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FINAL REMEDIAL INVESTIGATION REPORT FOR 80TH DIVISION SITE INSTALLATION RESTORATION PROGRAM WITH TRANSMITTAL LETTER FORT STORY VA
10/1/2008
MALCOLM PIRNIE

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FINAL

REMEDIAL INVESTIGATION REPORT
80TH DIVISION RESERVE SITE

Installation Restoration Program
Fort Story, Virginia

U. S. Army Garrison
Fort Eustis, Virginia

and

U.S. Army Corps of Engineers
Baltimore District

October 2008

0285-917

FINAL

REMEDIAL INVESTIGATION REPORT
80TH DIVISION RESERVE SITE

INSTALLATION RESTORATION PROGRAM
FORT STORY, VIRGINIA

PREPARED FOR:

U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT
BALTIMORE, MARYLAND

AND

U.S. ARMY GARRISON
FORT EUSTIS, VIRGINIA

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October 30, 2008

Ms. Joanna Bateman
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U.S. Army Garrison
Building 1407, ATZF-PWE
Fort Eustis, Virginia 23604-5332

Re: Final Remedial Investigation Report
80th Division Reserve Site
Fort Story, Virginia

Dear Ms. Bateman:

Malcolm Pirnie is pleased to provide to Fort Eustis this **Final Remedial Investigation (RI) Report** for the **80th Division Reserve Site (DRS)** at Fort Story, Virginia. We have enclosed three hard copies and one electronic copy of this report for your information. Additional copies (1 hard and 1 CD) have been submitted to the Virginia Department of Environmental Quality for their records.

It has been a pleasure to provide this document to Fort Eustis. We look forward to further discussions relative to this project.

Very truly yours,

MALCOLM PIRNIE, INC.

Anthony K. Pace
Project Manager

akp
0285-917

Enclosures

C: W. Smith, VDEQ, w/encl (1 hard copy/1 CD)

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J	Montgomery Watson Fort Story PA/SI Report

Malcolm Pirnie, Inc. was contracted by the U.S. Army Corps of Engineers (USACE), Baltimore District, to conduct a Remedial Investigation at the 80th Division Reserve Site (80th DRS) at Fort Story, Virginia. An extensive field investigation program was conducted in December 2002/January 2003 and June 2004 to acquire sufficient data to assess the nature and extent of contamination and risk to human health and the environment. A summary of the objectives, site description, nature and extent of contamination, fate and transport mechanisms, risk assessment, and recommendations are provided in the following sections.

ES.1 BACKGROUND

All work was conducted in accordance with the Scopes of Services developed by the USACE with field investigation procedures further developed in the Final Work Plan, dated November 2002, and approved by the USACE and the Virginia Department of Environmental Quality (VDEQ). The specific objectives of the RI were:

- Delineation of the nature and extent of contamination
- Evaluation of potential migration of contaminants
- Assessment of risks to human health and the environment
- Development of recommendations for future action based on the findings

ES.2 SITE DESCRIPTION

The 80th DRS area contains a 50-foot by 70-foot concrete pad surrounded by asphalt on the west, south, and east sides. The north side is bordered by sand that was used as the DRS staging area. Over time, this staging area apparently became contaminated with by-products (primarily petroleum products) of the washing and maintenance operations. A 1,000 gallon used oil UST, 250-gallon antifreeze aboveground storage tank (AST), and a former drum storage area were located west of the wash pad.

ES.3 NATURE AND EXTENT OF CONTAMINATION

Soil

A summary of the nature and extent of soil contamination is provided as follows:

VOCs

- Acetone, methylene chloride, and toluene were detected in more than 85 percent of the surface and subsurface soil samples collected at the site. Several other VOCs were detected frequently throughout the site. Concentrations of these compounds varied from surface to deeper depths with no apparent trends.

- The lateral extent of VOC contamination was not defined because VOCs were detected in all of the surface soil samples collected in this area. However, concentrations were several orders of magnitude lower than EPA screening criteria.

SVOCs

- SVOCs were detected in all soil samples collected from the site. The primary SVOCs detected were polynuclear aromatic hydrocarbons (PAHs), which are constituents of petroleum hydrocarbons. Bis(2-ethylhexyl)phthalate was the only SVOC detected in two of the soil borings, while only bis(2-ethylhexyl)phthalate, fluorene, phenanthrene, and pyrene were detected one of the borings indicating minimal downgradient migration of SVOCs in soils since these 3 borings are located directly downgradient of the former UST and AST, asphalted, and drum storage areas of the site.

- Although PAHs were detected throughout the site, the areas with the highest concentrations were centered on the former UST/AST area and the former drum storage area with lower concentrations in areas generally upgradient of these areas.

Pesticides

- Endrin ketone, DDT, and endosulfan sulfate were detected in site soil samples. Aldrin was the only pesticide detected above an EPA RBC for residential soils (38 ug/kg) in one sample on-site at a concentration of 73 ug/kg. Pesticides were detected in all soil samples at the site with little variation in location (upgradient, on-site, or downgradient) or with depth.

- Due to past widespread application of these pesticides, their presence at these low concentrations is expected at the site.

PCBs

- Aroclor-1260 was the only PCB detected at the site and it was detected in only 2 of 30 soil samples and at concentrations lower than EPA RBCs. Due to infrequent detection, there is no pattern to its distribution at the site.

Inorganics

- Metals were detected in soil samples throughout the site as would be expected since the majority of them are naturally occurring in various concentrations. Only three metals (arsenic, iron, and vanadium) concentrations exceeded EPA RBCs for residential soils, none exceeded industrial RBCs. Arsenic exceeded the RBC in 8 of 30 samples, iron exceeded the RBC in 6 of 30 samples, and vanadium exceeded the RBC in 3 of 30 samples

- In general, concentrations of metals typically were similar for soil samples collected from the surface and subsurface depths.

Groundwater

A summary of the nature and extent of ground water contamination is provided as follows:

VOCs/SVOCs

- Several VOCs and bis(2-ethylhexyl)phthalate were detected at concentrations greater than the EPA RBCs at the site.

- Other than toluene, which was detected in all 10 wells at the site, no other organics were detected in wells that are upgradient/cross-gradient of the former AST/UST and drum storage areas.

- The highest concentrations of organics were detected in the central portions of the site near the former UST/AST (assumed source area) and drum area, with some organics detected in downgradient wells.

- The lateral distribution of PCE, TCE, and cis 1,2-DCE implies these compounds have migrated with groundwater from the former UST area downgradient to the north/northwest in that these compounds have been detected in downgradient wells MW-5, MW-6, and MW-9.

- Bis(2-ethylhexyl)phthalate was detected in only one well on-site and its apparent distribution is limited to the former UST area.

Inorganics

Although most metals were detected in total and dissolved phase throughout the site, the distribution pattern will focus on those metals that exceeded EPA RBCs and/or MCLs:

- Total antimony concentrations are consistent across the site with detections in 8 of 10 wells across the site. The concentrations in the upgradient wells are greater than the concentrations in the central-site and downgradient wells. This indicates that the antimony concentrations detected at the site are probably naturally occurring levels and not influenced by the past operations at the former UST/AST and drum storage areas.

- Total arsenic was detected in only 3 of 10 wells with concentrations greatest in one central-site well and in two downgradient wells. Based on the low concentrations and infrequent detection, no discernible pattern is present and it is unclear if these concentrations are solely related to natural levels or are influenced by former site activities.

- Total iron was detected in all 10 wells with concentrations greatest in one central-site well (MW-7) and in three downgradient wells (MW-9, MW-10, and MW-11). These concentrations were the only total iron detects above the EPA RBC. Dissolved iron was also detected in all 10 wells with concentrations greatest in the same wells as the total iron concentrations. The highest concentrations of total and dissolved iron were present in downgradient wells MW-10

and MW-11 which are the least-impacted wells in relation to identified contaminants of concern for the site (VOCs and SVOCs from the former UST and drum storage areas). Based on the location of the highest iron concentrations (downgradient wells), it is unclear if these concentrations are solely related to natural levels or are influenced by former site activities.

- Total and dissolved manganese were detected in all 10 wells with concentrations greatest in two downgradient wells. These concentrations were the only total or dissolved manganese detects above the EPA RBC. The highest concentrations of total and dissolved manganese were present in two downgradient wells, which are the least-impacted wells in relation to identified contaminants of concern for the site (VOCs and SVOCs from the former UST and drum storage areas). Based on the location of the highest manganese concentrations (downgradient wells), it is unclear if these concentrations are solely related to natural levels or are influenced by former site activities.

- Total vanadium concentrations are fairly consistent across the site with detections in 9 of 10 wells across the site. The concentrations (1.2 to 4.2 µg/L) in the upgradient wells (MW-1 and MW-2) are consistent with the concentrations (1.1 to 6.3 µg/L) in the central-site wells (MW-3, MW-7, and MW-8) and greater than the concentrations (0.65 to 2.3 µg/L) in the downgradient wells. This indicates that the vanadium concentrations detected at the site are probably naturally occurring levels and not influenced by the past operations at the former UST/AST and drum storage areas.

ES.4 FATE AND TRANSPORT

Soils

PAHs, metals, and pesticides remain in the soil column because these compounds strongly adsorb to soil, especially the fine fraction (silt and clay). Thus, these compounds tend to remain at the source area with little migration. Biodegradation is expected to be an important fate process for PAHs and pesticides at the site. Due to the potential for transport of soil particles by storm water runoff or surface water, these compounds can migrate when adsorbed to soil or sediment particles. It is expected that transport from on-site to downgradient locations, is accomplished by these mechanisms.

Groundwater

Overall, VOCs were detected infrequently, with three constituents (cis 1,2-DCE, PCE, and TCE), detected above EPA criteria for tap water RBCs. PCE and TCE resist adsorption to soil and are identified as compounds that can leach into, and migrate in, groundwater. PCE can be biodegraded in to TCE. Confining layers in the subsurface restrict vertical migration.

Bis(2-ethylhexyl) phthalate (BEHP) was the only SVOC detected at the site. It was detected in the sample from MW-8 above the EPA risk screening criteria RBC. BEHP's long persistence in the subsurface and ability to migrate through the soil at low concentrations could indicate that BEHP

could be transported in site groundwater. As BEHP was detected in only one of 10 sample locations, BEHP contamination is not widely spread.

Numerous metals were detected in groundwater; however, the constituents most frequently detected over the RBCs were arsenic, iron and manganese. Dissolved phase inorganics will be transported with flowing groundwater, but most likely will not migrate as rapidly as the organics. Precipitation of the metals onto soil particles in the saturated zone may occur and impact dissolved inorganic concentrations available for migration.

ES.5 RISK ASSESSMENT

Human Health Risk Assessment

A summary of the non-carcinogenic and carcinogenic risk is provided in the following table:

Human Health Risk Assessment Summary					
Exposed Population	**Exposure Pathway**	**Non-Cancer Effects**		**Cancer Effects**	
		PHI	**TEHI**	**TPR**	**TER**
Fort Story/Future Industrial Site Workers	Ingestion of Soil	N/A	N/A	1.77×10^{-5}	3.29×10^{-5}
	Dermal Contact with Soil	N/A		1.52×10^{-5}	
	Inhalation of Soil Particulates	N/A		4.90×10^{-10}	
Construction Workers	Ingestion of Soil	N/A	0.275	5.70×10^{-7}	1.02×10^{-5}
	Dermal Contact with Soil	N/A		9.16×10^{-7}	
	Inhalation of Soil Particulates	N/A		1.59×10^{-9}	
	Ingestion of Groundwater	0.00512		1.60×10^{-8}	
	Dermal Contact with GW	0.104		9.45×10^{-8}	
	Inhalation of Vapors from GW	0.165		8.65×10^{-6}	

For Non-Carcinogens:
PHI – Pathway Hazard Index indicates non-carcinogenic risk for specific exposure pathways
TEHI – Total Exposure Hazard Index indicates non-carcinogenic risk for exposed population
Criterion of 1.0 is used to determine if adverse health effects are possible or unlikely.
N/A – Not applicable because non-cancer effects were not identified for this population.
For Carcinogens:
TPR – Total Pathway Risk indicates carcinogenic risk for specific exposure pathways
TER – Total Exposure Risk indicates carcinogenic risk for exposed population
USEPA Remediation goal of 10^{-4} to 10^{-6} used to assess carcinogenic risk.
Bolded and underlined text indicates value exceeds the non-cancer criterion of 1.0 or above the carcinogenic risk level of 10^{-4}.

Finally, the above summary of potentially exposed populations was based on a conservative approach rather than a more reasonable estimation of risk. Additional factors that affect the conclusions drawn from the risk characterization results include the following:

- The exceedences of the industrial soil RBCs for the PAHs is limited to a small portion of the site, in the interior area, near the former location of the storage tanks.

- The majority of the risk associated with construction worker exposure to contaminated groundwater is associated with TCE; however, the 95th UCL utilized in the risk calculations was only 3 µg/L which is lower than the USEPA drinking water MCL of 5 µg/L. The estimated cancer risk associated with the other groundwater COPCs combined was in the 10^{-7} range.

- The cancer risk established for the site workers (3.29×10^{-5}) and construction workers (1.02×10^{-5}) is within the EPA Superfund target risk level range. As quoted in Section 300.430(e)(2)(i)(A)(2) of the National Contingency Plan (NCP), "for known or suspected carcinogens, acceptable exposure levels are generally concentrations that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6};" therefore, the concentrations in soil and groundwater fall within the acceptable range based on carcinogenic risk.

Based on the limited soil area impacted by the PAHs, the relatively low concentration of TCE (and other constituents) in groundwater, and the calculated cancer risks for site and construction workers which is within the acceptable range per NCP guidance, no additional action is warranted at the site based on the potentially exposed populations.

Ecological Risk Assessment

This screening level ecological risk assessment (SLERA) was completed in accordance with USEPA guidelines. The results of the SLERA and conclusions for chemicals of potential concern (COPCs) are summarized below.

VOCs

A total of 21 VOCs were detected, 12 of these compounds had screening values. Only one compound, Tetrachloroethylene, had an EEQ of greater than one based on BTAG criteria. Nine compounds were retained as COPCs due to lack of screening values. There were no TRVs available to assess direct contact with plants or invertebrates for these initial ten COPCs. Five TRVs were available for mammalian receptors: 2-Butanone, Acetone, Carbon disulfide, Tetrachloroethylene and Trichlorofluoromethane. There were no avian TRVs available for VOCs. No hazard quotients for VOCs indicate these compounds present a potential risk to ecological receptors at the 80th DRS site.

SVOCs

All 24 SVOCs were initially retained as COPCs, either for exceeding the BTAG values or because they lacked TRV criteria. Seven of these SVOCs are PAHs and two are phthalates. Of the initial COPCs, 16 that had screening criteria available were retained. This included seven PAHs. No

phthalates were retained. Of the initial COPCs, only fluorene had a non-BTAG TRV available. Though fluorene did not exceed the invertebrate TRV, it was retained as a COPC for exceeding the BTAG screening value.

Mammalian TRV data was available for 11 of the COPCs. Avian TRV data was only available for bis(2-Ethylhexyl)phthalate. After completing the initial exposure assessment, eight COPCs were determined to have a HQ above one for mammalian species: Benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, fluoranthene, phenanthrene and pyrene. No COPCs were found to have an HQ greater than one for avian species. Using area use factors (AUFs) were used to refine the risk characterization. Only one COPC, pyrene, was identified for shrew populations. The HQ for pyrene in shrews was 3 using a NOAEL-based TRV. Due to the minimal NOAEL-based HQ for one indicator species, pyrene is not considered to pose a risk to ecological receptors at the 80th DRS and has not been retained as a COPC in this SLERA

Metals

Six metals were initially retained as COPCs. Three of these did not have screening values. Mammalian and avian TRV data was available for three COPC metals. After completing the initial exposure assessment, aluminum was found to have an HQ equal to or greater than one for all avian and mammalian species. Aluminum toxicity in a soil matrix is related to its solubility and, therefore, soil pH. For sites with soil pH above 5.5, USEPA guidelines do not recommend including aluminum as a COPC for ecological receptors. The soil conditions at the 80th DRS are consistent with elimination of aluminum as a COPC.

Conclusions

As stated in Section 7.1, the assessment endpoints at the 80th DRS site do not include vegetation or soil invertebrates due to the small size of the impacted site, the lack of endangered species on the site, and the type of soil and vegetation on the site. The appropriate evaluation of risk posed by COPCs in soil at this site was to determine the risk posed to the overall ecosystem at Fort Story. The assessment endpoints for this SLERA, therefore, were to evaluate: 1) Uptake of COPCs into food chain, 2) survival and reproduction of upper-trophic avian species, and 3) survival and reproduction of upper-trophic mammalian species.

