CPC?[7]
Metals (cont.) (mg/kg)										
Nickel	104/116	0.7	5.4	0.9	0.9	4.4	30	160	YES	NO
Potassium	99/116	28.2	74.5	34.7	34.7	157.0	NA	NA	NO	NO
Selenium	14/116	0.2	0.6	0.3	0.3	1.0	390	39	NO	NO
Silver	12/116	0.2	2.4	0.2	0.2	1.8	390	39	YES	NO
Sodium	1/116	47.6	128.0	48.5	48.5	91.4	NA	NA	YES	NO[13]
Thallium	1/116	0.2	0.5	0.3	0.3	2.0	NA	NA	NO	NO
Vanadium	95/116	1.8	6.5	2.3	2.3	3.1	11	55	YES	NO
Zinc	53/116	4.8	45.8	6.7	6.7	17.2	23,000	2,300	YES	NO

TABLE 2-3

SELECTION OF HUMAN HEALTH CHEMICALS OF POTENTIAL CONCERN
OU2 McCOY ANNEX LANDFILL, NAVAL TRAINING CENTER, ORLANDO, FLORIDA

Notes:

Conc. = concentration.
RBC = USEPA Region III Risk-Based Concentration.
SCG = Florida Soil Cleanup Goals.
CPC = chemical of potential concern.
EPC = exposure point concentration.
UCL = upper confidence limit.
NA = not available/not applicable.
µg/kg = micrograms per kilogram.
mg/kg = milligrams per kilogram.
pCi/g = picoCuries per gram.

1 Frequency of detection is the number of samples in which the analyte is detected over the total number of samples analyzed.
2 One-half the contract-required quantitation limit/contract-required detection limit (CRQL/CRDL) was used for nondetects in calculating the mean and the 95 percent upper confidence limit (UCL).
3 Exposure point concentration (EPC) is the lesser of 95 percent UCL and maximum detected concentration.
4 The background screening concentration is twice the mean of detected concentrations for inorganic analytes. The background concentrations were obtained from the NTC Orlando Background Sampling Report (ABB-ES, 1995).
5 Florida Soil Clean-up Goals (SCG) Residential Scenario (FDEP, September 1995 and January 19, 1996).
6 The USEPA Region III Risk-Based Concentrations (RBC) for Soil Residential Scenario based on a cancer risk of 10^{-6} and a hazard quotient of 0.1.
7 If the analyte's maximum detected concentration is less than or equal to the background screening concentration, or less than or equal to the RBC and the Florida SCG, then the analyte was not selected as a CPC.
8 Benzo(a)pyrene (equivalent) is calculated by multipling benzo(a)anthracene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3 - cd)pyrene concentrations by the appropriate equivalence factor and adding it to the concentration of benzo(a)pyrene.
9 Endrin was used as a surrogate for endrin ketone.
10 The RBC for OCDD was determined by dividing the RBC for TCDD by the appropriate USEPA Region IV toxicity equivalence factor of 0.001.
11 Naphthalene was used as a surrogate for diesel range organics.
12 Hexane was used as a surrogate for gasoline range organics.
13 Although the maximum concentration of sodium exceeds background, it was not selected as a CPC because it is an essential nutrient.

Total carcinogenic polycyclic aromatic hydrocarbons (PAHs) are presented as "benzo(a)pyrene (equivalent)". The equivalent concentration is calculated for each sample location by multiplying all of the concentrations of the carcinogenic PAHs by the appropriate equivalence factor and summing these values. If all of the carcinogenic PAHs were below detection limits at a sample location, then half the detection limit of benzo(a)pyrene was used for that location. If any of the carcinogenic PAHs were detected, then the benzo(a)pyrene (equivalent) was calculated using the sum of the adjusted detected concentrations plus one-half the adjusted detection limit of each of the carcinogenic PAHs that were not detected. All concentrations (both detected and nondetected) were adjusted by their respective benzo(a)pyrene equivalency factors before summing.

3.0 IDENTIFICATION OF CHEMICALS OF POTENTIAL CONCERN

Chemicals for which data of sufficient quality were available for use in this FRA and that were detected at least once in soil samples were the starting point for the development of the list of CPCs. The final list of CPCs is a subset of all compounds detected in the surface soil. CPCs were selected based on concentrations and frequency of detection; physical, chemical, and toxicological characteristics; and comparison of detected values to background and risk values.

3.1 CHEMICALS OF POTENTIAL CONCERN SCREENING CRITERIA

USEPA Region IV guidelines and criteria were used to select CPCs (USEPA, 1995b). The CPCs included chemicals that were positively identified in at least one sample and exceeded background and screening values. Each criterion listed below was by itself justification for excluding an analyte:

- *Less than Background Screening Concentrations.* If the maximum detected concentration of an analyte was less than twice the arithmetic mean of the background concentration (inorganics only), the analyte was not selected as a CPC (USEPA, 1995b). The background screening values for surface soil are identified in the Background Sampling Report (ABB-ES, 1995).

- *Less than 5 Percent Frequency of Detection.* If an analyte had a frequency of detection (number of samples in which the analyte is detected divided by the number of samples analyzed for that analyte) less than 5 percent (USEPA, 1995b), it was not selected as a CPC. Although some analytes were detected at less than 5 percent frequency of detection, no analytes were eliminated based on this selection criteria alone. In every case some other selection criterion also indicated that the analyte was not a CPC.

- *Less than Risk-Based Screening Concentrations, Standards, and Guidelines.* If the maximum concentration of the analyte was less than its corresponding adjusted USEPA Region III Risk-Based Concentration (RBC) (USEPA, 1996), and less than Florida Soil Cleanup Goals (SCGs), then the analyte was not selected as a CPC (USEPA, 1995b). The USEPA Region III RBC values were determined using a target hazard quotient equal to 1 and the target cancer risk equal to 1×10^{-6}. All RBCs based on noncarcinogenic effects were divided by ten (adjusted for a target hazard quotient of 0.1) in accordance with Region IV guidance (USEPA, 1995b). No RBC is available for lead in soil. Based on USEPA recommendation, a screening level of 400 mg/kg for lead under residential land use is used as the RBC for lead in soil (USEPA, 1994). No screening values are available for TPH as Gasoline Range Organics (GRO) or Diesel Range Organics (DRO); screening values for hexane were used as a surrogate for GRO, and screening values for naphthalene were used as a surrogate for DRO. This was done based on chemical property similarities, toxicological similarities, and professional judgment. Screening values were not available for endrin ketone; therefore, toxicity values for endrin were used as a surrogate based on chemical property similarities and professional judgment.

- *Essential Nutrients.* The essential nutrients (e.g., sodium, potassium, magnesium, and calcium) do not have USEPA Region III RBCs or Florida SCGs. In this case all the essential nutrients were present at concentrations less than, or slightly greater than, background values; therefore, additional screening criteria for CPC selection were not developed. Sodium was the only essential nutrient detected at a maximum concentration (128 mg/kg) was greater than the background value (91.4 mg/kg).

If the analyte met any of the above criteria, then the analyte was not selected as a CPC. In situations where multiple screening values were available, a chemical was excluded only if its maximum concentration was less than all of the corresponding screening values. After applying these criteria, CPCs were identified for soil as shown in Table 2-3.

3.2 SELECTION OF HUMAN HEALTH CHEMICALS OF POTENTIAL CONCERN

The first phase of this FRA was a screening of the analytes detected in the surface soil at OU2 against background, and SCGs and RBCs developed assuming a residential land use scenario. Three chemicals were selected for surface soil at OU2 because they were detected at a maximum concentration exceeding residential screening values. The analytes that were selected as CPCs were benzo(a)pyrene, arsenic, and barium. Table 2-3 presents the residential CPC screening for surface soil at OU2.

Gross alpha and beta radioactivity were also selected as CPCs because no background or screening criteria for surface soil were available. Only groundwater was tested for background values for gross alpha and beta radionuclides; thus, no comparison was possible. Selection of gross alpha and beta radioactivity as CPCs was not intended to imply that the radioactivity is site related, rather that there is a lack of background and toxicity benchmarks for comparison.

4.0 EXPOSURE ASSESSMENT

The exposure assessment was conducted to identify the pathways by which humans are potentially exposed, the magnitude of actual and/or potential human exposure, and the frequency and duration of exposure. This process involves several steps:

- Characterization of the exposure setting in terms of physical characteristics and the populations that may potentially be exposed to site-related chemicals.
- Identification of potential exposure pathways and receptors.
- Quantification of exposure for each population in terms of the amount of chemical either ingested, inhaled, or absorbed through the skin from all complete exposure pathways.

4.1 EXPOSURE SETTING CHARACTERIZATION

The McCoy Annex Landfill is located at the southern end of McCoy Annex. The western portion of the landfill was reportedly used by the Air Force and the Navy from about 1960 to 1972, while the eastern portion was used from 1972 until about 1978. The area was converted into a golf course in 1981. The property is currently being used as a golf course and is expected to remain a golf course for the foreseeable future. This FRA addresses potential future land uses that may occur when this property is transferred to the City of Orlando.

4.2 RECEPTOR IDENTIFICATION

A potential future recreational user and a site maintenance worker were evaluated as realistic receptors, because the site is going to be maintained as a golf course. Potential future adult and child residents were evaluated in the FRA as a conservative estimate and for information purposes only. Residential land use is not expected in the foreseeable future. All receptors were evaluated for inhalation of volatiles and particulates from surficial soils, incidental soil ingestion, and dermal contact with soil.

4.3 EXPOSURE QUANTIFICATION

The final step of the exposure assessment was exposure quantification (i.e., intake). All scenarios were evaluated assuming Reasonable Maximum Exposure (RME) and a representative Exposure Point Concentration (EPC). The RME value provides a conservative estimate of exposure using the reasonable maximum value for each parameter. The EPC was defined as the lesser of the lognormal 95 percent UCL or the maximum detected concentration. The EPC for each analyte is shown in Table 2-3.

This quantification process involved developing assumptions regarding exposure conditions and exposure scenarios for each receptor to estimate the total amount of contaminants that a receptor may ingest, dermally absorb, or inhale from each exposure pathway. These exposure scenarios are based on several variables, which can be grouped into chemical-, population-, and assessment-related variables.

