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DEFENSE LOGISTICS AGENCY

DSC Richmond

ADMINISTRATIVE RECORD COVER SHEET

AR File Number 847

FINAL

TECHNICAL MEMORANDUM
REVISED REMEDY SELECTION
FOR
OPERABLE UNIT 2 – AREA 50 LANDFILL

DEFENSE SUPPLY CENTER RICHMOND
RICHMOND, VIRGINIA

Prepared for:

Air Force Center for Environmental Excellence
3300 Sidney Brooks
Brooks City-Base, Texas 78235

Prepared by:

MACTEC Engineering and Consulting, Inc.
3200 Town Point Drive
Suite 100
Kennesaw, Georgia 30144

Contract No. F41624-03-D-8606
Task Order 81

28 July 2006
Revision 1

MACTEC

engineering and constructing a better tomorrow

28 July 2006

Project No. 6301-05-0016

Mr. Roy J. Shrove
HQ AFCEE/IWA – COR
3300 Sidney Brooks
Brooks City-Base, TX 78235-5112

Contract : **Contract No. F41624-03-D-8606 – TO 81**

Subject: **Technical Memorandum**
Revised Remedy Selection for Operable Unit 2 – Area 50 Landfill
Defense Supply Center Richmond (DSCR)

Dear Mr. Shrove:

MACTEC Engineering and Consulting, Inc., (MACTEC) is pleased to submit an electronic copy of the above-referenced document. The Technical Memorandum includes the OU 2 Human Health Baseline Risk Assessment and was prepared in continued support of the Defense Logistics Agency (DLA) at DSCR.

Additional copies of this document have been issued as shown in the attached distribution list. If you have any questions or need further information, please contact me at (770) 421-3458 or Steve Youngs at (770) 421-3377.

Sincerely,

MACTEC Engineering and Consulting, Inc.

Tammy H. Buchli
Senior Civil Engineer

Steven R. Youngs
Chief Scientist

BY

Enclosures

DISTRIBUTION LIST

FINAL
TECHNICAL MEMORANDUM
REVISED REMEDY SELECTION FOR OPERABLE UNIT 2 – AREA 50 LANDFILL

DEFENSE SUPPLY CENTER RICHMOND
RICHMOND, VIRGINIA

28 July 2006

Mr. Roy Shrove
HQ AFCEE/IWA – COR
3300 Sidney Brooks
Brooks City-Base, TX 78235-5112
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DOCUMENT RESPONSE TO COMMENT FORM	Date: 06 April 2006	Defense Supply Center Richmond Richmond, VA
To: Defense Supply Center Richmond (DSCR) Mr. Steven Edlavitch, Remedial Project Manager	From: Mr. John Fellinger, TechLaw	
Document Title & Location: **DRAFT TECHNICAL MEMORANDUM REVISED REMEDY SELECTION FOR OPERABLE UNIT 2 – AREA 50 LANDFILL DEFENSE SUPPLY CENTER RICHMOND; RICHMOND, VIRGINIA DATED DECEMBER 2005**	Contract No: F41624-03-D-8606 Delivery Order No.: 81	Response Status: DSCR Response – 16 June 2006

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Cmt. No.	Page No./ Section No.	ERP Team Member Comment:	MACTEC Response:	ERP Team Member – Review Action & Date
1	General	The Tech Memo states in the Executive summary and in Section 4.3 that the previous proposed use of the proposed remediated area (recreational, noted in the 2001 Technical Memorandum) was not appropriate since the proposed remediation area lies within the helicopter glide path. This is also noted as "recent information obtained" in the 2006 Tech Memo. Since the helicopter landing pad (and therefore the associated glide path) has not been relocated (to our knowledge) since 1971, please clarify why this is considered "recently obtained information." In addition, since land use controls (LUCs) are proposed as part of the new proposed alternative, please provide the procedures that will be utilized to ensure the proposed LUCs will be maintenance given this current situation/example of apparent non-communication between operators/users of the facility or stakeholders.	The proposed recreational use of the remediated area was based on information indicating that the helicopter landing pad would not be used in the future. The recently obtained information refers to information that the helicopter landing pad would remain available for use (though infrequently) thereby precluding recreational use of the remediated area.	
2	General	Recent correspondence provided by the facility has noted that data obtained prior to 1992 could not be validated in accordance with current protocols (e.g., the OU-11 FS Addendum, dated February 2006). The Tech Memo indicates that data collected between 1984 and 1998 were utilized in the human health baseline risk assessment (HHBRA). Please clarify if any of the data utilized in the HHBRA are subject to the same qualification(s).	Data collected prior to 1992 was used in the HHBRA. Use of data collected by Dames and Moore was required for this OU in order to achieve an effective delineation of soil constituent distributions across the OU.	

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3	General	The Tech Memo and associated HHBRA note that soil sampling was conducted and analyzed "selectively" for metals, volatile, and semivolatile compounds. The analytes list is not provided for the sampling conducted in the site groundwater. Since one of the remedial action objectives (RAOs) is to prevent or limit migration of contaminants to groundwater, please revise the Tech Memo to specifically list (or reference) the soil and groundwater analyses that were conducted as part of the 1984 to 1998 sampling events. In addition, please specifically indicate when/if perchlorates were included as analytes in soil and groundwater samples collected at the Area 50 Landfill.	A detailed listing of soil analytes is provided in Attachment A of the OU 2 HHBRA. Chemical classes include VOCs, SVOCs, inorganic compounds, pesticides, PCBs, and petroleum hydrocarbons. A detailed listing of groundwater analytes for OU 6 is provided in Appendix A of the OU 6 HHBRA. The potential risks associated with groundwater constituents will be addressed by OU 6. The potential for soil constituents to leach to groundwater is addressed in the OU 6 HHBRA. For ease of review, Table 1, attached, lists constituents analyzed from 1984 to 1998. Perchlorates have not been included as analytes for soil or groundwater. Perchlorate analysis will be added to the next biannual groundwater sampling event at OU 6.	
4	General	Figures 2-1 through 2-14 depict individual contaminant concentrations in the surface and sub-surface soils at OU-2. Please clarify which sampling event(s) were utilized in the generation of these figures. In addition, please identify the maximum historical detection for each constituent of concern.	The data in Figures 2-1 through 2-14 were from sampling events conducted during September and October 1984; May, June, and July 1985; October 1986; October 1988; October, November, and December 1994; and October 1998. The maximum historical detections for each constituent of concern are provided in Table 2, attached. The maximum detected constituent concentrations are also listed on Tables A-2-1 and A-2-2 of the OU 2 HHBRA.	

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5	General	The Tech Memo does not provide a reference or listing of assumptions utilized in the cost estimates presented in Appendix B. Please revise the Tech Memo to list references and assumptions utilized in the cost estimates provided.	The original source of the cost estimates in theTech Memo is the OU 2 FFS prepared in May 1999. The cost estimates presented in the Tech Memo were updated and revised using current information obtained from local contractors and RS Means Heavy Construction Cost Data for 2005. Appendix B will be amended to include the cost estimate calculation packages and supporting data.	
6 6 (cont)	RAOs RAOs	Section 1.5, RAOs, page 1-6: This section notes that the excavation, removal, and off-installation disposal of landfilled materials is neither feasible (given landfill area), practicable (given costs and unexploded ordnance [UXO] presence), and results in unacceptable levels of short-term risk to human health and the environment. Please provide additional details why the landfill area makes a removal action unfeasible and what the estimated costs are, that would make the removal action impractical. Since UXO removal actions are safely completed on a regular basis at other federal facilities located throughout the United States and abroad, at sites containing UXO and munitions of environmental concern (MEC) significantly more dangerous than the 40mm grenades and 90mm recoilless rifle rounds (e.g., munitions containing chemical warfare materials, 8-inch projectiles, etc.), the statement that attempting such an action is impractical cannot be supported at this time. Please remove this statement from	The Area 50 landfill was created in an uncontrolled manner from the late 1950s to the early 1970s. No records were kept of materials placed into the landfill or of the sequence and times of material placement. The heterogeneous nature of materials in the landfill was confirmed by thirty test trenches excavated at the landfill during October and November 1994. Seven trenches encountered shallow unexploded ordnance (UXO) at depths less than four feet and were stopped. Landfill material was encountered below groundwater in 13 of the 23 trenches that were not stopped due to UXO. The initial remedial action objectives (RAOs) for the Area 50 landfill were 1) to prevent human exposure to volatile emissions and fugitive dusts from impacted soils, 2) prevent constituent migration to groundwater, and 3) prevent exposure to ordnance and explosives hazards. Landfill materials have been in contact with groundwater since the early 1970s so that RAO 2 is unfeasible at this time. Constituents have been detected in the groundwater beneath the landfill since the early 1980s and have been detected through January 2006, but at much	

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Mr. Steven Edlavitch, Remedial Project Manager

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		the Tech Memo. In addition, this section indicates that constituent migration from material located above the water could be minimized by reducing infiltration. This statement is not supported by data such as vertical cross sectional figure(s) which depict the approximate landfill materials depth and the high and low seasonal water table levels. Please revise the Tech Memo to include these figures or to provide a reference to a previous report containing these figures.	lower concentrations. Some of the constituent mass has already adsorbed to the matrix of the upper water bearing unit (WBU) so that removal of landfill materials would not by itself achieve RAO 2. The impacted matrix of the upper WBU would have to be removed, which would be impractical due to the logistics of excavating below the water table. The order-of-magnitude cost estimate for removal and off-installation disposal of 54,000 cubic yards of landfill material was approximately $13,000,000. The estimate was based on a landfill area of approximately 5.5 acres and an average depth of six feet. The estimate included a nominal cost of $100,000 for dewatering during removal. The cost estimate calculations and supporting data will be added to Appendix B. The bottom of the upper WBU is approximately 20 feet below the bottom of landfill materials identified in soil borings and test trenches. If half of the upper WBU matrix had to be removed to achieve RAO 2, the estimated cost would more than double even without including dewatering and treatment to allow excavation below the water table. At such a cost it would be impractical to remove landfill material and impacted upper WBU matrix to achieve RAO 2. RAOs 1 and 3 would be achieved by the final remedy presented in the Draft Technical Memorandum (soil cover and land use controls). In addition to being feasible and practical, the final remedy is consistent with US Environmental Protection Agency (USEPA) presumptive	

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			remedy of containment for Comprehensive Environmental Reclamation, Compensation, and Liability Act municipal landfills (at *www.epa.gov/superfund/resources/presump/clms.htm*). The USEPA containment remedy includes preventing direct contact with landfill contents, minimizing infiltration, and controlling surface water runoff and erosion, all of which are included in the final remedy. The potential risks associated with groundwater constituents will be addressed by OU 6 and management of landfill gas is not needed due to the age of the Area 50 landfill and the nature of the wastes placed in it. The initial RAO 2 has been revised from "prevent" to "reduce" constituent migration to groundwater. The soil cover in the final remedy will be sloped to promote drainage of surface water runoff. Vertical cross sections depicting approximate depths of landfill material and the water table are presented in Figure 1-17 of the *Third Revised Final Focused Feasibility Study Report for Area 50 Landfill Source Area (Operable Unit 2)* (Law Engineering and Environmental Services, Inc., May 1999). Landfill materials are above the water table. A sloped soil cover would reduce surface water infiltration, reduce water movement through landfill materials above the water table, and thereby achieve revised RAO 2.	

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7	HHBRA	Appendix A, HHBRA: The references in the HHBRA list the April 2005 EPA risk based concentration (RBC) tables (page A-8-3), but tables A-2-1 and A-2-2 acknowledge the October 2005 RBC tables (most current). Please clarify which RBC table (April 2005 or October 2005) was utilized in the HHBRA. In addition, please note that the April 2006 RBC tables are expected to be published within the next 30 days.	The October 2005 RBC tables were used. The reference was not revised to reflect this. At the time these comments were received, the April 2006 tables have been issued. The table and text references will be revised to reflect the RBC tables used.	
8	HHBRA	Appendix A, HHBRA, Attachment B: The HHBRA provides a statistical comparison of detections to background values. Please provide references to the document(s) where these background values used are located.	The background data are presented in the Supplemental Feasibility Study Investigation Report, Volume 4 of 4, Appendix I, Revision 1, February 2006.	

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Table 1
Constituents Analyzed from 1984 to 1998

SOIL	
Volatile Organic Compounds	Diesel Fuel
2,4-Dinitrotoluene	Gasoline
Semivolatile Organic Compounds	Jet Fuel
Metals	Kerosene
Hexavalent Chromium	Mineral Oil
Pesticides	Paint Thinner
Total Petroleum Hydrocarbons	Naptha
Polychlorinated Biphenyls	Stoddard Solvent
GROUNDWATER	
Volatile Organic Compounds	Carbon Dioxide
2,4-Dinitrotoluene	Ethene & Ethane
Semivolatile Organic Compounds	Methane
Metals	Sulfate
Hexavalent Chromium	Nitrate & Nitrite
Pesticides	Chloride
Freon 112	Acidity
Cyanide	Alkalinity
Total Petroleum Hydrocarbons	Total Organic Carbon
Oil & Grease	Dissolved Organic Carbon

Perchlorates were not included as analytes for soil or groundwater samples.

Table 2

Maximum Historical Detections for Each Constituent of Concern

(Taken from sampling events conducted during September and October 1984; May, June, and July 1985; October 1986; October 1988; October, November, and December 1994; and October 1998)

FIGURE #	CONSTITUENT	MAXIMUM (mg/kg)
2-1	Arsenic	30
2-2	Benzo(a)anthracene	360
2-3	Banzo(a)pyrene	340
2-4	Benzo(b)fluoranthene	540
2-5	Benzo(k)fluoranthene	540
2-6	Dibenzo(ah)anthracene	72
2-7	Indeno(1,2,3-cd)pyrene	180
2-8	Aroclor 1260	47
2-9	Trichloroethene	53.4
2-10	Benzo(a)anthracene	360
2-11	Benzo(a)pyrene	340
2-12	Benzo(b)fluoranthene	540
2-13	Dibenzo(ah)anthracene	72
2-14	Indeno(1,2,3-cd)pyrene	180

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To: Defense Supply Center Richmond (DSCR) Mr. Steven Edlavitch, Remedial Project Manager	From: Ms. Nancy Rios-Jafolla USEPA	
Document Title & Location: **DRAFT TECHNICAL MEMORANDUM REVISED REMEDY SELECTION FOR OPERABLE UNIT 2 – AREA 50 LANDFILL DEFENSE SUPPLY CENTER RICHMOND; RICHMOND, VIRGINIA DATED DECEMBER 2005/FEBRUARY 2006**	Contract No: F41624-03-D-8606 Delivery Order No.: 81	Response Status: DSCR Response 15 June 2006

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1	General	The hydrogeologist may want to comment further on the proposed RAO for groundwater at this site.	Comment noted. Groundwater is not part of OU 2 and will be addressed under OU 6.	
2	General	Patricia Flores-Brown should review the particulate emissions and vapor intrusion models (see page A-3-2). Note that it is not clear whether the landfill gas model was previously reviewed by Patricia.	Comment noted. Materials placed in the Area 50 landfill were not putrescible, and therefore, landfill gas was not believed to be of concern. The modeling presented in the 2001 Draft Technical Memorandum confirmed that landfill gas is not an issue at the Area 50 landfill. Additional comments will be addressed, if received.	
3	General	Note that EPA Region 3 prefers that the upper slope factor for TCE be used in the baseline risk assessment.	As supplemental information in the risk characterization section of the HHBRA, risk associated with TCE has been calculated using the NCEA slope factor range. The overall conclusions remain unchanged.	

☐ Continued on Next Page ☒ End of Comments

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1	Section 1.5	Section 1.5 on page 1-6 lists the remedial action objectives (RAO) for the remedy. The RAOs focus almost entirely on the protection of human health. There is no RAO that discusses the protection of ecological receptors from exposure to surface soil. It is unclear if an ecological risk assessment was completed for surface soil. Section 4.3.2 discusses the protectiveness of Alternative 6A to ecological receptors. This section states that the placement of a soil cap addresses ecological risk. However, the section states that the soil cap will only be 6 inches deep around the edge of the cover. A soil cap of 6 inches around the edge is not sufficient to address the ecological risk as exposure can occur in soil deeper than 6 inches. BTAG recommends that the soil cap be at least 2 feet thick in areas of potential ecological risk to address this pathway of concern.	An ecological assessment was not completed for OU 2 because this area provides limited ecological habitat. OUs 1, 2 & 3 are in a developed and industrialized area of the installation and have been in industrial use for many years. OU 2 is fenced and completely grass-covered or paved. The grassed area is mowed on a routine basis and this maintenance will continued in the future. Therefore, the introduction of additional ecological species is unlikely to occur. A cap thickness of 6 inches is proposed around the perimeter of the Area 50 landfill. However, it should be noted, that the proposed cap thickness is in addition to the existing soil cap in-place. The Area 50 landfill currently has an 18-inch thick soil cap over the waste material. With the existing cap thickness, the final soil cap will be 2 feet thick at the edges of the landfill which is sufficient to address the concerns expressed in this comment.	

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2	Section 5.1.2	Section 5.1.2 on page 5-1 discusses the soil cover that is proposed for the landfill. The soil cover will be sloped at 3 to 5 percent to promote drainage of surface water runoff. Surface water runoff will be collected in ditches and conveyed from the OU. As stated in the 3-year Creek Monitoring Report, BTAG recommended better stormwater management on the base to prevent ongoing degradation of the stream channel and in-stream habitat. In addition to the soil erosion until the cap is fully vegetated, creating 13 additional acres of runoff will further degrade No-Name Creek. Therefore, BTAG recommends that a stormwater wetland/pond be constructed to collect surface water runoff and any eroded soil from the landfill cover for treatment prior to discharge to the storm sewer system and No-Name Creek.	It should be noted that additional runoff will not be created since drainage patterns will not be changed. The issue here seems to be related to the construction activities for installation of the cap system. The construction period will be limited in duration, and many methods of erosion and sediment control can be utilized to reduce the potential for sediment transport from the construction area. Further, sediment removed from stormwater runoff from the construction area will consist only of particulates from the clean soil fill to be utilized in the construction of the landfill cap. Note a vegetated, clean soil cap presently exists on the landfill area. Sediment can be controlled without the construction of a temporary pond. Soil stabilization through the use of straw or mulch and silt fencing within and around the landfill can be utilized to reduce or limit runoff until vegetation is established. These details will be addressed in the remedial design.	

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3	Section 5.2.4	Section 5.2.4 on page 5-3 states that the groundwater monitoring will be performed under OU6. If this contaminated groundwater is discharging to No-Name Creek, monitoring of surface water, sediment, and/or biota in No-Name Creek should be performed to assess ecological impacts. The type of sampling would be based on the fate and transport properties of the chemicals being released. The 3-year Creek Monitoring Report only addresses historical releases to the creek, and may not address current and future releases to the creek.	A sampling program for No-Name Creek is currently being developed. Surface water and sediments in No Name Creek can be sampled to further monitor the effectiveness of the completed remedy with this program designed to monitor constituents detected in OU 2 soil and OU 6 groundwater. The modified Alternative 6A will effectively protect the health of ecological receptors by eliminating future exposures. OU 2 has been identified as a soil operable unit. Groundwater issues, including the fate and transport properties of groundwater constituents discharging to No Name Creek, if any, will be addressed under OU 6.	

☐ Continued on Next Page ☒ End of Comments

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DOCUMENT RESPONSE TO COMMENT FORM	Date: 16 May 2006	Defense Supply Center Richmond Richmond, VA
To: Defense Supply Center Richmond (DSCR) Mr. Steven Edlavitch, Remedial Project Manager	From: Mr. William McKenty USEPA	
Document Title & Location: **DRAFT TECHNICAL MEMORANDUM REVISED REMEDY SELECTION FOR OPERABLE UNIT 2 – AREA 50 LANDFILL DEFENSE SUPPLY CENTER RICHMOND; RICHMOND, VIRGINIA DATED DECEMBER 2005/FEBRUARY 2006**	Contract No: F41624-03-D-8606 Delivery Order No.: 81	Response Status: DSCR Response – 21 June 2006

Type of Action: *(Check appropriate boxes)*

- ☒ Draft Document
- ☐ Pre-Final Document
- ☐ Final Document
- ☐ Other ________
- ☐ Chemistry
- ☒ Geology/Hydrogeology
- ☐ Safety & Health
- ☐ Engineering
- ☐ Risk Assessment
- ☐ Other ________

Cmt. No.	Page No./ Section No.	ERP Team Member Comment:	MACTEC Response:	ERP Team Member – Review Action & Date
1	General	An additional remedial alternative should be considered. Due to the documentation that the fill extends into the saturated zone within the footprint of the landfill, an evaluation should be made to consider dewatering the landfill. This would require pumping and effluent could be directed to either to a POTW or a treatment system, such as the one associated with the National Guard Area. The landfill will continue to impact groundwater otherwise on a continuing basis regardless of the effectiveness of the proposed cap.	The comment advocates consideration of a dewatering alternative for the Area 50 landfill noting that otherwise the landfill will continue to impact groundwater regardless of the effectiveness of the proposed cover. As stated in the OU 2 Technical Memorandum, the groundwater underlying the Area 50 landfill will be addressed in the OU 6 Focused Feasibility Study (FFS). The FFS will incorporate information from a treatability study to be conducted during the summer of 2006. The OU 2 remedial action objectives (RAOs) did not include prevention of Area 50 landfill constituent migration to groundwater, and remedial alternatives in the OU 2 Technical Memorandum did not include removal or hydraulic isolation of landfill materials, because groundwater impacted by the landfill does not pose a current risk to human health or the environment. The OU 2 RAOs are to: 1. Prevent human ingestion of, direct contact with, and inhalation of fugitive dusts from impacted soils (primarily for workers) 2. Reduce constituent migration to groundwater 3. Prevent exposure to ordnance and explosives (OE) hazards The RAOs will be achieved by the final remedy presented in the OU 2 Technical Memorandum (soil cover and land use controls).	

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To: Defense Supply Center Richmond (DSCR) Mr. Steven Edlavitch, Remedial Project Manager	From: Mr. William McKenty USEPA	
Document Title & Location: **DRAFT TECHNICAL MEMORANDUM REVISED REMEDY SELECTION FOR OPERABLE UNIT 2 – AREA 50 LANDFILL DEFENSE SUPPLY CENTER RICHMOND; RICHMOND, VIRGINIA DATED DECEMBER 2005/FEBRUARY 2006**	Contract No: F41624-03-D-8606 Delivery Order No.: 81	Response Status: DSCR Response – 21 June 2006

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Cmt. No.	Page No./ Section No.	ERP Team Member Comment:	MACTEC Response:	ERP Team Member – Review Action & Date
			It was noted in the OU 2 Technical Memorandum that materials disposed in the Area 50 landfill are already in contact with groundwater. The landfill area was originally a vegetated ravine lying roughly north-south through the center of OU 2. Prevention of landfill constituent migration to groundwater could not be achieved by any means other than complete excavation, removal, and off-site disposal of the land filled materials, actions that are neither feasible nor practical. The estimated dimensions of the landfill are approximately 230 feet by 1,050 feet, an area of 241,500 square feet (approximately 5.5 acres). If the average depth of landfill material in this area is approximately six feet, approximately 1,449,000 cubic feet, or approximately 54,000 cubic yards (CY), of landfill material would have to be removed. Hydraulic isolation of the landfill would require permanent pumping of groundwater which is neither feasible nor practical. The difficulty of long-term groundwater extraction from the upper water bearing unit (WBU) was demonstrated by the low operational efficiency of the OU 9 groundwater extraction system (1994 to Present). Some of the constituent mass has already adsorbed to the matrix of the upper WBU beneath the landfill so that removal or hydraulic isolation of landfill materials would not by itself eliminate landfill impacts. The impacted matrix of the upper WBU would have to be removed. Excavating to depths of just two to four feet into the upper WBU matrix	

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Cmt. No.	Page No./ Section No.	ERP Team Member Comment:	MACTEC Response:	ERP Team Member – Review Action & Date
			would results in an additional 18,000 to 36,000 CY of removed material. Doing this would be impractical due to the logistics of excavating below the water table. Upper WBU plumes beneath the Area 50 landfill and the National Guard Area (NGA) are separate. There have been no lower WBU plumes beneath the landfill. Plumes beneath the NGA extended east of the installation to No Name Creek while plumes resulting from impacts of the landfill have remained on the installation. Hydraulic isolation of landfill materials will do nothing to mitigate off-installation plumes. Groundwater impacted by the landfill is: 1) not moving past the installation boundary; 2) not creating potential risks to off-installation residential and recreational receptors; and 3) not discharging to No Name Creek and creating potential risks to ecological receptors. For these reasons the RAOs and remedial alternatives proposed for the Area 50 landfill are appropriate even without removal or hydraulic isolation of landfill materials.	

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LIST OF ACRONYMS

ADD	Average Daily Dose
ARAR	Applicable or Relevant and Appropriate Requirement
bgs	Below Ground Surface
COC	Chemical of Concern
COPC	Constituent of Potential Concern
CSM	Conceptual Site Model
DLA	Defense Logistics Agency
DSCR	Defense Supply Center Richmond
FFS	Focused Feasibility Study
HHBRA	Human Health Baseline Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
Law	Law Engineering and Environmental Services, Inc.
LUC	Land Use Control
LUCIP	Land Use Control Implementation Plan
MACTEC	MACTEC Engineering and Consulting, Inc.
mm	Millimeter
NGA	National Guard Area
NMOC	Non-methane Organic Compound
OE	Ordnance and Explosives
OSA	Open Storage Area
OU	Operable Unit
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PVC	Polyvinyl Chloride
RA	Remedial Action
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RfD	Reference Dose
ROD	Record of Decision

LIST OF ACRONYMS
(Continued)

RPO	Remedial Process Optimization
SF	Slope Factor
TBC	To-be-considered Criteria
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
UXO	Unexploded Ordnance
VC	Vinyl Chloride
VDEQ	Virginia Department of Environmental Quality
VOC	Volatile Organic Compound

EXECUTIVE SUMMARY

MACTEC Engineering and Consulting, Inc., (MACTEC) prepared this Technical Memorandum to supplement the *Third Revised Final Focused Feasibility Study, Area 50 Source Area – Operable Unit 2, Defense Supply Center – Richmond, Richmond, Virginia,* (FFS; Law Engineering and Environmental Services, Inc., [Law] 1999) for the Defense Supply Center Richmond (DSCR). This Technical Memorandum was prepared under Contract No. F41624-03-D-8606, Task Order 81, to the Air Force Center for Environmental Excellence. This report supersedes the *Final Technical Memorandum, Revised Remedy Selection for Operable Unit 2, Area 50 Landfill, Defense Supply Center Richmond, Richmond, Virginia* (2001 Final Technical Memorandum; Law, 2001).

Recent information obtained for Operable Unit (OU) 2 indicates that:

- Future use will remain industrial, not recreational.
- Ground surface will be limited to low-growing vegetation because OU 2 will continue to serve as a helicopter glide path, and the helicopter landing pad will remain available for use. Recreational use, considered in the 2001 Final Technical Memorandum (Law, 2001), assumed that the helicopter landing pad would not be used in the future.
- Storm sewer rehabilitation was recently completed by the U.S. Army Corps of Engineers under the DSCR Compliance Program.

Based upon the new information, review of the previously proposed remedy for OU 2 is warranted. Potential recreational use of OU 2 will no longer be considered. Rehabilitation of the storm sewer lines is no longer needed as a component of the selected remedy.

Groundwater will be addressed as part of OU 6, which underlies soil source areas OU 1 (Open Storage Area), OU 2, and OU 3 (National Guard Area).

The remedial action objectives (RAOs) for OU 2 as identified in the FFS (Law, 1999) are as follows:

1. Prevent human ingestion of, direct contact with, and inhalation of volatile emissions and fugitive dusts from impacted soils (primarily for workers).
2. Prevent constituent migration to groundwater.
3. Prevent exposure to ordnance and explosives (OE) hazards.

This Technical Memorandum provides information to support revising the wording for RAO 2 to "reduce constituent migration to groundwater." Information related to the reasons for recommending the revised wording is provided in the section detailing the RAOs.

The final remedy, modified Alternative 6A, recommended for implementation at OU 2 consists of the following components:

- A soil cover that provides a 3 to 5 percent grade to promote surface runoff and that has a minimum thickness of 6 inches
- Land use controls (LUCs), including "institutional controls and maintenance of existing access restrictions – fencing" (as previously identified in the 2001 Final Technical Memorandum [Law, 2001])

LUCs are included in the *Environmental Land Use Control Implementation Plan, Defense Supply Center Richmond, Richmond, Virginia* (LUCIP; MACTEC, 2005d). LUCs will be specified in the OU 2 Record of Decision, and an appendix to the LUCIP (MACTEC, 2005d) documenting the required LUCs specific to OU 2 will be prepared. LUCs include:

- Access Restrictions
- Intrusive Activity Restrictions and Signage
- Groundwater Restrictions
- Maintenance and Monitoring
- Property Transfer Restrictions

The following conclusions are supported by this Technical Memorandum:

- A review of trenching and historical water level elevations indicated that some landfill materials were disposed in the saturated zone and are exposed to groundwater.
- RAOs 1, 2, and 3 can be met with the installation of a landfill soil cover system designed and constructed to promote positive surface drainage and to minimize contact with soils and potential OE hazards.
- LUCs can be implemented as an added protective measure to comply with RAOs 1 and 3.

As a result, a soil cover of at least 6 inches to promote runoff is an appropriate alternative to the soil cap remedial option initially proposed in the FFS (Law, 1999).

1.0 INTRODUCTION

MACTEC Engineering and Consulting, Inc., (MACTEC) prepared this Technical Memorandum to supplement the *Third Revised Final Focused Feasibility Study, Area 50 Source Area – Operable Unit 2, Defense Supply Center – Richmond, Richmond, Virginia,* (FFS; Law Engineering and Environmental Services, Inc., [Law] 1999) for the Defense Supply Center Richmond (DSCR). This Technical Memorandum was prepared under Contract No. F41624-03-D-8606, Task Order 81, to the Air Force Center for Environmental Excellence. This report supersedes the *Final Technical Memorandum, Revised Remedy Selection for Operable Unit 2, Area 50 Landfill, Defense Supply Center Richmond, Richmond, Virginia* (2001 Final Technical Memorandum; Law, 2001).

The initial remedy selection for Operable Unit (OU) 2 presented in the FFS (Law, 1999) consisted of the following Remedial Actions (RAs):

- Capping the Area 50 landfill with a clay cover
- Storm sewer rehabilitation by slip lining or abandonment and relocation
- Institutional controls
- Source removal of soils saturated with free product

A revised remedy proposed in the 2001 Final Technical Memorandum (Law, 2001) consisted of the following RAs:

- Surface grading to promote drainage
- Storm sewer rehabilitation
- Institutional controls
- Groundwater monitoring requirements
- Maintaining access restrictions (fencing)

The 2001 Final Technical Memorandum (Law, 2001) also proposed a recreational land use.

This technical memorandum summarizes historical information and discusses additional information obtained by MACTEC following preparation of the 2001 Final Technical Memorandum (Law, 2001). The information presented herein provides the basis for a revised remedy and is based on the findings of the following documents, which are described in Section 2.0:

- *Draft Human Health Baseline Risk Assessment, Operable Unit 2, Defense Supply Center Richmond, Richmond, Virginia* (HHBRA; Appendix A)

- The Conceptual Site Model (CSM) for DSCR (under preparation)
- *Human Health Baseline Risk Assessment of the Creeks Adjacent to DSCR, Defense Supply Center Richmond, Richmond, Virginia* (Creeks HHBRA; MACTEC, 2005b)
- *Results of Three-year Creek Monitoring Program 2001–2004, Defense Supply Center Richmond, Richmond, Virginia* (MACTEC, 2005c)

1.1 PURPOSE

The purpose of this Technical Memorandum is to support the revised remedy selection. The remedy considered in the FFS (Law, 1999) included a cover system consisting of a 12-inch clay layer constructed to a permeability of 1×10^{-5} centimeters per second. Institutional controls and rehabilitation of the storm sewer were also included in the FFS (Law, 1999) proposed remedy. An alternative remedial strategy considered in the 2001 Final Technical Memorandum (Law, 2001) included a cover design modification to include fill material to promote positive surface drainage and allow recreational use. Institutional controls and storm sewer rehabilitation were also included in the remedy proposed in the 2001 Final Technical Memorandum (Law, 2001). In 2001, Remedial Process Optimization (RPO) was undertaken by the Defense Logistics Agency (DLA) at the installation. As a result of the RPO, DSCR shifted emphasis to other activities rather than implementation of the 2001 Proposed Remedy. These activities included revising the HHBRA Work Plan and the HHBRA (Appendix A). In the first quarter of 2005, stormwater system improvements were implemented at the installation. These improvements satisfy the storm sewer rehabilitation component of the previously proposed remedies. The revised remedy selection herein summarizes information published after the FFS (Law, 1999), including the HHBRA (Appendix A), the CSM, and U.S. Army Corps of Engineers (USACE) stormwater system improvements. An explanation of how the revised remedy meets the remedial action objectives (RAOs) is also provided.

1.2 LOCATION AND GEOLOGY

DSCR is located in Richmond, VA, as depicted in Figure 1-1. OU 2 is in the central region of the installation, between the Open Storage Area (OSA) and National Guard Area (NGA), as shown in Figure 1-2. OU 2 comprises approximately 13 acres. A ravine area, which was approximately 200 by 800 by 10 feet deep, consisted of wet soils, trees, shrubbery, and wild grasses, and was the area used for the Area 50 landfill. The approximate limits of the former Area 50 landfill are depicted in Figure 1-3.

The groundwater that underlies OU 2 is identified as "OU 6". The Area 50 landfill is suspected to be one of the contributing sources to the underlying groundwater.

Cross section A-A' (Figure 1-4) illustrates subsurface geologic conditions. The general stratigraphy is as follows:

- **Silty Sand, Sandy Silt, and Silty or Fat Clay.** The top of the unit is at the ground surface, and the bottom of the unit is approximately 13 to 26 feet below ground surface (bgs). The thickness of this unit is approximately 13 to 26 feet.
- **Poorly Graded Sand with Gravel, Interlayered with Poorly Graded Gravel.** The top of the unit is approximately 13 to 26 feet bgs, and the bottom of the unit is approximately 16 to 27 feet bgs. The thickness of this unit is approximately 0 to 7 feet. The unit is absent in the southern portion of cross section A-A'.
- **Silty and/or Fat Clay.** The top of the unit is approximately 16 to 27 feet bgs, and the bottom of the unit is approximately 26 to 37 feet bgs. The thickness of this unit is approximately 3 to 18 feet. This unit also is beneath the poorly graded sand with gravel unit, where that unit is present.
- **Poorly Graded Sand with Gravel and Silty Sand, Poorly Graded Sand with Gravel, and/or Poorly Graded Sand with Gravel Interlayered with Poorly Graded Gravel.** The top of this unit is approximately 26 to 37 feet bgs, and the bottom of the unit is approximately 46 to 72 feet bgs. The thickness of this unit is approximately 10 to 28 feet.

Beneath these sediments, from approximately 46 to 72 feet bgs, is saprolite weathered from the underlying granite bedrock. Bedrock was encountered in one boring at 101 feet bgs. The thickness of saprolite in this boring was 33 feet.

1.3 OPERABLE UNIT HISTORY

The Area 50 landfill was used for disposal of chemicals and construction debris from the late 1950s to the early 1970s. While the area was used as a landfill, material was placed in various parts of the original ravine, and previously used areas were regraded and revegetated. By 1975, the entire area had been graded and seeded (*Remedial Investigation – Area 50 Open Storage Area and National Guard Area for Defense General Supply Centers, Richmond, Virginia, Contract No. DACA65-86-C-0131* [Dames & Moore, 1989]).

An evaluation of aerial photographs taken from 1959 to 1982 indicated that from 1959 to 1969, a vegetated ravine lying roughly north to south dominated OU 2. The photographs indicated the following sequence of activities (*U.S. Army Corps of Engineers, Norfolk District, Phase I, Contamination Assessment, Defense General Supply Center, Richmond, Virginia, Contract No. DACA65-84-C-0071* [Dames & Moore, 1984]):

- **1959.** In the northeast quadrant, a disposal pile was observed next to an area of standing water. Older disposal areas with some vegetation were apparent along the west-central and southern parts of the ravine.
- **1965.** The northern end of the ravine was almost filled, and the disposal pile apparent in the 1959 photograph had been graded to street level and vegetated. The new area of activity appeared to be in the west-central portion.
- **1969.** The northern end was grassed and vegetated with large shrubs. The west-central portion appeared to be the area of disposal activity, having expanded to the east and south.
- **1971.** A helipad was constructed at the northern end, and a small parking area was constructed in the southeastern corner. The central portion appeared to be the area of disposal activity.
- **1972.** The central portion, south of the helipad, appeared to be the area of disposal activity.
- **1973.** The entire landfill appeared to be at street level, and the area of disposal activity in the central portion south of the helipad appeared to have been graded.
- **1975.** The entire landfill was grassed, and wet areas were apparent in the hummocky area south of the helipad.
- **1982.** The landfill appearance was similar to that in 1975, with the area hummocky and grass covered.

OU 2 is now generally level and covered with grass. A transformer storage area that contained polychlorinated biphenyl (PCB) transformers for an 18-month period ending in late 1983 was located in the southwestern corner. A helipad and parking area are now located near the northern boundary and southeastern corner, respectively (Dames & Moore, 1989). The locations of these features are depicted in Figure 1-3.

The materials that may have been disposed of include chemicals used in photographic development processes; organic solvents; pesticides and herbicides; acidic and alkaline chemicals; petroleum, oil, and lubricants; and PCBs (*Installation Assessment of Defense General Supply Center, Virginia* [U.S. Army

Toxic and Hazardous Materials Agency, 1981]). Boring logs advanced through OU 2 indicated wood, rubber, cinders, brick, concrete, wires, metal, and glass as deep as approximately 10 feet bgs. Such materials were encountered at most, but not all, boring locations (*U.S. Army Corps of Engineers, Norfolk District, Phase II (Final), Contamination Assessment, Defense General Supply Center, Richmond, Virginia, Contract No. DACA65-84-C-0071* [Dames & Moore, 1985]). Thirty test trenches were excavated during October and November 1994 (*Final Exploratory Trenching Report, Characterization Report for Area 50 Landfill, Defense Supply Center Richmond, Virginia* [Law, 1995]). Trench dimensions averaged 20 by 5 feet, with depths ranging from 2 to 13 feet bgs. Trenches were excavated until:

- The first occurrence of undisturbed soil
- Significant water flowed into the trench
- Unexploded ordnance (UXO) was encountered

Materials encountered in the test trenches included wood, coal ash and slag, crushed asphalt, concrete, automotive parts, scrap metal, and construction and demolition debris. Petroleum-stained soil was encountered in five trenches, free-phase fuel oil was encountered in two trenches, white powder was encountered in two trenches, and photographic chemicals were encountered in one trench. One trench had 55-gallon drums with unknown contents. UXO was encountered in seven trenches and included 40-millimeter (mm) grenades and 90-mm recoilless rifle rounds. Jet-assisted takeoff bottles were encountered in one trench.

Buried storm sewer lines transect OU 2 (Figure 1-5). USACE relined the storm sewer system in this area in January 2005. These storm sewers originate in the OSA and convey stormwater from OUs 1 and 2 to outfall 006A located along the NGA's northeastern boundary (Figure 1-6). This outfall discharges to No Name Creek, which flows south along the eastern NGA boundary. The creek ultimately discharges into the James River approximately 2 miles from the installation (Figure 1-2).

1.4 OVERVIEW OF OU 2

OU 2 is a soil source area associated with the former Area 50 landfill. Groundwater will be addressed as part of OU 6, which underlies soil source areas OU 1 (OSA), OU 2, and OU 3 (NGA).

An Interim RA for the OU 6 groundwater is underway and is designated as "OU 9". A Record of Decision (ROD) for OU 9 was issued in September 1993. An Explanation of Significant Differences was issued in 1995 to allow treated groundwater to discharge to Falling Creek. The OU 9 system was constructed and started in 1995 to treat groundwater downgradient of OUs 1, 2, and 3. The OU 9 system is scheduled for a one-year shutdown for evaluation of plume stability under non-pumping conditions.

1.5 RAOs

The RAOs for the initial preferred remedy are presented in the FFS (Law, 1999). The RAOs were developed based on the nature and extent of constituents and an OU-specific risk assessment. RAOs were identified as follows:

1. Prevent human ingestion of, direct contact with, and inhalation of volatile emissions and fugitive dusts from impacted soils (primarily for workers).
2. Prevent constituent migration to groundwater.
3. Prevent exposure to ordnance and explosives (OE) hazards.

Further review and investigation determined that portions of the materials placed in the landfill are below the water table. Because disposed materials are already in contact with groundwater, RAO 2 (as worded above) could be achieved only by excavation, removal, and off-installation disposal of the landfilled materials. Attempting such an action would result in an unacceptable level of short-term risk to human health and the environment. Further, removal was eliminated from consideration in the FFS (Law, 1999). Because the general response action of removal was previously screened from consideration, removal is not addressed in this document.

However, constituent migration from material above the water table to the groundwater could be minimized by reducing infiltration. Construction of a cover system to reduce infiltration through the landfill surface and diversion of stormwater runoff away from the landfill surface would reduce constituent migration. This scenario is feasible and practicable. For this reason, the suggested revised wording for RAO 2 is to "reduce constituent migration to groundwater." This wording is carried forward for evaluating compliance of the remedial alternatives with the RAOs:

1. Prevent human ingestion of, direct contact with, and inhalation of volatile emissions and fugitive dusts from impacted soils (primarily for workers).
2. Reduce constituent migration to groundwater.

3. Prevent exposure to OE hazards.

The initial RAO 2 has been revised from "prevent" to "reduce" constituent migration to groundwater. The soil cover in the final remedy will be sloped to promote drainage of surface water runoff. Vertical cross sections depicting approximate depths of landfill material and the water table are presented in Figure 1-17 of the FFS (Law, 1999). Portions of the landfill materials are above the water table. A sloped soil cover would reduce surface water infiltration, reduce water movement through landfill materials above the water table, and thereby achieve revised RAO 2.

The RAOs for OU 2 focus on the protection of human health. An ecological assessment was not completed for OU 2 because this area provides limited ecological habitat. OU 2 is in a developed and industrialized area of the installation and has been in industrial use for many years. OU 2 is fenced and completely grass-covered or paved. The grassed area is mowed on a routine basis, and this maintenance will continue in the future. Therefore, the introduction of additional ecological species is unlikely to occur.

2.0 SUMMARY OF NEW INFORMATION

Following the RPO performed by Parsons Engineering Science, Inc., in 2000 and 2001, MACTEC (formerly Law) was tasked with:

- **Revising the HHBRA to Include a Vapor Exposure Pathway for the Industrial Worker Scenario.** Future land use will remain industrial rather than residential as evaluated in the original HHBRA. The Revised HHBRA is provided in Appendix A.
- **Preparing a CSM.**
- **Performing Additional Investigative Work to Undertake the Previous Two Tasks.**

The following reports assess potential surface water impacts on human and ecological receptors:

- **Results of Three-year Creek Monitoring Program 2001-2004 (MACTEC, 2005c).** Impacts on No Name Creek downgradient of OU 2 are evaluated for ecological receptors.
- **Creeks HHBRA (MACTEC, 2005b).**

The following report provides data from the additional investigative work undertaken to assess previous data gaps:

- *Draft Supplemental Feasibility Study Investigation Report, Defense Supply Center Richmond, Richmond, Virginia* (MACTEC, 2005e).

2.1 CSM AND NATURE AND EXTENT OF SOIL CONSTITUENTS

In 2003, additional fieldwork was undertaken to prepare a refined CSM for DSCR. The purpose was to obtain additional information to fill data gaps. The most current data available for the soils at OU 2 are incorporated into the following description taken from the refined CSM.

Organic and inorganic constituents, including metals, PCBs, polycyclic aromatic hydrocarbons (PAHs), and volatile organic compounds (VOCs), were detected in soil and groundwater samples. Groundwater constituents associated with OU 2 will be addressed with OU 6.

Table 2-1 lists the chemicals of concern (COCs) in the surface and subsurface soils at OU 2. The distribution of COCs is depicted in Figures 2-1 through 2-14. The data in Figures 2-1 through 2-14 were from sampling events conducted during September and October 1984; May, June, and July 1985; October 1986; October 1988; October, November, and December 1994; and October 1998. Constituents analyzed from 1984 to 1998 are listed in Table 2-2. The maximum historical detections for each constituent of concern are provided in Table 2-3.

The maximum detected constituent concentrations are also listed in Tables A-2-1 and A-2-2 of the OU 2 HHBRA. Development of COCs is presented in Section 2.2.

2.2 REVISED OU 2 HHBRA

A revised HHBRA (Appendix A) was prepared to reflect exposure at the installation for the current and future industrial land use. This section summarizes the findings of the revised HHBRA (Appendix A).

The revised HHBRA (Appendix A) evaluated potential soil exposures for current and future outdoor industrial workers, future construction workers, and future indoor industrial workers. Risk associated with soil-to-groundwater leaching and groundwater contact will be addressed in a future revised OU 6 HHBRA.

Soil data collected from 1984 through 1998 were included in the risk assessment dataset. The surface soil dataset includes data collected from 0 to 2 feet in depth. The subsurface soil dataset includes data collected from 0 to 10 feet in depth.

All datasets utilized in the HHBRA were validated in accordance with validation standards at the time that they were collected. Data validation standards have changed since the Dames & Moore data were collected in 1984 to 1989. Use of the Dames & Moore data was required for OU 2 in order to achieve an effective delineation of soil constituent distributions across the OU. The difference in validation standards has been addressed under uncertainties in the HHBRA (Appendix A).

2.2.1 Exposure Pathways

Soil exposure pathways addressed in the revised HHBRA (Appendix A) included incidental ingestion, dermal absorption, and inhalation of fugitive dust and volatile emissions. These pathways were addressed for current and future outdoor industrial workers and future construction workers. Current workers were assumed to be exposed to surface soil only, while future workers were assumed to be exposed to surface and subsurface soils. It was assumed that future industrial workers will be exposed to a mix of surface and subsurface soils with no cover material because future activities (construction and grading) will mix these soils. One additional pathway, inhalation of volatile emissions in indoor air, was included to address potential risks for future indoor industrial workers.

2.2.2 Risk Characterization

2.2.2.1 Noncarcinogenic Effects

Noncarcinogenic toxicity was evaluated using reference doses (RfDs). The estimated average daily dose (ADD) developed during the exposure assessment and the RfD for each constituent of potential concern (COPC) were compared to characterize individual hazard quotients (HQs). The summation of HQs, or the cumulative hazard index (HI), for DSCR HHBRAs has been set at 1 (*Draft Revised Human Health Baseline Risk Assessment Work Plan, Defense Supply Center, Richmond, Virginia* [MACTEC, 2005a]).

Noncarcinogenic risk estimates were less than or equal to the DSCR risk goal of 1 for all four receptors:

- HIs for the current outdoor industrial worker were 0.3 (incidental soil ingestion) and 0.03 (dermal contact with soil). Surface soil COPCs had no documented impacts via the inhalation pathway.
- HIs for the future outdoor industrial worker were 0.3 (incidental soil ingestion), 0.2 (dermal contact with soil), 0.003 (inhalation of fugitive dusts), and 0.06 (inhalation of volatile compounds).
- HIs for the future construction worker were 1 (incidental soil ingestion), 0.3 (dermal contact with soil), and 0.06 (inhalation of volatile compounds).
- The HI for the future indoor industrial worker was 0.0001 (inhalation of VOCs from soil in indoor air).

2.2.2.2 Carcinogenic Effects

Carcinogenic toxicity was evaluated using cancer potency slope factors (SFs) or unit risk factors. To evaluate risks from exposure to potential carcinogens, the estimated lifetime ADD is multiplied by the SF to characterize potential carcinogenic effects. The results of the calculated risk estimates were expressed as upper-bound estimates of probability for the potential carcinogenic risk for each exposure point. The carcinogenic risk goal for DSCR HHBRAs has been established at 1×10^{-4} for on-installation receptors

(MACTEC, 2005a). If the cumulative excess cancer risk for an on-installation receptor exceeds 1×10^{-4}, those carcinogenic COPCs primarily responsible for the exceedance are identified as COCs:

- The total risk values for the current outdoor industrial worker were 9×10^{-4} (incidental ingestion of soil), 8×10^{-4} (dermal contact with soil), and 5×10^{-8} (inhalation of fugitive dusts). The cumulative risk for the current outdoor industrial worker was 2×10^{-3}.
- The total risk values for the future outdoor industrial worker were 2×10^{-4} (incidental ingestion of soil), 2×10^{-4} (dermal contact with soil), 2×10^{-8} (inhalation of fugitive dusts), and 5×10^{-5} (inhalation of volatile compounds). The cumulative risk for the future outdoor industrial worker was 4×10^{-4}.
- The total risk values for the future construction worker were 1×10^{-5} (incidental ingestion of soil), 5×10^{-6} (dermal contact with soil), 6×10^{-8} (inhalation of fugitive dusts), and 1×10^{-6} (inhalation of volatile compounds). The cumulative risk for the future construction worker was 2×10^{-5}.
- The total risk value for future indoor industrial workers potentially exposed to soil vapors in indoor air was 3×10^{-8}.

Excess cancer risk estimates for future construction workers and future indoor industrial workers were less than the DSCR risk goal of 1×10^{-4} for on-installation exposures. The estimated risk for the current and future outdoor industrial worker exceeded the DSCR risk goal.

2.2.3 COCs

Based on the results of the revised HHBRA (Appendix A), soil COCs were identified. Constituents with an associated cumulative cancer risk above 10^{-5} were selected as COCs. Tables 2-4 and 2-5, respectively, summarize the risks associated with each soil COC and each soil exposure pathway for the current and future outdoor industrial worker exposure scenarios. Eight constituents were selected as COCs in surface soil: arsenic, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, and PCB-1260. Six constituents were selected as COCs in subsurface soil: trichloroethene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene. Most soil impact was in the 0- to 1-foot interval. Most of the risk for the current and future outdoor industrial worker was associated with benzo(a)pyrene. The remainder of the excess cancer risk was associated with benzo(a)anthracene, benzo(b)fluoranthene, and dibenzo(a,h)anthracene. Risk-based remediation goals for COCs in surface and subsurface soils are presented in Table 2-6.

2.3 THREE-YEAR CREEK MONITORING PROGRAM

Monitoring programs for No Name Creek adjacent to the installation and areas downgradient of OU 2 were conducted from November 2001 to April 2004. The results of the monitoring program were described in *Results of Three-year Creek Monitoring Program 2001-2004* (MACTEC, 2005c).

The overall purpose of the monitoring program was to evaluate whether conditions at the installation were affecting ecological receptors in the creeks. The abundance of aquatic organisms and changes in environmental conditions over the monitoring period were evaluated. During each monitoring event, co-located surface water, sediment, and benthic macroinvertebrate samples were collected for analysis; selected physical/chemical parameters were measured *in situ*; and creek habitat assessments were performed.

Creek monitoring determined that there were no adverse ecological effects associated with the installation in No Name Creek, and that the benthic community was representative of the available habitat. Constituent concentrations in No Name Creek are not expected to pose an unacceptable risk to potential ecological receptors.

2.4 HHBRA OF THE CREEKS ADJACENT TO DSCR

A conservative HHBRA was performed for chemicals detected in No Name Creek surface water. The results were documented in the Creeks HHBRA (MACTEC, 2005b). The purpose of the HHBRA was to determine whether potential impacts related to historical installation activities detected in creek surface waters posed an unacceptable health hazard. The potential exposure scenario addressed in the HHBRA was based on current conditions for recreational child and adult receptors.

Of the 35 detected chemicals, 10 (aluminum, arsenic, iron, lead, manganese, thallium, vanadium, vinyl chloride [VC], styrene, and chrysene) were selected as COPCs. A risk assessment was conducted for the 10 COPCs for No Name Creek. The results showed that the concentrations of these 10 COPCs were less than an HI of 1 (HI of 0.2). The total excess cancer risk was 1×10^{-5}, which is within the U.S. Environmental Protection Agency (USEPA) acceptable range of 10^{-4} to 10^{-6}. The carcinogenic risk was associated with arsenic and VC, which were infrequently detected in surface water samples. The risk estimates were conservative and potentially overstated the actual risk. A no-further-action recommendation was made because installation-related activities were protective of human health in No

Name Creek. The potential for continuing discharges of impacted groundwater to No Name Creek will be further considered in the OU 6 HHBRA.

2.5 COMPLETED STORM SEWER REHABILITATION

The FFS (Law, 1999) presented alternatives for storm sewer rehabilitation. Storm sewer rehabilitation was included in the recommendation for final alternative selection, and the storm sewer lining (fold and form method) and storm sewer abandonment and relocation were retained as potential methods. The 2001 Final Technical Memorandum (Law, 2001) also included storm sewer rehabilitation as a component of the proposed revised remedy.

2.5.1 Storm Sewer Lining

During the last quarter of 2004 and the first quarter of 2005, USACE undertook storm sewer rehabilitation as part of the DSCR Compliance Program. The utilized method was the fold and form method described in the FFS (Law, 1999) and referenced in the 2001 Final Technical Memorandum (Law, 2001). Figure 2-15 depicts the storm sewer lines rehabilitated in the OU 2 vicinity.

The pipe lining was delivered to the installation as a flexible, folded polyvinyl chloride (PVC) alloy material. The folded material was lowered via a manhole into each pipe section. The material was pulled through the pipe, and the ends were plugged. The material was pressurized, and steam heat was used for in-place curing. Following curing, the ends and service laterals were reopened using a remote-controlled cutting device and video camera. The storm sewer was permanently sealed with a jointless, smooth liner that was formed tightly against the host pipe. Table 2-7 lists the storm sewer lines that were rehabilitated in the OU 2 vicinity using the PVC fold and form method.

2.5.2 Manhole Sealing

The existing brick manholes were sealed to reduce infiltration. A cement/epoxy spray sealer was applied to seal existing cracks in the manhole and form a watertight coating on the interior. At many manholes, new frames and covers and new concrete collars were installed to further reduce infiltration. Table 2-8 lists the manhole improvements.

3.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

DSCR Planning Team discussions regarding the preferred remedy were conducted during 2000. In general, these discussions focused on OU closure regulations. Comments from the Virginia Department of Environmental Quality (VDEQ) in 2000 cited Resource Conservation and Recovery Act (RCRA) regulations. In addition, VDEQ commented that Virginia Solid Waste Management regulations should also serve as applicable or relevant and appropriate requirements (ARARs) for closure. USEPA indicated that a "hybrid" closure is acceptable under the Comprehensive Environmental Response, Compensation, and Liability Act and that RCRA regulations may not be applicable but may be considered relevant and appropriate.

Table 3-1 lists the ARARs and to-be-considered criteria (TBCs) for the OU 2 soils. TBCs are criteria that can be used to help develop risk-based cleanup objectives in the absence of chemical-specific ARARs. Additional discussion of several ARARs is provided below.

3.1 FEDERAL

Based on the Federal Facilities Agreement for DSCR between DLA, USEPA, and the Commonwealth of Virginia, RCRA shall be considered an ARAR. RCRA is a relevant and appropriate requirement. Disposal activities occurred in the 1960s and 1970s, before promulgation of RCRA. Consequently, the intent of the RCRA regulations will be met.

3.2 STATE

The Virginia Solid Waste Management regulations are also relevant and appropriate requirements. Disposal activities occurred in the 1960s and 1970s, before promulgation of the solid waste management regulations. Furthermore, the regulations were intended to apply to municipal solid waste facilities. The intent of the regulations will be met.

In addition to the Virginia Solid Waste Management regulations, the Virginia Hazardous Waste regulations are relevant and appropriate, and the intent of the regulations will be met.

4.0 DESIGN ANALYSIS SUMMARY

This section discusses the initial remedy selection and changes in the preferred remedy presented in the 2001 Final Technical Memorandum (Law, 2001) based on new information.

4.1 INITIAL REMEDY SELECTION – 1999 FOCUSED FEASIBILITY STUDY

The RAOs, alternatives evaluation, and preferred remedy were presented in the FFS (Law, 1999). The RAOs were developed based on the nature and extent of constituents and the risk assessment for a residential scenario. The RAOs were to prevent human ingestion of, direct contact with, and inhalation of fugitive dusts from impacted soils; prevent constituent migration to groundwater; and prevent exposure to OE hazards.

The primary remedial objective in the FFS (Law, 1999) was preventing exposure to impacted soils and OE to protect human health and the environment. An additional goal was the mitigation of potential groundwater impacts or reduction of soil constituents leaching to groundwater. Therefore, remediation focuses on constituents that exceeded acceptable risk levels. Remediation would include UXO technicians at the OU during any intrusive activities and proper disposal of live OE. Areas within OU 2 that exceeded the soil remedial goals for COCs are depicted in Figures 2-1 through 2-14. Additional information related to data used in development of these figures is provided in Sections 2.1 and 2.2.

Alternatives were screened for effectiveness, implementability, and cost. The following alternatives were retained for detailed analysis:

Alternative 1: No-action alternative

Alternative 2: Institutional controls

Alternative 6A: Capping (soil cover) with storm sewer rehabilitation, institutional controls/land use controls (LUCs), and source removal of free product and saturated soils

Alternative 6B: Capping (clay cover) with storm sewer rehabilitation, institutional controls/LUCs, and source removal of free product and saturated soils

The following storm sewer rehabilitation alternatives were retained for further evaluation as a component of the capping alternatives (6A and 6B):

Alternative 4A: Storm sewer fold and form lining
Alternative 4B: Storm sewer slip lining
Alternative 5: Storm sewer abandonment and relocation

During the detailed analysis, these alternatives were evaluated further in accordance with the following criteria:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, and volume through treatment
- Short-term effectiveness during construction and implementation
- Implementability (technical and administrative)
- Cost

A comparative analysis was performed for each alternative based on these criteria. Comments received from the Commonwealth of Virginia indicated preference for a clay cap. Alternative 6B was preferred with capping (clay cover), storm sewer rehabilitation, source removal of free product and free-product-saturated soils, implementation of selected institutional controls/LUCs, and long-term groundwater monitoring.

The storm sewers at the Area 50 landfill would be lined or plugged and abandoned in place to prevent infiltration and migration of groundwater. Seepage collars would be installed to mitigate groundwater traveling beneath or around the pipes through gravel or other porous bedding material. The land surface would be regraded to direct runoff to newly installed catch basins. New eastern and western storm sewers would be constructed outside the landfilled area. The estimated cost for the relocated storm sewers would be approximately the same as that for feasible sewer lining technologies. The relocation of the storm sewers was therefore recommended for implementation.

4.2 2001 PROPOSED REVISED REMEDY

As described above, Alternative 6B was selected for implementation based on the FFS (Law, 1999). In 2000, discussions regarding the selected remedy were still ongoing. During the RA planning meeting conducted at DSCR on 9 and 10 August 2000, a revised remedy was proposed and included:

1. Institutional controls
2. Surface grading to promote drainage (potential fill)
3. Monitoring requirements to evaluate constituent migration

4. Storm sewer rehabilitation
5. Maintenance of access restrictions (fencing)

This revised remedy was presented in the 2001 Final Technical Memorandum (Law, 2001). The most significant changes included re-evaluation of the free product/saturated soil removal action and elimination of the clay cap. The rationale for these changes is discussed below.

4.2.1 Re-evaluation of Removal Action in the 2001 Proposed Revised Remedy

The removal action was re-evaluated because the risk associated with exposure to OE would be significant with any intrusive activity. This risk made any removal action unfavorable.

4.2.2 Re-evaluation of the Clay Cap in the 2001 Proposed Revised Remedy

The clay cap was re-evaluated based on the following rationale:

- The VDEQ representative indicated that a cap might not be necessary if data from the OU 6 groundwater sampling did not indicate that the Area 50 landfill was a continuing source.
- The RAOs would be met if the remedial alternative was changed to include storm sewer rehabilitation, surface grading, and institutional controls/LUCs. Long-term groundwater monitoring would be required to evaluate the RA's effectiveness.
- Surface grading would include placing a soil cover sloped to drain precipitation off the cover and to reduce infiltration to the landfilled area.

4.3 PROPOSED FINAL REMEDY – MODIFIED ALTERNATIVE 6A

This section summarizes the findings on which the modified Alternative 6A recommendation is based.

Based on the results of the revised HHBRA (Appendix A), CSM, and storm sewer rehabilitation efforts completed to date, a modification to Alternative 6A defined in the FFS (Law, 1999) is recommended for implementation. The modified Alternative 6A is defined with the following components:

- A soil cover that provides a 3 to 5 percent grade to promote surface runoff and that has a minimum thickness of 6 inches
- Institutional controls in the form of LUCs, including maintenance of access restrictions (fencing)

The modified Alternative 6A will meet the RAOs in the following ways:

- RAOs 1, 2, and 3 can be met with the application of soil cover over the landfill. The cover will be designed and constructed to promote positive surface drainage and minimize contact with soils and potential OE hazards.

- LUCs can be implemented as an added protective measure to comply with RAOs 1 and 3. LUCs are discussed in Section 5.1.1.

Recent information obtained for OU 2 indicates that:

- Future use will remain industrial, not recreational.

- Ground surface will be limited to low-growing vegetation because OU 2 will continue to serve as a helicopter glide path, and the helicopter landing pad will remain available for use. Recreational use, considered in the 2001 Final Technical Memorandum (Law, 2001), assumed that the helicopter landing pad would not be used in the future.

- Storm sewer rehabilitation was recently completed by USACE under the DSCR Compliance Program.

Groundwater issues underlying OU 2 will be addressed as part of OU 6.

The results of the revised HHBRA (Appendix A) and CSM indicates that:

- OU 2 is not a continuing source of groundwater impacts at concentrations observed in 1986.

- The groundwater COPCs consisted mainly of chlorinated VOCs and metals. Groundwater COPCs did not include PAHs associated with the petroleum products observed in the test pits in 1995.

- There were no unacceptable noncarcinogenic risks that exceeded the DSCR remediation goal of 1 for the current or future outdoor industrial worker, future construction worker, and future indoor industrial worker.

- There were cumulative excess cancer risks that exceeded the DSCR risk goal of 1×10^{-4} for exposure to soils for current and future outdoor industrial workers.

- There were no cumulative excess cancer risks that exceeded the DSCR risk goal of 1×10^{-4} for future construction workers.

A soil cover and LUCs will eliminate the exposure pathway, alleviating the cumulative excess cancer risks to meet DSCR's risk goal.

4.3.1 Protectiveness of Modified Alternative 6A – Human Health

The modified Alternative 6A includes regrading to support positive surface drainage by placement of a clean soil cover over the surface area, and long-term LUCs to protect on-installation workers if intrusive subsurface activities (i.e., construction or maintenance of utilities) should be required. Future use will remain industrial. As a result, a previous concern that the OU might be used for recreational purposes is removed (*Comments on Final Technical Memorandum, Revised Remedy Selection for Operable Unit 2* [USEPA, 2002]). The clean soil layer will be grass covered. OU 2 is in the direct flight path for the heliport; therefore, the surface will remain a grassed field. This soil layer and grass cover will be maintained to prevent direct soil contact or the generation of fugitive dust. Intrusive activities that would penetrate the clean soil layer will be strictly controlled by LUCs. Workers in the area will be required to follow protective health and safety protocols to limit exposures and potential contact with UXO in the landfill. Therefore, the modified Alternative 6A will effectively protect human health.

4.3.2 Protectiveness of Modified Alternative 6A – Ecological Risk

Comments on the previous Final Technical Memorandum (USEPA, 2002) expressed concern that potential risks for ecological receptors were not addressed by surface grading; therefore, a soil cap should be placed on the OU's surface. The modified Alternative 6A addresses this concern through the placement of a clean soil layer that will be at least 6 inches deep around the edge of the cover and may be significantly deeper in the central portion of the OU. However, it should be noted that the minimum 6 inch thickness is being placed over the existing surface, which includes approximately 18 inches of soil currently over the waste material. The top of the soil layer will be seeded with grass. These measures will minimize contact with and erosion of impacted soils.

As discussed previously in Section 1.5, as ecological assessment was not completed for OU 2 because this area provides limited ecological habitat. OU 2 is in a developed and industrialized area of the installation and has been in industrial use for many years. OU 2 is fenced and completely grass-covered or paved. The grassed area is mowed on a routine basis, and this maintenance will continue in the future. Therefore, the introduction of additional ecological species is unlikely to occur.

An additional concern raised by USEPA's Biological Technical Assistance Group on the previous Final Technical Memorandum (USEPA, 2002) was the potential for soil washing into the storm sewers and subsequent discharge of storm sewer sediments to No Name Creek. There was also some concern that impacted groundwater in the upper water bearing unit would preferentially flow through cracks in the storm sewers and be transported to No Name Creek. During 2005, the storm sewer system was flushed and lined. Thus, any impacted sediment materials in the storm sewers were removed and additional inflow of groundwater was precluded. After the landfill is regraded and the grass-covered clean soil cover is in place, additional runoff of impacted soils to the storm sewers will not occur. The modified Alternative 6A will effectively protect the health of ecological receptors by eliminating future exposures.

4.3.3 Comparative Analysis of Remedial Alternatives

With the identification of the modified Alternative 6A, the remedial alternatives retained from the FFS (Law, 1999) were re-evaluated. Table 4-1 provides a comparative analysis of the retained remedial alternatives and the modified Alternative 6A in accordance with the following criteria:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, and volume through treatment
- Short-term effectiveness during construction and implementation
- Implementability (technical and administrative)
- Cost
- State acceptance
- Community acceptance

Appendix B provides the cost estimates for each remedial alternative. The original source of the cost estimates is the OU 2 FFS prepared in May 1999. The cost estimates from the OU 2 FFS were updated and revised using current information obtained from local contractors and RS Means Heavy Construction Cost Data for 2005. The original cost estimates from the OU 2 FFS, the revised cost estimates prepared for this Technical Memorandum, and supporting information used to revise the cost estimates are provided in Appendix B.

The results of the comparative analysis indicated that the modified Alternative 6A is equally acceptable to each of the retained Alternatives 6A and 6B from the FFS (Law, 1999) using the criteria identified above. The modified Alternative 6A also has a lower cost than the retained Alternatives 6A and 6B.

5.0 FINAL REMEDY

The final remedy, modified Alternative 6A, recommended for implementation consists of the following components:

- A soil cover that provides a 3 to 5 percent grade to promote surface runoff and that has a minimum thickness of 6 inches (Sections 5.1.2 and 5.2)
- LUCs including "institutional controls and maintenance of access restrictions – fencing" (as previously identified in the 2001 Final Technical Memorandum [Law, 2001])

5.1 FINAL REMEDY COMPONENTS

5.1.1 LUCs

LUCs are any restriction or administrative action, including engineering and institutional controls, that prevent or limit human exposure to constituents by restricting resource (land and/or groundwater) use. Modified Alternative 6A would include LUCs to limit exposure to soil impacted with COCs. The specific requirements of the LUCs would be outlined in the Land Use Control Implementation Plan that would be prepared after approval of the ROD. The LUCs for OU 2 may include:

- Access Restrictions
- Intrusive Activity Restrictions and Signage
- Groundwater Restrictions
- Maintenance and Monitoring
- Property Transfer Restrictions

5.1.2 Soil Cover

A soil layer with a minimum thickness of 6 inches will be placed over the landfill. The soil cover will be sloped at 3 to 5 percent to promote drainage of surface water runoff. Sufficient soil fill will be placed near the center of the landfill to create a high point to promote drainage to the perimeter. Surface water run-on/runoff will be collected in ditches and conveyed from the OU. Because the minimum thickness of the soil cover will be 6 inches around the perimeter of the OU and the cover will be sloped at 3 to 5 percent from the high point near the center of the landfill, the maximum cover thickness near the center of the landfill is anticipated to be approximately 5 to 8 feet.

Additional soil cover design considerations are discussed below.

5.2 SOIL COVER DESIGN CONSIDERATIONS

5.2.1 Landfill Gas

The potential for landfill gas was addressed in the 2001 Final Technical Memorandum (Law, 2001). Because of the age of the Area 50 landfill and the nature of the wastes placed in it, engineering controls associated with landfill gas management will not be necessary. To confirm that landfill gas will not require engineering controls, the Area 50 landfill was modeled using USEPA's Landfill Air Emissions Estimation Model during preparation of the 2001 Final Technical Memorandum (Law, 2001).

Typically, gas generation is a product of the anaerobic decomposition of organic materials placed in a landfill. The composition of landfill gas is typically 50 percent methane, 40 percent carbon dioxide, and 10 percent other gases including nitrogen. As previously described, the materials identified during the Remedial Investigation phase included construction and demolition debris (concrete, asphalt, bricks, and metal) and metal-reinforced steel bar. Spent OE was encountered along with scrap metal (particularly automotive parts) in the northern portion of the Area 50 landfill. These studies also encountered various small chemical containers that included photographic chemicals (thiourea and glycerin) and cleaning chemicals (disinfectant and ammonia). Minimal amounts of organic material appear to have been placed within the landfill.

The 2001 Final Technical Memorandum (Law, 2001) presented the modeling results, which were used to calculate the methane and non-methane organic compound (NMOC) emission rates from the landfill. Because the model was developed for municipal solid waste, which readily generates higher methane and NMOC than construction/demolition debris landfills, the results represent worst-case conditions. The modeling results indicated that the landfill's methane and NMOC emission rates do not warrant a landfill gas recovery system.

5.2.2 Stormwater Evaluation

As part of the design effort, a stormwater conveyance will be evaluated for a 25-year, 24-hour storm. The proposed design will include run-on controls to prevent flow onto the closed landfill and runoff controls to collect and route stormwater.