Based on the results of this SLERA, COPCs in soil at the 80th DRS site are not likely to accumulate in the food chain of the ecosystem surrounding the site and, therefore, they do not pose a risk to upper-trophic avian or mammalian species. There is ample habitat at Fort Story surrounding the site to maintain a healthy, diverse ecosystem. As a result, the management goal for the 80th DRS site of protecting the ecosystem surrounding the site by evaluating uptake of COPCs from soil into the food chain can be achieved without establishing COPCs based on ecological endpoints.

Based on the combination of the low HQ value for pyrene, the elimination of aluminum as a COPC, and a conservative risk assessment approach, the conclusion of this risk characterization is that

concentrations of COPCs in soils at the 80th DRS do not pose a risk to upper trophic receptors. There is no evidence that remediation decisions should be based on existing adverse effects to ecological receptors. No further ecological risk assessment is recommended for this site.

ES.6 RECOMMENDATIONS

The recommendations for the site are based on the nature and extent of contamination, fate and transport characteristics and the results of the human health and ecological risk assessments.

Although contaminants have been detected across the site and some in concentrations greater than human health and ecological screening levels, based on the findings presented below, no additional investigative or remedial action is warranted. The reasons for the no further action recommendations include the following:

- Limited soil area impacted by the PAHs.
- The relatively low concentration of TCE (and other constituents) in groundwater.
- The calculated cancer risks for site and construction workers which is within the acceptable range per NCP guidance
- The low HQ value for pyrene.
- The elimination of aluminum as a COPC.
- A conservative risk assessment approach which concludes that concentrations of COPCs in soils at the 80th DRS do not pose a risk to upper trophic receptors.

A Decision Document will be prepared that presents the findings of this remedial investigation and any long term restrictions, if any, required for the site which will go through the public comment process.

Malcolm Pirnie, Inc. was contracted by the U.S. Army Corps of Engineers (USACE), Baltimore District to conduct a Remedial Investigation (RI) at the 80th Division Reserve Site (80th DRS) at Fort Story, Virginia under Contract DACA31-00-D-0043.

1.1 PURPOSE OF REPORT

The work was conducted under the requirements of the Department of Defense (DOD) Installation Restoration Program (IRP) that are consistent with the U.S. Environmental Protection Agency (EPA) guidelines. The EPA guidelines followed during the RI are set forth in "Guidance on Remedial Investigations and Feasibility Studies under CERCLA" (EPA, 1988). All work was conducted in accordance with the Scopes of Services developed by the USACE with field investigation procedures further developed in the *Final Work Plan*, dated November 2002 (Malcolm Pirnie, 2002a). A *Final Generic Quality Assurance Project Plan (QAPP)*, dated March 2002 (Malcolm Pirnie, 2002b) and a *Site Safety and Health Plan*, dated December 1994, (Malcolm Pirnie, 1994) for the FTA, LARC 60, and Auto Craft remedial investigations were also utilized as guidance and were referenced in the *Final Work Plan* for the 80th DRS RI.

The activities in the RI are geared towards collecting the information necessary to evaluate the type and magnitude of contamination as well as the transport mechanisms and impacts of contamination on various media such as groundwater and soil. The specific objectives of the RI were:

- Delineation of the nature and extent of contamination
- Evaluation of potential migration of contaminants
- Assessment of risks to human health and the environment
- Development of recommendations for future action based on the findings

1.2 BACKGROUND

1.2.1 Facility Description and History

Fort Story is located in southeastern Virginia within the city of Virginia Beach, Virginia. Fort Story occupies an area of approximately 1,451 acres and is situated on Cape Henry which roughly divides the waters of the Chesapeake Bay to the north and the Atlantic Ocean to the east.

On 10 March 1914, the Virginia General Assembly ceded 343.1 acres, located at Cape Henry in Princess Anne County, to the U.S. Government "to erect fortifications and for other military purposes." On 14 June 1914, the U.S. District Court acquired title for the land by condemnation proceedings against the Cape Henry Syndicate and other landowners in the Cape Henry subdivision. War Department General Order No. 31, dated 24 July 1916, named this newly acquired tract of land Fort Story in honor of Major General John Patton Story.

Construction of powder magazines and projectile rooms was initiated during the latter part of 1916 and by February 1917, construction of the 16-inch howitzer fortifications had begun. Also, during February 1917, the 2nd and 5th Coast Artillery Companies established the military garrison at Fort Story. From 1917 through 1925, the installation continued to develop as a small coastal artillery garrison consisting of little more than its armament. The only land expansion that occurred during the period was the acquisition of 9.38 acres from the Norfolk and Southern Railway Company in March 1917.

During World War I, Fort Story was integrated into the Coast Defenses of Chesapeake Bay that included Fort Monroe (Headquarters) and Fort Wool (located at the east entrance of the Hampton Roads Bridge Tunnel). On 9 June 1925, Fort Story was designated a Harbor Defense Command by War Department General Order No. 13, but the change in designation added little to the dwindling post-war activity of the garrison.

As World War II approached, Fort Story began an extensive development. Many of the facilities that exist at Fort Story today were constructed at that time, and the installation increased in size to 1,439 acres. An additional 11.82 acres were acquired in 1963 that increased its size to its present 1,451 acres. In the 1940s, the construction included temporary artillery batteries, theater, chapel, fire station, mess halls, barracks, Officer and NCO clubs, shops, additional powder magazines and projectile rooms, six underground storage bunkers and 19 seacoast searchlights.

In December 1941, the Headquarters of the Harbor Defense Command was moved from Fort Monroe to Fort Story. Two harbor defense installations were added to the network in 1941; Fort John Curtis and a mine base. On March 1, 1944, the Chesapeake Bay sector of the Harbor Defenses was inactivated, and control passed to Headquarters, Southeastern Sector, Eastern Defense Command.

By September 1944, Fort Story began a transition from a heavily fortified coast artillery garrison to a convalescent hospital. At the time of its closing on 15 March 1946, the hospital had accommodated over 13,472 patients. At the closing of World War II, Fort Story again changed missions. It assumed the role that it still has today, to train units and individuals for amphibious operations. Fort Story was officially transferred to the Transportation Corps in July 1948 as a subpost of the Transportation Training Command, Fort Eustis, Virginia.

Fort Story trains army personnel in amphibious and Logistics Over-the-Shore (LOTS) operations. Fort Story is the only available facility that has the necessary natural terrain features and beaches, sand, surf, variable tide conditions (bay and ocean) and hinterlands, all of which are normally experienced by amphibious and LOTS operations. In addition, Fort Story contains beach training areas, tactical training areas and a series of trails throughout the installation. The deep water ship anchorage, off-road driving areas and soil of sufficient bearing strength for the heavy vehicles are indispensable in amphibious training, LOTS training and the testing of new equipment, doctrines and techniques.

1.2.2 Site Description and History

The 80th DRS area contains a 50-foot by 70-foot concrete pad surrounded by asphalt on the west, south, and east sides. The north side is bordered by sand that was used as the DRS staging area. Over time, this staging area apparently became contaminated with by-products (primarily petroleum products) of the washing and maintenance operations. A 1,000 gallon used oil UST, 250-gallon antifreeze aboveground storage tank (AST), and a former drum storage area were located west of the wash pad. The location of the 80th DRS is presented on **Figure 1-1**.

1.2.3 Previous Investigations

A summary of previous investigations and studies conducted at this site is provided below.

Final Site Assessment Report,
Montgomery-Watson, May 1994

Montgomery Watson conducted an investigation from February to May 1994 to evaluate the presence of possible soil contamination in the LARC staging area of the site and around the existing concrete pad. Elevated levels of total petroleum hydrocarbons (TPH) – heavy oils and lead were detected in the shallow soils adjacent to the former drum storage area, tank area, and wash pad area. Based on the limited vertical extent of contaminated soil, excavation of soil and off-site treatment and disposal was feasible.

Site Characterization Report,
Environmental Restoration Company (ERC), June 1994

ERC conducted a site characterization of the site in 1994. Based on the site characterization, two areas of soil contamination and one area of groundwater contamination were identified at the site. TPH and lead contamination was discovered in the shallow soil of the LARC staging area. These contaminants are most likely the result of bilge water discharge and sandblasting. TCE and PCE were detected in monitoring well MW-4.

Removal Action Final Report,
IT Corporation, August 1995.

From April through July 1995, IT Corporation completed a removal action of contaminated soil from the LARC staging area and from the tank area. Approximately 3,500 tons of TPH-contaminated soils (from Area A) and 30 tons of PCE-contaminated soil (from Area B) were excavated from the site and transported off-site for thermal desorption. Significant quantities of contaminated soils remain in both areas. The areas were backfilled with clean fill. The removal areas are presented on **Figure 2-1**.

1.3 REPORT ORGANIZATION

A summary of the organizational format of the RI report is provided as follows:

Volume I

- **Section 1.0** addresses the **Introduction** to the report, provides background information including site descriptions and history and provides a discussion of previous investigations and provides the report organization.

- **Section 2.0** summarizes the **Field Investigation Procedures** at the three sites including a discussion of soil boring and monitoring well installations, direct push technology (DPT) sampling of soil and groundwater, environmental sampling, site surveying, tidal influence testing, and on-site analytical services.

- **Section 3.0** describes the **Physical Characteristics** of Fort Story and each site including geology/hydrogeology, climatology, ecology, and topography.

- **Section 4.0** discusses the **Nature and Extent of Contamination** detected at each site. A discussion of potential applicable or relevant and appropriate requirements (ARARs) is also provided.

- **Section 5.0** discusses the **Fate and Transport** mechanisms for contaminants at each site. Potential routes of transport, contaminant persistence and contaminant migration are discussed.

- **Section 6.0** presents the methodologies and results of the **Human Health Risk Assessment.**

- **Section 7.0** presents the methodologies and results of the **Ecological Risk Assessment.**

- **Section 8.0** presents the **Summary and Conclusions** of the investigation including the nature and extent of contamination and the assessment of human health and environmental risk.

- **Section 9.0** presents the **Recommendations** for each site.

Volume II

Appendices are provided with this report and include the following:

- Appendix A – References
- Appendix B - Sampling Forms
- Appendix C - Boring and Well Data
- Appendix D - Background Soils Data
- Appendix E – Human Health Risk Calculations
- Appendix F – Toxicity Profiles: Human Health Risk Assessment
- Appendix G – Toxicity Profiles: Ecological Risk Assessment
- Appendix H – Wildlife Species of the Fort Story/Cape Henry Region
- Appendix I – Ecological Risk Assessment Exposure Calculations

This section documents specific field investigation program for the Remedial Investigation (RI) at the 80th Division Reserve Site (80th DRS) at Fort Story. The initial field investigation which including monitoring well installations and sampling and soil sampling was conducted in December 2002 and January 2003. A second groundwater sampling event including the installation of two additional monitoring wells was conducted in June 2004 to further assess the nature and extent of groundwater contamination.

Field investigation procedures, sampling locations, analytical requirements, field documentation requirements, data quality objectives, and health and safety procedures were presented in the following Virginia Department of Environmental Quality (VDEQ) approved documents:

- *Final Work Plan,* Remedial Investigation. 80th DRS, Fort Story, Virginia, (Malcolm Pirnie, 2002a).
- *Final Generic Quality Assurance Project Plan (QAPP),* Fort Eustis, Virginia, (Malcolm Pirnie, 2002b).
- *Final Site Safety and Health Plan, Remedial Investigation for Fort Story, Virginia* (SSHP), (Malcolm Pirnie, 1994).

An overview of the field program including data gaps and needs is presented in Section 2.1, detailed field investigation procedures are described in Section 2.2, a summary of field investigations performed at each site is provided in Section 2.3, and a summary of changes to the field investigation program and rationale is provided in Section 2.4.

2.1 FIELD INVESTIGATION OVERVIEW

To better define data gaps and establish a comprehensive field investigation approach, an assessment of the existing database as it relates to the nature and extent of contamination and support of the risk assessment was necessary. The identification of data needs based on the uses and decisions we made were critical in establishing the field investigation approach for the project. These data needs focused on the following:

- Evaluating site physical characteristics such as topography, geology, and hydrogeology
- Determining the nature and extent of petroleum impacts to groundwater contamination
- Determining the presence/absence of trace levels of chlorinated organics in site groundwater
- Verifying the concentration of trace metals in site soils

The field investigation program was developed to augment the existing site database by:

- Installation of monitoring wells to supplement the data gathered during previous investigations and to fill necessary data gaps (vertical and lateral extent of groundwater contamination).
- Delineation of the existing groundwater plume by installation of additional monitoring wells and sampling of new and existing monitoring wells primarily to further characterize the nature and extent of groundwater contamination associated with the site and for use in assessing risk.
- Verification of the presence of chlorinated hydrocarbons in groundwater in the vicinity of monitoring well MW-4 (through monitoring well installation and sampling).
- Measurement of groundwater levels during the investigation to provide a database for establishing the ground water contours.
- Collection of surface soil samples throughout the site to assess the nature of contamination and for use in assessing risk.
- Collection of subsurface samples will be collected throughout the site to assess the nature of contamination and for use in assessing risk.
- Containment of investigation-derived waste (IDW) in DOT steel drums, staged at a temporary storage location, and sampled by Malcolm Pirnie.
- Surveying of the monitoring wells using horizontal and vertical control for accurate location.

2.2 FIELD INVESTIGATION PROCEDURES

2.2.1 Soil Sampling

Thirty soil samples from 10 locations were collected using a split spoon sampler from a drill rig at depths of 0 to 6 inches below land surface (BLS), 1 to 3 feet BLS, and 4 to 6 feet BLS throughout the site to assess the nature of contamination and for use in the subsequent risk assessment. Fifteen of the soil samples were collected from the locations of the five newly installed monitoring wells (MW-7, MW-8, MW-9, MW-10, and MW-11). Nine samples from three borings (SB-3, SB-4, and SB-5) were collected from locations surrounding the area that was removed due to PCE contamination (Area B) as identified in the IT Final Report. In addition, three soil samples were collected from a soil boring (SB-2) south of the former wash pad and another three soil samples were collected from a boring (SB-1) east

of the former wash pad. The locations of the soil samples are presented on **Figure 2-1**.

Aliquots for TCL volatile organic compounds (VOCs) analysis were taken directly from the split spoon sampler, packed tightly into EnCore® samplers, and immediately stored on-ice to cool to 4°C. With the exception of VOC samples, soil samples were homogenized by first removing rocks, twigs, leaves and other debris. The soil was then removed from the split spoon, placed in a decontaminated stainless steel bowl, and thoroughly mixed using a stainless steel spoon. The samples were collected in the following order: TCL VOCs, TCL semivolatile organics (SVOCs), TCL pesticides/PCBs, total organic carbon (TOC), and TAL metals. After mixing, a portion of the sample was placed in each sample container. The sample containers were then labeled, added to the chain-of-custody and stored at 4°C for shipping to the laboratory. Sampling forms for all sampling tasks are provided in **Appendix B**.

2.2.2 Monitoring Well Installation and Sampling

Monitoring Well Installation

Monitoring wells were installed using 4 1/4-inch inside diameter (I.D.) hollow stem augers. The augers were advanced either by a truck-mounted or all-terrain vehicle (ATV) drilling rig depending upon the ground surface conditions. Each monitoring well was constructed in accordance with the RCRA Groundwater Monitoring Technical Enforcement Guidance Document (TEGD).

Each monitoring well was installed through the hollow stem augers and was constructed of 2-inch I.D., flush-threaded PVC well screen and riser. A 10-foot screen was used for the monitoring wells. The well screen was constructed of 0.010-inch slot size to minimize the intrusion of finer materials. Morie Number 1 Filter Sand was placed in the annulus around the well screen as the sandpack to provide a filter zone. The sandpack was placed 2 feet above the top of the well screen. A minimum of 1 foot of bentonite seal was then placed above the sandpack while the remainder of the annular space was cement grouted to the surface. Each well was finished as either a flush-mounted or stickup-type well and constructed with a protective manhole. Well construction data (boring and well construction logs) for each well are provided in **Appendix C**.

A more detailed discussion of the installation procedures is provided as follows:

1. The hollow stem auger was slowly advanced to the desired depth.

2. The screen and riser pipe were assembled and lowered within the hollow stem augers. The well was suspended several inches off the bottom of the boring to ensure that the casing was not bowed during installation.