- In this FRA the chemical-related variable involved in the exposure quantification is simply the EPC.
- Population-related variables describe the characteristics of a hypothetical individual receptor within each potentially exposed population. These variables include contact rates, such as exposure frequencies and ingestion rates, and physical characteristics of human bodies, such as body weights and surface areas. When applicable, contact rates used are USEPA standard exposure factor default values (USEPA, 1991; USEPA, 1995b) or USEPA dermal guidance values (USEPA, 1992b). Some variables were altered to reflect the use of the site as a golf course. All of the population-related variables used in the FRA are shown in Appendix B.
- The assessment-related variable involved in exposure quantification is the averaging time. Averaging time reflects the duration of exposure and depends on the type of effect being evaluated. Exposure intake during a defined interval (e.g., a lifetime) is averaged over the entire period, resulting in an estimate of average daily intake. Two types of effects are evaluated in the FRA: carcinogenic and noncarcinogenic. According to USEPA guidance, the averaging time for carcinogenic effects is assumed to be a 70-year lifetime (USEPA, 1989a). The averaging time for noncarcinogenic effects is equivalent to the duration of exposure.

  Dermal absorption from soil was calculated in accordance with the USEPA *Dermal Exposure Assessment: Principles and Applications*, Interim Report (USEPA, 1992b). According to USEPA Region IV guidance (USEPA, 1995b), absorption factors for organics and inorganics are 1 percent and 0.1 percent, respectively. A soil adherence factor of 1 milligram of soil per square centimeter of skin (mg/cm^2) per event is used in the dermal intake equations (USEPA, 1995b).

5.0 TOXICITY ASSESSMENT

The purpose of the toxicity assessment was to identify the adverse effects that may be associated with exposure to each CPC and to identify the relationship between the level of exposure and the severity or likelihood of adverse effects. Two steps are typically associated with toxicity assessment: hazard identification and dose-response assessment.

5.1 HAZARD IDENTIFICATION

Hazard identification is the process of determining if exposure to an agent can cause a particular adverse health effect and, more importantly, if that effect may occur in humans. Characterizing the nature and strength of effect is a part of the hazard identification process. For a number of the chemicals at hazardous waste sites, potential toxic effects have already been identified. Consequently, the objectives of the hazard identification in the FRA are to (1) identify which of the contaminants detected at the site are potential hazards, and (2) briefly summarize their potential toxicity in nontechnical language.

5.2 DOSE-RESPONSE ASSESSMENT

A dose-response assessment is conducted to characterize and quantify the relationship between intake, or dose, of a CPC and the likelihood of a toxic effect or response. Two categories of toxic effects are evaluated in this FRA: carcinogenic and noncarcinogenic. Following USEPA guidance for risk assessments (USEPA, 1989a), these two types of endpoints (cancer and noncancer) were evaluated separately. As a result of the dose-response assessment, identified dose response values were used to estimate the incidence of adverse effects as a function of human exposure to a chemical. The two types of dose response values are Cancer Slope Factors (CSFs) for carcinogens and Reference Doses (RfDs) for noncarcinogens. For some compounds (such as arsenic), both types of values have been developed by USEPA because the chemicals cause both carcinogenic and noncarcinogenic effects. In addition, because the toxicity and/or carcinogenicity of a compound can depend on the route of exposure (i.e., oral, inhalation, or dermal), unique dose-response values are developed for the oral, dermal, and inhalation exposure routes. Toxicity information is not available for dermal exposure; therefore, it was necessary to adjust oral toxicity values that were based on administered doses so that they could be used for evaluation of absorbed doses. If no information was available on oral absorption efficiency, the conservative default values (USEPA, 1995b) of 80 percent for VOCs, 50 percent for SVOCs, and 20 percent for inorganics were used.

Appendix C contains dose-response information for the CPCs. This information was used to estimate the excess lifetime cancer risk (ELCR) for carcinogens and the hazard index (HI) for all CPCs in the risk characterization. Dose-response values current as of January 1998 from the Integrated Risk Information System (IRIS) (USEPA, 1998) and November 1995 from the Health Effects Assessment Summary Tables (HEAST) (USEPA, 1995a) were used in this FRA. Appendix A contains summaries of the potential toxicity for each of the CPCs.

6.0 RISK CHARACTERIZATION

Both carcinogenic and noncarcinogenic risks were estimated for each CPC provided the toxicity values were available. The chemical-specific risks for all carcinogenic and noncarcinogenic compounds were determined following the USEPA *Risk Assessment Guidance for Superfund* (USEPA, 1989a).

Carcinogenic risk estimates were calculated by integrating the exposure dose estimates with information on the strength or potency of a known or suspected carcinogen (i.e., CSF):

ELCR = Exposed or absorbed dose X CSF.

Cancer risk estimates are often compared to the 1×10^{-4} to 1×10^{-6} cancer risk range frequently used by USEPA in establishing standards and criteria and in determining the need for environmental remediation at sites undergoing environmental investigations.

Potential health risks resulting from exposure to noncarcinogenic compounds were estimated by comparing the maximum daily dose calculated for an exposure to an acceptable intake dose (i.e., the RfD):

Hazard Quotient (HQ) = Exposed or absorbed dose / RfD.

If the ratio between an exposure dose and the RfD exceeds unity (1.0), there is a potential for adverse noncarcinogenic health effects. The dose-to-RfD ratio is not a mathematical prediction of the severity of probability of toxic effects; it is simply a numerical indicator of the potential for adverse effects. The ratio of the exposure dose to the RfD is referred to as the HQ. The summation of HQs for several compounds is referred to as the HI.

CSFs and RfDs used to estimate carcinogenic and noncarcinogenic risks are identified in the risk calculation spreadsheets presented in Appendix C. CSFs and RfDs for the evaluation of the dermal route of exposure were derived in accordance with USEPA methodology (USEPA, 1989a).

Three scenarios were evaluated for this FRA. The recreational and site maintenance worker scenarios were evaluated to provide a risk range that can be used by decision makers and risk managers to evaluate the need for further action at OU2. The residential scenario was evaluated for comparison purposes only, because the site is expected to remain a golf course for the foreseeable future. The risk calculation sheets for all of the scenarios are provided in Appendix C. Hand calculations to support Appendix C are presented in Appendix D.

The USEPA guidelines, established in the National Oil and Hazardous Substances Contingency Plan (NCP), indicate that the total lifetime cancer risk due to exposure to the CPCs at a site, by each complete exposure pathway, should not exceed a range of 1 in 1,000,000 (1×10^{-6}) to 1 in 10,000 (1×10^{-4}) (USEPA, 1991). FDEP has indicated that chemical-specific risks greater than one in one million (1×10^{-6}) warrant further consideration.

An HI less than 1 indicates that adverse health effects are not expected to occur due to CPC exposure. HIs greater than 1 may be indicative of a possible noncarcinogenic toxic effects, but the circumstances must be evaluated on a case-by-case basis (USEPA, 1989a). As the HI increases, so does the likelihood that adverse effects might be associated with exposure.

6.1 RECREATIONAL USER RISK RESULTS

A future recreational exposure scenario was evaluated assuming this recreational receptor was a golfer exposed to soils at the site. Adult and adolescent recreational land use was evaluated in the FRA as one of the primary land use scenarios for OU2. Risks to potential future recreational users were evaluated for incidental ingestion, dermal contact, and inhalation of volatiles and particulates from surface soil.

The cancer risk estimate for potential future recreational users at OU2 (combined adult and adolescent) is 6.2×10^{-7}. The contributing CPCs were arsenic and benzo(a)pyrene. Table 6-1 presents the ELCR results for each analyte and pathway.

The noncancer HI for potential future adult and child recreational users is less than the target level of 1. The risk from radionuclides was not quantitatively evaluated. The risk calculation sheets for recreational users are presented in Appendix C.

6.2 SITE MAINTENANCE WORKER RISK RESULTS

This exposure scenario was evaluated assuming a site maintenance worker was exposed to soils at the golf course. This receptor was evaluated in the FRA because it is anticipated that the site will continue to be used as a golf course. Risks to this receptor were evaluated for incidental ingestion, dermal contact, and inhalation of volatiles and particulates from surface soil.

The cancer risk estimate for the site maintenance worker at OU2 is 8.3×10^{-7}. The contributing CPCs were arsenic and benzo(a)pyrene. Table 6-1 presents the ELCR results for each analyte and pathway.

The noncancer HI for potential future adult and child recreational users is less than the target level of 1. The risk from radionuclides was not quantitatively evaluated. The risk calculation sheets for site maintenance workers are presented in Appendix C.

6.3 RESIDENTIAL RISK RESULTS

The FRA carcinogenic results for the future resident (adult and child) are combined to determine a total receptor risk. The noncarciongenic results for the future residential adult and child receptor are considered separately. These risk results are then compared to the acceptable USEPA and Florida risk benchmarks.

Risks estimates for potential future residents were developed for incidental ingestion, dermal contact, and inhalation (of volatiles and particulates) exposures to surface soil. The cancer risk to potential future residents at OU2 (combined adult and child) is 7.4×10^{-6}. The residential risk is within the USEPA acceptable risk range but above the FDEP level of concern.

The noncancer HIs for potential future adult and child residents for both scenarios are each less than the target level of 1. The calculation sheets for a future resident (adult and child) are presented in tables in Appendix C.

TABLE 6-1

EXCESS LIFETIME CANCER RISK RESULTS
OU2 McCOY ANNEX LANDFILL, NAVAL TRAINING CENTER, ORLANDO, FLORIDA

PARAMETER	CONC	Recreational User ELCR				Site Maintenance Worker ELCR				Resident ELCR			
	mg/kg	Ingestion	Dermal Contact	Inhalation	Total	Ingestion	Dermal Contact	Inhalation	Total	Ingestion	Dermal Contact	Inhalation	Total
ARSENIC	1.6	2.5E-07	1.5E-08	1.7E-10	**2.7E-07**	4.2E-07	1.1E-08	1.4E-09	**4.3E-07**	3.8E-06	9.5E-08	3.4E-09	**3.9E-06**
BARIUM	7.7	NA	NA	NA	**NA**	NA	NA	NA	**NA**	NA	NA	NA	**NA**
BENZO(A)PYRENE (equivalent)	0.211	1.6E-07	1.9E-07	4.6E-12	**3.5E-07**	2.7E-07	1.3E-07	3.7E-11	**4.0E-07**	2.4E-06	1.2E-06	9.3E-11	**3.6E-06**
Total		**4.1E-07**	**2.0E-07**	**1.7E-10**	**6.1E-07**	**6.9E-07**	**1.4E-07**	**1.4E-09**	**8.3E-07**	**6.2E-06**	**1.3E-06**	**3.5E-09**	**7.4E-06**

7.0 REMEDIAL GOALS OPTIONS

Remedial Goal Options (RGOs) are calculated for CPCs with total estimated ELCR above 1 in 1,000,0000 or with a total HI greater than 1. The only scenario that had a ELCR greater than 1 X 10^{-6} was the residential scenario, which was evaluated as a conservative scenario that could be used for comparison purposes. The site is not expected to be used for residential purposes; therefore, RGOs were not required to be calculated.