5.2.3 Erosion and Sediment Control

The Virginia Erosion and Sediment Control Law and Regulations define the standards for an Erosion Control Program. These regulations are found in Code of Virginia §§ 10.1-560 *et seq.* and the Virginia Erosion and Sediment Regulations, Virginia Regulations § 625-02-00, with specific minimum standards in § 1.5. An Erosion and Sediment Control Plan will be developed and implemented to comply with regulatory requirements during construction.

As part of the final surface, a vegetative layer will play an important role in controlling erosion. Permanent seeding will occur across the entire modified surface. In addition, the design calculations will include an evaluation of the long-time average annual soil loss in general accordance with U.S. Department of Agriculture, Natural Resources Conservation Service, Technical Guidance. This evaluation will determine that the projected soil loss from the final slopes over time is within regulatory guidance.

5.2.4 Post-closure Care

Following construction, a Post-closure Care Plan will be developed for long-term OU maintenance. The plan will include a program of regular inspections, maintenance, and monitoring. Examples of components that may be included in the inspections are the final surface, settlement monitoring points, the stormwater drainage system, and the entrance fencing and gates. The groundwater monitoring will be performed under OU 6. Routine maintenance such as erosion repair and mowing will help to evaluate the current condition and maintain the remedy's effectiveness.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

The following conclusions are supported by this Technical Memorandum:

- A review of trenching and historical water level elevations at OU 2 indicated that some landfill materials were disposed in the saturated zone and are exposed to groundwater.
- RAOs 1, 2, and 3 can be met with the installation of a landfill soil cover system designed and constructed to promote positive surface drainage and minimize contact with soils and potential OE hazards.
- LUCs can be implemented as an added protective measure to comply with RAOs 1 and 3. LUCs are listed in Section 5.1.1.

The potential risks associated with groundwater constituents will be addressed under OU 6.

6.2 RECOMMENDATIONS

To facilitate closure, MACTEC recommends the following actions:

- Revise the draft Proposed Plan to reflect the revised remedy selection.
- Revise the draft ROD to reflect the revised remedy selection.
- Prepare an appendix to the *Environmental Land Use Control Implementation Plan, Defense Supply Center Richmond, Richmond, Virginia,* (MACTEC, 2005d) to reflect the LUCs required by the ROD.
- Prepare Remedial Design documents for OU 2.

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TABLES

TABLE 2-1

CHEMICALS OF CONCERN IN SURFACE AND SUBSURFACE SOILS
TECHNICAL MEMORANDUM
REVISED REMEDY SELECTION FOR OPERABLE UNIT 2 – AREA 50 LANDFILL
Defense Supply Center Richmond
Richmond, Virginia

Metals	PCBs	PAHs	VOCs
Arsenic	Aroclor-1260	Benzo(a)anthracene	Trichloroethene
		Benzo(a)pyrene	
		Benzo(b)fluoranthene	
		Benzo(k)fluoranthene	
		Chrysene	
		Dibenzo(a,h)anthracene	
		Indeno(1,2,3-cd)pyrene	

PREPARED/DATE: THB 2/9/06
CHECKED/DATE: LMS 2/24/06

TABLE 2-2

CONSTITUENTS ANALYZED FROM 1984 TO 1998
TECHNICAL MEMORANDUM
REVISED REMEDY SELECTION FOR OPERABLE UNIT 2 – AREA 50 LANDFILL
Defense Supply Center Richmond
Richmond, Virginia

SOIL	
Volatile Organic Compounds	Diesel Fuel
2,4-Dinitrotoluene	Gasoline
Semivolatile Organic Compounds	Jet Fuel
Metals	Kerosene
Hexavalent Chromium	Mineral Oil
Pesticides	Paint Thinner
Total Petroleum Hydrocarbons	Naptha
Polychlorinated Biphenyls	Stoddard Solvent
GROUNDWATER	
Volatile Organic Compounds	Carbon Dioxide
2,4-Dinitrotoluene	Ethene & Ethane
Semivolatile Organic Compounds	Methane
Metals	Sulfate
Hexavalent Chromium	Nitrate & Nitrite
Pesticides	Chloride
Freon 112	Acidity
Cyanide	Alkalinity
Total Petroleum Hydrocarbons	Total Organic Carbon
Oil & Grease	Dissolved Organic Carbon

Perchlorates were not included as analytes for soil or groundwater samples.

PREPARED/DATE: JLK 5/2/06
CHECKED/DATE: THB 7/20/06

TABLE 2-3

MAXIMUM HISTORICAL DETECTIONS FOR EACH CONSTITUENT OF CONCERN
TECHNICAL MEMORANDUM
REVISED REMEDY SELECTION FOR OPERABLE UNIT 2 – AREA 50 LANDFILL
Defense Supply Center Richmond
Richmond, Virginia

FIGURE #	CONSTITUENT	MAXIMUM (mg/kg)
2-1	Arsenic	30
2-2	Benzo(a)anthracene	360
2-3	Banzo(a)pyrene	340
2-4	Benzo(b)fluoranthene	540
2-5	Benzo(k)fluoranthene	540
2-6	Dibenzo(ah)anthracene	72
2-7	Indeno(1,2,3-cd)pyrene	180
2-8	Aroclor 1260	47
2-9	Trichloroethene	53.4
2-10	Benzo(a)anthracene	360
2-11	Benzo(a)pyrene	340
2-12	Benzo(b)fluoranthene	540
2-13	Dibenzo(ah)anthracene	72
2-14	Indeno(1,2,3-cd)pyrene	180

(Taken from sampling events conducted during September and October 1984; May, June, and July 1985; October 1986; October 1988; October, November, and December 1994; and October 1998)

PREPARED/DATE: JLK 5/2/06
CHECKED/DATE: THB 7/20/06

TABLE 2-4

RISK SUMMARY
REASONABLE MAXIMUM EXPOSURE
CURRENT INDUSTRIAL WORKERS
TECHNICAL MEMORANDUM
REVISED REMEDY SELECTION FOR OPERABLE UNIT 2 - AREA 50 LANDFILL
Defense Supply Center Richmond
Richmond, Virginia

Scenario Timeframe: Current
Receptor Population: Industrial
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil	Surface Soil	Surface Soil	Arsenic	1.E-05	1.E-08	2.E-06	1.E-05	Skin, Vascular System	0.1	--	0.01	0.1
			Benzo(a)anthracene	NA	NA	NA	0.E+00	NA	--	--	--	--
			Benzo(a)pyrene	NA	NA	NA	0.E+00	NA	--	--	--	--
			Benzo(b)fluoranthene	NA	NA	NA	0.E+00	NA	--	--	--	--
			Benzo(k)fluoranthene	0.E+00	0.E+00	0.E+00	0.E+00	NA	--	--	--	--
			Dibenzo(a,h)anthracene	6.E-05	NA	5.E-05	1.E-04	NA	--	--	--	--
			Indeno(1,2,3-cd)pyrene	6.E-04	4.E-08	5.E-04	1.E-03	NA	--	--	--	--
			PCB-1260	2.E-05	3.E-09	2.E-05	4.E-05	NA	--	--	--	--
			Total	7.E-04	5.E-08	6.E-04	1.E-03		0.1	--	0.01	0.1
		Exposure Point Total					1.E-03					0.1
Medium Total							1.E-03					0.1
Receptor Total						Receptor Risk Total	1.E-03				Receptor HI Total	0.1
						Total Risk Across All Media	1.E-03				Total Hazard Across All Media	0.1

Total Skin HI Across All Media =	0.1
Total Vascular System HI Across All Media =	0.1
Total Immune System HI Across All Media =	--
Total CNS HI Across All Media =	--

PREPARED/DATE: LMS 9/15/05
CHECKED/DATE: MKB 9/15/05

TABLE 2-5

RISK SUMMARY
REASONABLE MAXIMUM EXPOSURE
FUTURE INDUSTRIAL WORKERS
TECHNICAL MEMORANDUM
REVISED REMEDY SELECTION FOR OPERABLE UNIT 2 - AREA 50 LANDFILL
Defense Supply Center Richmond
Richmond, Virginia

Scenario Timeframe: Future
Receptor Population: Industrial
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil	Surface and Subsurface Soil	Surface and Subsurface Soil	Benzo(a)anthracene	NA	NA	NA	0.E+00	NA	--	--	--	--
			Benzo(a)pyrene	8.E-07	1.E-10	2.E-07	1.E-06	NA	--	--	--	--
			Benzo(b)fluoranthene	7.E-10	2.E-15	1.E-10	8.E-10	NA	--	--	--	--
			Dibenzo(a,h)anthracene	1.E-05	NA	1.E-05	2.E-05	NA	--	--	--	--
			Indeno(1,2,3-cd)pyrene	1.E-04	7.E-09	9.E-05	2.E-04	NA	--	--	--	--
			Trichloroethene	8.E-07	5.E-05	2.E-07	5.E-05	CNS, Liver, Kidney	0.04	0.06	0.01	0.1
			Total	1.E-04	5.E-05	1.E-04	3 E-04		--	--	--	--
		Exposure Point Total					3.E-04					--
Medium Total							3.E-04					--
Receptor Total						Receptor Risk Total	3.E-04				Receptor HI Total	0.1
						Total Risk Across All Media	3.E-04				Total Hazard Across All Media	0.1

Total CNS HI Across All Media = 0.1
Total Liver HI Across All Media = 0.1
Total Kidney HI Across All Media = 0.1

PREPARED/DATE: LMS 9/15/05
CHECKED/DATE: MKB 9/15/05

TABLE 2-6

RISK-BASED REMEDIATION GOALS FOR SURFACE AND SUBSURFACE SOILS
TECHNICAL MEMORANDUM
REVISED REMEDY SELECTION FOR OPERABLE UNIT 2 - AREA 50 LANDFILL
Defense Supply Center Richmond
Richmond, Virginia

Current Industrial Worker	Estimated Risk by Exposure Pathway				Surface Soil HHBRA EPC	Surface Soil Risk-Based Remediation Goal (10-5)
	Ingestion	Inhalation	Dermal Contact	Totals		
Arsenic	1.E-05	1.E-08	2.E-06	1.E-05	2.0E+01	1.8.E+01
Benzo(a)anthracene	6.E-05	NA	5.E-05	1.E-04	2.7E+02	2.3.E+01
Benzo(a)pyrene	6.E-04	4.E-08	5.E-04	1.E-03	2.5E+02	2.3.E+00
Benzo(b)fluoranthene	9.E-05	NA	8.E-05	2.E-04	4.0E+02	2.3.E+01
Benzo(k)fluoranthene	9.E-06	NA	8.E-06	2.E-05	4.0E+02	2.3.E+02
Dibenzo(a,h)anthracene	1.E-04	NA	1.E-04	2.E-04	5.3E+01	2.3.E+00
Indeno(1,2,3-cd)pyrene	3.E-05	NA	3.E-05	6.E-05	1.3E+02	2.3.E+01
PCB- 1260	2.E-05	3.E-09	2.E-05	4.E-05	3.4E+01	8.3.E+00
TOTALS	**9.E-04**	**5.E-08**	**8.E-04**	**2.E-03**		

Future Industrial Worker	Estimated Risk by Exposure Pathway				Subsurface Soil HHBRA EPC	Subsurface Soil Risk-Based Remediation Goal (10-5)
	Ingestion	Inhalation	Dermal Contact	Totals		
Benzo(a)anthracene	1.E-05	NA	1.E-05	2.E-05	5.1E+01	2.3.E+01
Benzo(a)pyrene	1.E-04	7.E-09	9.E-05	2.E-04	4.7E+01	2.3.E+00
Benzo(b)fluoranthene	3.E-05	NA	2.E-05	5.E-05	1.1E+02	2.3.E+01
Dibenzo(a,h)anthracene	2.E-05	NA	2.E-05	5.E-05	1.1E+01	2.3.E+00
Indeno(1,2,3-cd)pyrene	6.E-06	NA	5.E-06	1.E-05	2.5E+01	2.3.E+01
Trichloroethene	8.E-07	5.E-05	2.E-07	5.E-05	1.2E+01	2.5.E+00
TOTALS	**2.E-04**	**5.E-05**	**2.E-04**	**4.E-04**		

Notes:
EPC Exposure Point Concentrations from the HHBRA
HHBRA Human Health Baseline Risk Assessment

PREPARED/DATE: LMS 12/13/05
CHECKED/DATE: MKB 12/15/05

TABLE 2-7

STORM SEWERS LINED BY PVC FOLD AND FORM METHOD
TECHNICAL MEMORANDUM
REVISED REMEDY SELECTION FOR OPERABLE UNIT 2 – AREA 50 LANDFILL
Defense Supply Center Richmond
Richmond, Virginia

Storm Sewer Line Designation/Location	Beginning Manhole	Ending Manhole	Diameter	Length
East	585	584	12 inch	329 feet
	584	583	15 inch	332 feet
	583	668	18 inch	288 feet
	668	5'×5" box	18 inch	89 feet (test & seal)
	589	588	12 inch	62 feet
Central (formerly denoted as west line)	666	662	15 inch	328 feet
	662	659	18 inch	333 feet
	659	5'×5" box	24 inch	Internal spot repair
	563	562	12 inch	Internal spot repair
West (not previously labeled)	542	541	12 inch	244 feet
	537	532 @ 5'×5' box	24 inch	Internal spot repair

Note:
PVC Polyvinyl Chloride

PREPARED/DATE: THB 2/8/06
CHECKED/DATE: PKN 7/20/06

TABLE 2-8

STORM SEWER MANHOLE IMPROVEMENTS
TECHNICAL MEMORANDUM
REVISED REMEDY SELECTION FOR OPERABLE UNIT 2 – AREA 50 LANDFILL
Defense Supply Center Richmond
Richmond, Virginia

MACTEC Manhole Identification	USACE Manhole Identification	Rehabilitation Measures Implemented
EAST LINE	585	Water plug and seal 9.7 VLF Install new concrete collar
East MH 2	584	Water plug and seal 10.3 VLF Install new frame and cover Install new concrete collar
East MH 3	583	Water plug and seal 9.1 VLF Install new frame and cover Install concrete collar
	668	Raise buried structure
	589	Water plug and seal 5.9 VLF
CENTRAL LINE (formerly denoted as west line)	665	Abandon in place
	666	Water plug and seal 9.13 VLF
	667	Water plug and seal 5.0 VLF Install new concrete collar
MH 2	662	Water plug and seal 10.2 VLF Install new frame and cover
	663	Water plug and seal 7.46 VLF Install new concrete collar
	661	Water plug and seal 7.1 VLF Install new concrete collar
	660	Install new concrete collar
MH 3	659	Install new frame and cover Install concrete collar
	658	Water plug and seal 7.0 VLF Install new frame and cover Install new concrete collar
	564	Water plug and seal 3.9 VLF
	563	Water plug and seal 3.95 VLF
WEST LINE (not previously labeled)	540	Install new frame and cover
	539	Water plug and seal 6.3 VLF
	538	Water plug and seal 6.3 VLF
	537	Install new frame and cover

Note:
VLF vertical linear feet

PREPARED/DATE: THB 2/8/06
CHECKED/DATE: PKN 7/20/06

TABLE 3-1

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs) AND TO-BE-CONSIDERED CRITERIA (TBCs) FOR SOILS
TECHNICAL MEMORANDUM
REVISED REMEDY SELECTION FOR OPERABLE UNIT 2 – AREA 50 LANDFILL
Defense Supply Center Richmond
Richmond, Virginia

TYPE OF ARAR	ARARs	TBC REQUIREMENTS
Chemical-Specific	None Identified	None Identified
Location-Specific	None Identified	None Identified
Action-Specific		
No Action	None identified	None identified
Institutional Controls	None identified	None identified
Containment/Capping	RCRA - Closure Requirements (40 CFR 264 Subpart G; VHWMR 9 VAC 20-60-740, et seq.)	Calculated Risk-Based Soil Action Levels in Accordance with 40 CFR Part 300.430(e)(2)(i) of the National Oil and Hazardous Substances Pollution Contingency Plan
	VA Stormwater Management Regulations (4 VAC 3-20-10, et seq.)	
	VA Stormwater Management Act (Code of VA § 10.1-603.1 et. seq.)	
	VA Erosion and Sediment Control Regulations (Code of VA § 10.1-560, et seq.)	
	VA Erosion and Sediment Control Regulations (4 VAC 50-30-10, et seq.)	
	VA Standards of Performance for Visible Emissions and Fugitive Dust/ Emissions [Rule 5-1] (9 VAC 5-50-60, et seq.)	
	VA Closure and Post Closure Requirements (VHWMR 9 VAC 20-60-800, et seq.)	
Grading	VA Stormwater Management Regulations (4 VAC 30-20-10, et seq.)	None identified
	VA Erosion and Sediment Control Regulations (4 VAC 50-30-10, et seq.)	
	VA Stormwater Management Act (Code of VA § 10.1-603.1 et. seq.)	
	VA Erosion and Sediment Control Law (Code of VA § 10.1-560, et seq.)	
	VA Standards of Performance for Visible Emissions and Fugitive Dust/ Emissions [Rule 5-1] (9 VAC 5-50-60, et seq.)	

Prepared by: THB 12/15/05
Checked by: CED 12/15/05

TABLE 4-1

COMPARATIVE ANALYSIS OF RETAINED REMEDIAL ALTERNATIVES
TECHNICAL MEMORANDUM
REVISED REMEDY SELECTION FOR OPERABLE UNIT 2 - AREA 50 LANDFILL
Defense Supply Center Richmond
Richmond, Virginia

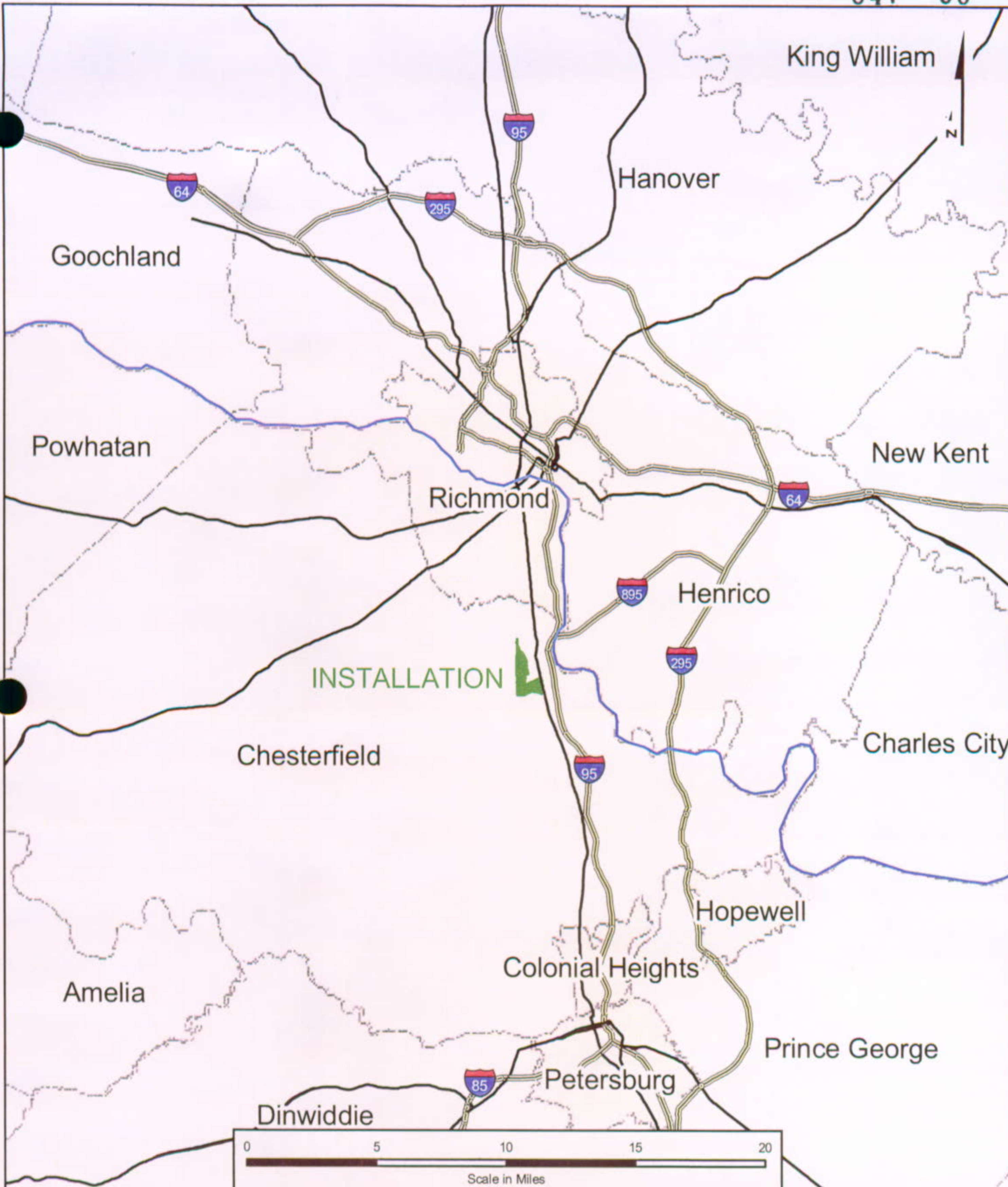
Alternatives		Evaluation Criteria								
		Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-term Effectiveness and Permanence	Reduction in Toxicity, Mobility, and Volume Through Treatment	Short-term Effectiveness	Implementability	Costs	State Acceptance	Community Acceptance
1.	No Action	Not protective	Not compliant	Not effective	No reduction because no treatment	Because there is no action, there are no short-term risks to workers or the community during construction.	Easy to implement because there are no actions except 5-year reviews.	No costs	Does not provide assurance that human health and the environment are protected.	Does not provide assurance that human health and the environment are protected.
2.	Institutional Controls	Not protective	Not compliant	Not effective	No reduction because no treatment	Land use controls and deed restrictions in the event of property transfer provide immediate prohibition against contact with onsite soils.	Institutional controls are easy to implement.	$150,000	ICs alone may not satisfy state ARARs.	ICs alone may not satisfy community that this remedial alternative is sufficiently protective of human health and the environment.
6A.	Soil cover, storm sewer rehabilitation, institutional controls, and source removal of free-product and saturated soils	Will be effective in protection of human health and the environment: landfilled materials left in place	Compliant with ARARs	Effective	No reduction because no treatment	Unacceptable short-term risks related to onsite construction and likelihood of encountering ordnance and explosives	Construction of soil cover is moderately easy to implement. ICs easy to implement. Removal of free-product and saturated soils difficult and hazardous to implement. Storm sewer rehabilitation has been completed.	$1,900,000	The combination of technologies provided in this alternative will satisfy state ARARs	The combination of technologies provided in this alternative is expected to satisfy the community that this alternative is sufficiently protective of human health and the environment.
6B.	Clay cover, storm sewer rehabilitation, institutional controls, and source removal of free-product and saturated soils	Will be effective in protection of human health and the environment: landfilled materials left in place	Compliant with ARARs	Effective	No reduction because no treatment	Unacceptable short-term risks related to onsite construction and likelihood of encountering ordnance and explosives.	Construction of clay cover is moderately easy to implement. ICs easy to implement. Removal of free-product and saturated soils difficult and hazardous to implement. Storm sewer rehabilitation has been completed.	$2,000,000	The combination of technologies provided in this alternative will satisfy state ARARs	The combination of technologies provided in this alternative is expected to satisfy the community that this alternative is sufficiently protective of human health and the environment
Modified 6A.	Soil cover, institutional controls	Will be effective in protection of human health and the environment. landfilled materials left in place	Compliant with ARARs	Effective	No reduction because no treatment	Acceptable short-term risks.	Construction of soil cover is moderately easy to implement. ICs easy to implement. Storm sewer rehabilitation has been completed.	$1,500,000	The combination of technologies provided in this alternative will satisfy state ARARs	The combination of technologies provided in this alternative is expected to satisfy the community that this alternative is sufficiently protective of human health and the environment

Notes:
ARARs Applicable or Relevant and Appropriate Requirements
ICs Institutional Controls
For purposes of comparison of costs, complete excavation and off-site disposal is estimated to be on the order of magnitude of $13 million.

PREPARED/DATE: THB 2/9/05
CHECKED/DATE: CED 2/9/05

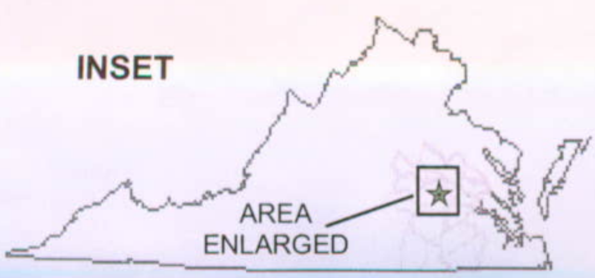
FIGURES

847 66



Legend

- INTERSTATE
- MAJOR ROAD
- JAMES RIVER
- MUNICIPALITIES
- COUNTIES



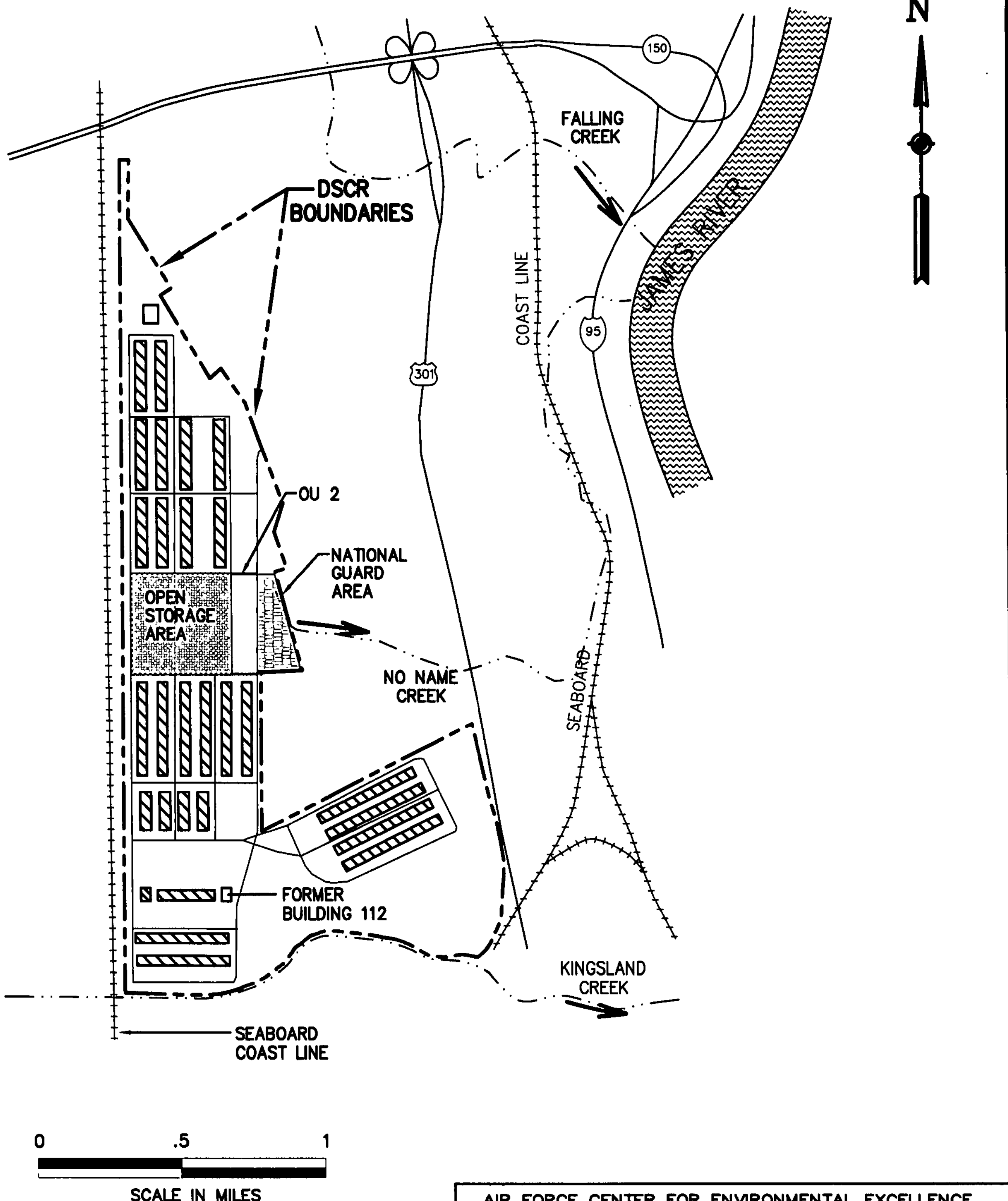
AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE

DEFENSE SUPPLY CENTER RICHMOND
RICHMOND, VIRGINIA

OU 2 TECHNICAL MEMORANDUM

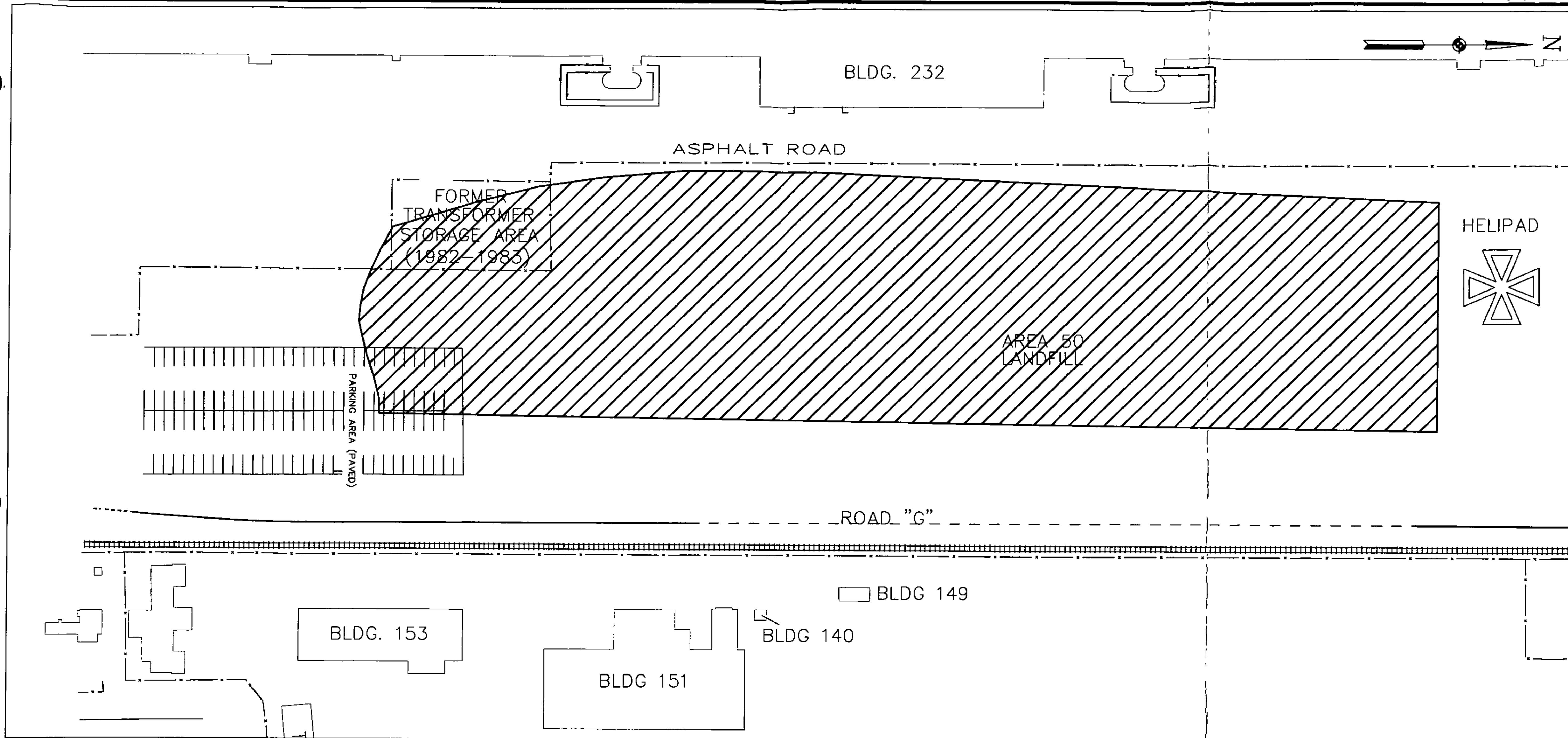
LOCATION OF THE INSTALLATION

PREPARED BY: THP	MACTEC	FIGURE NUMBER: 1-1
CHECKED BY: JLK		
PROJECT NO: 6301-05-0016		



SOURCE: DAMES AND MOORE (1989)

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE	
DEFENSE SUPPLY CENTER RICHMOND RICHMOND, VA	
OU 2 TECHNICAL MEMORANDUM	
DEFENSE SUPPLY CENTER RICHMOND AND SURROUNDING AREA	
PREPARED BY: R.A CHECKED BY: JLK PROJECT NO: 6301-05-0016	MACTEC	FIGURE NUMBER: 1-2



LEGEND:

APPROXIMATE EXTENT OF FORMER RAVINE INTERPRETED BASED ON 1949 AERIAL PHOTOGRAPH AND 1955 TOPOGRAPHIC SITE MAP.

NOTE:

LOCATION OF TRANSFORMER STORAGE AREA IS ESTIMATED FROM LOCATION REPORTED BY DAMES AND MOORE, 1989.

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE

DEFENSE SUPPLY CENTER RICHMOND
RICHMOND, VA

OU 2 TECHNICAL MEMORANDUM

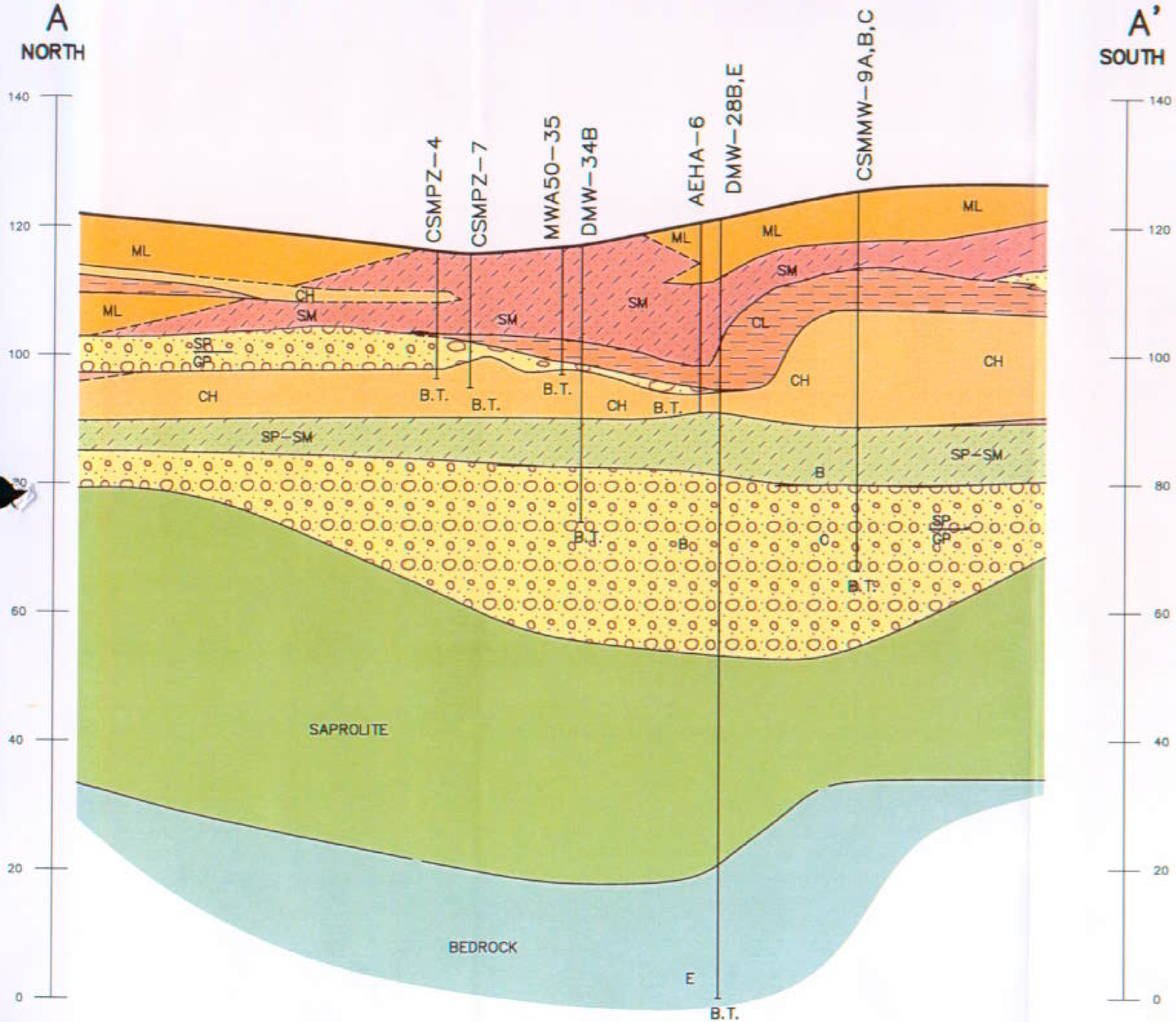
OU 2 SITE MAP

PREPARED BY: R.A
CHECKED BY: JLK
PROJECT NO: 6301-05-0016

MACTEC

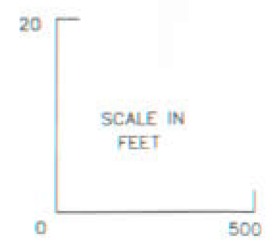
FIGURE NUMBER: 1-3

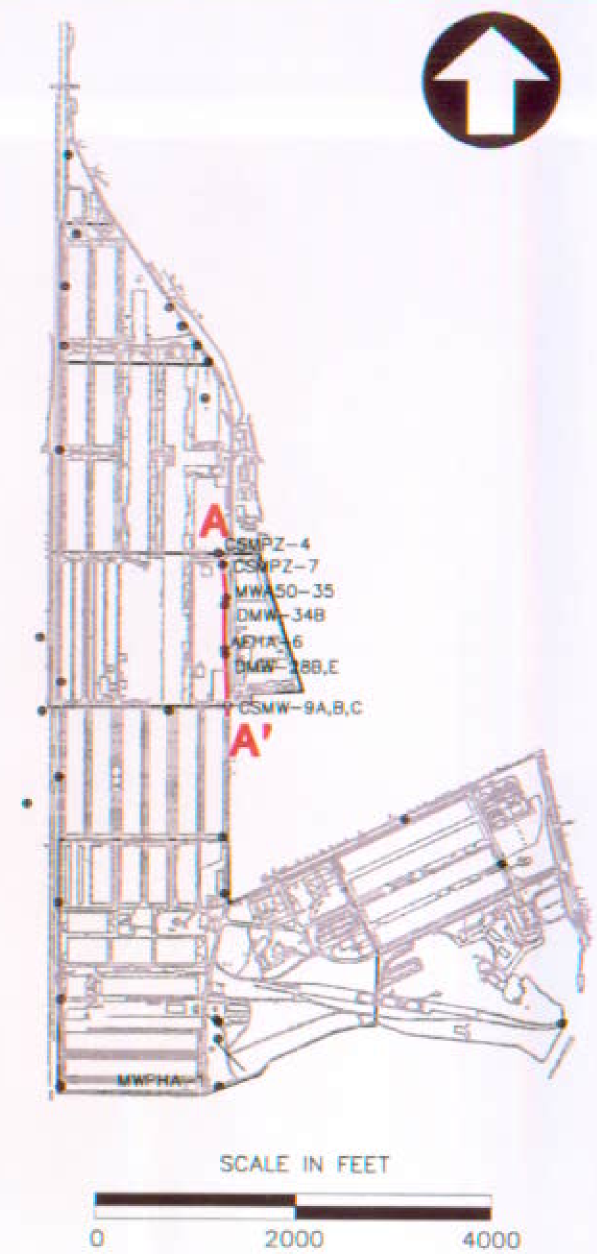
J:\DSCR\ACT[illegible]Rav-actn-2.dwg 12/19/2005 12:27pm ralexand



LEGEND

	GP/GM	
	SM	SILTY SAND
	SC	CLAYEY SAND
	SP	POORLY GRADED SAND WITH GRAVEL
	CL	SILTY CLAY
	GC	CLAYEY GRAVEL WITH SAND
	SW	WELL GRADED SAND WITH GRAVEL
	CH	FAT CLAY
	ML	SANDY SILT
	MH	ELASTIC SILT
	GP	POORLY GRADED GRAVEL WITH SAND
	GW	WELL GRADED GRAVEL WITH SAND
	SP-SM	POORLY GRADED SAND WITH GRAVEL WITH SILTY SAND
		SAPROLITE
		BEDROCK
	SP/GP	POORLY GRADED SAND WITH GRAVEL INTERLAYERED WITH POORLY GRADED GRAVEL
A — A'		CROSS SECTION LOCATION
B.T.		BORING TERMINATED
		GROUND SURFACE
		INTERPRETED LITHOLOGIC TRANSITION
		LITHOLOGIC TRANSITION





AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE

**DEFENSE SUPPLY CENTER RICHMOND
RICHMOND, VIRGINIA**

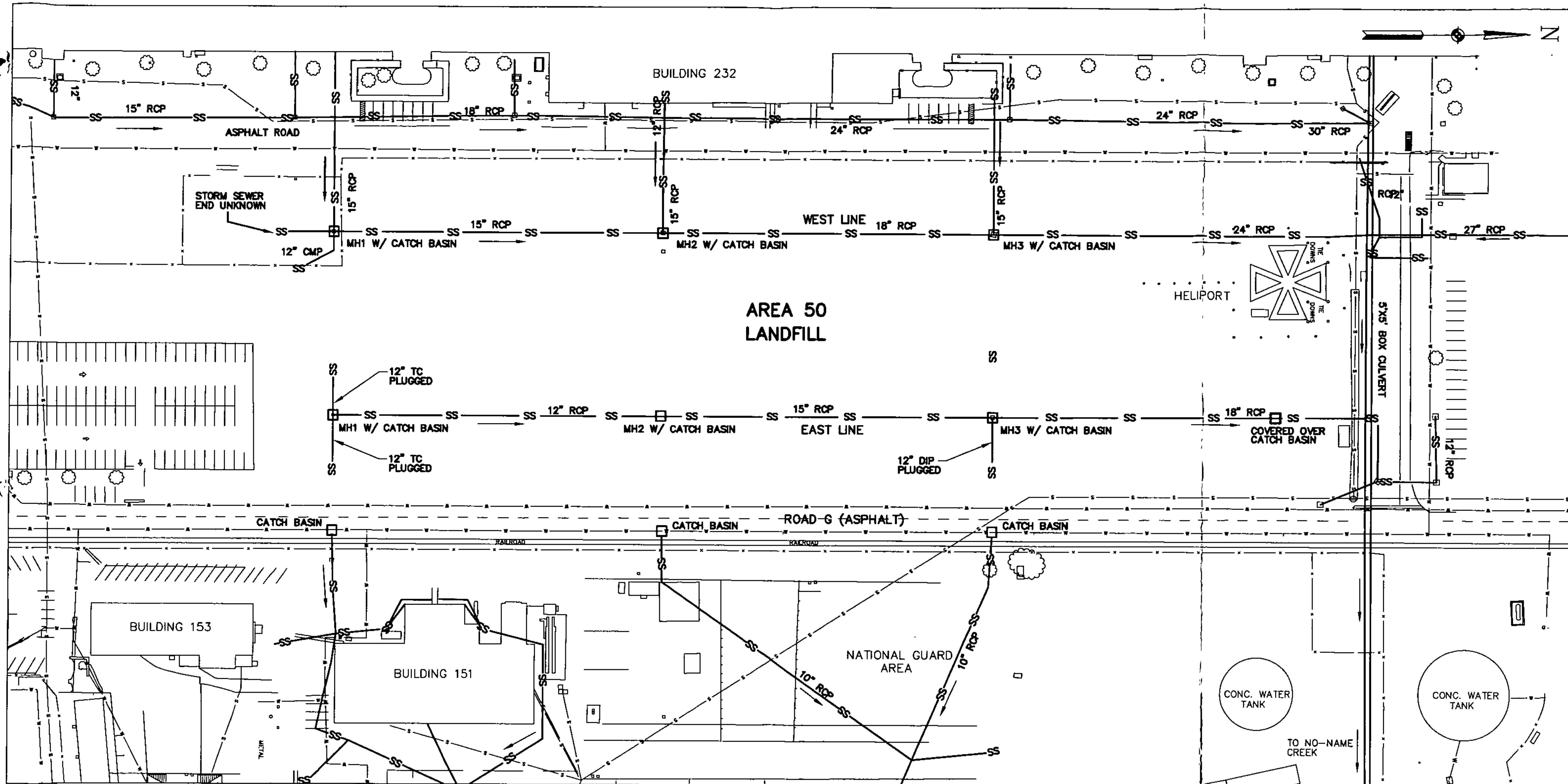
OU 2 TECHNICAL MEMORANDUM

CROSS SECTION A-A'

PREPARED BY: R.A
CHECKED BY: JLK
PROJECT NO: 6301-05-0016

MACTEC

FIGURE NUMBER: 1-4



LEGEND

- SS — STORM SEWER
- SANITARY SEWER
- WATER LINE
- FENCE
- ○ SHRUB OR TREE

0 100 200
SCALE IN FEET

SOURCE: ELECTRONIC FILE PROVIDED BY ANDERSON AND ASSOCIATES MARCH 1994.

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE

DEFENSE SUPPLY CENTER RICHMOND
RICHMOND, VA

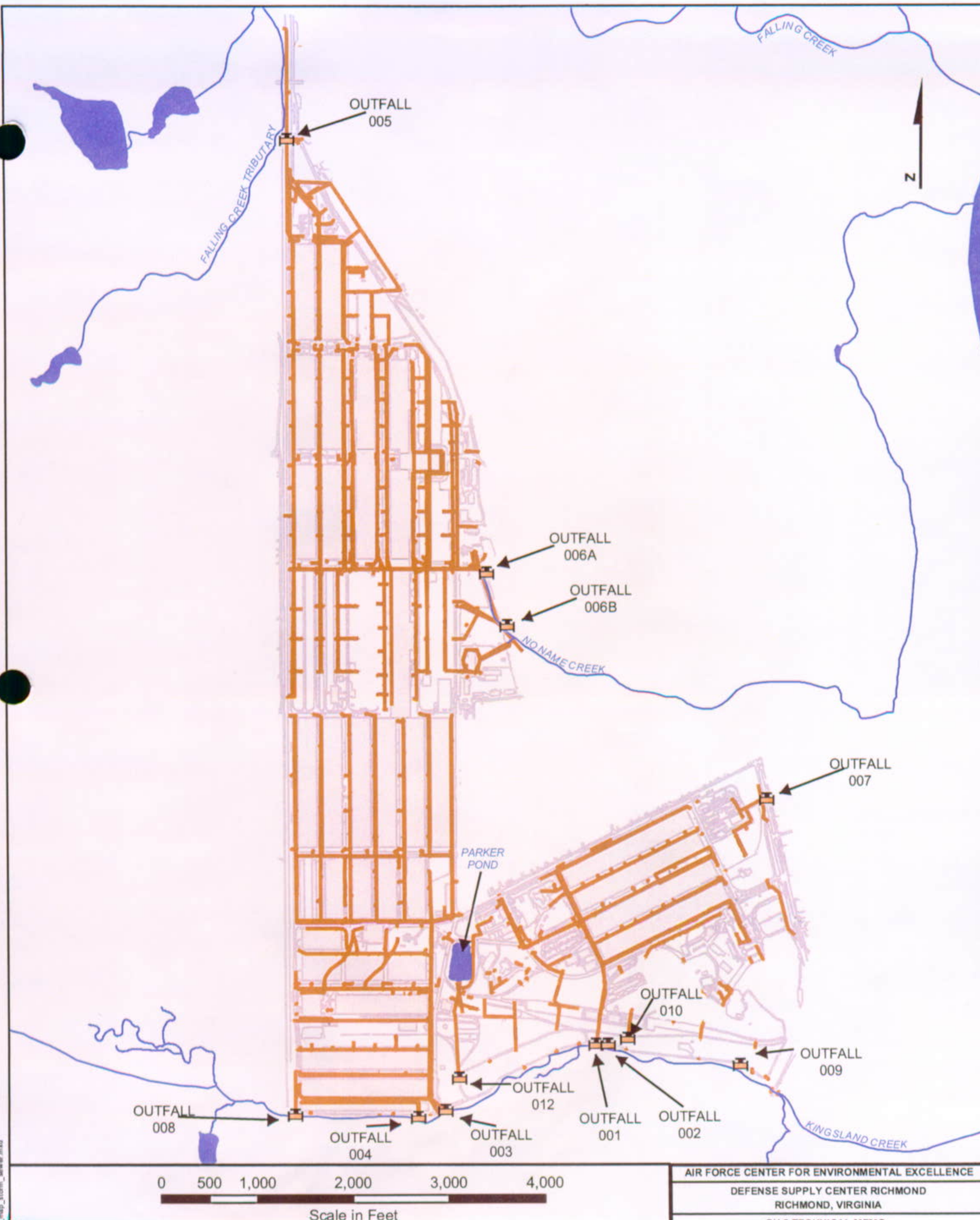
OU 2 TECHNICAL MEMORANDUM

OU 2 STORM SEWER LOCATIONS

PREPARED BY: R.A
CHECKED BY: JLK
PROJECT NO: 6301-05-0016

MACTEC

FIGURE NUMBER: 1-5



847 71

Legend

- BUILDINGS
- SURFACE WATER
- STORM SEWER
- STORM SEWER OUTFALLS

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE

DEFENSE SUPPLY CENTER RICHMOND
RICHMOND, VIRGINIA

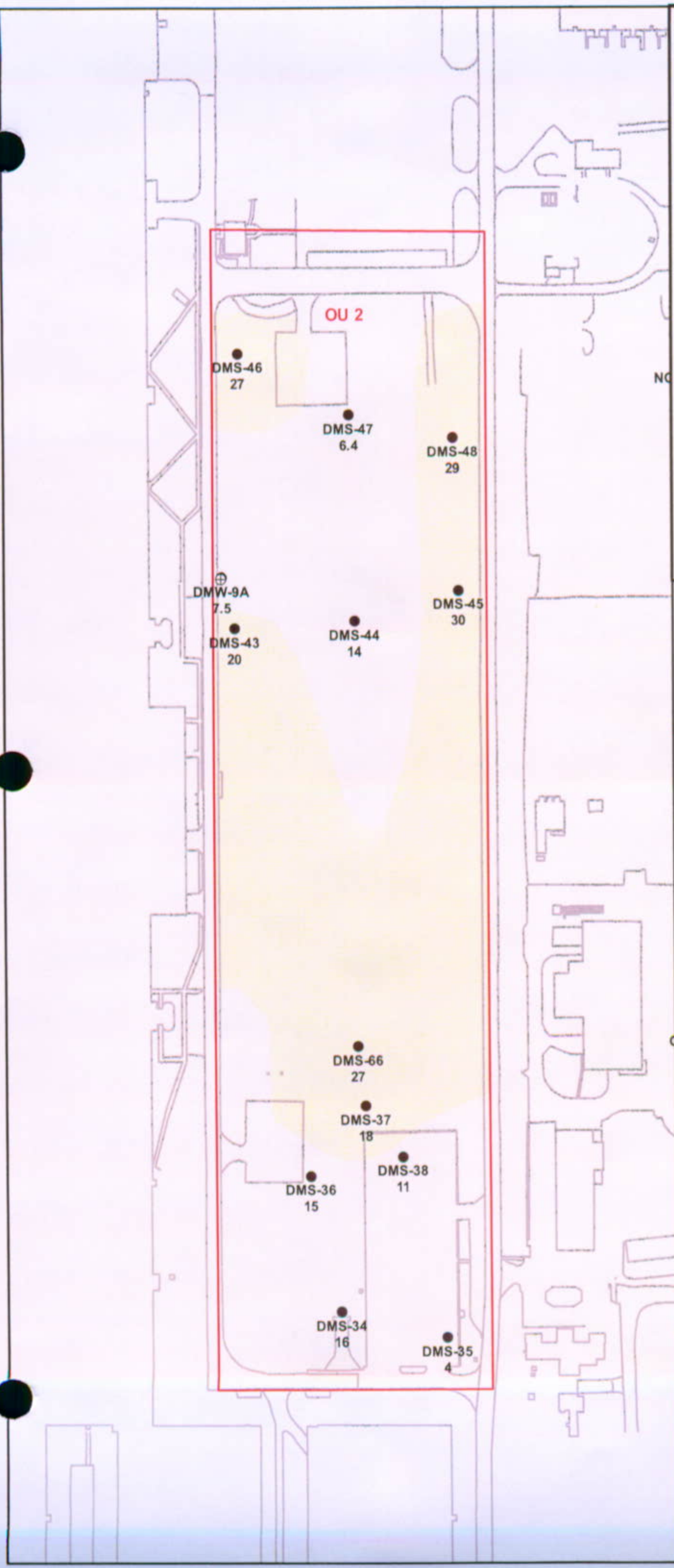
OU 2 TECHNICAL MEMO

DSCR STORM SEWERS

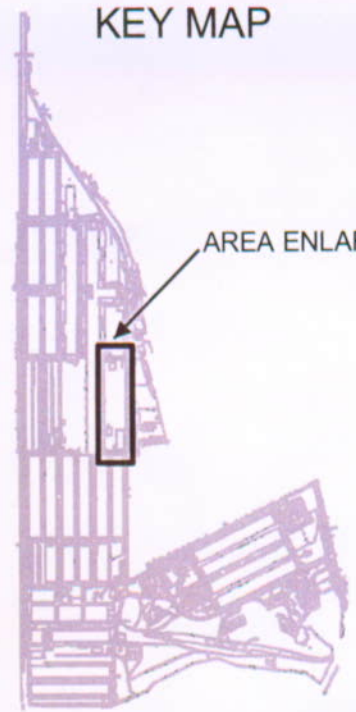
PREPARED BY: THP
CHECKED BY: JLK
PROJECT NO: 6301-05-0016

MACTEC

FIGURE NUMBER: 1-6



KEY MAP



N

Legend

- ● SOIL BORING SAMPLE
- ⊕ WELL BORING SAMPLE
- DMS-44 14 SAMPLE LOCATION DESIGNATION AND CONSTITUENT CONCENTRATION (mg/kg). A "0" INDICATES A CONCENTRATION BELOW THE ANALYTICAL DETECTION LIMIT.
- OPERABLE UNIT
- EXTENT OF ARSENIC EXCEEDING INDUSTRIAL SOIL RISK-BASED REMEDIATION GOAL (18 mg/kg)

0 100 200 400

Scale in Feet

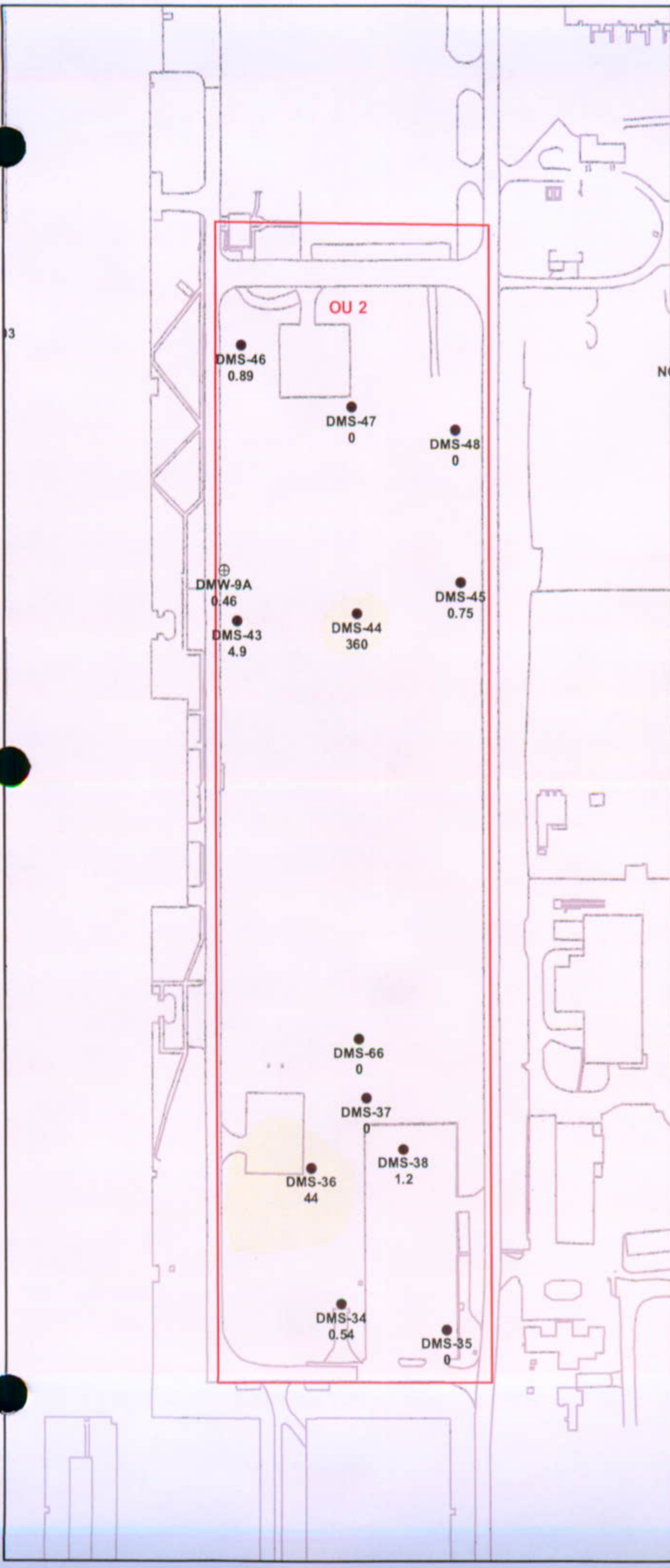
AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE

DEFENSE SUPPLY CENTER RICHMOND
RICHMOND, VIRGINIA

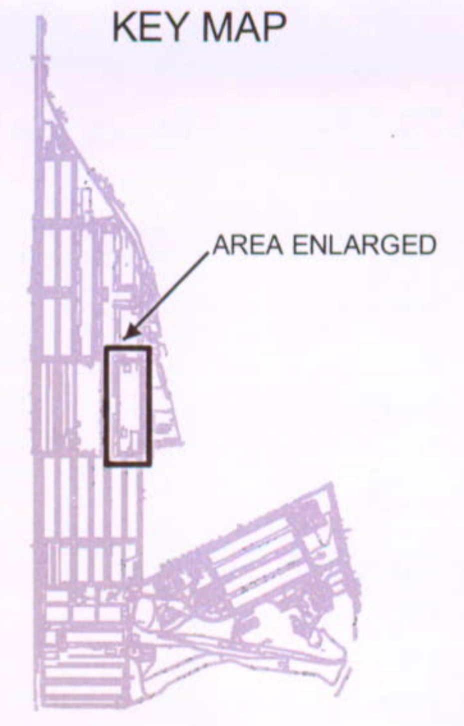
OU2 TECHNICAL MEMORANDUM

OU 2 COC IN SURFACE SOIL (0 - 2' bgs)
ARSENIC

PREPARED BY: GGH	MACTEC	FIGURE NUMBER: 2-1
CHECKED BY: THB		
PROJECT NO: 6301-05-0016		



KEY MAP



Legend

- ● SOIL BORING SAMPLE
- ⊕ WELL BORING SAMPLE
- DMS-44 360 — SAMPLE LOCATION DESIGNATION AND CONSTITUENT CONCENTRATION (mg/kg). A "0" INDICATES A CONCENTRATION BELOW THE ANALYTICAL DETECTION LIMIT.
- OPERABLE UNIT
- EXTENT OF BENZO(a)ANTHRACENE EXCEEDING INDUSTRIAL SOIL RISK-BASED REMEDIATION GOAL (23 mg/kg)

N

0 100 200 400

Scale in Feet

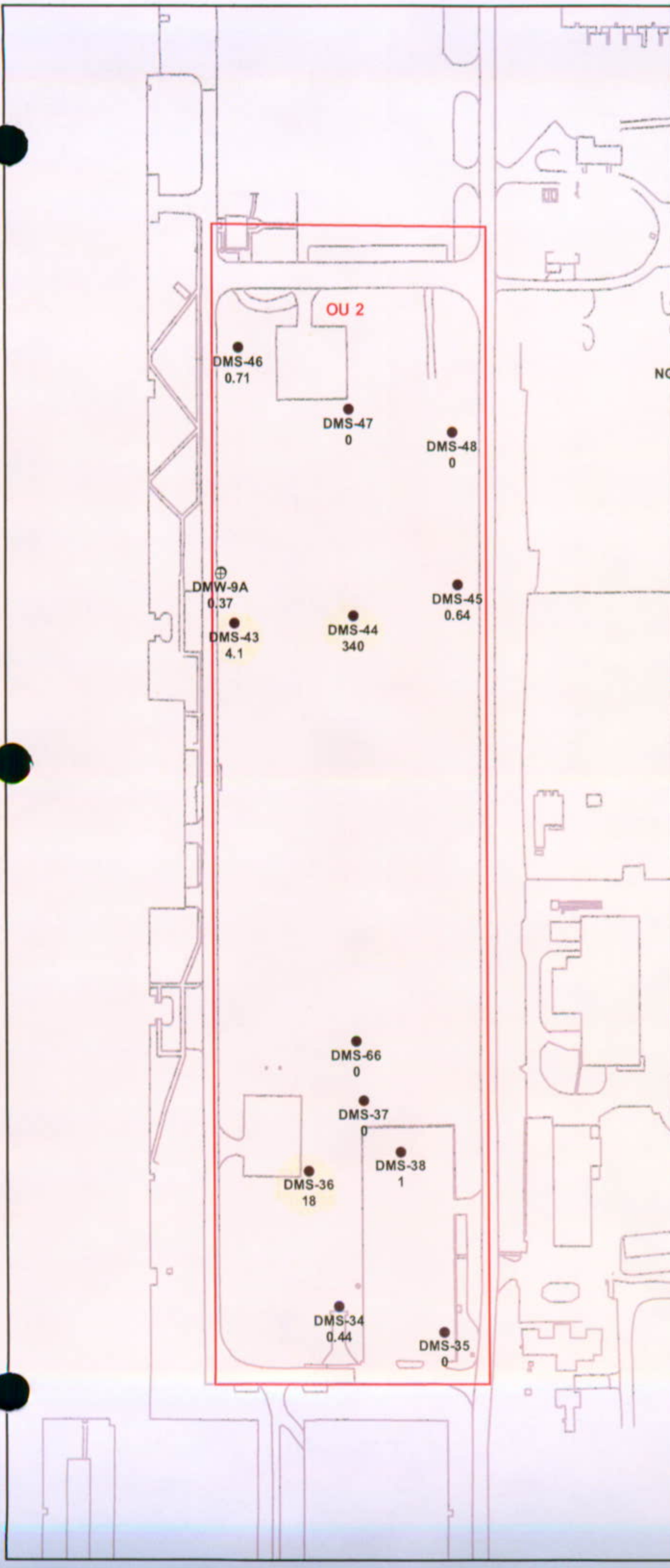
AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE

DEFENSE SUPPLY CENTER RICHMOND
RICHMOND, VIRGINIA

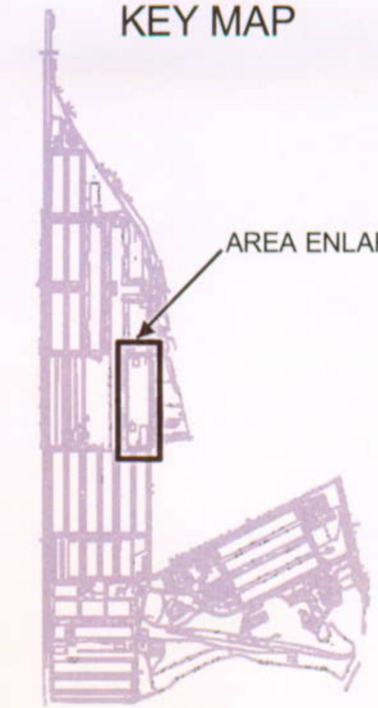
OU 2 TECHNICAL MEMORANDUM

OU 2 COC IN SURFACE SOIL (0 - 2' bgs)
BENZO(a)ANTHRACENE

PREPARED BY: GGH	MACTEC	FIGURE NUMBER: 2-2
CHECKED BY: THB		
PROJECT NO: 6301-05-0016		



KEY MAP



Legend

- ● SOIL BORING SAMPLE
- ⊕ WELL BORING SAMPLE
- DMS-43 4.1 — SAMPLE LOCATION DESIGNATION AND CONSTITUENT CONCENTRATION (mg/kg). A "0" INDICATES A CONCENTRATION BELOW THE ANALYTICAL DETECTION LIMIT.
- OPERABLE UNIT
- EXTENT OF BENZO(a)PYRENE EXCEEDING INDUSTRIAL SOIL RISK-BASED REMEDIATION GOAL (2.3 mg/kg)

N

0 100 200 400

Scale in Feet

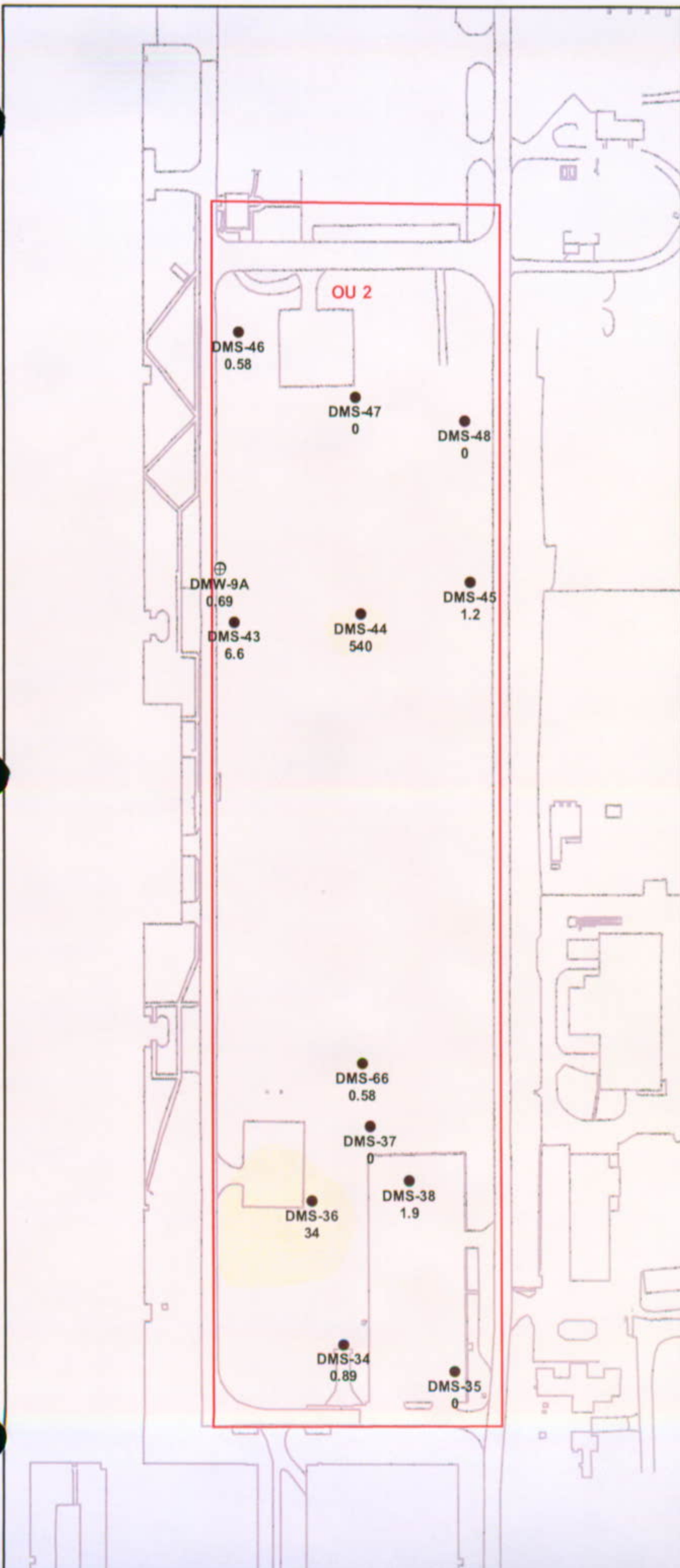
AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE

DEFENSE SUPPLY CENTER RICHMOND
RICHMOND, VIRGINIA

OU 2 TECHNICAL MEMORANDUM

OU 2 COC IN SURFACE SOIL (0 - 2' bgs)
BENZO(a)PYRENE

PREPARED BY: GGH	MACTEC	FIGURE NUMBER: 2-3
CHECKED BY: THB		
PROJECT NO: 6301-05-0016		



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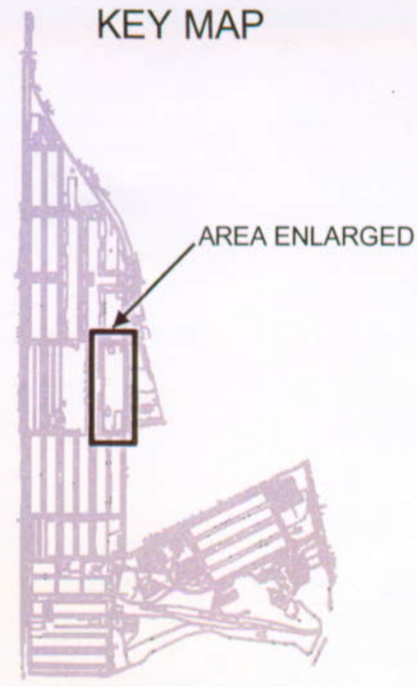