3. After the screen and riser pipes were in place, a sandpack was placed in the annular space to 2 feet above the top of the screen. As the sandpack was being poured into the annual space, the drilling augers in the hole were simultaneously withdrawn, to prevent the sandpack from becoming jammed (bridged) between the well casing and drilling tools.

4. A 2-foot thick bentonite seal was placed above the top of the screen (on top of the sandpack) to maintain a discrete sampling interval. It was important to seal the annulus to prevent water flow along a higher permeability zone in this space. This flow could alter the measured contamination.

5. A bentonite/cement seal was placed on top of the bentonite seal and extended to within about 12 inches of the ground surface.

6. For the stickup wells (MW-7, MW-9, MW-10, and MW-11), an outer steel protective casing (6-inch diameter) was placed over the stickup and anchored with a 3-foot square concrete pad. For the flush-mounted well (MW-8), the riser pipe was cutoff approximately 6 inches below ground surface and a steel manhole box and concrete pad was used.

Monitoring Well Development

All existing and new monitoring wells were developed as part of the field investigation. Well development included the overpumping and backwashing method. Overpumping was accomplished by using a submersible pump. Surging was accomplished by using a surge block and backwashing by airlift technologies. These methods of development consisted of alternately pumping the well at a high rate to draw the water level down and then "backwashing," reversing the flow direction so that water is passing from the well into the formation. This back and forth movement of water through the well screen and gravel pack served to remove fines from the formation while preventing bridging (wedging) of sand grains. Backwashing was accomplished by starting and stopping the equipment intermittently to cause the water level to fluctuate. Wells were considered developed when turbidity, pH, specific conductance and temperature stabilized for a minimum of three readings and all were within 10 percent of the previous two readings. Well development logs are provided in **Appendix C**.

Monitoring Well Sampling

Following monitoring well installation and development, groundwater samples were collected from monitoring wells for off-site laboratory analysis. Sampling of groundwater at each well location began no sooner than 14 days following well development.

Purging and sampling of the monitoring wells was conducted using a low-flow submersible pump. Groundwater monitoring wells were purged of three to five well volumes prior to sampling. Water levels were measured prior to purging and sample collection using an electronic water level probe.

Sampling of groundwater at each well location began no sooner than 14 days following well development.

A more detailed discussion of the groundwater sampling methodology utilized at the 80th DRS is provided as follows:

- A piece of polyethylene sheeting was fitted over the monitoring well and laid on the ground. The sampling equipment was placed on the polyethylene sheeting. The well cap was then removed for sampling.

- Sampling began by obtaining a static groundwater level measurement reading, which was achieved using a portable water level indicator.

- The water volume in the boring was calculated using the following equations:

  where:

  $V_1 = \pi(D_1/2)^2 H_1$
  $V_2 = N\pi H_2(D_3/2)^2 - (D_2/2)^2$
  $V_1 + V_2$ = Volume of Water

  V1 = volume of water in well casing (ft3)
  V2 = volume of water in filter pack (ft3)
  H1 = height of water column (ft.)
  H2 = length of filter pack or the height of the water column in water table wells (ft)
  N = porosity of filter pack
  D1 = casing internal diameter (ft.)
  D2 = casing outside diameter (ft.)
  D3 = diameter of borehole (ft.).

- Each well was purged of three to five well volumes (or more if required for stabilization of field parameters) prior to collecting groundwater samples. Stabilization of field parameters during purging is defined as less than 10 percent change in value over two successive measurements for turbidity, pH, temperature, and conductivity. The volume of standing water in the borehole was calculated using the pre-purge water level, total depth of the well and a known constant for the number of gallons of water per foot of well diameter. Water purged from the well before sampling was containerized in DOT-approved 55-gallon steel drums.

- After purging, groundwater samples were collected when the water level in the well recovered to a minimum of 75 percent of the pre-purge level or after 2 hours, whichever came first.

Field pH, conductivity, dissolved oxygen, temperature, and turbidity were measured for each well volume during purging in order to obtain a representative sample from the aquifer. When field parameters reached equilibrium as discussed above, samples were collected.

- The submersible pump was then utilized to pump the groundwater from the wells into the appropriate sample containers with VOCs collected first followed by the SVOCs, pesticides/PCBs, total metals, total suspended solids (TSS), and total dissolved solids (TDS). Following collection of the organics and total inorganic samples, the groundwater was filtered through an in-line 45-micron filter for the dissolved metals analysis.

- After collection and transfer to the appropriate sample container, the samples were then secured in a cooler at 4°C and made ready for shipment to the laboratory.

Each well was purged of at least three to five well volumes prior to collecting groundwater samples. The volume of standing water in the borehole was calculated using the pre-purge water level, total depth of the well and a constant for the number of gallons of water per foot of well diameter.

Water Level Measurements

Water levels were measured for all existing and newly constructed monitoring wells. Water levels were measured with a Solinst electronic water level indicator. The following procedures were used:

- Equipment operation and accuracy was checked and documented prior to taking measurements
- All pertinent well data was recorded
- The water level was recorded to nearest 0.05 foot
- Weather at time and date of measurement were recorded

Tidal influence tests were conducted at the 80th DRS through the measurement of water levels in all site wells during 3 events, one during high tide, one during low tide, and one during the transitional period between high and low tide. The purpose of these tests was to assess if there is any influence on the shallow water table aquifer due to the daily tides of the proximate Chesapeake Bay and Atlantic Ocean. Little variation in the water levels was noted during this tidal period. Groundwater flow direction remained constant. Water level data for each well is provided in **Appendix C**.

2.2.3 Equipment Decontamination

Procedures

All non-dedicated sampling equipment and boring materials were cleaned prior to being used and/or reused. All drilling equipment was steam cleaned in a predesignated location prior to use and

between locations. All soil and groundwater sampling equipment (i.e., stainless steel scoops and bowls, submersible pump, and split spoons) were decontaminated prior to use and between sampling locations using the following procedure:

- Wash and scrub with low phosphate, laboratory-grade detergent
- Rinse with tap water
- Rinse with methanol
- Rinse with deionized demonstrated analyte free water
- Rinse with tap water
- Rinse with dilute nitric acid if sampling for metals
- Rinse with deionized demonstrated analyte free water
- Air dry

Field instrumentation was cleaned as per manufacturer's instructions. Probes such as those used in pH and conductivity meters were rinsed prior to and after each use with deionized water.

Decontamination Solutions

- Detergent Wash - Alconox was used as the low phosphate, laboratory-grade detergent for the field investigation at the three sites at Fort Story.

- Solvent/Acid Rinses - Several different decontamination solutions were used during the RI field investigation. Pesticide-grade methanol and 0.1N nitric acid was used for the decontamination activities for the investigation.

- Rinse Water - Tap water from Fort Story was used for initial rinses during the decontamination procedure while deionized water was used as the final rinse water.

2.2.4 Investigation-Derived Waste Management

Drill cuttings generated during monitoring well installation were containerized in U.S. Department of Transportation (DOT) approved, 55-gallon steel drums with the contents identified and date of collection placed on drum exteriors. Groundwater from monitoring wells during purging, development and sampling activities was collected in DOT 55-gallon steel drums with the contents identified and date of collection placed on drum exteriors.

Malcolm Pirnie maintained a log of the drums and drum contents. The results of the analytical data obtained from the drums were submitted to Fort Eustis personnel for proper disposition. The data indicated that the containerized soil cuttings and purge water from the site was not classified as a hazardous waste. All results were less than TCLP limits.

2.2.5 Site Surveying

A site survey was completed using horizontal and vertical control to accurately locate monitoring wells at the site. Malcolm Pirnie subcontracted all surveying required for the project site to PHR+A, a professional land surveyor licensed in the Commonwealth of Virginia. The vertical and horizontal survey data for each well is presented in Table 3-4.

Vertical control of all monitoring wells installed during this field investigation was established using differential and trigonometric leveling to the nearest 0.01 foot. The elevations are referenced to the National Geodetic Vertical Datum of 1988 (NGVD). Horizontal locations are referenced to the Virginia State Plan Coordinate System.

2.2.6 Laboratory Analysis

Environmental media samples were submitted to CompuChem Laboratories for analysis. Samples were analyzed for a wide variety of chemical compounds. **Table 2-1** provides a summary of the compounds analyzed and the test methods used. Laboratory analytical reports are included in the *Quality Control Summary Report/Analytical Results Report (QCSR/ARR),* 80th DRS, Fort Story, Virginia submitted as a companion document to this RI Report. Method reporting levels for all compounds discussed in this report can also be found in the *QCSR/ARR.*

Data validation of analytical results utilizing EPA Region III IM-1 and M-2 procedures was performed by URS Corporation (subcontractor to Malcolm Pirnie). The results of the detailed validation are provided in the *QCSR/ARR.*

2.3 SITE-SPECIFIC FIELD INVESTIGATION

The potential impacted area at the site includes the area adjacent former UST and AST located adjacent to the wash pad and other downgradient locations. **Figure 2-1** provides the sampling locations for this site including the existing and new monitoring wells. **Table 2-2** summarizes our field investigations for this site.

During the initial 2002/2003 sampling event, all soil samples were analyzed for TCL VOCs, TCL SVOCs, TCL pesticides/PCBs, TAL metals, and TOC while all groundwater samples collected from monitoring wells were analyzed for TCL VOCs, TCL SVOCs, TCL pesticides/PCBs, total and dissolved TAL metals, TSS, and TDS. The additional June 2004 groundwater monitoring event included the analysis of groundwater samples for VOCs only.

The soil and groundwater samples were distributed throughout the site including upgradient, on-site and downgradient, and soil was collected at three distinct subsurface soil sampling depths. A summary of field activities by media is provided below:

Soil

- Ten soil borings were utilized to collect samples from 3 depths (0 to 6 inches, 1 to 3 feet, and 4 to 6 feet) to assess the vertical and lateral extent of contamination in surface and subsurface soils within the unsaturated zone.

Groundwater

January 2003 Sampling Event

- Five monitoring wells were installed and developed as part of this field investigation to supplement the data gathered from five existing monitoring wells. Former monitoring well MW-4 could not be located.

- Groundwater samples were collected from five existing and five new monitoring wells. Existing monitoring wells were redeveloped prior to sampling.

June 2004 Sampling Event

- Two additional monitoring wells (MW-12 and MW-13) were installed and developed as part of this field investigation to supplement the data gathered from the initial sampling event.

- Groundwater samples were collected from 10 existing wells and 1 new monitoring well.

2.4 FIELD INVESTIGATION CHANGES

The only change to the planned activities as described in the *Final Work Plan* was the installation of the additional monitoring wells (MW-12 and MW-13) and the second groundwater monitoring event.

Section 3.1 discusses the physical characteristics for Fort Story including data on topography, climate, hydrology, geology/hydrogeology, and ecology. Detailed descriptions of the site are provided in Section 3.2 for the 80th Division Reserve Site (80th DRS).

3.1 FORT STORY PHYSICAL CHARACTERISTICS

This section provides a summary of the physical characteristics of Fort Story including topography, climate, surface water hydrology, geology, hydrogeology and ecology.

3.1.1 Topography

Land features encountered at Fort Story consist of linear sand ridges, sand flats and wetland areas. The topography is dominated by a series of prominent linear, well-drained sand ridges that roughly bisect the Fort Story area. The central ridges trend parallel to the coastline and are characterized by maximum elevations in excess of 85 feet, National Geodetic Vertical Datum (NGVD) of 1929. A second series of sand ridges located on Fort Story are comprised of an active dune complex located adjacent to the coastline. The coastal sand ridges attain maximum elevation in excess of 25 feet NGVD. Broad, poorly drained sand flats are located adjacent to the sand ridge areas. Land surface elevations in the sand flat areas typically range between 5 and 10 feet, NGVD. Wetland areas, which are common features of the sand flats, occur locally in closed depressions. South of the central sand ridges, the Fort Story topography consists of an extensive wooded, wetland area, formerly a back-bay, lagoonal feature. Most of the installation's facilities and operations are confined to the sand ridge and sand flat areas.

3.1.2 Climate

Historical climatological data for the Fort Story area is recorded at the Norfolk-Virginia Beach Airport, and is available from the National Atmospheric and Oceanic Administration (NOAA) through the National Climatic Data Center. The Norfolk-Virginia Beach Airport is located approximately 8 miles west of Fort Story. **Table 3-1** summarizes average precipitation and temperature for the Fort Story area from 1941 to 1970.

Mild winters and hot summers characterize the climate at Fort Story. Temperatures are affected by air flowing through the area from the Atlantic Ocean. Average relative humidity is high in the area, with an afternoon average humidity of approximately 60 percent, which rises in the nighttime to 80 percent. In winter, the average temperature is 41°F, with the lowest temperature recorded of 5°F for the period of record. The average summer temperature is 76°F with a highest recorded temperature of 104°F. The greatest percentage of precipitation occurs between April and September, which encompasses most of the growing season. The maximum amount of rainfall recorded in the area was 9.95 inches in a one-day period.

3.1.3 Surface Water Hydrology

Surface water on Fort Story is conveyed by drainage ditches or storm water lines to the Chesapeake Bay on the northwestern portion of the facility, to the Atlantic Ocean on the northeast portion of the base or to wetland areas adjacent to Broad Bay on the southern portions of the facility. There are no major streams located on Fort Story. Several small ponds are located on Fort Story. Surface water transport is through the many small drainage ditches. Surface water on the southern portion of Fort Story flows into wetland and marshy areas with eventual flow across Route 60 and into Broad Bay south of the facility.

3.1.4 Geology

The geology of the eastern Coastal Plain and sedimentary characteristics in the Fort Story area has been described in a number of reports including Oaks and Coch (1973); Teifke (1973); and Onuschak (1973). Recent geologic studies of the eastern Coastal Plain re-defined the sedimentary units (formations names). These publications include the following: Ward and Blackwelder (1980); Johnson and Peebles (1984); Johnson and Ramsey (1987); Johnson et al., (1987); Laczniak and Meng (1988); Meng and Harsh (1988); and Mixon, et al., (1989). The formation names used for post Yorktown sediments (Windsor and Norfolk Formation) in Johnson (1972) have been revised in subsequent investigations. The more current formation names, which are described in the references listed above, have been used in this report.

Fort Story is located on Cape Henry within the eastern Coastal Plain of Virginia which is characterized by a series of gently sloping, highly dissected terraces bound by seaward-facing, ocean-cut escarpments. The escarpments (scarps) were formed by shoreline erosion during ancient sea level stands. The terraces (plains) are an emergent landform representing stream, estuarine, bay, and marsh deposits (Johnson and others, 1987). The scarp and terrace topography dominates the eastern Coastal Plain except along Cape Henry where recent sand ridges have formed over the older deposits. These recent dune deposits form a series of convex sand ridges with crests ranging in elevation from 20 to 85 feet above Mean Sea Level (MSL) (Oaks and Coch, 1973).

Coastal Plain sediments overlie crystalline rock and form an eastward thickening wedge of predominately unlithified marine, estuarine and riverine deposits. The sediments range in age from Cretaceous to Holocene (recent time). The sediments predominately form layers of unlithified gravel, sand, silt, and clay with variable amounts of shells. Although layers of hard rock are absent, cemented calcareous deposits can form local lithified strata.

Coastal Plain sediments range in thickness from nearly zero along an ancient ocean strandline in the vicinity of Richmond, Virginia to as much as 6,186 feet beneath the Eastern Shore Peninsula at Temperanceville, Virginia (Meng and Harsh, 1988). In the vicinity of Fort Story, the reported thickness of sediments ranged from 2,600 feet in Norfolk (Teifke, 1973) to approximately 3,500 feet

in Virginia Beach (Meng and Harsh, 1988). The uppermost surficial sediments that are significant to this study are approximately 420 feet thick in the vicinity of Fort Story (Meng and Harsh, 1988). These units include the following sedimentary units:

- Columbia Group - roughly the uppermost sediments (comprises the water table aquifer) that ranges from 40 to 60 feet thick.

- Yorktown Confining Unit - silty clay to clay unit that forms a confining unit between the water table aquifer and the underlying Yorktown-Eastover Aquifer and ranges from 40 to 50 feet thick.

- Yorktown-Eastover Formations - a potable use aquifer, the top of the aquifer occurs at approximately 100 to 142 feet below MSL (Meng and Harsh, 1988)

The upper 40 to 60 feet of surficial sediments belong to the Columbia Group. Although the Columbia Group includes the Holocene age Kennon Formation and the Pleistocene age sediments of the Windsor, Charles City, Chuckatuck, Shirley, and Tabb Formations; only the Kennon and Tabb Formations occur at Fort Story. Underlying the surficial sediments of the Columbia Group are the semi-confining unit and water bearing sediments of the Yorktown Formation. Since the physical and chemical characteristics of these sediments affect the potential for and rate of migration of fluids, these sediments are described in more detail on the following pages.