8.0 UNCERTAINTY

Because the cancer risk in OU2 surface soils is driven by arsenic, a naturally occurring metal and a historical component of pesticides, and PAHs, a chemical class common in urban areas, it is uncertain whether this risk to potential residents is actually due to past site operations.

Benzo(a)pyrene is a common anthropogenic contaminant. The concentrations may be the result of runoff from roadways or the result of automobile use or may be contamination from burning of brush or garbage.

Arsenic is a naturally occurring metal used prevalently in pesticides. Additionally, the risks associated with background screening levels can exceed the FDEP acceptable levels. Therefore, the risks associated with site-related arsenic may be overestimated due to the elevated natural risk from arsenic.

The risk from the radionuclides (gross alpha and gross beta) detected in the surface soil could not be quantitatively evaluated, and there were no background or screening values available for qualitative comparison.

Some uncertainty is also associated with the sampling interval used in collecting the surface soil samples for this FRA. Because arsenic and PAHs tend to occur preferentially in the top several inches of soil, considering the top 2 feet of soil as "surface soil" could underestimate the risk associated with soils at OU2. This underestimate would be due to a downward biasing of the concentrations detected in the data set (including nondetects in the statistical interpretation).

Uncertainty is also associated with determining EPCs. For this FRA the exposure point concentration was determined as the lesser of the lognormal 95 percent UCL or the maximum. It is likely that the actual average EPC would be much less than either of these values and the exposure is overestimated. It was also assumed that concentrations were lognormally distributed across the site. If this assumption is not correct, then the actual 95 percent UCL could be higher or lower than the UCL predicted with the lognormal distribution. The correlation coefficient for each analyte is presented in Table 2-2.

9.0 CONCLUSIONS

The total ELCR for the recreational receptor and site maintenance worker were 6.1×10^{-7} and 8.3×10^{-7}, respectively. These estimates are within the acceptable risk range of the USEPA and approximately equal to the level of concern as defined by the USEPA. Both of these receptors and HI values less than one. The two receptors were evaluated to provide conservative estimates of risk for the land use that is expected for this site.

The hypothetical future residential risk from soil exposure results is a risk level of 7.4×10^{-6}. This value is within the acceptable risk range of the USEPA, but above the level of concern as defined by the FDEP. Risk management decisions should consider the fact that the site is expected to remain a golf course for the foreseeable future.

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APPENDIX A

TOXICITY SUMMARIES

ARSENIC TOXICITY

April 1992

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Prepared for: OAK RIDGE RESERVATION ENVIRONMENTAL RESTORATION PROGRAM.

*Managed by Martin Marietta Energy Systems, Inc., for the U.S. Department of Energy under Contract No. DE-AC05-84OR21400.

The toxicity of inorganic arsenic (As) depends on its valence state (-3, +3, or +5), and also on the physical and chemical properties of the compound in which it occurs. Trivalent (As+3) compounds are generally more toxic than pentavalent (As+5) compounds, and the more water soluble compounds are usually more toxic and more likely to have systemic effects than the less soluble compounds, which are more likely to cause chronic pulmonary effects if inhaled. One of the most toxic inorganic arsenic compounds is arsine gas (AsH3). It should be noted that laboratory animals are generally less sensitive than humans to the toxic effects of inorganic arsenic. In addition, in rodents the critical effects appear to be immunosuppression and hepato-renal dysfunction, whereas in humans the skin, vascular system, and peripheral nervous system are the primary target organs.

Water soluble inorganic arsenic compounds are absorbed through the G.I. tract (>90%) and lungs; distributed primarily to the liver, kidney, lung, spleen, aorta, and skin; and excreted mainly in the urine at rates as high as 80% in 61 hr following oral dosing (U.S. EPA, 1984; ATSDR, 1989; Crecelius, 1977). Pentavalent arsenic is reduced to the trivalent form and then methylated in the liver to less toxic methylarsinic acids (ATSDR, 1989).

Symptoms of acute inorganic arsenic poisoning in humans are nausea, anorexia, vomiting, epigastric and abdominal pain, and diarrhea. Dermatitis (exfoliative erythroderma), muscle cramps, cardiac abnormalities, hepatotoxicity, bone marrow suppression and hematologic abnormalities (anemia), vascular lesions, and peripheral neuropathy (motor dysfunction, paresthesia) have also been reported (U.S. Air Force, 1990; ATSDR, 1989; Franzblau and Lilis, 1989; U.S. EPA, 1984; Armstrong et al., 1984; Hayes, 1982; Mizuta et al., 1956). Oral doses as low as 20-60 g/kg/day have been reported to cause toxic effects in some individuals (ATSDR, 1989). Severe exposures can result in acute encephalopathy, congestive heart failure, stupor, convulsions, paralysis, coma, and death. The acute lethal dose to humans has been estimated to be about 0.6 mg/kg/day (ATSDR, 1989). General symptoms of chronic arsenic poisoning in humans are weakness, general debility and lassitude, loss of appetite and energy, loss of hair, hoarseness of voice, loss of weight, and mental disorders (Hindmarsh and McCurdy, 1986). Primary target organs are the skin (hyperpigmentation and hyperkeratosis) [Terada et al. 1960; Tseng et al., 1968; Zaldivar 1974; Cebrian et al., 1983; Huang et al., 1985], nervous system (peripheral neuropathy) [Hindmarsh et al., 1977, 1986; Valentine et al., 1982; Heyman et al., 1956; Mizuta et al., 1956; Tay and Seah, 1975], and vascular system [Tseng et al., 1968; Borgano and Greiber, 1972; Salcedo et al., 1984; Wu et al., 1989; Hansen, 1990]. Anemia, leukopenia, hepatomegaly, and portal hypertension have also been reported (Terada et al., 1960; Viallet et al., 1972; Morris et al., 1974; Datta, 1976). In addition, possible reproductive effects include a high male to female birth ratio (Lyster, 1977).

In animals, acute oral exposures can cause gastrointestinal and neurological effects (Heywood and Sortwell, 1979). Oral LD50 values range from about 10 to 300 mg/kg (ASTDR, 1989; U.S. Air Force, 1990). Low subchronic doses can result in immunosuppression, (Blakely et al., 1980) and hepato-renal effects (Mahaffey et al., 1981; Brown et al., 1976; Woods and Fowler, 1977, 1978; Fowler and Woods, 1979; Fowler et al., 1979). Chronic exposures have also resulted in mild hyperkeratosis and bile duct enlargement with hyperplasia, focal necrosis, and fibrosis (Baroni et al., 1963; Byron et al., 1967). Reduction in litter size, high male/female birth ratios, and fetotoxicity without significant fetal abnormalities occur following oral exposures (Schroeder and Mitchener, 1971; Hood et al., 1977; Baxley et al., 1981); however, parenteral dosing has resulted in exencephaly, encephaloceles, skeletal defects, and urogenital system abnormalities (Ferm and Carpenter, 1968; Hood and Bishop, 1972; Beaudoin, 1974; Burk and Beandoin, 1977).

The Reference Dose for chronic oral exposures, 0.0003 mg/kg/day, is based on a NOAEL of 0.0008 mg/kg/day and a LOAEL of 0.014 mg/kg/day for hyperpigmentation, keratosis, and possible vascular complications in a human population consuming arsenic-contaminated drinking water (U.S. EPA, 1991a). Because of uncertainties in the data, U.S. EPA (1991a) states that "strong scientific arguments can be made for various values within a factor of 2 or 3 of the currently recommended RfD value." The subchronic Reference Dose is the same as the chronic RfD, 0.0003 mg/kg/day (U.S. EPA, 1992).

Acute inhalation exposures to inorganic arsenic can damage mucous membranes, cause rhinitis, pharyngitis and laryngitis, and result in nasal septum perforation (U.S. EPA, 1984). Chronic inhalation exposures, as occurring in the workplace, can lead to rhino-pharyno-laryngitis, tracheobronchitis, (Lundgren, 1954); dermatitis, hyperpigmentation, and hyperkeratosis (Perry et al., 1948; Pinto and McGill, 1955); leukopenia (Kyle and Pease, 1965; Hine et al., 1977); peripheral nerve dysfunction as indicated by abnormal nerve conduction velocities (Feldman et al., 1979; Blom et al., 1985; Landau et al., 1977); and peripheral vascular disorders as indicated by Raynaud's syndrome and increased vasospastic reactivity in fingers exposed to low temperatures (Lagerkvist et al., 1986). Higher rates of cardiovascular disease have also been reported in some arsenic-exposed workers (Lee and Fraumeni, 1969; Axelson et al., 1978; Wingren and Axelson, 1985). Possible reproductive effects include a high frequency of spontaneous abortions and reduced birth weights (Nordström et al., 1978a,b). Arsine gas (AsH3), at concentrations as low as 3-10 ppm for several hours, can cause toxic effects. Hemolysis, hemoglobinuria, jaundice, hemolytic anemia, and necrosis of the renal tubules have been reported in exposed workers (ACGIH, 1986; Fowler and Weissberg, 1974).

Animal studies have shown that inorganic arsenic, by intratracheal instillation, can cause pulmonary inflammation and hyperplasia (Webb et al., 1986, 1987), lung lesions (Pershagen et al., 1982), and immunosuppression (Hatch et al. (1985). Long-term inhalation exposures have resulted in altered conditioned reflexes and CNS damage (Rozenshstein, 1970). Reductions in fetal weight and in the number of live fetuses, and increases in fetal abnormalities due to retarded osteogenesis have been observed following inhalation exposures (Nagymajtenyi et al., 1985).

Subchronic and chronic RfCs for inorganic arsenic have not been derived.

Epidemiological studies have revealed an association between arsenic concentrations in drinking water and increased incidences of skin cancers (including squamous cell carcinomas and multiple basal cell carcinomas), as well as cancers of the liver, bladder, respiratory and gastrointestinal tracts (U.S. EPA, 1987; IARC, 1987; Sommers et al., 1953; Reymann et al., 1978; Dobson et al., 1965; Chen et al., 1985, 1986). Occupational exposure studies have shown a clear correlation between exposure to arsenic and lung cancer mortality (IARC, 1987; U.S. EPA, 1991a). U.S. EPA (1991a) has placed inorganic arsenic in weight-of-evidence group A, human carcinogen. A drinking water unit risk of 5E-5(ug/L)-1 has been proposed (U.S. EPA, 1991a); derived from drinking water unit risks for females and males that are equivalent to slope factors of 1.0E-3 (ug/kg/day)-1 (females) and 2.0E-3 (ug/kg/day)-1 (males) (U.S. EPA, 1987). For inhalation exposures, a unit risk of 4.3E-3 (ug/m3)-1 (U.S. EPA, 1991a) and a slope factor of 15.1 (mg/kg/day)-1 have been derived (U.S. EPA, 1992).