Legend

- ● SOIL BORING SAMPLE
- ⊕ WELL BORING SAMPLE
- DMS-42 / 88 — SAMPLE LOCATION DESIGNATION AND CONSTITUENT CONCENTRATION (mg/kg). A "0" INDICATES A CONCENTRATION BELOW THE ANALYTICAL DETECTION LIMIT.
- OPERABLE UNIT
- EXTENT OF BENZO(b)FLUORANTHENE EXCEEDING INDUSTRIAL SOIL RISK-BASED REMEDIATION GOAL (23 mg/kg)

N

0 100 200 400

Scale in Feet

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE

DEFENSE SUPPLY CENTER RICHMOND
RICHMOND, VIRGINIA

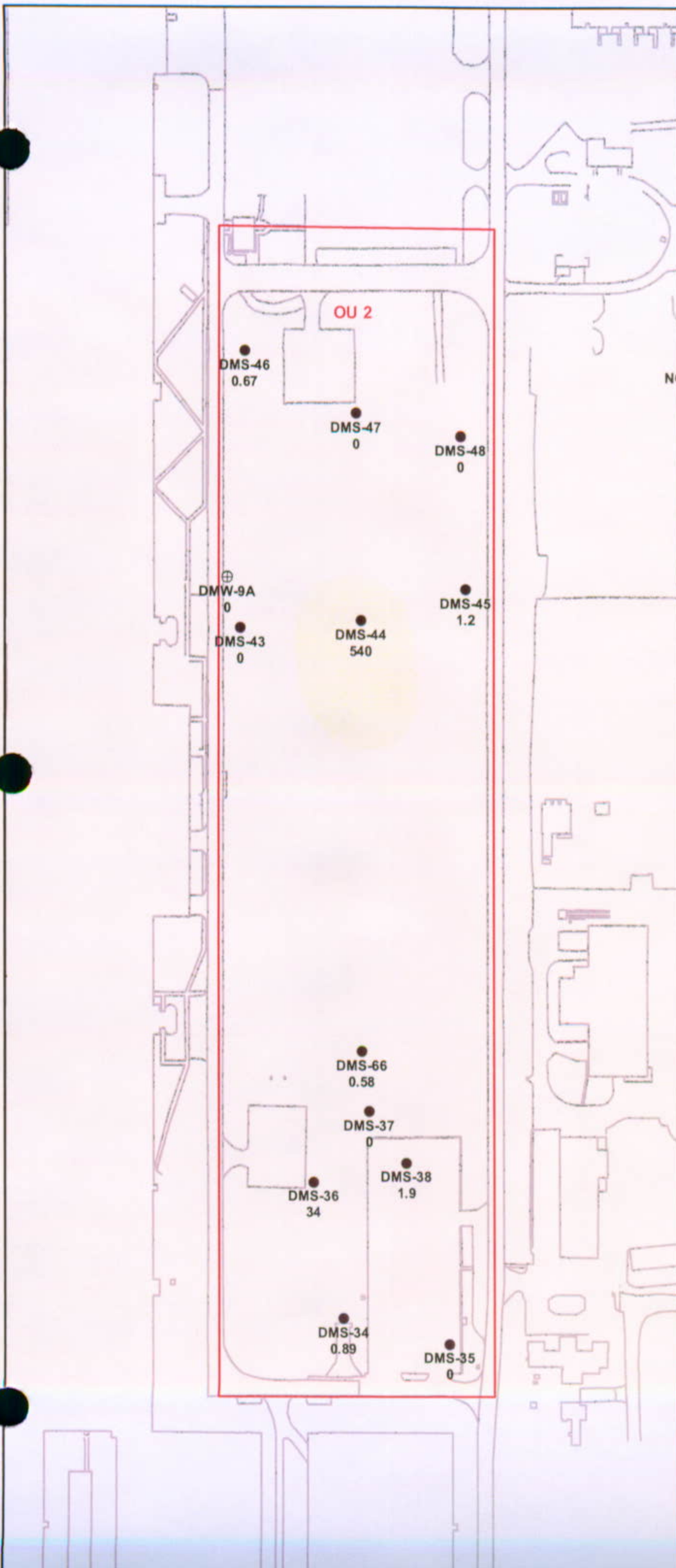
OU 2 TECHNICAL MEMORANDUM

OU 2 COC IN SURFACE SOIL (0 - 2' bgs)
BENZO(b)FLUORANTHENE

PREPARED BY: GGH
CHECKED BY: THB
PROJECT NO: 6301-05-0016

MACTEC

FIGURE NUMBER: 2-4



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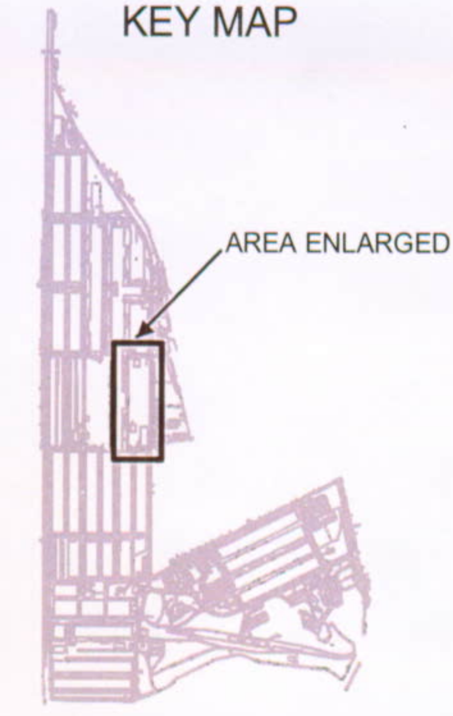


Legend

- ● SOIL BORING SAMPLE
- ⊕ WELL BORING SAMPLE
- DMS-44 540 — SAMPLE LOCATION DESIGNATION AND CONSTITUENT CONCENTRATION (mg/kg). A "0" INDICATES A CONCENTRATION BELOW THE ANALYTICAL DETECTION LIMIT.
- OPERABLE UNIT
- EXTENT OF BENZO(k)FLUORANTHENE EXCEEDING INDUSTRIAL SOIL RISK-BASED REMEDIATION GOAL (230 mg/kg)

N

0 100 200 400

Scale in Feet

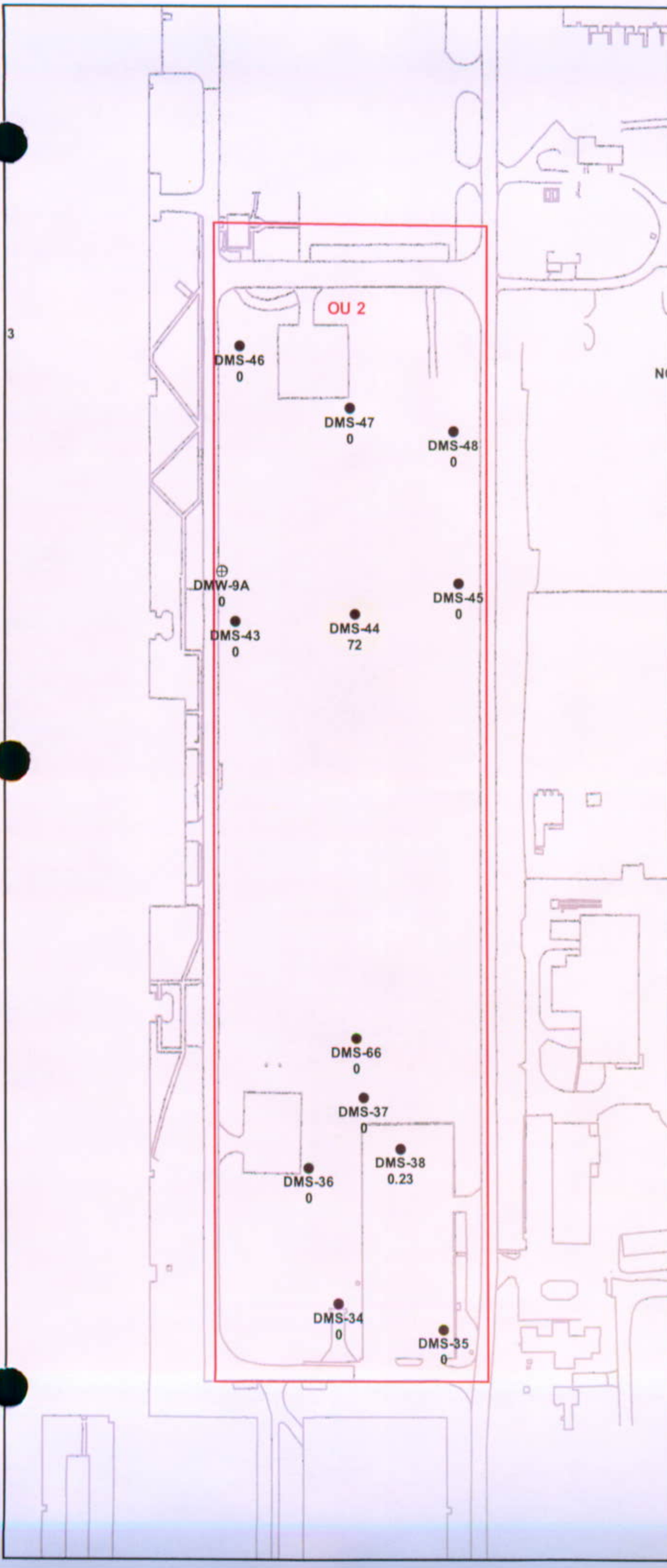
AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE

DEFENSE SUPPLY CENTER RICHMOND
RICHMOND, VIRGINIA

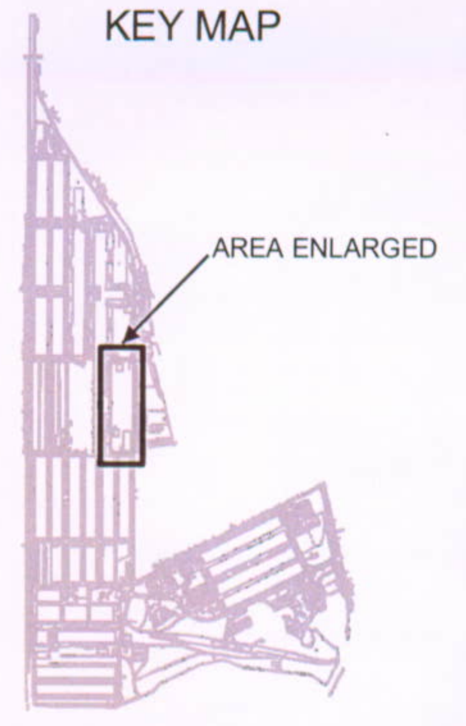
OU 2 TECHNICAL MEMORANDUM

OU 2 COC IN SURFACE SOIL (0 - 2' bgs)
BENZO(k)FLUORANTHENE

PREPARED BY: GGH	MACTEC	FIGURE NUMBER: 2-5
CHECKED BY: THB		
PROJECT NO: 6301-05-0016		



KEY MAP



Legend

- ● SOIL BORING SAMPLE
- ⊕ WELL BORING SAMPLE
- TEST TRENCH SAMPLE
- DMS-44 72 — SAMPLE LOCATION DESIGNATION AND CONSTITUENT CONCENTRATION (mg/kg). A "0" INDICATES A CONCENTRATION BELOW THE ANALYTICAL DETECTION LIMIT.
- OPERABLE UNIT
- EXTENT OF DIBENZO(ah)ANTHRACENE EXCEEDING INDUSTRIAL SOIL RISK-BASED REMEDIATION GOAL (2.3 mg/kg)

N

0 100 200 400

Scale in Feet

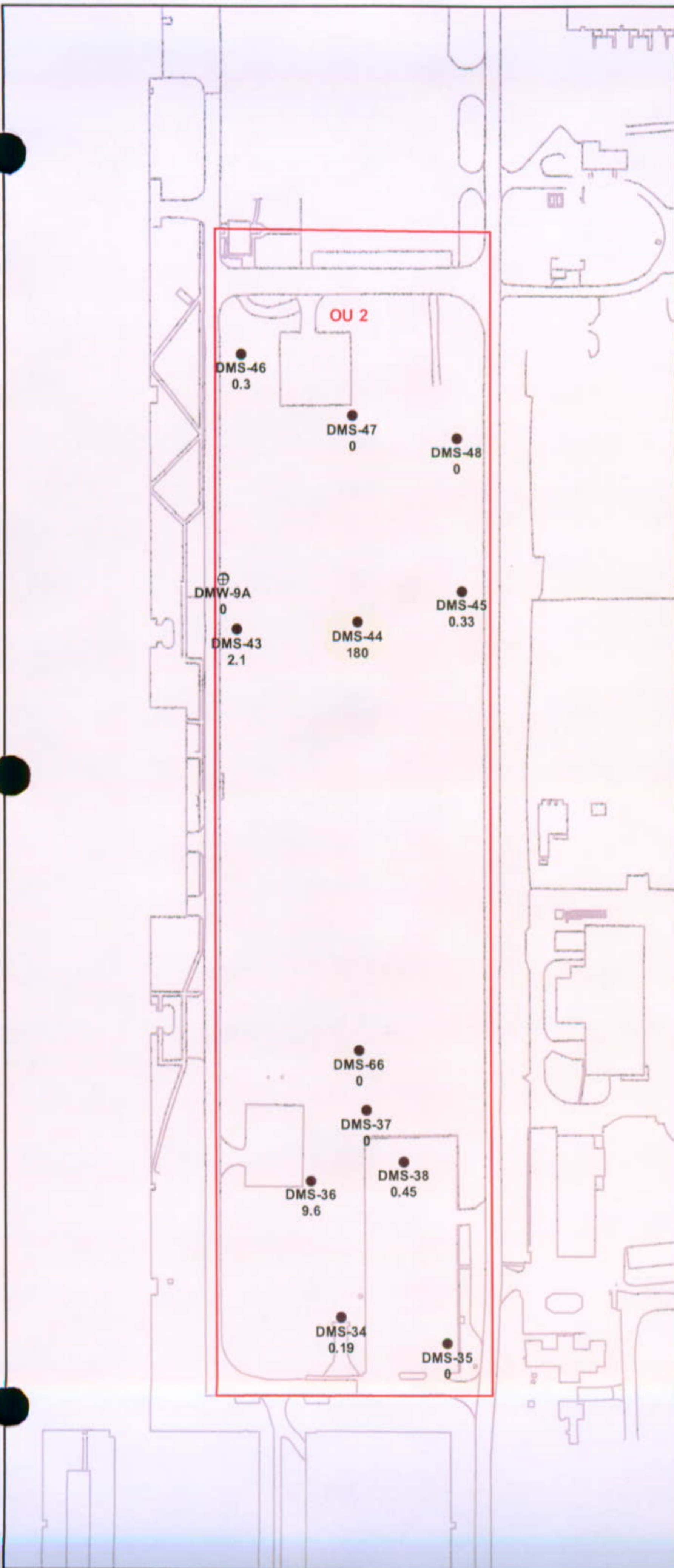
AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE

DEFENSE SUPPLY CENTER RICHMOND
RICHMOND, VIRGINIA

OU 2 TECHNICAL MEMORANDUM

OU 2 COC IN SURFACE SOIL (0 - 2' bgs)
DIBENZO(ah)ANTHRACENE

PREPARED BY: GGH	MACTEC	FIGURE NUMBER: 2-6
CHECKED BY: THB		
PROJECT NO: 6301-05-0016		



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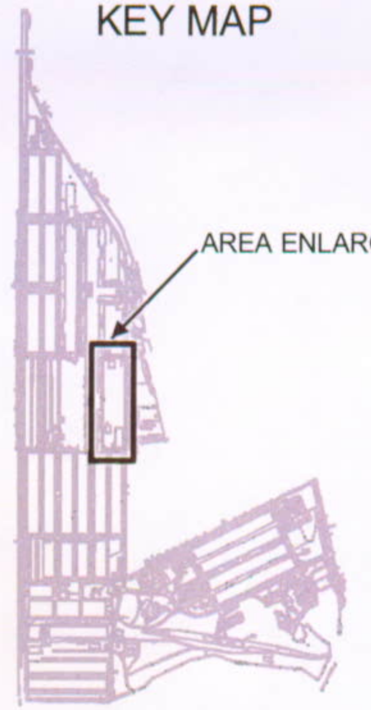


Legend

- ● SOIL BORING SAMPLE
- ⊕ WELL BORING SAMPLE
- DMS-44 / 180 — SAMPLE LOCATION DESIGNATION AND CONSTITUENT CONCENTRATION (mg/kg). A "0" INDICATES A CONCENTRATION BELOW THE ANALYTICAL DETECTION LIMIT.
- OPERABLE UNIT
- EXTENT OF INDENO(1,2,3-cd)PYRENE EXCEEDING INDUSTRIAL SOIL RISK-BASED REMEDIATION GOAL (23 mg/kg)

N

0 100 200 400

Scale in Feet

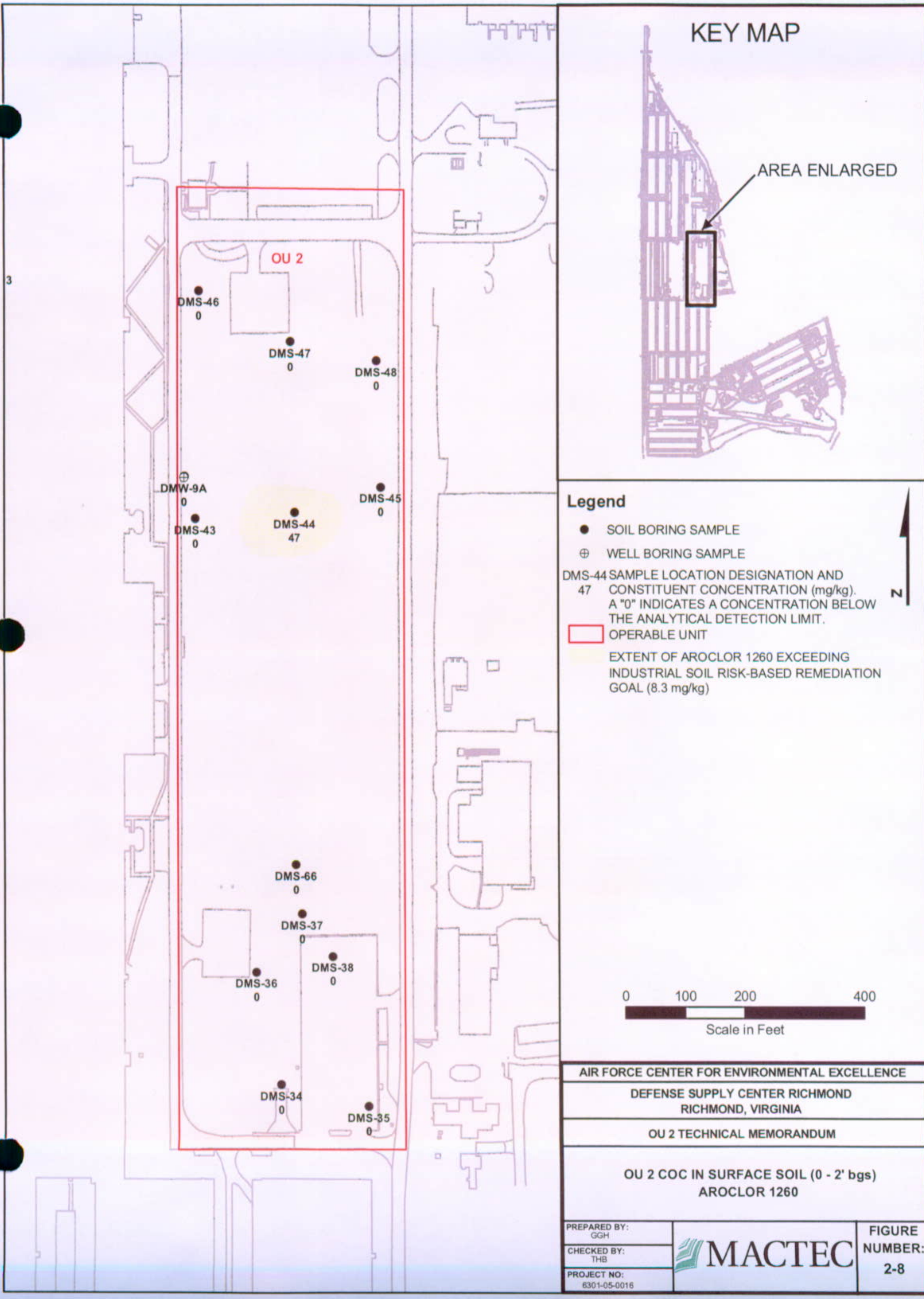
AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE

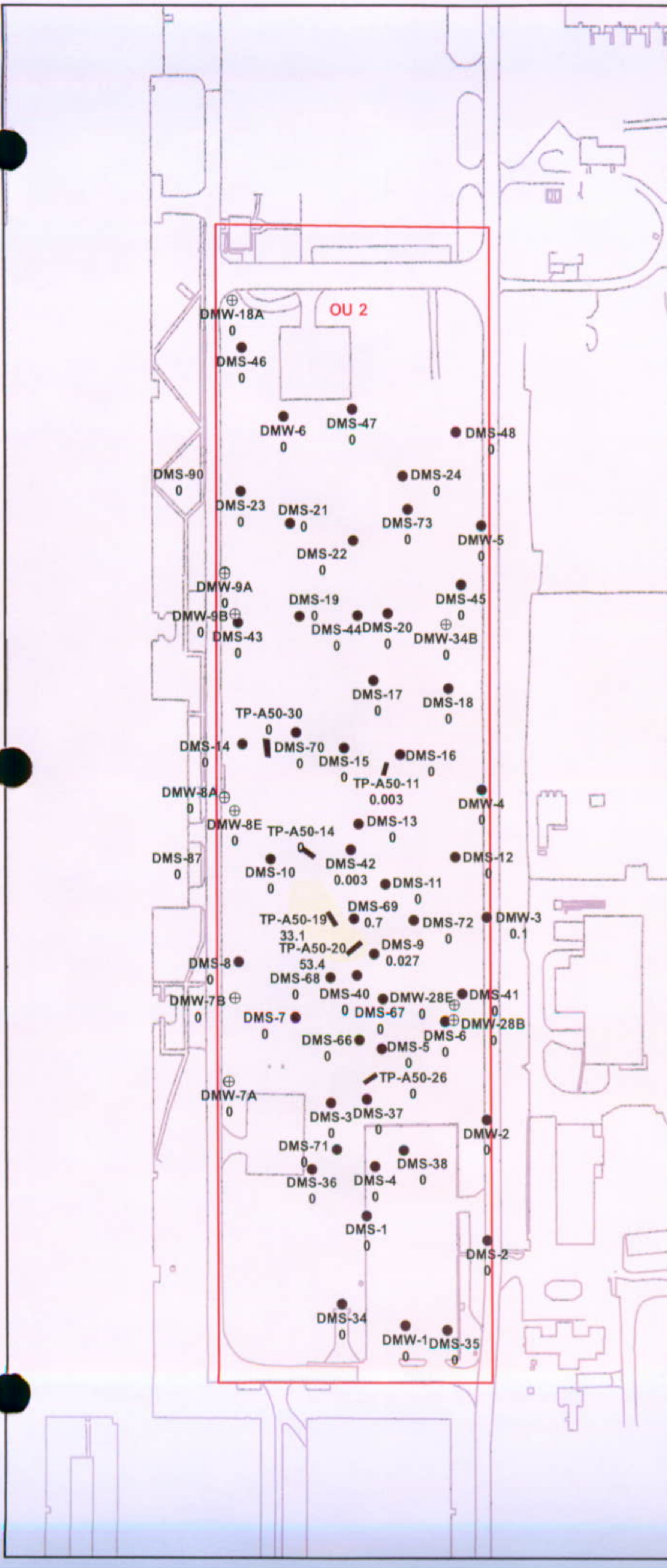
DEFENSE SUPPLY CENTER RICHMOND
RICHMOND, VIRGINIA

OU 2 TECHNICAL MEMORANDUM

OU 2 COC IN SURFACE SOIL (0 - 2' bgs)
INDENO(1,2,3-cd)PYRENE

PREPARED BY: GGH	MACTEC	FIGURE NUMBER: 2-7
CHECKED BY: THB		
PROJECT NO: 6301-05-0016		


KEY MAP
AREA ENLARGED
OU 2
DMS-46
0
DMS-47
0
DMS-48
0
DMW-9A
0
DMS-45
0
DMS-43
0
DMS-44
47
DMS-66
0
DMS-37
0
DMS-38
0
DMS-36
0
DMS-34
0
DMS-35
0
Legend
SOIL BORING SAMPLE
WELL BORING SAMPLE
DMS-44 47 SAMPLE LOCATION DESIGNATION AND CONSTITUENT CONCENTRATION (mg/kg). A "0" INDICATES A CONCENTRATION BELOW THE ANALYTICAL DETECTION LIMIT.
OPERABLE UNIT
EXTENT OF AROCLOR 1260 EXCEEDING INDUSTRIAL SOIL RISK-BASED REMEDIATION GOAL (8.3 mg/kg)
N
0
100
200
400
Scale in Feet
AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE
DEFENSE SUPPLY CENTER RICHMOND
RICHMOND, VIRGINIA
OU 2 TECHNICAL MEMORANDUM
OU 2 COC IN SURFACE SOIL (0 - 2' bgs)
AROCLOR 1260
PREPARED BY: GGH
CHECKED BY: THB
PROJECT NO: 6301-05-0016
MACTEC
FIGURE NUMBER: 2-8



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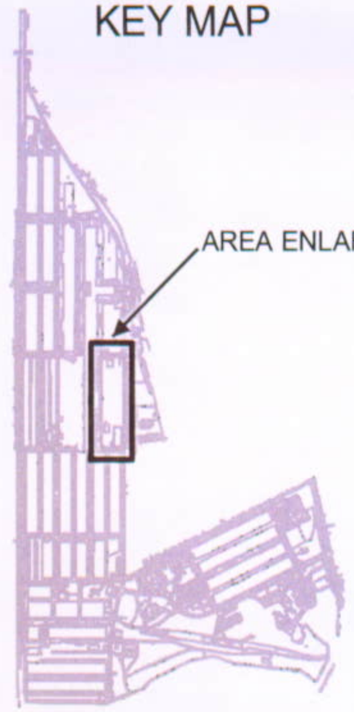


Legend

- ● SOIL BORING SAMPLE
- ⊕ WELL BORING SAMPLE
- ▬ TEST TRENCH SAMPLE
- DMS-42 0.003 — SAMPLE LOCATION DESIGNATION AND CONSTITUENT CONCENTRATION (mg/kg). A "0" INDICATES A CONCENTRATION BELOW THE ANALYTICAL DETECTION LIMIT.
- OPERABLE UNIT
- EXTENT OF TRICHLOROETHENE EXCEEDING INDUSTRIAL SOIL RISK-BASED REMEDIATION GOAL (2.5 mg/kg)

N

0 100 200 400

Scale in Feet

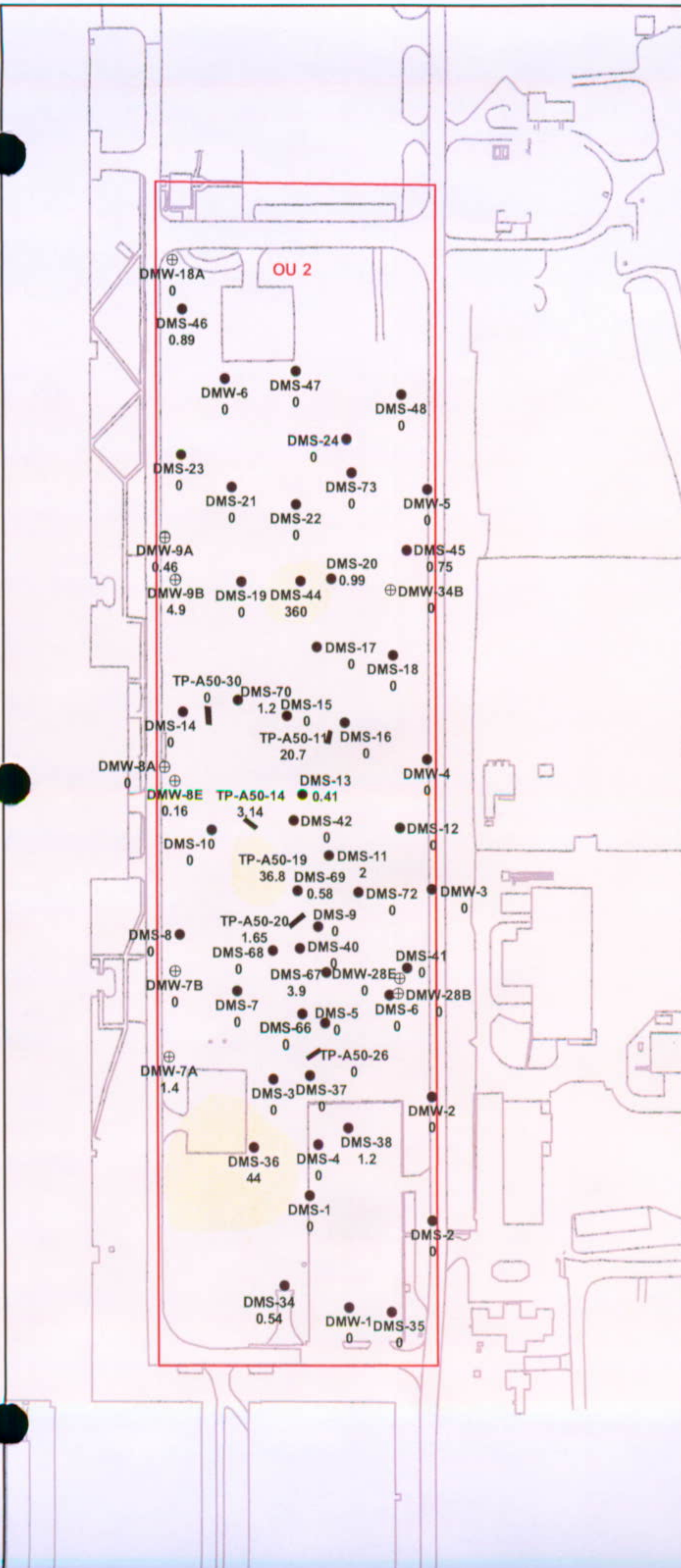
AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE

DEFENSE SUPPLY CENTER RICHMOND
RICHMOND, VIRGINIA

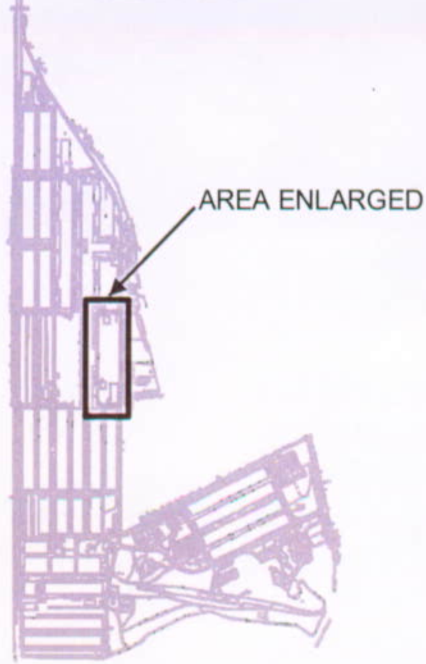
OU 2 TECHNICAL MEMORANDUM

OU 2 COC IN SUBSURFACE SOIL (0 - 10' bgs)
TRICHLOROETHENE

PREPARED BY: GGH CHECKED BY: THB PROJECT NO: 6301-05-0016	MACTEC	FIGURE NUMBER: 2-9



KEY MAP



Legend

- ● SOIL BORING SAMPLE
- ⊕ WELL BORING SAMPLE
- ▬ TEST TRENCH SAMPLE
- DMS-13 0.41 — SAMPLE LOCATION DESIGNATION AND CONSTITUENT CONCENTRATION (mg/kg). A "0" INDICATES A CONCENTRATION BELOW THE ANALYTICAL DETECTION LIMIT.
- OPERABLE UNIT
- EXTENT OF BENZO(a)ANTHRACENE EXCEEDING INDUSTRIAL SOIL RISK-BASED REMEDIATION GOAL (23 mg/kg)

N

0 100 200 400

Scale in Feet

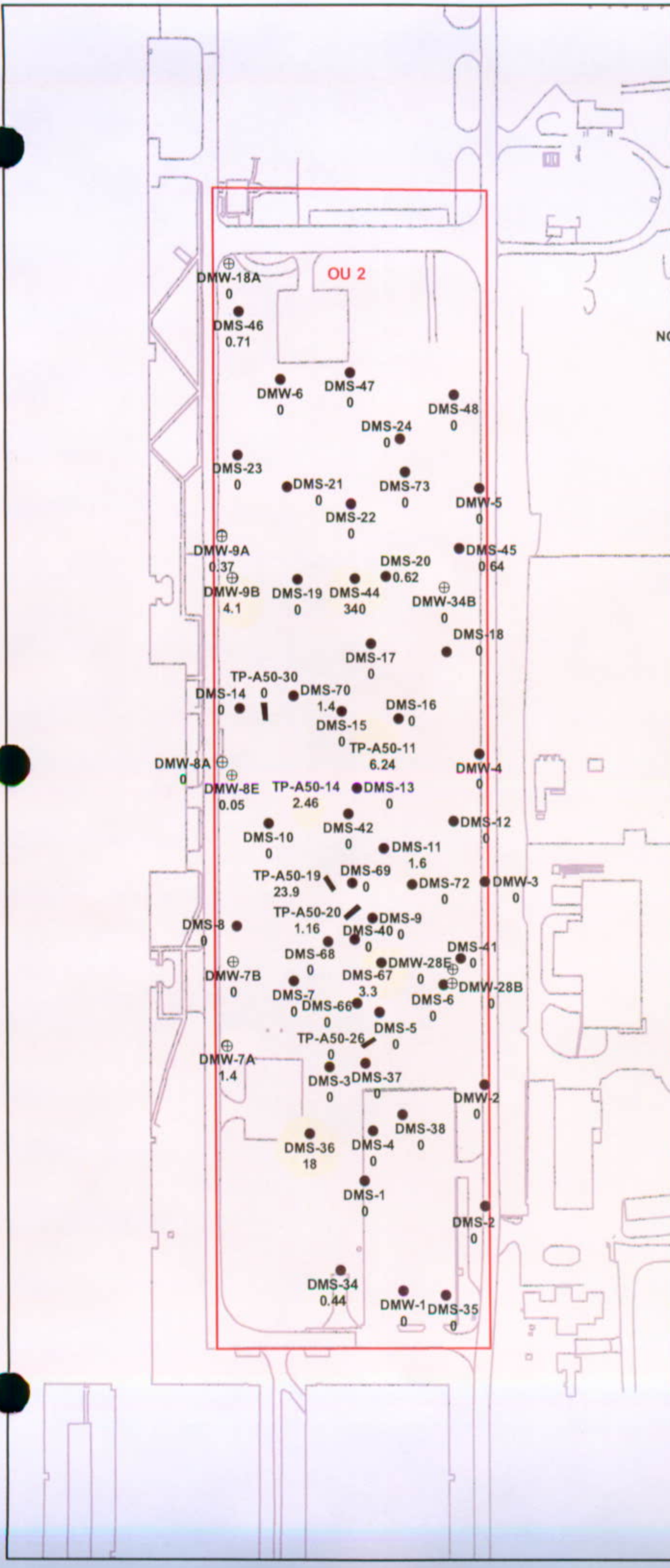
AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE

DEFENSE SUPPLY CENTER RICHMOND
RICHMOND, VIRGINIA

OU 2 TECHNICAL MEMORANDUM

OU 2 COC IN SUBSURFACE SOIL (0 - 10' bgs)
BENZO(a)ANTHRACENE

PREPARED BY: GGH	MACTEC	FIGURE NUMBER: 2-10
CHECKED BY: THB		
PROJECT NO: 6301-05-0016		



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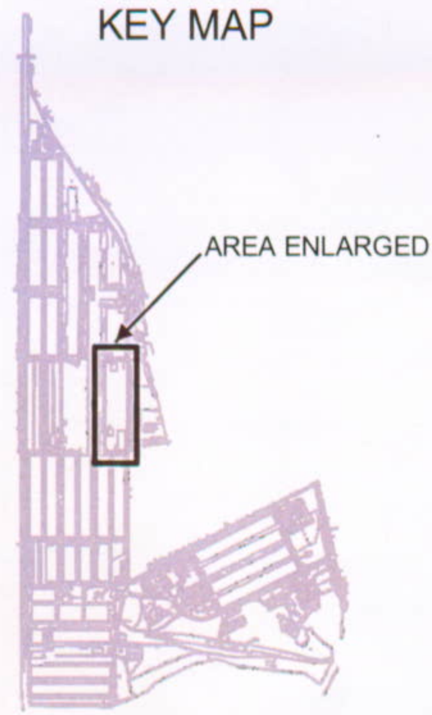


Legend

- ● SOIL BORING SAMPLE
- ⊕ WELL BORING SAMPLE
- ▬ TEST TRENCH SAMPLE
- DMS-20 / 0.62 — SAMPLE LOCATION DESIGNATION AND CONSTITUENT CONCENTRATION (mg/kg). A "0" INDICATES A CONCENTRATION BELOW THE ANALYTICAL DETECTION LIMIT.
- OPERABLE UNIT
- EXTENT OF BENZO(a)PYRENE EXCEEDING INDUSTRIAL SOIL RISK-BASED REMEDIATION GOAL (2.3 mg/kg)

N

0 100 200 400

Scale in Feet

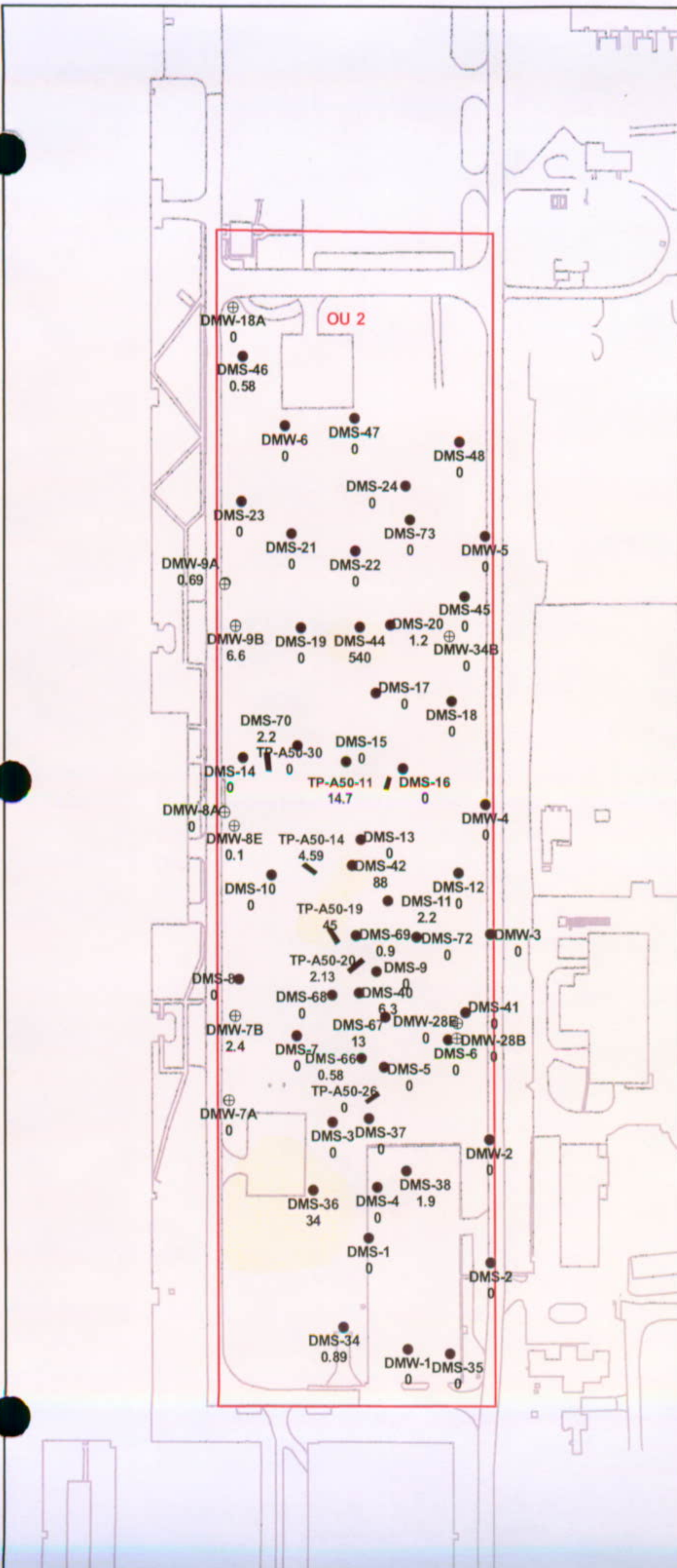
AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE

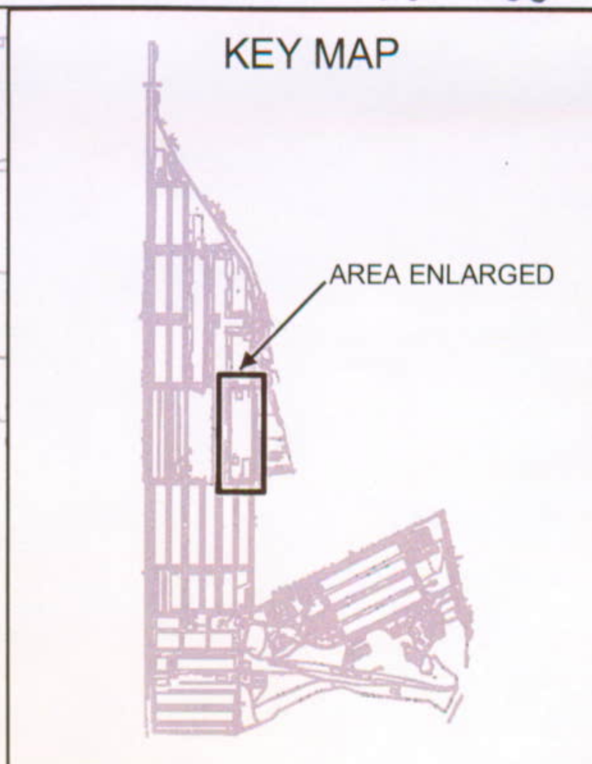
DEFENSE SUPPLY CENTER RICHMOND
RICHMOND, VIRGINIA

OU 2 TECHNICAL MEMORANDUM

OU 2 COC IN SUBSURFACE SOIL (0 - 10' bgs)
BENZO(a)PYRENE

PREPARED BY: GGH	MACTEC	FIGURE NUMBER: 2-11
CHECKED BY: THB		
PROJECT NO: 6301-05-0016		





Legend

- ● SOIL BORING SAMPLE
- ⊕ WELL BORING SAMPLE
- ▬ TEST TRENCH SAMPLE
- DMS-42 88 — SAMPLE LOCATION DESIGNATION AND CONSTITUENT CONCENTRATION (mg/kg). A "0" INDICATES A CONCENTRATION BELOW THE ANALYTICAL DETECTION LIMIT.
- ▭ OPERABLE UNIT
- EXTENT OF BENZO(b)FLUORANTHENE EXCEEDING INDUSTRIAL SOIL RISK-BASED REMEDIATION GOAL (23 mg/kg)

N

0 100 200 400

Scale in Feet

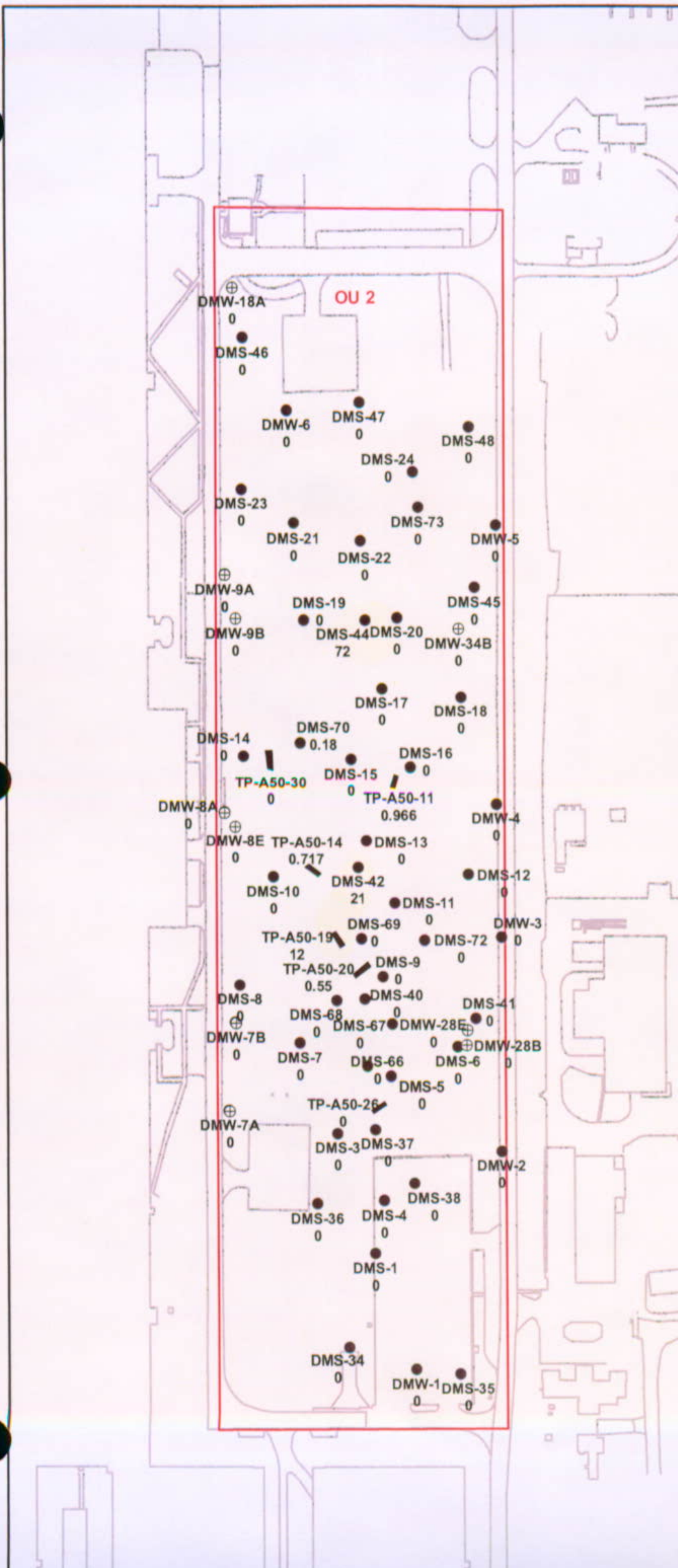
AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE

DEFENSE SUPPLY CENTER RICHMOND
RICHMOND, VIRGINIA

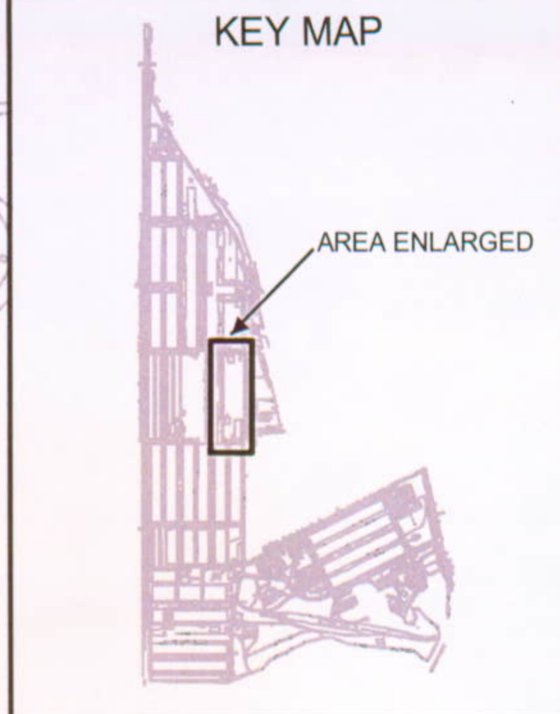
OU 2 TECHNICAL MEMORANDUM

OU 2 COC IN SUBSURFACE SOIL (0 - 10' bgs)
BENZO(b)FLUORANTHENE

PREPARED BY: GGH	MACTEC	FIGURE NUMBER: 2-12
CHECKED BY: THB		
PROJECT NO: 6301-05-0016		



KEY MAP



Legend

- ● SOIL BORING SAMPLE
- ⊕ WELL BORING SAMPLE
- ▬ TEST TRENCH SAMPLE
- DMS-42 / 21 — SAMPLE LOCATION DESIGNATION AND CONSTITUENT CONCENTRATION (mg/kg). A "0" INDICATES A CONCENTRATION BELOW THE ANALYTICAL DETECTION LIMIT.
- OPERABLE UNIT
- EXTENT OF DIBENZO(a,h)ANTHRACENE EXCEEDING INDUSTRIAL SOIL RISK-BASED REMEDIATION GOAL (2.3 mg/kg)

N

0 100 200 400

Scale in Feet

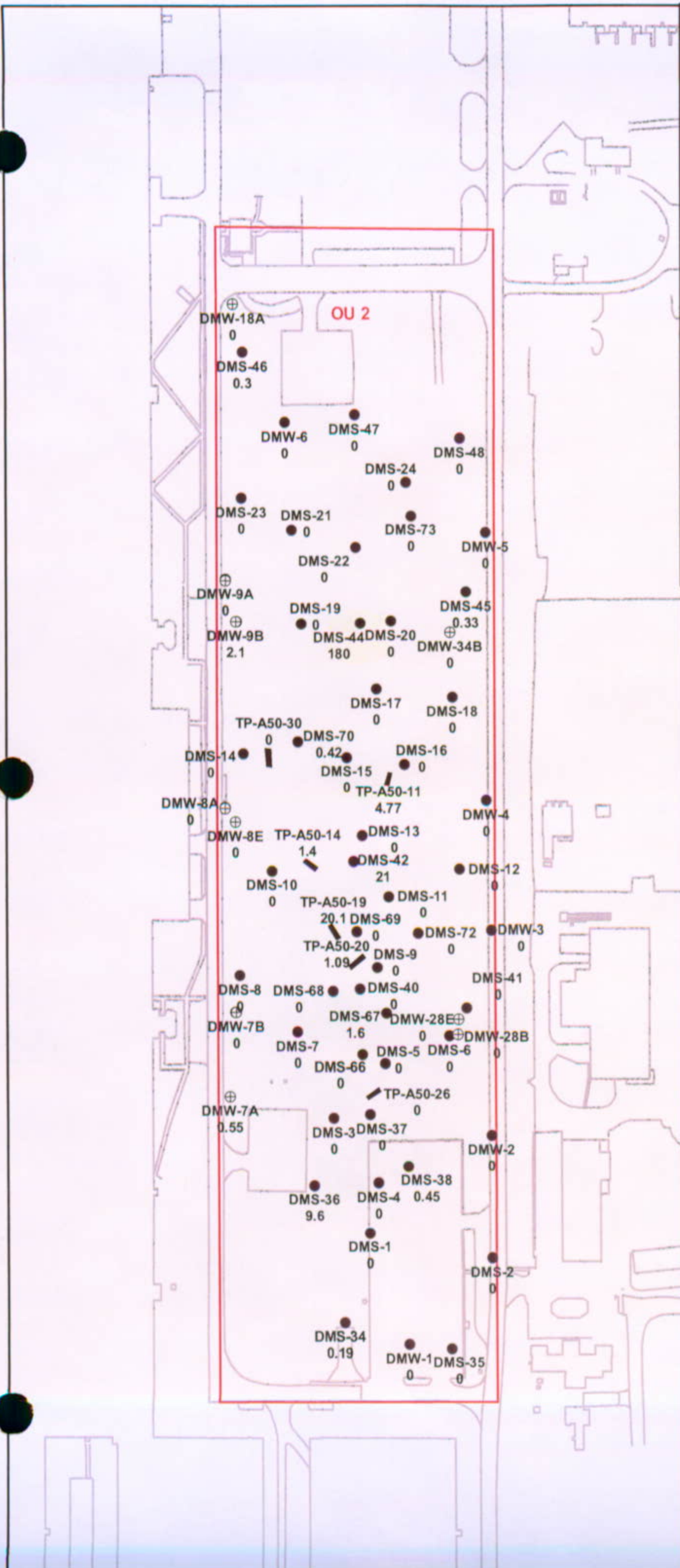
AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE

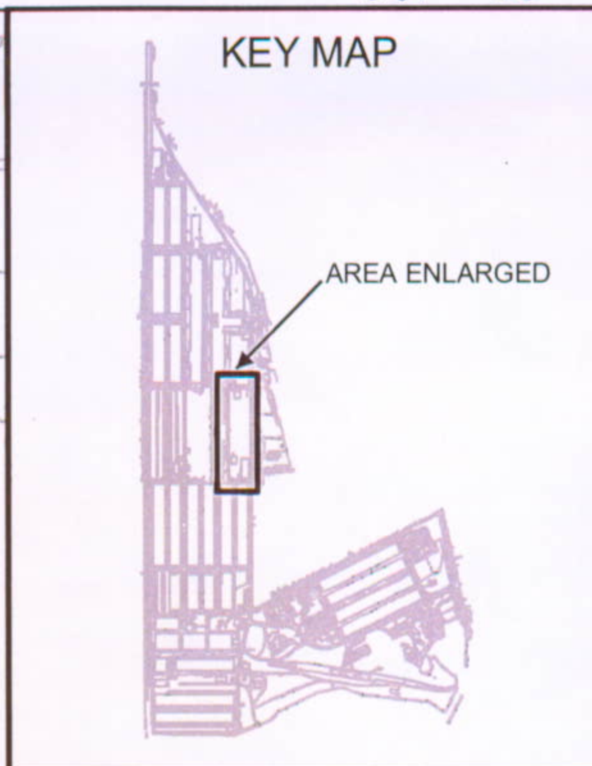
DEFENSE SUPPLY CENTER RICHMOND
RICHMOND, VIRGINIA

OU 2 TECHNICAL MEMORANDUM

OU 2 COC IN SUBSURFACE SOIL (0 - 10' bgs)
DIBENZO(a,h)ANTHRACENE

PREPARED BY: GGH	MACTEC	FIGURE NUMBER: 2-13
CHECKED BY: THB		
PROJECT NO: 6301-05-0016		





Legend

- SOIL BORING SAMPLE
- WELL BORING SAMPLE
- TEST TRENCH SAMPLE
- DMS-42 / 21 — SAMPLE LOCATION DESIGNATION AND CONSTITUENT CONCENTRATION (mg/kg). A "0" INDICATES A CONCENTRATION BELOW THE ANALYTICAL DETECTION LIMIT.
- OPERABLE UNIT
- EXTENT OF INDENO (1,2,3-cd) PYRENE EXCEEDING INDUSTRIAL SOIL RISK-BASED REMEDIATION GOAL (23 mg/kg)

N

0 100 200 400

Scale in Feet

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE

DEFENSE SUPPLY CENTER RICHMOND
RICHMOND, VIRGINIA

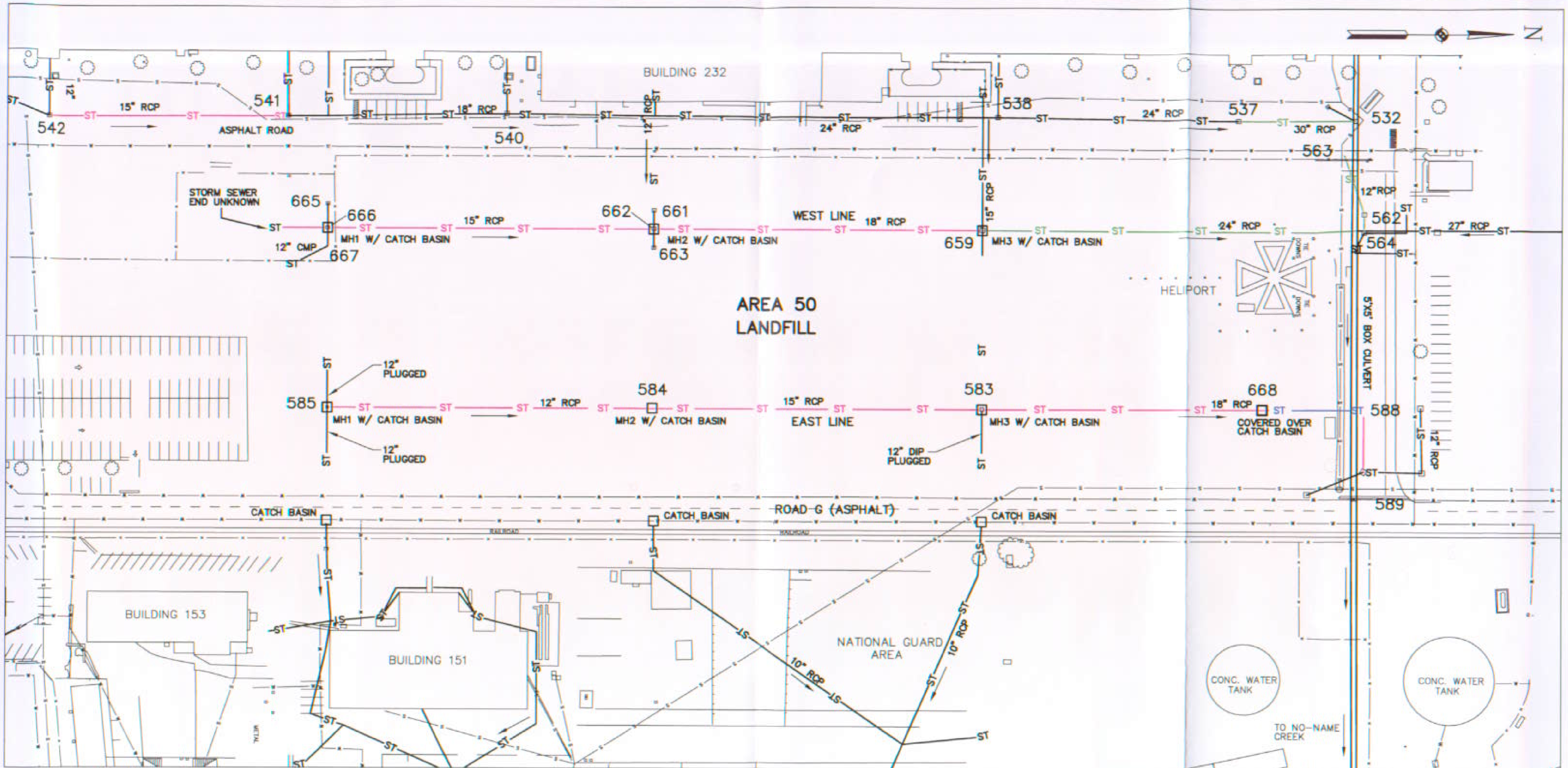
OU 2 TECHNICAL MEMORANDUM

**OU 2 COC IN SUBSURFACE SOIL (0 - 10' bgs)
INDENO(1,2,3-cd)PYRENE**

PREPARED BY: GGH	MACTEC	FIGURE NUMBER: 2-14
CHECKED BY: THB		
PROJECT NO: 6301-05-0016		

P:\...\ou2_nature_extent\ou2_indeno(123-cd)pyrene_subsurface.mxd

J:\DSCR\OU2\exist-ss-REHA-LOC.dwg 02/08/2006 3:33pm ralexand



LEGEND

ST	STORM SEWER
ST	LINED BY PVC FOLD AND FORM METHOD
ST	INTERNAL SPOT REPAIRED
ST	TEST AND SEAL
	SANITARY SEWER
	WATER LINE
	FENCE
○	SHRUB OR TREE
□	MANHOLE

RCP = REINFORCED CONCRETE PIPE
DIP = DUCTILE IRON PIPE
MH = MANHOLE

0 100 200
SCALE IN FEET

NOTE: STORM SEWER REHABILITATION PERFORMED BY AIR POWER UNDER CONTRACT TO COE.

SOURCE: ELECTRONIC FILE PROVIDED BY ANDERSON AND ASSOCIATES MARCH 1994.

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE

DEFENSE SUPPLY CENTER RICHMOND
RICHMOND, VA

OU 2 TECHNICAL MEMORANDUM

STORM SEWER REHABILITATION LOCATIONS

PREPARED BY: R.A
CHECKED BY: THB
PROJECT NO: 6301-05-0016

MACTEC

FIGURE NUMBER: 2-15

APPENDIX A

REVISED HUMAN HEALTH BASELINE RISK ASSESSMENT

847 88

FINAL
HUMAN HEALTH BASELINE RISK ASSESSMENT
OPERABLE UNIT 2

DEFENSE SUPPLY CENTER RICHMOND
RICHMOND, VIRGINIA

Prepared for:

Air Force Center for Environmental Excellence
3300 Sidney Brooks
Brooks City-Base, Texas 78235

Prepared by:

MACTEC Engineering and Consulting, Inc.
3200 Town Point Drive
Suite 100
Kennesaw, Georgia 30144

Contract No. F41624-03-D-8606
Task Order 81

28 July 2006
Revision 1

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Attachment

LIST OF ACRONYMS AND ABBREVIATIONS

95UCL	95 Percent Upper Confidence Limit on the Mean
ADD	Average Daily Dose
ADDc	Average Daily Dose for Carcinogen
ADDn	Average Daily Dose for Noncarcinogen
AT	Averaging Time
bgs	Below Ground Surface
CEM	Conceptual Exposure Model
CERCLA	Comprehensive Environmental Response, Conservation, and Liability Act
cm^2	Square Centimeters
cm/s	Centimeters per second
COC	Constituent of Concern
COPC	Constituent of Potential Concern
days/yr	Days per Year
DLA	Defense Logistics Agency
DQOs	Data Quality Objectives
DSCR	Defense Supply Center Richmond
ECR	Excess Cumulative Risk
EPC	Exposure Point Concentration
HHBRA	Human Health Baseline Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
IA	Intake Assumption
IRIS	Integrated Risk Information System
Johnson and Ettinger Model	Johnson and Ettinger Model for Subsurface Vapor Intrusion into Buildings, Version 3.1
Law	Law Engineering and Environmental Services, Inc.
MACTEC	MACTEC Engineering and Consulting, Inc.
MDC	Maximum Detected Concentration
µg/kg	Micrograms per kilogram
mg/kg	Milligram per kilogram
mg/day	Milligrams per day

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

mg/kg-d	Milligrams per kilogram per day
mg/m^3	Milligrams per cubic meter
NCEA	National Center for Environmental Assessment
ND	Nondetection
NGA	National Guard Area
OSA	Open Storage Area
OU	Operable Unit
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
RAGS-E	Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, Part E
RBC	Risk-Based Concentration
RfD	Reference Dose
RI	Remedial Investigation
SF	Slope Factor
SQL	Sample Quantitation Limit
SVOC	Semivolatile Organic Compound
TCE	Trichloroethene
URF	Unit Risk Factor
USEPA	U.S. Environmental Protection Agency
VOC	Volatile Organic Compound
WBU	Water Bearing Unit

EXECUTIVE SUMMARY

A human health baseline risk assessment (HHBRA) was conducted to evaluate the significance of potential exposures to various constituents detected in Operable Unit (OU) 2 surface and subsurface soil for current and future on-site outdoor industrial workers, future on-site construction workers, and future indoor industrial workers exposed to soil vapors in indoor air. A conservative screening assessment was performed to identify the constituents of potential concern (COPCs) in soil. Soil COPCs included aluminum, arsenic, copper, iron, vanadium, trichloroethene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, indeno(1,2,3-c,d)pyrene, and PCB-1260. Risk associated with soil-to-groundwater leaching and groundwater contact will be addressed in the OU 6 HHBRA.

No unacceptable noncancer hazards were estimated for any of the receptors. Excess cancer risk estimates for future construction workers and future indoor industrial workers were less than the Defense Supply Center Richmond (DSCR) risk goal of 10^{-4} for on-installation exposures. Table A-7-1 and Attachment 4 (Tables 4-1 and 4-2) summarize the risk estimates for the two on-installation receptors that potentially may be exposed to an unacceptable level of excess cancer risk: current and future outdoor industrial workers.

For the current industrial outdoor worker, excess cancer risks of 2×10^{-3} are associated with eight constituents of concern (COCs): arsenic, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenzo(a,h) anthracene, indeno(1,2,3-c,d)pyrene, and PCB-1260 (Table A-7-1 and Attachment Table 4-1). One-half of this risk is due to benzo(a)pyrene (1×10^{-3}). Remediation goals for the eight surface soil COCs will be developed in a Focused Feasibility Study.

For the future industrial outdoor worker, excess cancer risks of 3×10^{-4} are associated with five COCs: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-c,d)pyrene (Table A-7-1 and Attachment Table 4-2). Two-thirds of this risk is due to benzo(a)pyrene (2×10^{-4}). Remediation goals for the five surface and subsurface soil COCs will be developed in the Focused Feasibility Study.

Risk associated with surface soil COCs is an order of magnitude greater than risk due to intermixed surface and subsurface soils. Corrective action to address exposure to surface soil would greatly reduce estimated risks for both current and future soil receptors.

A-1.0 INTRODUCTION

The Air Force Center for Environmental Excellence, on behalf of the Defense Logistics Agency (DLA), contracted MACTEC Engineering and Consulting, Inc., (MACTEC) to prepare a human health baseline risk assessment (HHBRA) for the Defense Supply Center Richmond (DSCR) former Area 50 Landfill, designated as Operable Unit (OU) 2. DSCR, a primary field-level activity of DLA, is located in Chesterfield County, Virginia (Figure A-1-1). The installation is a National Priority List site and is therefore regulated by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended. A baseline risk assessment was originally conducted for the former Area 50 Landfill in the *Remedial Investigation for Area 50, Open Storage Area, and National Guard Area* (Dames & Moore, 1989) and last revised in the *Third Revised Final Focused Feasibility Study Report for Area 50 Landfill Source Area-Operable Unit 2* (Law, 1999). This report presents an updated HHBRA performed for an industrial land use scenario. Although the previous HHBRA for OU 2 included the evaluation of a residential scenario, DLA and DSCR plan to limit future risk evaluations to an industrial land use scenario based on current and anticipated future land use at the installation.

A.1.1 PURPOSE AND OBJECTIVES

The installation is under the jurisdiction of DLA and is assessed and managed in accordance with CERCLA and Defense Environmental Restoration Program protocols, with lead regulatory review by the United States Environmental Protection Agency (USEPA) Region 3 and the supporting secondary Virginia Department of Environmental Quality. The primary objective is to protect human health and the environment at sites with potential risks from past chemical releases

The purpose of this HHBRA is to determine whether constituents related to activities and detected in soil pose an unacceptable health hazard or risk for potentially exposed on-site industrial workers and construction workers, under "as is" baseline conditions (i.e., without future, active remedial measures). Ecological impacts at OU 2 are not of concern due to the industrial nature of the site and the site access restrictions.

A.1.2 BACKGROUND INFORMATION

The following sections present background information for DSCR and OU 2.

A.1.2.1 Description

The installation is located in Chesterfield County, Virginia, approximately 8 miles south of the city of Richmond and 12 miles north of the city of Petersburg. The general layout is shown in Figure A-1-1. Land use in Chesterfield County near the installation is primarily single-family residential, intermixed with retail stores and light industry. DSCR is the major industry in the area. The future land use of the installation is expected to remain industrial.

OU 2 is located in the central region of DSCR between the Open Storage Area (OSA) and the National Guard Area (NGA), as shown in Figure A-1-2. OU 2 comprises approximately 13 acres and formerly contained a low-lying ravine approximately 200 feet by 800 feet by 10 feet deep consisting of wet soils, trees, shrubbery, and wild grasses. OU 2 is also the location of a former landfill that is suspected to be a contributing source of impacted groundwater at OU 6. Buried storm sewer lines for the stormwater drainage system transect OU 2 and provided potential migration pathways until the relining of the system was completed in 2005. These storm sewers originate in the OSA and convey stormwater from OU 1 and OU 2 to an outfall located along the northeastern boundary of the NGA (Figure A-1-3). This outfall discharges the stormwater to No Name Creek, which flows to the south along the eastern boundary of the NGA. The creek ultimately discharges into the James River approximately 2 miles from the installation.

A.1.2.2 Local Geology and Hydrogeology

The United States Geological Survey has divided the unconsolidated soils below OU 2 into five separate formations:

- The surface soils are primarily of fill material, ranging form approximately 0 to 5 feet below ground surface (bgs) in depth.
- The Eastover Formation occurs immediately below the surface soil zone and consists of silty sand, sandy silt, and silty or fat clay. The top of the unit is at the ground surface, and the bottom of the unit is approximately 12 to 25 feet bgs. The thickness of this unit is approximately 12 to 25 feet.
- The Calvert Formation consists of poorly graded sand with gravel, interlayered with poorly graded gravel. The top of the unit is approximately 12 to 25 feet bgs, and the bottom of the unit is approximately 16 to 30 feet bgs. The thickness of this unit is 0 to approximately 10 feet. The unit is present throughout most of Zone 2 (OUs 1, 2, and 3) and is absent in the southeastern portion of the zone.
- The Aquia Formation consists of silty and/or fat clay. The top of the unit is approximately 16 to 30 feet bgs, and the bottom of the unit is approximately 25 to 41 feet bgs. The thickness of this unit is approximately 3 to 27 feet. This unit is present

throughout Zone 2 and is beneath the poorly graded sand with gravel unit where it is present in Zone 2.