Columbia Group

The surficial sediments of the Columbia Group are eolian, estuarine and riverine sediments of Holocene (Kennon Formation) and Pleistocene (Tabb Formation) age.

Kennon Formation

Sediments comprising the Kennon Formation include contiguous marine, estuarine, paludal, fluvial and eolian sedimentary deposits along and in streams (tidal and unidirectional), bays and near shore marine environments. Sediments deposited in these environments can contain highly organic deposits that impact the geochemical and hydraulic behavior of fluids. The deposits of this formation vary greatly in thickness, mineral composition and fossil content but intergrade with one another and disconformably overlie Pleistocene deposits (Johnson et al., 1987 and Johnson and Ramsey, 1987). The Kennon Formation is described as light orange brown quartz sand to silty sand. It is unbedded and has an indistinct lower boundary (Johnson and Ramsey, 1987). The indistinct lower boundary can make it indistinguishable from the underlying Tabb Formation in the Fort Story area.

Tabb Formation

Sediments comprising the Tabb Formation are predominately found east of the Suffolk and Harpersville Scarps; thus the formations occur east of Newport News, in Hampton, Poquoson, eastern York County, Norfolk and in Virginia Beach. These sediments were deposited under fluvial and estuarine conditions in the Late Pleistocene. The Tabb Formation has been divided into three members; the Poquoson Member, Lynnhaven Member, and Sedgefield Member. Based on the sedimentary descriptions from on-site borehole data, the sediments will not be differentiated by members in this report.

All three members contain a basal deposit of coarse pebbly sand with rare occurrence of cobbles and boulders, which fine upwards to cross-bedded sands, silts, and clayey sands. The cross-bedded sands are commonly capped by a clay to silty clay unit. The clayey-silt layers have been reported to contain as much as 20 percent quartz, 5 to 20 percent feldspar, 0 to 20 percent vermiculite, 0 to 20 percent kaolinite or chlorite, and 0 to 20 percent Illite or Muscovite (Oaks and Coch, 1973). Along the Suffolk and Harpersville Scarps (east of Hampton) the unit is very thin but thickens eastward to more than 50 feet in paleochannels in the vicinity of Fort Story. The paleochannels are recognized by a basal pebbly to cobblely sand grading upward into a crossbedded fine to coarse sand with organic-rich silty clay and peat. Tree stumps in living position and other plant remains are associated with the organic-rich clays.

Background soil samples were collected during the PA/SI from three soil borings, one near the eastern perimeter of Fort Story, one adjacent to the western boundary, and one in the north-central perimeter of Fort Story. Two samples were collected from each boring and analyzed for pesticides/PCBs, volatile organics, semivolatile organics, total metals, and EP toxicity metals. Of the parameters analyzed, only five metals (chromium, copper, zinc, arsenic, and lead) were detected. An upper 95 percent confidence limit value was calculated for each. A summary of the background soils analysis is provided as follows:

PARAMETER	BACKGROUND 95% UCL (mg/kg)
Arsenic	2.1
Barium	Not Detected
Cadmium	Not Detected
Chromium	2.8
Copper	1.4
Lead	7.1
Mercury	Not Detected
Nickel	Not Detected
Zinc	5.7

Chesapeake Group

Yorktown Formation

Although no boreholes penetrated the Yorktown Formation, the formation is described in detail due to its significance as a confining unit (Morgarts Beach Member) overlying a potable aquifer comprised in part by sediments of the Yorktown Formation. The Rushmere and Sunken Meadow Members along with The Cobham Bay Member of the Eastover Formation form the Yorktown-Eastover Aquifer.

The current definition of the Yorktown Formation is described in the USGS Bulletin 1482-D, Stratigraphic Revision of Upper Miocene and Lower Pliocene Beds of the Chesapeake Group, Middle Atlantic Coastal Plain (Ward and Blackwelder, 1980). The Yorktown Formation consists of shallow marine deposits of Pliocene age which unconformably overlie Late Miocene sediments of the Eastover Formation. Based on lithologic and faunal assemblage changes, the Yorktown Formation has been subdivided into four members:

- Moore House Member - an upper sandy shell hash
- Morgarts Beach Member - a very fine-grained sandy clay unit (forms a confining unit)
- Rushmere Member - a shelly fine-grained sand unit
- Sunken Meadow Member - a basal, pebbly coarse-grained sand unit

The uppermost unit of the Yorktown, the Moore House Member, typically consists of quartz sand shell beds, cross-bedded shell hash and bioclastic sands. The sediments range from an orange, fragmental shell hash, with some fine quartz sand and bryozoan and mollusc fragments to a tan, clayey, phosphatic, glauconitic, poorly-sorted, sand, with abundant molluscs (Crepidula, oysters, and pectens), foraminifers, and ostracodes. In some areas the shell hash is moderately cemented, such as along the bluffs of the York River near Yorktown, Virginia. Areal extent of this member is more restricted than the other members, and is confined to an area east of the Suffolk Scarp, extending to the west as far as Williamsburg, Virginia, extending as far north as the southern third of Gloucester County, Virginia, and as far south as the northern third of Currituck County, North Carolina. From this point, the Moore House sediments tend to thicken to the east and northeast. Maximum thickness of this member is approximately 18 feet. The Moore House Member conformably overlies the Morgarts Beach Member with a sharp contact that can be gradational in some localities (Ward and Blackwelder, 1980).

The Morgarts Beach Member consists of gray (unweathered) or tan (weathered), very fine-grained, sandy to silty clay with a few silty, very fine sand beds. Abundant mollusks (Mulinia) occur; however, mollusks are less abundant than in the underlying Rushmere and Sunken Meadow Members. The Morgarts Beach Member is distinguishable by its fine, clayey lithology and abundance of small molluscs (Mulinia congesta). This Member of the Yorktown Formation represents the confining layer for the Yorktown Aquifer. The Morgarts Beach Member conformably overlies the Rushmere Member

and the contact is sharp but can be gradational in some localities (Ward and Blackwelder, 1980). The Rushmere Member is blue-gray, fine, well-sorted, shelly sand. It commonly contains phosphatic and glauconitic sands in amounts of less then 10 percent. The unit can contain some medium-grained well-rounded quartz sands. The Rushmere Member is distinguished from the overlying Morgarts Beach Member based on the higher content of sand and mollusks. The basal contact with the Sunken Meadow Member is sharp and may have some coarse sand and pebbles at the contact (Ward and Blackwelder, 1980).

The Sunken Meadow Member is described as a coarse to medium, poorly sorted sand with abundant shells. In the vicinity of Fort Story, the basal contact with the Eastover Formation typically is recognized by the occurrence of a glauconitic and phosphatic fine sand with abundant shells. The Rushmere and Sunken Meadow Members, along with the Cobham Bay Member of the Eastover Formation, comprise the Yorktown Aquifer (Ward and Blackwelder, 1980).

3.1.5 Hydrogeology

The Virginia Coastal Plain sediments underlying Fort Story are comprised of interlayered gravel, sand, silt, and clay with varying amounts of shells. The permeable and non-permeable sedimentary units were delineated into a hydrogeologic system of eight aquifers and eight intervening confining units by Meng and Harsh (1988). A description of the sedimentary sequence is presented in Section 3.1.4. This discussion of the regional hydrogeology focuses on the hydrogeology of the eastern portion of the Virginia Coastal Plain in the vicinity of Fort Story.

Sources of current hydrogeologic information for the eastern Coastal Plain include Siudyla (1981), Laczniak and Meng (1988); and Meng and Harsh (1988). Based on well data from the Virginia Coastal Plain, Meng and Harsh (1988) delineated the hydrogeologic framework for the Virginia Coastal Plain. In the Fort Story area, Meng and Harsh (1988) delineated four aquifer units separated by intervening confining units. One of these aquifers (the Yorktown-Eastover) consists of three major water-bearing sand units (roughly 5 to 20 feet thick each) which are referred to as the Upper, Middle, and Lower Yorktown Aquifer. Each of the water-bearing sand units is separated by intervening confining units. In order of increasing age and depth from ground surface, these aquifers include:

- The Columbia Aquifer - This is the water table aquifer and is comprised of Holocene age sediments (Kennon Formation) and Pleistocene age sediments (Tabb Formation). Thickness is approximately 40 to 60 feet in the Fort Story area (Meng and Harsh, 1988).

- The Yorktown-Eastover Aquifer - This aquifer occurs within the water bearing strata of the Yorktown and Eastover Formations of Pliocene and Miocene age, respectively. The Yorktown - Eastover Aquifer is divided into three water bearing units (Upper, Middle, and Lower Yorktown) and intervening confining units. The aquifer attains a thickness of 240 feet in the vicinity of Fort Story; however, it generally ranges from 100 to 200 feet thick.

- The Chickahominy-Piney Point Aquifer - This aquifer occurs within the Old Church Formation of Oligocene Age, where present, and the Chickahominy and Piney Point Formations of Eocene Age. The aquifer ranges in thickness from 50 to 100 feet throughout the Virginia Coastal Plain.

- The Upper, Middle, and Lower Potomac Aquifers - These aquifers occur within the Potomac Group of Early Cretaceous age. In Virginia, the sediments of these aquifers have not been studied extensively; however, based on the known well data these aquifers can attain thicknesses of over 100, 900, and 3,000 feet respectively.

The Columbia, Yorktown-Eastover, and Chickahominy-Piney Point aquifers and intervening confining units are approximately 858 feet thick and comprise approximately the upper 28 percent of the total thickness of approximately 3,500 feet of coastal plain sediments in the Fort Story area. The remaining sediment thickness (approximately 2300 feet), in turn, consists of the Nanjemoy-Marlboro confining unit which overlies the Upper, Middle and Lower Potomac aquifers. The Upper, Middle, and Lower Potomac aquifers are separated by intervening confining units that comprise the Potomac Group of Cretaceous age. In consideration of the nature and distribution of the compounds of concern, the hydraulic characteristics of the sediments and thickness (40 to 50 feet) of the Yorktown confining unit; the following discussion of the conditions of the hydrogeologic units will be restricted to the Columbia Aquifer, the Upper Yorktown Aquifer and intervening confining unit. These hydrogeologic units are comprised by roughly the upper 150 feet of sediments that does not include the water bearing units of the middle and lower water bearing strata of the Yorktown-Eastover aquifer.

Columbia Aquifer

Based on studies of the Virginia Coastal Plain which incorporated the general area of Fort Story (Meng and Harsh, 1988; Siudyla, 1981; Teifke, 1973; Oaks and Coch, 1973) and boreholes drilled at Fort Story, the thickness of the Columbia Aquifer in the Fort Story area is approximately 40 to 60 feet. It is separated from the underlying Yorktown-Eastover Aquifer by the Yorktown confining unit, which is roughly 40 to 50 feet thick. The Columbia aquifer is mostly unconfined; however, clayey sediments can produce locally confined or semi-confined conditions. No confined or semi-confined conditions have been delineated by subsurface investigations at Fort Story. The Columbia Aquifer occurs approximately 6 to 8 feet below land surface (BLS) and extends approximately to a depth of 40 to 60 feet BLS in the area of Fort Story.

The Columbia Aquifer is comprised of a sequence of several geologic formations deposited during marine transgressions; thus, each formation exhibits a coarse-grained basal deposit which grades upward to fine-grained sediments. The Columbia Aquifer is predominately sand with interbedded coarse gravel lag deposits which grade upward into silts and clays. Previous subsurface investigations at Fort Story included slug tests on 28 wells. Based on these aquifer tests, the

estimated average hydraulic conductivity was 8.21 x 10^{-3} centimeters per second (cm/sec). Based on studies of the Columbia Aquifer, reported transmissivity values range from 300 to 8,000 square feet per day (ft^2/day) and specific capacity values range from 1.7 to 35 gallons per minute per foot (gpm/ft) in the vicinity of Fort Story (Hamilton and Larson, 1988).

Based on records of water levels of wells located in northern Virginia Beach, the potentiometric surface of the Columbia Aquifer has fluctuated approximately 1 to 12 feet BLS (Siudyla, 1981). Precipitation is the primary source of recharge to the Columbia Aquifer and averages about 44 inches per year (Siudyla, 1981). In 1981 Siudyla estimated that approximately 30 to 50 percent was available to recharge the aquifer. Although the Virginia Beach area has developed rapidly since Siudyla's 1981 study, there have been only limited construction of paved areas and other impermeable structures at Fort Story so the estimated recharge amount would still be adequate.

Groundwater flow in the Columbia Aquifer moves under the influence of gravity to areas of discharge, such as streams, lakes or other surface water bodies. A portion of the groundwater flows vertically downward through the underlying Yorktown confining unit and is a recharge source for the Upper Yorktown Aquifer (Siudyla, 1981). Siudyla (1981) noted that water levels in wells constructed in the Upper Yorktown Aquifer were approximately 3 feet lower than water levels of wells constructed in the Columbia Aquifer for the same area. Due to the variations within the sediments, which comprise the two aquifers, Siudyla (1981) noted that hydraulic recharge from the Columbia Aquifer through the Yorktown confining unit to the Upper Yorktown Aquifer varied greatly throughout the southeastern Virginia Coastal Plain.

Based on water level measurements obtained from monitoring wells installed for the PA/SI, other studies in the general area, and for the current study, the water table occurs at roughly 4 to 10 feet BLS feet in the Fort Story area. The PA/SI concluded that a local groundwater divide in the vicinity of the central sand ridge complex existed; however, this could not be confirmed based on the available data. In consideration of available data, the PA/SI concluded that the general ambient groundwater flow directions are northward toward the coastline and southward toward the wooded wetland, from the central sand ridge area.

Limited water quality data exists for the Columbia Aquifer because most hydrogeologic studies of the area have focused on the potable use aquifers. Some of water quality data for the water table aquifer as reported by Siudyla (1981) is covered in the following discussion.

Water quality of the water table aquifer is highly variable. Local features can affect the concentration of certain water quality parameters such as chloride. Chloride concentration is generally low except in areas adjacent to tidal waters where the levels ranged from 221 to 450 mg/L. Groundwater of the Columbia Aquifer ranges from hard (121 to 180 mg/L) to moderately hard (61 to 120 mg/L). The most prevalent water quality concern for the water table aquifer is low pH and high iron content. The low pH (acidic) water is very corrosive to metal that may be used for well construction, plumbing or

other industrial uses. Iron content in the Columbia Aquifer commonly exceeds 5 mg/L. At this level, staining can occur when the water comes into contact with air thus initiating precipitation of iron as iron hydroxide. Dissolved solids range from 200 to 300 mg/L.

Due to the variable water quality (e.g., high chlorides, low pH, and high iron content) of the Columbia Aquifer at Fort Story, it is not currently used as a drinking water source. However, there are currently several housing communities located within 1 mile west of Fort Story that are developing shallow drinking water wells in the water table aquifer due to the City of Virginia Beach's restrictions on new hook-ups to their distribution system because of their water shortfall.

Although no background groundwater samples were collected during the PA/SI and RI, several groundwater samples were collected at upgradient locations of the site where no site impacts to groundwater quality were anticipated. A discussion of these wells is provided in Section 3.2.3.

Yorktown Confining Unit

The Morgarts Beach Member of the Yorktown Formation forms the underlying Yorktown semi-confining unit. This unit is comprised of marine silt with occasional interbeds of fine sand and coquina. It is characterized by blue-gray to green-gray clay interbedded with massive silty clay, fine sand, and calcareous shell fragments. The Yorktown confining unit extends from approximately 50 to 60 feet BLS and is estimated to be approximately 40 to 50 feet thick (Meng and Harsh, 1988). Vertical hydraulic conductivity for the Yorktown confining unit has been reported to range from 5.9×10^{-4} to 3.9×10^{-3} ft/day based on laboratory tests (Harsh and Laczniak, 1990). The leakance for the confining unit has been reported to range from 0.00013 to 0.00018 per day (Harsh and Laczniak, 1990).