A GI absorption value of .95 from the following reference was used for calculating dermal toxicity values: Bettley, F.R., O'Shea, J.A. 1975. The absorption of arsenic and its relation to carcinoma. Br. J. Dermatology. 92:563. (Cited in Hindmarsh and McCurdy, 1986).

BARIUM TOXICITY

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*Managed by Martin Marietta Energy Systems, Inc., for the U.S. Department of Energy under Contract No. DE-AC05-84OR21400

The soluble salts of barium, an alkaline earth metal, are toxic in mammalian systems. They are absorbed rapidly from the gastrointestinal tract and are deposited in the muscles, lungs, and bone. Barium is excreted primarily in the feces.

At low doses, barium acts as a muscle stimulant and at higher doses affects the nervous system eventually leading to paralysis. Acute and subchronic oral doses of barium cause vomiting and diarrhea, followed by decreased heart rate and elevated blood pressure. Higher doses result in cardiac irregularities, weakness, tremors, anxiety, and dyspnea. A drop in serum potassium may account for some of the symptoms. Death can occur from cardiac and respiratory failure. Acute doses around 0.8 grams can be fatal to humans.

Subchronic and chronic oral or inhalation exposure primarily affects the cardiovascular system resulting in elevated blood pressure. A lowest-observed-adverse-effect level (LOAEL) of 0.51 mg barium/kg/day based on increased blood pressure was observed in chronic oral rat studies (Perry et al. 1983), whereas human studies identified a no-observed-adverse-effect level (NOAEL) of 0.21 mg barium/kg/day (Wones et al. 1990, Brenniman and Levy 1984). The human data were used by the EPA to calculate a chronic and subchronic oral reference dose (RfD) of 0.07 mg/kg/day (EPA 1995a,b). In the Wones et al. study, human volunteers were given barium up to 10 mg/L in drinking water for 10 weeks. No clinically significant effects were observed. An epidemiological study was conducted by Brenniman and Levy in which human populations ingesting 2 to 10 mg/L of barium in drinking water were compared to a population ingesting 0 to 0.2 mg/L. No significant individual differences were seen; however, a significantly higher mortality rate from all combined cardiovascular diseases was observed with the higher barium level in the 65+ age group. The average barium concentration was 7.3 mg/L, which corresponds to a dose of 0.20 mg/kg/day. Confidence in the oral RfD is rated medium by the EPA.

Subchronic and chronic inhalation exposure of human populations to barium-containing dust can result in a benign pneumoconiosis called "baritosis." This condition is often accompanied by an elevated blood pressure but does not result in a change in pulmonary function. Exposure to an air concentration of 5.2 mg barium carbonate/m3 for 4 hours/day for 6 months has been reported to result in elevated blood pressure and decreased body weight gain in rats (Tarasenko et al. 1977). Reproduction and developmental effects were also observed. Increased fetal mortality was seen after untreated females were mated with males exposed to 5.2 mg/m3 of barium carbonate. Similar results were obtained with female rats treated with 13.4 mg barium carbonate/m3. The NOAEL for developmental effects was 1.15 mg/m3 (equivalent to 0.8 mg barium/m3). An inhalation reference concentration (RfC) of 0.005 mg/m3 for subchronic and 0.0005 mg/m3 for chronic exposure was calculated by the EPA based on the NOAEL for developmental effects (EPA 1995a). These effects have not been substantiated in humans or other animal systems.

The GI absorption value of 0.07, used for calculating dermal toxicity values, was taken from the following reference:
ATSDR (Agency for Toxic Substances and Disease Registry). 1992. Toxicological Profile for Barium. ATSDR/U.S. Public Health Service

Barium has not been evaluated by the EPA for evidence of human carcinogenic potential (EPA 1995b).

BENZ(A)ANTHRACENE

September 1992

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Prepared for OAK RIDGE RESERVATION ENVIRONMENTAL RESTORATION PROGRAM.

*Managed by Martin Marietta Energy Systems, Inc., for the U.S. Department of Energy under Contract No. DE-AC05-84OR21400.

Benz(a)anthracene, along with a number of other polycyclic aromatic hydrocarbons, are natural products produced by the incomplete combustion of organic material. The arrangement of the aromatic rings in the benz(a)anthracene molecule gives it a "bay region" often correlated with carcinogenic properties. In general, the bay-region polycyclic aromatic hydrocarbons and some of their metabolites are known to react with cellular macromolecules, including DNA, which may account for both their toxicity and carcinogenicity. The inducible mixed-function oxidase enzymes oxidize benz(a)anthracene to form metabolites with increased water solubility that can be efficiently excreted in the urine. A minor product of this oxidation, a bay-region diol epoxide, reacts readily with DNA and has been shown to be highly carcinogenic (U.S. EPA, 1980; 1984; Jerina, et al., 1977).

The toxic effects of benz(a)anthracene and similar polycyclic aromatic hydrocarbons are primarily directed toward tissues that contain proliferating cells. Animal studies indicate that exposure to bay-region polycyclic aromatic hydrocarbons can damage the hematopoietic system leading to progressive anemia as well as agranulocytosis (Robinson, et al., 1975; Cawein and Sydnor, 1968). The lymphoid system can also be affected resulting in lymphopenia. Toxic effects have been observed in the rapidly dividing cells of the intestinal epithelium, spermatogonia and resting spermatocytes in the testis and primary oocytes of the ovary (Philips et al., 1973; Mackinzie and Angevine, 1981; Kraup, 1970; Ford and Huggins, 1963; Mattison and Thorgeirsson, 1977; U.S. EPA, 1980; 1984). Most of these effects have occurred following both oral and parenteral exposure. Epithelial proliferation and cell hyperplasia in the respiratory tract have been reported following subchronic inhalation exposure (Reznik-Schuller and Mohr, 1974; Saffiotti et al., 1968).

However, because of the lack of quantitative data, neither a reference dose nor a reference concentration have been derived (U.S. EPA, 1991).

The primary concern with benz(a)anthracene exposure is its potential carcinogenicity. There is no unequivocal, direct evidence of the carcinogenicity of the compound to humans, however, benz(a)anthracene and other known carcinogenic polycyclic aromatic hydrocarbons are components of coal tar, soot, coke oven emissions and tobacco smoke. There is adequate evidence of its carcinogenic properties in animals. Oral exposures of mice to benz(a)anthracene have resulted in hepatomas, pulmonary adenomas and forestomach papillomas (Klein, 1963; Bock and King, 1959; U.S. EPA, 1991). The EPA weight-of-evidence classification is: B2, probable human carcinogen, for both oral and inhalation exposure based on adequate animal evidence and no human evidence (U.S. EPA, 1991). A slope factor has not been derived specifically for benz(a)anthracene by the EPA (U.S. EPA, 1991). However, an oral slope factor of 7.3 (mg/kg/day)-1 has been calculated for benzo(a)pyrene based on the incidence of stomach tumors in mice treated with benzo(a)pyrene (Neal and Rigdon, 1967; U.S. EPA, 1980; 1984; 1992a). A drinking water unit risk of 2.1E-4 (g/L)-1 has also been calculated for benzo(a)pyrene (U.S. EPA, 1992a). An inhalation slope factor of 6.1 (mg/kg/day)-1 (U.S. EPA, 1992b) was calculated for benzo(a)pyrene based on the incidence of respiratory tumors in golden hamsters treated with benzo(a)pyrene (Thyssen et al., 1981; U.S. EPA, 1980; 1984). An inhalation unit risk of 1.7E-3 (g/m3)-1 has also been calculated for benzo(a)pyrene (U.S. EPA, 1992b).

BENZ(A)PYRENE TOXICITY

December 1994

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Prepared for: OAK RIDGE RESERVATION ENVIRONMENTAL RESTORATION PROGRAM.

*Managed by Martin Marietta Energy Systems, Inc., for the U.S. Department of Energy under Contract No. DE-AC05-84OR21400.

Benzo(a)pyrene is a polycyclic aromatic hydrocarbon (PAH) that can be derived from coal tar. Benzo(a)pyrene occurs ubiquitously in products of incomplete combustion of fossil fuels and has been identified in ambient air, surface water, drinking water, waste water, and char-broiled foods (IARC, 1983). Benzo(a)pyrene is primarily released to the air and removed from the atmosphere by photochemical oxidation and dry deposition to land or water. Biodegradation is the most important transformation process in soil or sediment (ATSDR, 1990).

Benzo(a)pyrene is readily absorbed following inhalation, oral, and dermal routes of administration (ATSDR, 1990). Following inhalation exposure, benzo(a)pyrene is rapidly distributed to several tissues in rats (Sun et al., 1982; Weyand and Bevan, 1986). The metabolism of benzo(a)pyrene is complex and includes the formation of a proposed ultimate carcinogen, benzo(a)pyrene 7,8 diol-9,10-epoxide (IARC, 1983). The major route of excretion is hepatobiliary followed by elimination in the feces (EPA, 1991).

No data are available on the systemic (non-carcinogenic) effects of benzo(a)pyrene in humans. In mice, genetic differences appear to influence the toxicity of benzo(a)pyrene. Subchronic dietary administration of 120 mg/kg benzo(a)pyrene for up to 180 days resulted in decreased survival due to hematopoietic effects (bone narrow depression) in a "nonresponsive" strain of mice (i.e., a strain whose cytochrome P-450 mediated enzyme activity is not induced as a consequence of PAH exposure). No adverse effects were noted in "responsive" mice (i.e., a strain capable of inducing increased cytochrome P-450 mediated enzyme activity as a consequence of PAH exposure) (Robinson et al., 1975). Immunosuppression has been reported in mice administered daily intraperitoneal injections of 40 or 160 mg/kg of benzo(a)pyrene for 2 weeks, with more pronounced effects apparent in "nonresponsive" mice (Blanton et al., 1986; White et al., 1985). In utero exposure to benzo(a)pyrene has produced adverse developmental/reproductive effects in mice. Dietary administration of doses as low as 10 mg/kg during gestation caused reduced fertility and reproductive capacity in offspring (Mackenzie and Angevine, 1981), and treatment by gavage with 120 mg/kg/day during gestation caused stillbirths, resorptions, and malformations (Legraverend et al., 1984). Similar effects have been reported in intraperitoneal injection studies (ATSDR, 1990). Neither a reference dose (RfD) nor a reference concentration (RfC) has been derived for benzo(a)pyrene.