- Alluvial sediments of the Potomac Formation underlie the Calvert and Aquia Formations. This formation consists of poorly graded sand with gravel and silty sand, poorly graded sand with gravel, and/or poorly graded sand with gravel interlayered with poorly graded gravel. The top of the unit is approximately 25 to 41 feet bgs, and the bottom of the unit is approximately 42 to 72 feet bgs. The thickness of this unit is approximately 10 to 37 feet. This unit is present throughout Zone 2.

The fining-upward stratigraphic sequences indicate fluvial or marine environments of deposition for the coastal plain sediments. Beneath the coastal plain sediments, from approximately 42 to 72 feet bgs, is saprolite weathered from the underlying Petersburg Granite bedrock. Bedrock was encountered in three borings at depths of 94 to 106 feet bgs. The thickness of saprolite in these borings was 18 to 40 feet (Law, 1999).

An unconfined water bearing unit (WBU) lies beneath OU 2 in the unconsolidated sediments of the Eastover Formation. The unconfined WBU is referred to as the upper WBU in this report to distinguish it from a confined or semiconfined lower WBU that exists in the Potomac Formation. The upper WBU would be the first unit impacted by surface releases from OU 2.

The average depth to upper WBU groundwater typically ranges from approximately 7 feet in the southern portion of OU 2 to 22 feet in the north. Calculated horizontal hydraulic conductivity values (k) from slug tests performed by Dames & Moore in the high-permeability zone of the upper WBU ranged between 1.52×10^{-3} to 9.12×10^{-3} centimeters per second (cm/s) with an average of 5.56×10^{-3} cm/s. The horizontal velocity was estimated to be 180 feet per year with a hydraulic gradient (I) of 0.0095 and porosity (n) of 0.3 (Dames & Moore, 1989).

A.1.2.3 Nature and Extent of Impacts

The former ravine was reported to have been used as a disposal site for liquid chemicals used in photographic development processes, organic solvents, petroleum oils, and other unidentified chemicals. Investigations conducted at OU 2 have identified that the former ravine area was used for disposal and was the probable primary source of groundwater impacts to the upper WBU at OU 6. The following section summarizes the investigation activities and their results.

Since March 1982, groundwater and soil sampling and analysis programs have been performed at DSCR to evaluate the magnitude and extent of impacts within OU 2 and at downgradient locations.

A geophysical survey conducted in April 1984 as part of the site assessment identified potential areas of impacts within OU 2. Iron sources were also identified during this survey using a magnetometer. From September 1984 to November 1988, 128 soil samples were collected and analyzed from 69 soil borings (Figure A-1-2). The soil samples were selectively analyzed for metals, volatile and semivolatile compounds, and other organic constituents. The complete analytical results are included in the Remedial Investigation (RI) Report (Dames & Moore, 1989).

The following summary is based on a review of the soil analytical data in the RI (Dames & Moore, 1989):

- Semivolatile organic compounds (SVOCs) were the predominant constituent group encountered in the soil samples collected from OU 2. These constituents were detected in soils to a depth of 23.5 feet bgs. SVOCs were detected most frequently and at the highest concentrations in the 0- to 2-foot soil depth interval. Samples from soil borings DMS-36 and DMS-44 showed higher than expected concentrations of total SVOCs at 311 and 5,844 mg/kg, respectively. The vertical extent of these constituents was unexpected in consideration of the reported "clean fill" covering the OU as stated in the RI Report (Dames & Moore, 1989). At the 2- to 6-foot soil interval, the areal extent of SVOCs appeared to decrease significantly, and observed concentrations were generally lower than observed at the 0- to 2-foot interval. In summary, the primary concentration of SVOCs occurs in the upper 6 feet. The most consistent concentration with respect to depth occurs in the vicinity of borings DMS-40 northward to DMS-13, where SVOCs were detected to a depth of 23.5 feet bgs.

- Volatile organic compounds (VOCs) were detected in soil samples from DMS-69, located in the central portion of OU 2 (Figure A-1-2). The highest concentrations were associated with constituents commonly found to be laboratory contaminants (acetone, 2-butanone, methylene chloride, 4-methyl-2-pentanone). Other VOCs detected at low concentrations at this location are considered site-related, including trans-1,2-dichloroethene (0.55 micrograms per kilogram [μg/kg]), toluene (0.55 μg/kg), and trichloroethene (0.70 μg/kg). Generally, no other significant VOC detections occurred from soil borings other than those associated with laboratory and analytical methods.

- Aroclor-1260 was detected in one sample (DMS-44) at 47.0 mg/kg at a depth of 2 feet bgs.

- Concentrations of inorganic constituents varied widely among soil samples collected from OU 2. Inorganics naturally occur in the soils based on background comparisons.

In 1994, Law Engineering and Consulting, Inc. (Law) completed exploratory trenching to further investigate five geophysical anomalies identified during the RI and identify potential sources of continuing groundwater impacts. A total of 30 trenches were installed within the five anomalies (Figure A-1-2). The trenching activities identified construction and demolition debris (concrete, asphalt, bricks, and metal, including rebar). A number of spent ordnance and explosives were encountered along with scrap metal, particularly automotive parts, in the northern portion. Various small chemical containers were also encountered; however; no large containers were found. Chemicals discovered included photographic chemicals (thiourea and glycerine) and cleaning chemicals (disinfectant and ammonia). Free-phase petroleum product was observed during the 1994 exploratory trenching in four trenches (TP-A50-17, 19, 21, 24). To further define the areal extent of the observed free product, temporary wells were installed upgradient and downgradient of these trenches. Free-product levels (approximately 0.1 inch in thickness) were detected in the upgradient wells only.

No specific measurements of free product thickness are available from the exploratory trenching; however, several inches of free product in the open trenches were observed and reported. Additionally, visual observation suggested that the physical characteristics of the free product corresponded to that of motor or light lubricating oil. Analytical data for the free product is not available; however, petroleum-impacted soil sampled from one test pit contained toluene, carbon tetrachloride, phenanthrene, and bis(2-ethylhexyl)phthalate (Law, 1995).

SVOCs and VOCs were also detected in several soil samples collected from trenches. These samples consisted primarily of polycyclic aromatic hydrocarbons (PAHs) and trichloroethene (TCE). The trenching activities performed in 1994 were fully documented in the *Final Exploratory Trenching Characterization Report for Area 50 Landfill* (Law, 1995).

To address the constituents identified during the trenching activities performed in 1994, a *Draft Action Memorandum, Area 50 Service Area – Operable Unit 2, Interim Removal Action* (Law, 1998) was prepared and submitted for regulatory comment in July 1998. As a result of the proposed removal action memorandum, additional field activities were performed during October 1998 to delineate the suspected areas of petroleum hydrocarbon. These activities were performed by HydroGeoLogic, Inc. under contract to the U.S. Army Corp of Engineers Norfolk Division. A full description of these field activities can be found in the *Draft Technical Report for the Liquid Petroleum Hydrocarbon Delineation and Removal at Area 50* (HydroGeoLogic, 1998).

The delineation performed by HydroGeoLogic in 1998 consisted of installing 26 soil testing borings. The constituents identified during the HydroGeoLogic delineation consisted primarily of petroleum hydrocarbons. The results indicated a maximum concentration of diesel fuel at 4,856 mg/kg in boring HGL-SB-05, and a maximum concentration of heavy oil at 12,288 mg/kg in boring HGL-SB-01. Unknown hydrocarbons were detected in samples HGL-SB-20 and HGL-SB-14 at concentrations of 57.6 and 70.1 mg/kg, respectively. The remainder of the compounds consisted of gasoline, jet fuel, kerosene, mineral oil, naphthalene, paint thinner, and Stoddard solvent, which were all below their respective detection limits (HydroGeoLogic, 1998).

A.1.3 CERCLA RISK ASSESSMENT PROCESS

This HHBRA was performed in accordance with USEPA guidance for conducting CERCLA risk assessments (USEPA 1989, 1991, 2003a, 2003b, 2004). This document supplements the Focused Feasibility Study for OU 2. This HHBRA was based on the *Final Revised Human Health Risk Assessment Work Plan* (MACTEC, 2006).

The CERCLA risk assessment protocol includes the following steps:

- Data Evaluation
- Exposure Assessment
- Toxicity Assessment
- Risk Characterization
- Uncertainties Analysis

In the data evaluation, available chemical data are reviewed. The data selected for use comprise the risk assessment dataset. Once this dataset has been established, a Conceptual Exposure Model (CEM) is developed to identify potential exposure pathways. The risk assessment data undergo a conservative screening process to identify constituents of potential concern (COPCs). This process involves comparing the maximum detected concentrations (MDCs) with appropriate screening criteria. COPCs are the focus of the site-specific HHBRA.

In the exposure assessment, COPC concentrations are mathematically combined with "intake assumptions" (IAs) and average daily doses (ADDs) for each COPC, receptor, and pathway. COPC concentrations are determined statistically for each applicable medium. Statistics are used to identify the 95 percent upper confidence limit on the mean (95UCL) detected concentrations. These 95UCLs are then compared with the MDCs, and the lesser of the two is selected for subsequent use in the HHBRA per USEPA (1989 and 2002a) guidance.

In the toxicity assessment, toxicity values are obtained from appropriate regulatory sources. These values are necessary to evaluate both noncarcinogenic and carcinogenic health effects from potential exposures to COPCs (via the pathways identified in the CEM). Toxicity values reflect the "dose-response" behavior for each COPC by toxicity type (i.e., carcinogenic or noncarcinogenic [systemic effects]).

In the risk characterization, the ADDs (computed in the exposure assessment) are combined with the dose-response values (identified in the toxicity assessment) to predict the site-specific health effects for each receptor, pathway, and COPC. These individual responses, in the form of noncarcinogenic "hazard quotients" (HQs) or individual cancer risks, are then summed to give the total noncarcinogenic "hazard index" (HI) and cumulative risk. Calculated values are compared to levels considered acceptable by regulatory agencies. If the HI and cumulative risk exceed acceptable levels, the contributing chemicals are identified as constituents of concern (COCs). Should COCs be identified, a subsequent remedial action plan may present target cleanup levels based on risk.

In the uncertainties analysis, the variabilities associated with each step (including computations, methods, and assumptions) are identified and evaluated. The goal of this analysis is to qualify the level of conservatism in the HHBRA results (i.e., estimated levels over- or underestimate actual risk) so that managers may make sound decisions regarding the need for remedial action.

A-2.0 DATA EVALUATION

Soil and groundwater data were collected during numerous field investigation activities. During the data evaluation, the site data were reviewed, data were selected for use in the HHBRA, and the COPCs were identified.

A.2.1 DATA COLLECTION

Data has been collected since the 1980s to characterize the environmental conditions at OU 2. Environmental media that were sampled include groundwater, surface and subsurface soils, and sediments. These samples were analyzed for most of the common chemical classes, including:

- Metals and inorganic compounds (including hexavalent chromium)
- VOCs
- SVOCs
- Organochlorine pesticides (e.g., dichlorodiphenyltrichloroethane)
- Polychlorinated biphenyls (PCBs)
- Petroleum hydrocarbons (i.e., diesel, gasoline, jet fuel, kerosene, mineral oil, paint thinner, naphtha, and Stoddard solvent)
- 2,4-Dinitrotoluene

Soil samples have been collected using various techniques, including direct push methods and auger drilling, and analyzed according to the sampling and analysis procedures appropriate to the collection period (Law, 1992; MACTEC, 2004). Based on the explosive materials reportedly disposed at this site, perchlorates were not included as analytes for soil or groundwater samples.

A.2.2 RISK ASSESSMENT DATASETS

The initial component of the HHBRA began with the evaluation of historical chemical data to determine which were appropriate for use in the risk assessment (USEPA, 1989). The risk assessment datasets comprised those chemicals detected in at least one sample not excluded by the following data selection rules and conservatively assumed to be present due to historical activities attributable to OU 2. The risk assessment dataset contained the chemicals evaluated during the COPC identification process.

Several data selection rules were applied to the total chemical soil dataset (Attachment 1). The data selection rules, which were developed based on the Data Quality Objectives (DQOs) for the project (Law, 1992; MACTEC 2003), are as follows:

- Due to the long history of data collection at the installation, the database potentially contained aged analytical results that were not representative of current conditions. According to the *Final Revised Human Health Risk Assessment Work Plan* (MACTEC, 2006), soil data collected prior to 1992 have not been independently validated in accordance with current validation practices and were not to be used; however, due to the low number of samples collected since 1992, soil data used in the RI (1984 through 1988) were also included in the risk assessment dataset.

- Data for essential nutrients that did not have a USEPA Region 3 Risk-Based Concentration (RBC) for comparison (i.e., calcium, potassium, chloride, and sodium) were not included in the risk assessment dataset (USEPA, 1989).

- Organic data qualified as "B" ("result is estimated due to blank contamination") were removed. Organic data that were B-qualified represented analytical results that were less than 5 or 10 times the concentration detected in the associated laboratory and/or field blank, depending on the constituent (USEPA, 1989). All data qualified with "R" ("unusable") were also removed. The determination to flag specific data points was previously made (MACTEC, 2004) in accordance with regional and national USEPA data validation procedures (USEPA, 1992, 1994, 2000, 2001).

- Data for chemicals for which all results were below the sample quantitation limit (SQL) were removed.

- "Technical chlordane" data was combined with alpha- and gamma-chlordane. This was done because technical chlordane and alpha- and gamma-chlordane were analyzed in separate samples. Alpha- and gamma-chlordane data were summed in the same samples before being combined with the technical chlordane data. Screening levels were compared to total chlordane results, and risk was calculated for total chlordane.

- When a duplicate pair of samples was present in the dataset, the duplicate and original results were averaged. If one of the pair had a nondetect result, then the SQL for that sample was halved and added to the other result to obtain an average. The average result was used to calculate the exposure point concentration (EPC).

Data not excluded by one or more of the rules defined above represented the risk assessment dataset. These data are summarized in Tables A-2-1 and A-2-2 and presented in Attachment 1.

As shown in Table A-2-1, 18 metals/inorganics, 6 VOCs, 5 SVOCs, 14 PAHs, 5 pesticides, and 1 PCB comprised the soil risk assessment dataset for surficial soils. For subsurface soils (Table A-2-2), 22 metals/ inorganics, 27 VOCs, 10 SVOCs, 18 PAHS, 5 pesticides, 1 PCB, and total petroleum hydrocarbons comprised the soil risk assessment dataset.

As Table A-2-1 shows, with the exception of acetone and methylene chloride, the risk assessment dataset for surface soil comprised at least 15 analyses for each detected constituent. There were 9 valid analyses for acetone and 7 analyses for methylene chloride. Table A-2-2 shows, with the exception of

6 constituents, the risk assessment dataset for subsurface soils comprised between 27 and 56 analyses for each detected constituent. Molybdenum was included as an analyte once; 1,1,2 trichloroethene was analyzed 8 times; total 1,2-dichloroethene was analyzed 11 times; carbazole and 2,4-dichlorophenol were analyzed 6 times; and p-isopropyltoluene was analyzed twice. Except for molybdenum and p-isopropyltoluene data were sufficient (four per analyte) to complete statistical analyses.

A.2.3 CONCEPTUAL EXPOSURE MODEL

The CEM was developed considering the risk assessment datasets, the current and anticipated future land use, and site features. The CEM is a tool to identify the exposure pathways for HHBRA evaluation. The CEM is shown in Figure A-2-1 and is discussed below.

An exposure pathway is the mechanism by which receptors may come into contact with COPCs. A pathway has four sequential components, defined by USEPA (1989) as follows:

- A source and mechanism of chemical release (e.g., chemical use at the installation)
- A retention or transport medium
- An exposure route (e.g., ingestion)
- A receptor

For any site, there are three possible types of exposure pathways:

- Incomplete pathways
- Complete but likely insignificant pathways
- Complete and potentially significant pathways

Consistent with USEPA (1989 and 2001a) recommendations, only complete and potentially significant pathways were evaluated in the HHBRA. The exposure pathways considered in this HHBRA are summarized in Table A-2-3.

A.2.3.1 Complete Exposure Pathways

For an exposure pathway to be considered complete, all four of the previously listed components must be present (USEPA, 1989). As an example, Figure A-2-1 shows that incidental ingestion of stormwater runoff is an incomplete pathway for the outdoor industrial and construction worker receptors because the storm sewers are underground and workers are assumed not to come into contact with stormwater runoff at OU 2. Although this pathway satisfies the first two components, there is no exposure point, resulting in an incomplete pathway.

A.2.3.2 Significant Exposure Pathways

In addition to the criterion of pathway completeness, the potential significance of a complete pathway is also considered. That is, an exposure pathway may be considered complete, but after consideration it is unlikely to significantly contribute to the overall chemical exposures a receptor may receive. Insignificant pathways may have multiple media transfer steps that tend to dilute and reduce the chemical concentration that ultimately reaches a receptor exposure point. An example of this type of pathway is inhalation by off-installation residential receptors of chemicals bound to suspended, airborne dusts.

Given the above information and the CEM in Figure A-2-1, the following complete and potentially significant pathways were identified for evaluation in the HHBRA for the current and future on-site industrial worker and the future on-site construction worker. While current industrial workers are assumed to have direct-contact with surface soils only, future conditions may allow for mixing of subsurface and surface soils during construction and/or regrading. Therefore, future on-site receptors are assumed to be exposed to both subsurface and surface soils. There are no current on-site construction workers or off-installation residential receptors. The nearest off-installation residents are located to the south and east in Rayon Park, less than 50 feet from OU 2.

<u>On-site Current Outdoor Industrial Worker</u>

- Incidental ingestion of shallow soil via direct contact
- Dermal contact with shallow soil via direct contact
- Inhalation of fugitive dusts derived from shallow soil

<u>On-site Future Outdoor Industrial Worker</u>

- Incidental ingestion of surficial and subsurface soil via direct contact
- Dermal contact with surficial and subsurface soil via direct contact
- Inhalation of fugitive dusts derived from surficial and subsurface soil
- Inhalation of volatile emissions from surficial and subsurface soil

<u>On-site Future Construction Worker</u>

- Incidental ingestion of surficial and subsurface soil via direct contact
- Dermal contact with surficial and subsurface soil via direct contact
- Inhalation of fugitive dusts derived from surficial and subsurface soil

- Inhalation of volatile emissions from surficial and subsurface soil

On-site Future Indoor Industrial Worker

- Inhalation of vapors from volatile compounds in the soil due to indoor vapor intrusion

The on-site industrial worker receptor was conservatively assumed to work outdoors for the full workday. Any time spent indoors would reduce direct soil exposures. Two additional pathways were included because volatile COPCs are present in subsurface soil. The additional pathways consider the potential for volatilization from soil to outdoor air and vapor intrusion into an indoor work space. Note that groundwater exposure pathways are not evaluated in OU 2 because the groundwater underlying OU 2 soils will be addressed as part of the OU 6 HHBRA.

A.2.4 CONSTITUENTS OF POTENTIAL CONCERN

COPCs are those constituents that are likely to contribute most significantly to the overall health risk. Conservative screening criteria are applied to the risk assessment dataset, COPCs are identified, and other chemicals eliminated from further evaluation. This process focuses the risk assessment on those chemicals most likely to contribute to an unacceptable risk.

One screening criterion was used to identify soil COPCs: comparison of MDCs with health-based screening values that address direct contact with soils. The potential for future leaching of soil constituents to groundwater is addressed in the OU 6 HHBRA. The dataset was statistically compared with the installation-wide background groundwater dataset, but the comparison was not used as a method of eliminating potential COPCs (Attachment 2).

Before these COPC criteria are further described and implemented, the operational history is presented to provide perspective.

A.2.4.1 Operational History

From the early 1960s to the early 1970s, the area was reported to have been used as a disposal site for outdated or damaged containers of stock chemicals and/or construction debris. The former ravine area was also used for the disposal of bulk liquids and containers containing toxic or reactive chemicals from photographic development processes, organic solvents, pesticides and herbicides, acid and alkaline chemicals, petroleum oils and lubricants, PCBs, and other unidentified chemicals.

The original land surface has been altered by grading and filling operations. By 1975, the entire former landfill area had been graded to street level, seeded, and re-vegetated. Transformers containing PCBs were stored in the southwestern portion of the OU for approximately 18 months, from 1982 to 1983 (Dames & Moore, 1989). In addition, a parking area is located in the southeastern portion of OU 2.

A.2.4.2 Soil Screening Criteria

Various regulatory agencies have developed health-based screening values. These screening values are allowable soil chemical concentrations mathematically associated with acceptable non-cancer target hazards and cancer target risks. Because of the conservative methods and assumptions used to develop these screening values, they can be used at any generic site to identify COPCs. For OU 2, the industrial soil RBCs provided in the USEPA Region 3 RBC tables (USEPA, 2006) were used as risk-based screening criteria for selecting soil COPCs. RBCs are acceptable soil concentrations that address risks due to direct-contact exposures (i.e., incidental soil ingestion). An evaluation of soil's potential to leach to groundwater will be included in the OU 6 HHBRA.

Because receptors are typically exposed to multiple COPCs, soil RBCs associated with noncarcinogenic toxicity were divided by a factor of 10 to correspond to an HQ of 0.1. No such adjustment is necessary for Region 3 RBCs based on carcinogenic risk because they are based on an excess cancer risk (ECR) of 1×10^{-6} (1 in 1 million).

A.2.4.3 Use of Background Data

The Mann-Whitney test, a variation of the Wilcoxon Rank Sum test, was used to compare data to the installation background data (USEPA, 2002a). This test involves the "null hypothesis" and the determination of single or multiple data populations, based on a desired statistical confidence level; the 95 percentile ($\alpha = 0.05$) was used for all Mann-Whitney tests. The output from these tests is included in Attachment 2, and the results are shown in Tables A-2-1 and A-2-2. The results of the background comparison indicated that aluminum, copper, iron, and vanadium site concentrations are consistent with background. These background comparisons helped identify potential risks from installation-related activities, but they were not used as a means to eliminate constituents as COPCs.

A.2.4.4 Identification of Soil COPCs

A total of 11 constituents (3 metals, 7 PAHs, and 1 PCB) were detected at concentrations greater than their respective RBCs for surficial soils. These 11 constituents were identified as direct-contact COPCs in surface soils (Table A-2-1). A total of 16 constituents (5 metals, 3 VOCs, 7 PAHs, and PCB-1260) were detected at concentrations greater than their respective RBCs for subsurface soils, and they were identified as direct-contact COPCs in subsurface soils (Table A-2-2). Chemicals selected as direct-contact soil COPCs include aluminum (subsurface only), arsenic, copper, iron, vanadium (subsurface only), total 1,2-dichloroethene (subsurface only), TCE (subsurface only), vinyl chloride (subsurface only), benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, indeno(1,2,3-c,d)pyrene, and PCB-1260.

A-3.0 EXPOSURE ASSESSMENT

The exposure assessment for this HHBRA was conducted in accordance with the *Final Revised Human Health Risk Assessment Work Plan* for DSCR (MACTEC, 2006). ADDs were estimated for each toxicity endpoint (i.e., cancer or noncancer), COPC, pathway, and receptor per exposure unit. An exposure unit is an area in which people might move around while performing activities and, in doing so, might be exposed to substances in environmental media. Sampling results allow risk managers to determine the ADD that an individual could receive over time through exposure to an area.

The ADD for a COPC includes two components: IAs and EPCs for each exposure medium. IAs include parameters such as ingestion rate, body weight, and exposure duration. Both the EPC and the IA components of the ADD may be receptor- and pathway-specific. The EPC is the chemical concentration that a receptor may contact at a specific location (i.e., the "exposure point"). The EPCs developed for the OU 2 HHBRA were based on directly measured data.

ADDs are computed separately for noncarcinogens and carcinogens. The difference between noncarcinogenic ADDs (ADDn) and carcinogenic ADDs (ADDc) is in the averaging time (AT). For noncarcinogens, the AT is equal to the exposure duration for that particular receptor, while the AT for carcinogens is set equal to a human lifetime (70 years or 25,550 days).

A.3.1 EXPOSURE POINT CONCENTRATIONS

The analytical results for the COPCs include both detections and nondetections (NDs) (i.e., the constituent is not detected above the SQL). Where analytical results are reported as ND, the ND concentrations are estimated to be equal to one-half of the sample quantitation limit (USEPA, 2002a). The detected values, along with the one-half SQL values, comprise the statistical datasets. The lesser of the MDC and the 95UCL concentration is used as the EPC for each COPC. The use of the lesser of the MDC and the 95UCL concentration is consistent with the USEPA CERCLA protocol for conducting site-specific, reasonable maximum exposure risk assessments (USEPA, 1989 and 2002d).

ProUCL, Version 3.0, a USEPA statistical package, computes UCLs using a variety of methods and then recommends which method (and value) is "best" based on statistical tests of the dataset. Results of the statistical analysis are presented in Attachment 2. EPCs for each receptor pathway are summarized in Table A-3-1.

To evaluate the indirect pathways addressed in this HHBRA, two dust models were used to estimate dust chemical EPCs for the industrial worker and the construction worker. These models are discussed in the *Final Revised Human Health Risk Assessment Work Plan* (MACTEC, 2006). Table A-3-1 shows the use of the ambient Particle Emissions Factor in developing EPCs for the dust pathway.

MACTEC used USEPA's *Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils* (USEPA, 2002c) for guidance in evaluating the vapor intrusion pathways. In accordance with this guidance document, the USEPA *Johnson and Ettinger Model for Subsurface Vapor Intrusion into Buildings, Version 3.1* (the Johnson and Ettinger Model) was used to calculate an estimated indoor air concentration associated with exposure to VOCs in subsurface soils via the indoor air vapor intrusion pathway (USEPA, 2002c).

The Johnson and Ettinger Model incorporates both convective and diffusive mechanisms for estimating vapor transport from either subsurface soils or groundwater into indoor spaces directly above the source. The model is a one-dimensional analytical solution to vapor transport into indoor spaces, relating the vapor concentration in the building to the vapor concentration at the subsurface soil source area. Model inputs include chemical properties of the constituent, saturated and unsaturated zone soil properties, and structural properties of the building. Site-specific information was used for soil parameters (based on site boring logs). The air exchange rate for commercial/industrial buildings was based on the literature (ASTM, 2002). ASTM recommends an air exchange rate of 0.83 exchange per hour for commercial/ industrial buildings. Otherwise, site-specific or model default assumptions (protective of occupational receptors) were assumed. The assumptions used are in shown Table A-3-2.

The point of potential exposure was assumed to be a hypothetical future office building constructed over the former ravine (approximate size: 200 feet by 200 feet). This structure was assumed to be on a slab foundation rather than a basement foundation. The Johnson and Ettinger Model was used to estimate the indoor air concentration ($C_{building}$) in the calculation of ADDs. The long-term on-site receptor for this exposure route was assumed to be an indoor industrial receptor. An exposure duration of 25 years and exposure frequency of 250 days per year were used in the model (USEPA, 1991) for industrial receptors. The Johnson and Ettinger Model results are provided in Attachment 2, and the $C_{building}$ terms are listed in Table A-3-1.

A.3.2 INTAKE ASSUMPTIONS

IAs are exposure assessment input values that are receptor- or behavior-specific. Examples include the water ingestion rate, inhalation rate, and exposed skin surface area. IAs were obtained from appropriate regulatory guidance or were based on professional judgment. Table A-3-2 shows the IAs used for the outdoor industrial worker, the construction worker, and the indoor industrial worker and presents the basis for selection.

Table A-3-3 shows the IAs for the outdoor industrial worker. Current outdoor industrial workers were assumed to be exposed only to surficial soils while performing their activities. Future outdoor industrial workers were assumed to be exposed to both surface and subsurface soils from the redistribution of soil during construction activity. These workers were assumed to incidentally ingest soil at the rate of 100 mg/day (USEPA, 2002b). The outdoor industrial worker was assumed to have an exposed skin surface area of 3,300 square centimeters (cm^2) (USEPA, 2002b, 2004). In accordance with USEPA guidance, industrial worker activities were assumed to occur for 25 years, 225 days per year (days/yr) (USEPA, 2002d).

Table A-3-3 shows the IAs for construction workers who were assumed to be exposed to site soils encountered between 0 and 10 feet bgs during subsurface excavations. In accordance with USEPA guidance, these workers were assumed to incidentally ingest soil at the rate of 330 mg/day (USEPA, 2002b), and the construction worker was assumed to have an exposed skin surface area of 3,300 cm^2 (USEPA, 2004). Construction was assumed to occur for 0.5 year, and the workers were assumed to be exposed for half of a year's working days (250 days/yr) (site-specific assumption based on professional judgment).

Table A-3-3 also shows the IAs for the indoor industrial workers. These workers were assumed to inhale vapors from VOCs detected in subsurface soils. The workers were assumed to be exposed 250 days/yr over a period of 25 years (USEPA, 1991).

A.3.3 AVERAGE DAILY DOSES

The ADD calculations are provided in Attachment 3. Attachment Table 3-1 lists the dermal absorption factors for soil that were used in the risk characterization. Attachment Tables 3-2 through 3-11 show the results of the ADD computations for both noncarcinogenic and carcinogenic COPCs for on-site receptors.

A-4.0 TOXICITY ASSESSMENT

In the toxicity assessment, values necessary to evaluate both noncarcinogenic and carcinogenic effects associated with the COPCs are identified using USEPA's hierarchy for toxicological information (USEPA, 2003c). USEPA's Integrated Risk Information System (IRIS) is used as the primary source of toxicity data; if data are unavailable on IRIS, values proposed by the National Center for Environmental Assessment (NCEA) are used (USEPA, 2006).

A.4.1 NONCARCINOGENIC TOXICITY

Noncarcinogenic toxicity is evaluated using reference doses (RfDs). RfDs are expressed in milligrams per kilogram per day (mg/kg-d). Inhalation RfDs may be derived from reference concentrations (RfCs), which are expressed in milligrams per cubic meter (mg/m^3). Table A-4-1 presents the noncarcinogenic toxicity values used for risk characterization of the soil COPCs.

A.4.2 CARCINOGENIC TOXICITY

Carcinogenic toxicity is evaluated using cancer potency slope factors (SFs) or Unit Risk Factors (URFs). SFs are expressed in $mg/kg\text{-}d^{-1}$ and URFs are expressed in $mg/m^{3\text{-}1}$. Table A-4-1 presents the toxicity values used for carcinogenic risk characterization of the soil COPCs.

A.4.3 TOXICITY VIA DERMAL ABSORPTION

USEPA has not developed toxicity values specifically for the dermal exposure route, and oral toxicity values are used as surrogate values (USEPA, 2004). Exhibit 4-1 from *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), Final* (RAGS-E; USEPA, 2004) lists the gastrointestinal absorption rates for commonly detected chemicals used in this HHBRA. Only vanadium required adjustment in this HHBRA.

A-5.0 RISK CHARACTERIZATION

Risk characterization quantitatively integrates the results of the exposure and toxicity assessments. Comparisons are made between the estimated ADDn and the RfD for each noncarcinogenic COPC to characterize potential noncarcinogenic effects. The estimated ADDc is multiplied by the SF to characterize potential carcinogenic effects. Cumulative risks for each receptor, for multi-chemical and multi-pathway results, are summarized in the following tables. The risk characterization is key in the remedial decision-making process (USEPA, 1989).

A.5.1 NONCARCINOGENIC RISK CHARACTERIZATION

The following sections present the noncarcinogenic risk characterization for soil COPCs. The cumulative HI for DSCR HHBRAs has been set at 1 (MACTEC, 2006). If the organ-specific HI for a particular receptor exceeds 1, those COPCs and pathways primarily responsible for the exceedance are identified. Those COPCs contributing to unacceptable risk are identified as COCs, which then become the focus of risk management decisions.

Attachment Table 3-1 presents the dermal absorption factors for the soil COPCs. Attachment Tables 3-2 to 3-13 show the results of risk characterization for each receptor for the noncarcinogenic COPCs. Table A-5-1 summarizes these results and presents the total multi-chemical, multi-pathway HIs.

- HIs for the current outdoor industrial worker are 0.3 (incidental soil ingestion) and 0.03 (dermal contact with soil).
- HIs for the future outdoor industrial worker are 0.3 (incidental soil ingestion), 0.2 (dermal contact with soil), 0.003 (inhalation of fugitive dusts), and 0.06 (inhalation of volatile compounds).
- HIs for the future construction worker are 1 (incidental soil ingestion), 0.3 (dermal contact with soil), and 0.06 (inhalation of fugitive dust and volatile compounds).
- The HI for the future indoor industrial worker is 0.0001 (inhalation of VOCs from soil in indoor air).

The HIs for all receptors evaluated in this HHBRA are equivalent to or less than the DSCR remediation goal of 1.

A.5.2 CARCINOGENIC RISK CHARACTERIZATION

The carcinogenic risk goal for DSCR HHBRAs has been established at 1×10^{-4} for on-installation receptors (MACTEC, 2006). If the cumulative excess cancer risk for an on-site receptor exceeds 1×10^{-4}, those carcinogenic COPCs primarily responsible for the exceedance are identified as COCs.

Attachment Tables 3-2 through 3-11 present the results of risk characterization for the carcinogenic COPCs. Table A-5-1 summarizes these results and gives the total multi-chemical, multi-pathway risk for the HHBRA.

- The total risk values for the current outdoor industrial worker are 9×10^{-4} (incidental ingestion of soil), 8×10^{-4} (dermal contact with soil), and 5×10^{-8} (inhalation of fugitive dusts). Cumulative risk for the current outdoor industrial worker is 2×10^{-3}.
- The total risk values for the future outdoor industrial worker are 2×10^{-4} (incidental ingestion of soil), 2×10^{-4} (dermal contact with soil), 2×10^{-8} (inhalation of fugitive dusts), and 5×10^{-5} (inhalation of volatile compounds). Cumulative risk for the future outdoor industrial worker is 4×10^{-4}.
- The total risk values for the future construction worker are 1×10^{-5} (incidental ingestion of soil), 5×10^{-6} (dermal contact with soil), 6×10^{-8} (inhalation of fugitive dusts), and 1×10^{-6} (inhalation of volatile compounds). Cumulative risk for the future construction worker is 2×10^{-5}.
- The total risk value for future indoor industrial workers potentially exposed to soil vapors in indoor air is 3×10^{-8}.

The cumulative risk for current and future outdoor industrial workers exceeds the DSCR risk goal of 1×10^{-4}. The majority of the risk for the current outdoor industrial worker is associated with benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, and benzo(a)anthracene. The remainder of the exceedance is associated with arsenic, benzo(k)fluoranthene, indeno(1,2,3-c,d)pyrene, and PCB-1260. The majority of the risk for the future outdoor industrial worker is associated with benzo(a)pyrene. The remainder of the exceedance is associated with benzo(a)anthracene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, indeno(1,2,3-c,d)pyrene, and trichloroethene. The risk associated with surface soil exposures exceeds that for mixed horizon soils (0 to 10 feet), indicating the majority of the estimated risk is associated with soil constituents within the top 2 feet of ground surface.

The risks presented above are based on the mid-point of the TCE cancer slope factors. If risks are recalculated using the NCEA provisional range of slope factors or the California Environmental Protection Agency slope factors for TCE, the results vary only slightly:

- The risk for the current outdoor industrial worker remains 2×10^{-3}.
- The risk for future outdoor industrial workers ranges from 3×10^{-4} to 4×10^{-4}.
- The risk for the future construction worker remains 2×10^{-5}.
- The risk for future indoor workers ranges from 9×10^{-9} to 6×10^{-8}.

The use of the mid-point of the provisional NCEA cancer slope range for TCE has no impact on the outcome of the HHBRA for OU 2.

A-6.0 UNCERTAINTIES ANALYSIS

Uncertainty is inherent in the risk assessment process. Exposure is hypothetical, and the calculations are based largely on assumed conditions. An important part of the risk assessment process is characterizing the main underlying uncertainties. Understanding the uncertainties is important for the interpretation and ultimate use of the risk assessment results because actual risk may be under- or overestimated.

A qualitative uncertainties analysis was performed. Uncertainties for each component of the HHBRA are discussed and evaluated as follows.

A.6.1 DATA EVALUATION

The following uncertainties apply to the data evaluation:

Uncertainty	Resolution
The nature and extent of chemical impacts have been adequately characterized.	The OU has been investigated over a period of several years. Data were collected for multiple purposes and the dataset as a whole adequately characterizes the nature and extent of COPC distributions.
The analytical results that constitute the risk assessment dataset represent validated data that conform to the quality control standards and DQOs for site investigation as established in the project *Sampling and Analysis Plan and Quality Assurance Program Plan* (MACTEC, 2004) and for use in quantitative risk assessment.	Data collected prior to 1992 were included in the database because very few soil samples have been collected at this OU since the RI was completed. More recent sampling results do not confirm the findings of the RI data. For example, PCB-1260 has only been found in 1 of 50 samples, and this sample was collected in 1986. The RI data were validated to the standards current of that time period and are considered usable for the purposes of risk assessment. Use of older data with uncertain data quality has tended to overestimate risk at this OU.
Chemicals eliminated as COPCs will not significantly contribute to HIs and/or cumulative excess cancer risks.	The screening process used to identify COPCs was conservatively biased so that the likelihood of eliminating a chemical that might be associated with an unacceptable risk is small.

Based on the above analysis, uncertainties associated with the data evaluation process are considered acceptable. The conservative COPC screening process would generally tend to overestimate the risk results.

A.6.2 EXPOSURE ASSESSMENT

The following uncertainties apply to the exposure assessment:

Uncertainty	Resolution
The environmental media, receptors, and exposure pathways identified and quantified in the HHBRA capture the potentially significant exposures and risks under current and future on-site industrial land use scenarios and future on-site construction scenarios.	DLA and DSCR are committed to restricting future land use at OU 2 to industrial uses only; therefore, it is highly unlikely that significant current or future exposure pathways were excluded from the HHBRA. No other pathways or receptors are considered significant. The on-site pathways are hypothetical and tend to overstate potential future risks.
The statistical methods employed generate representative, site-wide EPCs.	USEPA's ProUCL software was used for all on-site soil statistics. This statistical software program was developed specifically for use with environmental data. Overall, the derivation of EPCs is considered conservative and could overestimate actual risk.
The intake assumptions employed are reasonable reflections of the behavior of actual current and future anticipated site receptors.	Most of the intake assumptions used in the HHBRA were obtained from USEPA regulatory guidance, which are conservative and may overestimate actual current and future exposures.
Current soil concentrations accurately represent future soil conditions.	Rather than soil concentrations remaining stable, the detected soil chemicals are subject to natural degradation and attenuation; therefore, site concentrations are expected to decrease with time. Using current and historical concentrations for future exposures will therefore overestimate actual risk.

Based on the above analysis, uncertainties associated with the exposure assessment process are considered conservative, and they would generally overestimate actual risk.

A.6.3 TOXICITY ASSESSMENT

The following uncertainty applies to the toxicity assessment:

Uncertainty	Resolution
The toxicity values used in the HHBRA accurately reflect the dose-response behavior of the evaluated chemicals.	In general, there is significant uncertainty in the development and use of USEPA's toxicity values. To characterize these uncertainties as conservative or non-conservative is unclear for many chemicals. For example, much of the site risk is associated with large-chain PAHs. The size of these molecules may limit their ability to pass through the stratum corneum. Therefore, risk associated with dermal risk may be overestimated.

Based on the preceding analysis, the uncertainty associated with the toxicity assessment is considered acceptable and represents the best available information.

A.6.4 RISK CHARACTERIZATION

The following uncertainty applies to the risk characterization:

Uncertainty	Resolution
The summing of HQs for noncarcinogens to generate an HI result leads to reasonable estimates of the total noncarcinogenic effects resulting from exposure to COPCs.	For this site, exposure to noncarcinogens is not associated with excess systemic risk for on-site receptors. Therefore, summing the systemic risk to generate a cumulative HI should not overestimate noncarcinogenic effects.

Based on the analysis, the uncertainty associated with the risk characterization represents the best available information.

A.6.5 UNCERTAINTIES CONCLUSIONS

The uncertainties identified and discussed in this section were evaluated, along with their estimated magnitudes and directions (i.e., tendency to under- or overestimate risk). Overall, the conservative uncertainties outweigh the non-conservative uncertainties, and the final risk estimates presented in this HHBRA are likely higher than the actual risk posed by constituents detected at OU 2.

A-7.0 CONCLUSIONS

A conservative HHBRA was conducted to evaluate the significance of potential exposures to various chemicals detected in surface and subsurface soil for four types of worker receptors: a current on-site outdoor industrial worker, a future on-site outdoor industrial worker, a future on-site construction worker, and a future indoor industrial worker exposed to soil vapors in indoor air. A conservative screening assessment was first performed to identify the COPCs, which included aluminum, arsenic, copper, iron, vanadium, trichloroethene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k) fluoranthene, chrysene, dibenzo(a,h)anthracene, indeno(1,2,3-c,d)pyrene and PCB-1260. Non-carcinogenic risk estimates were less than the DSCR risk goal of 1 for all four receptors. Excess cancer risk estimates for future construction workers and future indoor industrial workers were less than the DSCR risk goal of 1×10^{-4} for on-installation exposures.

Table A-7-1 and Attachment 4 (Attachment Tables 4-1 and 4-2) summarize the risk estimates for the two on-installation receptors that potentially may be exposed to an unacceptable level of excess cancer risk: current and future outdoor industrial workers.

For the current industrial outdoor worker, excess cancer risks of 2×10^{-3} are associated with eight COCs: arsenic, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenzo(a,h) anthracene, indeno(1,2,3-c,d)pyrene, and PCB-1260 (Table A-7-1 and Attachment Table 4-1). One-half of this risk is associated with benzo(a)pyrene (1×10^{-3}). Remediation goals for the eight surface soil COCs were developed for the OU 2 Technical Memorandum.

For the future industrial indoor worker, excess cancer risks of 4×10^{-4} are associated with six COCs: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, indeno(1,2,3-c,d)pyrene, and trichloroethene (Table A-7-1 and Attachment Table 4-2). Two-thirds of this risk is associated with benzo(a)pyrene (2×10^{-4}). Remediation goals for the six surface and subsurface soil COCs were developed for the OU 2 Technical Memorandum.

Risk associated with surface soil COCs is an order of magnitude greater than risk due to intermixed surface and subsurface soils. Corrective action to address exposure to surface soil would greatly reduce estimated risks for both current and future soil receptors.

A-8.0 REFERENCES

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TABLES

TABLE A-2-1

SELECTION OF CONSTITUENTS OF POTENTIAL CONCERN IN SURFACE SOILS (0-2 FT)
HUMAN HEALTH BASELINE RISK ASSESSMENT
OPERABLE UNIT 2
Defense Supply Center Richmond
Richmond, Virginia

Chemical	Number of Detections (a)	Number of Analyses (a)	Frequency of Detection (b)	Frequency of Detection ≥ 5%?	Minimum Detected Concentration (mg/kg) (a)	Maximum Detected Concentration (mg/kg) (a)	Industrial Soil Risk-Based Concentration (RBC) (mg/kg) (c)	Maximum Detected Concentration > RBC?	Site Concentrations > Background (d) ?	Direct Contact Soil COPC?
Metals/Inorganics										
Aluminum	15	15	100%	YES	3.58E+03	2.18E+04	1.00E+05 (e)	NO	NA	NO
Arsenic	15	15	100%	YES	4.00E+00	3.00E+01	1.90E+00	YES	YES	**YES**
Barium	15	15	100%	YES	2.00E+01	1.74E+03	2.00E+04	NO	NA	NO
Cadmium	5	15	33%	YES	1.90E+00	5.00E+00	1.00E+02	NO	NA	NO
Chromium	15	15	100%	YES	4.00E+00	7.20E+01	3.10E+02 (f)	NO	NA	NO
Cobalt	1	15	7%	YES	2.00E+01	2.00E+01	2.00E+03 (e)	NO	NA	NO
Copper	15	15	100%	YES	2.50E+00	1.41E+04	4.10E+03	YES	NO	**YES**
Iron	14	15	93%	YES	5.23E+03	3.97E+04	3.10E+04	YES	NO	**YES**
Lead	15	15	100%	YES	2.40E+01	3.80E+02	8.00E+02 (g)	NO	NA	NO
Manganese	15	15	100%	YES	3.00E+01	8.25E+02	2.00E+03	NO	NA	NO
Mercury	13	15	87%	YES	8.00E-02	5.90E-01	3.10E+01 (h)	NO	NA	NO
Nickel	8	15	53%	YES	1.70E+00	1.00E+01	2.00E+03	NO	NA	NO
Selenium	2	15	13%	YES	3.74E-01	1.50E+00	5.10E+02	NO	NA	NO
Silver	4	15	27%	YES	1.00E+00	1.60E+01	5.10E+02	NO	NA	NO
Thallium	1	15	7%	YES	1.20E+00	1.20E+00	7.20E+00	NO	NA	NO
Tin	7	15	47%	YES	4.00E+00	3.80E+01	6.10E+04	NO	NA	NO
Vanadium	15	15	100%	YES	1.00E+01	6.20E+01	1.00E+02	NO	NA	NO
Zinc	15	15	100%	YES	5.00E+00	6.29E+02	3.10E+04	NO	NA	NO
VOCs										
Acetone	7	9	78%	YES	6.10E-03	1.10E-01	9.20E+04	NO	NA	NO
Methylene chloride	7	7	100%	YES	7.60E-03	2.60E-02	3.80E+02	NO	NA	NO
Tetrachloroethene	1	15	7%	YES	1.40E-02	1.40E-02	5.30E+00	NO	NA	NO
Toluene	1	15	7%	YES	1.60E-02	1.60E-02	8.20E+03	NO	NA	NO
trans-1,2-Dichloroethene	1	15	7%	YES	2.00E-01	2.00E-01	2.00E+03	NO	NA	NO
Trichloroethene	1	15	7%	YES	8.40E-02	8.40E-02	7.20E+00	NO	NA	NO
PAHs										
Acenaphthene	4	15	27%	YES	1.90E-01	8.40E+01	6.10E+03	NO	NA	NO
Anthracene	4	15	27%	YES	2.50E-01	7.00E+02	3.10E+04	NO	NA	NO
Benzo(a)anthracene	8	15	53%	YES	4.60E-01	3.60E+02	3.90E+00	YES	NO	**YES**
Benzo(a)pyrene	8	15	53%	YES	3.70E-01	3.40E+02	3.90E-01	YES	NO	**YES**
Benzo(b)fluoranthene	9	15	60%	YES	5.80E-01	5.40E+02	3.90E+00	YES	NO	**YES**
Benzo(ghi)perylene	8	15	53%	YES	5.60E-03	1.90E+02	3.10E+03 (h)	NO	NA	NO
Benzo(k)fluoranthene	7	15	47%	YES	5.80E-01	5.40E+02	3.90E+01	YES	NO	**YES**
Chrysene	8	15	53%	YES	4.70E-01	4.00E+02	3.90E+02	YES	NO	**YES**
Dibenzo(a,h)anthracene	2	15	13%	YES	2.30E-01	7.20E+01	3.90E-01	YES	NO	**YES**
Fluoranthene	8	15	53%	YES	1.00E+00	7.00E+02	4.10E+03	NO	NA	NO
Fluorene	2	15	13%	YES	2.10E-01	8.70E+01	4.10E+03	NO	NA	NO
Indeno((1,2,3-cd)pyrene	7	15	47%	YES	1.90E-01	1.80E+02	3.90E+00	YES	NO	**YES**
Phenanthrene	8	15	53%	YES	5.50E-01	7.00E+02	3.10E+03 (h)	NO	NA	NO
Pyrene	7	15	47%	YES	7.00E-01	9.00E+02	3.10E+03	NO	NA	NO

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Chemical	Number of Detections (a)	Number of Analyses (a)	Frequency of Detection (b)	Frequency of Detection ≥ 5%?	Minimum Detected Concentration (mg/kg) (a)	Maximum Detected Concentration (mg/kg) (a)	Industrial Soil Risk-Based Concentration (RBC) (mg/kg) (c)	Maximum Detected Concentration > RBC?	Site Concentrations > Background (d) ?	Direct Contact Soil COPC?
SVOCs										
Benzyl alcohol	1	15	7%	YES	2.00E-01	2.00E-01	3.10E+04	NO	NA	NO
bis(2-Ethylhexyl)phthalate	5	15	33%	YES	2.10E-01	3.70E-01	2.00E+02	NO	NA	NO
Dibenzofuran	1	15	7%	YES	5.10E+01	5.10E+01	2.00E+02 (e)	NO	NA	NO
Di-n-octyl phthalate	2	15	13%	YES	3.10E-01	4.60E-01	4.10E+03	NO	NA	NO
Phenol	5	55	9%	YES	4.70E-01	2.40E+00	3.10E+04	NO	NA	NO
Pesticides										
4,4'-DDD	2	15	13%	YES	3.60E-03	1.90E-02	1.20E+01	NO	NA	NO
4,4'-DDE	4	15	27%	YES	2.30E-03	7.90E-02	8.40E+00	NO	NA	NO
4,4'-DDT	2	15	13%	YES	1.10E-02	1.20E-01	8.40E+00	NO	NA	NO
Dieldrin	1	13	8%	YES	1.20E-02	1.20E-02	1.80E-01	NO	NA	NO
Technical Chlordane	1	15	7%	YES	1.50E-01	1.50E-01	8.20E+00 (h)	NO	NA	NO
PCBs										
PCB-1260	1	15	7%	YES	4.70E+01	4.70E+01	1.40E+00	YES	NA	**YES**

Notes:
Bolded chemicals exceed one or more screening criteria
mg/kg Milligrams of chemical per kilogram of soil
RBC Risk-Based Concentration
COPC Constituent of potential concern
PAHs Polycyclic aromatic hydrocarbons
VOCs Volatile organic compounds
SVOCs Semivolatile organic compounds
PCB Polychlorinated biphenyls
NA Not applicable

(a) See Attachment 1 for site data.
(b) (No. Detections/ No. Analyses) x 100.
(c) From USEPA (2006).
(d) See Attachment 2 for background comparison results.
(e) RBC value listed was obtained from the April 2005 version of the Region 3 RBC table. The constituent has been withdrawn from the current version.
(f) Value for chromium VI used as a surrogate since it is the most conservative value for chromium
(g) From Adult Lead Methodology Frequently Asked Questions, www.epa.gov/superfund/programs/lead/almfaq.htm, April 2004.
(h) Value for mercuric chloride used as a surrogate for mercury; pyrene used a surrogate for benzo(ghi)perylene and phenanthrene; and chlordane used as a surrogate for technical chlordane.

PREPARED/DATE: MKB 8/15/05
CHECKED/DATE: LMS 5/9/06

TABLE A-2-2

SELECTION OF CONSTITUENTS OF POTENTIAL CONCERN IN SURFACE AND SUBSURFACE SOILS (0-10 FT)
HUMAN HEALTH BASELINE RISK ASSESSMENT
OPERABLE UNIT 2
Defense Supply Center Richmond
Richmond, Virginia

Chemical	Number of Detections (a)	Number of Analyses (a)	Frequency of Detection (b)	Frequency of Detection ≥ 5%?	Minimum Detected Concentration (mg/kg) (a)	Maximum Detected Concentration (mg/kg) (a)	Industrial Soil Risk-Based Concentration (RBC) (mg/kg) (c)	Maximum Detected Concentration > RBC?	Site Concentrations > Background (d) ?	Direct Contact Soil COPC?
Metals/Inorganics										
Aluminum	45	45	100%	YES	2.55E+03	1.28E+05	1.00E+05 (e)	YES	NO	YES
Antimony	2	56	4%	NO	6.00E-01	7.00E-01	NA	NA	NA	NO
Arsenic	48	56	86%	YES	2.30E-01	4.10E+01	1.90E+00	YES	YES	YES
Barium	40	47	85%	YES	9.50E+00	1.74E+03	2.00E+04	NO	NA	NO
Beryllium	16	56	29%	YES	1.57E-01	1.10E+00	2.00E+02	NO	NA	NO
Cadmium	18	55	33%	YES	4.00E-01	8.00E+00	1.00E+02	NO	NA	NO
Chromium	54	56	96%	YES	1.40E+00	1.22E+02	3.10E+02 (f)	NO	NA	NO
Chromium (VI)	2	42	5%	YES	3.00E-01	4.00E-01	3.10E+02	NO	NA	NO
Cobalt	10	46	22%	YES	1.02E+00	2.00E+01	2.00E+03 (e)	NO	NA	NO
Copper	43	56	77%	YES	1.02E+00	1.41E+04	4.10E+03	YES	NO	YES
Cyanide	1	49	2%	NO	1.00E+00	1.00E+00	NA	NA	NA	NO
Iron	45	46	98%	YES	1.15E+03	7.65E+04	3.10E+04	YES	NO	YES
Lead	54	56	96%	YES	2.40E+00	3.80E+02	8.00E+02 (g)	NO	NA	NO
Manganese	45	46	98%	YES	3.00E+00	3.34E+03	2.00E+04	NO	NA	NO
Mercury	39	56	70%	YES	2.10E-03	5.90E-01	3.10E+01 (h)	NO	NA	NO
Molybdenum	1	1	100%	YES	3.96E-01	3.96E-01	5.10E+02	NO	NA	NO
Nickel	23	56	41%	YES	1.00E+00	3.40E+01	2.00E+03	NO	NA	NO
Selenium	11	56	20%	YES	1.00E-01	1.50E+00	5.10E+02	NO	NA	NO
Silver	10	55	18%	YES	4.50E-01	1.60E+01	5.10E+02	NO	NA	NO
Thallium	2	57	4%	NO	1.20E+00	1.20E+01	NA	NA	NA	NO
Tin	13	32	41%	YES	4.00E+00	3.80E+01	6.10E+04	NO	NA	NO
Vanadium	46	46	100%	YES	3.40E+00	3.89E+02	1.00E+02	YES	NO	YES
Zinc	56	56	100%	YES	1.00E+00	6.29E+02	3.10E+04	NO	NA	NO
VOCs										
1,1,1-Trichloroethane	1	55	2%	NO	3.43E+00	3.43E+00	NA	NA	NA	NO
1,1,2-Trichloroethane	1	8	13%	YES	2.49E-01	2.49E-01	5.00E+01	NO	NA	NO
1,2,4-Trichlorobenzene	1	50	2%	NO	2.39E-01	2.39E-01	NA	NA	NA	NO
1,2-Dichlorobenzene	3	57	5%	YES	1.18E-01	1.80E+01	9.20E+03	NO	NA	NO
1,2-Dichloroethane	1	58	2%	NO	3.43E-01	3.43E-01	NA	NA	NA	NO
1,2-Dichloroethene, total	2	11	18%	YES	1.92E+00	9.40E+00	9.20E+02	NO	NA	YES (i)
trans-1,2-Dichloroethene	2	48	4%	NO	2.00E-01	5.50E-01	NA	NA	NA	NO
1,3-Dichlorobenzene	1	57	2%	NO	1.19E+00	1.19E+00	NA	NA	NA	NO
1,4-Dichlorobenzene	3	57	5%	YES	7.80E-01	9.20E+01	1.20E+02	NO	NA	NO
2-Butanone	9	47	19%	YES	3.30E-03	1.40E+01	6.10E+04	NO	NA	NO
2-Hexanone	1	45	2%	NO	7.00E-03	7.00E-03	NA	NA	NA	NO
4-Methyl-2-pentanone	1	48	2%	NO	6.20E+00	6.20E+00	NA	NA	NA	NO
Acetone	22	29	76%	YES	2.60E-03	4.57E+00	9.20E+04	NO	NA	NO
Benzene	1	55	2%	NO	2.41E-01	2.41E-01	NA	NA	NA	NO
Carbon Disulfide	1	49	2%	NO	4.40E-03	4.40E-03	NA	NA	NA	NO
Carbon Tetrachloride	1	54	2%	NO	1.14E+01	1.14E+01	NA	NA	NA	NO
Chlorobenzene	4	57	7%	YES	5.10E-02	2.26E+01	2.00E+03	NO	NA	NO

TABLE A-2-2

SELECTION OF CONSTITUENTS OF POTENTIAL CONCERN IN SURFACE AND SUBSURFACE SOILS (0-10 FT)
HUMAN HEALTH BASELINE RISK ASSESSMENT
OPERABLE UNIT 2
Defense Supply Center Richmond
Richmond, Virginia

Chemical	Number of Detections (a)	Number of Analyses (a)	Frequency of Detection (b)	Frequency of Detection ≥ 5%?	Minimum Detected Concentration (mg/kg) (a)	Maximum Detected Concentration (mg/kg) (a)	Industrial Soil Risk-Based Concentration (RBC) (mg/kg) (c)	Maximum Detected Concentration > RBC?	Site Concentrations > Background (d) ?	Direct Contact Soil COPC?
Chloroform	2	58	3%	NO	1.00E-03	1.40E+01	NA	NA	NA	NO
Ethylbenzene	5	57	9%	YES	4.75E-03	2.54E+00	1.00E+04	NO	NA	NO
Methylene chloride	22	37	59%	YES	4.68E-03	1.80E+00	3.80E+02	NO	NA	NO
p-Isopropyltoluene	1	2	50%	YES	1.20E-03	1.20E-03	1.00E+03 (h)	NO	NA	NO
Tetrachloroethene	4	57	7%	YES	5.67E-03	2.84E+00	5.30E+00	NO	NA	NO
Toluene	11	57	19%	YES	1.00E-03	6.60E+01	8.20E+03	NO	NA	NO
Trichloroethene	6	57	11%	YES	2.97E-03	5.34E+01	7.20E+00	YES	NA	YES
Vinyl chloride	1	57	2%	NO	3.00E-03	3.00E-03	4.00E+00	NO	NA	YES (i)
m,p-Xylene	3	6	50%	YES	1.28E-02	4.60E+00	2.00E+04 (h)	NO	NA	NO
o-Xylene	3	6	50%	YES	5.63E-03	2.35E+00	2.00E+04 (h)	NO	NA	NO
Xylenes, total	1	39	3%	NO	1.60E-02	1.60E-02	NA	NA	NA	NO
<u>PAHs</u>										
Acenaphthene	10	53	19%	YES	1.90E-01	9.30E+01	6.10E+03	NO	NA	NO
Acenaphthylene	2	55	4%	NO	8.27E-02	7.79E-01	NA	NA	NA	NO
Anthracene	13	55	24%	YES	2.50E-01	7.00E+02	3.10E+04	NO	NA	NO
Benzo(a)anthracene	18	55	33%	YES	4.60E-01	3.60E+02	3.90E+00	YES	NA	YES
Benzo(a)pyrene	17	55	31%	YES	3.70E-01	3.40E+02	3.90E-01	YES	NA	YES
Benzo(b)fluoranthene	20	55	36%	YES	5.80E-01	5.40E+02	3.90E+00	YES	NA	YES
Benzo(ghi)perylene	14	55	25%	YES	5.60E-03	1.90E+02	3.10E+03 (h)	NO	NA	NO
Benzo(k)fluoranthene	14	55	25%	YES	5.80E-01	5.40E+02	3.90E+01	YES	NA	YES
Carbazole	3	6	50%	YES	3.06E-01	7.95E+00	1.40E+02	NO	NA	NO
Chrysene	19	55	35%	YES	2.80E-01	4.00E+02	3.90E+02	YES	NA	YES
Dibenzo(a,h)anthracene	8	55	15%	YES	1.80E-01	7.20E+01	3.90E-01	YES	NA	YES
Fluoranthene	21	55	38%	YES	1.54E-01	7.00E+02	4.10E+03	NO	NA	NO
Fluorene	11	55	20%	YES	1.80E-01	8.70E+01	4.10E+03	NO	NA	NO
Indeno((1,2,3-cd)pyrene	15	55	27%	YES	1.90E-01	1.80E+02	3.90E+00	YES	NA	YES
2-Methylnaphthalene	3	45	7%	YES	7.08E+00	3.93E+02	4.10E+02	NO	NA	NO
Naphthalene	7	55	13%	YES	7.90E-02	5.32E+01	2.00E+03	NO	NA	NO
Phenanthrene	21	55	38%	YES	1.35E-01	7.00E+02	3.10E+03 (h)	NO	NA	NO
Pyrene	20	55	36%	YES	1.16E-01	9.00E+02	3.10E+03	NO	NA	NO
<u>SVOCs</u>										
2,4-Dichlorophenol	1	6	17%	YES	7.46E-01	7.46E-01	3.10E+02	NO	NA	NO
2,4-Dimethylphenol	2	55	4%	NO	1.43E+00	7.40E+00	NA	NA	NA	NO
2-Methylphenol	1	45	2%	NO	7.84E-01	7.84E-01	NA	NA	NA	NO
4-Methylphenol	3	46	7%	YES	6.53E-02	3.17E+00	5.10E+02	NO	NA	NO
Benzyl alcohol	1	39	3%	NO	2.00E-01	2.00E-01	NA	NA	NA	NO
bis(2-Ethylhexyl)phthalate	10	55	18%	YES	1.20E-02	1.16E+00	2.00E+02	NO	NA	NO
Dibenzofuran	7	47	15%	YES	1.40E-01	5.31E+01	2.00E+02 (e)	NO	NA	NO
Di-n-butyl phthalate	6	55	11%	YES	4.95E-01	4.00E+00	1.00E+04	NO	NA	NO
Di-n-octyl phthalate	3	55	5%	YES	2.00E-01	4.60E-01	4.10E+03 (e)	NO	NA	NO
Phenol	5	55	9%	YES	4.70E-01	2.40E+00	3.10E+04	NO	NA	NO

TABLE A-2-2

SELECTION OF CONSTITUENTS OF POTENTIAL CONCERN IN SURFACE AND SUBSURFACE SOILS (0-10 FT)
HUMAN HEALTH BASELINE RISK ASSESSMENT
OPERABLE UNIT 2
Defense Supply Center Richmond
Richmond, Virginia

Chemical	Number of Detections (a)	Number of Analyses (a)	Frequency of Detection (b)	Frequency of Detection ≥ 5%?	Minimum Detected Concentration (mg/kg) (a)	Maximum Detected Concentration (mg/kg) (a)	Industrial Soil Risk-Based Concentration (RBC) (mg/kg) (c)	Maximum Detected Concentration > RBC?	Site Concentrations > Background (d) ?	Direct Contact Soil COPC?
Pesticides										
4,4'-DDD	8	55	15%	YES	2.10E-03	5.26E-01	1.20E+01	NO	NA	NO
4,4'-DDE	8	55	15%	YES	2.20E-03	7.90E-02	8.40E+00	NO	NA	NO
4,4'-DDT	4	55	7%	YES	1.10E-02	1.20E-01	8.40E+00	NO	NA	NO
Dieldrin	2	53	4%	NO	1.30E-03	1.20E-02	NA	NA	NA	NO
Technical Chlordane	1	46	2%	NO	1.50E-01	1.50E-01	NA	NA	NA	NO
PCBs										
PCB-1260	1	50	2%	NO	4.70E+01	4.70E+01	1.40E+00	YES	NA	YES (j)
Petroleum Hydrocarbons										
Diesel Fuel	9	26	35%	YES	6.40E+00	4.86E+03	NA	NA	NA	NA
Heavy Oil	7	26	27%	YES	6.82E+01	1.23E+04	NA	NA	NA	NA
Total Petroleum Hydrocarbons	11	45	24%	YES	1.00E+00	1.55E+02	NA	NA	NA	NA
Total Unknown Hydrocarbons	4	26	15%	YES	3.74E+01	7.01E+01	NA	NA	NA	NA

Notes:
Bolded chemicals exceed one or more screening criteria

mg/kg Milligrams of chemical per kilogram of soil
RBC Risk-Based Concentration
COPC Constituent of potential concern
PAHs Polycyclic aromatic hydrocarbons
VOCs Volatile organic compounds
SVOCs Semivolatile organic compounds
PCB Polychlorinated biphenyls
NA Not applicable

(a) See Attachment 1 for site data.
(b) (No. Detections/ No. Analyses) x 100.
(c) From USEPA (2006).
(d) See Attachment 2 for background comparison results.
(e) RBC value listed was obtained from the April 2005 version of the Region 3 RBC table. The constituent has been withdrawn from the current version.
(f) Value for chromium VI used as a surrogate since it is the most conservative value for chromium.
(g) From Adult Lead Methodology Frequently Asked Questions, www.epa.gov/superfund/programs/lead/almfaq.htm, April 2004.
(h) Value for mercuric chloride used as a surrogate for mercury; cumene used as a surrogate for p-isopropyltoluene; total xylene used as a surrogate for m,p- and o-xylene; pyrene used a surrogate for benzo(ghi)perylene and phenanthrene.
(i) Total 1,2-dichloroethene and vinyl chloride are infrequently detected, but were selected as COPCs because they are potential break-down products of trichloroethene.
(j) Although PCB-1260 was detected at a very low frequency, it is included as a COPC because of its toxicity.

PREPARED/DATE: MKB 9/22/05
CHECKED/DATE: LMS 5/9/06

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SELECTION OF EXPOSURE PATHWAYS
HUMAN HEALTH BASELINE RISK ASSESSMENT
OPERABLE UNIT 2
Defense Supply Center Richmond
Richmond, Virginia

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Current	Surface Soil	Soil	Industrial Use	Outdoor Industrial Worker	Adult	Ingestion	Quant	Pathway potentially complete.
				Outdoor Industrial Worker	Adult	Dermal	Quant	Pathway potentially complete.
		Air	Fugitive Dust	Outdoor Industrial Worker	Adult	Inhalation	Quant	Pathway potentially complete.
Future	Surface and Subsurface Soils	Soil	Industrial Use	Outdoor Industrial Worker	Adult	Ingestion	Quant	Pathway potentially complete.
				Outdoor Industrial Worker	Adult	Dermal	Quant	Pathway potentially complete.
		Air	Volatilization	Outdoor Industrial Worker	Adult	Inhalation	Quant	Pathway potentially complete.
		Air	Fugitive Dust	Outdoor Industrial Worker	Adult	Inhalation	Quant	Pathway potentially complete.
Future	Surface and Subsurface Soils	Soil	Industrial Use	Construction Worker	Adult	Ingestion	Quant	Pathway potentially complete.
				Construction Worker	Adult	Dermal	Quant	Pathway potentially complete.
		Air	Volatilization	Construction Worker	Adult	Inhalation	Quant	Pathway potentially complete.
		Air	Fugitive Dust	Construction Worker	Adult	Inhalation	Quant	Pathway potentially complete.
Current/Future	Surface and Subsurface Soils	Air	Vapor Emission	Indoor Industrial Worker	Adult	Inhalation	Quant	Pathway potentially complete.
Current /Future	Groundwater	Groundwater	Tapwater	Indoor Industrial Worker	Adult	Ingestion	None	Facility does not allow and will not allow the use of groundwater as potable water.
				Indoor Industrial Worker	Adult	Dermal	None	Facility does not allow and will not allow the use of groundwater as potable water.
				Indoor Industrial Worker	Adult	Inhalation	None	Facility does not allow and will not allow the use of groundwater as potable water.
Future	Groundwater	Groundwater	Incidental Contact	Construction Worker / Outdoor Industrial Worker	Adult	Ingestion	None	May come into contact with groundwater during subsurface excavations. Pathway evaluated in HHBRA for OU 6.
				Construction Worker / Outdoor Industrial Worker	Adult	Dermal	None	May come into contact with groundwater during subsurface excavations. Pathway evaluated in HHBRA for OU 6.
			Vapor Emissions in Trench	Construction Worker	Adult	Inhalation	None	May come into contact with groundwater during subsurface excavations. Pathway evaluated in HHBRA for OU 6.
Future	Groundwater	Groundwater	Tapwater	Off-Site Resident	Child/Adult	Ingestion	None	Potential for exposure to hypothetical off-site resident is evaluated in the HHBRA for OU 6.
				Off-Site Resident	Child/Adult	Dermal	None	Potential for exposure to hypothetical off-site resident is evaluated in the HHBRA for OU 6.
		Air	Water Vapors while Showering	Off-Site Resident	Adult	Inhalation	None	Potential for exposure to hypothetical off-site resident is evaluated in the HHBRA for OU 6.
		Air	Vapor Emissions	Off-Site Resident	Child/Adult	Inhalation	None	Potential for exposure to hypothetical off-site resident is evaluated in the HHBRA for OU 6.