Upper Yorktown Aquifer

The Yorktown - Eastover Aquifer underlies the Yorktown confining unit and is encountered between the depths of roughly 140 and 200 feet below ground surface. The sediments of the Upper Yorktown Aquifer are comprised of thick, massively-bedded shelly sands (Meng and Harsh, 1988). Groundwater in the Yorktown-Eastover Aquifer generally flows to the east. Within the Upper Yorktown, Siudyla (1981) noted that in some areas the groundwater flow was influenced by local conditions such as topography, streams, lakes, and pumping from the Columbia Aquifer. Siudyla (1981) reported that this was a localized condition which varied with the sedimentary features of the Columbia Aquifer, Yorktown Confining Unit and Upper Yorktown Aquifer. Hydraulic parameters reported for the Upper Yorktown Aquifer include: transmissivity which ranged from approximately 1,200 to 36,000 gallons per day (gpd/day), specific capacity which ranged from 0.8 to 9.5 gpm/ft, and storage coefficient which ranged from 0.0035 to 0.00008 (Siudyla, 1981). The potentiometric surface of the Upper Yorktown Aquifer has fluctuated from approximately 7 to 16 feet BLS (Siudyla, 1981). Local recharge to the Upper Yorktown Aquifer is from vertical flow of groundwater through the

overlying Yorktown Confining Unit from the Columbia Aquifer (Siudyla, 1981). Recharge from precipitation occurs in the western portion of the Coast Plain where past erosion has exposed the Yorktown Formation and the Yorktown Aquifer is unconfined. The exposed portions of the Yorktown Formation are approximately 80 miles west of Fort Story.

Water quality of the Yorktown Aquifer is suitable for potable water use as well as many other uses. Water quality is variable - even within the same well field. Variation of water quality parameters is as follows: hardness ranges from 1 to 1430 mg/L, iron from 0.1 to 48 mg/L, chloride from 6 to 2000 mg/L, and total dissolved solids from 77 to 4110 mg/L. In comparison to the Columbia Aquifer, corrosion and high iron levels are less severe in the Yorktown Aquifer. However, due to the variation with the aquifer, some public supply water systems treat for high iron levels. Brackish water (more than 250 mg/L of chloride) in the Yorktown Aquifer can be a problem in some areas. For example, in the Fort Story area the water-salt water interface of the Yorktown Aquifer occurs approximately along the shoreline of the Atlantic Ocean and Chesapeake Bay and turns inward along tidal estuaries or bays such as the Lynnhaven River, the Elizabeth River, and Back Bay. The water-saltwater interface occurs approximately 100 to 120 feet BLS in inland areas but can be as shallow as 50 to 60 feet BLS in coastal areas. In these areas, the presence of brackish water may affect the chemical behavior of the affected sediments.

3.1.6 Ecology

Flora

Most of Fort Story is covered by the southeastern evergreen forest community. This forest type is the northernmost extension of a vegetation type in which long-needled pines dominate. This forest type extends along the Gulf and Atlantic coastal plains from eastern Texas to the James River. The southeastern evergreen forest south of the James River is characterized by Loblolly Pine (*Pinus taeda*) interspersed with various oaks and other hardwoods. This forest community is a mosaic of plant assemblages controlled largely by soils and drainage patterns. The indicator species of the southeastern evergreen forest was historically Longleaf Pine (*Pinus palustris*). Loblolly Pine now predominates in this area since it rapidly colonizes old fields, out competes Longleaf Pine and has been extensively planted.

Due to fire suppression, many portions of the region are now populated with hardwoods such as White Oak (*Quercus alba*), Southern Red Oak (*Quercus falcata*), Post Oak (*Quercus stellata*), Swamp Chestnut Oak (*Quercus michauxii*), Water Oak (*Quercus nigra*), hickories, gums, maples, and ash. On the heavier alluvial deposits, swamp forests dominate, characterized by Baldcypress (*Taxodium distichum*), Tupelo (*Nyssa aquatica*), Green Ash (*Fraxinus pensylvanica*), Black Gum (*Nyssa sylvatica*), Red Maple (*Acer rubrum*), and Sweet Gum (*Liquidambar styraciflua*).

A portion of Fort Story contains maritime forests which are characterized by Live Oak (*Quercus virginiana*), hollies, Red Bay (*Persea borbonia*), and Loblolly Pine interspersed with dense thickets of Wax Myrtle (*Myrica cerifera*), Eastern Redcedar (*Juniperus virginiana*), Poison Ivy (*Rhus toxicodendron*), Virginia Creeper (*Parthenocissus quinquefolia*), and Greenbrier (*Smilax rotundifolia*). These forests typically contain stunted trees influenced by salt spray from the Atlantic Ocean, though they are somewhat protected by sand dunes.

Fort Story also contains old field communities which are dominated by Broomsedge (*Andropogon virginicus*), Eastern Red cedar, rag weeds, asters and young Loblolly Pine. These fields experience higher thermal extremes, greater diurnal and seasonal fluctuations in temperature, and lower moisture regimes than the forested areas on the facility. However, they are an important component of the natural ecosystem of the facility and support a wide variety of animals.

Fauna

Wildlife found at Fort Story is typical of that found in the Virginia Beach and Seashore State Park area. Common mammal species found at the installation include Muskrat (Ondontra zibethicus), Eastern Cottontail (Sylvilagus floridanus), Raccoon (Procyon lotor), Opossum (Didelphis virginiana), and Squirrel (Scuirus spp.). Some White-tailed Deer (Odocoileus virginianus) may take temporary residence in and around the cypress swamp.

Common species of birds include seagulls (Larus spp.), European Starling (Sturnus vulgaris), Robin (Turdus migratorius), American Crow (Corvus brachyrhynchos), and Blue jay (Cyanocitta cristata).

Typical species of amphibians and reptiles found within the installation include common species of frogs, turtles, and snakes, such as the Green Frog (Hyla cinerea), Eastern Box Turtle (Terrapene carolina carolina), and Copperhead Snake (Agkistrodon contorix contorix). (Horne Engineering and Environmental Services, 1995)

The four freshwater lakes have been stocked and managed through an agreement with the U.S. Fish and Wildlife Service (USFWS). Species stocked include a variety of bass (Micropterus spp.) and sunfish (Lepomis spp.). Fish populations within the lakes are monitored and stocked by the USFWS as needed.

According to the Virginia Department of Conservation and Recreation, Division of Natural Heritage study conducted for Virginia Beach, several threatened and endangered species may occur in the vicinity of Fort Story where suitable habitat exists. These species are the Federal threatened Bald Eagle (Haliaeetus leucocephalus) the Federal threatened Dismal Swamp Shrew (Sorex longirostris fisheri), the State Endangered Chicken Turtle (Deirochelys reticularia), and the State threatened Eastern Glass Lizard (Ophisaurus ventralis).

An ongoing study by Old Dominion University on the Chicken Turtle at Seashore State Park and a portion of Fort Story has recorded no incidence of the turtle on the installation. Occurrences of the other species also need to be confirmed. (Horne Engineering and Environmental Services, 1995)

3.2 80TH DRS PHYSICAL CHARACTERISTICS

This section provides a detailed description of the 80th DRS area. The 80th DRS is located north of DaNang Road and east of Hospital Road. The area contains a 50-foot by 70-foot concrete pad surrounded by asphalt on the west, south, and east sides. The north side is bordered by sand that was used as the DRS staging area. Over time, this staging area apparently became contaminated with by-products (primarily petroleum products) of the washing and maintenance operations. A 1,000 gallon used oil underground storage tank (UST), 250-gallon antifreeze aboveground storage tank (AST), and a former drum storage area were located west of the wash pad.

3.2.1 Topography

The 80th DRS area is at an elevation of approximately 10 feet above mean sea level (amsl) and is generally devoid of topographic features. The asphalt area on the south half of the site is flat. The north half of the site is located in a sandy flat area with low sand ridges.

3.2.2 Surface Hydrology

A summary of the surface hydrology across the site is presented as follows:

- Surface water flow on the wash pad flows northward to the three catch basins located on the northern edge of the wash pad.
- Flow across the other asphalted areas of the site is radial in nature with surface water flowing off of the asphalt and onto the ground surface.
- Minimal lateral flow movement downgradient of the asphalted areas exists because of the presence of large sandy areas that allow significant infiltration rather than surface flow.
- No drainage ditches or streams were present in the site area.

3.2.3 Geology/Hydrogeology

Geology and hydrogeology data were obtained through current drilling activities and from previous investigations. Five permanent monitoring wells and five borings from the current investigation along with five existing permanent monitoring wells, two piezocone borings, and nine soil borings from the

previous investigations were reviewed to evaluate the site geology. The site is underlain by sand deposits of the Kennon Formation and Columbia Group of Holocene and Pleistocene in age respectively. The upper forty feet of sediments were described with respect to lithology and sedimentary features during drilling activities (current and previous). Based on lithology, the sediments can be separated into four layers as follows:

DEPTH (FT BLS)	USCS SOIL TYPE	DESCRIPTION
0 - 2	SM-SP	Medium sand to silty sand.
2 - 18	SP	Medium sand, rounded to subrounded, well sorted, with trace amounts heavy minerals, grading to coarse to very coarse sand at approximately 18 feet BLS.
18 - 40	SW	Interlayers of coarse to very coarse sand and gravel, heavy minerals, well sorted within layers, rounded to subrounded.
40 - 46	SM	Sharp contact with overlying unit. Fine sand to silty sand, some shell fragments, non-cohesive, non-plastic.

Previous investigations described silty sand present from 0 to 2 feet BLS across the site which extended to a depth of 4 feet in the eastern area of the site. The sand was subrounded to subangular, usually well sorted and medium to coarse grained at depths greater than 4 feet which corresponds to the sand layers encountered 2 to 18 ft BLS in the previous investigations. The current investigation found a medium to medium-coarse sand with subrounded to subangular grains, and well sorted from 0 to 12 ft BLS. **Figures 3-1 and 3-2** present schematics of the cross-section view of the site. The cross-sections incorporate borehole data from the PA/SI with data from the current investigation. The boring and well construction logs are presented in **Appendix C**.

Previous investigations reported that the water table elevations ranged from 8.5 feet NGVD in the northern portion of the site to less than 8.3 feet NGVD in the southern portion. The water table was encountered approximately six feet BLS during drilling activities. Based on water elevations measured in the on-site wells, the water table occurs at 6.9 to 7.0 feet National Geodetic Vertical Datum (NGVD) of 1929.

Tables 3-2 and 3-3 present a summary of well construction details and water elevations, respectively, for all existing wells at the site. Based on measured water levels from January 20, 2003, groundwater flows from the south to the north. **Figure 3-3** presents a water table contour map.

Tidal influence tests were conducted at the 80th DRS through the measurement of water levels in all site wells during 3 events, one during high tide, one during low tide, and one during the transitional period between high and low tide. The purpose of these tests was to assess if there is any influence on the shallow water table aquifer due to the daily tides of the proximate Chesapeake Bay and Atlantic Ocean. Little variation in the water levels was noted during this tidal period. Groundwater flow direction remained constant. Water level data for each well is provided in **Appendix C**.

This section provides a preliminary identification of the applicable or relevant and appropriate requirements (ARARs) and the environmental media analytical results and an assessment of the nature and extent of contamination for the 80th Division Reserve Site (80th DRS).

The quality of the analytical data is presented in the Quality Control Summary/Analytical Results Report (QCS/ARR) submitted separately. The results of the data validation as conducted by our subcontractor, URS Corporation, are provided in Appendix C of the QCS/ARR.

Based on the data validation results, the analytical data were generally considered acceptable and valid for use in determining the nature and extent of contamination and in performance of the baseline risk assessment provided in Sections 6.0 and 7.0 of this report. Qualifiers are provided for those results that are considered deficient based on the data validation.

The data reported in the summary tables in this section include the highest concentration detected for a contaminant whether in the original, dilution, re-extraction, or duplicate sample so that the maximum concentration is shown and evaluated especially in the subsequent risk assessment.

4.1 IDENTIFICATION OF ARARS

4.1.1 Definition of ARARs

The National Contingency Plan (NCP) and Section 121 of the Comprehensive Environmental Response, Compensation and Liabilities Act (CERCLA) require that CERCLA remedial actions attain Federal and State ARARs unless specific waivers are granted. State ARARs must be attained under Section 121(d) of CERCLA, if they are legally enforceable and consistently enforced statewide. ARARs may be classified as either applicable or relevant and appropriate. In addition to ARARs, other guidance and regulations may be classified as guidance "to be considered" (TBC). Potential ARARs and TBCs are identified in this section to aid in development of remedial actions and in establishment of required cleanup levels. Additionally, ARARs and TBCs are used to scope and formulate remedial action alternatives and to govern implementation and operation of the selected remedial alternatives.

Discussions of ARARs and TBC criteria are provided as follows:

- **Applicable Requirements**. Applicable requirements refer to those Federal or State requirements that would be legally enforceable. An example of an applicable requirement would be the Safe Drinking Water Act's Maximum Contaminant Levels (MCLs) for a site that contaminates a public drinking water supply.

- **Relevant and Appropriate Requirements**. Relevant and appropriate requirements are Federal or State standards, criteria or guidelines that are not legally enforceable at a site, but where application is appropriate because they address problems similar to those on-site. Relevant and appropriate requirements have the same weight and consideration as applicable requirements. An example of Relevant and Appropriate Requirements might be

state groundwater protection levels established for other regulatory programs such as UST or RCRA Subtitle D.

- **To Be Considered (TBC).** Other Federal and State recommended standards or criteria applicable to a specific site which are not generally enforceable but are advisory are categorized as TBC. For example, where no specific ARAR exists for a chemical or situation, or where such an ARAR is not sufficient to be protective of human health or the environment, Federal and/or State guidance or advisories may be considered in determining the necessary level of cleanup for protection of public health and the environment. An example of a TBC would be use of EPA risk screening criteria or EPA Health Advisories for specific chemicals in determining action or cleanup levels.

4.1.2 Development of ARARs and TBCs

The development of ARARs and TBCs is conducted on a site-specific basis. ARARs and TBCs are further categorized as either chemical-specific, location-specific or action-specific. CERCLA actions may have to comply with them as follows:

- **Chemical-Specific**. Chemical-specific requirements define acceptable exposure levels for specific hazardous substances and therefore may be used as a basis for establishing preliminary remediation goals and cleanup levels for chemicals of concern in the designated media. Chemical-specific ARARs and TBCs are also used to determine treatment and disposal requirements for remedial actions. In the event a chemical has more than one requirement, the more stringent of the two requirements will be used.

- **Location-Specific**. Location-specific requirements set restrictions on the types of remedial actions that can be performed based on site-specific characteristics or location. Alternative remedial actions may be restricted or precluded based on Federal and State laws for hazardous waste facilities, proximity to wetlands or floodplains, or to man-made features such as existing landfills, disposal areas and local historic landmarks or buildings.

- **Action-Specific**. Action-specific requirements set controls or restrictions on the design, implementation and performance of remedial actions. They are triggered by the particular types of treatment or remedial actions that are selected to accomplish the cleanup. After remedial alternatives are developed, action-specific ARARs and TBCs which specify remedial action performance levels as well as specific contaminant levels for discharge of media or residual chemical levels for media left in place, are used as a basis for assessing the feasibility and effectiveness of the remedial action.

4.1.3 Identification of ARARs and TBCs

Chemical-Specific ARARs and TBCs

As a basis for comparison of the contaminant concentrations discussed in this section, lists of

chemical-specific ARARs and TBC criteria has been developed for the 80th DRS. These chemical-specific ARARs and TBCs have been identified for soil and groundwater in **Tables 4-1 and 4-2**, respectively. Chemical-specific ARARs and TBCs that have been identified from the following regulations and standards:

ARARs

- Virginia Groundwater Quality Standards
- Safe Drinking Water Act EPA Maximum Contaminant Levels (40 CFR 141 and 143)

TBC Criteria

- EPA Region III Risk-based Concentration Tables (October 2006)
- EPA Region III BTAG Screening Levels (August 1995)
- Virginia Groundwater Quality Criteria

Location-Specific ARARs and TBC

Identification of potential location-specific ARARs and TBC include the following:

- Virginia Stormwater Management Regulations
- Virginia Pollution Abatement (VPA) Permits
- Virginia Water Protection Permit Regulations
- Virginia Hazardous Waste Management Regulations
- Virginia Solid Waste Management Regulations
- Virginia Regulations for Transportation of Hazardous Materials
- Resource Conservation and Recovery Act (RCRA) Regulations (40 CFR 261-270)
- DOT Transportation Regulations (49 CFR 107, 171)
- Virginia Regulations for the Control and Abatement of Air Pollution
- Clean Air Act Regulations
- Virginia Erosion and Sediment Control Regulations

Action-Specific ARARs and TBC

Identification of potential action-specific ARARs and TBC may include the following based on the required remedial action:

- National (40 CFR 122) and Virginia Pollutant Discharge Elimination System permits
- Virginia and Federal Endangered Species Act
- Virginia Wetlands Regulations
- Federal Water Pollution Control Act Regulations (Clean Water Act)(33 CFR 323)
- Federal Wetlands Executive Order 11990
- Chesapeake Bay Preservation Regulations

- Virginia Beach Coastal Management Plan
- Virginia Historic Resources Law and Antiquities Act
- Federal Floodplain Executive Order 11988
- Local Noise Statutes

The applicability and refinement of these chemical, location and action-specific ARARs and TBC to future remedial actions will be evaluated in detail on a more site-specific basis in the feasibility study process, if required.