Numerous epidemiologic studies have shown a clear association between exposure to various mixtures of PAHs containing benzo(a)pyrene (e.g., coke oven emissions, roofing tar emissions, and cigarette smoke) and increased risk of lung cancer and other tumors. However, each of the mixtures also contained other potentially carcinogenic PAHs; therefore, it is not possible to evaluate the contribution of benzo(a)pyrene to the carcinogenicity of these mixtures (IARC, 1983; EPA, 1991). An extensive data base is available for the carcinogenicity of benzo(a)pyrene in experimental animals. Dietary administration of benzo(a)pyrene has produced papillomas and carcinomas of the forestomach in mice (Neal and Rigdon, 1967), and treatment by gavage has produced mammary tumors in rats (McCormick et al., 1981) and pulmonary adenomas in mice (Wattenberg and Leong, 1970). Exposure by inhalation and intratracheal instillation has resulted in benign and malignant tumors of the respiratory and upper digestive tracts of hamsters (Ketkar et al., 1978; Thyssen et al., 1981). Numerous topical application studies have shown that benzo(a)pyrene induces skin tumors in several species, although mice appear to be the most sensitive species. Benzo(a)pyrene is a complete carcinogen and also an initiator of skin tumors (IARC, 1973; EPA, 1991). Benzo(a)pyrene has also been reported to induce tumors in animals when administered by other routes, such as intravenous, intraperitoneal, subcutaneous, intrapulmonary, and transplacental.

Based on United States Environmental Protection Agency (EPA) guidelines, benzo(a)pyrene was assigned to weight-of-evidence group B2, probable human carcinogen. For oral exposure, the slope factor and unit risk are 7.3E+0 (mg/kg/day)-1 and 2.1E-4 (ug/L)-1, respectively (EPA, 1994). For inhalation exposure the provisional slope factor developed by NCEA is 3.1E+0 (mg/kg/day).

The GI absorption value of .5, used for calculating dermal toxicity values.

BENZO(B)FLUORANTHENE TOXICITY

May 1994

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*Managed by Martin Marietta Energy Systems, Inc., for the U.S. Department of Energy under Contract No. DE-AC05-84OR21400.

Benzo(b)fluoranthene, a crystalline solid with a chemical formula of C20H12 and a molecular weight of 252.32 (Lide, 1991), is a polycyclic aromatic hydrocarbon (PAH) with one five-membered ring and four six-membered rings. There is no commercial production or known use of this compound (IARC, 1983). Benzo(b)fluoranthene is found in fossil fuels and occurs ubiquitously in products of incomplete combustion. It has been detected in mainstream cigarette smoke; urban air; gasoline engine exhaust; emissions from burning coal and from oil-fired heating; broiled and smoked food; oils and margarine (IARC, 1983); and in soils, groundwater, and surface waters at hazardous waste sites (ATSDR, 1990).

No absorption data were available for benzo(b)fluoranthene; however, by analogy to structurally-related PAHs, primarily benzo(a)pyrene, it would be expected to be absorbed from the gastrointestinal tract, lungs, and skin (EPA, 1991). Major metabolites of benzo(b)fluoranthene formed in vitro in rat liver include dihydrodiols and monohydroxy derivatives (Amin et al., 1982) and monohydroxy derivatives in mouse epidermis (Geddie et al., 1987).

No data were found concerning the acute, subchronic, chronic, developmental, or reproductive toxicity of benzo(b)fluoranthene. No data were available for the derivation of an oral reference dose (RfD) or inhalation reference concentration (RfC) (EPA, 1994).

No long-term oral or inhalation bioassays were available to assess the carcinogenicity of benzo(b)fluoranthene. Benzo(b)fluoranthene was tested for carcinogenicity in dermal application, lung implantation, subcutaneous (s.c.) injection, and intraperitoneal (i.p.) injection studies. Dermal applications of 0.01-0.5% solutions of benzo(b)fluoranthene for life produced a high incidence of skin papillomas and carcinomas in mice (Wynder and Hoffmann, 1959). In initiation-promotion assays, the compound was active as an initiator of skin carcinogenesis in mice (LaVoie et al., 1982; Amin et al., 1985). Sarcomas and carcinomas of the lungs and thorax were seen in rats receiving single lung implants of 0.1-1 mg benzo(b)fluoranthene (Deutsch-Wenzel et al., 1983). Newborn mice receiving 0.5 umol benzo(b)fluoranthene via i.p. injection developed liver and lung tumors (LaVoie et al., 1987), and mice administered three s.c. injections of 0.6 mg benzo(b)fluoranthene developed injection site sarcomas (IARC, 1993).

Based on no human data and sufficient evidence for carcinogenicity in animals, EPA has assigned a weight-of-evidence classification of B2, probable human carcinogen, to benzo(b)fluoranthene (EPA, 1994).

INDENO(1,2,3-CD)PYRENE TOXICITY

MAY 1994

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*Managed by Martin Marietta Energy Systems, Inc., for the U.S. Department of Energy under Contract No. DE-AC05-84OR21400.

Indeno(1,2,3-cd)pyrene, a crystalline solid with a chemical formula of C22H12 and a molecular weight of 276.3, is a polycyclic aromatic hydrocarbon (PAH). There is no commercial production or known use of this compound (IARC, 1983). Indeno(1,2,3-cd)pyrene is found in fossil fuels and occurs ubiquitously in products of incomplete combustion (IARC, 1983) and has been identified in soils, groundwater, and surface waters at hazardous waste sites (ATSDR, 1990).

No absorption data were available for indeno(1,2,3-cd)pyrene; however, by analogy to structurally-related PAHs, primarily benzo(a)pyrene, it would be expected to be absorbed from the gastrointestinal tract, lungs, and skin (EPA, 1991). In vivo metabolites identified in mouse skin include the trans-1,2-dihydrodiol and 8- and 9-hydroxy forms of indeno(1,2,3-cd)pyrene (Rice et al., 1986). Similar metabolites were formed in vitro in rat liver microsomes (Rice et al., 1985).

No data were found concerning the acute, subchronic, chronic, developmental, or reproductive toxicity of indeno(1,2,3-cd)pyrene. Because of a lack of toxicity data, an oral reference dose (RfD) or inhalation reference concentration (RfC) has not been derived (EPA, 1994).

No long-term oral or inhalation bioassays were available to assess the carcinogenicity of indeno(1,2,3-cd)pyrene. The compound was tested for carcinogenicity in dermal application, lung implant, subcutaneous (s.c.) injection, and intraperitoneal (i.p.) injection studies. Dermal application of 0.1-0.5% solutions of indeno(1,2,3-cd)pyrene in acetone produced skin papillomas and carcinomas in mice (Hoffmann and Wynder, 1966). In initiation-promotion assays, indeno(1,2,3-cd)pyrene was active as an initiator of skin carcinogenesis (Hoffmann and Wynder, 1966; Rice et al., 1986). Dose-related increases of epidermoid carcinomas of the lungs were reported in rats receiving single lung implants of 0.16-4.15 mg indeno(1,2,3-cd)pyrene (Deutsch-Wenzel et al., 1983). Injection site sarcomas developed in mice given three s.c. injections of 0.6 mg indeno(1,2,3-cd)pyrene (Lacassagne et al., 1963). The compound was not tumorigenic when newborn mice received 2.1 mol indeno(1,2,3-cd)pyrene via i.p. injection (LaVoie et al., 1987).

Based on no human data and sufficient evidence for carcinogenicity in animals, the United Stated Environmental Protection Agency (EPA) has assigned a weight-of-evidence classification of B2, probable human carcinogen, to indeno(1,2,3-cd)pyrene (EPA, 1994).

APPENDIX B
EXPOSURE PARAMETERS

TABLE B-1

EXPOSURE PARAMETERS FOR RECREATIONAL USER (ADULT AND ADOLESCENT) OU2 McCOY ANNEX LANDFILL, NAVAL TRAINING CENTER, ORLANDO, FLORIDA

$$INTAKE_{ing} = \frac{CS \times IR_{soil} \times FI \times CF \times EF \times ED}{BW \times AT \times 365 \text{ days / year}}$$

$$INTAKE_{dermal} = \frac{CS \times AF \times ABS_d \times CF \times SA \times EF \times ED}{BW \times AT \times 365 \text{ days / year}}$$

$$INTAKE_{inh} = \frac{CA \times IR_{air} \times ET \times EF \times ED}{BW \times AT \times 365 \text{ days / year}}$$

$$CA = CS \times \left(\frac{1}{PEF} + \frac{1}{VF}\right)$$

Parameter	Symbol	Adolescent (Age 6-16)	Adult	Units	Source
Concentration in Soil	CS	----------------Chemical-specific----------------			
Particulate Emission Factor	PEF	1.24×10^9	1.24×10^9	m^3/kg	Florida default
Soil Ingestion Rate	IR_{soil}	50	50	mg/day	Assumption
Fraction Ingested	FI	100%	100%	unitless	Assumption based on 5 hr ET
Conversion Factor	CF	1×10^{-6}	1×10^{-6}	kg/mg	
Exposure Frequency	EF	100	100	days/year	Assumption
Exposure Duration	ED	10	20	years	Assumption
Exposure Time[1]	ET	5	5	hours/day	Assumption
Averaging Time	AT				
Cancer		70	70	years	[2]
Non-cancer		10	20	years	Assumption
Surface Area	SA	4540	5000	cm^2	[3]
Age-weighted Surface Area	$SA_{soil/adj}$	1136	1429	cm^2-year/kg	[3]
Inhalation Rate	IR_{air}	0.833	0.833	m^3/hr	[2]
Body Weight	BW	40	70	kg	[2,5]
Adherence Factor	AF	0.6	0.6	mg/cm^2-event	[3]
Absorption Fraction	ABS_d	Chemical-specific		unitless	[4]
Concentration in Air	CA	Chemical-specific		mg/m^3	
Volatilization Factor	VF	Chemical-specific		mg^3/kg	

References:

[1] Exposure Time is used only in the Inhalation of Particulate Scenario.

[2] USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Parameters.

[3] USEPA, 1992b. Dermal Exposure Assessment: Principles and Applications; EPA/600/8-91/011B.

[4] USEPA, 1995b. Supplemental Guidance to RAGS: Region IV Bulletins, Human Health Risk Assessment (Interim Guidance). Waste Management Division, Office of Health Assessment.

[5] USEPA, 1989b. Exposure Factors Handbook; EPA/600/8-89/043.