PREPARED BY: MKB 8/24/05
CHECKED BY: LMS 9/23/05

TABLE A-3-1

EXPOSURE POINT CONCENTRATIONS
HUMAN HEALTH BASELINE RISK ASSESSMENT
OPERABLE UNIT 2
Defense Supply Center Richmond
Richmond, Virginia

COPC	Current Outdoor Industrial Worker, Direct Contact (IWcur,dc) (mg/kg) (a)	Current Outdoor Industrial Worker, Dust (IWcur,du) (mg/m^3) (b)	Current Outdoor Industrial Worker, Air Chemical-Dust (IWcur,du,c) (mg/m^3) (c)	Future Outdoor Industrial Worker, Direct Contact (IWfut,dc) (mg/kg) (d)	Future Outdoor Industrial Worker, Dust (IWfut,du) (mg/m^3) (b)	Future Outdoor Industrial Worker, Air Chemical-Dust (IWfut,du,c) (mg/m^3) (e)	Future Construction Worker, Direct Contact (CWdc) (mg/kg) (d)	Future Construction Worker, Dust (CWdu) (mg/m^3) (f)	Future Construction Worker, Air Chemical-Dust (CWdu,c) (mg/m3) (g)	Future Indoor Industrial Worker, Indoor Air Vapor Concentration ($C_{building}$) (µg/m3) (h)
Metals/Inorganics										
Aluminum	NA	NA	NA	2.32E+04	7.35E-04	1.71E-05	2.32E+04	1.34E-01	3.11E-03	NA
Arsenic	2.03E+01	7.35E-04	1.49E-08	1.12E+01	7.35E-04	8.25E-09	1.12E+01	1.34E-01	1.50E-06	NA
Copper	1.03E+04	7.35E-04	7.56E-06	1.83E+03	7.35E-04	1.35E-06	1.83E+03	1.34E-01	2.46E-04	NA
Iron	2.11E+04	7.35E-04	1.55E-05	3.70E+04	7.35E-04	2.72E-05	3.70E+04	1.34E-01	4.96E-03	NA
Vanadium	NA	NA	NA	6.69E+01	7.35E-04	4.92E-08	6.69E+01	1.34E-01	8.96E-06	NA
VOCs										
1,2-Dichloroethene, total	NA	NA	NA	9.40E+00	7.35E-04	6.91E-09	9.40E+00	1.34E-01	1.26E-06	1.99E-03
Trichloroethene	NA	NA	NA	1.24E+01	7.35E-04	9.12E-09	1.24E+01	1.34E-01	1.66E-06	1.87E-03
Vinyl chloride	NA	NA	NA	3.00E-03	7.35E-04	2.21E-12	3.00E-03	1.34E-01	4.02E-10	5.89E-03
PAHs										
Benzo(a)anthracene	2.66E+02	7.35E-04	1.96E-07	5.13E+01	7.35E-04	3.77E-08	5.13E+01	1.34E-01	6.88E-06	NA
Benzo(a)pyrene	2.49E+02	7.35E-04	1.83E-07	4.72E+01	7.35E-04	3.47E-08	4.72E+01	1.34E-01	6.32E-06	NA
Benzo(b)fluoranthene	3.96E+02	7.35E-04	2.91E-07	1.13E+02	7.35E-04	8.29E-08	1.13E+02	1.34E-01	1.51E-05	NA
Benzo(k)fluoranthene	3.96E+02	7.35E-04	2.91E-07	7.46E+01	7.35E-04	5.49E-08	7.46E+01	1.34E-01	1.00E-05	NA
Chrysene	2.95E+02	7.35E-04	2.17E-07	5.65E+01	7.35E-04	4.15E-08	5.65E+01	1.34E-01	7.57E-06	NA
Dibenzo(a,h)anthracene	5.26E+01	7.35E-04	3.87E-08	1.06E+01	7.35E-04	7.81E-09	1.06E+01	1.34E-01	1.42E-06	NA
Indeno(1,2,3-cd)pyrene	1.32E+02	7.35E-04	9.70E-08	2.51E+01	7.35E-04	1.85E-08	2.51E+01	1.34E-01	3.37E-06	NA
PCBs										
PCB-1260	3.43E+01	7.35E-04	2.52E-08	6.72E+00	7.35E-04	4.94E-09	6.72E+00	1.34E-01	9.00E-07	NA

Notes:

mg/kg	Milligrams per kilogram
mg/m^3	Milligrams per cubic meter
COPC	Chemical of Potential Concern
VOC	Volatile Organic Compound
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
NA	Not Applicable

(a) Concentration is the lesser of the maximum detected concentration and the recommended upper confidence limit soil chemical concentration derived from surface soil samples (0-2') (Attachment 1).
(b) Derived from the reciprocal of the ambient Particulate Emissions Factor (PEF) of 1.36E+09 m^3/kg (USEPA, 1996, Soil Screening Guidance: User's Guide. Publication 9355.4-23). Represents concentration of dust particles in air.
(c) IWcur,dc x IWcur,du x 1E-06 kg/mg.
(d) Concentration is the lesser of the maximum detected concentration and the recommended upper confidence limit soil chemical concentration derived from surface and subsurface soil samples (0-10') (Attachment 1).
(e) IWfut,dc x IWfut,du x 1×10^{-6} kg/mg.
(f) Reciprocal of installation-specific particulate emission factor for construction work (7.44×10^6 m^3/kg).
(g) CWdc x CWdu x 1×10^{-6} kg/mg.
(h) Results from Johnson & Ettinger Model for Indoor Air Vapor Intrusion, Attachment 2.

PREPARED/DATE: MKB 8/24/05
CHECKED/DATE: CMB 8/25/05

TABLE A-3-2

OCCUPATIONAL ASSUMPTIONS USED IN JOHNSON AND ETTINGER MODEL
INDOOR INDUSTRIAL WORKER EXPOSURES
HUMAN HEALTH BASELINE RISK ASSESSMENT
OPERABLE UNIT 2
Defense Supply Center Richmond
Richmond, Virginia

Parameter	Value	Justification
Average Soil Temp.	16°C	Average site temperature
Depth Below Grade to Enclosed Space Floor	15 cm	Slab-on-Grade
Depth Below Grade to top of contamination	0 cm	Contamination located at all soil sample depths
Depth Below Grade to bottom of contamination	259 cm	Average depth to water table (8.5ft)
SCS Soil Type	L	Loam – Boring logs indicate a heterogeneous fill mixture of sand, silt, and clay
Soil Dry Bulk Density	1.59 g/cm^3	Loam model default
Soil Total Porosity	0.399 unitless	Loam model default
Soil Water-filled Porosity	0.148 cm^3/cm^3	Loam model default
Enclosed Space Floor Thickness	10 cm	Model default
Soil-Building Pressure Differential	40 $g/cm\text{-}s^2$	Model default
Enclosed Space Floor Length	6,096 cm	Length of hypothetical building over former ravine (200 ft)
Enclosed Space Floor Width	6,096 cm	Width of hypothetical building over former ravine (200 ft)
Enclosed Space Height	366 cm	Ceiling Height (12 ft)
Floor-Wall Seam Crack Width	0.1 cm	Model default
Indoor Air Exchange Rate	0.83/hour	Value from the literature for commercial/ industrial (ASTM, 2002)
Averaging Time, Carcinogens	70 years	Model default
Averaging Time, Noncarcinogens	25 years	Model default; Reasonable Maximum Exposure Time for Occupational Scenario (USEPA, 1991)
Exposure Duration	25 years	Model default; Reasonable Maximum Exposure Time for Occupational Scenario (USEPA, 1991)
Exposure Frequency	250 days/year	Default for occupational
Target Risk for Carcinogens	10^{-4} unitless	Target Risk for industrial/commercial scenario
Target Risk for Noncarcinogens	1 unitless	Target Risk

PREPARED/DATE: MKB 8/25/05
CHECKED/DATE: LMS 8/25/05

TABLE A-3-3

INTAKE ASSUMPTIONS
HUMAN HEALTH BASELINE RISK ASSESSMENT
OPERABLE UNIT 2
Defense Supply Center Richmond
Richmond, Virginia

Outdoor Industrial Worker

Intake Assumption	Symbol	Units	Value	
Soil Ingestion Rate	IR	mg/d	100	(a)
Soil Adherence Factor	SAF	mg/cm^2-d	0.2	(b)
Exposed Skin Area	SA	cm^2	3300	(b)
Inhalation Rate	InR	m^3/d	20	(c)
Unit Conversion Factor	UCF	kg/mg	1.E-06	
Exposure Frequency	EF	d/yr	225	(a)
Exposure Duration	ED	yr	25	(a)
Carcinogenic Averaging Time	ATc	d	25550	(a)
Non-carcinogenic Averaging Time	ATn	d	9125	(e)
Body Weight	BW	kg	70	(a)

Construction Worker

Intake Assumption	Symbol	Units	Value	
Soil Ingestion Rate	IR	mg/d	330	(a)
Soil Adherence Factor	SAF	mg/cm^2-d	0.3	(a)
Exposed Skin Area	SA	cm^2	3300	(a), (b)
Inhalation Rate	InR	m^3/d	20	(c)
Unit Conversion Factor	UCF	kg/mg	1.E-06	
Exposure Frequency	EF	d/yr	250	(f)
Exposure Duration	ED	yr	0.5	(f)
Carcinogenic Averaging Time	ATc	d	25550	
Non-carcinogenic Averaging Time	ATn	d	182.5	(e)
Body Weight	BW	kg	70	(a)

Indoor Industrial Worker

Intake Assumption	Symbol	Units	Value	
Inhalation Rate	InR	m^3/d	20	(c)
Unit Conversion Factor	UCF	mg/µg	1.E-03	
Exposure Frequency	EF	d/yr	250	(a)
Exposure Duration	ED	yr	25	(a)
Carcinogenic Averaging Time	ATc	d	25550	(a)
Non-carcinogenic Averaging Time	ATn	d	9125	(e)
Body Weight	BW	kg	70	(a)

Notes:

mg/d	milligrams per day
mg/cm^2-d	milligrams per centimeter squared per day
cm^2	centimeters squared
m^3/d	cubic meter per day
kg/mg	kilograms per milligram
d/yr	days per year
yr	year
d	day
kg	kilogram

(a) Recommendation for indoor, outdoor and construction workers (USEPA, 2002b), Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites.
(b) USEPA (2004), RAGS Part E.
(c) Based on 20 m^3/d (USEPA, 2003a)
(d) Typical workday
(e) ED x 365 d/yr
(f) Site-specific assumption

PREPARED/DATE: MKB 8/24/05
CHECKED/DATE: CMB 8/25/05

TABLE A-4-1

TOXICITY VALUES
HUMAN HEALTH BASELINE RISK ASSESSMENT
OPERABLE UNIT 2
Defense Supply Center Richmond
Richmond, Virginia

Chemical	Inhalation Reference Concentration (mg/m^3)	Source	Inhalation Reference Dose (RfDi) (mg/kg-d)	Source	Oral Reference Dose (RfDo) (mg/kg-d)	Source	Dermal Reference Dose (RfDd) (mg/kg-d)	Source	Inhalation Unit Risk Factor (URF) (mg/m^3)$^{-1}$	Source	Inhalation Slope Factor (SFi) (mg/kg-d)$^{-1}$	Source	Oral Slope Factor (SFo) (mg/kg-d)$^{-1}$	Source	Dermal Slope Factor (SFd) (mg/kg-d)$^{-1}$	Source	Weight of Evidence	Source
Metals/Inorganics:																		
Aluminum	NA	IRIS	1.0E-03	EPA PPV	1.0E+00	EPA PPV	1.0E+00	RfDo	NA	IRIS	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	NA	IRIS	NA	NA	3.0E-04	IRIS	3.0E-04	RfDo	4.3E+00	IRIS	1.5E+01	URF	1.5E+00	IRIS	1.5E+00	SFo	A	IRIS
Copper	NA	IRIS	NA	NA	4.0E-02	HEAST	4.0E-02	RfDo	NA	IRIS	NA	NA	NA	NA	NA	NA	NA	NA
Iron	NA	IRIS	NA	NA	3.0E-01	NCEA	3.0E-01	RfDo	NA	IRIS	NA	NA	NA	NA	NA	NA	D	NCEA
Vanadium	NA	IRIS	NA	NA	1.0E-03	NCEA	2.6E-05 (a)	RfDo	NA	IRIS	NA	NA	NA	NA	NA	NA	ND	IRIS
VOCs																		
1,2-Dichloroethene, total	NA	NA	NA	NA	9.0E-03	HEAST	9.0E-03	RfDo	NA	IRIS	NA	NA	NA	NA	NA	NA	NA	NA
Trichloroethene	4.0E-02	NCEA	1.1E-02	NCEA	3.0E-04	NCEA	3.0E-04	RfDo	6.0E-02	Mid-point	2.1E-01	Mid-Point	2.1E-01	Mid-Point	2.1E-01	SFo	B-C	NCEA
Vinyl chloride	1.0E-01	IRIS	2.8E-02	IRIS	3.0E-03	IRIS	3.0E-03	RfDo	4.4E-03	IRIS	1.5E-02	IRIS	7.2E-01	IRIS	7.2E-01	SFo	A	IRIS
PAHs:																		
Benzo(a)anthracene	NA	IRIS	NA	NA	NA	NA	NA	NA	NA	IRIS	NA	NA	7.3E-01	NCEA	7.3E-01	SFo	B2	IRIS
Benzo(a)pyrene	NA	IRIS	NA	NA	NA	NA	NA	NA	NA	IRIS	3.1E+00	NCEA	7.3E+00	IRIS	7.3E+00	SFo	B2	IRIS
Benzo(b)fluoranthene	NA	IRIS	NA	NA	NA	NA	NA	NA	NA	IRIS	NA	NA	7.3E-01	NCEA	7.3E-01	SFo	B2	IRIS
Benzo(k)fluoranthene	NA	IRIS	NA	NA	NA	NA	NA	NA	NA	IRIS	NA	NA	7.3E-02	NCEA	7.3E-02	SFo	B2	IRIS
Chrysene	NA	IRIS	NA	NA	NA	NA	NA	NA	NA	IRIS	NA	NA	7.3E-03	NCEA	7.3E-03	SFo	B2	IRIS
Dibenzo(a,h)anthracene	NA	IRIS	NA	NA	NA	NA	NA	NA	NA	IRIS	NA	NA	7.3E+00	NCEA	7.3E+00	SFo	B2	IRIS
Indeno(1,2,3-cd)pyrene	NA	IRIS	NA	NA	NA	NA	NA	NA	NA	IRIS	NA	NA	7.3E-01	NCEA	7.3E-01	SFo	B2	IRIS
PCBs																		
PCB-1260	NA	IRIS	NA	NA	NA	IRIS	NA	RfDo	NA	IRIS	2.0E+00	IRIS	2.0E+00	IRIS	2.0E+00	SFo	B2	IRIS

Notes:

NA	Not applicable/not available
mg/m^3	Milligrams per cubic meter
mg/kg-d	Milligrams per kilogram per day
(mg/m^3)$^{-1}$	Per milligram per cubic meter
(mg/kg-d)$^{-1}$	Per milligram per kilogram per day
EPA PPV	USEPA Provisional Peer-reviewed Value
IRIS	Integrated Risk Information System
NCEA	National Center for Environmental Assessment
HEAST	Health Effects Assessment Summary Tables

(a) Dermal reference dose is calculated using the equation: RfDo x ABS_{GI}, where ABS_{GI} is the fraction of contaminant absorbed in the gastrointestinal tract. ABS_{GI} for Vanadium is 2.6%.
Equation and Values from USEPA (2004).
Weight of evidence. A = Human carcinogen; B = Probable human carcinogen; D = Not classifiable as to human carcinogenicity.

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CHECKED/DATE: CMB 8/25/05

TABLE A-5-1

RISK CHARACTERIZATION SUMMARY
HUMAN HEALTH BASELINE RISK ASSESSMENT
OPERABLE UNIT 2
Defense Supply Center Richmond
Richmond, Virginia

Current Outdoor Industrial Worker		Hazard Index	Excess Cancer Risk	Reference
Soil Ingestion		0.3	9.E-04	Table 3-2
Dermal Soil Contact		0.03	8.E-04	Table 3-3
Fugitive Dust Inhalation		NA	5.E-08	Table 3-4
	TOTALS	**0.4**	**2.E-03**	
Future Outdoor Industrial Worker		**Hazard Index**	**Excess Cancer Risk**	
Soil Ingestion		0.3	2.E-04	Table 3-5
Dermal Soil Contact		0.2	2.E-04	Table 3-6
Fugitive Dust Inhalation		0.003	2.E-08	Table 3-7
Inhalation of Volatile Compounds		0.06	5.E-05	Table 3-12
	TOTALS	**0.5**	**4.E-04**	
Future Construction Worker		**Hazard Index**	**Excess Cancer Risk**	
Soil Ingestion		1	1.E-05	Table 3-8
Dermal Soil Contact		0.3	5.E-06	Table 3-9
Fugitive Dust Inhalation		NA	6.E-08	Table 3-10
Inhalation of Volatile Compounds		0.06	1.E-06	Table 3-13
	TOTALS	**1**	**2.E-05**	
Future Indoor Industrial Worker		**Hazard Index**	**Excess Cancer Risk**	
Inhalation of VOCs		0.0001	3.E-08	Table 3-11
	TOTALS	**0.0001**	**3.E-08**	

TABLE A-7-1

SUMMARY OF CHEMICALS OF CONCERN
HUMAN HEALTH BASELINE RISK ASSESSMENT
OPERABLE UNIT 2
Defense Supply Center Richmond
Richmond, Virginia

Current Industrial Worker

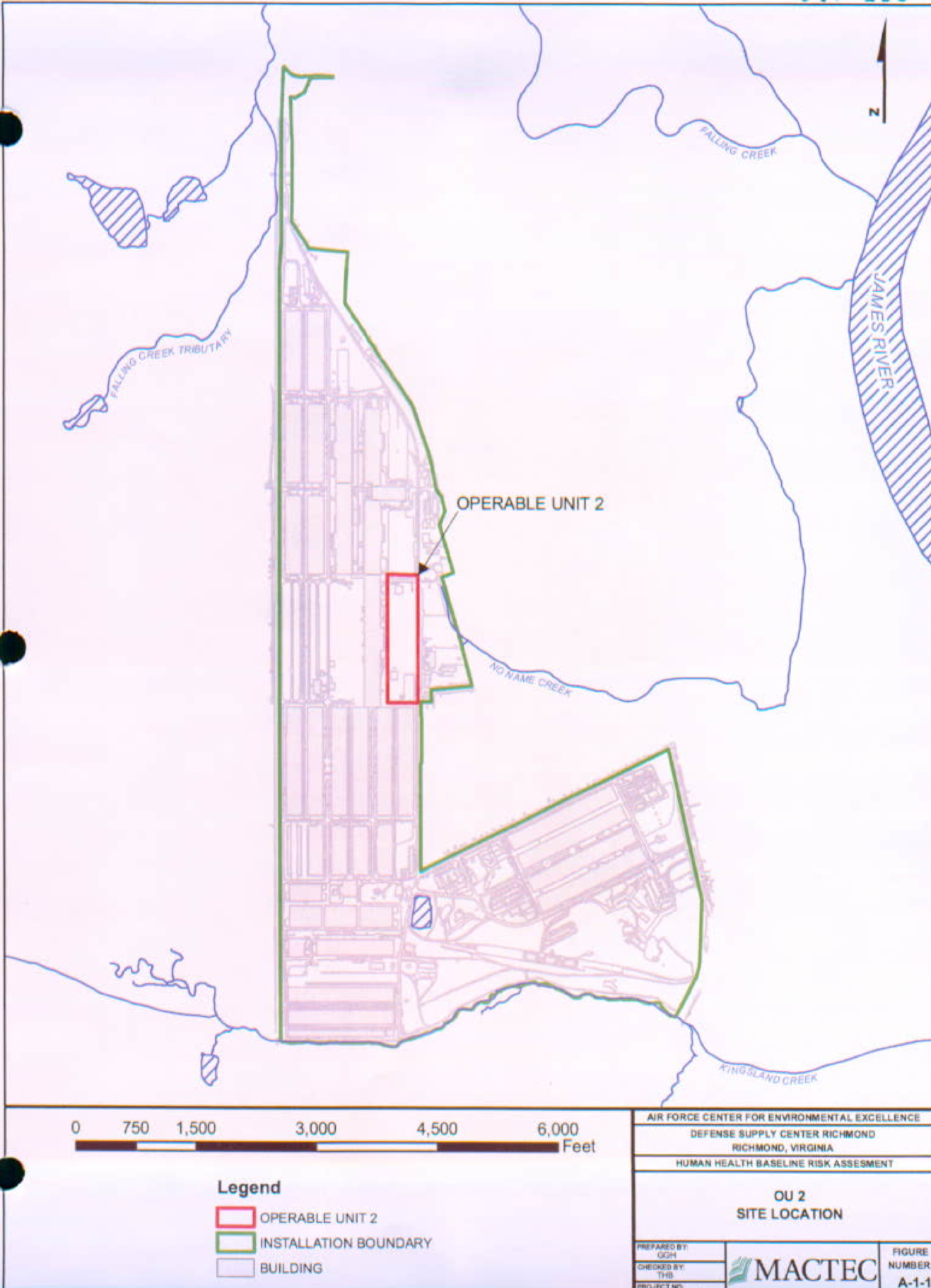
	Ingestion	Inhalation	Dermal Contact	Totals	Reference
Arsenic	1.E-05	1.E-08	2.E-06	1.E-05	Table 4-1
Benzo(a)anthracene	6.E-05	NA	5.E-05	1.E-04	Table 4-1
Benzo(a)pyrene	6.E-04	4.E-08	5.E-04	1.E-03	Table 4-1
Benzo(b)fluoranthene	9.E-05	NA	8.E-05	2.E-04	Table 4-1
Benzo(k)fluoranthene	9.E-06	NA	8.E-06	2.E-05	Table 4-1
Dibenzo(a,h)anthracene	1.E-04	NA	1.E-04	2.E-04	Table 4-1
Indeno(1,2,3-cd)pyrene	3.E-05	NA	3.E-05	6.E-05	Table 4-1
PCB- 1260	2.E-05	3.E-09	2.E-05	4.E-05	Table 4-1
TOTALS	**9.E-04**	**5.E-08**	**8.E-04**	**2.E-03**	

Future Industrial Worker

	Ingestion	Inhalation	Dermal Contact	Totals	Reference
Benzo(a)anthracene	1.E-05	NA	1.E-05	2.E-05	Table 4-2
Benzo(a)pyrene	1.E-04	7.E-09	9.E-05	2.E-04	Table 4-2
Benzo(b)fluoranthene	3.E-05	NA	2.E-05	5.E-05	Table 4-2
Dibenzo(a,h)anthracene	2.E-05	NA	2.E-05	5.E-05	Table 4-2
Indeno(1,2,3-cd)pyrene	6.E-06	NA	5.E-06	1.E-05	Table 4-2
Trichloroethene	8.E-07	5.E-05	2.E-07	5.E-05	Table 4-2
TOTALS	**2.E-04**	**5.E-05**	**2.E-04**	**4.E-04**	

PREPARED/DATE: LMS 9/15/05
CHECKED/DATE: MKB 9/15/05

FIGURES



AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE

DEFENSE SUPPLY CENTER RICHMOND
RICHMOND, VIRGINIA

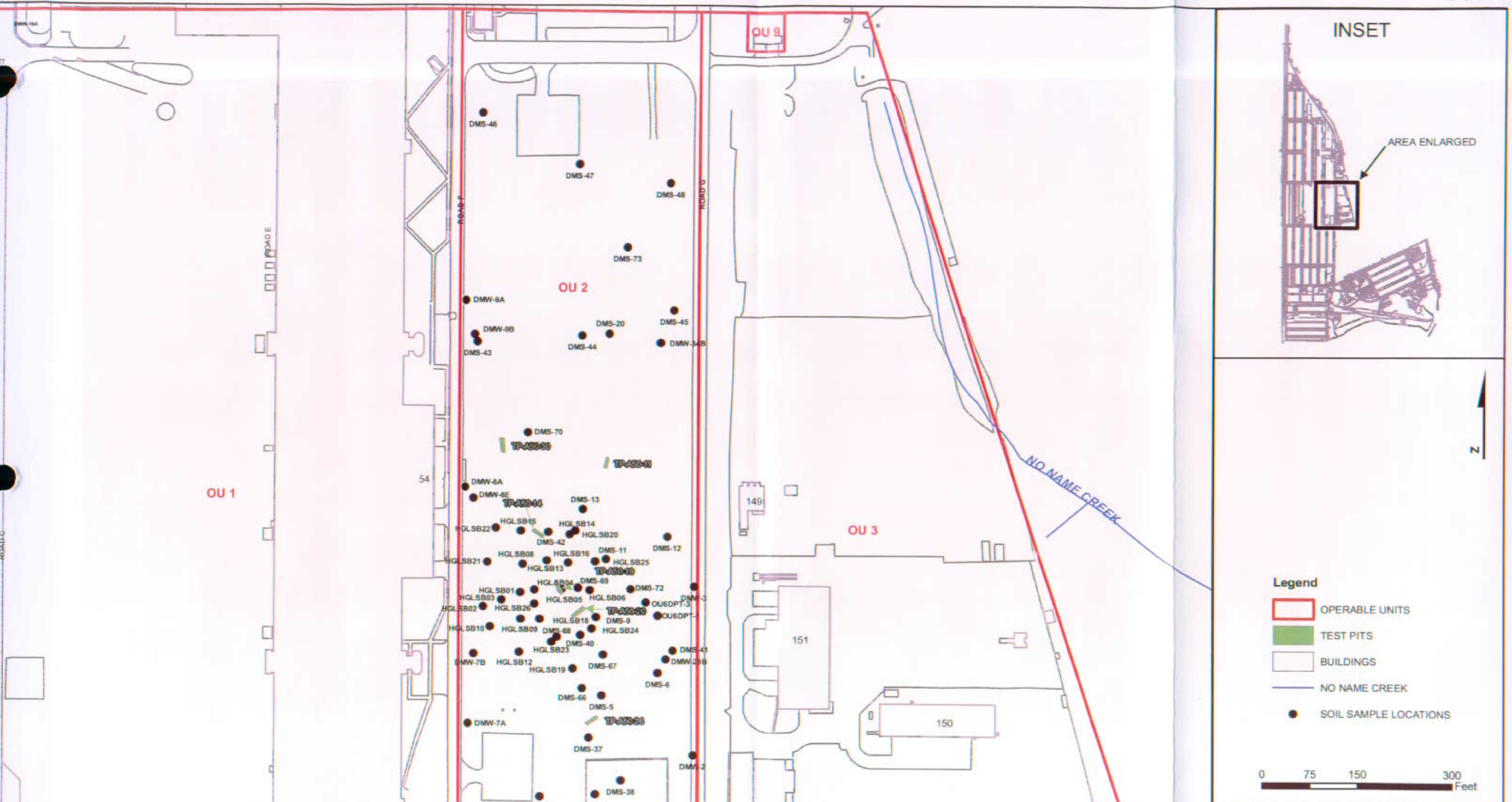
HUMAN HEALTH BASELINE RISK ASSESMENT

OU 2
SITE LOCATION

PREPARED BY: GGH
CHECKED BY: THB
PROJECT NO: 6301-03-0011

MACTEC

FIGURE NUMBER: A-1-1



AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE

DEFENSE SUPPLY CENTER RICHMOND
RICHMOND, VIRGINIA

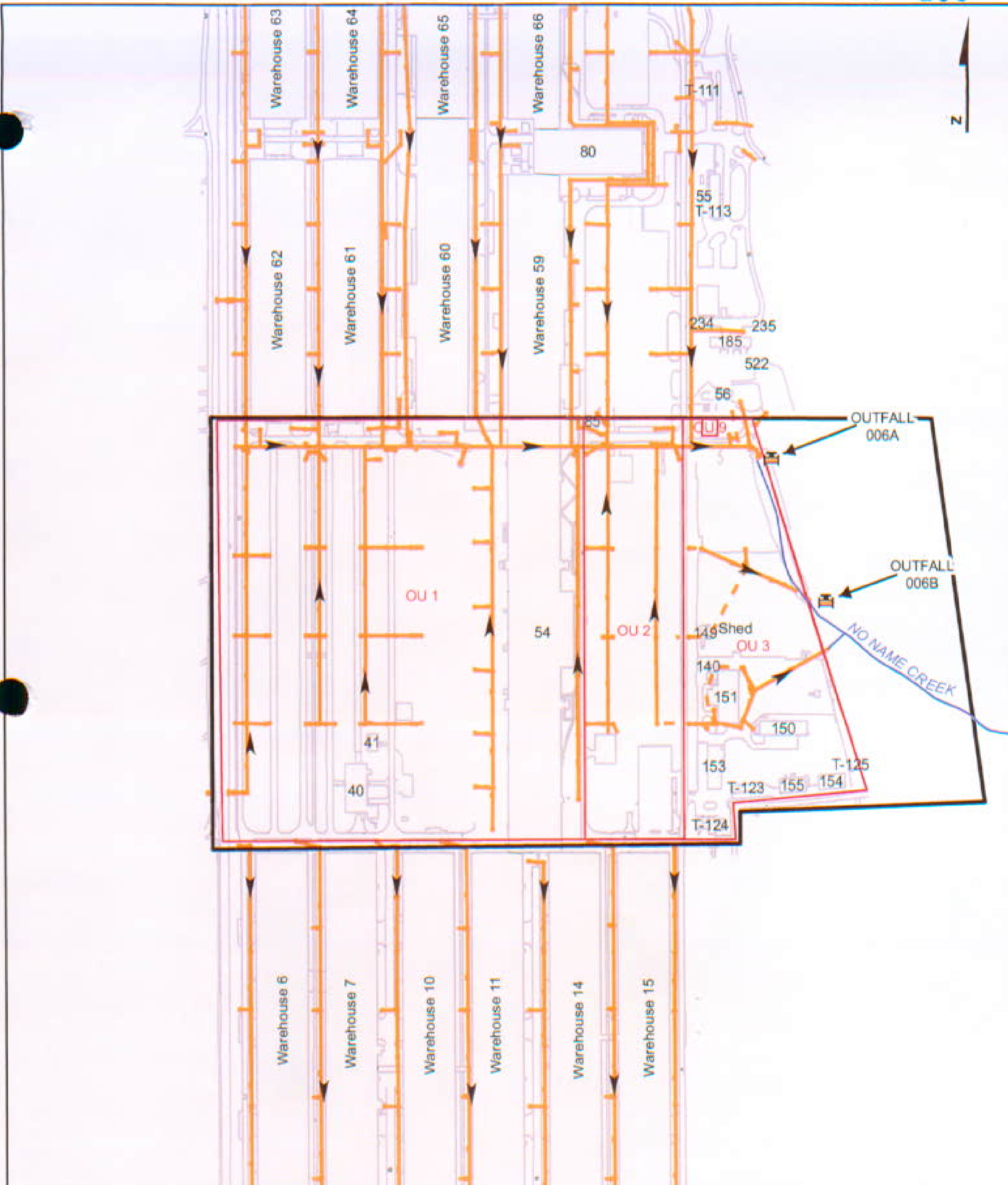
HUMAN HEALTH BASELINE RISK ASSESMENT

OU 2 SOIL SAMPLING LOCATIONS

PREPARED BY: GGH
CHECKED BY: THB
PROJECT NO: 6301050016

MACTEC

FIGURE NUMBER: A-1-2



0 250 500 1,000 1,500 2,000

Scale in Feet

Legend

- STORM SEWER OUTFALLS
- ZONE 2
- BUILDINGS
- OPERABLE UNIT
- 2000 STORM SEWER
- 1988 STORM SEWER
- DIRECTION OF FLOW

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE

DEFENSE SUPPLY CENTER RICHMOND
RICHMOND, VIRGINIA

HUMAN HEALTH BASELINE RISK ASSESMENT

OU 2 AND OU 3
STORM SEWER DRAINAGE

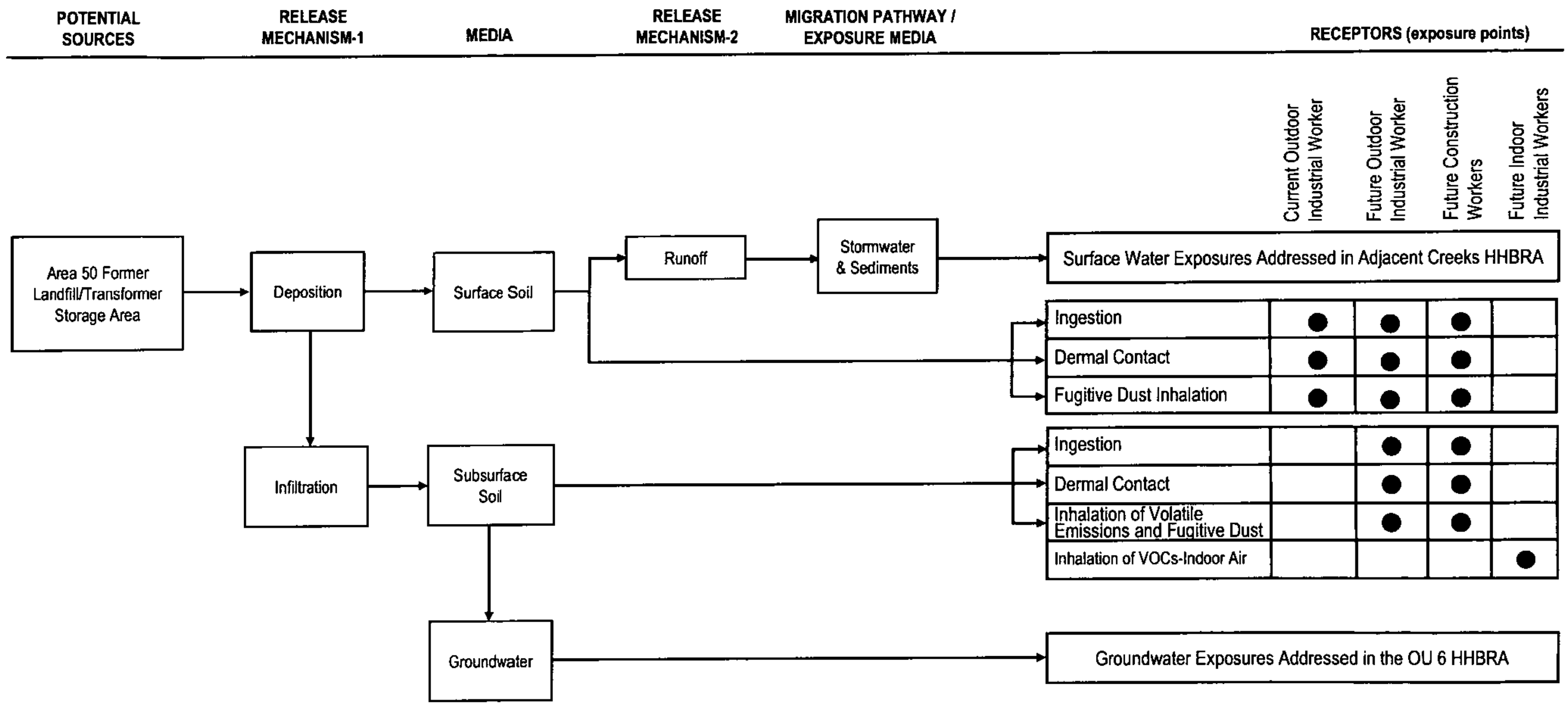
PREPARED BY: GGH
CHECKED BY: THB
PROJECT NO: 6301-03-0011

MACTEC

FIGURE NUMBER: A-1-3

FIGURE A-2-1

CONCEPTUAL EXPOSURE MODEL
HUMAN HEALTH BASELINE RISK ASSESSMENT
OPERABLE UNIT 2
Defense Supply Center Richmond
Richmond, Virginia



● Complete and potentially significant exposure pathway evaluated in HHBRA

PREPARED/DATE: MKB 8/24/05
CHECKED/DATE: LMS 9/13/05

050016.05

ATTACHMENT 1

SITE DATASETS (AVAILABLE ON CD)

ATTACHMENT 2

STATISTICAL ANALYSIS OF SITE AND BACKGROUND DATASETS

ATTACHMENT 2-1

BACKGROUND

POPULATION COMPARISON – BACKGROUND AND SITE DATA
OPERABLE UNIT 2

Surface Soils

Mann-Whitney Test and CI: s_Arsenic, b_Arsenic

s_Arseni N = 15 Median = 15.000
b_Arseni N = 18 Median = 1.810
Point estimate for ETA1-ETA2 is 12.270
95.1 Percent CI for ETA1-ETA2 is (6.649,17.721)
W = 376.0
Test of ETA1 = ETA2 vs ETA1 > ETA2 is significant at 0.0000
The test is significant at 0.0000 (adjusted for ties)

Conclusion: The background and site samples DO NOT come from the same population and site samples tend to be of larger magnitude.

Mann-Whitney Test and CI: s_Copper, b_Copper

s_Copper N = 15 Median = 8.0
b_Copper N = 17 Median = 6.4
Point estimate for ETA1-ETA2 is 1.4
95.0 Percent CI for ETA1-ETA2 is (-2.8,6.1)
W = 267.0
Test of ETA1 = ETA2 vs ETA1 > ETA2 is significant at 0.2365
The test is significant at 0.2365 (adjusted for ties)

Cannot reject at alpha = 0.05

Conclusion: The background and site samples come from the same population.

Mann-Whitney Test and CI: s_Iron, b_Iron

s_Iron N = 15 Median = 15389
b_Iron N = 17 Median = 13100
Point estimate for ETA1-ETA2 is 2598
95.0 Percent CI for ETA1-ETA2 is (-4292,9047)
W = 269.0
Test of ETA1 = ETA2 vs ETA1 > ETA2 is significant at 0.2139

Cannot reject at alpha = 0.05

Conclusion: The background and site samples come from the same population.

Mann-Whitney Test and CI: s_Benzo(a)anthracene, b_Benzo(a)anthracene

s_Benzo(N = 15 Median = 0.46
b_Benzo(N = 16 Median = 0.22
Point estimate for ETA1-ETA2 is 0.16
95.4 Percent CI for ETA1-ETA2 is (-0.01,0.70)

W = 271.0
Test of ETA1 = ETA2 vs ETA1 > ETA2 is significant at 0.1140
The test is significant at 0.1126 (adjusted for ties)

Cannot reject at alpha = 0.05

Conclusion: The background and site samples come from the same population.

Mann-Whitney Test and CI: s_Benzo(a)pyrene, b_Benzo(a)pyrene

s_Benzo(N = 15 Median = 0.37
b_Benzo(N = 17 Median = 0.25
Point estimate for ETA1-ETA2 is 0.10
95.0 Percent CI for ETA1-ETA2 is (-0.10,0.52)
W = 280.0
Test of ETA1 = ETA2 vs ETA1 > ETA2 is significant at 0.1134
The test is significant at 0.1122 (adjusted for ties)

Cannot reject at alpha = 0.05

Conclusion: The background and site samples come from the same population.

Mann-Whitney Test and CI: s_Benzo(b)fluoranthene, b_Benzo(b)fluoranthene

s_Benzo(N = 15 Median = 0.6
b_Benzo(N = 17 Median = 0.3
Point estimate for ETA1-ETA2 is 0.2
95.0 Percent CI for ETA1-ETA2 is (-0.0,0.9)
W = 284.5
Test of ETA1 = ETA2 vs ETA1 > ETA2 is significant at 0.0840
The test is significant at 0.0833 (adjusted for ties)

Cannot reject at alpha = 0.05

Conclusion: The background and site samples come from the same population.

Mann-Whitney Test and CI: s_Benzo(k)fluoranthene, b_Benzo(k)fluoranthene

s_Benzo(N = 15 Median = 0.2
b_Benzo(N = 17 Median = 0.3
Point estimate for ETA1-ETA2 is 0.1
95.0 Percent CI for ETA1-ETA2 is (-0.1,0.6)
W = 262.0
Test of ETA1 = ETA2 vs ETA1 > ETA2 is significant at 0.2985
The test is significant at 0.2971 (adjusted for ties)

Cannot reject at alpha = 0.05

Conclusion: The background and site samples come from the same population.

Mann-Whitney Test and CI: s_Chrysene, b_Chrysene

s_Chryse N = 15 Median = 0.5
b_Chryse N = 17 Median = 0.3
Point estimate for ETA1-ETA2 is 0.2
95.0 Percent CI for ETA1-ETA2 is (-0.1,0.7)
W = 282.0
Test of ETA1 = ETA2 vs ETA1 > ETA2 is significant at 0.0996
The test is significant at 0.0984 (adjusted for ties)

Cannot reject at alpha = 0.05

Conclusion: The background and site samples come from the same population.

Mann-Whitney Test and CI: s_Dibenzo(a,h)anthracene, b_Dibenzo(a,h)anthracene

s_Dibenz N = 15 Median = 0.17
b_Dibenz N = 17 Median = 0.15
Point estimate for ETA1-ETA2 is 0.03
95.0 Percent CI for ETA1-ETA2 is (-0.02,0.10)
W = 281.5
Test of ETA1 = ETA2 vs ETA1 > ETA2 is significant at 0.1029
The test is significant at 0.0951 (adjusted for ties)

Cannot reject at alpha = 0.05

Conclusion: The background and site samples come from the same population.

Mann-Whitney Test and CI: s_Indeno(123-cd)pyrene, b_Indeno(123-cd)pyrene

s_Indeno N = 15 Median = 0.17
b_Indeno N = 17 Median = 0.19
Point estimate for ETA1-ETA2 is 0.07
95.0 Percent CI for ETA1-ETA2 is (-0.01,0.18)
W = 270.5
Test of ETA1 = ETA2 vs ETA1 > ETA2 is significant at 0.1978
The test is significant at 0.1959 (adjusted for ties)

Cannot reject at alpha = 0.05

Conclusion: The background and site samples come from the same population.

Surface and Subsurface Soils

Mann-Whitney Test and CI: s_Aluminum, b_Aluminum

s_Alumin N = 44 Median = 8571.5
b_Alumin N = 35 Median = 8630.0
Point estimate for ETA1-ETA2 is -605.0
95.1 Percent CI for ETA1-ETA2 is (-2792.0,1665.1)
W = 1709.5
Test of ETA1 = ETA2 vs ETA1 > ETA2
Cannot reject since W is < 1760.0

Conclusion: The background and site samples are from the same population.

Mann-Whitney Test and CI: s_Arsenic, b_Arsenic

s_Arseni N = 55 Median = 4.700
b_Arseni N = 36 Median = 1.069
Point estimate for ETA1-ETA2 is 3.300
95.0 Percent CI for ETA1-ETA2 is (1.838,6.040)
W = 3014.0
Test of ETA1 = ETA2 vs ETA1 > ETA2 is significant at 0.0000
The test is significant at 0.0000 (adjusted for ties)

Conclusion: The background and site samples DO NOT come from the same population and site samples tend to be of larger magnitude.

Mann-Whitney Test and CI: s_Copper, b_Copper

s_Copper N = 55 Median = 4.300
b_Copper N = 35 Median = 8.840
Point estimate for ETA1-ETA2 is -3.500
95.0 Percent CI for ETA1-ETA2 is (-6.038,-1.200)
W = 2139.5
Test of ETA1 = ETA2 vs ETA1 > ETA2
Cannot reject since W is < 2502.5

Conclusion: The background and site samples come from the same population.

Mann-Whitney Test and CI: s_Iron, b_Iron

s_Iron N = 45 Median = 14800
b_Iron N = 35 Median = 9560
Point estimate for ETA1-ETA2 is 3116
95.1 Percent CI for ETA1-ETA2 is (-1019,6670)
W = 1977.5
Test of ETA1 = ETA2 vs ETA1 > ETA2 is significant at 0.0670
The test is significant at 0.0670 (adjusted for ties)

Cannot reject at alpha = 0.05

Conclusion: The background and site samples come from the same population.

Mann-Whitney Test and CI: s_Vanadium, b_Vanadium

s_Vanadi N = 45 Median = 23.00
b_Vanadi N = 35 Median = 22.20
Point estimate for ETA1-ETA2 is 0.80
95.1 Percent CI for ETA1-ETA2 is (-5.60,7.30)
W = 1847.0
Test of ETA1 = ETA2 vs ETA1 > ETA2 is significant at 0.4080
The test is significant at 0.4080 (adjusted for ties)

Cannot reject at alpha = 0.05

Conclusion: The background and site samples come from the same population.

ATTACHMENT 2-2

SURFACE SOILS

Arsenic (0-2)

Data File P:\dscr\RISK\OU 2\Working Files\Stats\OU2_Sta Variable: Arsenic

Raw Statistics	
Number of Valid Samples	15
Number of Unique Samples	14
Minimum	4
Maximum	30
Mean	16.326667
Median	15
Standard Deviation	8.6346864
Variance	74.55781
Coefficient of Variation	0.5288701
Skewness	0.3475356

Gamma Statistics	
k hat	3.4096206
k star (bias corrected)	2.7721409
Theta hat	4.7884115
Theta star	5.8895515
nu hat	102.28862
nu star	83.164228
Approx.Chi Square Value (.05)	63.143285
Adjusted Level of Significance	0.03235
Adjusted Chi Square Value	60.998013

Log-transformed Statistics	
Minimum of log data	1.3862944
Maximum of log data	3.4011974
Mean of log data	2.6390471
Standard Deviation of log data	0.6067278
Variance of log data	0.3681187

RECOMMENDATION
Data are normal (0.05)

Use Student's-t UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.9282437
Shapiro-Wilk 5% Critical Value	0.881
Data are normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	20.253448

Gamma Distribution Test	
A-D Test Statistic	0.2635849
A-D 5% Critical Value	0.7426749
K-S Test Statistic	0.1491127
K-S 5% Critical Value	0.222981
Data follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	21.503389
Adjusted Gamma UCL	22.259653

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.9456321
Shapiro-Wilk 5% Critical Value	0.881
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	24.000358
95% Chebyshev (MVUE) UCL	28.403981
97.5% Chebyshev (MVUE) UCL	33.514201
99% Chebyshev (MVUE) UCL	43.552239

95% Non-parametric UCLs	
CLT UCL	19.993813
Adj-CLT UCL (Adjusted for skewness)	20.207577
Mod-t UCL (Adjusted for skewness)	20.286791
Jackknife UCL	20.253448
Standard Bootstrap UCL	19.785578
Bootstrap-t UCL	20.577483
Hall's Bootstrap UCL	20.11414
Percentile Bootstrap UCL	19.826667
BCA Bootstrap UCL	20.093333
95% Chebyshev (Mean, Sd) UCL	26.044686
97.5% Chebyshev (Mean, Sd) UCL	30.24968
99% Chebyshev (Mean, Sd) UCL	38.509578

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Copper (0-2)

Data File P:\dscr\RISK\OU 2\Working Files\Stats\OU2_Sta Variable: Copper

Raw Statistics	
Number of Valid Samples	15
Number of Unique Samples	13
Minimum	2.5
Maximum	14082
Mean	951.14667
Median	8
Standard Deviation	3632.5695
Variance	13195561
Coefficient of Variation	3.8191476
Skewness	3.872879

Gamma Statistics	
k hat	0.1794179
k star (bias corrected)	0.1879788
Theta hat	5301.2922
Theta star	5059.8625
nu hat	5.3825367
nu star	5.6393627
Approx.Chi Square Value (.05)	1.4579664
Adjusted Level of Significance	0.03235
Adjusted Chi Square Value	1.2140903

Log-transformed Statistics	
Minimum of log data	0.9162907
Maximum of log data	9.5526527
Mean of log data	2.6866827
Standard Deviation of log data	2.0639931
Variance of log data	4.2600677

RECOMMENDATION

Data are Non-parametric (0.05)

Use 99% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.286831
Shapiro-Wilk 5% Critical Value	0.881
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	2603.1241

Gamma Distribution Test	
A-D Test Statistic	4.1286826
A-D 5% Critical Value	0.8838549
K-S Test Statistic	0.4572053
K-S 5% Critical Value	0.2458704
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	3679.0017
Adjusted Gamma UCL	4418.0084

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.6426407
Shapiro-Wilk 5% Critical Value	0.881
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	1641.4459
95% Chebyshev (MVUE) UCL	323.83305
97.5% Chebyshev (MVUE) UCL	425.74284
99% Chebyshev (MVUE) UCL	625.9249

95% Non-parametric UCLs	
CLT UCL	2493.8967
Adj-CLT UCL (Adjusted for skewness)	3496.0566
Mod-t UCL (Adjusted for skewness)	2759.4408
Jackknife UCL	2603.1241
Standard Bootstrap UCL	2447.2022
Bootstrap-t UCL	404658.09
Hall's Bootstrap UCL	296972.21
Percentile Bootstrap UCL	2827.1867
BCA Bootstrap UCL	3766.5867
95% Chebyshev (Mean, Sd) UCL	5039.4687
97.5% Chebyshev (Mean, Sd) UCL	6808.489
99% Chebyshev (Mean, Sd) UCL	10283.387

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Iron (0-2)

Data File P:\dscr\RISK\OU 2\Working Files\Stats\OU2_Sta Variable: Iron

Raw Statistics	
Number of Valid Samples	15
Number of Unique Samples	15
Minimum	5
Maximum	39693
Mean	16660.333
Median	15389
Standard Deviation	9717.1161
Variance	94422345
Coefficient of Variation	0.5832486
Skewness	0.8194448

Gamma Statistics	
k hat	0.9964887
k star (bias corrected)	0.8416354
Theta hat	16719.04
Theta star	19795.192
nu hat	29.89466
nu star	25.249061
Approx.Chi Square Value (.05)	14.800619
Adjusted Level of Significance	0.03235
Adjusted Chi Square Value	13.82214

Log-transformed Statistics	
Minimum of log data	1.6094379
Maximum of log data	10.58893
Mean of log data	9.141297
Standard Deviation of log data	2.1381715
Variance of log data	4.5717774

RECOMMENDATION
Data are normal (0.05)

Use Student's-t UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.9338116
Shapiro-Wilk 5% Critical Value	0.881
Data are normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	21079.37

Gamma Distribution Test	
A-D Test Statistic	1.8200011
A-D 5% Critical Value	0.7631997
K-S Test Statistic	0.3121321
K-S 5% Critical Value	0.2279523
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	28421.633
Adjusted Gamma UCL	30433.622

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.4925888
Shapiro-Wilk 5% Critical Value	0.881
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	1454305.6
95% Chebyshev (MVUE) UCL	237520.23
97.5% Chebyshev (MVUE) UCL	312928.07
99% Chebyshev (MVUE) UCL	461052.18

95% Non-parametric UCLs	
CLT UCL	20787.187
Adj-CLT UCL (Adjusted for skewness)	21354.4
Mod-t UCL (Adjusted for skewness)	21167.843
Jackknife UCL	21079.37
Standard Bootstrap UCL	20700.918
Bootstrap-t UCL	21757.252
Hall's Bootstrap UCL	25006.004
Percentile Bootstrap UCL	20817.333
BCA Bootstrap UCL	21163.133
95% Chebyshev (Mean, Sd) UCL	27596.587
97.5% Chebyshev (Mean, Sd) UCL	32328.712
99% Chebyshev (Mean, Sd) UCL	41624.057

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Benzo(a)anthracene (0-2)

Data File P:\dscr\RISK\OU 2\Working Files\Stats\OU2_Sta Variable: Benzo(a)anthracene

Raw Statistics		Normal Distribution Test	
Number of Valid Samples	15	Shapiro-Wilk Test Statisitic	0.3374415
Number of Unique Samples	9	Shapiro-Wilk 5% Critical Value	0.881
Minimum	0.165	Data not normal at 5% significance level	
Maximum	360		
Mean	27.593	95% UCL (Assuming Normal Distribution)	
Median	0.46	Student's-t UCL	69.721423
Standard Deviation	92.637116		
Variance	8581.6353	Gamma Distribution Test	
Coefficient of Variation	3.3572687	A-D Test Statistic	2.8917387
Skewness	3.7820734	A-D 5% Critical Value	0.8734295
		K-S Test Statistic	0.3905015
Gamma Statistics		K-S 5% Critical Value	0.2446726
k hat	0.2080517	Data do not follow gamma distribution	
k star (bias corrected)	0.2108858	at 5% significance level	
Theta hat	132.62569		
Theta star	130.84333	95% UCLs (Assuming Gamma Distribution)	
nu hat	6.2415508	Approximate Gamma UCL	96.5304
nu star	6.326574	Adjusted Gamma UCL	114.27384
Approx.Chi Square Value (.05)	1.8084371		
Adjusted Level of Significance	0.03235	Lognormal Distribution Test	
Adjusted Chi Square Value	1.5276388	Shapiro-Wilk Test Statisitic	0.7400495
		Shapiro-Wilk 5% Critical Value	0.881
Log-transformed Statistics		Data not lognormal at 5% significance level	
Minimum of log data	-1.80181		
Maximum of log data	5.886104	95% UCLs (Assuming Lognormal Distribution)	
Mean of log data	-0.19785	95% H-UCL	289.51497
Standard Deviation of log data	2.3105767	95% Chebyshev (MVUE) UCL	29.306228
Variance of log data	5.3387647	97.5% Chebyshev (MVUE) UCL	38.777436
		99% Chebyshev (MVUE) UCL	57.38179
		95% Non-parametric UCLs	
		CLT UCL	66.935926
		Adj-CLT UCL (Adjusted for skewness)	91.893601
		Mod-t UCL (Adjusted for skewness)	73.614316
		Jackknife UCL	69.721423
		Standard Bootstrap UCL	64.284751
		Bootstrap-t UCL	2105.9113
RECOMMENDATION		Hall's Bootstrap UCL	1955.1636
Data are Non-parametric (0.05)		Percentile Bootstrap UCL	73.235333
		BCA Bootstrap UCL	102.67533
Use 99% Chebyshev (Mean, Sd) UCL		95% Chebyshev (Mean, Sd) UCL	131.85263
		97.5% Chebyshev (Mean, Sd) UCL	176.96586
		99% Chebyshev (Mean, Sd) UCL	265.58206

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Benzo(a)pyrene (0-2)

Data File P:\dscr\RISK\OU 2\Working Files\Stats\OU2_Sta Variable: Benzo(a)pyrene

Raw Statistics	
Number of Valid Samples	15
Number of Unique Samples	9
Minimum	0.165
Maximum	340
Mean	24.427667
Median	0.37
Standard Deviation	87.420405
Variance	7642.3272
Coefficient of Variation	3.5787456
Skewness	3.8551271

Gamma Statistics	
k hat	0.2070647
k star (bias corrected)	0.2100962
Theta hat	117.9712
Theta star	116.26897
nu hat	6.21194
nu star	6.3028854
Approx.Chi Square Value (.05)	1.7960284
Adjusted Level of Significance	0.03235
Adjusted Chi Square Value	1.5164774

Log-transformed Statistics	
Minimum of log data	-1.80181
Maximum of log data	5.8289456
Mean of log data	-0.339092
Standard Deviation of log data	2.1925465
Variance of log data	4.8072601

RECOMMENDATION
Data are Non-parametric (0.05)

Use 99% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.3101951
Shapiro-Wilk 5% Critical Value	0.881
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	64.183695

Gamma Distribution Test	
A-D Test Statistic	3.136115
A-D 5% Critical Value	0.8738365
K-S Test Statistic	0.3941846
K-S 5% Critical Value	0.2447225
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	85.725136
Adjusted Gamma UCL	101.52791

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.7239626
Shapiro-Wilk 5% Critical Value	0.881
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	142.67139
95% Chebyshev (MVUE) UCL	20.157926
97.5% Chebyshev (MVUE) UCL	26.596119
99% Chebyshev (MVUE) UCL	39.242702

95% Non-parametric UCLs	
CLT UCL	61.555059
Adj-CLT UCL (Adjusted for skewness)	85.562212
Mod-t UCL (Adjusted for skewness)	67.928326
Jackknife UCL	64.183695
Standard Bootstrap UCL	59.664536
Bootstrap-t UCL	2116.6211
Hall's Bootstrap UCL	1967.0087
Percentile Bootstrap UCL	68.756667
BCA Bootstrap UCL	115.945
95% Chebyshev (Mean, Sd) UCL	122.81609
97.5% Chebyshev (Mean, Sd) UCL	165.38883
99% Chebyshev (Mean, Sd) UCL	249.01475

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Benzo(b)fluoranthene (0-2)

Data File P:\dscr\RISK\OU 2\Working Files\Stats\OU2_Sta Variable: Benzo(b)fluoranthene

Raw Statistics	
Number of Valid Samples	15
Number of Unique Samples	9
Minimum	0.165
Maximum	540
Mean	39.162
Median	0.58
Standard Deviation	138.82203
Variance	19271.556
Coefficient of Variation	3.5448146
Skewness	3.847899

Gamma Statistics	
k hat	0.2010075
k star (bias corrected)	0.2052505
Theta hat	194.82854
Theta star	190.80104
nu hat	6.0302252
nu star	6.1575135
Approx.Chi Square Value (.05)	1.7203694
Adjusted Level of Significance	0.03235
Adjusted Chi Square Value	1.4485117

Log-transformed Statistics	
Minimum of log data	-1.80181
Maximum of log data	6.2915691
Mean of log data	0.0094176
Standard Deviation of log data	2.333725
Variance of log data	5.4462725

RECOMMENDATION

Data are Non-parametric (0.05)

Use 99% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.3145994
Shapiro-Wilk 5% Critical Value	0.881
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	102.29386

Gamma Distribution Test	
A-D Test Statistic	2.8057133
A-D 5% Critical Value	0.8763345
K-S Test Statistic	0.3711649
K-S 5% Critical Value	0.245029
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	140.16789
Adjusted Gamma UCL	166.4747

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.784307
Shapiro-Wilk 5% Critical Value	0.881
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	399.44568
95% Chebyshev (MVUE) UCL	37.758627
97.5% Chebyshev (MVUE) UCL	49.987603
99% Chebyshev (MVUE) UCL	74.009059

95% Non-parametric UCLs	
CLT UCL	98.11963
Adj-CLT UCL (Adjusted for skewness)	136.17108
Mod-t UCL (Adjusted for skewness)	108.22911
Jackknife UCL	102.29386
Standard Bootstrap UCL	98.981459
Bootstrap-t UCL	3317.893
Hall's Bootstrap UCL	3053.3615
Percentile Bootstrap UCL	110.607
BCA Bootstrap UCL	148.894
95% Chebyshev (Mean, Sd) UCL	195.40104
97.5% Chebyshev (Mean, Sd) UCL	263.0058
99% Chebyshev (Mean, Sd) UCL	395.80225

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Benzo(k)fluoranthene (0-2)

Data File P:\dscr\RISK\OU 2\Working Files\Stats\OU2_Sta Variable: Benzo(k)fluoranthene

Raw Statistics		Normal Distribution Test	
Number of Valid Samples	15	Shapiro-Wilk Test Statisitic	0.3111196
Number of Unique Samples	8	Shapiro-Wilk 5% Critical Value	0.881
Minimum	0.165	Data not normal at 5% significance level	
Maximum	540		
Mean	38.704	95% UCL (Assuming Normal Distribution)	
Median	0.165	Student's-t UCL	101.89328
Standard Deviation	138.94831		
Variance	19306.632	Gamma Distribution Test	
Coefficient of Variation	3.5900245	A-D Test Statistic	3.3166715
Skewness	3.8480057	A-D 5% Critical Value	0.8812605
		K-S Test Statistic	0.4159322
Gamma Statistics		K-S 5% Critical Value	0.2455817
k hat	0.1869337	Data do not follow gamma distribution	
k star (bias corrected)	0.1939914	at 5% significance level	
Theta hat	207.04671		
Theta star	199.51403	95% UCLs (Assuming Gamma Distribution)	
nu hat	5.6080099	Approximate Gamma UCL	145.51125
nu star	5.8197412	Adjusted Gamma UCL	174.03648
Approx.Chi Square Value (.05)	1.5479714		
Adjusted Level of Significance	0.03235	Lognormal Distribution Test	
Adjusted Chi Square Value	1.2942531	Shapiro-Wilk Test Statisitic	0.6922916
		Shapiro-Wilk 5% Critical Value	0.881
Log-transformed Statistics		Data not lognormal at 5% significance level	
Minimum of log data	-1.80181		
Maximum of log data	6.2915691	95% UCLs (Assuming Lognormal Distribution)	
Mean of log data	-0.322274	95% H-UCL	311.76753
Standard Deviation of log data	2.3505198	95% Chebyshev (MVUE) UCL	28.024946
Variance of log data	5.5249434	97.5% Chebyshev (MVUE) UCL	37.115231
		99% Chebyshev (MVUE) UCL	54.971335
		95% Non-parametric UCLs	
		CLT UCL	97.71526
		Adj-CLT UCL (Adjusted for skewness)	135.80238
		Mod-t UCL (Adjusted for skewness)	107.83411
		Jackknife UCL	101.89328
		Standard Bootstrap UCL	95.753376
		Bootstrap-t UCL	10577.796
RECOMMENDATION		Hall's Bootstrap UCL	6214.6075
Data are Non-parametric (0.05)		Percentile Bootstrap UCL	108.516
		BCA Bootstrap UCL	146.59067
Use 99% Chebyshev (Mean, Sd) UCL		95% Chebyshev (Mean, Sd) UCL	195.08516
		97.5% Chebyshev (Mean, Sd) UCL	262.75141
		99% Chebyshev (Mean, Sd) UCL	395.66867

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Chrysene (0-2)

Data File P:\dscr\RISK\OU 2\Working Files\Stats\OU2_Sta Variable: Chrysene

Raw Statistics	
Number of Valid Samples	15
Number of Unique Samples	9
Minimum	0.165
Maximum	400
Mean	30.267
Median	0.47
Standard Deviation	102.89435
Variance	10587.247
Coefficient of Variation	3.3995555
Skewness	3.7987601

Gamma Statistics	
k hat	0.204725
k star (bias corrected)	0.2082245
Theta hat	147.84221
Theta star	145.35756
nu hat	6.1417508
nu star	6.246734
Approx.Chi Square Value (.05)	1.7667038
Adjusted Level of Significance	0.03235
Adjusted Chi Square Value	1.4901164

Log-transformed Statistics	
Minimum of log data	-1.80181
Maximum of log data	5.9914645
Mean of log data	-0.171523
Standard Deviation of log data	2.3271852
Variance of log data	5.4157907

RECOMMENDATION
Data are Non-parametric (0.05)

Use 99% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.3323182
Shapiro-Wilk 5% Critical Value	0.881
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	77.060087

Gamma Distribution Test	
A-D Test Statistic	2.9023704
A-D 5% Critical Value	0.8748014
K-S Test Statistic	0.3934961
K-S 5% Critical Value	0.2448409
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	107.01845
Adjusted Gamma UCL	126.88263

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.743162
Shapiro-Wilk 5% Critical Value	0.881
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	322.6739
95% Chebyshev (MVUE) UCL	31.10041
97.5% Chebyshev (MVUE) UCL	41.166948
99% Chebyshev (MVUE) UCL	60.940713

95% Non-parametric UCLs	
CLT UCL	73.966166
Adj-CLT UCL (Adjusted for skewness)	101.80958
Mod-t UCL (Adjusted for skewness)	81.403097
Jackknife UCL	77.060087
Standard Bootstrap UCL	72.21265
Bootstrap-t UCL	2606.7779
Hall's Bootstrap UCL	2356.4368
Percentile Bootstrap UCL	80.958
BCA Bootstrap UCL	115.92833
95% Chebyshev (Mean, Sd) UCL	146.07077
97.5% Chebyshev (Mean, Sd) UCL	196.17915
99% Chebyshev (Mean, Sd) UCL	294.60736

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Dibenzo(a,h)anthracene (0-2)

Data File P:\dscr\RISK\OU 2\Working Files\Stats\OU2_Sta Variable: Dibenzo(a,h)anthracene

Raw Statistics		Normal Distribution Test	
Number of Valid Samples	15	Shapiro-Wilk Test Statisitic	0.2845364
Number of Unique Samples	3	Shapiro-Wilk 5% Critical Value	0.881
Minimum	0.165	Data not normal at 5% significance level	
Maximum	72		
Mean	4.9583333	95% UCL (Assuming Normal Distribution)	
Median	0.165	Student's-t UCL	13.392705
Standard Deviation	18.546526		
Variance	343.97363	Gamma Distribution Test	
Coefficient of Variation	3.7404758	A-D Test Statistic	5.4990113
Skewness	3.8729779	A-D 5% Critical Value	0.8601526
		K-S Test Statistic	0.5604558
Gamma Statistics		K-S 5% Critical Value	0.2430436
k hat	0.2402459	Data do not follow gamma distribution	
k star (bias corrected)	0.2366412	at 5% significance level	
Theta hat	20.638575		
Theta star	20.952961	95% UCLs (Assuming Gamma Distribution)	
nu hat	7.2073773	Approximate Gamma UCL	15.82346
nu star	7.0992352	Adjusted Gamma UCL	18.487388
Approx.Chi Square Value (.05)	2.2245688		
Adjusted Level of Significance	0.03235	Lognormal Distribution Test	
Adjusted Chi Square Value	1.904021	Shapiro-Wilk Test Statisitic	0.3059292
		Shapiro-Wilk 5% Critical Value	0.881
Log-transformed Statistics		Data not lognormal at 5% significance level	
Minimum of log data	-1.80181		
Maximum of log data	4.2766661	95% UCLs (Assuming Lognormal Distribution)	
Mean of log data	-1.374436	95% H-UCL	4.1098109
Standard Deviation of log data	1.5656686	95% Chebyshev (MVUE) UCL	2.2332106
Variance of log data	2.4513182	97.5% Chebyshev (MVUE) UCL	2.879247
		99% Chebyshev (MVUE) UCL	4.1482603
		95% Non-parametric UCLs	
		CLT UCL	12.835031
		Adj-CLT UCL (Adjusted for skewness)	17.951811
		Mod-t UCL (Adjusted for skewness)	14.19082
		Jackknife UCL	13.392705
		Standard Bootstrap UCL	N/R
		Bootstrap-t UCL	N/R
RECOMMENDATION		Hall's Bootstrap UCL	N/R
Data are Non-parametric (0.05)		Percentile Bootstrap UCL	N/R
		BCA Bootstrap UCL	N/R
Use 99% Chebyshev (Mean, Sd) UCL		95% Chebyshev (Mean, Sd) UCL	25.83176
		97.5% Chebyshev (Mean, Sd) UCL	34.863708
		99% Chebyshev (Mean, Sd) UCL	52.605221

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Indeno(1,2,3-cd)pyrene (0-2)

Data File P:\dscr\RISK\OU 2\Working Files\Stats\OU2_Sta Variable: Indeno(1,2,3-cd)pyrene

Raw Statistics	
Number of Valid Samples	15
Number of Unique Samples	8
Minimum	0.165
Maximum	180
Mean	12.952667
Median	0.165
Standard Deviation	46.276075
Variance	2141.4751
Coefficient of Variation	3.5727064
Skewness	3.8550417

Gamma Statistics	
k hat	0.2200785
k star (bias corrected)	0.2205073
Theta hat	58.854747
Theta star	58.740314
nu hat	6.6023562
nu star	6.6152183
Approx.Chi Square Value (.05)	1.9613681
Adjusted Level of Significance	0.03235
Adjusted Chi Square Value	1.6655113

Log-transformed Statistics	
Minimum of log data	-1.80181
Maximum of log data	5.1929569
Mean of log data	-0.732646
Standard Deviation of log data	2.0111787
Variance of log data	4.0448399

RECOMMENDATION
Data are Non-parametric (0.05)

Use 99% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.3093599
Shapiro-Wilk 5% Critical Value	0.881
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	33.997558

Gamma Distribution Test	
A-D Test Statistic	3.6543038
A-D 5% Critical Value	0.8684696
K-S Test Statistic	0.425822
K-S 5% Critical Value	0.244064
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	43.686198
Adjusted Gamma UCL	51.446493

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.6191644
Shapiro-Wilk 5% Critical Value	0.881
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	42.72104
95% Chebyshev (MVUE) UCL	9.5829122
97.5% Chebyshev (MVUE) UCL	12.578385
99% Chebyshev (MVUE) UCL	18.46241

95% Non-parametric UCLs	
CLT UCL	32.606087
Adj-CLT UCL (Adjusted for skewness)	45.314015
Mod-t UCL (Adjusted for skewness)	35.979738
Jackknife UCL	33.997558
Standard Bootstrap UCL	31.707981
Bootstrap-t UCL	1195.3754
Hall's Bootstrap UCL	1163.6855
Percentile Bootstrap UCL	36.811333
BCA Bootstrap UCL	50.017
95% Chebyshev (Mean, Sd) UCL	65.034671
97.5% Chebyshev (Mean, Sd) UCL	87.570596
99% Chebyshev (Mean, Sd) UCL	131.83806

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PCB-1260 (0-2)

Data File P:\dscr\RISK\OU 2\Working Files\Stats\OU2_Sta Variable: PCB-1260

Raw Statistics	
Number of Valid Samples	15
Number of Unique Samples	2
Minimum	0.02
Maximum	47
Mean	3.152
Median	0.02
Standard Deviation	12.130184
Variance	147.14136
Coefficient of Variation	3.8484086
Skewness	3.8729833

Gamma Statistics	
k hat	0.166596
k star (bias corrected)	0.1777212
Theta hat	18.920022
Theta star	17.73564
nu hat	4.9978801
nu star	5.3316374
Approx.Chi Square Value (.05)	1.3079829
Adjusted Level of Significance	0.03235
Adjusted Chi Square Value	1.0811548

Log-transformed Statistics	
Minimum of log data	-3.912023
Maximum of log data	3.8501476
Mean of log data	-3.394545
Standard Deviation of log data	2.0041838
Variance of log data	4.0167528

RECOMMENDATION
Data are Non-parametric (0.05)

Use 99% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.2841696
Shapiro-Wilk 5% Critical Value	0.881
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	8.668423

Gamma Distribution Test	
A-D Test Statistic	5.5943344
A-D 5% Critical Value	0.8882811
K-S Test Statistic	0.5891927
K-S 5% Critical Value	0.2463627
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	12.848272
Adjusted Gamma UCL	15.543863

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.2841696
Shapiro-Wilk 5% Critical Value	0.881
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	2.8946555
95% Chebyshev (MVUE) UCL	0.6601961
97.5% Chebyshev (MVUE) UCL	0.8663727
99% Chebyshev (MVUE) UCL	1.2713668

95% Non-parametric UCLs	
CLT UCL	8.3036816
Adj-CLT UCL (Adjusted for skewness)	11.650269
Mod-t UCL (Adjusted for skewness)	9.190423
Jackknife UCL	8.668423
Standard Bootstrap UCL	N/R
Bootstrap-t UCL	N/R
Hall's Bootstrap UCL	N/A
Percentile Bootstrap UCL	N/R
BCA Bootstrap UCL	N/R
95% Chebyshev (Mean, Sd) UCL	16.804071
97.5% Chebyshev (Mean, Sd) UCL	22.711334
99% Chebyshev (Mean, Sd) UCL	34.315007