4.2 ANALYTICAL RESULTS

Soil and groundwater samples were collected at the 80th DRS to define the nature and extent of contamination. Surface and subsurface soil samples were collected by split spoon method using a drill rig. In addition, groundwater samples were collected from newly installed and existing monitoring wells.

In this section analytical data for all media is compared against EPA risk screening criteria. Groundwater data is screened against EPA RBC for tap water and EPA MCLs while soils data are compared to EPA RBC for industrial and residential soils. This initial screening against these criteria is only used to assign significance to the analytical data and not as an analysis of risk or impacts. A detailed risk assessment, which screens the data against all ARARs such as MCLs, EPA RBC soil criteria, EPA Region III BTAG ecological risk levels, etc. is provided in Sections 6.0 (Human Health Risk Assessment) and 7.0 (Ecological Risk Assessment).

4.2.1 Soil

Soil samples were collected from 10 soil borings with samples collected from three depths to assess the lateral and vertical extent of contamination in the vadose zone. All soil samples were analyzed for target compound list (TCL) volatile organic compounds (VOCs), TCL semivolatile organic compounds (SVOCs), TCL pesticides and PCBs, and target analyte list (TAL) metals.

Tables 4-3 through 4-6 provide the analytical results for the soil samples collected at the site. As shown in these tables, only those contaminants detected are presented. The entire data set (including those compounds that were not detected) are presented in the Data Validation Report (Appendix C of the QCS/AR Report). Additionally, the EPA Region III Risk-based Concentration (RBC) Criteria for Industrial and Residential Soils are presented for comparison purposes. The EPA Region III RBCs for industrial and residential soils for non-carcinogenic compounds presented in the tables have been adjusted to a hazard quotient of 0.1 by dividing them by a factor of ten. The RBCs were established for single contaminant exposure situations, however, because multiple contaminants have been detected for soil, the RBCs have been adjusted.

The risk assessment provided in Section 6.0 of this report will provide a more detailed risk screening against all chemical-specific ARARs and TBC criteria.

VOCs

As presented in **Table 4-3**, numerous VOCs were detected in surface and subsurface soils. A summary of these detects including range of detection, frequency of detection, and comparison to EPA RBCs for industrial and residential soils are provided in the table below:

VOC RESULTS
RANGE AND FREQUENCY OF DETECTION IN SOIL SAMPLES

Compound	Range (µg/kg)	Frequency	EPA RBC (Ind/Res) (µg/kg)
Acetone	5 to 57	26 of 30	9.2 E+07 / 7 E+06
2-Butanone (MEK)	5	1 of 30	6.1E+07 / 4.7E+06
Carbon Disulfide	0.8 to 6	9 of 30	10E+07 / 7.8E+-05
Chlorobenzene	0.5	5 of 30	2E+06 / 1.6E +05
1,2-Dichlorobenzene	0.3	1 of 30	9.2E+06 / 7E+05
1,3-Dichlorobenzene	0.5	1 of 30	3.1E+05 / 2.3E+04
1,4-Dichlorobenzene	0.3 to 0.5	6 of 30	1.2E+05 / 2.7E+04
Dichlorodifluoromethane	0.6	3 of 30	2E+07 / 1.6E+06
1,2-Dichloroethane (1,2-DCA)	3	1 of 30	3.1E+04 / 7E+03
trans 1,2-Dichlorothene (1,2-DCE)	0.7 to 1	7 of 30	2E+06 / 1.6E+05
Ethylbenzene	0.5 to 0.7	6 of 30	1E+07 / 7.8E+06
2-Hexanone	13 to 230	2 of 30	4.1E+06 / 3.1E+05
Methyl acetate	5 to 69	3 of 30	1E+08 / 7.8E+06
Methylene chloride	4 to 10	26 of 30	3.8E+05 / 8.5E+04
4-Methyl-2-pentanone (MIBK)	5 to 16	8 of 30	---
Tetrachloroethene (PCE)	2 to 120	14 of 30	5.3 E+03/ 1.6E+03
Toluene	0.7 to 5	28 of 30	8.2E+06 / 6.3E+06
Trichloroethene (TCE)	0.5 to 1	7 of 30	7.2E+03 / 1.6E+03
Trichlorofluoromethane	0.8 to 3	8 of 30	3.1E+07 / 2.3E+06
1,1,2-Trichloro-1,2,2-trifluoroethane	0.7 to 2	15 of 30	3.1E+09 / 2.3E+08
Xylenes (total)	1 to 7	11 of 30	2E+07 / 1.6E+06

All concentrations were at least three orders of magnitude less than the risk screening criteria for industrial and residential soils. As reported in the EPA Region III Modifications to the National Functional Guidelines for Organic Review, methylene chloride, MEK and acetone are typical laboratory artifacts.

SVOCs

As presented in **Table 4-4**, numerous SVOCs were detected in soils at the site. A summary of these detects including range of detection, frequency of detection, and comparison to EPA RBCs for industrial and residential soils are provided in the table below:

SVOC RESULTS
RANGE AND FREQUENCY OF DETECTION IN SOIL SAMPLES

Compound	Range (µg/kg)	Frequency	EPA RBC (Ind/Res) (µg/kg)
Acenaphthene	49 to 960	7 of 30	6.1E+06 / 4.7E+05
Acenaphthylene	21 to 2,200	18 of 30	--- / ---
Anthracene	32 to 2,500	15 of 30	3.1E+07 / 2.3E+06
Benzo(a)anthracene	45 to 5,600	18 of 30	3.9E+03 / 2.2E+02
Benzo(a)pyrene	28 to 5,500	19 of 30	3.9E+02 / 2.2E+01
Benzo(b)fluoranthene	69 to 6,800	18 of 30	3.9E+03 / 2.2E+02
Benzo(g,h,i)perylene	26 to 3,700	20 of 30	--- / ---
Benzo(k)fluoranthene	36 to 4,100	19 of 30	3.9E+04 / 2.2E+03
1,1'-Biphenyl	26 to 470	6 of 30	5.1E+06 / 3.9E+04
Bis(2-ethylhexyl)phthalate	40 to 880	27 of 30	2E+05 / 4.6E+04
Carbazole	48 to 490	5 of 30	1.4E+05 / 3.2E+04
Chrysene	34 to 6,000	19 of 30	3.9E+05 / 8.7E+04
Dibenzo(a,h)anthracene	30 to 1,500	14 of 30	3.9E+02 / 2.2E+01
Dibenzofuran	30 to 790	6 of 30	2E+05 / 1.6E+04
3,3'-Dichlorobenzidine	41 to 290	2 of 30	6.4E+03 / 1.4E+03
2,4-Dinitrotoluene	130	1 of 30	2E+05 / 1.6E+04
2,6-Dinitortoluene	51	1 of 30	1E+05 / 7.8E+03
Di-n-octyl phthalate	24 to 280	6 of 30	--- / ---
Fluoranthene	28 to 9,800	21 of 30	4.1E+06 / 3.1E+05
Fluorene	28 to 1,600	12 of 30	4.1E+06 / 3.1E+05
Indeno(1,2,3-cd)pyrene	25 to 3,600	19 of 30	3.9E+03 / 2.2E+02
2-Methylnaphthalene	34 to 2,400	11 of 30	4.1E+05 / 3.1E+04
N-Nitrosodiphenylamine	150	1 of 30	5.8E+05 / 1.3E+05
Naphthalene	31 to 1,200	6 of 30	2E+06 / 1.6E+05
Phenanthrene	29 to 12,000	20 of 30	--- / ---
Pyrene	43 to 16,000	20 of 30	3.1E+06 / 2.3E+05

The primary SVOCs detected in site soils were the polynuclear aromatic hydrocarbons (PAHs), which were detected in approximately two-thirds of the samples collected. PAHs are typical constituents of petroleum hydrocarbons such as diesel fuels, hydraulic fluids, and other oils such as lube oils and motor oils. Only five SVOCs (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene and indeno(1,2,3-cd)pyrene) exceeded EPA risk screening criteria for industrial or residential soils.

Pesticides

As presented in **Table 4-5**, numerous pesticides were detected in soils at the site. A summary of these detects including range of detection, frequency of detection, and comparison to EPA RBCs for industrial and residential soils are provided in the table below:

PESTICIDE RESULTS
RANGE AND FREQUENCY OF DETECTION IN SOIL SAMPLES

Compound	Range (µg/kg)	Frequency	EPA RBC (Ind/Res) (µg/kg)
Aldrin	0.98 to 73	5 of 30	170 / 38
alpha-BHC	0.53 to 1.7	3 of 30	450 / 100
beta-BHC	2.4 to 100	3 of 30	1,600 / 350
delta-BHC	0.66	1 of 30	450 / 100
gamma-BHC (Lindane)	0.37 to 0.39	2 of 30	2,200 / 490
Chlordane (gamma)	1.7	1 of 30	8,200 / 1,800
4,4'-DDD	0.42 to 6.4	5 of 30	12,000 / 2,700
4,4'-DDE	1.6 to 3.1	4 of 30	8,400 / 1,900
4,4'-DDT	0.91 to 8.8	8 of 30	8,400 / 1,900
Dieldrin	7.1 to 27	3 of 30	180 / 40
Endosulfan I	0.9	1 of 30	610,000 / 47,000
Endosulfan II	18	1 of 30	610,000 / 47,000
Endosulfan sulfate	0.8 to 110	7 of 30	610,000 / 47,000
Endrin aldehyde	0.88 to 0.97	2 of 30	31,000 / 2,300
Endrin ketone	1.1 to 110	17 of 30	31,000 / 2,300
Heptachlor	1	1 of 30	640 / 140

Aldrin was the only compound detected above the EPA RBC for residential soils and it was detected above the criteria in only one sample (surface sample at boring SB-5). Pesticide concentrations at this site are consistent with levels seen on military installations from the widespread pesticide application and not from waste disposal or spills.

PCBs

As presented in **Table 4-5**, Aroclor-1260 was the only PCB detected in soils at the site. A summary of these detects including range of detection, frequency of detection, and comparison to EPA RBCs for industrial and residential soils are provided in the table below:

PCB RESULTS
RANGE AND FREQUENCY OF DETECTION IN SOIL SAMPLES

Compound	Range (µg/kg)	Frequency	EPA RBC (Ind/Res) (µg/kg)
Aroclor-1016	---	0 of 30	41,000 / 550
Aroclor-1221	---	0 of 30	1,400 / 320
Aroclor-1232	---	0 of 30	1,400 / 320
Aroclor-1242	---	0 of 30	1,400 / 320
Aroclor-1248	---	0 of 30	1,400 / 320
Aroclor-1254	---	0 of 30	1,400 / 320
Aroclor-1260	21 to 67	2 of 30	1,400 / 320

Aroclor-1260 was detected in only 2 of 30 samples and its concentrations (21 to 67 µg/kg) were well below the EPA RBCs (1,400 µg/kg for industrial soils and 320 µg/kg for residential soils).

Metals

As presented in **Table 4-6**, numerous metals were detected in soils at the site. A summary of these detects including range of detection, frequency of detection, and comparison to EPA RBCs for industrial and residential soils are provided in the table below:

METAL RESULTS
RANGE AND FREQUENCY OF DETECTION IN SOIL SAMPLES

Compound	Range (mg/kg)	Frequency	EPA RBC (Ind/Res) (mg/kg)
Aluminum	135 to 8,530	30 of 30	--- / ---
Antimony	0.35 to 2.1	20 of 30	41 / 3.1
Arsenic	0.35 to 1.2	13 of 30	1.9 / 0.43
Barium	0.98 to 15.8	30 of 30	20,000 / 1,600
Beryllium	0.01 to 0.12	21 of 30	200 / 16

METAL RESULTS RANGE AND FREQUENCY OF DETECTION IN SOIL SAMPLES			
Compound	**Range (mg/kg)**	**Frequency**	**EPA RBC (Ind/Res) (mg/kg)**
Cadmium	0.11	1 of 30	100 / 7.8
Calcium	18.2 to 3,060	30 of 30	--- / ---
Chromium	1 to 10	30 of 30	310 / 23
Cobalt	0.07 to 0.93	27 of 30	--- / ---
Copper	0.28 to 6.3	15 of 30	4,100 / 310
Iron	335 to 10,100	30 of 30	31,000 / 2,300
Lead	0.5 to 33.9	30 of 30	400 / 400
Magnesium	20.8 to 504	30 of 30	--- / ---
Manganese	1.9 to 69.1	30 of 30	2,000 / 160
Mercury	0.017 to 0.035	11 of 30	31 / 2.3
Nickel	0.13 to 3.7	26 of 30	2,000 / 160
Potassium	39.7 to 494	29 of 30	--- / ---
Selenium	0.37 to 0.74	5 of 30	510 / 39
Silver	0.09	1 of 30	510 / 39
Sodium	44.5 to 133	30 of 30	--- / ---
Thallium	---	0 of 30	7.2 / 0.55
Vanadium	0.76 to 19.4	30 of 30	100 / 7.8
Zinc	1.1 to 81.8	30 of 30	31,000 / 2,300

The majority of the TAL metals were detected in soil at the site. However, only three compounds (arsenic, iron, and vanadium) exceeded EPA RBCs for residential soils. Arsenic exceeded the EPA RBC of 0.43 mg/kg in 8 of 30 samples while iron exceeded the EPA RBC of 2,300 mg/kg in 6 of 30 samples. Vanadium exceeded the residential RBC of 7.8 mg/kg in 3 of 30 samples. None of these metals exceeded the EPA RBCs for industrial soils.

Soil detects above EPA RBCs are presented on **Figure 4-1**.

4.2.2 Groundwater

4.2.2.1 January 2003 Groundwater Sampling Event

Groundwater samples were collected from 10 monitoring wells to assess the lateral and vertical extent of contamination in the Columbia Aquifer (water table aquifer). All groundwater samples were analyzed for VOCs, SVOCs, pesticides, PCBs, and total and dissolved metals. **Table 4-7** provides a

summary of the analytical parameters and results for the monitoring well samples collected at the site. In **Table 4-7**, only those compounds detected are presented. The entire data set (including those compounds that were not detected) are presented in the Data Validation Report (Appendix C of the QCS/AR Report). In addition, the EPA Region III RBC Criteria for Tap Water and EPA MCLs are presented for comparison purposes. The EPA Region III RBCs for tap water for non-carcinogenic compounds presented in **Table 4-7** have been adjusted to a hazard quotient of 0.1 by dividing them by a factor of ten. The RBCs were established for single contaminant exposure situations, however, because multiple contaminants have been detected for groundwater, the RBCs have been adjusted.

A more detailed risk evaluation which provides a comparative analysis of sample results and ARARs and TBC criteria is provided in the baseline risk assessment in Section 6.0.

Organics

For the organic analyses, the following table provides a summary of the range of concentrations detected by analytical parameter and frequency of detection:

ORGANIC RESULTS
RANGE AND FREQUENCY OF DETECTION IN GROUNDWATER SAMPLES

Compound	Range (µg/L)	Frequency of Detection	EPA RBC/ MCL (1)
VOCs			
cis 1, 2-DCE	0.70	1 of 10	6.1 / 70
PCE	0.30 to 6.0	4 of 10	0.10 / 5
Toluene	0.2 to 1.0	10 of 10	230 / 1,000
TCE	0.8 to 3.0	3 of 10	0.026 / 5
1,2,4-Trichlorobenzene	0.20	1 of 10	6.1 / 70
SVOCs			
Bis(2-ethylhexyl)phthalate	5.0	1 of 10	4.8 / 6

Notes:
1. EPA Region III Risk-based Concentration Criteria for Tap Water and EPA MCLs

Analysis of monitoring well groundwater samples detected only six organic compounds including cis 1,2-DCE, PCE, toluene, TCE, 1,2,4-trichlorobenzene (1,2,4-TCB), and bis(2-ethylhexyl)phthalate. Concentrations of PCE, TCE, and bis(2-ethylhexyl)phthalate exceeded EPA RBCs while only one detect of PCE (6 µg/L in MW-8) exceeded the EPA MCL. No pesticides or PCBs were detected in any of the 10 monitoring wells sampled.