TABLE B-2

EXPOSURE PARAMETERS FOR SITE MAINTENANCE WORKER
OU2 McCOY ANNEX LANDFILL, NAVAL TRAINING CENTER, ORLANDO, FLORIDA

$$INTAKE_{ing} = \frac{CS \times IR_{soil} \times FI \times CF \times EF \times ED}{BW \times AT \times 365 \text{ days / year}}$$

$$INTAKE_{dermal} = \frac{CS \times AF \times ABS_{d} \times CF \times SA \times EF \times ED}{BW \times AT \times 365 \text{ days / year}}$$

$$INTAKE_{inh} = \frac{CA \times IR_{air} \times EF \times ED}{BW \times AT \times 365 \text{ days / year}}$$

$$CA = CS \times \left(\frac{1}{PEF} + \frac{1}{VF}\right)$$

Parameter	Symbol	Value	Units	Source
Concentration in Soil	CS	---------Chemical-specific---------		
Particulate Emission Factor	PEF	1.24×10^{9}	m^3/kg	Florida default
Soil Ingestion Rate	IR_{soil}	50	mg/day	[1]
Fraction Ingested	FI	100%	unitless	Assumption
Conversion Factor	CF	1×10^{-6}	kg/mg	
Exposure Frequency	EF	250	days/year	[1]
Exposure Duration	ED	25	years	[1]
Averaging Time	AT			
Cancer		70	years	[1]
Non-cancer		25	years	[1]
Surface Area	SA	2000	cm^2	[2]
Inhalation Rate	IR_{air}	20	m^3/day	[1]
Body Weight	BW	70	kg	[1]
Adherence Factor	AF	0.6	mg/cm^2-event	[2]
Absorption Fraction	ABS_d	Chemical-specific	unitless	[3]
Concentration in Air	CA	Chemical-specific	mg/m^3	
Volatilization Factor	VF	Chemical-specific	m^3/kg	

References:
[1] USEPA, 1991. Risk Assessment Guidance for Superfund (RAGS), Volume 1, Part B.
[2] USEPA, 1992b. Dermal Exposure Assessment: Principles and Applications; EPA/600/8-91/011B.
[3] USEPA, 1995b. Supplemental Guidance to RAGS: Region IV Bulletins, Human Health Risk Assessment (Interim Guidance). Waste Management Division, Office of Health Assessment.

TABLE B-3

EXPOSURE PARAMETERS FOR RESIDENT (ADULT AND CHILD)
OU2 McCOY ANNEX LANDFILL, NAVAL TRAINING CENTER, ORLANDO, FLORIDA

$$INTAKE_{ing} = \frac{CS \times IR_{soil} \times FI \times CF \times EF \times ED}{BW \times AT \times 365 \text{ days / year}}$$

$$INTAKE_{dermal} = \frac{CS \times AF \times ABS_d \times CF \times SA \times EF \times ED}{BW \times AT \times 365 \text{ days / year}}$$

$$INTAKE_{inh} = \frac{CA \times IR_{air} \times ET \times EF \times ED}{BW \times AT \times 365 \text{ days / year}}$$

$$CA = CS \times \left(\frac{1}{PEF} + \frac{1}{VF}\right)$$

Parameter	Symbol	Child (Age 0-6)	Adult	Units	Source
Concentration in Soil	CS	----------------Chemical-specific----------------			
Particulate Emission Factor	PEF	1.24×10^9	1.24×10^9	m^3/kg	Florida default
Soil Ingestion Rate	IR_{soil}	200	100	mg/day	Assumption
Fraction Ingested	FI	100%	100%	unitless	Assumption based on 5 hr ET
Conversion Factor	CF	1×10^{-6}	1×10^{-6}	kg/mg	
Exposure Frequency	EF	350	350	days/year	Assumption
Exposure Duration	ED	6	24	years	Assumption
Exposure Time[1]	ET	24	24	hours/day	Assumption
Averaging Time	AT				
Cancer		70	70	years	[2]
Non-cancer		6	24	years	Assumption
Surface Area	SA	1915	5750	cm^2	[3]
Inhalation Rate	IR_{air}	0.625	0.833	m^3/hr	[2]
Body Weight	BW	15	70	kg	[2,5]
Adherence Factor	AF	1	1	mg/cm^2-event	[3]
Absorption Fraction	ABS_d	Chemical-specific		unitless	[4]
Concentration in Air	CA	Chemical-specific		mg/m^3	
Volatilization Factor	VF	Chemical-specific		m^3/kg	

References:

[1] Exposure Time is used only in the Inhalation of Particulate Scenario.

[2] USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Parameters.

[3] USEPA, 1992b. Dermal Exposure Assessment: Principles and Applications; EPA/600/8-91/011B.

[4] USEPA, 1995b. Supplemental Guidance to RAGS: Region IV Bulletins, Human Health Risk Assessment (Interim Guidance). Waste Management Division, Office of Health Assessment.

[5] USEPA, 1989B. Exposure Factors Handbook; EPA/600/8-89/043.

APPENDIX C
RISK CALCULATION SHEETS

FUTURE RESIDENT	ELCR	Adult HI	Child HI
Incidental Soil Ingestion	6.17E-06	7.48E-03	6.96E-02
Dermal Contact with Soil	1.25E-06	5.66E-04	8.80E-04
Inhalation of Volatiles and Particulates from Soils	3.52E-09	1.19E-05	4.16E-05
Total	7.43E-06	8.05E-03	7.05E-02

Incidental Soil Ingestion

	(mg/kg)	AdultIR	Child IR	CF	FI	EF	Adult ED	Child ED	Adult BW	Child BW	Combined IF	AT carc	Sfo	Child AT noncarc	Adult AT noncarc	RFDo	ELCR	Adult HQ	Child HQ
ARSENIC	1.6	100	200	0.000001	1	350	24	6	70	15	114.29	25550	1.5	2190	8736	3.00E-04	3.76E-06	7.33E-03	6.82E-02
BARIUM	7.7	100	200	0.000001	1	350	24	6	70	15	114.29	25550	NA	2190	8736	7.00E-02	NA	1.51E-04	1.41E-03
BENZO(A)PYRENE (equivalent)	0.211	100	200	0.000001	1	350	24	6	70	15	114.29	25550	7.3	2190	8736	NA	2.42E-06	NA	NA
																Totals	**6.17E-06**	**7.48E-03**	**6.96E-02**

Dermal Contact with Soil

	(mg/kg)	CF	Adult SA	Child SA	AF	ABS	EF	Adult ED	Child ED	Adult BW	Child BW	ED*SA/BW	Atcarc	SFd	Adult AT	Child AT	RFDd	ELCR	Adult HQ	Child HQ
ARSENIC	1.6	1.00E-06	5.75E+03	1.92E+03	1.00E+00	0.001	3.50E+02	2.40E+01	6	7.00E+01	15	2737	25550	1.58	8760	2190	2.85E-04	9.48E-08	4.42E-04	6.87E-04
BARIUM	7.7	1.00E-06	5.75E+03	1.92E+03	1.00E+00	0.001	3.50E+02	2.40E+01	6	7.00E+01	15	2737	25550		8760	2190	4.90E-03	NA	1.24E-04	1.92E-04
BENZO(A)PYRENE (equivalent)	0.211	1.00E-06	5.75E+03	1.92E+03	1.00E+00	0.01	3.50E+02	2.40E+01	6	7.00E+01	15	2737	25550	14.6	8760	2190		1.16E-06	NA	NA
																	Totals	**1.25E-06**	**5.66E-04**	**8.80E-04**

Inhalation of Vapors and Particulates from Soil

	(mg/kg)	EF	Adult ED	Child ED	ET	VF	PF	1/VF+1/PF	Adult IR	Child IR	Adult BW	Child BW	Atcarc	Sfi	Adult AT	Child AT	RFDi	ELCR	Adult HQ	Child HQ
ARSENIC	1.6	350	24	6	24	N/A	1.24E+09	8.06E-10	0.833	0.625	70	15	25550	1.51E+01	8760	2190	NA	3.43E-09	NA	NA
BARIUM	7.7	350	24	6	24	N/A	1.24E+09	8.06E-10	0.833	0.625	70	15	25550	NA	8760	2190	1.43E-04	NA	1.19E-05	4.16E-05
BENZO(A)PYRENE (equivalent)	0.211	350	24	6	24	N/A	1.24E+09	8.06E-10	0.833	0.625	70	15	25550	3.10E+00	8760	2190	NA	9.31E-11	NA	NA
																	Totals	**3.52E-09**	**1.19E-05**	**4.16E-05**

Definition of all variables and equations are presented in Appendix B

CURRENT RECREATOR	ELCR	Adult HI	Adolescent HI
Incidental Soil Ingestion	4.13E-07	1.07E-03	1.86E-03
Dermal Contact with Soil	2.01E-07	8.44E-05	1.34E-04
Inhalation of Volatiles and Particulates from Soils	1.75E-10	7.08E-07	1.24E-06
Total	6.15E-07	1.15E-03	2.00E-03

Incidental Soil Ingestion

	EPC (mg/kg)	IR	CF	FI	EF	Adolescent ED	Adult ED	Adolescent BW	Adult BW	IF	AT carc	Sfo	Adolescent AT	Adult AT	RFDo	ELCR	Adult HQ	Adolescent HQ
ARSENIC	1.6	50	0.000001	1	100	10	20	40	70	26.78571429	25550	1.50E+00	3650	7300	3.00E-04	2.52E-07	1.04E-03	1.83E-03
BARIUM	7.7	50	0.000001	1	100	10	20	40	70	26.78571429	25550	NA	3650	7300	7.00E-02	NA	2.15E-05	3.77E-05
BENZO(A)PYRENE (equivalent)	0.211	50	0.000001	1	100	10	20	40	70	26.78571429	25550	7.30E+00	3650	7300	NA	1.62E-07	NA	NA
															Totals	**4.13E-07**	**1.07E-03**	**1.86E-03**

Dermal Contact with Soil

	EPC (mg/kg)	CF	Adult SA	Adolescent SA	AF	ABS	EF	Adult ED	Adolescent ED	Adult BW	Adolescent BW	ED*SA/BW (avg)	Atcarc	SFd	Adult AT noncarc	Adolescent AT noncarc	RFDd	ELCR	Adult HQ	Adolescent HQ
ARSENIC	1.6	1.00E-06	5.00E+03	4.54E+03	6.00E-01	0.001	1.00E+02	2.00E+01	10	70	40	2564.57	2.56E+04	1.58E+00	7300	3650	2.85E-04	1.52E-08	6.59E-05	1.05E-04
BARIUM	7.7	1.00E-06	5.00E+03	4.54E+03	6.00E-01	0.001	1.00E+02	2.00E+01	10	70	40	2564.57	2.56E+04		7300	3650	4.90E-03	NA	1.85E-05	2.93E-05
BENZO(A)PYRENE (equivalent)	0.211	1.00E-06	5.00E+03	4.54E+03	6.00E-01	0.01	1.00E+02	2.00E+01	10	70	40	2564.57	2.56E+04	1.46E+01	7300	3650		1.86E-07	NA	NA
																	Totals	**2.01E-07**	**8.44E-05**	**1.34E-04**