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ATTACHMENT 2-3

ALL SOILS

Aluminum (0-10)

Data File P:\dscr\RISK\OU 2\Revised Files 9-22-05\OU2_S Variable: Aluminum

Raw Statistics	
Number of Valid Samples	45
Number of Unique Samples	44
Minimum	2550
Maximum	128000
Mean	11305.222
Median	8443
Standard Deviation	18346.069
Variance	336578248
Coefficient of Variation	1.622796
Skewness	6.1037355

Gamma Statistics	
k hat	1.6001634
k star (bias corrected)	1.5083006
Theta hat	7065.0424
Theta star	7495.3374
nu hat	144.01471
nu star	135.74706
Approx.Chi Square Value (.05)	109.82327
Adjusted Level of Significance	0.0446667
Adjusted Chi Square Value	109.05197

Log-transformed Statistics	
Minimum of log data	7.8438486
Maximum of log data	11.759786
Mean of log data	8.989102
Standard Deviation of log data	0.6901455
Variance of log data	0.4763008

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.348166191
Shapiro-Wilk 5% Critical Value	0.945
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	15900.4329

Gamma Distribution Test	
A-D Test Statistic	2.575204364
A-D 5% Critical Value	0.766391605
K-S Test Statistic	0.189778188
K-S 5% Critical Value	0.134015765
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	13973.82064
Adjusted Gamma UCL	14072.65461

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.909277346
Shapiro-Wilk 5% Critical Value	0.945
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	12574.80688
95% Chebyshev (MVUE) UCL	15043.55849
97.5% Chebyshev (MVUE) UCL	17180.4296
99% Chebyshev (MVUE) UCL	21377.89912

95% Non-parametric UCLs	
CLT UCL	15803.68388
Adj-CLT UCL (Adjusted for skewness)	18462.61222
Mod-t UCL (Adjusted for skewness)	16315.17198
Jackknife UCL	15900.4329
Standard Bootstrap UCL	15664.03427
Bootstrap-t UCL	26868.11534
Hall's Bootstrap UCL	33523.66405
Percentile Bootstrap UCL	16708.08889
BCA Bootstrap UCL	20362.15556
95% Chebyshev (Mean, Sd) UCL	23226.24634
97.5% Chebyshev (Mean, Sd) UCL	28384.483
99% Chebyshev (Mean, Sd) UCL	38516.84008

RECOMMENDATION
Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

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Arsenic (0-10)

Data File P:\dscr\RISK\OU 2\Revised Files 9-22-05\OU2_S Variable: Arsenic

Raw Statistics	
Number of Valid Samples	56
Number of Unique Samples	43
Minimum	0.23
Maximum	41
Mean	8.5083929
Median	4.5
Standard Deviation	9.298795
Variance	86.467588
Coefficient of Variation	1.0928968
Skewness	1.5330495

Gamma Statistics	
k hat	0.7645625
k star (bias corrected)	0.7355086
Theta hat	11.128446
Theta star	11.56804
nu hat	85.631001
nu star	82.37696
Approx.Chi Square Value (.05)	62.45696
Adjusted Level of Significance	0.0457143
Adjusted Chi Square Value	61.999122

Log-transformed Statistics	
Minimum of log data	-1.469676
Maximum of log data	3.7135721
Mean of log data	1.3601076
Standard Deviation of log data	1.4947796
Variance of log data	2.2343662

Normal Distribution Test	
Lilliefors Test Statisitic	0.200594342
Lilliefors 5% Critical Value	0.11839673
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	10.5873107

Gamma Distribution Test	
A-D Test Statistic	0.464625872
A-D 5% Critical Value	0.791812458
K-S Test Statistic	0.079392792
K-S 5% Critical Value	0.123624877
Data follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	11.22205658
Adjusted Gamma UCL	11.30492687

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.126992352
Lilliefors 5% Critical Value	0.11839673
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	21.13938261
95% Chebyshev (MVUE) UCL	24.76400755
97.5% Chebyshev (MVUE) UCL	30.52889519
99% Chebyshev (MVUE) UCL	41.85290064

95% Non-parametric UCLs	
CLT UCL	10.55229414
Adj-CLT UCL (Adjusted for skewness)	10.8242981
Mod-t UCL (Adjusted for skewness)	10.62973782
Jackknife UCL	10.5873107
Standard Bootstrap UCL	10.56446954
Bootstrap-t UCL	10.8802551
Hall's Bootstrap UCL	10.85201187
Percentile Bootstrap UCL	10.49732143
BCA Bootstrap UCL	10.85857143
95% Chebyshev (Mean, Sd) UCL	13.92477702
97.5% Chebyshev (Mean, Sd) UCL	16.26845078
99% Chebyshev (Mean, Sd) UCL	20.87214405

RECOMMENDATION

Data follow gamma distribution (0.05)

Use Approximate Gamma UCL

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Copper (0-10)

Data File P:\dscr\RISK\OU 2\Revised Files 9-22-05\OU2_S Variable: Copper

Raw Statistics	
Number of Valid Samples	56
Number of Unique Samples	35
Minimum	0.5
Maximum	14082
Mean	263.74893
Median	4.3
Standard Deviation	1880.6122
Variance	3536702.3
Coefficient of Variation	7.1303122
Skewness	7.4772455

Gamma Statistics	
k hat	0.1828556
k star (bias corrected)	0.1849645
Theta hat	1442.3891
Theta star	1425.9433
nu hat	20.479828
nu star	20.716028
Approx.Chi Square Value (.05)	11.379146
Adjusted Level of Significance	0.0457143
Adjusted Chi Square Value	11.195689

Log-transformed Statistics	
Minimum of log data	-0.693147
Maximum of log data	9.5526527
Mean of log data	1.4942718
Standard Deviation of log data	1.7099776
Variance of log data	2.9240234

Normal Distribution Test	
Lilliefors Test Statisitic	0.508477798
Lilliefors 5% Critical Value	0.11839673
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	684.1946191

Gamma Distribution Test	
A-D Test Statistic	14.07144834
A-D 5% Critical Value	0.921124466
K-S Test Statistic	0.441311005
K-S 5% Critical Value	0.132492056
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	480.161714
Adjusted Gamma UCL	488.0297981

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.149621719
Lilliefors 5% Critical Value	0.11839673
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	39.44159114
95% Chebyshev (MVUE) UCL	43.40635502
97.5% Chebyshev (MVUE) UCL	54.3544744
99% Chebyshev (MVUE) UCL	75.85993495

95% Non-parametric UCLs	
CLT UCL	677.1127807
Adj-CLT UCL (Adjusted for skewness)	945.4205693
Mod-t UCL (Adjusted for skewness)	726.045212
Jackknife UCL	684.1946191
Standard Bootstrap UCL	676.8607734
Bootstrap-t UCL	57475.09256
Hall's Bootstrap UCL	32037.8501
Percentile Bootstrap UCL	766.5119643
BCA Bootstrap UCL	1028.02625
95% Chebyshev (Mean, Sd) UCL	1359.172392
97.5% Chebyshev (Mean, Sd) UCL	1833.163
99% Chebyshev (Mean, Sd) UCL	2764.225766

RECOMMENDATION
Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

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Iron (0-10)

Data File P:\dscr\RISK\OU 2\Revised Files 9-22-05\OU2_S Variable: Iron

Raw Statistics	
Number of Valid Samples	46
Number of Unique Samples	44
Minimum	5
Maximum	76461
Mean	16211.87
Median	14756.5
Standard Deviation	14160.53
Variance	200520612
Coefficient of Variation	0.8734668
Skewness	2.619721

Gamma Statistics	
k hat	1.3332884
k star (bias corrected)	1.2608276
Theta hat	12159.312
Theta star	12858.118
nu hat	122.66253
nu star	115.99614
Approx.Chi Square Value (.05)	92.125657
Adjusted Level of Significance	0.0447826
Adjusted Chi Square Value	91.437631

Log-transformed Statistics	
Minimum of log data	1.6094379
Maximum of log data	11.244536
Mean of log data	9.2737676
Standard Deviation of log data	1.3855109
Variance of log data	1.9196405

RECOMMENDATION
Data are Non-parametric (0.05)

Use 99%

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.73798201
Shapiro-Wilk 5% Critical Value	0.945
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	19718.27183

Gamma Distribution Test	
A-D Test Statistic	1.599140816
A-D 5% Critical Value	0.77098621
K-S Test Statistic	0.148794988
K-S 5% Critical Value	0.133314132
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	20412.49208
Adjusted Gamma UCL	20566.08675

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.655667507
Shapiro-Wilk 5% Critical Value	0.945
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	49447.70477
95% Chebyshev (MVUE) UCL	57395.33119
97.5% Chebyshev (MVUE) UCL	70648.98005
99% Chebyshev (MVUE) UCL	96683.20681

95% Non-parametric UCLs	
CLT UCL	19646.0875
Adj-CLT UCL (Adjusted for skewness)	20507.78955
Mod-t UCL (Adjusted for skewness)	19852.67994
Jackknife UCL	19718.27183
Standard Bootstrap UCL	19578.37026
Bootstrap-t UCL	21629.76502
Hall's Bootstrap UCL	22462.44162
Percentile Bootstrap UCL	19878.34783
BCA Bootstrap UCL	20656.34783
95% Chebyshev (Mean, Sd) UCL	25312.62398
97.5% Chebyshev (Mean, Sd) UCL	29250.52768
99% Chebyshev (Mean, Sd) UCL	36985.77698

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Vanadium (0-10)

Data File P:\dscr\RISK\OU 2\Revised Files 9-22-05\OU2_S Variable: Vanadium

Raw Statistics	
Number of Valid Samples	46
Number of Unique Samples	33
Minimum	3.4
Maximum	389
Mean	31.25
Median	22.5
Standard Deviation	55.475139
Variance	3077.491
Coefficient of Variation	1.7752044
Skewness	6.2113872

Gamma Statistics	
k hat	1.3204374
k star (bias corrected)	1.2488147
Theta hat	23.6664
Theta star	25.023729
nu hat	121.48024
nu star	114.89095
Approx.Chi Square Value (.05)	91.14037
Adjusted Level of Significance	0.0447826
Adjusted Chi Square Value	90.456184

Log-transformed Statistics	
Minimum of log data	1.2237754
Maximum of log data	5.9635793
Mean of log data	3.0177997
Standard Deviation of log data	0.8183599
Variance of log data	0.669713

RECOMMENDATION
Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.342483335
Shapiro-Wilk 5% Critical Value	0.945
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	44.98664338

Gamma Distribution Test	
A-D Test Statistic	2.171458628
A-D 5% Critical Value	0.771236907
K-S Test Statistic	0.172194373
K-S 5% Critical Value	0.133351759
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	39.39354459
Adjusted Gamma UCL	39.69150673

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.930978676
Shapiro-Wilk 5% Critical Value	0.945
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	37.15765109
95% Chebyshev (MVUE) UCL	45.01891746
97.5% Chebyshev (MVUE) UCL	52.2498809
99% Chebyshev (MVUE) UCL	66.45370839

95% Non-parametric UCLs	
CLT UCL	44.70385482
Adj-CLT UCL (Adjusted for skewness)	52.70790093
Mod-t UCL (Adjusted for skewness)	46.23511282
Jackknife UCL	44.98664338
Standard Bootstrap UCL	44.5477885
Bootstrap-t UCL	79.31783246
Hall's Bootstrap UCL	99.16030741
Percentile Bootstrap UCL	47.07391304
BCA Bootstrap UCL	56.84782609
95% Chebyshev (Mean, Sd) UCL	66.90301652
97.5% Chebyshev (Mean, Sd) UCL	82.33010525
99% Chebyshev (Mean, Sd) UCL	112.6336338

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VC (0-10)

Data File

Variable: Vinyl chloride

Raw Statistics	
Number of Valid Samples	56
Number of Unique Samples	8
Minimum	0.00245
Maximum	0.85
Mean	0.0352781
Median	0.005
Standard Deviation	0.158217
Variance	0.0250326
Coefficient of Variation	4.484848
Skewness	5.1419872

Gamma Statistics	
k hat	0.374997
k star (bias corrected)	0.3668126
Theta hat	0.0940758
Theta star	0.0961748
nu hat	41.999665
nu star	41.083016
Approx.Chi Square Value (.05)	27.39102
Adjusted Level of Significance	0.0457143
Adjusted Chi Square Value	27.095162

Log-transformed Statistics	
Minimum of log data	-6.011667
Maximum of log data	-0.162519
Mean of log data	-5.117678
Standard Deviation of log data	0.9845713
Variance of log data	0.9693806

Normal Distribution Test	
Lilliefors Test Statisitic	0.525263329
Lilliefors 5% Critical Value	0.11839673
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	0.070650472

Gamma Distribution Test	
A-D Test Statistic	20.76098754
A-D 5% Critical Value	0.845059212
K-S Test Statistic	0.541770957
K-S 5% Critical Value	0.1278498
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	0.052912661
Adjusted Gamma UCL	0.053490428

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.48349951
Lilliefors 5% Critical Value	0.11839673
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	0.013154699
95% Chebyshev (MVUE) UCL	0.016083349
97.5% Chebyshev (MVUE) UCL	0.018886803
99% Chebyshev (MVUE) UCL	0.024393645

95% Non-parametric UCLs	
CLT UCL	0.070054673
Adj-CLT UCL (Adjusted for skewness)	0.085577707
Mod-t UCL (Adjusted for skewness)	0.073071752
Jackknife UCL	0.070650472
Standard Bootstrap UCL	0.069438223
Bootstrap-t UCL	4.41033982
Hall's Bootstrap UCL	3.03856355
Percentile Bootstrap UCL	0.080146875
BCA Bootstrap UCL	0.095597321
95% Chebyshev (Mean, Sd) UCL	0.127436756
97.5% Chebyshev (Mean, Sd) UCL	0.167313869
99% Chebyshev (Mean, Sd) UCL	0.245644736

RECOMMENDATION
Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

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TCE (0-10)

Data File P:\dscr\RISK\OU 2\Revised Files 9-22-05\OU2_S Variable: TCE

Raw Statistics	
Number of Valid Samples	57
Number of Unique Samples	13
Minimum	0.00105
Maximum	53.4
Mean	1.5351262
Median	0.0025
Standard Deviation	8.2519964
Variance	68.095444
Coefficient of Variation	5.3754514
Skewness	5.6241802

Gamma Statistics	
k hat	0.135356
k star (bias corrected)	0.1399279
Theta hat	11.3414
Theta star	10.970839
nu hat	15.43058
nu star	15.951778
Approx.Chi Square Value (.05)	7.9269117
Adjusted Level of Significance	0.0457895
Adjusted Chi Square Value	7.7796763

Log-transformed Statistics	
Minimum of log data	-6.858965
Maximum of log data	3.9778107
Mean of log data	-5.333678
Standard Deviation of log data	2.0080964
Variance of log data	4.0324511

RECOMMENDATION
Data are Non-parametric (0.05)

Use 99% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.517163128
Lilliefors 5% Critical Value	0.117353567
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	3.363198865

Gamma Distribution Test	
A-D Test Statistic	19.694491
A-D 5% Critical Value	0.955721814
K-S Test Statistic	0.537699123
K-S 5% Critical Value	0.133050507
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	3.08922232
Adjusted Gamma UCL	3.147687842

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.405256121
Lilliefors 5% Critical Value	0.117353567
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	0.092650755
95% Chebyshev (MVUE) UCL	0.089584929
97.5% Chebyshev (MVUE) UCL	0.114124893
99% Chebyshev (MVUE) UCL	0.162328899

95% Non-parametric UCLs	
CLT UCL	3.332957199
Adj-CLT UCL (Adjusted for skewness)	4.202966332
Mod-t UCL (Adjusted for skewness)	3.498902708
Jackknife UCL	3.363198865
Standard Bootstrap UCL	3.344599825
Bootstrap-t UCL	137.3619834
Hall's Bootstrap UCL	165.4317759
Percentile Bootstrap UCL	3.443991579
BCA Bootstrap UCL	4.570367895
95% Chebyshev (Mean, Sd) UCL	6.299418557
97.5% Chebyshev (Mean, Sd) UCL	8.360931654
99% Chebyshev (Mean, Sd) UCL	12.41037494

PREPARED/DATE: MKB 8/24/05
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12DCE (0-10)

Data File

Variable: T 1,2-DCE

Raw Statistics	
Number of Valid Samples	11
Number of Unique Samples	7
Minimum	0.00115
Maximum	9.4
Mean	1.0897318
Median	0.0025
Standard Deviation	2.8179118
Variance	7.9406269
Coefficient of Variation	2.5858764
Skewness	3.0812686

Gamma Statistics	
k hat	0.1726339
k star (bias corrected)	0.186158
Theta hat	6.3123875
Theta star	5.8538019
nu hat	3.7979449
nu star	4.0954751
Approx.Chi Square Value (.05)	0.7594754
Adjusted Level of Significance	0.02783
Adjusted Chi Square Value	0.5599014

Log-transformed Statistics	
Minimum of log data	-6.767993
Maximum of log data	2.2407097
Mean of log data	-4.27438
Standard Deviation of log data	3.3361733
Variance of log data	11.130052

RECOMMENDATION

Data are Non-parametric (0.05)

Use Hall's Bootstrap UCL

Recommended UCL exceeds the maximum obser

In case Hall's Bootstrap method yields an erratic, unreasonably large UCL value, use 99% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.460454642
Shapiro-Wilk 5% Critical Value	0.85
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	2.629657426

Gamma Distribution Test	
A-D Test Statistic	1.921121933
A-D 5% Critical Value	0.86964352
K-S Test Statistic	0.447976905
K-S 5% Critical Value	0.283108534
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	5.876384789
Adjusted Gamma UCL	7.97099152

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.683691401
Shapiro-Wilk 5% Critical Value	0.85
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	23815.4862
95% Chebyshev (MVUE) UCL	3.318778808
97.5% Chebyshev (MVUE) UCL	4.460317265
99% Chebyshev (MVUE) UCL	6.702648518

95% Non-parametric UCLs	
CLT UCL	2.487252709
Adj-CLT UCL (Adjusted for skewness)	3.330674229
Mod-t UCL (Adjusted for skewness)	2.761214139
Jackknife UCL	2.629657426
Standard Bootstrap UCL	2.435028275
Bootstrap-t UCL	15.92966591
Hall's Bootstrap UCL	16.74024371
Percentile Bootstrap UCL	2.624127273
BCA Bootstrap UCL	3.768286364
95% Chebyshev (Mean, Sd) UCL	4.79319347
97.5% Chebyshev (Mean, Sd) UCL	6.395684285
99% Chebyshev (Mean, Sd) UCL	9.543467188

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Benzo(a)anthracene (0-10)

Data File P:\dscr\RISK\OU 2\Working Files\Stats\OU2_Sta Variable: Benzo(a)anthracene

Raw Statistics		Normal Distribution Test	
Number of Valid Samples	55	Lilliefors Test Statisitic	0.44936002
Number of Unique Samples	21	Lilliefors 5% Critical Value	0.11946822
Minimum	0.1	Data not normal at 5% significance level	
Maximum	360		
Mean	9.8768182	95% UCL (Assuming Normal Distribution)	
Median	0.165	Student's-t UCL	20.9842107
Standard Deviation	49.221061		
Variance	2422.7129	Gamma Distribution Test	
Coefficient of Variation	4.9834937	A-D Test Statistic	11.2696528
Skewness	6.9327581	A-D 5% Critical Value	0.89443767
		K-S Test Statistic	0.33241909
Gamma Statistics		K-S 5% Critical Value	0.13217898
k hat	0.2310403	Data do not follow gamma distribution	
k star (bias corrected)	0.2305593	at 5% significance level	
Theta hat	42.749327		
Theta star	42.838509	95% UCLs (Assuming Gamma Distribution)	
nu hat	25.414435	Approximate Gamma UCL	16.8263315
nu star	25.361527	Adjusted Gamma UCL	17.0748606
Approx.Chi Square Value (.05)	14.886857		
Adjusted Level of Significance	0.0456364	Lognormal Distribution Test	
Adjusted Chi Square Value	14.670175	Lilliefors Test Statisitic	0.33481307
		Lilliefors 5% Critical Value	0.11946822
Log-transformed Statistics		Data not lognormal at 5% significance level	
Minimum of log data	-2.302585		
Maximum of log data	5.886104	95% UCLs (Assuming Lognormal Distribution)	
Mean of log data	-0.823292	95% H-UCL	6.07684008
Standard Deviation of log data	1.8819608	95% Chebyshev (MVUE) UCL	6.1829872
Variance of log data	3.5417763	97.5% Chebyshev (MVUE) UCL	7.83038334
		99% Chebyshev (MVUE) UCL	11.066374
		95% Non-parametric UCLs	
		CLT UCL	20.7936567
		Adj-CLT UCL (Adjusted for skewness)	27.4230646
		Mod-t UCL (Adjusted for skewness)	22.0182644
		Jackknife UCL	20.9842107
		Standard Bootstrap UCL	20.5703066
		Bootstrap-t UCL	66.2841242
		Hall's Bootstrap UCL	54.7395169
		Percentile Bootstrap UCL	22.2762727
		BCA Bootstrap UCL	30.7633636
		95% Chebyshev (Mean, Sd) UCL	38.8066847
		97.5% Chebyshev (Mean, Sd) UCL	51.324661
		99% Chebyshev (Mean, Sd) UCL	75.9138016

RECOMMENDATION
Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

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Benzo(a)pyrene (0-10)

Data File P:\dscr\RISK\OU 2\Working Files\Stats\OU2_Sta Variable: Benzo(a)pyrene

Raw Statistics	
Number of Valid Samples	55
Number of Unique Samples	20
Minimum	0.1
Maximum	340
Mean	8.3339091
Median	0.165
Standard Deviation	46.122796
Variance	2127.3124
Coefficient of Variation	5.5343532
Skewness	7.1522833

Gamma Statistics	
k hat	0.2322749
k star (bias corrected)	0.2317265
Theta hat	35.879512
Theta star	35.964412
nu hat	25.550236
nu star	25.48992
Approx.Chi Square Value (.05)	14.98538
Adjusted Level of Significance	0.0456364
Adjusted Chi Square Value	14.767914

Log-transformed Statistics	
Minimum of log data	-2.302585
Maximum of log data	5.8289456
Mean of log data	-0.973965
Standard Deviation of log data	1.7649725
Variance of log data	3.1151278

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.445661091
Lilliefors 5% Critical Value	0.119468216
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	18.7421366

Gamma Distribution Test	
A-D Test Statistic	12.13953476
A-D 5% Critical Value	0.893871811
K-S Test Statistic	0.368019012
K-S 5% Critical Value	0.132144531
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	14.17586234
Adjusted Gamma UCL	14.3846098

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.353207155
Lilliefors 5% Critical Value	0.119468216
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	3.859991657
95% Chebyshev (MVUE) UCL	4.137879611
97.5% Chebyshev (MVUE) UCL	5.203288544
99% Chebyshev (MVUE) UCL	7.296078088

95% Non-parametric UCLs	
CLT UCL	18.56357719
Adj-CLT UCL (Adjusted for skewness)	24.97239708
Mod-t UCL (Adjusted for skewness)	19.74178299
Jackknife UCL	18.7421366
Standard Bootstrap UCL	18.38516809
Bootstrap-t UCL	104.7444466
Hall's Bootstrap UCL	75.54659092
Percentile Bootstrap UCL	20.41309091
BCA Bootstrap UCL	32.23409091
95% Chebyshev (Mean, Sd) UCL	35.44275861
97.5% Chebyshev (Mean, Sd) UCL	47.17277945
99% Chebyshev (Mean, Sd) UCL	70.21413401

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Benzo(b)fluoranthene (0-10)

Data File P:\dscr\RISK\OU 2\Working Files\Stats\OU2_Sta Variable: Benzo(b)fluoranthene

Raw Statistics	
Number of Valid Samples	55
Number of Unique Samples	22
Minimum	0.1
Maximum	540
Mean	14.059545
Median	0.165
Standard Deviation	73.55663
Variance	5410.5778
Coefficient of Variation	5.2317929
Skewness	7.0404785

Gamma Statistics	
k hat	0.2202152
k star (bias corrected)	0.2203247
Theta hat	63.844567
Theta star	63.812845
nu hat	24.223674
nu star	24.235716
Approx.Chi Square Value (.05)	14.026327
Adjusted Level of Significance	0.0456364
Adjusted Chi Square Value	13.816601

Log-transformed Statistics	
Minimum of log data	-2.302585
Maximum of log data	6.2915691
Mean of log data	-0.648278
Standard Deviation of log data	2.0165749
Variance of log data	4.0665743

RECOMMENDATION
Data are Non-parametric (0.05)

Use 99% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.431297554
Lilliefors 5% Critical Value	0.119468216
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	30.65858532

Gamma Distribution Test	
A-D Test Statistic	10.24386221
A-D 5% Critical Value	0.899399353
K-S Test Statistic	0.310700665
K-S 5% Critical Value	0.132480995
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	24.29311402
Adjusted Gamma UCL	24.66186628

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.316347638
Lilliefors 5% Critical Value	0.119468216
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	10.50816217
95% Chebyshev (MVUE) UCL	9.946714116
97.5% Chebyshev (MVUE) UCL	12.69020488
99% Chebyshev (MVUE) UCL	18.07926125

95% Non-parametric UCLs	
CLT UCL	30.37381881
Adj-CLT UCL (Adjusted for skewness)	40.43483214
Mod-t UCL (Adjusted for skewness)	32.22790009
Jackknife UCL	30.65858532
Standard Bootstrap UCL	29.96000719
Bootstrap-t UCL	142.5213801
Hall's Bootstrap UCL	99.16573593
Percentile Bootstrap UCL	33.19990909
BCA Bootstrap UCL	52.99218182
95% Chebyshev (Mean, Sd) UCL	57.29273513
97.5% Chebyshev (Mean, Sd) UCL	75.99977084
99% Chebyshev (Mean, Sd) UCL	112.7461201

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Benzo(k)fluoranthene (0-10)

Data File P:\dscr\RISK\OU 2\Working Files\Stats\OU2_Sta Variable: Benzo(k)fluoranthene

Raw Statistics	
Number of Valid Samples	55
Number of Unique Samples	22
Minimum	0.095
Maximum	540
Mean	12.729182
Median	0.165
Standard Deviation	73.512286
Variance	5404.0563
Coefficient of Variation	5.7750991
Skewness	7.1076112

Gamma Statistics	
k hat	0.2041441
k star (bias corrected)	0.2051302
Theta hat	62.353909
Theta star	62.054168
nu hat	22.455849
nu star	22.564318
Approx.Chi Square Value (.05)	12.760599
Adjusted Level of Significance	0.0456364
Adjusted Chi Square Value	12.561497

Log-transformed Statistics	
Minimum of log data	-2.353878
Maximum of log data	6.2915691
Mean of log data	-1.049475
Standard Deviation of log data	1.8113425
Variance of log data	3.2809615

RECOMMENDATION
Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.463887336
Lilliefors 5% Critical Value	0.119468216
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	29.31821501

Gamma Distribution Test	
A-D Test Statistic	13.70155302
A-D 5% Critical Value	0.906765558
K-S Test Statistic	0.395102053
K-S 5% Critical Value	0.13292938
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	22.50876382
Adjusted Gamma UCL	22.86553158

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.370146744
Lilliefors 5% Critical Value	0.119468216
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	4.026970932
95% Chebyshev (MVUE) UCL	4.233317266
97.5% Chebyshev (MVUE) UCL	5.338736153
99% Chebyshev (MVUE) UCL	7.510117506

95% Non-parametric UCLs	
CLT UCL	29.03362017
Adj-CLT UCL (Adjusted for skewness)	39.18444469
Mod-t UCL (Adjusted for skewness)	30.9015385
Jackknife UCL	29.31821501
Standard Bootstrap UCL	28.66881714
Bootstrap-t UCL	198.4906788
Hall's Bootstrap UCL	194.4322242
Percentile Bootstrap UCL	32.06118182
BCA Bootstrap UCL	51.89072727
95% Chebyshev (Mean, Sd) UCL	55.93630851
97.5% Chebyshev (Mean, Sd) UCL	74.63206675
99% Chebyshev (Mean, Sd) UCL	111.3562636

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Chrysene (0-10)

Data File P:\dscr\RISK\OU 2\Working Files\Stats\OU2_Sta Variable: Chrysene

Raw Statistics	
Number of Valid Samples	55
Number of Unique Samples	21
Minimum	0.1
Maximum	400
Mean	10.585273
Median	0.165
Standard Deviation	54.549792
Variance	2975.6798
Coefficient of Variation	5.1533667
Skewness	7.0036634

Gamma Statistics	
k hat	0.2252552
k star (bias corrected)	0.2250897
Theta hat	46.992362
Theta star	47.0269
nu hat	24.778069
nu star	24.759872
Approx.Chi Square Value (.05)	14.426211
Adjusted Level of Significance	0.0456364
Adjusted Chi Square Value	14.213227

Log-transformed Statistics	
Minimum of log data	-2.302585
Maximum of log data	5.9914645
Mean of log data	-0.846919
Standard Deviation of log data	1.885055
Variance of log data	3.5534323

Normal Distribution Test	
Lilliefors Test Statisitic	0.451321567
Lilliefors 5% Critical Value	0.119468216
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	22.89516483

Gamma Distribution Test	
A-D Test Statistic	11.63992184
A-D 5% Critical Value	0.89708929
K-S Test Statistic	0.342062642
K-S 5% Critical Value	0.132340381
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	18.16762514
Adjusted Gamma UCL	18.43986538

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.330131277
Lilliefors 5% Critical Value	0.119468216
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	5.984280296
95% Chebyshev (MVUE) UCL	6.079612045
97.5% Chebyshev (MVUE) UCL	7.70084226
99% Chebyshev (MVUE) UCL	10.88543509

95% Non-parametric UCLs	
CLT UCL	22.68398123
Adj-CLT UCL (Adjusted for skewness)	30.10624001
Mod-t UCL (Adjusted for skewness)	24.05288721
Jackknife UCL	22.89516483
Standard Bootstrap UCL	22.80495869
Bootstrap-t UCL	86.37715028
Hall's Bootstrap UCL	66.77990359
Percentile Bootstrap UCL	23.93554545
BCA Bootstrap UCL	34.47845455
95% Chebyshev (Mean, Sd) UCL	42.64712116
97.5% Chebyshev (Mean, Sd) UCL	56.52030858
99% Chebyshev (Mean, Sd) UCL	83.77149891

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

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Dibenzo(a,h)anthracene (0-10)

Data File P:\dscr\RISK\OU 2\Working Files\Stats\OU2_Sta Variable: Dibenzo(a,h)anthracene

Raw Statistics	
Number of Valid Samples	55
Number of Unique Samples	13
Minimum	0.01
Maximum	72
Mean	2.1072364
Median	0.165
Standard Deviation	10.117989
Variance	102.37369
Coefficient of Variation	4.8015442
Skewness	6.4707977

Gamma Statistics	
k hat	0.3097282
k star (bias corrected)	0.3049552
Theta hat	6.8035011
Theta star	6.9099872
nu hat	34.070105
nu star	33.545069
Approx.Chi Square Value (.05)	21.298937
Adjusted Level of Significance	0.0456364
Adjusted Chi Square Value	21.03567

Log-transformed Statistics	
Minimum of log data	-4.60517
Maximum of log data	4.2766661
Mean of log data	-1.469413
Standard Deviation of log data	1.3419466
Variance of log data	1.8008207

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.490357186
Lilliefors 5% Critical Value	0.119468216
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	4.390496169

Gamma Distribution Test	
A-D Test Statistic	15.85421158
A-D 5% Critical Value	0.860509574
K-S Test Statistic	0.493237556
K-S 5% Critical Value	0.130090836
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	3.318822473
Adjusted Gamma UCL	3.360358398

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.366214922
Lilliefors 5% Critical Value	0.119468216
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	0.921630742
95% Chebyshev (MVUE) UCL	1.10747701
97.5% Chebyshev (MVUE) UCL	1.34892481
99% Chebyshev (MVUE) UCL	1.823202258

95% Non-parametric UCLs	
CLT UCL	4.351325473
Adj-CLT UCL (Adjusted for skewness)	5.62327458
Mod-t UCL (Adjusted for skewness)	4.588894525
Jackknife UCL	4.390496169
Standard Bootstrap UCL	4.310398305
Bootstrap-t UCL	13.00472879
Hall's Bootstrap UCL	14.05997288
Percentile Bootstrap UCL	4.711890909
BCA Bootstrap UCL	6.505618182
95% Chebyshev (Mean, Sd) UCL	8.05412275
97.5% Chebyshev (Mean, Sd) UCL	10.62734524
99% Chebyshev (Mean, Sd) UCL	15.68194255

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Indeno(123-cd)pyrene (0-10)

Data File P:\dscr\RISK\OU 2\Working Files\Stats\OU2_Sta Variable: Indeno(1,2,3-cd)pyrene

Raw Statistics	
Number of Valid Samples	55
Number of Unique Samples	19
Minimum	0.165
Maximum	180
Mean	4.5739091
Median	0.165
Standard Deviation	24.42747
Variance	596.70129
Coefficient of Variation	5.3406112
Skewness	7.1234731

Gamma Statistics	
k hat	0.2745327
k star (bias corrected)	0.2716794
Theta hat	16.660708
Theta star	16.835686
nu hat	30.198597
nu star	29.884734
Approx.Chi Square Value (.05)	18.400219
Adjusted Level of Significance	0.0456364
Adjusted Chi Square Value	18.157006

Log-transformed Statistics	
Minimum of log data	-1.80181
Maximum of log data	5.1929569
Mean of log data	-1.027973
Standard Deviation of log data	1.4697454
Variance of log data	2.1601515

Normal Distribution Test	
Lilliefors Test Statisitic	0.449425164
Lilliefors 5% Critical Value	0.119468216
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	10.08629526

Gamma Distribution Test	
A-D Test Statistic	13.910983
A-D 5% Critical Value	0.874502938
K-S Test Statistic	0.409078507
K-S 5% Critical Value	0.130965538
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	7.428719145
Adjusted Gamma UCL	7.528226702

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.323579174
Lilliefors 5% Critical Value	0.119468216
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	1.852404504
95% Chebyshev (MVUE) UCL	2.175811046
97.5% Chebyshev (MVUE) UCL	2.678790892
99% Chebyshev (MVUE) UCL	3.666797404

95% Non-parametric UCLs	
CLT UCL	9.991726963
Adj-CLT UCL (Adjusted for skewness)	13.37228193
Mod-t UCL (Adjusted for skewness)	10.61359352
Jackknife UCL	10.08629526
Standard Bootstrap UCL	9.987441714
Bootstrap-t UCL	45.82336732
Hall's Bootstrap UCL	39.01251145
Percentile Bootstrap UCL	10.93072727
BCA Bootstrap UCL	17.01454545
95% Chebyshev (Mean, Sd) UCL	18.93124776
97.5% Chebyshev (Mean. Sd) UCL	25.14367967
99% Chebyshev (Mean, Sd) UCL	37.3467992

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

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PCB-1260 (0-10)

Data File

Variable: PCB-1260 (0-10)

Raw Statistics	
Number of Valid Samples	51
Number of Unique Samples	9
Minimum	0.02
Maximum	47
Mean	0.9675392
Median	0.02
Standard Deviation	6.5752113
Variance	43.233404
Coefficient of Variation	6.7958086
Skewness	7.139875

Gamma Statistics	
k hat	0.2189504
k star (bias corrected)	0.2191429
Theta hat	4.4189873
Theta star	4.4151064
nu hat	22.332945
nu star	22.352576
Approx.Chi Square Value (.05)	12.601325
Adjusted Level of Significance	0.0452941
Adjusted Chi Square Value	12.387553

Log-transformed Statistics	
Minimum of log data	-3.912023
Maximum of log data	3.8501476
Mean of log data	-3.346617
Standard Deviation of log data	1.2708895
Variance of log data	1.6151601

Normal Distribution Test	
Lilliefors Test Statisitic	0.513268825
Lilliefors 5% Critical Value	0.124064815
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	2.510567766

Gamma Distribution Test	
A-D Test Statistic	16.52362212
A-D 5% Critical Value	0.899093655
K-S Test Statistic	0.485059161
K-S 5% Critical Value	0.137212155
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	1.71624755
Adjusted Gamma UCL	1.745864917

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.377682588
Lilliefors 5% Critical Value	0.124064815
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	0.126060045
95% Chebyshev (MVUE) UCL	0.151847172
97.5% Chebyshev (MVUE) UCL	0.184317782
99% Chebyshev (MVUE) UCL	0.248100009

95% Non-parametric UCLs	
CLT UCL	2.481978564
Adj-CLT UCL (Adjusted for skewness)	3.465560543
Mod-t UCL (Adjusted for skewness)	2.663986678
Jackknife UCL	2.510567766
Standard Bootstrap UCL	2.47973655
Bootstrap-t UCL	215.244873
Hall's Bootstrap UCL	76.7635008
Percentile Bootstrap UCL	2.804303922
BCA Bootstrap UCL	3.751696078
95% Chebyshev (Mean, Sd) UCL	4.980837397
97.5% Chebyshev (Mean, Sd) UCL	6.717394726
99% Chebyshev (Mean, Sd) UCL	10.12852534

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

PREPARED/DATE: MKB 8/24/05

CHECKED/DATE: CMS 9/23/05

ATTACHMENT 2-4

SOIL VAPOR MODELING

SL-ADV
Version 3.1; 02/04

Reset to Defaults

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

YES [X]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [ ]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (µg/kg)	Chemical
156592	9.40E+03	cis-1,2-Dichloroethylene

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Totals must add up to value of L_t (cell G28) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
16.6	15	15	259	15			L		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil Parameters)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil Parameters)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
L	1.59	0.399	0.148	0.002										

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	6096	6096	366	0.1	0.83	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-04	1

Used to calculate risk-based soil concentration.

END

PREPARED/DATE:MKB 8/25/05
CHECKED/DATE: LMS 9/14/05

CHEMICAL PROPERTIES SHEET

Diffusivity in air, D_a (cm^2/s)	Diffusivity in water, D_w (cm^2/s)	Henry's law constant at reference temperature, H ($atm\text{-}m^3/mol$)	Henry's law constant reference temperature, T_R (°C)	Enthalpy of vaporization at the normal boiling point, $\Delta H_{v,b}$ (cal/mol)	Normal boiling point, T_B (°K)	Critical temperature, T_C (°K)	Organic carbon partition coefficient, K_{oc} (cm^3/g)	Pure component water solubility, S (mg/L)	Unit risk factor, URF ($(\mu g/m^3)^{-1}$)	Reference conc., RfC (mg/m^3)	Physical state at soil temperature, (S,L,G)
7.36E-02	1.13E-05	4.07E-03	25	7,192	333.65	544.00	3.55E+01	3.50E+03	0.0E+00	3.5E-02	L

END

INTERMEDIATE CALCULATIONS SHEET

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (µg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
7.88E+08	1	0.251	ERROR	ERROR	0.257	1.87E-09	0.854	1.60E-09	24,384	1.00E+00	3.14E+06

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
3.75E+07	6.50E-05	15	7,668	2.80E-03	1.18E-01	1.77E-04	4.63E-03	0.00E+00	0.00E+00	4.63E-03	1	15

Soil-water partition coefficient, K_d (cm^3/g)	Source vapor conc., C_{source} (µg/m^3)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, exp(Pe^f) (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ (µg/m^3)	Finite source β term (unitless)	Finite source ψ term $(sec)^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
7.10E-02	6.44E+02	0.10	9.69E+00	4.63E-03	2.44E+03	5.30E+03	NA	NA	1.79E+04	1.88E-03	2.35E+09	NO

Finite source indoor attenuation coefficient, <α> (unitless)	Mass limit bldg. conc., $C_{building}$ (µg/m^3)	Finite source bldg. conc., $C_{building}$ (µg/m^3)	Final finite source bldg. conc., $C_{building}$ (µg/m^3)	Unit risk factor, URF $(µg/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
3.08E-06	NA	1.99E-03	1.99E-03	NA	3.5E-02

END

FUTURE ON-SITE VAPOR INTRUSION
INDUSTRIAL WORKER EXPOSURE - TCE

SL-ADV
Version 3.1; 02/04

Reset to Defaults

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

YES [X]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [ ]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (µg/kg)	Chemical
79016	1.24E+04	Trichloroethylene

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Totals must add up to value of L_t (cell G28) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
16.6	15	15	259	15			L		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil Parameters)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil Parameters)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
L	1.59	0.399	0.148	0.002										

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	6096	6096	366	0.1	0.83	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-04	1

Used to calculate risk-based soil concentration.

END

PREPARED/DATE:MKB 8/25/05
CHECKED/DATE: LMS 9/14/05

CHEMICAL PROPERTIES SHEET

Diffusivity in air, D_a (cm^2/s)	Diffusivity in water, D_w (cm^2/s)	Henry's law constant at reference temperature, H ($atm\text{-}m^3/mol$)	Henry's law constant reference temperature, T_R (^oC)	Enthalpy of vaporization at the normal boiling point, $\Delta H_{v,b}$ (cal/mol)	Normal boiling point, T_B (^oK)	Critical temperature, T_C (^oK)	Organic carbon partition coefficient, K_{oc} (cm^3/g)	Pure component water solubility, S (mg/L)	Unit risk factor, URF ($\mu g/m^3$)$^{-1}$	Reference conc., RfC (mg/m^3)	Physical state at soil temperature, (S,L,G)
7.90E-02	9.10E-06	1.03E-02	25	7,505	360.36	544.20	1.66E+02	1.47E+03	1.1E-04	4.0E-02	L

END

INTERMEDIATE CALCULATIONS SHEET

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (μg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
7.88E+08	1	0.251	ERROR	ERROR	0.257	1.87E-09	0.854	1.60E-09	24,384	1.00E+00	3.14E+06

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} ($atm\text{-}m^3/mol$)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
3.75E+07	6.50E-05	15	8,475	6.79E-03	2.85E-01	1.77E-04	4.97E-03	0.00E+00	0.00E+00	4.97E-03	1	15

Soil-water partition coefficient, K_d (cm^3/g)	Source vapor conc., C_{source} (μg/m³)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, exp(Pe^f) (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ (μg/m³)	Finite source β term (unitless)	Finite source ψ term (sec)$^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
3.32E-01	6.07E+02	0.10	9.69E+00	4.97E-03	2.44E+03	2.95E+03	NA	NA	1.93E+04	1.90E-03	2.49E+09	NO

Finite source indoor attenuation coefficient, <α> (unitless)	Mass limit bldg. conc., $C_{building}$ (μg/m³)	Finite source bldg. conc., $C_{building}$ (μg/m³)	Final finite source bldg. conc., $C_{building}$ (μg/m³)	Unit risk factor, URF (μg/m³)$^{-1}$	Reference conc., RfC (mg/m³)
3.08E-06	NA	1.87E-03	1.87E-03	1.1E-04	4.0E-02

END

SL-ADV
Version 3.1; 02/04

Reset to Defaults

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

YES [X]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [ ]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemical
75014	3.00E+00	Vinyl chloride (chloroethene)

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Totals must add up to value of L_t (cell G28) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
16.6	15	15	259	15			L		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil Parameters)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil Parameters)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
L	1.59	0.399	0.148	0.002										

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	6096	6096	366	0.1	0.83	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-04	1

Used to calculate risk-based soil concentration.

END

PREPARED/DATE:MKB 8/25/05
CHECKED/DATE: LMS 9/14/05

CHEMICAL PROPERTIES SHEET

Diffusivity in air, D_a (cm^2/s)	Diffusivity in water, D_w (cm^2/s)	Henry's law constant at reference temperature, H ($atm\text{-}m^3/mol$)	Henry's law constant reference temperature, T_R (°C)	Enthalpy of vaporization at the normal boiling point, $\Delta H_{v,b}$ (cal/mol)	Normal boiling point, T_B (°K)	Critical temperature, T_C (°K)	Organic carbon partition coefficient, K_{oc} (cm^3/g)	Pure component water solubility, S (mg/L)	Unit risk factor, URF ($(\mu g/m^3)^{-1}$)	Reference conc., RfC (mg/m^3)	Physical state at soil temperature, (S,L,G)
1.06E-01	1.23E-05	2.69E-02	25	5,250	259.25	432.00	1.86E+01	8.80E+03	8.8E-06	1.0E-01	G

END

INTERMEDIATE CALCULATIONS SHEET

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (μg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
7.88E+08	1	0.251	ERROR	ERROR	0.257	1.87E-09	0.854	1.60E-09	24,384	1.00E+00	3.14E+06

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} ($atm\text{-}m^3/mol$)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
3.75E+07	6.50E-05	15	4,926	2.12E-02	8.90E-01	1.77E-04	6.67E-03	0.00E+00	0.00E+00	6.67E-03	1	15

Soil-water partition coefficient, K_d (cm^3/g)	Source vapor conc., C_{source} (μg/m³)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ (μg/m³)	Finite source β term (unitless)	Finite source ψ term $(sec)^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
3.72E-02	3.29E+03	0.10	9.69E+00	6.67E-03	2.44E+03	3.86E+02	NA	NA	2.58E+04	1.38E-02	4.58E+08	YES

Finite source indoor attenuation coefficient, <α> (unitless)	Mass limit bldg. conc., $C_{building}$ (μg/m³)	Finite source bldg. conc., $C_{building}$ (μg/m³)	Final finite source bldg. conc., $C_{building}$ (μg/m³)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m³)
NA	5.89E-03	NA	5.89E-03	8.8E-06	1.0E-01

END

ATTACHMENT 3

RISK CHARACTERIZATION TABLES

TABLE 3-1

DERMAL ABSORPTION FACTORS
BASELINE RISK ASSESSMENT
OPERABLE UNIT 2
Third Revised Final Focused Feasibility Study Report
Defense Supply Center Richmond
Richmond, Virginia

Chemical	Dermal Absorption Factor	
Metals/Inorganics:		
Aluminum	0.01	(b)
Arsenic	0.03	(a)
Copper	0.01	(b)
Iron	0.01	(b)
Vanadium	0.01	(b)
VOCs		
1,2-Dichloroethene	0.03	(b)
Trichloroethene	0.03	(b)
Vinyl chloride	0.03	(b)
PAHs		
Benzo(a)anthracene	0.13	(a)
Benzo(a)pyrene	0.13	(a)
Benzo(b)fluoranthene	0.13	(a)
Benzo(k)fluoranthene	0.13	(a)
Chrysene	0.13	(a)
Dibenzo(a,h)anthracene	0.13	(a)
Indeno(1,2,3-cd)pyrene	0.13	(a)
PCBs		
PCB-1260	0.14	(a)

Notes:

(a) USEPA (2004), RAGS Part E, Exhibit 3-4.

(b) From USEPA (2003b). In the absence of chemical-specific values, general chemical classes were used.

PREPARED/DATE: MKB 8/24/05
CHECKED/DATE: CMB 8/25/05

TABLE 3-2

RISK CHARACTERIZATION
SOIL INGESTION - CURRENT INDUSTRIAL WORKER
HUMAN HEALTH BASELINE RISK ASSESSMENT
OPERABLE UNIT 2
Defense Supply Center Richmond
Richmond, Virginia

Chemical	Average Daily Dose (ADDn) (a) (mg/kg-d)	Oral Reference Dose (RfDo) (b) (mg/kg-d)	Hazard Quotient (c)	Average Daily Dose (ADDc) (a) (mg/kg-d)	Oral Slope Factor (SFo) (b) $(mg/kg\text{-}d)^{-1}$	Excess Cancer Risk (d)
Metals/Inorganics						
Arsenic	1.8E-05	3.0E-04	0.1	6.4E-06	1.5E+00	9.6E-06
Copper	9.1E-03	4.0E-02	0.2	3.2E-03	NA	NA
Iron	1.9E-02	3.0E-01	0.06	6.6E-03	NA	NA
PAHs						
Benzo(a)anthracene	2.3E-04	NA	NA	8.4E-05	7.3E-01	6.1E-05
Benzo(a)pyrene	2.2E-04	NA	NA	7.8E-05	7.3E+00	5.7E-04
Benzo(b)fluoranthene	3.5E-04	NA	NA	1.2E-04	7.3E-01	9.1E-05
Benzo(k)fluoranthene	3.5E-04	NA	NA	1.2E-04	7.3E-02	9.1E-06
Chrysene	2.6E-04	NA	NA	9.3E-05	7.3E-03	6.8E-07
Dibenzo(a,h)anthracene	4.6E-05	NA	NA	1.7E-05	7.3E+00	1.2E-04
Indeno(1,2,3-cd)pyrene	1.2E-04	NA	NA	4.2E-05	7.3E-01	3.0E-05
PCBs						
PCB-1260	3.0E-05	NA	NA	1.1E-05	2.0E+00	2.2E-05
Total			**0.3**			**9.E-04**

Notes:

ADDn Average Daily Dose (non-carcinogenic)
RfDo Reference Dose (oral)
ADDc Average Daily Dose (carcinogenic)
SFo Cancer Slope Factor (oral)
NA Not Applicable

(a) ADDn = (IWdc x UCF x IR x EF x ED)/(BW x ATn); ADDc = (IWdc x UCF x IR x EF x ED)/(BW x ATc); From Table A-3-1 and Table A-3-3.
(b) From Table A-4-1.
(c) ADDn/RfDo.
(d) ADDc x SFo.

PREPARED/DATE: MKB 8/24/05
CHECKED/DATE: CMB 8/25/05

TABLE 3-3

RISK CHARACTERIZATION
SOIL DERMAL CONTACT - CURRENT INDUSTRIAL WORKER
HUMAN HEALTH BASELINE RISK ASSESSMENT
OPERABLE UNIT 2
Defense Supply Center Richmond
Richmond, Virginia

Chemical	Average Daily Dose (ADDn) (a) (mg/kg-d)	Dermal Reference Dose (RfDd) (b) (mg/kg-d)	Hazard Quotient (c)	Average Daily Dose (ADDc) (a) (mg/kg-d)	Dermal Slope Factor (SFd) (b) $(mg/kg\text{-}d)^{-1}$	Excess Cancer Risk (d)
Metals/Inorganics						
Arsenic	3.5E-06	3.0E-04	0.01	1.3E-06	1.5E+00	1.9E-06
Chromium	6.0E-04	4.0E-02	0.01	2.1E-04	NA	NA
Iron	1.2E-03	3.0E-01	0.004	4.4E-04	NA	NA
PAHs						
Benzo(a)anthracene	2.0E-04	NA	NA	7.2E-05	7.3E-01	5.2E-05
Benzo(a)pyrene	1.9E-04	NA	NA	6.7E-05	7.3E+00	4.9E-04
Benzo(b)fluoranthene	3.0E-04	NA	NA	1.1E-04	7.3E-01	7.8E-05
Benzo(k)fluoranthene	3.0E-04	NA	NA	1.1E-04	7.3E-02	7.8E-06
Chrysene	2.2E-04	NA	NA	8.0E-05	7.3E-03	5.8E-07
Dibenzo(a,h)anthracene	4.0E-05	NA	NA	1.4E-05	7.3E+00	1.0E-04
Indeno(1,2,3-cd)pyrene	1.0E-04	NA	NA	3.6E-05	7.3E-01	2.6E-05
PCBs						
PCB-1260	2.8E-05	NA	NA	1.0E-05	2.0E+00	2.0E-05
Total			**0.03**			**8.E-04**

Notes:

ADDn Average Daily Dose (non-carcinogenic)
RfDd Reference Dose (dermal)
ADDc Average Daily Dose (carcinogenic)
SFd Cancer Slope Factor (dermal)
NA Not Applicable

(a) ADDn = (IWdc x SAF X UCF X SA X DAF X EF x ED)/(BW x ATn);
ADDc = (IWdc x SAF x UCF x SA x DAF x EF x ED)/(BW x ATc); From Tables A-3-1, A-3-3 and 3-1.
(b) From Table A-4-1.
(c) ADDn/RfDd.
(d) ADDc x SFd.

PREPARED/DATE: MKB 8/24/05
CHECKED/DATE: CMB 8/25/05

TABLE 3-4

RISK CHARACTERIZATION
DUST INHALATION - CURRENT INDUSTRIAL WORKER
HUMAN HEALTH BASELINE RISK ASSESSMENT
OPERABLE UNIT 2
Defense Supply Center Richmond
Richmond, Virginia

Chemical	Average Daily Dose (ADDn) (a) (mg/kg-day)	Inhalation Reference Dose (RfDi) (b) (mg/kg-day)	Hazard Quotient (c)	Average Daily Dose (ADDc) (a) (mg/kg-day)	Inhalation Slope Factor (SFi) (b) $(mg/kg\text{-}day)^{-1}$	Excess Cancer Risk (d)
Metals/Inorganics						
Arsenic	2.6E-09	NA	NA	9.4E-10	1.5E+01	1.4E-08
Copper	1.3E-06	NA	NA	4.8E-07	NA	NA
Iron	2.7E-06	NA	NA	9.7E-07	NA	NA
PAHs						
Benzo(a)anthracene	3.4E-08	NA	NA	1.2E-08	NA	NA
Benzo(a)pyrene	3.2E-08	NA	NA	1.2E-08	3.1E+00	3.6E-08
Benzo(b)fluoranthene	5.1E-08	NA	NA	1.8E-08	NA	NA
Benzo(k)fluoranthene	5.1E-08	NA	NA	1.8E-08	NA	NA
Chrysene	3.8E-08	NA	NA	1.4E-08	NA	NA
Dibenzo(a,h)anthracene	6.8E-09	NA	NA	2.4E-09	NA	NA
Indeno(1,2,3-cd)pyrene	1.7E-08	NA	NA	6.1E-09	NA	NA
PCBs						
PCB-1260	4.4E-09	NA	NA	1.6E-09	2.0E+00	3.2E-09
Total			**NA**			**5.E-08**

Notes:
ADDn Average Daily Dose (non-carcinogenic)
RfDi Reference Dose (inhalation)
ADDc Average Daily Dose (carcinogenic)
SFi Cancer Slope Factor (inhalation)
NA Not Applicable

(a) ADDn = (IWdu,c x InR x EF x ED)/(BW x ATn); ADDc = (IWdu,c x InR x EF x ED)/(BW x ATc); From Table A-3-1 and Table A-3-3.
(b) From Table A-4-1.
(c) ADDn/RfDi.
(d) ADDc x SFi.

PREPARED/DATE: MKB 8/24/05
CHECKED/DATE: CMB 8/25/05

TABLE 3-5

RISK CHARACTERIZATION
SOIL INGESTION - FUTURE INDUSTRIAL WORKER
HUMAN HEALTH BASELINE RISK ASSESSMENT
OPERABLE UNIT 2
Defense Supply Center Richmond
Richmond, Virginia

Chemical	Average Daily Dose (ADDn) (a) (mg/kg-d)	Oral Reference Dose (RfDo) (b) (mg/kg-d)	Hazard Quotient (c)	Average Daily Dose (ADDc) (a) (mg/kg-d)	Oral Slope Factor (SFo) (b) $(mg/kg\text{-}day)^{-1}$	Excess Cancer Risk (d)
Metals/Inorganics						
Aluminum	2.0E-02	1.0E+00	0.02	7.3E-03	NA	NA
Arsenic	9.9E-06	3.0E-04	0.03	3.5E-06	1.5E+00	5.3E-06
Copper	1.6E-03	4.0E-02	0.04	5.8E-04	NA	NA
Iron	3.3E-02	3.0E-01	0.1	1.2E-02	NA	NA
Vanadium	5.9E-05	1.0E-03	0.06	2.1E-05	NA	NA
VOCs						
1,2-Dichloroethene	8.3E-06	9.0E-03	0.001	3.0E-06	NA	NA
Trichloroethene	1.1E-05	3.0E-04	0.04	3.9E-06	2.1E-01	8.2E-07
Vinyl chloride	2.6E-09	3.0E-03	0.000001	9.4E-10	7.2E-01	6.8E-10
PAHs						
Benzo(a)anthracene	4.5E-05	NA	NA	1.6E-05	7.3E-01	1.2E-05
Benzo(a)pyrene	4.2E-05	NA	NA	1.5E-05	7.3E+00	1.1E-04
Benzo(b)fluoranthene	9.9E-05	NA	NA	3.5E-05	7.3E-01	2.6E-05
Benzo(k)fluoranthene	6.6E-05	NA	NA	2.3E-05	7.3E-02	1.7E-06
Chrysene	5.0E-05	NA	NA	1.8E-05	7.3E-03	1.3E-07
Dibenzo(a,h)anthracene	9.4E-06	NA	NA	3.3E-06	7.3E+00	2.4E-05
Indeno(1,2,3-cd)pyrene	2.2E-05	NA	NA	7.9E-06	7.3E-01	5.8E-06
PCBs						
PCB-1260	5.9E-06	NA	NA	2.1E-06	2.0E+00	4.2E-06
Total			**0.3**			**2.E-04**

Notes:
ADDn Average Daily Dose (non-carcinogenic)
RfDo Reference Dose (oral)
ADDc Average Daily Dose (carcinogenic)
SFo Cancer Slope Factor (oral)
NA Not Applicable

(a) ADDn = (IWdc x UCF x IR x EF x ED)/(BW x ATn); ADDc = (IWdc x UCF x IR x EF x ED)/(BW x ATc); From Table A-3-1 and Table A-3-3.
(b) From Table A-4-1.
(c) ADDn/RfDo.
(d) ADDc x SFo.

PREPARED/DATE: MKB 8/24/05
CHECKED/DATE: CMB 8/25/05

TABLE 3-6

RISK CHARACTERIZATION
SOIL DERMAL CONTACT - FUTURE INDUSTRIAL WORKER
HUMAN HEALTH BASELINE RISK ASSESSMENT
OPERABLE UNIT 2
Defense Supply Center Richmond
Richmond, Virginia

Chemical	Average Daily Dose (ADDn) (a) (mg/kg-d)	Dermal Reference Dose (RfDd) (b) (mg/kg-d)	Hazard Quotient (c)	Average Daily Dose (ADDc) (a) (mg/kg-d)	Dermal Slope Factor (SFd) (b) $(mg/kg\text{-}d)^{-1}$	Excess Cancer Risk (d)
Metals/Inorganics						
Aluminum	1.3E-03	1.0E+00	0.001	4.8E-04	NA	NA
Arsenic	2.0E-06	3.0E-04	0.01	7.0E-07	1.5E+00	1.0E-06
Copper	1.1E-04	4.0E-02	0.003	3.8E-05	NA	NA
Iron	2.1E-03	3.0E-01	0.007	7.7E-04	NA	NA
Vanadium	3.9E-06	2.6E-05	0.1	1.4E-06	NA	NA
VOCs						
1,2-Dichloroethene	1.6E-06	9.0E-03	0.0002	5.9E-07	NA	NA
Trichloroethene	2.2E-06	3.0E-04	0.007	7.7E-07	2.1E-01	1.6E-07
Vinyl chloride	5.2E-10	3.0E-03	0.0000002	1.9E-10	7.2E-01	1.3E-10
PAHs						
Benzo(a)anthracene	3.9E-05	NA	NA	1.4E-05	7.3E-01	1.0E-05
Benzo(a)pyrene	3.6E-05	NA	NA	1.3E-05	7.3E+00	9.3E-05
Benzo(b)fluoranthene	8.5E-05	NA	NA	3.0E-05	7.3E-01	2.2E-05
Benzo(k)fluoranthene	5.6E-05	NA	NA	2.0E-05	7.3E-02	1.5E-06
Chrysene	4.3E-05	NA	NA	1.5E-05	7.3E-03	1.1E-07
Dibenzo(a,h)anthracene	8.0E-06	NA	NA	2.9E-06	7.3E+00	2.1E-05
Indeno(1,2,3-cd)pyrene	1.9E-05	NA	NA	6.8E-06	7.3E-01	5.0E-06
PCBs						
PCB-1260	5.5E-06	NA	NA	2.0E-06	2.0E+00	3.9E-06
Total			**0.2**			**2.E-04**

Notes:

ADDn Average Daily Dose (non-carcinogenic)
RfDd Reference Dose (dermal)
ADDc Average Daily Dose (carcinogenic)
SFd Cancer Slope Factor (dermal)
NA Not Applicable

(a) ADDn = (IWdc x SAF X UCF X SA X DAF X EF x ED)/(BW x ATn);
ADDc = (IWdc x SAF x UCF x SA x DAF x EF x ED)/(BW x ATc); From Table A-3-3, Table A-3-1, and Table 3-1.
(b) From Table A-4-1.
(c) ADDn/RfDd.
(d) ADDc x SFd.

PREPARED/DATE: MKB 8/24/05
CHECKED/DATE: CMB 8/25/05

TABLE 3-7

RISK CHARACTERIZATION
DUST INHALATION - FUTURE INDUSTRIAL WORKER
HUMAN HEALTH BASELINE RISK ASSESSMENT
OPERABLE UNIT 2
Defense Supply Center Richmond
Richmond, Virginia

Chemical	Average Daily Dose (ADDn) (a) (mg/kg-day)	Inhalation Reference Dose (RfDi) (b) (mg/kg-day)	Hazard Quotient (c)	Average Daily Dose (ADDc) (a) (mg/kg-day)	Inhalation Slope Factor (SFi) (b) $(mg/kg\text{-}day)^{-1}$	Excess Cancer Risk (d)
Metals/Inorganics						
Aluminum	3.0E-06	1.0E-03	0.003	1.1E-06	NA	NA
Arsenic	1.5E-09	NA	NA	5.2E-10	1.5E+01	7.8E-09
Copper	2.4E-07	NA	NA	8.5E-08	NA	NA
Iron	4.8E-06	NA	NA	1.7E-06	NA	NA
Vanadium	8.7E-09	NA	NA	3.1E-09	NA	NA
VOCs						
1,2-Dichloroethene	1.2E-09	NA	NA	4.3E-10	NA	NA
Trichloroethene	1.6E-09	1.1E-02	1.E-07	5.7E-10	2.1E-01	1.2E-10
Vinyl chloride	3.9E-13	2.8E-02	1.E-11	1.4E-13	1.5E-02	2.1E-15
PAHs						
Benzo(a)anthracene	6.6E-09	NA	NA	2.4E-09	NA	NA
Benzo(a)pyrene	6.1E-09	NA	NA	2.2E-09	3.1E+00	6.8E-09
Benzo(b)fluoranthene	1.5E-08	NA	NA	5.2E-09	NA	NA
Benzo(k)fluoranthene	9.7E-09	NA	NA	3.5E-09	NA	NA
Chrysene	7.3E-09	NA	NA	2.6E-09	NA	NA
Dibenzo(a,h)anthracene	1.4E-09	NA	NA	4.9E-10	NA	NA
Indeno(1,2,3-cd)pyrene	3.3E-09	NA	NA	1.2E-09	NA	NA
PCBs						
PCB-1260	8.7E-10	NA	NA	3.1E-10	2.0E+00	6.2E-10
Total			**0.003**			**2.E-08**

Notes:
ADDn Average Daily Dose (non-carcinogenic)
RfDi Reference Dose (inhalation)
ADDc Average Daily Dose (carcinogenic)
SFi Cancer Slope Factor (inhalation)
NA Not Applicable

(a) ADDn = (IWdu,c x InR x EF x ED)/(BW x ATn); ADDc = (IWdu,c x InR x EF x ED)/(BW x ATc); From Table A-3-1 and Table A-3-3.
(b) From Table A-4-1.
(c) ADDn/RfDi.
(d) ADDc x SFi.

PREPARED/DATE: MKB 8/24/05
CHECKED/DATE: CMB 8/25/05

TABLE 3-8

RISK CHARACTERIZATION
SOIL INGESTION - FUTURE CONSTRUCTION WORKER
HUMAN HEALTH BASELINE RISK ASSESSMENT
OPERABLE UNIT 2
Defense Supply Center Richmond
Richmond, Virginia

Chemical	Average Daily Dose (ADDn) (a) (mg/kg-d)	Oral Reference Dose (RfDo) (b) (mg/kg-d)	Hazard Quotient (c)	Average Daily Dose (ADDc) (a) (mg/kg-d)	Oral Slope Factor (SFo) (b) $(mg/kg\text{-}day)^{-1}$	Excess Cancer Risk (d)
Metals/Inorganics						
Aluminum	7.5E-02	1.0E+00	0.07	5.4E-04	NA	NA
Arsenic	3.6E-05	3.0E-04	0.1	2.6E-07	1.5E+00	3.9E-07
Copper	5.9E-03	4.0E-02	0.1	4.2E-05	NA	NA
Iron	1.2E-01	3.0E-01	0.4	8.5E-04	NA	NA
Vanadium	2.2E-04	1.0E-03	0.2	1.5E-06	NA	NA
VOCs						
1,2-Dichloroethene	3.0E-05	9.0E-03	0.003	2.2E-07	NA	NA
Trichloroethene	4.0E-05	3.0E-04	0.1	2.9E-07	2.1E-01	6.0E-08
Vinyl chloride	9.7E-09	3.0E-03	0.000003	6.9E-11	7.2E-01	5.0E-11
PAHs						
Benzo(a)anthracene	1.7E-04	NA	NA	1.2E-06	7.3E-01	8.6E-07
Benzo(a)pyrene	1.5E-04	NA	NA	1.1E-06	7.3E+00	7.9E-06
Benzo(b)fluoranthene	3.6E-04	NA	NA	2.6E-06	7.3E-01	1.9E-06
Benzo(k)fluoranthene	2.4E-04	NA	NA	1.7E-06	7.3E-02	1.3E-07
Chrysene	1.8E-04	NA	NA	1.3E-06	7.3E-03	9.5E-09
Dibenzo(a,h)anthracene	3.4E-05	NA	NA	2.5E-07	7.3E+00	1.8E-06
Indeno(1,2,3-cd)pyrene	8.1E-05	NA	NA	5.8E-07	7.3E-01	4.2E-07
PCBs						
PCB-1260	2.2E-05	NA	NA	1.5E-07	2.0E+00	3.1E-07
Total			**1**			**1.E-05**

Notes:

ADDn	Average Daily Dose (non-carcinogenic)
RfDo	Reference Dose (oral)
HQ	Hazard Quotient
ADDc	Average Daily Dose (carcinogenic)
SFo	Cancer Slope Factor (oral)
NA	Not Applicable

(a) ADDn = (CWdc x UCF x IR x EF x ED)/(BW x ATn); ADDc = (CWdc x UCF x IR x EF x ED)/(BW x ATc); From Table A-3-1 and Table A-3-3.
(b) From Table A-4-1.
(c) ADDn/RfDo.
(d) ADDc x SFo.

PREPARED/DATE: MKB 8/24/05
CHECKED/DATE: CMB 8/25/05

TABLE 3-9

RISK CHARACTERIZATION
SOIL DERMAL CONTACT - FUTURE CONSTRUCTION WORKER
BASELINE RISK ASSESSMENT
OPERABLE UNIT 2
Defense Supply Center Richmond
Richmond, Virginia

Chemical	Average Daily Dose (ADDn) (a) (mg/kg-d)	Dermal Reference Dose (RfDd) (b) (mg/kg-d)	Hazard Quotient (c)	Average Daily Dose (ADDc) (a) (mg/kg-d)	Dermal Slope Factor (SFd) (b) $(mg/kg\text{-}d)^{-1}$	Excess Cancer Risk (d)
Metals/Inorganics						
Aluminum	2.2E-03	1.0E+00	0.002	1.6E-05	NA	NA
Arsenic	3.3E-06	3.0E-04	0.01	2.3E-08	1.5E+00	3.5E-08
Copper	1.8E-04	4.0E-02	0.004	1.3E-06	NA	NA
Iron	3.6E-03	3.0E-01	0.01	2.6E-05	NA	NA
Vanadium	6.5E-06	2.6E-05	0.2	4.6E-08	NA	NA
VOCs						
1,2-Dichloroethene	2.7E-06	9.0E-03	0.0003	2.0E-08	NA	NA
Trichloroethene	3.6E-06	3.0E-04	0.01	2.6E-08	2.1E-01	5.4E-09
Vinyl chloride	8.7E-10	3.0E-03	0.0000003	6.2E-12	7.2E-01	4.5E-12
PAHs						
Benzo(a)anthracene	6.5E-05	NA	NA	4.6E-07	7.3E-01	3.4E-07
Benzo(a)pyrene	5.9E-05	NA	NA	4.2E-07	7.3E+00	3.1E-06
Benzo(b)fluoranthene	1.4E-04	NA	NA	1.0E-06	7.3E-01	7.4E-07
Benzo(k)fluoranthene	9.4E-05	NA	NA	6.7E-07	7.3E-02	4.9E-08
Chrysene	7.1E-05	NA	NA	5.1E-07	7.3E-03	3.7E-09
Dibenzo(a,h)anthracene	1.3E-05	NA	NA	9.6E-08	7.3E+00	7.0E-07
Indeno(1,2,3-cd)pyrene	3.2E-05	NA	NA	2.3E-07	7.3E-01	1.7E-07
PCBs						
PCB-1260	9.1E-06	NA	NA	6.5E-08	2.0E+00	1.3E-07
Total			**0.3**			**5.E-06**

Notes:

ADDn Average Daily Dose (non-carcinogenic)
RfDd Reference Dose (dermal)
ADDc Average Daily Dose (carcinogenic)
SFd Cancer Slope Factor (inhalation)
NA Not Applicable

(a) ADDn = (CWdc x SAF X UCF X SA X DAF X EF x ED)/(BW x ATn);
ADDc = (CWdc x SAF x UCF x SA x DAF x EF x ED)/(BW x ATc); From Table A-3-1, Table A-3-3, and Table 3-1.
(b) From Table A-4-1.
(c) ADDn/RfDd.
(d) ADDc x SFd.