Metals

Numerous metals were detected in monitoring well samples. The following table provides a summary of the range of detected concentrations of metals and frequency of detection:

INORGANIC RESULTS
RANGE AND FREQUENCY OF DETECTION IN GROUNDWATER SAMPLES

Compound	Total Metals		Dissolved Metals		EPA RBCs/ MCLs[1] (ug/l)
	Range (ug/l)	Frequency	Range (ug/l)	Frequency	
Aluminum	56.5 to 953	10 of 10	37.9 to 207	10 of 10	--- / ---
Antimony	2.5 to 6.4	8 of 10	---	0 of 10	1.5 / 6.0
Arsenic	4.8 to 6.0	3 of 10	5.0 to 5.4	2 of 10	0.045 / 10
Barium	5.2 to 30.8	10 of 10	4.9 to 28.2	10 of 10	730 / 2,000
Cadmium	0.41 to 1.1	3 of 10	0.98	1 of 10	1.8 / 5.0
Calcium	7,970 to 26,700	10 of 10	8,190 to 27,500	10 of 10	---
Chromium	1.0 to 6.6	10 of 10	0.78 to 1.2	4 of 10	11 / 100
Cobalt	0.53 to 0.59	2 of 10	0.53 to 1.1	3 of 10	73 / ---
Copper	1.9 to 4.2	2 of 10	2.1	2 of 10	150 / 1,300
Iron	292 to 5,130	10 of 10	81.6 to 4,650	10 of 10	1,100 / ---
Lead	1.2 to 4	4 of 10	1.2 to 1.3	2 of 10	15[2]
Magnesium	1,130 to 3,160	10 of 10	1,150 to 3,260	10 of 10	---
Manganese	10.6 to 165	10 of 10	9.7 to 167	10 of 10	73 / ---
Mercury	0.10 to 0.13	6 of 10	0.11 to 0.13	5 of 10	1.1 / 2.0
Nickel	2.5	1 of 10	1.5 to 2.2	3 of 10	73 / ---
Potassium	1,040 to 4,920	10 of 10	1,200 to 5,520	10 of 10	---
Selenium	2.6 to 3.5	2 of 10	3.0 to 10.3	6 of 10	18 / 50
Sodium	3,160 to 11,700	10 of 10	2,930 to 11,900	10 of 10	---
Vanadium	0.65 to 6.3	9 of 10	0.48 to 4.8	10 of 10	3.7 / ---
Zinc	6.8 to 309	10 of 10	3.6 to 299	10 of 10	1,100 / ---

Notes:
1. EPA Region III Risk-based Concentration Criteria for Tap Water and EPA MCLs.
2. USEPA Action Level for Lead in Drinking Water.

The detected concentrations of total arsenic, iron, manganese, and vanadium were over the EPA screening criteria in several wells (arsenic in MW-8, MW-10, and MW-11, iron in MW-7, MW-9, MW-10, and MW-11, manganese in MW-10 and MW-11, and vanadium in MW-2, MW-8, and MW-10). Total antimony was detected in concentrations above the EPA RBC of 1.5 µg/L in 8 of 10 wells but above the EPA MCL of 6 µg/L in only one well (MW-2). The dissolved metals detected above the EPA RBCs were as follows:

- Dissolved arsenic levels in MW-5 (5. 4 µg/l) and MW-8 (5 µg/l) were above EPA RBCs for tap water of 1.5 µg/l but were below the USEPA MCL for drinking water of 10 µg/l.
- Dissolved iron levels were above the EPA RBC of 1,100 µg/l in three wells (MW-7, MW-10, and MW-11) at a concentration range of 1,170 to 4,650 µg/l.
- Dissolved manganese levels were above the EPA RBC of 73 µg/l in two wells (MW-10 and MW-11) at a concentration range of 123 to 167 µg/l.
- Dissolved vanadium levels were above the EPA RBC of 3.7 µg/l in only one well (MW-8) at a concentration of 4.8 µg/l.

Groundwater detects above EPA RBCs and/or MCLs are presented on **Figure 4-2**.

4.2.2.2 June 2004 Groundwater Sampling Event

In June of 2004 a second round of groundwater samples were collected from monitoring wells MW-1 through MW-13, and were analyzed for VOCs. Constituents detected in this round of sampling included cis-1,2-dichloroethene, TCE, and tetrachloroethene. Specifically, Cis1,2-DCE and TCE were detected in MW-6 and MW-9. Tetrachloroethene was detected in MW-5, MW-6 and MW-9. **Table 4-8** contains the data collected in this round of sampling.

JUNE 2004 VOC RESULTS
RANGE AND FREQUENCY OF DETECTION IN GROUNDWATER SAMPLES

Compound	Range (µg/L)	Frequency of Detection	EPA RBC/ MCL [1]
VOCs			
cis 1, 2-DCE	1.9 to 11	2 of 12	6.1 / 70
PCE	1.2 to 6.3	3 of 12	0.10 / 5
TCE	1.5 to 7.5	2 of 12	0.026 / 5

Notes:
1. EPA Region III Risk-based Concentration Criteria for Tap Water and EPA MCLs

4.3 NATURE AND EXTENT OF CONTAMINATION

4.3.1 Nature and Extent of Soil Contamination

Acetone, methylene chloride, and toluene were detected in more than 85 percent of the surface and subsurface soil samples collected at the site. Many other VOCs including carbon disulfide, 1,4-dichlorobenzene, trans 1,2-DCE, ethylbenzene, MIBK, PCE, trichlorofluoromethane, 1,1,2-trichloro-1,2,2-trifluoroethane, and xylenes were detected frequently (in greater than 20 percent of the samples) throughout the site. Concentrations of these compounds varied from surface to deeper depths with no apparent trends (i.e., concentrations decreasing/increasing with depth). The lateral extent of VOC contamination was not defined because VOCs were detected in all of the surface soil samples collected in this area. However, as discussed in Section 4.2.1, concentrations were several orders of magnitude lower than EPA screening criteria.

SVOCs were detected in all soil samples collected from the site. The primary SVOCs detected were PAHs, which are constituents of petroleum hydrocarbons. Bis(2-ethylhexyl)phthalate was the only SVOC detected in soil borings MW-9 and MW-11 while only bis(2-ethylhexyl)phthalate, fluorene, phenanthrene, and pyrene were detected at MW-10 indicating minimal downgradient migration of SVOCs in soils since these 3 borings are located directly downgradient of the industrialized areas (e.g., former UST and AST, asphalted, and drum storage areas) of the site. Although PAHs were detected throughout the site, the areas with the highest concentrations were centered around the former UST/AST area and the former drum storage area with lower concentrations in areas generally upgradient of these areas as the data shows for borings SB-1 and SB-2.

Endrin ketone was detected in over 50 percent of the soil samples while DDT and endosulfan sulfate were detected in over 20 percent of the soils samples. Aldrin was the only pesticide detected above an EPA screening criteria and it was detected above the EPA RBC for residential soils (38 ug/kg) in one sample on-site at a concentration of 73 ug/kg. Pesticides were detected in all soil samples at the site with little variation in location (upgradient, on-site, or downgradient) or with depth. As previously discussed, due to past widespread application of these pesticides, their presence at these low concentrations are expected at the site.

Aroclor-1260 was the only PCB detected at the site and it was detected in only 2 of 30 soil samples and at concentrations lower than EPA RBCs. Due to infrequent detection, there is no pattern to its distribution at the site.

Metals were detected in soil samples throughout the site as would be expected since the majority of them are naturally occurring in various concentrations. Only three metals (arsenic, iron, and vanadium) concentrations exceeded EPA RBCs for residential soils, none exceeded industrial RBCs. Arsenic exceeded the RBC in 8 of 30 samples while iron exceeded the RBC in 6 of 30 samples and vanadium exceeded the RBC in 3 of 30 samples.

4.3.2 Nature and Extent of Groundwater Contamination

Several VOCs and bis(2-ethylhexyl)phthalate were detected at concentrations greater than the EPA RBCs at the site. Other than toluene, which was detected in all 10 wells at the site during the 2003 sampling event but not detected in 2004, no other organics were detected in wells that are upgradient (MW-1 and MW-2) or cross-gradient (MW-3) of the former AST/UST and drum storage areas. The highest concentrations of organics were detected in the central portions of the site (wells MW-7 and MW-8) near the former UST/AST and drum areas, with some organics detected in downgradient wells (TCE in MW-5 and PCE in MW-9) as well.

The former UST was used to store waste oil and probably also contained PCE and other chlorinated solvents (degreasers from maintenance operations). Groundwater samples in the former UST area contained low concentrations of PCE and its degradation compounds (cis 1,2-DCE and TCE). If the former UST Area is assumed to be the source of the release of these compounds based on historical use of the former UST and the groundwater data which shows elevated levels of VOCs especially chlorinated hydrocarbons, then an apparent vertical and lateral distribution of PCE and degradation compounds can be discerned. Bis(2-ethylhexyl)phthalate was detected in only one well on-site and its apparent distribution is limited to the former UST area.

Based on the assumption that the former UST was the source of the release, the lateral distribution of PCE, TCE, and cis 1,2-DCE implies these compounds have migrated with groundwater from the former UST area downgradient to the north/northwest in that these compounds have been detected in downgradient wells MW-5 and MW-9. Although chlorinated organics were detected in MW-9, which is located approximately 60 feet downgradient of the former UST, no chlorinated organics have been detected in MW-6, which is located another 50 feet downgradient of MW-9. Although greater than the EPA RBCs in the downgradient wells (MW-5 and MW-9), concentrations of PCE and TCE are less than 1 µg/L in the downgradient wells. The downgradient lateral extent of contamination has been fully delineated; however, it should be noted that the westward cross-gradient extent of chlorinated organic contamination may not fully be delineated in that the PCE concentration in MW-8 is the highest on-site at 6 µg/L and no monitoring wells are located to the west of this well.

The June 2004 sampling results seem to confirm the lateral spread of chlorinated organics. As only three VOCs were detected (only VOCs were analyzed), cis 1,2-DCE, TCE and PCE, and all detection areas are indicative of gradual low concentration spread down gradient from the UST source location. As was noted in prior sampling results no detections of COCs were detected in monitoring wells up gradient from the UST site. Except for the PCE detection in MW-5, the only wells to contain detectable levels of VOCs were MW-6 and MW-9. This presents a different snapshot of the site as prior sampling events found no detection in MW-6, where in the June 2004 sampling event the same COCs were detected in MW-9 and MW-6. As MW-6 is located approximately 50 feet in the down gradient direction from MW-9, it is reasonable that the concentrations of the detected COCs would be significantly less in MW-6, which follows a plume emanating from the UST sites up gradient of these wells. Additionally, samples from MW-12 and MW-13 (which lie to the west of MW-8) did not contain VOCs. Therefore, it appears that the area containing the VOCs has been bounded.

Although most metals were detected in total and dissolved phase throughout the site, the distribution pattern will focus on those metals that exceeded EPA RBCs and/or MCLs, which were total antimony and total and dissolved arsenic, iron, manganese, and vanadium. A summary of the lateral distribution of the above-referenced metals is provided as follows:

- Total antimony concentrations are fairly consistent across the site with detections in 8 of 10 wells across the site. The concentrations (5.1 to 6.4 µg/L) in the upgradient wells (MW-1 and MW-2) are greater than the concentrations (3.1 to 4.0 µg/L) in the central-site wells (MW-3, MW-7, and MW-8) and the concentrations (2.5 to 4.6 µg/L) in the downgradient wells. This indicates that the antimony concentrations detected at the site are probably naturally occurring levels and not influenced by the past operations at the former UST/AST and drum storage areas.

- Total arsenic was detected in only 3 of 10 wells with concentrations greatest in one central-site well (MW-8) and in two downgradient wells (MW-10 and MW-11). These concentrations were the only total arsenic detects above the EPA RBC (they were below the EPA MCL). Dissolved arsenic was detected in only 2 of 10 wells (MW-5 and MW-8). Based on the low concentrations and infrequent detection, no discernible pattern is present and it is unclear if these concentrations are solely related to natural levels or are influenced by former site activities.

- Total iron was detected in all 10 wells with concentrations greatest in one central-site well (MW-7) and in three downgradient wells (MW-9, MW-10, and MW-11). These concentrations were the only total iron detects above the EPA RBC. Dissolved iron was also detected in all 10 wells with concentrations greatest in the same wells as the total iron concentrations. The highest concentrations of total and dissolved iron were present in downgradient wells MW-10 and MW-11 which are the least-impacted wells in relation to identified contaminants of concern for the site (VOCs and SVOCs from the former UST and drum storage areas). Based on the location of the highest iron concentrations (downgradient wells), it is unclear if these concentrations are solely related to natural levels or are influenced by former site activities.

- Total and dissolved manganese were detected in all 10 wells with concentrations greatest in two downgradient wells (MW-10 and MW-11). These concentrations were the only total or dissolved manganese detects above the EPA RBC. As for iron, the highest concentrations of total and dissolved manganese were present in downgradient wells MW-10 and MW-11 which are the least-impacted wells in relation to identified contaminants of concern for the site (VOCs and SVOCs from the former UST and drum storage areas). Based on the location of the highest manganese concentrations (downgradient wells), it is unclear if these concentrations are solely related to natural levels or are influenced by former site activities.

- Total vanadium concentrations are fairly consistent across the site with detections in 9 of 10 wells across the site. The concentrations (1.2 to 4.2 µg/L) in the upgradient wells (MW-1 and MW-2) are consistent with the concentrations (1.1 to 6.3 µg/L) in the central-site wells (MW-3, MW-7, and MW-8) and greater than the concentrations (0.65 to 2.3 µg/L) in the downgradient

wells. This indicates that the vanadium concentrations detected at the site are probably naturally occurring levels and not influenced by the past operations at the former UST/AST and drum storage areas.

At this time, no specific assessment was made related to the vertical delineation of contamination at the site. All wells were screened in the upper 10 feet of the shallow water table aquifer (Columbia Aquifer) at the site which in the Fort Story area is present to a depth of 40 to 60 feet below ground surface. In that the organic contamination in the shallow part of the aquifer is low (highest organic concentration was PCE at 6 µg/L), the vertical extent of contamination within this shallow aquifer is not anticipated to be significant.

This section provides a qualitative evaluation of contaminant fate and transport at the 80th DRS. Known and potential contaminant sources, site physical characteristics, physical and chemical properties of the contaminants, and the nature and extent of contamination are discussed.

A breakdown of the issues to be discussed in each subsection is provided as follows:

- Section 5.1 provides a general discussion of the mechanisms that influence the various contaminant transport pathways. Section 5.1 also identifies the physical and chemical properties of contaminants that control their environmental fate and transport.
- Section 5.2 discusses the contaminant transport pathways that are applicable to the site.
- Section 5.3 presents the conceptual fate and transport model developed for the site.
- Section 5.4 discusses the specific transport mechanisms, and pertinent physical and chemical properties of contaminants, where applicable, to support the site specific conceptual fate and transport model.

5.1 TRANSPORT MECHANISMS AND CONTAMINANT PROPERTIES

The fate and transport of contaminants in the environment is influenced by the following mechanisms:

- **Adsorption/Desorption**. The process by which contaminant transport is retarded due to adsorption of contaminants to soil particles. Desorption is the reverse process of adsorption.
- **Advection**. The physical process by which contaminants are transported in solution at the average linear velocity of groundwater in the direction of groundwater flow.
- **Complexation**. The chemical process by which dissolved species are formed from two or more simpler dissolved species, each of which can exist in an aqueous solution.
- **Diffusion**. The chemical process that results in the movement of contaminants in response to concentration gradients.
- **Dispersion**. The mechanical process of mixing that results from local variations in the average velocity of groundwater.
- **Dissolution/Precipitation**. The chemical process by which a material is dissolved in a liquid solvent such as water. Precipitation is the reverse process of dissolution.
- **Ion Exchange**. The chemical process involving the reversible exchange of ions between a liquid and a solid.

- **Reduction/Oxidation.** A chemical reaction (redox reaction) involving changes in the oxidation states of elements.

- **Transformation.** The loss or degradation of contaminants from the environment as a result of chemical reactions of microbial activity.

- **Volatilization.** The transfer of contaminants from the liquid phase to the vapor phase (i.e., soil gas in unsaturated environments or the atmosphere).