Inhalation of Vapors and Particulates from Soil

	EPC (mg/kg)	EF	Adult ED	Adolescent ED	ET	VF	PF	1/VF+1/PF	IR	Adult BW	Adolescent BW	Atcarc	Sfi	Adult AT noncarc	Adolescent AT noncarc	RFDi	ELCR	Adult HQ	Adolescent HQ
ARSENIC	1.6	100	20	10	5	N/A	1.24E+09	8.06452E-10	0.833333333	70	40	25550	1.51E+01	7300	3650	NA	1.70E-10	NA	NA
BARIUM	7.7	100	20	10	5	N/A	1.24E+09	8.06452E-10	0.833333333	70	40	25550	NA	7300	3650	1.43E-04	NA	7.08E-07	1.24E-06
BENZO(A)PYRENE (equivalent)	0.211	100	20	10	5	N/A	1.24E+09	8.06452E-10	0.833333333	70	40	25550	3.10E+00	7300	3650	NA	4.62E-12	NA	NA
															Totals	**1.75E-10**	**7.08E-07**	**1.24E-06**

Definition of all variables and equations are presented in Appendix B

SITE MAINTEANCE WORKER	ELCR	HI
Incidental Soil Ingestion	6.89E-07	2.66E-03
Dermal Contact with Soil	1.40E-07	8.44E-05
Inhalation of Volatiles and Particulates from Soils	1.40E-09	8.50E-06
Total	8.30E-07	2.76E-03

Incidental Soil Ingestion

	(mg/kg)	IR	CF	FI	EF	Adult ED	Adult BW	AT carc	Sfo	AT	RFDo	ELCR	Adult HQ
ARSENIC	1.6	50	0.000001	1	250	25	70	25550	1.50E+00	9125	3.00E-04	4.19E-07	2.61E-03
BARIUM	7.7	50	0.000001	1	250	25	70	25550	NA	9125	7.00E-02	NA	5.38E-05
BENZO(A)PYRENE (equivalent)	0.211	50	0.000001	1	250	25	70	25550	7.30E+00	9125	NA	2.70E-07	NA
											Totals	**6.89E-07**	**2.66E-03**

Dermal Contact with Soil

	(mg/kg)	CF	Adult SA	AF	ABS	EF	Adult ED	Adult BW	Atcarc	SFd	Adult AT	RFDo	ELCR	Adult HQ
ARSENIC	1.6	0.000001	2000	0.6	0.001	250	25	70	25550	1.58	9125	2.85E-04	1.06E-08	6.59E-05
BARIUM	7.7	0.000001	2000	0.6	0.001	250	25	70	25550		9125	4.90E-03	NA	1.85E-05
BENZO(A)PYRENE (equivalent)	0.211	0.000001	2000	0.6	0.01	250	25	70	25550	14.6	9125		1.29E-07	NA
												Totals	**1.40E-07**	**8.44E-05**

Inhalation of Vapors and Particulates from Soil

	(mg/kg)	EF	Adult ED	VF	PF	1/VF+1/P	IR	Adult BW	Atcarc	Sfi	Adult AT	RFDi	ELCR	Adult HQ
ARSENIC	1.6	250	25	N/A	1.24E+09	8.06E-10	20.000	70	25550	1.51E+01	9125	NA	1.36E-09	NA
BARIUM	7.7	250	25	N/A	1.24E+09	8.06E-10	20.000	70	25550	NA	9125	1.43E-04	NA	8.50E-06
BENZO(A)PYRENE (equivalent)	0.211	250	25	N/A	1.24E+09	8.06E-10	20.000	70	25550	3.10E+00	9125	NA	3.69E-11	NA
												Totals	**1.40E-09**	**8.50E-06**

Definition of all variables and equations are presented in Appendix B

APPENDIX D
HAND CALCULATIONS

CALCULATION WORKSHEET

CLIENT	JOB NUMBER		
NTC ORLANDO	7457		
SUBJECT			
GENERAL STATISTICS			
BASED ON	DRAWING NUMBER		
AROCLOR - 1254			
BY	CHECKED BY	APPROVED BY	DATE
M. SHOESMITH	Kelley S. Davis	[signature]	8-31-98

TOTAL AROCLOR 1254 DATA SET:

12.5 U, 12 U, 12 U, 30.5, 12 U, 12 U, 12 U, 12.5 U, 12 U ug/kg

MEAN (USING ½ DETECTION LIMIT FOR ALL NONDETECTS)

$$\text{MEAN} = (6.25 + 6 + 6 + 30.5 + 6 + 6 + 6 + 6.25 + 6)/9$$

$$= 8.77$$

95% UPPER CONFIDENCE LIMIT - LOGNORMAL DISTRIBUTION

$$UCL_{95} = \exp\left(\bar{y} + 0.5(S_y)^2 + \frac{S_y H_{.95,n}}{\sqrt{n-1}}\right) \checkmark$$

AROCLOR 1254 RESULT (x)	LOG-TRANSFORMED (y) = ln(x)	y^2
6.25	1.83	3.36
6	1.79	3.21
6	1.79	3.21
30.5	3.42	11.68
6	1.79	3.21
6	1.79	3.21
6	1.79	3.21
6.25	1.83	3.36
6	1.79	3.21
	$\sum y = 17.82$	$\sum y^2 = 37.66$

CLIENT NTC ORLANDO		JOB NUMBER 7457	
SUBJECT GENERAL STATISTICS			
BASED ON AROCLOR-1254		DRAWING NUMBER	
BY M SHOESMITH	CHECKED BY K. Davis	APPROVED BY	DATE 8-31-98

MEAN OF TRANSFORMED VALUES

$$\bar{y} = \frac{\Sigma y}{n} = \frac{17.82}{9} = 1.98$$

STANDARD DEVIATION OF TRANSFORMED VALUES

$$S_y = \sqrt{\frac{\sum y_i^2 - n\bar{y}^2}{n-1}} = \sqrt{\frac{37.66-(9)(1.98)^2}{9-1}} = .5450$$

FROM H VALUE TABLE DETERMINE $H_{.95,n}$ WHERE $n=9$ and $S_y=.5450$ (GILBERT 1987)

$H_{0.95,7}$ WITH $S_y = .5 = 2.465$ $\quad$ $H_{0.95,10}$ WITH $S_y = .5 = 2.220$

$H_{0.95,7}$ WITH $S_y = .6 = 2.673$ $\quad$ $H_{0.95,10}$ WITH $S_y = .6 = 2.368$

INTERPOLATE TO DETERMINE $H_{0.95,9}$ WITH $S_y = .5$

$$y - y_1 = \frac{y_2 - y_1}{x_2 - x_1}(x - x_1)$$

WHERE

$x_1 = 7$ $\quad x_2 = 10$ $\quad y_1 = 2.465$ $\quad y_2 = 2.220$

$$y - 2.465 = \frac{2.220 - 2.465}{10-7}(9-7)$$

$$y = 2.302$$

CALCULATION WORKSHEET

CLIENT: NTC ORLANDO			JOB NUMBER: 7457	
SUBJECT: GENERAL STATISTICS				
BASED ON: AROCLOR-1254			DRAWING NUMBER	
BY: M. SHOESMITH	CHECKED BY: K. Davis	APPROVED BY: [signature]	DATE: 8-31-98	REVISED DATE: 12-14-98

REVISED BY: M. SHOESMITH
CHECKED BY: R. A[illegible]

INTERPOLATE TO DETERMINE $H_{0.95,9}$ WITH $S_y = .6$

$$y - y_1 = \frac{y_2 - y_1}{x_2 - x_1}(x - x_1)$$

WHERE

$x_1 = 7 \quad x_2 = 10 \quad y_1 = 2.673 \quad y_2 = 2.368$

$$y - 2.673 = \frac{2.368 - 2.673}{10 - 7}(9 - 7)$$

$$y = 2.470$$

INTERPOLATE TO DETERMINE $H_{0.95,9}$ WITH $S_y = .5450 = x$

$$y - y_1 = \frac{y_2 - y_1}{x_2 - x_1}(x - x_1)$$

WHERE

$x_1 = .5 \quad x_2 = .6 \quad y_1 = \cancel{2.470}\ 2.302 \quad y_2 = \cancel{2.302}\ 2.470$ MAS RDA

$$y - \cancel{2.470}\ 2.302 = \frac{\cancel{2.302}\ 2.470 - \cancel{2.470}\ 2.302}{.6 - .5}(.5450 - .5)$$ MAS

$y = \cancel{2.394}\ 2.378 \therefore H_{0.95,9}$ WITH $S_y = .5450 = \cancel{2.394}\ 2.378$ MAS RDA

CALCULATION WORKSHEET

CLIENT NTC ORLANDO		JOB NUMBER 7457			
SUBJECT GENERAL STATISTICS					
BASED ON AROCLOR-1254		DRAWING NUMBER			
BY M. SHOESMITH	CHECKED BY K. Davis	APPROVED BY		DATE 8-31-98	REVISED DATE 12-14-98

REVISED BY M SHOESMITH

CHECKED BY R.A.

95% UCL

$$UCL_{95} = \exp\left(\bar{y} + 0.5 (S_y)^2 + \frac{S_y \, H_{.95,n}}{\sqrt{n-1}} \right)$$

$$UCL_{95} = \exp\left(1.98 + .5 (5450)^2 + \frac{.5450 \; \overset{2.378}{\cancel{2.394}}}{\sqrt{9-1}} \right)$$ MAS DOR

$UCL_{95} = 13.3$ (13.2 TABLE 2-3)

$13.3 \approx 13.2$ SMALL ERROR DUE TO ROUNDING

CALCULATION WORKSHEET

CLIENT	JOB NUMBER		
NTC ORLANDO	7457		
SUBJECT: EVALUATION OF SOIL INGESTION			
BASED ON: SITE MAINTENANCE WORKER AND ARSENIC	DRAWING NUMBER		
BY: M. SHOESMITH	CHECKED BY: K. Davis	APPROVED BY: JB	DATE: 9-24-98
REVISED DATE: 12-14-98	REVISED BY: M SHOESMITH	CHECKED BY: R.	