PREPARED/DATE: MKB 8/24/05
CHECKED/DATE: CMB 8/25/05

TABLE 3-10

RISK CHARACTERIZATION
DUST INHALATION - FUTURE CONSTRUCTION WORKER
HUMAN HEALTH BASELINE RISK ASSESSMENT
OPERABLE UNIT 2
Defense Supply Center Richmond
Richmond, Virginia

Chemical	Average Daily Dose (ADDn) (a) (mg/kg-day)	Inhalation Reference Dose (RfDi) (b) (mg/kg-day)	Hazard Quotient (c)	Average Daily Dose (ADDc) (a) (mg/kg-day)	Inhalation Slope Factor (SFi) (b) $(mg/kg\text{-}day)^{-1}$	Excess Cancer Risk (d)
Metals/Inorganics						
Aluminum	6.1E-04	1.0E-03	0.6	4.4E-06	NA	NA
Arsenic	2.9E-07	NA	NA	2.1E-09	1.5E+01	3.2E-08
Copper	4.8E-05	NA	NA	3.4E-07	NA	NA
Iron	9.7E-04	NA	NA	6.9E-06	NA	NA
Vanadium	1.8E-06	NA	NA	1.3E-08	NA	NA
VOCs						
1,2-Dichloroethene	2.5E-07	NA	NA	1.8E-09	NA	NA
Trichloroethene	3.3E-07	1.1E-02	3.E-05	2.3E-09	2.1E-01	4.9E-10
Vinyl chloride	7.9E-11	2.8E-02	3.E-09	5.6E-13	1.5E-02	8.4E-15
PAHs						
Benzo(a)anthracene	1.3E-06	NA	NA	9.6E-09	NA	NA
Benzo(a)pyrene	1.2E-06	NA	NA	8.8E-09	3.1E+00	2.7E-08
Benzo(b)fluoranthene	3.0E-06	NA	NA	2.1E-08	NA	NA
Benzo(k)fluoranthene	2.0E-06	NA	NA	1.4E-08	NA	NA
Chrysene	1.5E-06	NA	NA	1.1E-08	NA	NA
Dibenzo(a,h)anthracene	2.8E-07	NA	NA	2.0E-09	NA	NA
Indeno(1,2,3-cd)pyrene	6.6E-07	NA	NA	4.7E-09	NA	NA
PCBs						
PCB-1260	1.8E-07	NA	NA	1.3E-09	2.0E+00	2.5E-09
Total			**0.6**			**6E-08**

Notes:

ADDn	Average Daily Dose (non-carcinogenic)
RfDi	Reference Dose (inhalation)
ADDc	Average Daily Dose (Carcinogenic)
SFi	Cancer Slope Factor (inhalation)
NA	Not Applicable

(a) ADDn = (CWdu,c x InR x EF x ED)/(BW x ATn); ADDc = (CWdu,c x InR x EF x ED)/(BW x ATc); From Table A-3-1 and Table A-3-3.
(b) From Table A-4-1.
(c) ADDn/RfDi.
(d) ADDc x SFi.

PREPARED/DATE: MKB 8/24/05
CHECKED/DATE: CMB 8/25/05

TABLE 3-11

RISK CHARACTERIZATION
INHALATION OF VOLATILES - FUTURE INDOOR INDUSTRIAL WORKER
HUMAN HEALTH BASELINE RISK ASSESSMENT
OPERABLE UNIT 2
Defense Supply Center Richmond
Richmond, Virginia

Chemical	Average Daily Dose (ADDn) (a) (mg/kg-day)	Inhalation Reference Dose (RfDi) (b) (mg/kg-day)	Hazard Quotient (c)	Average Daily Dose (ADDc) (a) (mg/kg-day)	Inhalation Slope Factor (SFi) (b) $(mg/kg\text{-}day)^{-1}$	Excess Cancer Risk (d)
VOCs						
1,2-Dichloroethene	3.9E-07	NA	NA	1.4E-07	NA	NA
Trichloroethene	3.7E-07	1.1E-02	0.00003	1.3E-07	2.1E-01	3.E-08
Vinyl chloride	1.2E-06	2.8E-02	0.00004	4.1E-07	1.5E-02	6.E-09
Total			**0.0001**			**3E-08**

Notes:
ADDn Average Daily Dose (non-carcinogenic)
RfDi Reference Dose (inhalation)
ADDc Average Daily Dose (Carcinogenic)
SFi Cancer Slope Factor (inhalation)
NA Not Applicable

(a) ADDn = ($C_{building}$ x UCF x InR x EF x ED)/(BW x ATn); ADDc = ($C_{building}$ x UCF x InR x EF x ED)/(BW x ATc); From Table A-3-1 and Table A-3-3.
(b) From Table A-4-1.
(c) ADDn/RfDi.
(d) ADDc x SFi.

PREPARED/DATE: MKB 8/24/05
CHECKED/DATE: CMB 8/25/05

TABLE 3-12

RISK CHARACTERIZATION
INHALATION OF VOLATILES - FUTURE OUTDOOR INDUSTRIAL WORKER
HUMAN HEALTH BASELINE RISK ASSESSMENT
OPERABLE UNIT 2
Defense Supply Center Richmond
Richmond, Virginia

Chemical	Volatilization Factor (m^3/kg) (a)	Average Daily Dose (ADDn) (b) (mg/kg-day)	Inhalation Reference Concentration (RfC) (c) (mg/m^3)	Hazard Quotient (d)	Average Daily Dose (ADDc) (b) (mg/kg-day)	Unit Risk Factor (URF) (c) $(mg/m^3)^{-1}$	Excess Cancer Risk (e)
VOCs							
1,2-Dichloroethene	3.52E+03	1.6E-03	NA	NA	5.9E-04	NA	NA
Trichloroethene	3.43E+03	2.2E-03	4.0E-02	0.06	8.0E-04	6.0E-02	4.8.E-05
Vinyl chloride	1.31E+03	1.4E-06	1.0E-01	0.00001	5.0E-07	4.4E-03	2.2.E-09
Total				**0.06**			**5E-05**

Notes:

ADDn Average Daily Dose (non-carcinogenic)
RfDi Reference Dose (inhalation)
ADDc Average Daily Dose (Carcinogenic)
SFi Cancer Slope Factor (inhalation)
NA Not Applicable

(a) VRP, 2005.
(b) ADDn = (IWfut,dc x EF x ED x (1/VF))/(ATn); ADDc = ((IWfut,dc x EF x ED x (1/VF))/ATc); From Table A-3-1 and Table A-3-3.
(c) From Table A-4-1.
(d) ADDn/RfDi.
(e) ADDc x SFi.

PREPARED/DATE: LMS 9/23/05
CHECKED/DATE: MKB 9/26/05

TABLE 3-13

RISK CHARACTERIZATION
INHALATION OF VOLATILES - FUTURE CONSTRUCTION WORKER
HUMAN HEALTH BASELINE RISK ASSESSMENT
OPERABLE UNIT 2
Defense Supply Center Richmond
Richmond, Virginia

Chemical	Volatilization Factor (m^3/kg) (a)	Average Daily Dose (ADDn) (b) (mg/kg-day)	Inhalation Reference Concentration (RfC) (c) (mg/m^3)	Hazard Quotient (d)	Average Daily Dose (ADDc) (b) (mg/kg-day)	Unit Risk Factor (URF) (c) ($(mg/m^3)^{-1}$)	Excess Cancer Risk (e)
VOCs							
1,2-Dichloroethene	3.52E+03	1.8E-03	NA	NA	1.3E-05	NA	NA
Trichloroethene	3.43E+03	2.5E-03	4.0E-02	0.06	1.8E-05	6.0E-02	1.E-06
Vinyl chloride	1.31E+03	1.6E-06	1.0E-01	0.00002	1.1E-08	4.4E-03	5.E-11
Total				**0.06**			**1E-06**

Notes:
ADDn Average Daily Dose (non-carcinogenic)
RfDi Reference Dose (inhalation)
ADDc Average Daily Dose (Carcinogenic)
SFi Cancer Slope Factor (inhalation)
NA Not Applicable

(a) VRP, 2005.
(b) ADDn = (IWfut,dc x EF x ED x (1/VF))/(ATn); ADDc = ((IWfut,dc x EF x ED x (1/VF))/ATc); From Table A-3-1 and Table A-3-3.
(c) From Table A-4-1.
(d) ADDn/RfDi.
(e) ADDc x SFi.

PREPARED/DATE: LMS 9/23/05
CHECKED/DATE: MKB 9/26/05

ATTACHMENT 4

RAGS PART D TABLE FOR COCS

TABLE 4-1

RISK SUMMARY
REASONABLE MAXIMUM EXPOSURE
HUMAN HEALTH BASELINE RISK ASSESSMENT
OPERABLE UNIT 2
Defense Supply Center Richmond
Richmond, Virginia

Scenario Timeframe: Current
Receptor Population: Industrial
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil	Surface Soil	Surface Soil	Arsenic	1.E-05	1.E-08	2.E-06	1.E-05	Skin, Vascular System	0.1	--	0.01	0.1
			Benzo(a)anthracene	6.E-05	NA	5.E-05	1.E-04	NA	--	--	--	--
			Benzo(a)pyrene	6.E-04	4.E-08	5.E-04	1.E-03	NA	--	--	--	--
			Benzo(b)fluoranthene	9.E-05	NA	8.E-05	2.E-04	NA	--	--	--	--
			Benzo(k)fluoranthene	9.E-06	NA	8.E-06	2.E-05	NA	--	--	--	--
			Dibenzo(a,h)anthracene	1.E-04	NA	1.E-04	2.E-04	NA	--	--	--	--
			Indeno(1,2,3-cd)pyrene	3.E-05	NA	3.E-05	6.E-05	NA	--	--	--	--
			PCB-1260	2.E-05	3.E-09	2.E-05	4.E-05	NA	--	--	--	--
			Total	9.E-04	5.E-08	8.E-04	2.E-03		0.1	--	0.01	0.1
		Exposure Point Total					2.E-03					0.1
Medium Total							2.E-03					0.1
Receptor Total							2.E-03				Receptor HI Total	0.1
							2.E-03				Total Hazard Across All Media	0.1

Total Skin HI Across All Media =	0.1
Total Vascular System HI Across All Media =	0.1
Total Immune System HI Across All Media =	--
Total CNS HI Across All Media =	--

PREPARED/DATE: LMS 9/15/05
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847 202

TABLE 4-2

RISK SUMMARY
REASONABLE MAXIMUM EXPOSURE
HUMAN HEALTH BASELINE RISK ASSESSMENT
OPERABLE UNIT 2
Defense Supply Center Richmond
Richmond, Virginia

Scenario Timeframe: Future
Receptor Population: Industrial
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil	Surface and Subsurface Soil	Surface and Subsurface Soil	Benzo(a)anthracene	1.E-05	NA	1.E-05	2.E-05	NA	--	--	--	--
			Benzo(a)pyrene	1.E-04	7.E-09	9.E-05	2.E-04	NA	--	--	--	--
			Benzo(b)fluoranthene	3.E-05	NA	2.E-05	5.E-05	NA	--	--	--	--
			Dibenzo(a,h)anthracene	2.E-05	NA	2 E-05	5.E-05	NA	--	--	--	--
			Indeno(1,2,3-cd)pyrene	6.E-06	NA	5.E-06	1.E-05	NA	--	--	--	--
			Trichloroethene	8.E-07	5.E-05	2.E-07	5.E-05	CNS, Liver, Kidney	0.04	0.06	0.01	0.1
			Total	2.E-04	5.E-05	2.E-04	4.E-04		--	--	--	--
		Exposure Point Total					4.E-04					--
Medium Total							4.E-04					--
Receptor Total							4.E-04				Receptor HI Total	0.1
							4.E-04				Total Hazard Across All Media	0.1

Total CNS HI Across All Media = 0.1
Total Liver HI Across All Media = 0.1
Total Kidney HI Across All Media = 0.1

PREPARED/DATE: LMS 9/15/05
CHECKED/DATE: MKB 9/15/05

APPENDIX B

COST ESTIMATES FOR REMEDIAL ALTERNATIVES

ALTERNATIVE 2 - INSTITUTIONAL CONTROLS
TECHNICAL MEMORANDUM
REVISED REMEDY SELECTION FOR OPERABLE UNIT 2 - AREA 50 LANDFILL
Defense Supply Center Richmond
Richmond, Virginia

Category	Unit	Quantity	Cost/Unit $	Cost $
Capital Costs:				
Health & Safety Plan	LS	1	$2,000.00	$2,000
Legal Services	LS	1	$15,000 00	$15,000
Subtotal				$17,000
Contingency	25%			$4,250
TOTAL CAPITAL COSTS				$21,250

Category	Unit	Quantity	Cost/Unit $	Cost $
Annual O&M Costs:				
Annual Report	LS	1	$2,500	$2,500
Report Review/Meetings	LS	1	$2,500	$2,500
ODCs	LS	1	$2,000	$2,000
Fence Maintenance	LS	1	$1,000	$1,000
Legal Services	LS	1	$1,500	$1,500
5-Year Review*	LS	1	$1,000	$1,000
TOTAL ANNUAL O&M COSTS				$10,500

* 5-Year Reviews - 4 over 20-year period - (cost annualized).

PRESENT WORTH OF O&M = ANNUAL O&M x $\frac{(1+i)^n - 1}{i \times (1+i)^n}$ = $130,853

Assume: 20 years of O&M and 5% interest annually.

TOTAL CAPITAL COSTS = $ 21,250
TOTAL PRESENT WORTH = O&M PRESENT WORTH + CAPITAL COSTS = $ 152,103

ALTERNATIVE 6A - SOIL COVER WITH STORM SEWER REHABILITATION, INSTITUTIONAL CONTROLS, SOURCE REMOVAL
TECHNICAL MEMORANDUM
REVISED REMEDY SELECTION FOR OPERABLE UNIT 2 - AREA 50 LANDFILL
Defense Supply Center Richmond
Richmond, Virginia

Category	Unit	Quantity	Cost/Unit $	Cost $
Direct Costs:				
Mobilization and Demobilization	LS	1	$10,000.00	$10,000
Strip and clear grass, light brush, and other deleterious materials	CY	3388	$7.65	$25,918
Dispose cleared materials off site	CY	3388	$18.00	$60,984
Silt Fence - Type C	LF	2,580	$2.10	$5,418
Fill - borrow and transport	CY	17176	$12.00	$206,112
Fill - spread	CY	17,176	$1.59	$27,310
Fill - compact	CY	17,176	$2.81	$48,265
Fill - grade	SY	40656	$0.63	$25,613
Cover Soil - borrow and transport	CY	10051	$24.00	$241,224
Cover Soil - spread	CY	10,051	$1.59	$15,981
Cover Soil - grade	SY	40656	$0.63	$25,613
Vegetative Cover (seed, lime, fertilizer)	SY	40656	$0.41	$16,669
Storm Sewer Rehabilitation - **(completed 1st quarter 2005)**	LS	1	$0.00	$0
Drop Inlets and Manholes (w/ frames, grates, installed)	Each	2	$1,600.00	$3,200
Source Removal/OE Identification & Disposal	LS	1	$250,000.00	$250,000
Health & Safety Plan	LS	1	$2,000.00	$2,000
Subtotal				$964,307
Contingency	25%			$241,077
TOTAL DIRECT COSTS				$1,205,384

Category	Unit	Quantity	Cost/Unit $	Cost $
Indirect Costs:				
Design/Construction Support - Cover	LS			$90,000
Design/Construction Support - Storm Sewer - **(completed)**	LS			$0
Construction Management	10%			$120,538
Contractor Overhead	3%			$36,162
Health & Safety Monitoring	3%			$36,162
Permitting	5%			$60,269
Subtotal				$343,131
Contingency	25%			$85,783
TOTAL INDIRECT COSTS				$428,913
TOTAL CAPITAL COSTS				$1,634,297

Category	Unit	Quantity	Cost/Unit $	Cost $
Annual O&M Costs:				
Annual Report	LS	1	$2,500	$2,500
Report Review/Meetings	LS	1	$2,500	$2,500
Long-Term Monitoring	LS	1	$5,000	$5,000
ODCs	LS	1	$2,000	$2,000
Quarterly Inspections	Each	4	$1,500	$6,000
Cover and Fence Repair	Each	4	$300	$1,200
Mowing	Each	2	$750	$1,500
Legal Services	LS	1	$2,500	$2,500
5-Year Review*	LS	1	$1,250	$1,250
TOTAL ANNUAL O&M COSTS				$24,450

* 5-Year Reviews - 4 over 20-year period - (cost annualized)

PRESENT WORTH OF O&M = ANNUAL O&M x $\frac{(1+i)^n - 1}{i \times (1+i)^n}$ = **$304,701**

Assume: 20 years of O&M and 5% interest annually.

TOTAL CAPITAL COSTS = $ 1,634,297
TOTAL PRESENT WORTH = O&M PRESENT WORTH + CAPITAL COSTS = $ 1,938,998

ALTERNATIVE 6B - CLAY COVER WITH STORM SEWER REHABILITATION, INSTITUTIONAL CONTROLS, SOURCE REMOVAL
TECHNICAL MEMORANDUM
REVISED REMEDY SELECTION FOR OPERABLE UNIT 2 - AREA 50 LANDFILL
Defense Supply Center Richmond
Richmond, Virginia

Category	Unit	Quantity	Cost/Unit $	Cost $
Direct Costs:				
Mobilization and Demobilization	LS	1	$10,000.00	$10,000
Strip and clear grass, light brush, and other deleterious materials	CY	3388	$7.65	$25,918
Dispose cleared materials off site	CY	3388	$18.00	$60,984
Silt Fence - Type C	LF	2,580	$2.10	$5,418
Fill - borrow and transport - Clay	CY	13552	$20.00	$271,040
Fill - spread - Clay	CY	13,552	$2.40	$32,525
Fill - compact - Clay	CY	13,552	$3.50	$47,432
Fill - grade - Clay	SY	40656	$0.95	$38,623
Cover Soil - borrow and transport	CY	6776	$24.00	$162,624
Cover Soil - spread	CY	6,776	$1.59	$10,774
Cover Soil - grade	SY	40656	$0.63	$25,613
Grassing (fertilizer, lime & seed)	SY	40656	$0.41	$16,669
Storm Sewer Rehabilitation - **(completed 1st quarter 2005)**	LS	1	$0.00	$0
Drop Inlets and Manholes (w/ frames, grates, installed)	Each	2	$1,600.00	$3,200
Source Removal/OE Identification & Disposal	LS	1	$250,000.00	$250,000
Health & Safety Plan	LS	1	$2,000.00	$2,000
Legal Services	LS	1	$25,000.00	$25,000
Subtotal				$987,820
Contingency	25%			$246,955
TOTAL DIRECT COSTS				**$1,234,775**

Category	Unit	Quantity	Cost/Unit $	Cost $
Indirect Costs:				
Design/Construction Support - Cover	LS			$90,000
Design/Construction Support - Storm Sewer - **(completed)**	LS			$0
Construction Management	10%			$123,478
Contractor Overhead	3%			$37,043
Health & Safety Monitoring	3%			$37,043
Permitting	5%			$61,739
Subtotal				$349,303
Contingency	25%			$87,326
TOTAL INDIRECT COSTS				**$436,629**
TOTAL CAPITAL COSTS				**$1,671,404**

Category	Unit	Quantity	Cost/Unit $	Cost $
Annual O&M Costs:				
Annual Report	LS	1	$2,500	$2,500
Report Review/Meetings	LS	1	$2,500	$2,500
Long-Term Monitoring	LS	1	$5,000	$5,000
ODCs	LS	1	$2,000	$2,000
Quarterly Inspections	Each	4	$1,500	$6,000
Cover and Fence Repair	Each	4	$300	$1,200
Mowing	Each	2	$750	$1,500
Legal Services	LS	1	$2,500	$2,500
5-Year Review*	LS	1	$1,250	$1,250
TOTAL ANNUAL O&M COSTS				**$24,450**

* 5-Year Reviews - 4 over 20-year period - (cost annualized).

PRESENT WORTH OF O&M = ANNUAL O&M x $\frac{(1+i)^n - 1}{i \times (1+i)^n}$ = **$304,701**

Assume: 20 years of O&M and 5% interest annually.

TOTAL CAPITAL COSTS = **$ 1,671,404**
TOTAL PRESENT WORTH = O&M PRESENT WORTH + CAPITAL COSTS = **$ 1,976,105**

MODIFIED ALTERNATIVE 6A - SOIL COVER WITH INSTITUTIONAL CONTROLS*
TECHNICAL MEMORANDUM
REVISED REMEDY SELECTION FOR OPERABLE UNIT 2 - AREA 50 LANDFILL
Defense Supply Center Richmond
Richmond, Virginia

* Storm sewer rehabilitation completed 2005.

Category	Unit	Quantity	Cost/Unit $	Cost $
Direct Costs:				
Mobilization and Demobilization	LS	1	$10,000.00	$10,000
Strip and clear grass, light brush, and other deleterious materials	CY	3388	$7 65	$25,918
Dispose cleared materials off site	CY	3388	$18.00	$60,984
Silt Fence - Type C	LF	2,580	$2.10	$5,418
Fill - borrow and transport	CY	17176	$12.00	$206,112
Fill - spread	CY	17,176	$1.59	$27,310
Fill - compact	CY	17,176	$2.81	$48,265
Fill - grade	SY	40656	$0.63	$25,613
Cover Soil - borrow and transport	CY	10051	$24.00	$241,224
Cover Soil - spread	CY	10,051	$1.59	$15,981
Cover Soil - grade	SY	40656	$0.63	$25,613
Vegetative Cover (seed, lime, fertilizer)	SY	40656	$0.41	$16,669
Drop Inlets and Manholes (w/ frames, grates, installed)	Each	2	$1,600.00	$3,200
Health & Safety Plan	LS	1	$2,000.00	$2,000
Subtotal				$714,307
Contingency	25%			$178,577
TOTAL DIRECT COSTS				$892,884

Category	Unit	Quantity	Cost/Unit $	Cost $
Indirect Costs:				
Design/Construction Support - Cover	LS			$90,000
Construction Management	10%			$89,288
Contractor Overhead	3%			$26,787
Health & Safety Monitoring	3%			$26,787
Permitting	5%			$44,644
Subtotal				$277,506
Contingency	25%			$69,376
TOTAL INDIRECT COSTS				$346,882
TOTAL CAPITAL COSTS				$1,239,766

Category	Unit	Quantity	Cost/Unit $	Cost $
Annual O&M Costs:				
Annual Report	LS	1	$2,500	$2,500
Report Review/Meetings	LS	1	$2,500	$2,500
Long-Term Monitoring	LS	1	$5,000	$5,000
ODCs	LS	1	$2,000	$2,000
Quarterly Inspections	Each	4	$1,500	$6,000
Cover and Fence Repair	Each	4	$300	$1,200
Mowing	Each	2	$750	$1,500
Legal Services	LS	1	$2,500	$2,500
5-Year Review*	LS	1	$1,250	$1,250
TOTAL ANNUAL O&M COSTS				$24,450

* 5-Year Reviews - 4 over 20-year period - (cost annualized).

PRESENT WORTH OF O&M = ANNUAL O&M x $\frac{(1+i)^n - 1}{i \times (1+i)^n}$ = **$304,701**

Assume. 20 years of O&M and 5% interest annually.

TOTAL CAPITAL COSTS = $ 1,239,766
TOTAL PRESENT WORTH = O&M PRESENT WORTH + CAPITAL COSTS = $ 1,544,467

DRAFT ORDER OF MAGNITUDE COSTS
EXCAVATION AND OFF-SITE DISPOSAL OF LANDFILLED MATERIALS*
TECHNICAL MEMORANDUM
REVISED REMEDY SELECTION FOR OPERABLE UNIT 2 - AREA 50 LANDFILL
Defense supply Center Richmond
Richmond, Virginia

* Cost Estimate Prepared at client's request. Not considered as an alternative because removal was eliminated during screening in the Third Revised Final FFS (Law, 1999)

Description	Estimated Quantity	Units	Unit Cost	Subtotal Costs	Total Item Cost
Mob, Demob, Clearing & Grubbing, etc.					$112,320
Mobilization and Demobilization	LS	1	$20,000.00	$20,000	
Strip and clear grass, light brush, and deleterious materials	CY	3388	$7.65	$25,918	
Dispose cleared materials off site	CY	3388	$18.00	$60,984	
Silt Fence - Type C	LF	2,580	$2.10	$5,418	
Excavation (assume avg depth 6' over 5.5 acres)					$424,000
Unspecified waste	54,000	C.Y.	$6 00	$324,000	
Dewatering	1	L S.	$100,000.00	$100,000	
UXO Monitoring, Excavation, Transport & Disposal					$300,000
Monitoring (assume 50,000 cy in 20 cy trucks, 25 trucks/day)	100	days	$2,000.00	$200,000	
UXO Excavation, transport & disposal	10	event	$10,000 00	$100,000	
Transport and Dispose					$7,920,000
Unspecified Material	66,000	tons	$120 00	$7,920,000	
Backfill (assume clean soil fill)					$1,050,000
Load and Transport from Off-Site Source	60,000	C.Y.	$12 00	$720,000	
Place Backfill Material	60,000	C Y.	$2.00	$120,000	
Compact Backfill Material	60,000	C.Y.	$3 50	$210,000	
Demolish Existing Storm Sewer					$45,300
Excavate	2,500	L.F.	$9.00	$22,500	
Transport & Dispose	190	tons	$120 00	$22,800	
Seeding and Mulching					$20,000
Seeding (hydroseed, mulch and fertilizer)	10 0	Acres	$2,000	$20,000	
Health and Safety Plan					$5,000
Health and Safety Plan	1	LS	$5,000	$5,000	
			Total Direct Costs		**$9,876,620**

Indirect Costs		
Design/Construction Support	10%	$987,662
Construction Management	10%	$987,662
Contractor Overhead	3%	$296,299
Health & Safety Monitoring	3%	$296,299
Permitting	5%	$493,831
Total Indirect Costs		**$3,061,752**
Total Capital Costs		**$12,938,372**

O&M Costs (assume 5 yr review)			
5 Year Review Report	LS	$5,000	
Report Review/Meetings	LS	$5,000	
ODCs	LS	$2,000	
Inspections	LS	$5,000	
Cover and Fence Repairs	LS	$2,000	
Mowing	LS	$2,000	
Legal Services	LS	$5,000	
Total O&M Costs			**$26,000**
Total Project Costs			**$12,964,372**

PREPARED/DATE: THB 01/24/06
CHECKED/DATE: DK 01/24/06

MACTEC

MACTEC ENGINEERING AND CONSULTING, INC.
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JOB NO. 6301-05-0016 SHEET 1 OF 22
PHASE 0410.0010 TASK
JOB NAME DSCR OU2 Tech Memo 2005
BY T. Buchli DATE 1/25/06
CHECKED BY D. Kraft DATE 1-25-06

Update the Cost Estimates for the Retained Remedial Alternatives from the OU2 ~~FFS~~:

~~Alt 1 No Action~~ Not nec.

Alt. 2 Institutional Controls

Alt. 6A Soil Cover + Storm Sewer Rehabilitation + ICs + Source Removal

Alt. 6B Clay Cover + Storm Sewer Rehab + ICs + Source Removal

Prepare cost estimate for new alternative presented in OU2 Tech Memo 2005:

Modified Alt. 6A: Soil Cover + Institutional Controls

MACTEC

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JOB NO. 6301-05-0016 SHEET 2 OF 22
PHASE 0410.0010 TASK
JOB NAME DSCR OU2 Tech Memo 2005
BY T. Buchli DATE 1/25/06
CHECKED BY D. Kraft DATE 1-25-06

~~For updating Alt 6A and Alt 6B~~
Areas to be excavated for source removal: Fig 1-16

130' × 30' = 3900 sq. ft.
+ 40' × 25' = 1000 sq. ft.

4900 sq. ft.

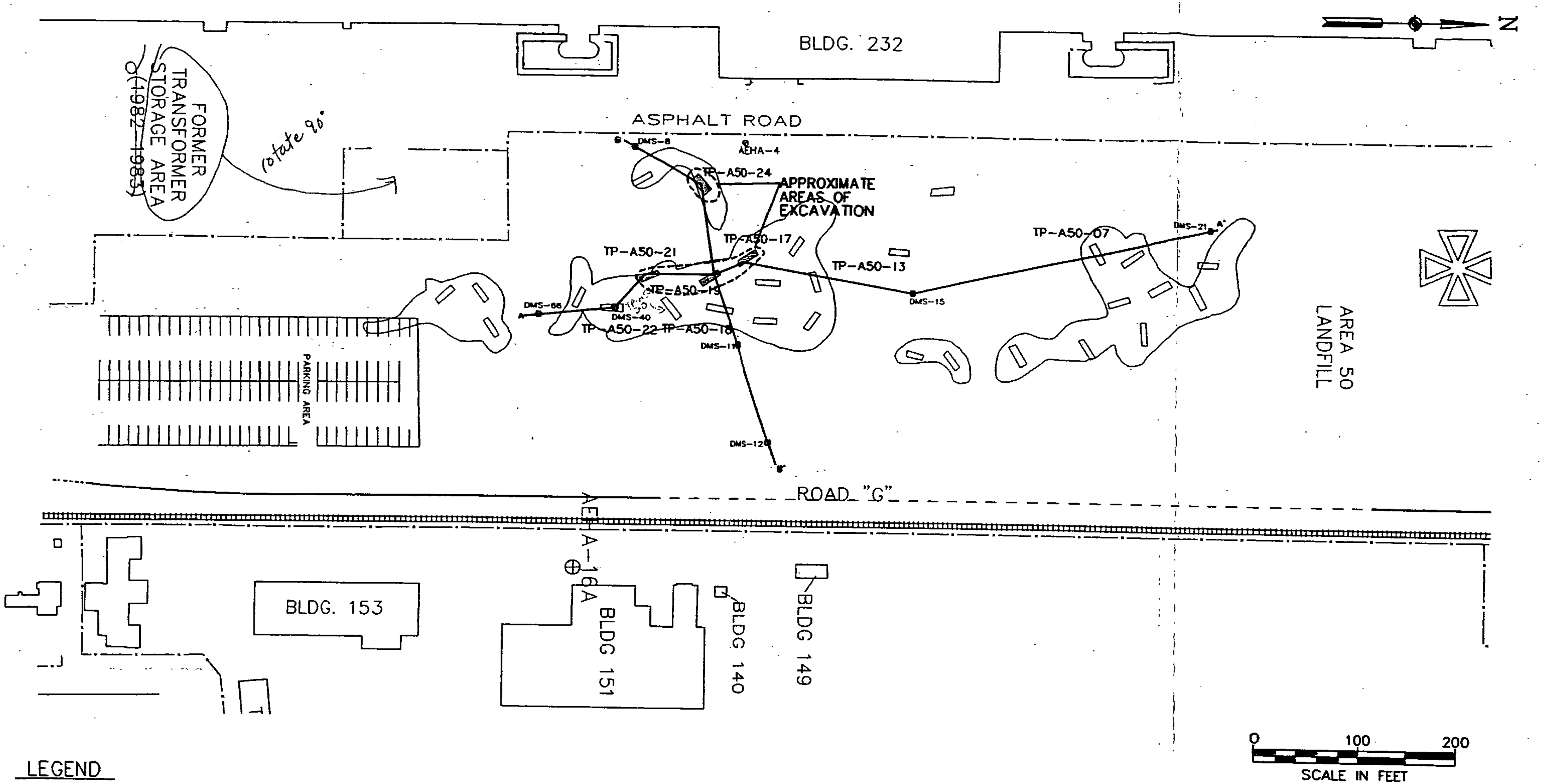
assume 8' deep 4900 sq. ft. × 8' = 39,200 c.f.
(from cross-sections on Fig 1-17) see sheet 14
39,200 cf. $\frac{1 \text{ cy}}{27 \text{ cf}}$ = 1452 cy

From Exhibit A Sheet 3

Excavation $8/cy
UXO $6/cy (adder for potential)
Transport & Dispose $120/cy
Backfill $18/cy

$152/cy

1500 cy × $152/cy = $228,000
use $250,000



LEGEND

TP-A50-22 SOIL TEST TRENCH

DMS-66 ● SOIL TEST BORING

TRENCH WITH OBSERVED FREE PRODUCT (TP-A50-17,19,21, AND 24)

U.S. ARMY ENGINEERING AND SUPPORT CENTER HUNTSVILLE
DEFENSE SUPPLY CENTER-RICHMOND
RICHMOND, VIRGINIA

OU2 FOCUSED FEASIBILITY STUDY

CROSS SECTION LOCATIONS AND AREAS TO BE EXCAVATED TO REMOVE FREE PRODUCT

AREA 50

PREPARED BY: A. WHITNEY	FIGURE NUMBER:	FILE DATE:	09.JUNE.97
CHECKED BY: T.TALELE	1-16	PLOT DATE:	06.NOV.97
PROJECT NO. 10300-5-3109		FILE NAME:	HOME/DCSR/XSECT/XSECT2A

DRAFT Order of Magnitude Costs
DSCR OU 2
Excavate Dispose Off-site

"Exhibit A" Attached for Reference

MACTEC Project Number: 6301-05-0015
January 24, 2006

Order of Magnitude Cost Estimate
Excavation and Off-Site Disposal of Landfilled Materials
DSCR OU 2 Technical Memorandum 2005
Cost Estimate Prepared at client's request. Not considered a feasible alternative due to UXO risks.

Description	Estimated Quantity	Units	Unit Cost	Subtotal Costs	Total Item Cost
Mob, Demob, Clearing & Grubbing, etc.					
Mobilization and Demobilization					$112,320
Strip and clear grass, light brush, and deleterious materials	LS	1	$20,000.00	$20,000	
Dispose cleared materials off site	CY	3388	$7.65	$25,918	
Silt Fence - Type C	CY	3388	$18.00	$60,984	
	LF	2,580	$2.10	$5,418	
Excavation (assume avg depth 6' over 5.5 acres)					
Unspecified waste					$424,000 ÷ 54,000 cy = $8/cy
Dewatering	54,000	C.Y.	$6.00	$324,000	
	1	L.S.	$100,000.00	$100,000	
UXO Monitoring, Excavation, Transport & Disposal					
Monitoring (assume 50,000 cy in 20 cy trucks, 25 trucks/da					$300,000 ÷ 54,000 cy = $6/cy
UXO Excavation, transport & disposal	100	days	$2,000.00	$200,000	
	10	event	$10,000.00	$100,000	
Transport and Dispose					
Unspecified Material					$7,920,000
	66,000	tons	$120.00	$7,920,000	
Backfill (assume clean soil fill)					
Load and Transport from Off-Site Source					$1,050,000 ÷ 60,000 cy = $18/cy
Place Backfill Material	60,000	C.Y.	$12.00	$720,000	
Compact Backfill Material	60,000	C.Y.	$2.00	$120,000	
	60,000	C.Y.	$3.50	$210,000	
Demolish Existing Storm Sewer					
Excavate					$45,300
Transport & Dispose	2,500	L.F.	$9.00	$22,500	
	190	tons	$120.00	$22,800	
Seeding and Mulching					
Seeding (hydroseed, mulch and fertilizer)					$20,000
	10.0	Acres	$2,000	$20,000	
Health and Safety Plan					
Health and Safety Plan					$5,000
	1	LS	$5,000	$5,000	
			Total Direct Costs		**$9,876,620**

Indirect Costs		
Design/Construction Support	10%	$987,662
Construction Management	10%	$987,662
Contractor Overhead	3%	$296,299
Health & Safety Monitoring	3%	$296,299
Permitting	5%	$493,831
Total Indirect Costs		**$3,061,752**
Total Capital Costs		**$12,938,372**

O&M Costs (assume 5 yr review)			
5 Year Review Report	LS	$5,000	
Report Review/Meetings	LS	$5,000	
ODCs	LS	$2,000	
Inspections	LS	$5,000	
Cover and Fence Repairs	LS	$2,000	
Mowing	LS	$2,000	
Legal Services	LS	$5,000	
Total O&M Costs			**$26,000**
Total Project Costs			**$12,964,372**

Prepared by: THB 01/24/06
Checked by DK 01/24/06

DSCR

ALTERNATIVE 2 - INSTITUTIONAL CONTROLS

Category	Unit	Quantity	Cost/Unit $	Cost $
Capital Costs:				
Health & Safety Plan	LS	1	$2,000.00	$2,000
Legal Services	LS	1	$15,000.00	$15,000
Subtotal				$17,000
Contingency	25%			$4,250
TOTAL CAPITAL COSTS				**$21,250**
Annual O&M Costs:				
Annual Report	LS	1	$2,500	$2,500
Report Review/Meetings	LS	1	$2,500	$2,500
ODCs	LS	1	$2,000	$2,000
Fence Maintenance	LS	1	$1,000	$1,000
Legal Services	LS	1	$1,500	$1,500
5-Year Review*	LS	1	$1,000	$1,000
TOTAL ANNUAL O&M COSTS				**$10,500**

* 5-Year Reviews - 4 over 20-year period - (cost annualized).

PRESENT WORTH OF O&M = ANNUAL O&M x $\frac{(1+i)^n - 1}{i \times (1+i)^n}$ **=** **$130,853**

Assume: 20 years of O&M and 5% interest annually.

TOTAL CAPITAL COSTS = **$ 21,250**

TOTAL PRESENT WORTH = O&M PRESENT WORTH + CAPITAL COSTS = **$ 152,103**

Old Cost Estimate Provided for Reference

ALTERNATIVE 2 - INSTITUTIONAL CONTROLS

Category	Unit	Quantity	Cost/Unit ($)	Total ($)
Capital Costs:				
LUCIP Preparation	L.S.	1	$ 4,000.00	$ 4,000
Legal Services/LUCIP	L.S.	1	$ 1,000.00	$ 1,000
Subtotal				$ 5,000
Contingency	25%			$ 1,300
TOTAL CAPITAL COSTS				**$ 6,300**
Annual O & M Costs:				
Annual Report	LS	1	$ 2,000.00	$ 2,000
Report Review/Meetings	LS	1	$ 2,000.00	$ 2,000
Long Term Monitoring	LS	1	$4,000.00	$ 4,000
Site Maintenance	LS	1	$ 2,000.00	$ 1,000
TOTAL ANNUAL O&M COSTS				**$ 9,000**

PRESENT WORTH OF O&M = ANNUAL O&M $\dfrac{(1+i)^n - 1}{i \times (1+i)^n}$ = **$ 112,200**

Reviews

Five Year Review	LS	1 at Year 5	$5,000	$3,900
Five Year Review	LS	1 at Year 10	$5,000	$3,100
Five Year Review	LS	1 at Year 15	$5,000	$2,400
Five Year Review	LS	1 at Year 20	$5,000	$1,900
				$ 11,300

(Assume 20 years of operation and 5% interest annually.)

TOTAL PRESENT WORTH = O&M PRESENT WORTH + CAPITAL COSTS = $ 129,800

Prepared by: TT/JS	Date: 2/12/98
Checked by: FDS/DW	Date: 5/10/99

1/24/06
Current Task: Update Cost Estimate

ALTERNATIVE 6A - SOIL COVER WITH STORM SEWER REHABILITATION, INSTITUTIONAL CONTROLS, SOURCE REMOVAL

Category	Unit	Quantity	Cost/Unit $	Cost $
Direct Costs:				
Mobilization-and-Demobilization	LS	1	$10,000.00	$10,000
Strip and clear grass, light brush, and other deleterious materials	CY	3388	$7.65	$25,918
Dispose cleared materials off site	CY	3388	$18.00	$60,984
Silt Fence - Type C	LF	2,580	$2.10	$5,418
Fill - borrow and transport	CY	17176	$12.00	$206,112
Fill - spread	CY	17,176	$1.59	$27,310
Fill - compact	CY	17,176	$2.81	$48,265
Fill - grade	SY	40656	$0.63	$25,613
Cover Soil - borrow and transport	CY	10051	$24.00	$241,224
Cover Soil - spread	CY	10,051	$1.59	$15,981
Cover Soil - grade	SY	40656	$0.63	$25,613
Vegetative Cover (seed, lime, fertilizer)	SY	40656	$0.41	$16,669
Storm Sewer Rehabilitation - **(completed 1st quarter 2005)**	LS	1	$0.00	$0
Drop Inlets and Manholes (w/ frames, grates, installed)	Each	2	$1,600.00	$3,200
Source Removal/OE Identification & Disposal	LS	1	$250,000.00	$250,000
Health & Safety Plan	LS	1	$2,000.00	$2,000
Subtotal				$964,307
Contingency	25%			$241,077
TOTAL DIRECT COSTS				**$1,205,384**
Indirect Costs:				
Design/Construction Support - Cover	LS			$90,000
Design/Construction Support - Storm Sewer - **(completed)**	LS			$0
Construction Management	10%			$120,538
Contractor Overhead	3%			$36,162
Health & Safety Monitoring	3%			$36,162
Permitting	5%			$60,269
Subtotal				$343,131
Contingency	25%			$85,783
TOTAL INDIRECT COSTS				**$428,913**
TOTAL CAPITAL COSTS				**$1,634,297**
Annual O&M Costs:				
Annual Report	LS	1	$2,500	$2,500
Report Review/Meetings	LS	1	$2,500	$2,500
Long-Term Monitoring	LS	1	$5,000	$5,000
ODCs	LS	1	$2,000	$2,000
Quarterly Inspections	Each	4	$1,500	$6,000
Cover and Fence Repair	Each	4	$300	$1,200
Mowing	Each	2	$750	$1,500
Legal Services	LS	1	$2,500	$2,500
5-Year Review*	LS	1	$1,250	$1,250
TOTAL ANNUAL O&M COSTS				**$24,450**

* 5-Year Reviews - 4 over 20-year period - (cost annualized).

PRESENT WORTH OF O&M = ANNUAL O&M x $\frac{(1+i)^n - 1}{i \times (1+i)^n}$ = **$304,701**

Assume: 20 years of O&M and 5% interest annually.

TOTAL CAPITAL COSTS = **$ 1,634,297**

TOTAL PRESENT WORTH = O&M PRESENT WORTH + CAPITAL COSTS = **$ 1,938,998**

Focused Feasibility Study
Remedial Alternative Cost Breakdown

Old Cost Estimate Provided for Reference

ALTERNATIVE 6A - SOIL COVER WITH STORM SEWER REHABILITATION (completed)
INSTITUTIONAL CONTROLS, SOURCE REMOVAL

Category	Unit	Quantity	Cost/Unit ($)	Total ($)
Direct Costs:				
Borrow, Transport, and Place(Soil)	cubic yards	17176	$ 8.95	$ 153,800
Compaction	cubic yards	17176	$ 0.70	$ 12,100
Cover Soil	cubic yards	10051	$ 8.95	$ 90,000
Re-vegetation	acre	8.4	$ 1,500.00	$ 12,600
Source Removal/OE Identification	L.S.	1	$ 118,000.00	$ 118,000
Storm Sewer Relocation (completed)	L.S.	1	$ ~~212,200.00~~ 0	$ ~~212,200~~
Health & Safety Plan	L.S.	1	$ 1,500.00	$ 1,500
Mobilization/Startup	L.S.	1	$ 50,000.00	$ 50,000
Subtotal				$ 650,200
Contingency	25%			$ 162,550
TOTAL DIRECT COSTS				**$ 812,800**
Indirect Costs:				
Design/Construction Support	L.S.			$ 80,000
Design/Construction Support (Sewers)	L.S.			$ 31,800
Construction Management	10%			$ 81,300
Contractor Overhead	3%			$ 24,400
Health & Safety Monitoring	3%			$ 24,400
Permitting	5%			$ 40,700
Subtotal				$ 282,600
Contingency	25%			$ 70,650
Total Indirect Costs				**$ 353,300**
TOTAL CAPITAL COSTS				**$ 1,166,100**
Annual O & M Costs:				
Annual Report	LS	1	$ 2,000.00	$ 2,000
Report Review/Meetings	LS	1	$ 2,000.00	$ 2,000
Long Term Monitoring	LS	1	$4,000.00	$ 4,000
ODCs	LS	1	$ 2,000.00	$ 2,000
Maintenance of Fence	LS	1	$ 1,000.00	$ 1,000
Surface Cover Inspection/Maintenance	LS	1	$ 5,000.00	$ 5,000
Mowing	LS	1	$ 750.00	$ 750
Inspect and Maintain Sewer	LS	1	$ 500.00	$ 500
Legal Services	LS	1	$ 2,000.00	$ 2,000
5-Year Review*	LS	1	$ 910.00	$ 910
TOTAL ANNUAL O&M COSTS				**$ 20,160**

*(5-Year Reviews total of 4 over 20 year period. (Cost Annualized))

PRESENT WORTH OF O&M = ANNUAL O&M x $\frac{(1+i)^n - 1}{i \times (1+i)^n}$ **=** **$ 251,300**

(Assume 20 years of operation and 5% interest annually.)

TOTAL CAPITAL COSTS = **$ 1,166,100**
TOTAL PRESENT WORTH = O&M PRESENT WORTH + CAPITAL COSTS = **$ 1,417,400**

Prepared by: EFW	Date: 11/09/98
Checked by: FDS	Date: 3/25/99

1/24/06
Current Task: Update Cost Estimate

ALTERNATIVE 6B - CLAY COVER WITH STORM SEWER REHABILITATION, INSTITUTIONAL CONTROLS, SOURCE REMOVAL

Category	Unit	Quantity	Cost/Unit $	Cost $
Direct Costs:				
~~Mobilization and Demobilization~~	LS	1	$10,000.00	$10,000
Strip and clear grass, light brush, and other deleterious materials	CY	3388	$7.65	$25,918
Dispose cleared materials off site	CY	3388	$18.00	$60,984
Silt Fence - Type C	LF	2,580	$2.10	$5,418
Fill - borrow and transport - Clay	CY	13552	$20.00	$271,040
Fill - spread - Clay	CY	13,552	$2.40	$32,525
Fill - compact - Clay	CY	13,552	$3.50	$47,432
Fill - grade - Clay	SY	40656	$0.95	$38,623
Cover Soil - borrow and transport	CY	6776	$24.00	$162,624
Cover Soil - spread	CY	6,776	$1.59	$10,774
Cover Soil - grade	SY	40656	$0.63	$25,613
Grassing (fertilizer, lime & seed)	SY	40656	$0.41	$16,669
Storm Sewer Rehabilitation - (completed 1st quarter 2005)	ls	1	$0.00	$0
Drop Inlets and Manholes (w/ frames, grates, installed)	Each	2	$1,600.00	$3,200
Source Removal/OE Identification & Disposal	LS	1	$250,000.00	$250,000
Health & Safety Plan	LS	1	$2,000.00	$2,000
Legal Services	LS	1	$25,000.00	$25,000
Subtotal				$987,820
Contingency	25%			$246,955
TOTAL DIRECT COSTS				$1,234,775
Indirect Costs:				
Design/Construction Support - Cover	LS			$90,000
Design/Construction Support - Storm Sewer - (completed)	LS			$0
Construction Management	10%			$123,478
Contractor Overhead	3%			$37,043
Health & Safety Monitoring	3%			$37,043
Permitting	5%			$61,739
Subtotal				$349,303
Contingency	25%			$87,326
TOTAL INDIRECT COSTS				$436,629
TOTAL CAPITAL COSTS				$1,671,404
Annual O&M Costs:				
Annual Report	LS	1	$2,500	$2,500
Report Review/Meetings	LS	1	$2,500	$2,500
Long-Term Monitoring	LS	1	$5,000	$5,000
ODCs	LS	1	$2,000	$2,000
Quarterly Inspections	Each	4	$1,500	$6,000
Cover and Fence Repair	Each	4	$300	$1,200
Mowing	Each	2	$750	$1,500
Legal Services	LS	1	$2,500	$2,500
5-Year Review*	LS	1	$1,250	$1,250
TOTAL ANNUAL O&M COSTS				$24,450

* 5-Year Reviews - 4 over 20-year period - (cost annualized).

PRESENT WORTH OF O&M = ANNUAL O&M x $\frac{(1+i)^n - 1}{i \times (1+i)^n}$ = $304,701

Assume: 20 years of O&M and 5% interest annually.

TOTAL CAPITAL COSTS = $ 1,671,404

TOTAL PRESENT WORTH = O&M PRESENT WORTH + CAPITAL COSTS = $ 1,976,105

847 219
10 of 22

Focused Feasibility Study
Remedial Alternative Cost Breakdown

Old Cost Estimates Provided for Reference

ALTERNATIVE 6B - CLAY COVER WITH STORM SEWER REHABILITATION (completed)
INSTITUTIONAL CONTROLS, SOURCE REMOVAL

Category	Unit	Quantity	Cost/Unit ($)	Total ($)
Direct Costs:				
Borrow, Transport, and Place(Clay)	cubic yards	17176	$ 13.95	$ 239,700
Compaction	cubic yards	17176	$ 0.70	$ 12,100
Cover Soil	cubic yards	10051	$ 8.95	$ 90,000
Re-vegetation	acre	8.4	$ 1,500.00	$ 12,600
Source Removal/OE Identification	L.S.	1	$ 118,000.00	$ 118,000
Storm Sewer Relocation (completed)	L.S.	1	$ 0 ~~212,200.00~~	$ ~~212,200~~
Health & Safety Plan	L.S.	1	$ 1,500.00	$ 1,500
Mobilization/Startup	L.S.	1	$ 50,000.00	$ 50,000
Subtotal				$ 736,100
Contingency	25%			$ 184,025
TOTAL DIRECT COSTS				**$ 920,200**
Indirect Costs:				
Design/Construction Support	L.S.			$ 80,000
Design/Construction Support (Sewers)	L.S.			$ 31,800
Construction Management	10%			$ 73,700
Contractor Overhead	3%			$ 22,100
Health & Safety Monitoring	3%			$ 22,100
Permitting	5%			$ 36,900
QA\QC Testing for Permeability	test	10	$ 250.00	$ 2,500
Subtotal				$ 269,100
Contingency	25%			$ 67,275
Total Indirect Costs				**$ 336,400**
TOTAL CAPITAL COSTS				**$ 1,256,600**
Annual O & M Costs:				
Annual Report	LS	1	$ 2,000.00	$ 2,000
Report Review/Meetings	LS	1	$ 2,000.00	$ 2,000
Long Term Monitoring	LS	1	$4,000.00	$ 4,000
ODCs	LS	1	$ 2,000.00	$ 2,000
Maintenance of Fence	LS	1	$ 1,000.00	$ 1,000
Surface Cover Inspection/Maintenance	LS	1	$ 5,000.00	$ 5,000
Mowing	LS	1	$ 750.00	$ 750
Inspect and Maintain Sewer	LS	1	$ 500.00	$ 500
Legal Services	LS	1	$ 2,000.00	$ 2,000
5-Year Review*	LS	1	$ 910.00	$ 910
TOTAL ANNUAL O&M COSTS				**$ 20,160**

*(5-Year Reviews total of 4 over 20 year period. (Cost Annualized))

PRESENT WORTH OF O&M = ANNUAL O&M x $\frac{(1+i)^n - 1}{i \times (1+i)^n}$ **= $ 251,300**

(Assume 20 years of operation and 5% interest annually.)

TOTAL CAPITAL COSTS = $ 1,256,600

TOTAL PRESENT WORTH = O&M PRESENT WORTH + CAPITAL COSTS = $ 1,507,900

Prepared by: EFW	Date: 11/09/98
Checked by: FDS	Date: 3/25/99

1/24/06
Current Task: Update Cost Estimate

MODIFIED ALTERNATIVE 6A - SOIL COVER WITH INSTITUTIONAL CONTROLS

Category	Unit	Quantity	Cost/Unit $	Cost $
Direct Costs:				
Mobilization and Demobilization	LS	1	$10,000.00	$10,000
Strip and clear grass, light brush, and other deleterious materials	CY	3388	$7.65	$25,918
Dispose cleared materials off site	CY	3388	$18.00	$60,984
Silt Fence - Type C	LF	2,580	$2.10	$5,418
Fill - borrow and transport	CY	17176	$12.00	$206,112
Fill - spread	CY	17,176	$1.59	$27,310
Fill - compact	CY	17,176	$2.81	$48,265
Fill - grade	SY	40656	$0.63	$25,613
Cover Soil - borrow and transport	CY	10051	$24.00	$241,224
Cover Soil - spread	CY	10,051	$1.59	$15,981
Cover Soil - grade	SY	40656	$0.63	$25,613
Vegetative Cover (seed, lime, fertilizer)	SY	40656	$0.41	$16,669
Drop Inlets and Manholes (w/ frames, grates, installed)	Each	2	$1,600.00	$3,200
Health & Safety Plan	LS	1	$2,000.00	$2,000
Subtotal				$714,307
Contingency	25%			$178,577
TOTAL DIRECT COSTS				$892,884
Indirect Costs:				
Design/Construction Support - Cover	LS			$90,000
Construction Management	10%			$89,288
Contractor Overhead	3%			$26,787
Health & Safety Monitoring	3%			$26,787
Permitting	5%			$44,644
Subtotal				$277,506
Contingency	25%			$69,376
TOTAL INDIRECT COSTS				$346,882
TOTAL CAPITAL COSTS				$1,239,766
Annual O&M Costs:				
Annual Report	LS	1	$2,500	$2,500
Report Review/Meetings	LS	1	$2,500	$2,500
Long-Term Monitoring	LS	1	$5,000	$5,000
ODCs	LS	1	$2,000	$2,000
Quarterly Inspections	Each	4	$1,500	$6,000
Cover and Fence Repair	Each	4	$300	$1,200
Mowing	Each	2	$750	$1,500
Legal Services	LS	1	$2,500	$2,500
5-Year Review*	LS	1	$1,250	$1,250
TOTAL ANNUAL O&M COSTS				$24,450

* 5-Year Reviews - 4 over 20-year period - (cost annualized).

PRESENT WORTH OF O&M = ANNUAL O&M x $\frac{(1 + i)^n - 1}{i \times (1 + i)^n}$ = $304,701

Assume: 20 years of O&M and 5% interest annually.

TOTAL CAPITAL COSTS = $ 1,239,766

TOTAL PRESENT WORTH = O&M PRESENT WORTH + CAPITAL COSTS = $ 1,544,467

Modified Old 6A Cost Est. Provided for Reference

ALTERNATIVE 6A - SOIL COVER WITH ~~STORM SEWER REHABILITATION~~ INSTITUTIONAL CONTROLS, ~~SOURCE REMOVAL~~

Category	Unit	Quantity	Cost/Unit ($)	Total ($)
Direct Costs:				
Borrow, Transport, and Place(Soil)	cubic yards	17176	$ 8.95	$ 153,800
Compaction	cubic yards	17176	$ 0.70	$ 12,100
Cover Soil	cubic yards	10051	$ 8.95	$ 90,000
Re-vegetation	acre	8.4	$ 1,500.00	$ 12,600
~~Source Removal/OE Identification~~	~~L.S.~~	~~1~~	~~$ 118,000.00~~	~~$ 118,000~~
~~Storm Sewer Relocation~~	~~L.S.~~	~~1~~	~~$ 212,200.00~~	~~$ 212,200~~
Health & Safety Plan	L.S.	1	$ 1,500.00	$ 1,500
Mobilization/Startup	L.S.	1	$ 50,000.00	$ 50,000
Subtotal				$ 650,200
Contingency	25%			$ 162,550
TOTAL DIRECT COSTS				**$ 812,800**
Indirect Costs:				
Design/Construction Support	L.S.			$ 80,000
Design/Construction Support (Sewers)	L.S.			$ 31,800
Construction Management	10%			$ 81,300
Contractor Overhead	3%			$ 24,400
Health & Safety Monitoring	3%			$ 24,400
Permitting	5%			$ 40,700
Subtotal				$ 282,600
Contingency	25%			$ 70,650
Total Indirect Costs				**$ 353,300**
TOTAL CAPITAL COSTS				**$ 1,166,100**
Annual O & M Costs:				
Annual Report	LS	1	$ 2,000.00	$ 2,000
Report Review/Meetings	LS	1	$ 2,000.00	$ 2,000
Long Term Monitoring	LS	1	$4,000.00	$ 4,000
ODCs	LS	1	$ 2,000.00	$ 2,000
Maintenance of Fence	LS	1	$ 1,000.00	$ 1,000
Surface Cover Inspection/Maintenance	LS	1	$ 5,000.00	$ 5,000
Mowing	LS	1	$ 750.00	$ 750
Inspect and Maintain Sewer	LS	1	$ 500.00	$ 500
Legal Services	LS	1	$ 2,000.00	$ 2,000
5-Year Review*	LS	1	$ 910.00	$ 910
TOTAL ANNUAL O&M COSTS				**$ 20,160**

*(5-Year Reviews total of 4 over 20 year period. (Cost Annualized))

PRESENT WORTH OF O&M = ANNUAL O&M x $\frac{(1+i)^n - 1}{i \times (1+i)^n}$ = **$ 251,300**

(Assume 20 years of operation and 5% interest annually.)

TOTAL CAPITAL COSTS = **$ 1,166,100**

TOTAL PRESENT WORTH = O&M PRESENT WORTH + CAPITAL COSTS = **$ 1,417,400**

Prepared by: EFW	Date: 11/09/98
Checked by: FDS	Date: 3/25/99

1/24/06

Current Task: Update Cost Estimate and Remove Storm Sewer Rehab & Source Removal

KJELLSTROM & LEE CONSTRUCTION

~~John D. Green~~
~~Project Superintendent~~

→ Pete Alcorn x 246

Contacted
1-24-06

KJELLSTROM AND LEE, INC.
1607 OWNBY LANE
RICHMOND, VA 23220
804.288.0082
FAX 804.285.4288
~~MOBILE 434.466.8148~~
~~jgreen~~@kjellstrom-lee.com

804-513-5918 (M)

$12 yd non-structural fill
$24 yd top soil
$20 yd clay

DSCR

ALTERNATIVE 6A - SOIL COVER WITH STORM SEWER REHABILITATION, INSTITUTIONAL CONTROLS, SOURCE REMOVAL

Category	Unit	Quantity	Cost/Unit $	Cost $	Cost Source
Direct Costs:					
Mobilization and Demobilization	LS	1	$10,000.00	$10,000	Estimated
Strip and clear grass, light brush, and other deleterious materials	CY	3388	$7.65	$25,918	~~Means, 02315-432-4440~~
~~Dispose cleared materials off site~~	CY	3388	$18.00	$60,984	Estimated
Silt Fence - Type C	LF	2,580	$2.10	$5,418	Means, 02370-700-1100 + 100%
Fill - borrow and transport	CY	17176	$12.00	$206,112	Local contractor
Fill - spread	CY	17,176	$1.59	$27,310	Means, 02315-520-0010
Fill - compact	CY	17,176	$2.81	$48,265	Means, 02315-110-1600
Fill - grade	SY	40656	$0.63	$25,613	Means, 02310-100-0100
Cover Soil - borrow and transport	CY	10051	$24.00	$241,224	Local contractor
Cover Soil - spread	CY	10,051	$1.59	$15,981	Means, 02315-520-0010
Cover Soil - grade	SY	40656	$0.63	$25,613	Means, 02310-100-0100
Vegetative Cover (seed, lime, fertilizer)	SY	40656	$0.41	$16,669	Means, 02920-310-0300
Storm Sewer Rehabilitation - (completed 1st quarter 2005)	LS	1	$0.00	$0	
Drop Inlets and Manholes (w/ frames, grates, installed)	Each	2	$1,600.00	$3,200	Means, 02630-400-1110
Source Removal/OE Identification & Disposal	LS	1	$250,000.00	$250,000	
Health & Safety Plan	LS	1	$2,000.00	$2,000	
Subtotal				$964,307	
Contingency	25%			$241,077	
TOTAL DIRECT COSTS				$1,205,384	
Indirect Costs:					
Design/Construction Support - Cover	LS			$90,000	
Design/Construction Support - Storm Sewer - (completed)	LS			$0	
Construction Management	10%			$120,538	
Contractor Overhead	3%			$36,162	
Health & Safety Monitoring	3%			$36,162	
Permitting	5%			$60,269	
Subtotal				$343,131	
Contingency	25%			$85,783	
TOTAL INDIRECT COSTS				$428,913	
TOTAL CAPITAL COSTS				$1,634,297	
Annual O&M Costs:					
Annual Report	LS	1	$2,500	$2,500	
Report Review/Meetings	LS	1	$2,500	$2,500	
Long-Term Monitoring	LS	1	$5,000	$5,000	
ODCs	LS	1	$2,000	$2,000	
Quarterly Inspections	Each	4	$1,500	$6,000	
Cover and Fence Repair	Each	4	$300	$1,200	
Mowing	Each	2	$750	$1,500	
Legal Services	LS	1	$2,500	$2,500	
5-Year Review*	LS	1	$1,000	$1,000	
TOTAL ANNUAL O&M COSTS				$24,200	

* 5-Year Reviews - 4 over 20-year period - (cost annualized).

PRESENT WORTH OF O&M = ANNUAL O&M x $\frac{(1+i)^n - 1}{i \times (1+i)^n}$ = $301,585   5% 20

Assume: 20 years of O&M and 5% interest annually.

TOTAL CAPITAL COSTS = $ 1,634,297

TOTAL PRESENT WORTH = O&M PRESENT WORTH + CAPITAL COSTS = $ 1,935,883

Prepared by:	D Kraft	1/25/2006
Checked by:	T Buchli	1/25/2006

ALTERNATIVE 6B - CLAY COVER WITH STORM SEWER REHABILITATION, INSTITUTIONAL CONTROLS, SOURCE REMOVAL

Category	Unit	Quantity	Cost/Unit $	Cost $	Cost Source
Direct Costs:					
Mobilization and Demobilization	LS	1	$10,000.00	$10,000	Estimated
Strip and clear grass, light brush, and other deleterious materials	CY	3388	$7.65	$25,918	Means, 02315-432-4440
Dispose cleared materials off site	CY	3388	$18.00	$60,984	Estimated
Silt Fence - Type C	LF	2,580	$2.10	$5,418	Means, 02370-700-1100 + 100%
Fill - borrow and transport - Clay	CY	13552	$20.00	$271,040	Local contractor
Fill - spread - Clay	CY	13,552	$2.40	$32,525	Means, 02315-520-0010 + 50%
Fill - compact - Clay	CY	13,552	$3.50	$47,432	Means, 02315-110-1600 + 25%
Fill - grade - Clay	SY	40656	$0.95	$38,623	Means, 02310-100-0100 + 50%
Cover Soil - borrow and transport	CY	6776	$24.00	$162,624	Local contractor
Cover Soil - spread	CY	6,776	$1.59	$10,774	Means, 02315-520-0010
Cover Soil - grade	SY	40656	$0.63	$25,613	Means, 02310-100-0100
Grassing (fertilizer, lime & seed)	SY	40656	$0.41	$16,669	Means, 02920-310-0300
Storm Sewer Rehabilitation - (completed 1st quarter 2005)	ls	1	$0.00	$0	
Drop Inlets and Manholes (w/ frames, grates, installed)	Each	2	$1,600.00	$3,200	Means, 02630-400-1110
Source Removal/OE Identification & Disposal	LS	1	$250,000.00	$250,000	
Health & Safety Plan	LS	1	$2,000.00	$2,000	
Legal Services	LS	1	$25,000.00	$25,000	
Subtotal				$987,820	
Contingency	25%			$246,955	
TOTAL DIRECT COSTS				$1,234,775	
Indirect Costs:					
Design/Construction Support - Cover	LS			$90,000	
Design/Construction Support - Storm Sewer - (completed)	LS			$0	
Construction Management	10%			$123,478	
Contractor Overhead	3%			$37,043	
Health & Safety Monitoring	3%			$37,043	
Permitting	5%			$61,739	
Subtotal				$349,303	
Contingency	25%			$87,326	
TOTAL INDIRECT COSTS				$436,629	
TOTAL CAPITAL COSTS				$1,671,404	
Annual O&M Costs:					
Annual Report	LS	1	$2,500	$2,500	
Report Review/Meetings	LS	1	$2,500	$2,500	
Long-Term Monitoring	LS	1	$5,000	$5,000	
ODCs	LS	1	$2,000	$2,000	
Quarterly Inspections	Each	4	$1,500	$6,000	
Cover and Fence Repair	Each	4	$300	$1,200	
Mowing	Each	2	$750	$1,500	
Legal Services	LS	1	$2,500	$2,500	
5-Year Review*	LS	1	$2,500	$2,500	
TOTAL ANNUAL O&M COSTS				$25,700	

* 5-Year Reviews - 4 over 20-year period - (cost annualized).

PRESENT WORTH OF O&M = ANNUAL O&M x $\frac{(1+i)^n - 1}{i \times (1+i)^n}$ = $320,279   5%   20

Assume: 20 years of O&M and 5% interest annually.