OBJECTIVE TO DETERMINE ELCR AND HQ FROM ARSENIC BY A SITE MAINTENANCE WORKER'S SOIL INGESTION.

$$INTAKE = \frac{CS \times IR_{SOIL} \times FI \times CF \times EF \times ED}{BW \times AT \times 365 \ ^{DAYS}/_{YEAR}}$$

ALL PARAMETERS ARE DEFINED IN APPENDIX B - TABLE B-2

WHERE:

$CS = 1.6 \ ^{mg}/_{kg}$

$IR_{SOIL} = 50 \ ^{mg}/_{DAY}$

$FI = 1$

$CF = 1 \times 10^{-6} \ ^{kg}/_{mg}$

$EF = 250 \ ^{DAYS}/_{YEAR}$

$ED = 15$ YEARS

$BW = 70$ kg

$AT =$ 70 YEARS FOR CARCINOGENS 15 (NONCARCINOGENS)

$$INTAKE_{CARC} = \frac{1.6 \ ^{mg}/_{kg} \times 50 \ ^{mg}/_{DAY} \times 1 \times 1 \times 10^{-6} \ ^{kg}/_{mg} \times 250 \ ^{DAYS}/_{YEAR} \times \cancel{15}\ 25 \ \text{YEAR}}{70 \ kg \times 70 \ \text{YEARS} \times 365 \ ^{DAYS}/_{YEAR}}$$ MAS

$$INTAKE_{CARC} = \cancel{1.677 \times 10^{-7}}\ 2.796 \times 10^{-7} \ \frac{mg}{kg\ DAY}$$ MAS

$$INTAKE_{NONCARC} = \cancel{1.677 \times 10^{-7}}\ 2.796 \times 10^{-7} \times \frac{70 \ \text{YEARS}}{\cancel{15}\ 25 \ \text{YEARS}} = 7.828 \times 10^{-7} \ \frac{mg}{kg\ DAY}$$ MAS

ELCR

$$ELCR = INTAKE_{CARC} \times SF$$

WHERE:

$$SF_{ARSENIC\ ING} = 1.5 \ \frac{kg\ DAY}{mg}$$

$$ELCR = \cancel{1.677 \times 10^{-7}}\ 2.796 \times 10^{-7} \ \frac{mg}{kg\ DAY} \times 1.5 \ \frac{kg\ DAY}{mg} = \cancel{2.50 \times 10^{-7}}\ 4.194 \times 10^{-7}$$ (AS SHOWN IN TABLE 6.1) MAS

CALCULATION WORKSHEET

CLIENT		JOB NUMBER	
NTC ORLANDO		7457	
SUBJECT			
EVALUATION OF SOIL INGESTION			
BASED ON		DRAWING NUMBER	
SITE MAINTENANCE WORKER AND ARSENIC			
BY	CHECKED BY	APPROVED BY	DATE
M. SHOESMITH	K. Davis	[signature]	9-1

HQ

$$HQ = INTAKE_{NONCARC} / RfD_{ARSENIC\ ING}$$

WHERE

$$RfD_{ARSENIC\ ING} = 3 \times 10^{-4}$$

$$HQ = 7.828 \times 10^{-7} \frac{mg}{kg\,DAY} / 3 \times 10^{-4} \frac{mg}{kg\,DAY} = 2.61 \times 10^{-3}$$ (AS SHOWN IN APPENDIX C)

CLIENT		JOB NUMBER		
NTC ORLANDO		7457		
SUBJECT				
EVALUATION OF INHALTION OF PARTICULATES				
BASED ON		DRAWING NUMBER		
SITE MAINTENANCE WORKER AND ARSENIC				
BY	CHECKED BY	APPROVED BY	DATE	REVISED DATE
M. SHOESMITH	K. Davis		9-24-98	12-14-98
				REVISED BY M. SHOESMITH
				CHECKED BY KD

OBJECTIVE TO DETERMINE ELCR AND HQ FROM ARSENIC FOR A SITE MAINTENANCE WORKER FROM INHALATION OF PARTICULATE AND VOLATILES.

$$INTAKE = \frac{CA \times IR_{air} \times EF \times ED}{BW \times AT \times 365 \ ^{DAYS}/_{YEAR}}$$

ALL PARAMETERS ARE DEFINED IN APPENDIX B TABLE B-2

$$CA = CS \times \left(\frac{1}{PEF} + \frac{1}{VF} \right)$$

WHERE:

$CS = 1.6 \ ^{mg}/_{kg}$

$PEF = 1.24 \times 10^{9} \ ^{m^3}/_{kg}$

VF = DOES NOT APPLY TO ARSENIC

$IR_{air} = 20 \ ^{m^3}/_{DAY}$

$EF = 250 \ ^{DAYS}/_{YEAR}$

$ED = 15$ YEARS

$BW = 70$ kg

$AT = 70$ YEARS (CARCINOGENS), 15 YEARS (NONCARCINOGENS)

$$CA = 1.6 \ ^{mg}/_{kg} \times \left(\frac{1}{1.24 \times 10^{9} \ ^{m^3}/_{kg}} \right) = 1.29 \times 10^{-9} \ ^{mg}/_{m^3} \checkmark$$

$$INTAKE_{CARC} = \frac{1.29 \times 10^{-9} \ ^{mg}/_{m^3} \times 20 \ ^{m^3}/_{DAY} \times 250 \ ^{DAYS}/_{YEAR} \times \cancel{15}\ 25 \ YEARS}{70 \ kg \times 70 \ YEARS \times 365 \ ^{DAYS}/_{YEAR}}$$ MAS

$$INTAKE_{CARC} = \cancel{5.410 \times 10^{-11}}\ 9.016 \times 10^{-11} \ \frac{mg}{kg \ DAY}$$ MAS RD

$$INTAKE_{NONCARC} = \cancel{5.410 \times 10^{-11}}\ 9.016 \times 10^{-11} \ \frac{mg}{kg \ DAY} \times \frac{70 \ YEARS}{\cancel{15}\ 25 \ YEARS} = 2.525 \times 10^{-10} \ \frac{mg}{kg \ DAY} \checkmark$$ MAS

CALCULATION WORKSHEET

CLIENT	JOB NUMBER
NTC ORLANDO	7457

SUBJECT
EVALUATION OF INHALATION OF PARTICULATES

BASED ON	DRAWING NUMBER
SITE MAINTENANCE WORKER AND ARSENIC	

BY	CHECKED BY	APPROVED BY	DATE	REVISED DATE
M. SHOESMITH	K. Davis		9-24-98	12-14-98

REVISED BY	CHECKED BY
M SHOESMITH	RAM

ELCR

$$ELCR = INTAKE_{CARC} \times SF_i = \cancel{5.410 \times 10^{-11}}\ 9.016 \times 10^{-11} \frac{mg}{kg\ DAY} \times 15.1 \frac{kg\ DAY}{mg} = \cancel{8.17 \times 10^{-10}}\ 1.36 \times 10^{-9}$$ MAS (AS SHOWN IN APPENDIX C)

HQ

NO RfD_i VALUE EXISTS FOR ARSENIC ∴ HQ = 0

CALCULATION WORKSHEET

CLIENT NTC ORLANDO		JOB NUMBER 7457	
SUBJECT EVALUATION OF DERMAL CONTACT WITH SOIL			
BASED ON RECREATIONAL USER AND BENZO(A) PYRENE		DRAWING NUMBER	
BY M. SHOESMITH	CHECKED BY K.S Davis	APPROVED BY	DATE 9-24-98

OBJECTIVE TO DETERMINE ELCR AND HQ FROM BENZO(A) PYRENE BY AN ADOLESCENT AND ADULT RECEPTORS' DERMAL CONTACT WITH SOIL.

$$INTAKE = \frac{CS \times AF \times ABSd \times CF \times SA \times EF \times ED}{BW \times AT \times 365 \ DAYS/YEAR}$$

ALL PARAMETERS ARE DEFINED IN APPENDIX B TABLE B-1

WHERE:

$CS = 0.2114 \ mg/kg$
$AF = 0.6 \ mg/cm^2$
$ABSd = 0.01$
$CF = 1 \times 10^{-6} \ kg/mg$
$SA =$ 4540 (ADOLESCENT), 5000 (ADULT) cm^2/DAY
$EF =$ 100 DAYS/YEAR
$ED =$ 10 (ADOLESCENT), 20 (ADULT) YEARS
$BW =$ 40 (ADOLESCENT), 70 (ADULT)
$AT =$ 70 (CARCINOGENS), 10 (NONCARINOGEN ADOLESCENT), 20 (NONCARCINOGEN ADULT)

$$INTAKE_{CARC\ ADULT} = \frac{.2114 \frac{mg}{kg} \times 0.6 \frac{mg}{cm^2} \times .01 \times 1\times10^{-6} \frac{kg}{mg} \times 5000 \frac{cm^2}{DAY} \times 100 \frac{DAYS}{YEAR} \times 20 \ YEARS}{70 \ kg \times 70 \ YEARS \times 365 \frac{DAYS}{YEAR}}$$

$$INTAKE_{CARC\ ADULT} = 7.092 \times 10^{-9} \frac{mg}{kg\ day}$$

$$INTAKE_{NONCARC\ ADULT} = 7.092 \times 10^{-9} \frac{mg}{kg\ day} \times \frac{70 \ YEAR}{20 \ YEAR} = 2.482 \times 10^{-8} \frac{mg}{kg\ day}$$

CALCULATION WORKSHEET

CLIENT: NTC ORLANDO		JOB NUMBER: 7457	
SUBJECT: EVALUATION OF DERMAL CONTACT WITH SOIL			
BASED ON: RECREATIONAL USER AND BENZO(A)PYRENE		DRAWING NUMBER:	
BY: M. SHOESMITH	CHECKED BY: K. Davis	APPROVED BY: [signature]	DATE: 9-1-98

$$INTAKE_{CARC\ ADOLESCENT} = \frac{.2114\ mg/kg \times 6\ mg/cm^2 \times .01 \times 1\times10^{-6}\ kg/mg \times 4540\ cm^2/DAY \times 100\ DAYS/YEAR \times 10\ YEARS}{40\ kg \times 70\ YEARS \times 365\ DAYS/YEAR}$$

$$INTAKE_{CARC\ ADOLESCENT} = 5.635 \times 10^{-9}\ \frac{mg}{kg\ day}$$

$$INTAKE_{NONCARC\ ADOLESCENT} = 3.944 \times 10^{-8}\ \frac{mg}{kg\ day}$$ ✓

ELCR

$$ELCR = (INTAKE_{CARC\ ADULT} + INTAKE_{CARC\ ADOLESCENT})\ SF_d$$

$$ELCR = \left(7.092 \times 10^{-9}\ \frac{mg}{kg\ day} + 5.635 \times 10^{-9}\ \frac{mg}{kg\ day}\right) 14.6\ \frac{kg\ day}{mg}$$

$ELCR = 1.86 \times 10^{-7}$ (AS SHOWN IN APPENDIX C) ✓

HQ

NO RfD VALUES EXIST FOR BENZO(A)PYRENE ∴ ALL $HQ_s = 0$