TOTAL CAPITAL COSTS = $ 1,671,404

TOTAL PRESENT WORTH = O&M PRESENT WORTH + CAPITAL COSTS = $ 1,991,683

02300 | Earthwork

02305 | Equipment

			CREW	DAILY OUTPUT	LABOR-HOURS	UNIT	2005 BARE COSTS MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P	
250	2000	Crane, truck-mounted, up to 75 ton (incl both mob & demob) R01590-100	1 EQHV	3.60	2.222	Ea.		80		80	120	250
	2100	Crane, truck-mounted, over 75 ton	A-3E	2.50	6.400			203	34	237	350	
	2200	Crawler-mounted, up to 75 ton	A-3F	2	8			254	278	532	690	
	2300	Over 75 ton	A-3G	1.50	10.667	↓		340	405	745	960	
	2500	For each additional 5 miles haul distance, add						10%	10%			
	3000	For large pieces of equipment, allow for assembly/knockdown										
	3001	For mob/demob of vibrofloatation equip, see section 02250-900										
	3100	For mob/demob of micro-tunneling equip, see section 02441-400										
	3200	For mob/demob of pile driving equip, see section 02455-650										
	3300	For mob/demob of caisson drilling equip, see 02465-950										

02310 | Grading

			CREW	DAILY OUTPUT	LABOR-HOURS	UNIT	MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P	
100	0010	FINISH GRADING										100
	0012	Finish grading area to be paved with grader, small area	B-11L	400	.040	S.Y.		1.23	1.14	2.37	3.14	
	0100	Large area		2,000	.008			.25	.23	.48	.63	
	1100	Fine grade for slab on grade, machine	↓	1,040	.015			.47	.44	.91	1.20	
	1150	Hand grading	B-18	700	.034	↓		.94	.05	.99	1.52	

02315 | Excavation and Fill

			CREW	DAILY OUTPUT	LABOR-HOURS	UNIT	MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P	
110	0010	BACKFILL, GENERAL R02315-300										110
	0015	By hand, no compaction, light soil	1 Clab	14	.571	L.C.Y.		15.25		15.25	23.50	
	0100	Heavy soil		11	.727	"		19.40		19.40	30	
	0300	Compaction in 6" layers, hand tamp, add to above	↓	20.60	.388	E.C.Y.		10.35		10.35	16.15	
	0400	Roller compaction operator walking, add	B-10A	100	.120			3.84	1.23	5.07	7.20	
	0500	Air tamp, add	B-9D	190	.211			5.70	.93	6.63	9.95	
	0600	Vibrating plate, add	A-1D	60	.133			3.56	.42	3.98	6	
	0800	Compaction in 12" layers, hand tamp, add to above	1 Clab	34	.235			6.30		6.30	9.80	
	0900	Roller compaction operator walking, add	B-10A	150	.080			2.56	.82	3.38	4.79	
	1000	Air tamp, add	B-9	285	.140			3.80	.50	4.30	6.45	
	1100	Vibrating plate, add	A-1E	90	.089	↓		2.37	.41	2.78	4.14	
	1300	Dozer backfilling, bulk, up to 300' haul, no compaction	B-10B	1,200	.010	L.C.Y.		.32	.77	1.09	1.33	
	1400	Air tamped, add	B-11B	80	.200	E.C.Y.		6	2.30	8.30	11.70	
	1600	Compacting backfill, 6" to 12" lifts, vibrating roller	B-10C	800	.015			.48	1.89	2.37	2.81	
	1700	Sheepsfoot roller	B-10D	750	.016	↓		.51	2.04	2.55	3.02	
	1900	Dozer backfilling, trench, up to 300' haul, no compaction	B-10B	900	.013	L.C.Y.		.43	1.02	1.45	1.77	
	2000	Air tamped, add	B-11B	80	.200	E.C.Y.		6	2.30	8.30	11.70	
	2200	Compacting backfill, 6" to 12" lifts, vibrating roller	B-10C	700	.017			.55	2.16	2.71	3.20	
	2300	Sheepsfoot roller	B-10D	650	.018	↓		.59	2.35	2.94	3.49	
	2350	Spreading in 8" layers, small dozer	B-10B	1,060	.011	L.C.Y.		.36	.87	1.23	1.50	
120	0010	BACKFILL, STRUCTURAL Dozer or F.E. loader										120
	0020	From existing stockpile, no compaction										
	2000	75 H.P., 50' haul, sand & gravel	B-10L	1,100	.011	L.C.Y.		.35	.29	.64	.84	
	2020	Common earth		975	.012			.39	.32	.71	.96	
	2040	Clay		850	.014			.45	.37	.82	1.10	
	2400	300' haul, sand & gravel		370	.032			1.04	.85	1.89	2.52	
	2420	Common earth		330	.036			1.16	.95	2.11	2.82	
	2440	Clay	↓	290	.041			1.32	1.09	2.41	3.20	
	3000	105 H.P., 50' haul, sand & gravel	B-10W	1,350	.009			.28	.34	.62	.80	
	3020	Common earth		1,225	.010			.31	.37	.68	.89	
	3040	Clay		1,100	.011			.35	.41	.76	.98	
	3300	300' haul, sand & gravel		465	.026			.83	.98	1.81	2.33	
	3320	Common earth		415	.029			.93	1.09	2.02	2.61	
	3340	Clay	↓	370	.032			1.04	1.23	2.27	2.93	
	4000	200 H.P., 50' haul, sand & gravel	B-10B	2,500	.005			.15	.37	.52	.63	
	4020	Common earth	↓	2,200	.005	↓		.17	.42	.59	.73	

SITE CONSTRUCTION 2

For expanded coverage of these items see *Means Heavy Construction Cost Data 2005*

Excavation and Fill

			Crew	Daily Output	Labor-Hours	Unit	Mat.	Labor	Equip.	Total	Total Incl O&P
432	4200	150′ haul, sand & gravel	B-10B	595	.020	B.C.Y.		.65	1.55	2.20	[illegible]
	4220	Common earth		516	.023			.74	1.78	2.52	[illegible]
	4240	Clay		325	.037			1.18	2.83	4.01	4.9[illegible]
	4400	300′ haul, sand & gravel		310	.039			1.24	2.97	4.21	5.1[illegible]
	4420	Common earth		270	.044			1.42	3.41	4.83	5.9[illegible]
	4440	Clay		170	.071			2.26	5.40	7.66	9.4[illegible]
	5000	300 H.P., 50′ haul, sand & gravel	B-10M	1,900	.006			.20	.63	.83	[illegible]
	5020	Common earth		1,650	.007			.23	.72	.95	1.1[illegible]
	5040	Clay		1,025	.012			.37	1.17	1.54	1.8[illegible]
	5200	150′ haul, sand & gravel		920	.013			.42	1.30	1.72	2.0[illegible]
	5220	Common earth		800	.015			.48	1.49	1.97	2.3[illegible]
	5240	Clay		500	.024			.77	2.39	3.16	3.80
	5400	300′ haul, sand & gravel		470	.026			.82	2.54	3.36	4.0[illegible]
	5420	Common earth		410	.029			.94	2.91	3.85	4.63
	5440	Clay		250	.048			1.54	4.78	6.32	7.60
	5500	460 H.P., 50′ haul, sand & gravel	B-10X	1,930	.006			.20	.79	.99	1.17
	5510	Common earth		1,680	.007			.23	.91	1.14	1.35
	5520	Clay		1,050	.011			.37	1.45	1.82	2.16
	5530	150′ haul, sand & gravel		1,290	.009			.30	1.18	1.48	1.75
	5540	Common earth		1,120	.011			.34	1.36	1.70	2.02
	5550	Clay		700	.017			.55	2.18	2.73	3.22
	5560	300′ haul, sand & gravel		660	.018			.58	2.31	2.89	3.42
	5570	Common earth		575	.021			.67	2.65	3.32	3.94
	5580	Clay		350	.034			1.10	4.35	5.45	6.45
	6000	700 H.P., 50′ haul, sand & gravel	B-10V	3,500	.003			.11	.90	1.01	1.16
	6010	Common earth		3,035	.004			.13	1.03	1.16	1.33
	6020	Clay		1,925	.006			.20	1.63	1.83	2.09
	6030	150′ haul, sand & gravel		2,025	.006			.19	1.55	1.74	2
	6040	Common earth		1,750	.007			.22	1.79	2.01	2.30
	6050	Clay		1,100	.011			.35	2.85	3.20	3.67
	6060	300′ haul, sand & gravel		1,030	.012			.37	3.05	3.42	3.92
	6070	Common earth		900	.013			43	3.49	3.92	4.49
	6080	Clay		550	.022			.70	5.70	6.40	7.35

			Crew	Daily Output	Labor-Hours	Unit	Mat.	Labor	Equip.	Total	Total Incl O&P
452	0010	**EXCAVATION, BULK, SCRAPERS**									
	0100	Elev. scraper 11 C.Y., sand & gravel 1500′ haul, 1/4 dozer (R02315-400)	B-33F	690	.020	B.C.Y.		.66	1.62	2.28	2.78
	0150	3000′ haul		610	.023			.74	1.83	2.57	3.15
	0200	5000′ haul		505	.028			.90	2.21	3.11	3.80
	0300	Common earth, 1500′ haul		600	.023			.76	1.86	2.62	3.20
	0350	3000′ haul		530	.026			.86	2.11	2.97	3.62
	0400	5000′ haul		440	.032			1.03	2.54	3.57	4.36
	0500	Clay, 1500′ haul		375	.037			1.21	2.98	4.19	5.10
	0550	3000′ haul		330	.042			1.37	3.39	4.76	5.80
	0600	5000′ haul		275	.051			1.65	4.07	5.72	6.95
	1000	Self propelled scraper, 14 C.Y. 1/4 push dozer, sand									
	1050	Sand and gravel, 1500′ haul	B-33D	920	.015	B.C.Y.		.49	2.01	2.50	2.96
	1100	3000′ haul		805	.017			.56	2.30	2.86	3.38
	1200	5000′ haul		645	.022			.70	2.87	3.57	4.23
	1300	Common earth, 1500′ haul		800	.017			.57	2.31	2.88	3.40
	1350	3000′ haul		700	.020			.65	2.64	3.29	3.89
	1400	5000′ haul		560	.025			.81	3.31	4.12	4.87
	1500	Clay, 1500′ haul		500	.028			.91	3.70	4.61	5.45
	1550	3000′ haul		440	.032			1.03	4.21	5.24	6.20
	1600	5000′ haul		350	.040			1.30	5.30	6.60	7.75
	2000	21 C.Y., 1/4 push dozer, sand & gravel, 1500′ haul	B-33E	1,180	.012			.38	2.22	2.60	3.02
	2100	3000′ haul		910	.015			.50	2.87	3.37	3.92

BEST AVAILABLE COPY

		Description	Crew	Daily Output	Labor-Hours	Unit	2005 Bare Costs Mat.	Labor	Equip.	Total	Total Incl O&P
462	9030	For sheeting or soldier beams/lagging, see 02250 & 02260									
	9040	For trench excavation of strip footings, see div. 02315-610 R02315-400									
490	0010	**HAULING**, excavated or borrow, loose cubic yards									
	0012	no loading included, highway haulers R02315-400									
	0020	6 C.Y. dump truck, 1/4 mile round trip, 5.0 loads/hr.	B-34A	195	.041	L.C.Y.		1.13	1.68	2.81	3.5
	0030	1/2 mile round trip, 4.1 loads/hr.		160	.050			1.38	2.04	3.42	4.3
	0040	1 mile round trip, 3.3 loads/hr.		130	.062			1.70	2.51	4.21	5.3
	0100	2 mile round trip, 2.6 loads/hr.		100	.080			2.20	3.27	5.47	6.95
	0150	3 mile round trip, 2.1 loads/hr.		80	.100			2.76	4.08	6.84	8.70
	0200	4 mile round trip, 1.8 loads/hr.		70	.114			3.15	4.67	7.82	9.95
	0310	12 C.Y. dump truck, 1/4 mile round trip 3.7 loads/hr.	B-34B	288	.028			.77	1.66	2.43	2.99
	0320	1/2 mile round trip, 3.2 loads/hr.		250	.032			.88	1.91	2.79	3.44
	0330	1 mile round trip 2.7, loads/hr.		210	.038			1.05	2.27	3.32	4.10
	0400	2 mile round trip, 2.2 loads/hr.		180	.044			1.22	2.65	3.87	4.78
	0450	3 mile round trip, 1.9 loads/hr.		170	.047			1.30	2.80	4.10	5.05
	0500	4 mile round trip, 1.6 loads/hr.		125	.064			1.76	3.81	5.57	6.90
	0540	5 mile round trip, 1 load/hr.		78	.103			2.83	6.10	8.93	11
	0550	10 mile round trip, 0.60 load/hr.		58	.138			3.80	8.20	12	14.85
	0560	20 mile round trip, 0.4 load/hr.		39	.205			5.65	12.20	17.85	22
	0600	16.5 C.Y. dump trailer, 1 mile round trip, 2.6 loads/hr.	B-34C	280	.029			.79	1.45	2.24	2.79
	0700	2 mile round trip, 2.1 loads/hr.		225	.036			.98	1.80	2.78	3.47
	1000	3 mile round trip, 1.8 loads/hr.		193	.041			1.14	2.10	3.24	4.05
	1100	4 mile round trip, 1.6 loads/hr.		172	.047			1.28	2.35	3.63	4.54
	1110	5 mile round trip, 1 load/hr.		108	.074			2.04	3.75	5.79	7.25
	1120	10 mile round trip, .60 load/hr.		80	.100			2.76	5.05	7.81	9.75
	1130	20 mile round trip, .4 load/hr.		54	.148			4.08	7.50	11.58	14.45
	1150	20 C.Y. dump trailer, 1 mile round trip, 2.5 loads/hr.	B-34D	325	.025			.68	1.28	1.96	2.44
	1200	2 mile round trip, 2 loads/hr.		260	.031			.85	1.61	2.46	3.06
	1220	3 mile round trip, 1.7 loads/hr.		221	.036			1	1.89	2.89	3.60
	1240	4 mile round trip, 1.5 loads/hr.		195	.041			1.13	2.14	3.27	4.07
	1245	5 mile round trip, 1.1 load/hr.		143	.056			1.54	2.92	4.46	5.55
	1250	10 mile round trip, .75 load/hr.		110	.073			2	3.80	5.80	7.20
	1255	20 mile round trip, .5 load/hr.		78	.103			2.83	5.35	8.18	10.20
	1300	Hauling in medium traffic, add				C.Y.				20%	20%
	1400	Heavy traffic, add				"				30%	30%
	1600	Grading at dump, or embankment if required, by dozer	B-10B	1,000	.012	L.C.Y.		.38	.92	1.30	1.59
	1800	Spotter at fill or cut, if required	1 Clab	8	1	Hr.		26.50		26.50	41.50
510	0010	**FILL BY BORROW**, load, 1 mile haul, spread with dozer									
	0020	for embankments	B-15	1,200	.023	L.C.Y.	6	.69	1.56	8.25	9.35
	0100	Select fill for shoulders & embankments	"	1,200	.023	"	7.90	.69	1.56	10.15	11.40
	0201	For hauling over 1 mile, add to above per C.Y., see div 02315-490				Mile				.69	.92
520	0010	**FILL**, spread dumped material, no compaction									
	0020	By dozer, no compaction	B-10B	1,000	.012	L.C.Y.		.38	.92	1.30	1.59
	0100	By hand	1 Clab	12	.667	"		17.80		17.80	27.50
	0500	Gravel fill, compacted, under floor slabs, 4" deep	B-37	10,000	.005	S.F.	.16	.13	.01	.30	.39
	0600	6" deep		8,600	.006		.24	.16	.01	.41	.51
	0700	9" deep		7,200	.007		.39	.19	.01	.59	.74
	0800	12" deep		6,000	.008		.55	.22	.02	.79	.98
	1000	Alternate pricing method, 4" deep		120	.400	E.C.Y.	11.80	11.25	.90	23.95	31.50
	1100	6" deep		160	.300		11.80	8.45	.67	20.92	27
	1200	9" deep		200	.240		11.80	6.75	.54	19.09	24
	1300	12" deep		220	.218		11.80	6.15	.49	18.44	23
	1500	For fill under exterior paving, see division 02720-200									
610	0010	**EXCAVATING, TRENCH** or continuous footing, common earth									
	0020	No sheeting or dewatering included									

02300 | Earthwork

02360 | Soil Treatment

		Description	Crew	Daily Output	Labor-Hours	Unit	2005 Bare Costs Mat.	Labor	Equip.	Total	Total Incl O&P	
200	0100	Commercial, minimum	1 Skwk	2,496	.003	SF Flr.	.30	.11		.41	.50	200
	0200	Maximum		1,645	.005		.45	.17		.62	.76	
	0400	Insecticides for termite control, minimum		14.20	.563	Gal.	11.60	19.65		31.25	43.50	
	0500	Maximum		11	.727	"	19.85	25.50		45.35	61.50	

02370 | Erosion & Sedimentation Control

		Description	Crew	Daily Output	Labor-Hours	Unit	Mat.	Labor	Equip.	Total	Total Incl O&P	
450	0010	RIP-RAP & ROCK LINING, Random, broken stone										450
	0100	Machine placed for slope protection	B-12G	62	.258	L.C.Y.	25	8.10	8.75	41.85	49.50	
	0110	3/8 to 1/4 C.Y. pieces, grouted	B-13	80	.700	S.Y.	36.50	20	7.70	64.20	79.50	
	0200	18" minimum thickness, not grouted	"	53	1.057	"	15.55	30.50	11.65	57.70	77	
	0300	Dumped, 50 lb. average	B-11A	800	.020	Ton	17.90	.61	1.15	19.66	22	
	0350	100 lb. average		700	.023		25.50	.70	1.31	27.51	30.50	
	0370	300 lb. average		600	.027		30	.82	1.53	32.35	36	
	0400	Gabions, galvanized steel mesh mats or boxes, stone filled, 6" deep	B-13	200	.280	S.Y.	16.90	8.05	3.08	28.03	34.50	
	0500	9" deep		163	.344		26	9.90	3.78	39.68	48	
	0600	12" deep		153	.366		27.50	10.55	4.03	42.08	50.50	
	0700	18" deep		102	.549		35	15.80	6.05	56.85	69.50	
	0800	36" deep		60	.933		59.50	27	10.30	96.80	118	
700	0010	SYNTHETIC EROSION CONTROL										700
	0020	Jute mesh, 100 SY per roll, 4' wide, stapled	B-80A	2,400	.010	S.Y.	.69	.27	.07	1.03	1.26	
	0100	Plastic netting, stapled, 2" x 1" mesh, 20 mil	B-1	2,500	.010		.63	.26		.89	1.10	
	0200	Polypropylene mesh, stapled, 6.5 oz./S.Y.		2,500	.010		1.30	.26		1.56	1.84	
	0300	Tobacco netting, or jute mesh #2, stapled		2,500	.010		.07	.26		.33	.49	
	1000	Silt fence, polypropylene, 3' high, ideal conditions	2 Clab	1,600	.010	L.F.	.32	.27		.59	.77	
	1100	Adverse conditions	"	950	.017	"	.32	.45		.77	1.05	
	1200	Place and remove hay bales	A-2	3	8	Ton	52	214	43	309	435	
	1250	Hay bales, staked	"	2,500	.010	L.F.	2.08	.26	.05	2.39	2.75	

02390 | Shore Protect/Mooring Structures

		Description	Crew	Daily Output	Labor-Hours	Unit	Mat.	Labor	Equip.	Total	Total Incl O&P	
340	0010	JETTIES, DOCKS Floating, recreational, prefabricated galvanized steel with										340
	0020	polyethylene encased polystyrene, no pilings included	F-3	330	.121	S.F.	27	4.19	1.83	33.02	38	
	0200	Pile supported, shore constructed, bare, 3" decking		130	.308		18.45	10.65	4.64	33.74	42	
	0250	4" decking		120	.333		17.80	11.55	5	34.35	43	
	0400	Floating, small boat, prefab, no shore facilities, minimum		250	.160		9.10	5.55	2.41	17.06	21	
	0500	Maximum		150	.267		31	9.20	4.02	44.22	52.50	
	0700	Per slip, minimum (180 S.F. each)		1.59	25.157	Ea.	1,950	870	380	3,200	3,925	
	0800	Maximum		1.40	28.571	"	5,800	990	430	7,220	8,375	

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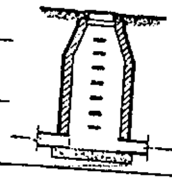
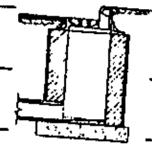
02400 | Tunneling, Boring & Jacking

02441 | Microtunneling

		Description	Crew	Daily Output	Labor-Hours	Unit	2005 Bare Costs Mat.	Labor	Equip.	Total	Total Incl O&P	
400	0010	MICROTUNNELING Not including excavation, backfill, shoring,										400
	0020	or dewatering, average 50'/day, slurry method										
	0100	24" to 48" outside diameter, minimum				L.F.					640	
	0110	Adverse conditions, add				%					50%	
	1000	Rent microtunneling machine, average monthly lease				Month					85,500	
	1010	Operating technician				Day					640	
	1100	Mobilization and demobilization, minimum				Job					42,800	
	1110	Maximum				"					430,000	

2 SITE CONSTRUCTION





Sect.	Line	Description	Crew	Daily Output	Labor-Hours	Unit	2005 Bare Costs Mat.	Labor	Equip.	Total	Total Incl. O&P
400	0050	Brick, 4' inside diameter, 4' deep	D-1	1	16	Ea.	320	495		815	[illegible]
	0100	6' deep		.70	22.857		445	710		1,155	[illegible]
	0150	8' deep		.50	32		565	995		1,560	[illegible]
	0200	For depths over 8', add		4	4	V.L.F.	174	124		298	[illegible]
	0400	Concrete blocks (radial), 4' I.D., 4' deep		1.50	10.667	Ea.	255	330		585	[illegible]
	0500	6' deep		1	16		335	495		830	[illegible]
	0600	8' deep		.70	22.857		415	710		1,125	1,525
	0700	For depths over 8', add		5.50	2.909	V.L.F.	41.50	90.50		132	[illegible]
	0800	Concrete, cast in place, 4' x 4', 8" thick, 4' deep	C-14H	2	24	Ea.	445	810	12	1,267	1,750
	0900	6' deep		1.50	32		650	1,075	16	1,741	2,400
	1000	8' deep		1	48		920	1,625	24	2,569	3,575
	1100	For depths over 8', add		8	6	V.L.F.	107	202	3	312	435
	1110	Precast, 4' I.D., 4' deep	B-22	4.10	7.317	Ea.	675	229	58	962	1,175
	1120	6' deep		3	10		870	315	79.50	1,264.50	1,525
	1130	8' deep		2	15		1,025	470	119	1,614	1,975
	1140	For depths over 8', add		16	1.875	V.L.F.	143	58.50	14.85	216.35	264
	1150	5' I.D., 4' deep	B-6	3	8	Ea.	720	231	72	1,023	1,225
	1160	6' deep		2	12		970	345	108	1,423	1,725
	1170	8' deep		1.50	16		1,225	460	144	1,829	2,225
	1180	For depths over 8', add		12	2	V.L.F.	159	57.50	18	234.50	283
	1190	6' I.D., 4' deep		2	12	Ea.	1,175	345	108	1,628	1,950
	1200	6' deep		1.50	16		1,525	460	144	2,129	2,550
	1210	8' deep		1	24		1,875	690	216	2,781	3,375
	1220	For depths over 8', add		8	3	V.L.F.	246	86.50	27	359.50	435
	1250	Slab tops, precast, 8" thick									
	1300	4' diameter manhole	B-6	8	3	Ea.	165	86.50	27	278.50	345
	1400	5' diameter manhole		7.50	3.200		325	92	29	446	535
	1500	6' diameter manhole		7	3.429		405	99	31	535	630
	3800	Steps, heavyweight cast iron, 7" x 9"	1 Bric	40	.200		12.20	7.05		19.25	24
	3900	8" x 9"		40	.200		18.35	7.05		25.40	31
	3928	12" x 10-1/2"		40	.200		16.40	7.05		23.45	29
	4000	Standard sizes, galvanized steel		40	.200		15.30	7.05		22.35	27.50
	4100	Aluminum		40	.200		18.90	7.05		25.95	32

Sect.	Line	Description	Crew	Daily Output	Labor-Hours	Unit	2005 Bare Costs Mat.	Labor	Equip.	Total	Total Incl. O&P
510	0010	PIPING, STORM DRAINAGE, CORRUGATED METAL									
	0020	Not including excavation or backfill									
	2000	Corrugated metal pipe, galvanized and coated									
	2020	Bituminous coated with paved invert, 20' lengths									
	2040	8" diameter, 16 ga.	B-14	330	.145	L.F.	8.95	4.09	.65	13.69	16.85
	2060	10" diameter, 16 ga.		260	.185		10.75	5.20	.83	16.78	20.50
	2080	12" diameter, 16 ga.		210	.229		12.85	6.40	1.03	20.28	25
	2100	15" diameter, 16 ga.		200	.240		15.65	6.75	1.08	23.48	29
	2120	18" diameter, 16 ga.		190	.253		20	7.10	1.14	28.24	34.50
	2140	24" diameter, 14 ga. CN		160	.300		24.50	8.45	[illegible]	[illegible]	[illegible]
	2160	30" diameter, 14 ga.	B-13	120	.467		32.50	13.45	5.15	51.10	61.50
	2180	36" diameter, 12 ga.		120	.467		47.50	13.45	5.15	66.10	78.50
	2200	48" diameter, 12 ga.		100	.560		72.50	16.10	6.15	94.75	111
	2220	60" diameter, 10 ga.	B-13B	75	.747		93.50	21.50	11.95	126.95	149
	2240	72" diameter, 8 ga.	"	45	1.244		140	36	19.90	195.90	231
	2500	Galvanized, uncoated, 20' lengths									
	2520	8" diameter, 16 ga.	B-14	355	.135	L.F.	6.90	3.80	.61	11.31	14.10
	2540	10" diameter, 16 ga.		280	.171		7.60	4.82	.77	13.19	16.65
	2560	12" diameter, 16 ga.		220	.218		8.65	6.15	.98	15.78	20
	2580	15" diameter, 16 ga.		220	.218		11	6.15	.98	18.13	22.50
	2600	18" diameter, 16 ga.		205	.234		14.55	6.60	1.05	22.20	27.50
	2620	24" diameter, 14 ga.		175	.274		21	7.70	1.23	29.93	36.50

02915 | Shrub and Tree Transplanting

			CREW	DAILY OUTPUT	LABOR-HOURS	UNIT	2005 BARE COSTS MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P	
200	0010	GROUND COVER Plants, pachysandra, in prepared beds	B-1	15	1.600	C	25	44		69	95.50	200
	[illegible]	Vinca minor, 1 yr, bare root		12	2	"	26	54.50		80.50	114	
	0600	Stone chips, in 50 lb. bags, Georgia marble		520	.046	Bag	2.35	1.26		3.61	4.56	
	0700	Onyx gemstone		260	.092		17	2.53		19.53	22.50	
	0800	Quartz		260	.092		6.35	2.53		8.88	10.95	
	0900	Pea gravel, truckload lots		28	.857	Ton	24.50	23.50		48	63.50	

02920 | Lawns & Grasses

			CREW	DAILY OUTPUT	LABOR-HOURS	UNIT	MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P	
310	0010	SEEDING, GENERAL										
	0020	Mechanical seeding, 215 lb./acre (R02920-500)	B-66	1.50	5.333	Acre	510	176	115	801	955	310
	0100	44 lb./M.S.Y.	"	2,500	.003	S.Y.	.15	.11	.07	.33	.41	
	0300	Fine grading and seeding incl. lime, fertilizer & seed,										
	0310	with equipment	B-14	1,000	.048	S.Y.	.16	1.35	.22	1.73	2.51	
	0600	Limestone hand push spreader, 50 lbs. per M.S.F.	1 Clab	180	.044	M.S.F.	3.38	1.19		4.57	5.55	
	0800	Grass seed hand push spreader, 4.5 lbs. per M.S.F.	"	180	.044	"	16.65	1.19		17.84	20	
	1000	Hydro or air seeding for large areas, incl. seed and fertilizer	B-81	8,900	.003	S.Y.	.15	.08	.05	.28	.34	
	1100	With wood fiber mulch added	"	8,900	.003	"	.27	.08	.05	.40	.47	
	1300	Seed only, over 100 lbs., field seed, minimum				Lb.	1.10			1.10	1.21	
	1400	Maximum					3.68			3.68	4.05	
	1500	Lawn seed, minimum					1.71			1.71	1.88	
	1600	Maximum					4.47			4.47	4.92	
	1800	Aerial operations, seeding only, field seed	B-58	50	.480	Acre	360	13.85	47.50	421.35	470	
	1900	Lawn seed		50	.480		555	13.85	47.50	616.35	685	
	2100	Seed and liquid fertilizer, field seed		50	.480		430	13.85	47.50	491.35	545	
	2200	Lawn seed		50	.480		625	13.85	47.50	686.35	765	
400	0010	SODDING										
	0020	Sodding, 1" deep, bluegrass sod, on level ground, over 8 MSF	B-63	22	1.818	M.S.F.	217	51	7	275	325	400
	[illegible]	4 M.S.F.		17	2.353		243	66	9.05	318.05	380	
	[illegible]	1000 S.F.		13.50	2.963		265	83	11.40	359.40	430	
	0500	Sloped ground, over 8 M.S.F.		6	6.667		217	186	25.50	428.50	555	
	0600	4 M.S.F.		5	8		243	224	30.50	497.50	645	
	0700	1000 S.F.		4	10		265	280	38.50	583.50	765	
	1000	Bent grass sod, on level ground, over 6 M.S.F.		20	2		485	56	7.70	548.70	630	
	1100	3 M.S.F.		18	2.222		540	62	8.55	610.55	700	
	1200	Sodding 1000 S.F. or less		14	2.857		615	80	10.95	705.95	815	
	1500	Sloped ground, over 6 M.S.F.		15	2.667		485	74.50	10.25	569.75	660	
	1600	3 M.S.F.		13.50	2.963		540	83	11.40	634.40	735	
	1700	1000 S.F.		12	3.333		615	93	12.80	720.80	840	

02930 | Exterior Plants

			CREW	DAILY OUTPUT	LABOR-HOURS	UNIT	MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P	
050	0010	TRAVEL To all nursery items, for 10 to 20 miles, add				All					5%	050
	0100	30 to 50 miles, add				"					10%	
310	0010	SHRUBS AND TREES Evergreen, in prepared beds, B & B										
	0100	Arborvitae pyramidal, 4'-5'	B-17	30	1.067	Ea.	42.50	30.50	18.10	91.10	113	310
	0150	Globe, 12"-15"	B-1	96	.250		10.85	6.85		17.70	22.50	
	0300	Cedar, blue, 8'-10'	B-17	18	1.778		179	50.50	30	259.50	310	
	0500	Hemlock, canadian, 2-1/2'-3'	B-1	36	.667		22.50	18.25		40.75	53.50	
	[illegible]	Holly, Savannah, 8' - 10' H		9.68	2.479		515	68		583	675	
	0600	Juniper, andorra, 18"-24"		80	.300		15.60	8.20		23.80	30	
	[illegible]	Wiltoni, 15"-18"		80	.300		14.80	8.20		23	29	
	[illegible]	Skyrocket, 4-1/2'-5'	B-17	55	.582		47	16.60	9.85	73.45	88	
	[illegible]	Blue pfitzer, 2'-2-1/2'	B-1	44	.545		24.50	14.95		39.45	50	
	[illegible]	Ketleene, 2-1/2'-3'		50	.480		31	13.15		44.15	55	
	[illegible]	[illegible] black, 2-1/2'-3'		50	.480		38.50	13.15		51.65	62.50	

[illegible] coverage of these items see *Means Site Work and Landscape Cost Data 2005*

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JOB NO. 6301-05-0016 SHEET 1 OF 14
PHASE 0410-0010 TASK
JOB NAME DSCR OU2 Tech Memo 2005
BY T. Buehli DATE 1/24/06
CHECKED BY D. Kraft DATE 1-25-06

Estimate the volume of material in the former Area 50/OU2 Landfill.

Estimate the cost for removal/excavation and offsite disposal of landfilled materials.

Order of Magnitude Cost Estimate
Excavation and Off-Site Disposal of Landfilled Materials
DSCR OU 2 Technical Memorandum 2005
Cost Estimate Prepared at client's request. Not considered a feasible alternative due to UXO risks.

Description	Estimated Quantity	Units	Unit Cost	Subtotal Costs	Total Item Cost
Mob, Demob, Clearing & Grubbing, etc.					$112,320
Mobilization and Demobilization	LS	1	$20,000.00	$20,000	
Strip and clear grass, light brush, and deleterious materials	CY	3388	$7.65	$25,918	
Dispose cleared materials off site	CY	3388	$18.00	$60,984	
Silt Fence - Type C	LF	2,580	$2.10	$5,418	
Excavation (assume avg depth 6' over 5.5 acres)					$424,000
Unspecified waste	54,000	C.Y.	$6.00	$324,000	
Dewatering	1	L.S.	$100,000.00	$100,000	
UXO Monitoring, Excavation, Transport & Disposal					$300,000
Monitoring (assume 50,000 cy in 20 cy trucks, 25 trucks/da	100	days	$2,000.00	$200,000	
UXO Excavation, transport & disposal	10	event	$10,000.00	$100,000	
Transport and Dispose					$7,920,000
Unspecified Material	66,000	tons	$120.00	$7,920,000	
Backfill (assume clean soil fill)					$1,050,000
Load and Transport from Off-Site Source	60,000	C.Y.	$12.00	$720,000	
Place Backfill Material	60,000	C.Y.	$2.00	$120,000	
Compact Backfill Material	60,000	C.Y.	$3.50	$210,000	
Demolish Existing Storm Sewer					$45,300
Excavate	2,500	L.F.	$9.00	$22,500	
Transport & Dispose	190	tons	$120.00	$22,800	
Seeding and Mulching					$20,000
Seeding (hydroseed, mulch and fertilizer)	10.0	Acres	$2,000	$20,000	
Health and Safety Plan					$5,000
Health and Safety Plan	1	LS	$5,000	$5,000	
				Total Direct Costs	**$9,876,620**

Indirect Costs		
Design/Construction Support	10%	$987,662
Construction Management	10%	$987,662
Contractor Overhead	3%	$296,299
Health & Safety Monitoring	3%	$296,299
Permitting	5%	$493,831
	Total Indirect Costs	**$3,061,752**

Total Capital Costs **$12,938,372**

O&M Costs (assume 5 yr review)		
5 Year Review Report	LS	$5,000
Report Review/Meetings	LS	$5,000
ODCs	LS	$2,000
Inspections	LS	$5,000
Cover and Fence Repairs	LS	$2,000
Mowing	LS	$2,000
Legal Services	LS	$5,000
	Total O&M Costs	**$26,000**

Total Project Costs **$12,964,372**

Prepared by: THB 01/24/06
Checked by. DK 01/24/06

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JOB NO. 6301-05-0016 SHEET 3 OF 14
PHASE 0410.0010 TASK
JOB NAME DSCR OU2 Tech Memo. 2005
BY T. Buchli DATE 1/24/06
CHECKED BY D. RzH DATE 1-24-06

Estimate the volume of material deposited in the Former Area 50 Landfill. The purpose is to prepare a rough cost estimate for complete excavation and off-site disposal of all landfilled materials. Client requested this info to show that costs for removal are prohibitive even if UXO risks did not exist.

Given: Depth & Extent of waste materials shown on Fig 1-2, 1-16, & 1-17 from OU2 FFS.

Find: Volume of waste

Area: 1050' x 230' = 241,500 ft² from Fig 1-2

Depth: Assumed avg depth ≅ 6' from Fig 1-17

Volume: 241,500 sq.ft x 6' = 1,449,000 cu ft.

$1,449,000 \times \frac{1}{27\ cy/cf} = 53,667$ c.y.

≅ 54,000 c.y.

Assumed Density of Waste: 90 lb/cf

Convert volume to tons $54,000\ cy \times \frac{27\ cf}{cy} \times \frac{90\ lb}{cf} \times \frac{1\ t}{2000}$

= 65,610 tons

≅ [illegible]

MACTEC

MACTEC ENGINEERING AND CONSULTING, INC.
3200 Town Point Drive NW, Suite 100, Kennesaw, GA 30144
phone 770.421.3400, fax 770.421.3486
website www.mactec.com

JOB NO. 6301-05-0016 SHEET 4 OF 14
PHASE 0410-0010 TASK
JOB NAME DSCR OU2 Tech Memo 2005
BY T. Buchli DATE 1/24/06
CHECKED BY D. Kraft DATE 1-24-06

Assumptions:

Solid Waste Density: 90 lb/cf — J. Studer

Cost for Transport & Disposal: $120/ton — S. Youngs

Since ≈ 50,000 cy (Assume 20 cy trucks)

50,000 cy / 20 cy/truck = 2500 trucks

Assume 25 trucks/day

∴ Assume 100 days of excavation

UXO Monitoring: 100 days

$200/hr ~~+ equipment~~ x 8 hrs = $1600

Assume $2000/day for labor + equipment

UXO Handling: Assume small amount of UXO encountered daily, set aside, then transported offsite for disposal every 10 days.

Assume $10,000/disposal event

Cost for Excavation:

Assume $6/cy for unspecified (from Means $3/cy for heavy clay X 2)

Assume $12/cy for UXO

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3200 Town Point Drive NW, Suite 100, Kennesaw, GA 30144
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website www.mactec.com

JOB NO. 6301-05-0016 SHEET 5 OF 14

PHASE 0410-0010 TASK

JOB NAME DSCA OU2 Tech Memo 2005

BY T. Buchli DATE 1/24/06

CHECKED BY D. Kraft DATE 1-24-06

Assumptions (cont.)

Storm Sewer to be demolished & disposed: 2500 L.F.

Wt per LF of concrete pipe (15" Ø): 150 lb/L.F.

Total weight of storm sewer material to be disposed:

$$2500' \times 150\ \text{lb/LF} = 375{,}000\ \text{lb}$$

$$= 375{,}000\ \text{lb} \times \frac{1\ \text{ton}}{2000\ \text{lb}} = 187.5\ \text{tons}$$

$$\cong 190\ \text{tons}$$

CONCRETE PIPE DESIGN MANUAL

GARY CONCRETE PRODUCTS, INC.
P. O. BOX 4600
AUGUSTA, GEORGIA 30907

Prepared by
AMERICAN CONCRETE PIPE ASSOCIATION
8320 Old Courthouse Road
Vienna, Virginia 22180

$22.50

point of structural strength, hydraulic characteristics and type of appl[ication]. Illustration 5.3 includes the dimensions and approximate weights of elliptical concrete pipe.

Horizontal Elliptical (HE) Pipe. Horizontal elliptical concrete pipe is installed with the major axis horizontal and is extensively used for mini[mum] cover conditions or where vertical clearance is limited by existing structures. It offers the hydraulic advantage of greater capacity for the same depth of flow than most other structures of equivalent water-way area. Under most embankment conditions, its wide span results in greater earth loadings for the same height of cover than for the equivalent size circular pipe and, at the same time, there is a reduction in effective lateral support due to the smaller vertical dimension of the section. Earth loadings are normally greater than for the equivalent circular pipe in the trench

Illustration 5.2 — Dimensions and Approximate Weights of Concrete Pipe

ASTM C 14 – Nonreinforced Sewer and Culvert Pipe, Bell and Spigot Joint.

	CLASS 1		CLASS 2		CLASS 3	
Internal Diameter, Inches	Minimum Wall Thickness, Inches	Approx. Weight, pounds per foot	Minimum Wall Thickness, Inches	Approx. Weight, pounds per foot	Minimum Wall Thickness, Inches	Approx. Weight, pounds per foot
4	⅝	9.5	¾	13	⅞	15
6	⅝	17	¾	20	1	24
8	¾	27	⅞	31	1⅛	36
10	⅞	37	1	42	1¼	50
12	1	50	1⅜	68	1¾	90
15	1¼	80	1⅜	100	1⅞	120
18	1½	110	2	160	2¼	170
21	1¾	160	2¼	210	2¾	260
24	2⅛	200	3	320	3¾	350
27	3¼	390	4	450	4⅞	450
30	3½	450	4¼	540	4¼	540
33	3¾	520	4½	620	4½	620
36	4	580	4¾	700	4¾	700

ASTM C 76 – Reinforced Concrete Culvert, Storm Drain and Sewer Pipe, Bell and Spigot Joint.

	WALL A		WALL B	
Internal Diameter, Inches	Minimum Wall Thickness Inches	Approximate Weight, pounds per foot	Minimum Wall Thickness, Inches	Approximate Weight, pounds per foot
12	1¾	90	2	110
15	1⅞	120	2¼	150
18	2	160	2½	200
21	2¼	210	2¾	260
24	2½	270	3	330
27	2⅝	310	3¼	390
30	2¾	360	3½	450

Illustration 5.2 (Continued) — Dimensions and Appro[ximate] Weights of Concrete Pipe

ASTM C 76

Reinforced Concrete Culvert, Storm Drain and Sewer Pipe, Tongue and Groove Joints

	WALL A		WALL B		WALL C	
Internal Diameter, Inches	Minimum Wall Thickness, inches	Approximate Weight, pounds per foot	Minimum Wall Thickness, Inches	Approximate Weight, pounds per foot	Minimum Wall Thickness, inches	Approximate Weight, pounds per foot
12	1¾	79	2	93	–	–
15	1⅞	103	2¼	127	–	–
18	2	131	2½	168	–	–
21	2¼	171	2¾	214	–	–
24	2½	217	3	264	3¾	366
27	2⅝	255	3¼	322	4	420
30	2¾	295	3½	384	4¼	476
33	2⅞	336	3¾	451	4½	552
36	3	383	4	524	4¾	654
42	3½	520	4½	686	5¼	811
48	4	683	5	867	5¾	1011
54	4½	864	5½	1068	6¼	1208
60	5	1064	6	1295	6¾	1473
66	5½	1287	6½	1542	7¼	1735
72	6	1532	7	1811	7¾	2015
78	6½	1797	7½	2100	8¼	2410
84	7	2085	8	2409	8¾	2660
90	7½	2395	8½	2740	9¼	3020
96	8	2710	9	3090	9¾	3355
102	8½	3078	9½	3480	10¼	3760
108	9	3446	10	3865	10¾	4160

Large Sizes of Pipe Tongue and Groove Joint

Internal Diameter Inches	Internal Diameter Feet	Wall Thickness Inches	Approximate Weight pounds per foot
114	9½	9½	3840
120	10	10	4263
126	10½	10½	4690
132	11	11	5148
138	11½	11½	5627
144	12	12	6126
150	12½	12½	6647
156	13	13	7190
162	13½	13½	7754
168	14	14	8339
174	14½	14½	8945
180	15	15	9572

These tables are based on concrete weighing 150 pounds per cubic foot and will vary with heavier or lighter weight concrete.

condition, since a greater trench width is usually required for HE pipe. For shallow cover, where live load requirements control the design, loading is almost identical to that for an equivalent size circular pipe with the same invert elevation.

Vertical Elliptical (VE) Pipe. Vertical elliptical concrete pipe is

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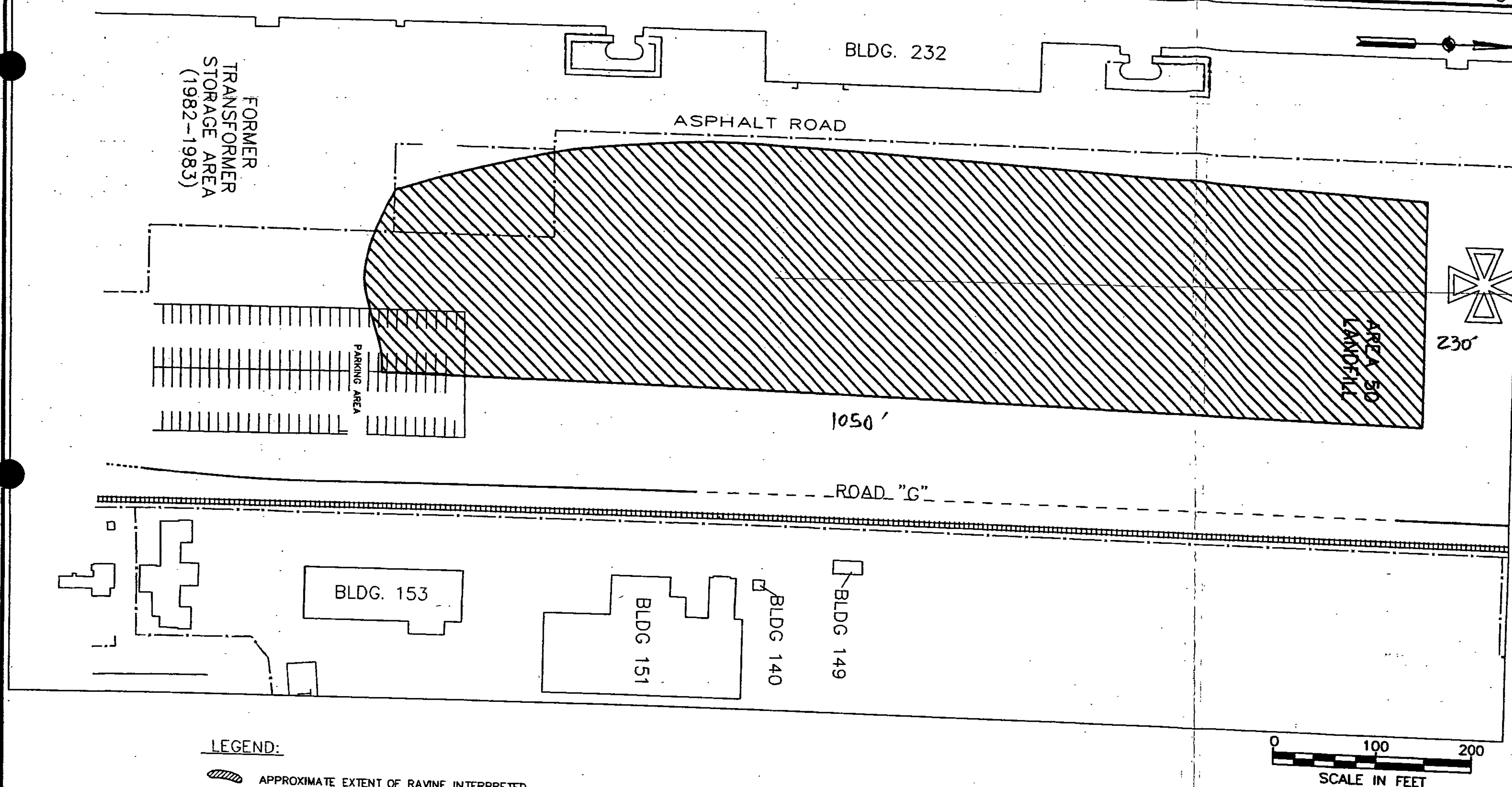
847 237 7 of 14



LEGEND:

APPROXIMATE EXTENT OF RAVINE INTERPRETED BASED ON 1949 AERIAL PHOTOGRAPH AND 1955 TOPOGRAPHIC SITE MAP

NOTE:

LOCATION OF TRANSFORMER STORAGE AREA IS INFERRED FROM LOCATION REPORTED IN DAMES AND MOORE, 1989.

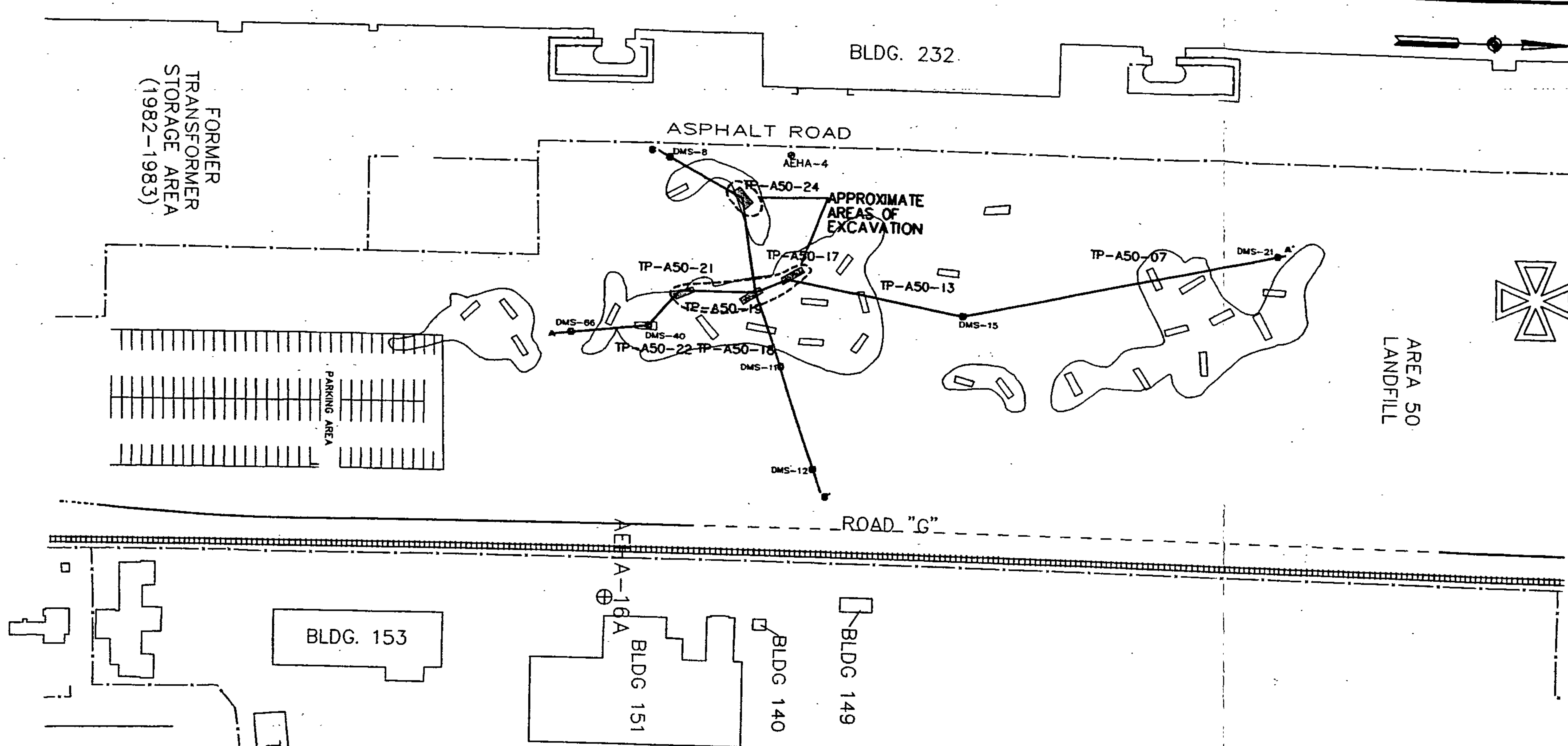
U.S. ARMY ENGINEERING AND SUPPORT CENTER HUNTSVILLE
DEFENSE SUPPLY CENTER –RICHMOND
RICHMOND, VA

OU2 FOCUSED FEASIBILITY STUDY

APPROXIMATE LOCATION OF FORMER RAVINE

AREA 50

PREPARED BY: A. WHITNEY	FIGURE NUMBER:	FILE DATE: 24.FEB.97
CHECKED BY: T. TALELE		PLOT DATE: 06 NOV 97



0 100 200
SCALE IN FEET

LEGEND

TP-A50-22 SOIL TEST TRENCH

DMS-66 ● SOIL TEST BORING

TRENCH WITH OBSERVED FREE PRODUCT (TP-A50-17,19,21, AND 24)

U.S. ARMY ENGINEERING AND SUPPORT CENTER HUNTSVILLE

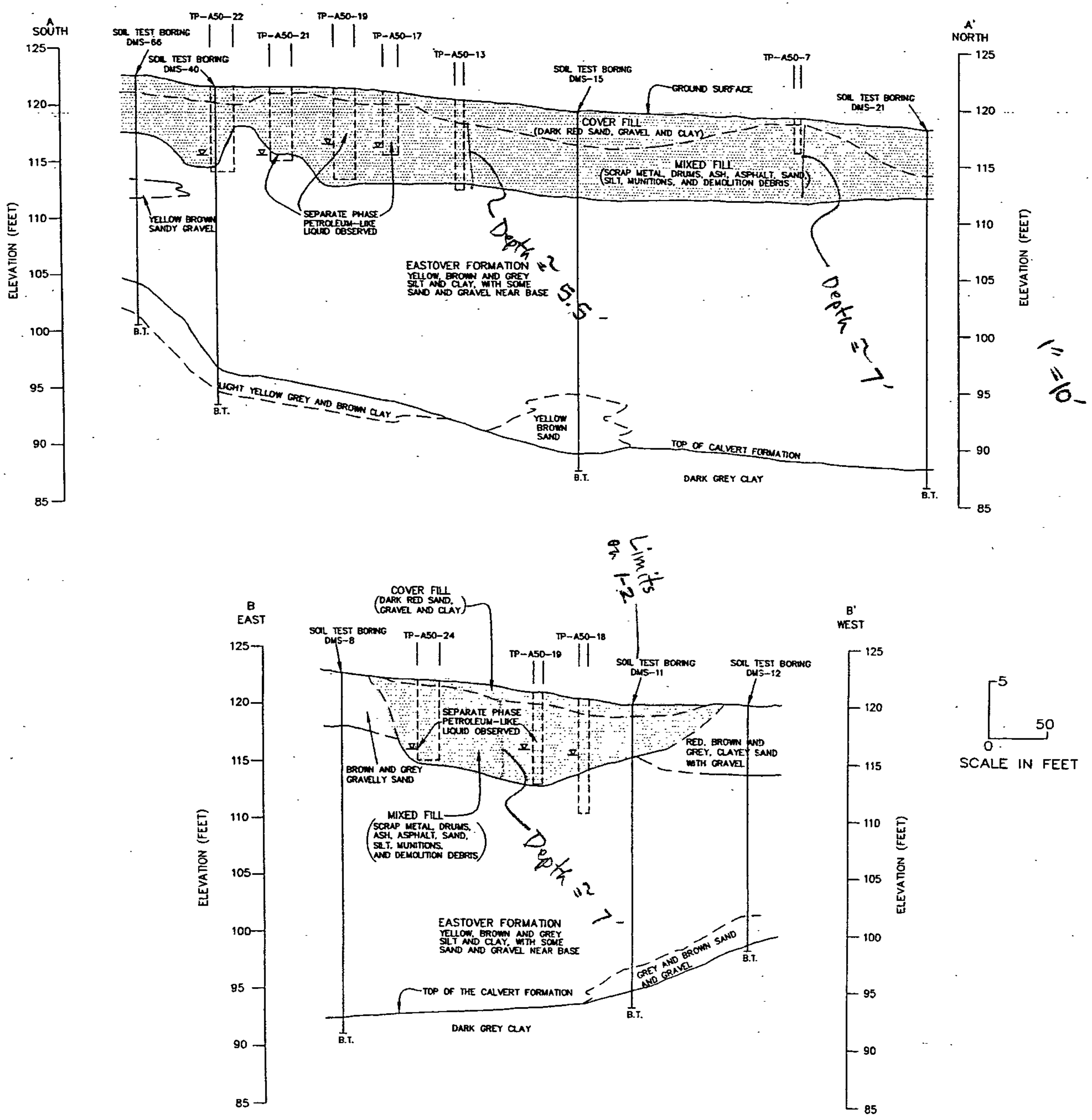
DEFENSE SUPPLY CENTER-RICHMOND
RICHMOND, VIRGINIA

OU2 FOCUSED FEASIBILITY STUDY

CROSS SECTION LOCATIONS AND AREAS TO BE EXCAVATED TO REMOVE FREE PRODUCT

AREA 50

PREPARED BY: A. WHITNEY	FIGURE NUMBER:	FILE DATE: 09.JUNE.97	
CHECKED BY:			



LEGEND:

- SOIL TEST TRENCH
- B.T. SOIL TEST BORING TERMINATION
- DEPTH OF GROUNDWATER OBSERVED IN SOIL TEST TRENCH
- FILL

SOURCES:

1) FINAL EXPLORATORY TRENCHING EXPLORATION REPORT AREA 50 LANDFILL, MAY 1995; LAW ENVIRONMENTAL INC.
2) REMEDIAL INVESTIGATION AREA 50, OPEN STORAGE AREA AND NATIONAL GUARD AREA, JULY 1989; DAMES & MOORE

US ARMY ENGINEERING AND SUPPORT CENTER HUNTSVILLE
DEFENSE SUPPLY CENTER-RICHMOND
RICHMOND, VIRGINIA

OU2 FOCUSED FEASIBILITY STUDY

CROSS SECTIONS A-A' AND B-B' AREA 50 LANDFILL

AREA 50

PREPARED BY: T. TALELE	FIGURE NUMBER: 1-17	FILE DATE: 25.FEB.97	
CHECKED BY: K. L. ALLEN		PLOT DATE: 06.NOV.97	
PROJECT NO. 10300-5-3109		FILE NAME:	

KJELLSTROM & LEE CONSTRUCTION

~~John D. Green~~
~~Project Superintendent~~

Contacted 1-24-06 → Pete Alcorn x 246

KJELLSTROM AND LEE, INC.
1607 OWNBY LANE
RICHMOND, VA 23220
804.288.0082
FAX 804.285.4288
~~MOBILE 434.466.8148~~
~~jgreen@kjellstrom-lee.com~~

804-513-5918 (M)

$12 yd non-structural fill
$24 yd top soil
$20 yd clay

02300 | Earthwork

02305 | Equipment

	Line	Description	Crew	Daily Output	Labor-Hours	Unit	Mat.	Labor	Equip.	Total	Total Incl O&P	
							2005 Bare Costs					
	2000	Crane, truck-mounted, up to 75 ton (incl both mob & demob) R01590-100	1 EQHV	3.60	2.222	Ea.		80		80	120	250
	[illegible]	Crane, truck-mounted, over 75 ton	A-3E	2.50	6.400			203	34	237	350	
	2200	Crawler-mounted, up to 75 ton	A-3F	2	8			254	278	532	690	
	2300	Over 75 ton	A-3G	1.50	10.667			340	405	745	960	
	2500	For each additional 5 miles haul distance, add						10%	10%			
	3000	For large pieces of equipment, allow for assembly/knockdown										
	3001	For mob/demob of vibrofloatation equip, see section 02250-900										
	3100	For mob/demob of micro-tunneling equip, see section 02441-400										
	3200	For mob/demob of pile driving equip, see section 02455-650										
	3300	For mob/demob of caisson drilling equip, see 02465-950										

02310 | Grading

	Line	Description	Crew	Daily Output	Labor-Hours	Unit	Mat.	Labor	Equip.	Total	Total Incl O&P	
0	0010	FINISH GRADING										100
	0012	Finish grading area to be paved with grader, small area	B-11L	400	.040	S.Y.		1.23	1.14	2.37	3.14	
	0100	Large area		2,000	.008			.25	.23	.48	.63	
	1100	Fine grade for slab on grade, machine		1,040	.015			.47	.44	.91	1.20	
	1150	Hand grading	B-18	700	.034			.94	.05	.99	1.52	

02315 | Excavation and Fill

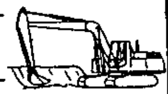
	Line	Description	Crew	Daily Output	Labor-Hours	Unit	Mat.	Labor	Equip.	Total	Total Incl O&P	
10	0010	BACKFILL, GENERAL R02315-300										110
	0015	By hand, no compaction, light soil	1 Clab	14	.571	L.C.Y.		15.25		15.25	23.50	
	0100	Heavy soil		11	.727	"		19.40		19.40	30	
	0300	Compaction in 6" layers, hand tamp, add to above		20.60	.388	E.C.Y.		10.35		10.35	16.15	
	0400	Roller compaction operator walking, add	B-10A	100	.120			3.84	1.23	5.07	7.20	
	0500	Air tamp, add	B-9D	190	.211			5.70	.93	6.63	9.95	
	[illegible]	Vibrating plate, add	A-1D	60	.133			3.56	.42	3.98	6	
	[illegible]	Compaction in 12" layers, hand tamp, add to above	1 Clab	34	.235			6.30		6.30	9.80	
	0900	Roller compaction operator walking, add	B-10A	150	.080			2.56	.82	3.38	4.79	
	1000	Air tamp, add	B-9	285	.140			3.80	.50	4.30	6.45	
	1100	Vibrating plate, add	A-1E	90	.089			2.37	.41	2.78	4.14	
	1300	Dozer backfilling, bulk, up to 300' haul, no compaction	B-10B	1,200	.010	L.C.Y.		.32	.77	1.09	1.33	
	1400	Air tamped, add	B-11B	80	.200	E.C.Y.		6	2.30	8.30	11.70	
	1600	Compacting backfill, 6" to 12" lifts, vibrating roller	B-10C	800	.015			.48	1.89	2.37	2.81	
	1700	Sheepsfoot roller	B-10D	750	.016			.51	2.04	2.55	3.02	
	1900	Dozer backfilling, trench, up to 300' haul, no compaction	B-10B	900	.013	L.C.Y.		.43	1.02	1.45	1.77	
	2000	Air tamped, add	B-11B	80	.200	E.C.Y.		6	2.30	8.30	11.70	
	2200	Compacting backfill, 6" to 12" lifts, vibrating roller	B-10C	700	.017			.55	2.16	2.71	3.20	
	2300	Sheepsfoot roller	B-10D	650	.018			.59	2.35	2.94	3.49	
	2350	Spreading in 8" layers, small dozer	B-10B	1,060	.011	L.C.Y.		.36	.87	1.23	1.50	
120	0010	BACKFILL, STRUCTURAL Dozer or F.E. loader										120
	0020	From existing stockpile, no compaction										
	2000	75 H.P., 50' haul, sand & gravel	B-10L	1,100	.011	L.C.Y.		.35	.29	.64	.84	
	2020	Common earth		975	.012			.39	.32	.71	.96	
	2040	Clay		850	.014			.45	.37	.82	1.10	
	2400	300' haul, sand & gravel		370	.032			1.04	.85	1.89	2.52	
	2420	Common earth		330	.036			1.16	.95	2.11	2.82	
	2440	Clay		290	.041			1.32	1.09	2.41	3.20	
	3000	105 H.P., 50' haul, sand & gravel	B-10W	1,350	.009			.28	.34	.62	.80	
	3020	Common earth		1,225	.010			.31	.37	.68	.89	
	3040	Clay		1,100	.011			.35	.41	.76	.98	
	3300	300' haul, sand & gravel		465	.026			.83	.98	1.81	2.33	
	[illegible]	Common earth		415	.029			.93	1.09	2.02	2.61	
	[illegible]	Clay		370	.032			1.04	1.23	2.27	2.93	
	4000	200 H.P., 50' haul, sand & gravel	B-10B	2,500	.005			.15	.37	.52	.63	
	4020	Common earth		2,200	.005			.17	.42	.59	.73	

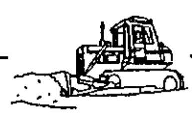
SITE CONSTRUCTION 2

[illegible] coverage of these items see Means Heavy Construction Cost Data 2005

02315 | Excavation and Fill

	02315 Excavation and Fill	CREW	DAILY OUTPUT	LABOR-HOURS	UNIT	2005 BARE COSTS MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P
424 0200	Backhoe, hydraulic, crawler mtd., 1 C.Y. cap. = 75 C.Y./hr. R02315-400	B-12A	600	.027	B.C.Y.		.83	.93	1.76	2.30
[illegible]50	1-1/2 C.Y. cap. = 100 C.Y./hr.	B-12B	800	.020			.63	.90	1.53	1.95
0260	2 C.Y. cap. = 130 C.Y./hr. R02315-450	B-12C	1,040	.015			.48	.87	1.35	1.70
0300	3 C.Y. cap. = 160 C.Y./hr.	B-12D	1,280	.013			.39	1.58	1.97	2.34
0310	Wheel mounted, 1/2 C.Y. cap. = 30 C.Y./hr.	B-12E	240	.067			2.09	1.39	3.48	4.71
0360	3/4 C.Y. cap. = 45 C.Y./hr.	B-12F	360	.044			1.39	1.32	2.71	3.58
0500	Clamshell, 1/2 C.Y. cap. = 20 C.Y./hr.	B-12G	160	.100			3.13	3.39	6.52	8.50
0550	1 C.Y. cap. = 35 C.Y./hr.	B-12H	280	.057			1.79	3.13	4.92	6.15
0950	Dragline, 1/2 C.Y. cap. = 30 C.Y./hr.	B-12I	240	.067			2.09	2.71	4.80	6.15
1000	3/4 C.Y. cap. = 35 C.Y./hr.	"	280	.057			1.79	2.32	4.11	5.30
1050	1-1/2 C.Y. cap. = 65 C.Y./hr.	B-12P	520	.031			.96	1.77	2.73	3.41
1200	Front end loader, track mtd., 1-1/2 C.Y. cap. = 70 C.Y./hr.	B-10N	560	.021			.69	.56	1.25	1.65
1250	2-1/2 C.Y. cap. = 95 C.Y./hr.	B-10O	760	.016			.51	.73	1.24	1.57
1300	3 C.Y. cap. = 130 C.Y./hr.	B-10P	1,040	.012			.37	.76	1.13	1.39
1350	5 C.Y. cap. = 160 C.Y./hr.	B-10Q	1,280	.009			.30	.86	1.16	1.40
1500	Wheel mounted, 3/4 C.Y. cap. = 45 C.Y./hr.	B-10R	360	.033			1.07	.54	1.61	2.21
1550	1-1/2 C.Y. cap. = 80 C.Y./hr.	B-10S	640	.019			.60	.38	.98	1.32
1600	2-1/4 C.Y. cap. = 100 C.Y./hr.	B-10T	800	.015			.48	.38	.86	1.15
1650	5 C.Y. cap. = 185 C.Y./hr.	B-10U	1,480	.008			.26	.47	.73	.91
1800	Hydraulic excavator, truck mtd, 1/2 C.Y. = 30 C.Y./hr.	B-12J	240	.067			2.09	3.49	5.58	7.05
1850	48 inch bucket, 1 C.Y. = 45 C.Y./hr.	B-12K	360	.044			1.39	2.70	4.09	5.10
3700	Shovel, 1/2 C.Y. capacity = 55 C.Y./hr.	B-12L	440	.036			1.14	1.26	2.40	3.13
3750	3/4 C.Y. capacity = 85 C.Y./hr.	B-12M	680	.024			.74	1	1.74	2.23
3800	1 C.Y. capacity = 120 C.Y./hr.	B-12N	960	.017			.52	.93	1.45	1.82
3850	1-1/2 C.Y. capacity = 160 C.Y./hr.	B-12O	1,280	.013			.39	.75	1.14	1.42
3900	3 C.Y. cap. = 250 C.Y./hr.	B-12T	2,000	.008			.25	.63	.88	1.07
[illegible]000	For soft soil or sand, deduct								15%	15%
4100	For heavy soil or stiff clay, add								60%	60%
4200	For wet excavation with clamshell or dragline, add								100%	100%
4250	All other equipment, add								50%	50%
4400	Clamshell in sheeting or cofferdam, minimum	B-12H	160	.100			3.13	5.50	8.63	10.85
4450	Maximum	"	60	.267			8.35	14.60	22.95	29
8000	For hauling excavated material, see div. 02315-490									
432 0010	**EXCAVATING, BULK, DOZER** Open site									
2000	80 H.P., 50' haul, sand & gravel	B-10L	460	.026	B.C.Y.		.83	.68	1.51	2.02
2020	Common earth		400	.030			.96	.79	1.75	2.33
2040	Clay		250	.048			1.54	1.26	2.80	3.73
2200	150' haul, sand & gravel		230	.052			1.67	1.37	3.04	4.05
2220	Common earth		200	.060			1.92	1.57	3.49	4.65
2240	Clay		125	.096			3.07	2.52	5.59	7.45
2400	300' haul, sand & gravel		120	.100			3.20	2.62	5.82	7.75
2420	Common earth		100	.120			3.84	3.15	6.99	9.30
2440	Clay		65	.185			5.90	4.84	10.74	14.35
3000	105 H.P., 50' haul, sand & gravel	B-10W	700	.017			.55	.65	1.20	1.54
3020	Common earth		610	.020			.63	.74	1.37	1.78
3040	Clay		385	.031			1	1.18	2.18	2.82
3200	150' haul, sand & gravel		310	.039			1.24	1.46	2.70	3.49
3220	Common earth		270	.044			1.42	1.68	3.10	4.01
3240	Clay		170	.071			2.26	2.67	4.93	6.35
3300	300' haul, sand & gravel		140	.086			2.74	3.24	5.98	7.75
3320	Common earth		120	.100			3.20	3.78	6.98	9.05
3340	Clay		100	.120			3.84	4.54	8.38	10.85
4000	200 H.P., 50' haul, sand & gravel	B-10B	1,400	.009			.27	.66	.93	1.14
4020	Common earth		1,230	.010			.31	.75	1.06	1.29
4040	Clay		770	.016			.50	1.19	1.69	2.07





5 CONSTRUCTION

02200 | Site Preparation

02220 | Site Demolition

		02220 Site Demolition		Crew	Daily Output	Labor-Hours	Unit	Mat.	Labor	Equip.	Total	Total Incl O&P	
								2005 Bare Costs					
240	1100	Cavity wall	R02220 -510	B-5	2,200	.025	C.F.		.74	.42	1.16	1.61	240
	1200	Brick, solid			900	.062			1.82	1.03	2.85	3.94	
	1300	With block back-up			1,130	.050			1.45	.82	2.27	3.14	
	1400	Stone, with mortar			900	.062			1.82	1.03	2.85	3.94	
	1500	Dry set			1,500	.037			1.09	.62	1.71	2.36	
	1600	Median barrier, precast concrete, remove and store		B-3	430	.112	L.F.		3.20	4.05	7.25	9.35	
	1610	Remove and reset		"	390	.123			3.53	4.47	8	10.30	
	2900	Pipe removal, sewer/water, no excavation, 12" diameter		B-6	175	.137			3.95	1.23	5.18	7.45	
	2930	15"-18" diameter			150	.160			4.61	1.44	6.05	8.70	
	2960	21"-24" diameter			120	.200			5.75	1.80	7.55	10.85	
	3000	27"-36" diameter			90	.267			7.70	2.40	10.10	14.45	
	3200	Steel, welded connections, 4" diameter			160	.150			4.32	1.35	5.67	8.15	
	3300	10" diameter			80	.300			8.65	2.70	11.35	16.25	
	3500	Railroad track removal, ties and track		B-13	330	.170			4.89	1.87	6.76	9.55	
	3600	Ballast		B-14	500	.096	C.Y.		2.70	.43	3.13	4.65	
	3700	Remove and re-install, ties & track using new bolts & spikes			50	.960	L.F.		27	4.32	31.32	46.50	
	3800	Turnouts using new bolts and spikes			1	48	Ea.		1,350	216	1,566	2,325	
	4000	Sidewalk removal, bituminous, 2-1/2" thick		B-6	325	.074	S.Y.		2.13	.66	2.79	4	
	4050	Brick, set in mortar			185	.130			3.74	1.17	4.91	7.05	
	4100	Concrete, plain, 4"			160	.150			4.32	1.35	5.67	8.15	
	4200	Mesh reinforced			150	.160			4.61	1.44	6.05	8.70	
	5000	Slab on grade removal, plain		B-5	45	1.244	C.Y.		36.50	20.50	57	78.50	
	5100	Mesh reinforced			33	1.697			49.50	28	77.50	108	
	5200	Rod reinforced			25	2.240			65.50	37	102.50	142	
	5500	For congested sites or small quantities, add up to									200%	200%	
	5550	For disposal on site, add		B-11A	232	.069			2.12	3.96	6.08	7.60	
	5600	To 5 miles, add		B-34D	76	.105			2.90	5.50	8.40	10.45	
250	0010	**DEMOLISH, REMOVE PAVEMENT AND CURB**	R02220 -510										250
	5010	Pavement removal, bituminous roads, 3" thick		B-38	690	.058	S.Y.		1.74	1.20	2.94	3.98	
	5050	4" to 6" thick			420	.095			2.85	1.96	4.81	6.55	
	5100	Bituminous driveways			640	.063			1.87	1.29	3.16	4.29	
	5200	Concrete to 6" thick, hydraulic hammer, mesh reinforced			255	.157			4.70	3.24	7.94	10.75	
	5300	Rod reinforced			200	.200			6	4.13	10.13	13.75	
	5400	Concrete, 7" to 24" thick, plain			33	1.212	C.Y.		36.50	25	61.50	83	
	5500	Reinforced			24	1.667	"		50	34.50	84.50	115	
	5600	With hand held air equipment, bituminous, to 6" thick		B-39	1,900	.025	S.F.		.71	.07	.78	1.18	
	5700	Concrete to 6" thick, no reinforcing			1,600	.030			.84	.09	.93	1.40	
	5800	Mesh reinforced			1,400	.034			.96	.10	1.06	1.60	
	5900	Rod reinforced			765	.063			1.76	.19	1.95	2.93	
	6000	Curbs, concrete, plain		B-6	360	.067	L.F.		1.92	.60	2.52	3.61	
	6100	Reinforced			275	.087			2.52	.78	3.30	4.73	
	6200	Granite			360	.067			1.92	.60	2.52	3.61	
	6300	Bituminous			528	.045			1.31	.41	1.72	2.46	
310	0010	**SELECTIVE DEMOLITION, CUTOUT**	R02220 -510										31
	0020	Concrete, elev. slab, light reinforcement, under 6 CF		B-9C	65	.615	C.F.		16.70	2.18	18.88	28.50	
	0050	Light reinforcing, over 6 C.F.		"	75	.533	"		14.45	1.89	16.34	24.50	
	0200	Slab on grade to 6" thick, not reinforced, under 8 S.F.		B-9	85	.471	S.F.		12.75	1.67	14.42	21.50	
	0250	8 - 16 S.F.		"	175	.229	"		6.20	.81	7.01	10.55	
	0255	For over 16 SF see 02220-130-0400											
	0600	Walls, not reinforced, under 6 C.F.		B-9	60	.667	C.F.		18.05	2.36	20.41	30.50	
	0650	6 - 12 C.F.		"	80	.500	"		13.55	1.77	15.32	23	
	0655	For over 12 CF see 02220-130-2500											
	1000	Concrete, elevated slab, bar reinforced, under 6 C.F.		B-9C	45	.889	C.F.		24	3.15	27.15	41	
	1050	Bar reinforced, over 6 C.F.		"	50	.800	"		21.50	2.83	24.33	36.50	
	1200	Slab on grade to 6" thick, bar reinforced, under 8 S.F.		B-9	75	.533	S.F.		14.45	1.89	16.34	24.50	

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