The following sections discuss the physical and chemical properties of organic and inorganic contaminants that influence these fate and transport mechanisms.

5.1.1 Organic Contaminants

Several VOCs, SVOCs, pesticides, and PCBs were detected at the site. The frequency of organic compounds detected in at least one media include the following (number of detects/number of samples):

Parameter	Surface / Subsurface Soil	Groundwater
Volatile Organics		
Acetone	26 of 30	----
2-Butanone (MEK)	1 of 30	----
Carbon Disulfide	9 of 30	----
Chlorobenzene	5 of 30	----
Dichlorobenzene (o, m, & p)	6 of 30	----
Dichlorodifluoromethane	3 of 30	----
1,2-Dichloroethane (1,2-DCA)	1 of 30	----
cis 1,2-Dichlorothene (1,2-DCE)	----	1 of 10
trans 1,2-Dichlorothene (1,2-DCE)	7 of 30	----
Ethylbenzene	6 of 30	----
2-Hexanone	2 of 30	----
Methyl acetate	3 of 30	----
Methylene chloride	26 of 30	----
4-Methyl-2-pentanone (MIBK)	8 of 30	----
Tetrachloroethene (PCE)	14 of 30	4 of 10
Toluene	28 of 30	10 of 10
1,2,4-Trchlorobenzene (1,2,4-TCB)	----	1 of 10
Trichloroethene (TCE)	7 of 30	3 of 10
Trichlorofluoromethane	8 of 30	----

Parameter	Surface / Subsurface Soil	Groundwater
1,1,2-Trichloro-1,2,2-trifluoroethane	15 of 30	----
Xylenes (total)	11 of 30	----
Semivolatile Organics		
PAHs(1)	21 of 30	----
Phthalates(2)	27 of 30	1 of 10
1,1'-Biphenyl	6 of 30	----
3,3'-Dichlorobenzidine	2 of 30	----
2,4-Dinitrotoluene	1 of 30	----
2,6-Dinitortoluene	1 of 30	----
N-Nitrosodiphenylamine	1 of 30	----
Pesticides/PCBs		
Aldrin	5 of 30	----
BHC (alpha, beta, delta, & gamma [Lindane])	3 of 30	----
Chlordane (gamma)	1 of 30	----
4,4'-DDD/4,4'-DDE/4,4'-DDT	8 of 30	----
Dieldrin	3 of 30	----
Endosulfan (I, II, and sulfate)	7 of 30	----
Endrin (aldehyde and ketone)	17 of 30	----
Heptachlor	1 of 30	----
Aroclor-1260	2 of 30	----

(1) PAHs grouped together and considered as one detection
(2) Phthalates grouped together and considered as one detection

As shown in the table above, several VOCs, SVOCs, and pesticides were detected infrequently (one detection in groundwater and three or less detections in soil) and they will not be discussed further because their impact on site conditions and risk is minimal.

The potential for a chemical to elicit an adverse human health or ecological effect depends upon the chemical's potential to migrate and persist in an environmental media. Factors that influence chemical mobility include: the physical and chemical properties of a chemical, the physical characteristics of the environmental media, and the site chemistry. This section presents a discussion of the various physical and chemical properties of the types of compounds detected at the 80th DRS. The section also discusses the fate and transport of the detected organics at the site.

Table 5-1 presents a summary of some physical and chemical properties associated with organic compounds detected at the 80th DRS. The potential for chemical mobility and fate is determined by the chemical's properties and its interaction with the site's physical and chemical properties. Physical and chemical properties of organic compounds that affect mobility include:

- Vapor Pressure
- Water Solubility
- Octanol/Water Partition Coefficient
- Organic Carbon Adsorption Coefficient (Sediment partition)
- Specific Gravity
- Henry's Law Constant
- Mobility Index

Vapor pressure provides an indication of the rate at which a chemical volatilizes. Significant volatilization occurs at interfaces such as surface soil and air or surface water and air, and to a lesser extent, at the water table and overlying unsaturated shallow soils. Volatilization impacts selection of remedial technologies for groundwater and subsurface soils. Generally vapor pressure for monocyclic aromatics is higher than that of PAHs. Chemicals with high vapor pressure such as volatile organic compounds (VOCs) enter the atmosphere more rapidly than those with low vapor pressures such as semivolatile organic compounds (SVOCs).

Water solubility impacts the rate at which a compound leaches from soil via infiltrating precipitation. More soluble compounds (e.g., VOCs) leach more readily than less soluble compounds (e.g., SVOCs or inorganics). Water solubility data indicates that VOCs are several-orders-of-magnitude more soluble than PAHs; therefore, highly soluble compounds (e.g., VOCs) migrate more rapidly than less water-soluble compounds (e.g., SVOCs or inorganics).

The octanol/water partition coefficient (K_{ow}) is the ratio of a chemical's soluble concentration in octanol divided by the soluble concentration in water. This coefficient correlates well with bioconcentration factors in aquatic organisms and adsorption to soil or sediment. A linear relationship has been demonstrated between the K_{ow} and the uptake of chemicals by fatty tissues in animal and human receptors (the bioconcentration factor - BCF) (Lyman et al., 1982). This coefficient also assists with characterizing the sorption of compounds by organic soils where experimental data does not exist.

The organic carbon adsorption coefficient (K_{oc}) describes the tendency of a chemical to adhere to soil particles high in organic carbon. The solubility of a chemical in water is inversely proportional to the K_{oc}. Compounds with a high soil/sediment adsorption coefficient generally have low water solubilities. For example, PCBs, which are relatively immobile in the environment, tend to preferentially sorb to soil/sediments and are less likely to migrate via aqueous transport mechanisms. However, erosional properties of surface soils that sorb immobile compounds must be considered in determining the potential for migration.

Specific density is the ratio of the weight of a given volume of pure chemical to the weight of the same volume of water at a specified temperature. Specific density primarily assists in determining the potential for a compound to form a non-aqueous phase (NAPL) on top or at the base of an aquifer, if the compound concentration exceeds 1 to 10 percent of its corresponding water solubility. Henry's law constant (K_h) uses vapor pressure and water solubility to determine volatilization rates from surface water and groundwater for a compound. This constant is an estimate of the concentration of a compound at equilibrium in the water phase and in the air directly above the water.

A general method used for estimating the rate at which a compound volatilizes uses the henry's law constant as follows:

- $10^{-3} > K_h < 10^{-5}$ rapid volatilization
- $10^{-5} > K_h < 10^{-7}$ slow volatilization
- $K_h > 10^{-7}$ low volatilization

The Mobility Index (MI) assesses quantitatively the mobility of a compound based on its water solubility (S), vapor pressure (VP), and organic carbon coefficient (K_{oc}) as defined by:

$$MI = \log ((S*VP)/K_{oc})$$

Ford and Gurba (1984) presented a relative scale that assists in evaluating MI and Dragun presented a summary that related mobility to the K_{oc} as follows:

Relative MI[1]	Mobility Description	log K_{oc}[2]
>5	extremely mobile (EM)	< 1.7
0 to 5	very mobile (VM)	1.7 to 2
-5 to 0	slightly mobile (SM)	2 to 2.7
-10 to –5	immobile (IM)	2.7 to 3.3
< -10	very immobile (VIM)	> 3.3

Notes:
1. From Ford and Gurba (1984)
2. From Dragun (1988)

A general discussion of the fate and transport of the general category of organic contaminants detected at the 80th DRS is presented below. The information is included in this section but not included in the site-specific conceptual model discussion (Section 5.3) in order to provide a general understanding of the fate and transport processes that may be applicable to the site.

VOCs

VOCs detected in at least one media on site include chlorobenzene, dichlorobenzene, ethylbenzene, 1,2,4-TCB, carbon disulfide, methylene chloride, methyl acetate, dichlorofluoromethane, 1,1,2-trichloro-1,2,2-trifluoroethane, trichlorofluoromethane, TCE, 1,2-DCA, cis and trans 1,2-DCE, MIBK, PCE, 2-butanone, 2-hexanone, acetone, xylene, and toluene. A discussion of the fate and transport of each of these VOCs is provided below.

Acetone

Acetone may be relatively mobile in the soil/groundwater system when present at low concentrations

(dissolved in water and sorbed on soil) or as a separate organic phase resulting from a spill of significant quantities of the chemical. In the unsaturated zone, equilibrium models (Mackay's Equilibrium Partitioning Model) indicate that little acetone is expected to be sorbed onto soil particles. The bulk of the acetone is expected to partition to the soil-water phase, and is thus available to migrate by bulk transport (e.g., downward movement of infiltrating water), dispersion, and diffusion. In the saturated zone, almost all of the acetone is predicted to be present in the soil-water phase and available for transport with flowing groundwater.

The portion of acetone that has been released from the soil into the air will either return to the soil via atmospheric washout or eventually undergo photochemical oxidation. Under normal environmental conditions, hydrolysis is not expected to occur at a rate competitive with volatilization or biodegradation. Acetone is expected to be highly susceptible to microbial biodegradation. In typical subsurface environments, the concentration of microorganisms capable of biodegrading acetone may be low and is expected to drop off sharply with depth. However, persistence of acetone in environments with sufficient active microbial populations is not expected.

Toluene

Toluene may be relatively mobile in the soil/groundwater system when present at low concentrations (dissolved in water and sorbed on soil) or as a separate organic phase resulting from a spill of significant quantities of the chemical. In the unsaturated zone, equilibrium models (Mackay's Equilibrium Partitioning Model) indicate that the bulk of the toluene will sorb to the soil particles. However, the amount of toluene typically available in the soil-air phase is high enough for volatilization to be an important pathway. The amount in soil-water is fairly low but migration with infiltrating rainwater, dispersion, and diffusion will occur. In saturated soils, a much higher fraction of toluene is in the soil-water phase and this would be readily transported with flowing groundwater.

The persistence of toluene in the subsurface should be assumed to be from months to years. Toluene under normal environmental conditions is not expected to undergo hydrolysis. Further, toluene is not expected to be susceptible to oxidation or reduction reactions in the subsurface. Available data indicate that toluene is biodegradable in the subsurface. A number of species of microorganisms are capable of using toluene as the sole carbon source. However, in most subsurface environments, such aerobic degradation would be of minimal importance because of the low concentration of microorganisms (at depth) and the low dissolved oxygen conditions.

Xylenes (Total)

Xylenes may be moderately mobile in the soil/groundwater system when present at low concentrations (dissolved in water and sorbed on soil) or as a separate organic phase resulting from a spill of significant quantities of the chemical. In the unsaturated zone, equilibrium models (Mackay's Equilibrium Partitioning Model) indicate that the bulk of the xylenes (99%) will sorb to the soil particles; however, the amount of xylenes typically available in the soil-air phase is high enough for volatilization to be an important pathway. The amount in soil-water is fairly low but migration with

infiltrating rainwater, dispersion, and diffusion will occur. In saturated soils, a much higher fraction of xylenes (74%) is in the soil-water phase and this would be readily transported with flowing groundwater.

The persistence of xylenes in the subsurface should be assumed to be from months to years. Xylenes under normal environmental conditions are not expected to undergo hydrolysis. Further, xylenes are not expected to be susceptible to oxidation or reduction reactions in the subsurface. Available data indicate that xylenes are biodegradable in the subsurface. A number of species of microorganisms are capable of using xylenes as the sole carbon source. However, in most subsurface environments, such aerobic degradation would be of minimal importance because of the low concentration of microorganisms (at depth) and the low dissolved oxygen conditions.

2-Butanone (MEK)

2-Butanone, used as a solvent, is often discharged into the atmosphere or in wastewater. If 2-butanone is released into the soil, it will partially evaporate into the atmosphere from the surface soils, and it will not hydrolyze in soil. Based on its estimated Koc, 2-butanone is expected to be very mobile and therefore, it may leach into the groundwater. According to biodegradability studies, 2-butanone in groundwater may slowly degrade in anaerobic conditions. If 2-butanone is released into surface water, it will be evaporate (half-life of 3-12 days) or slowly biodegrade. It will not photooxidize in surface waters, adsorb to sediment, or bioconcentrate in aquatic organisms; however, it may be subject to direct photolysis. 2-butanone in the atmoshere may be subject to photolysis and removal from rain. Fate and transport data for 2-butanone obtained from *Handbook of Environmental Fate and Exposure Data for Organic Chemicals, Volume III, Pesticides,* Philip H. Howard, 1991.

2-Hexanone

2-hexanone, used as a solvent, typically is released into the environment through volatilization during its manufacture and evaporation of materials in which it is contained. 2-hexanone is highly mobile and if released to soil, it may biodegrade rapidly. If released to water, it is also capable of undergoing rapid biodegradation; however, it will not undergo aqueous hydrolysis, adsorption to sediment, or bioconcentration in aquatic organisms. Volatilization from soil and water to the atmosphere is a significant fate process. In addition, the water solubility of 2-hexanone indicates that physical removal from air through wet deposition is a significant fate process. Fate and transport data for 2-hexanone obtained from *Handbook of Environmental Fate and Exposure Data for Organic Chemicals, Volume III, Pesticides,* Philip H. Howard, 1991.

Chlorobenzene

The main routs for chlorobeneze released into the air is to be diluted and photooxidized. Chlorobenzene released into water or onto land will be lost to evaporation or slowly biodegrade. It does not adsorb to soil, sediment or non-organic suspended solids. Chlorobenzene has the potential to leach into the groundwater, especially if the soil has low organic carbon content. Little

bioconcentration is expected in fish or food products.

Dichlorobenzene (o, p & m)

Dichlorobenzene released onto and into soil may tightly adsorb to the sediment though the presence of dichlorobenzene in groundwater indicates that leaching may occur. Volatilization from soil and water is an important transport mechanism. It is possible that dichlorobenzene will biodegrade under aerobic conditions but is unlikely under anaerobic conditions. Transformation in soil or water by hydrolysis, oxidation or direct photolysis is not expected to occur. When released to water strong adsorption to sediment is expected. When released to air it will predominantly remain in the vapor phase and will react with photochemically produced hydroxyl radicals with a half-life of about 14-31 days. Direct photolysis is not expected to occur to dichlorobenzene, though the detection of dichlorobenzene in rainwater has indicated that wet washout is possible.

Ethylbenzene

Ethylbenzene released into the atmosphere will exist in the vapor phase, and will photochemically degrade by reaction with hydroxyl radicals, with a half-life from a few hours to two days. It may under go wet deposition, and is not expected to undergo direct photolysis. In water loss will be mainly to biodegradation and evaporation with half-lives between a few days to a few weeks. Ethylbenzene sorbs moderately to sediments, and is not expected to bioaccumulate in aquatic biota. Released into soil it will moderately adsorb to sediment and can leach into the groundwater, where some can undergo biodegradation.

1,2,4-Trichlorobenzene

1,2,4-Trichlorobenzene sorbs strongly to soil, though some sites have shown 1,2,4-Trichlorobenzene in the groundwater indicating that some leaching may occur. 1,2,4-Trichlorobenzene will not biodegrade or hydrolyze in groundwater, but may slowly biodegrade in soil. 1,2,4-Trichlorobenzene released into water will bioaccumulate or adsorb to sediments and suspended solids. It will not hydrolyze in surface water but may significantly biodegrade. Evaporation is expected to be a significant loss with a half-life measured in hours. It is expected to have a vapor phase half-life of about 18.5 days due to reactions with photochemically produced hydroxyl radicals.

Carbon Disulfide

Carbon disulfide released into the ground will primarily be lost though volatilization and will also readily leach into groundwater where it may biodegrade. In water carbon disulfide is lost to volatilization, with a half-life of approximately 2.6 hours, whereas bioaccumulation and sorption to sediment should not be significant. In the atmosphere carbon disulfide is degraded y reacting with elemental oxygen and photochemically generated hydroxyl radicals. Soil can become a natural sink for carbon disulfide as it can be adsorbed then biodegraded.

1,2-Dichloroethene (1,2-DCE)

In the atmosphere 1,2-DCE can travel long distances and is primarily removed by photooxidation, with a half-life of approximately 1 month. Decomposition elements are CO_2 and HCl. Releases to water are mainly removed by evaporation, with half-lives of up to 10 days. Hydrolysis and sorption to sediment are unlikely in water or in soil. On soil it is likely to either volatilize or percolate though the subsurface to the groundwater where it will be very persistent. It is not likely to bioaccumulate.

cis-1,2-Dichloroethene (cis 1,2-DCE)

Cis-1,2-DCE that is released at the soil surface either evaporates or leaches into the groundwater. Cis-1,2-DCE that leaches into the subsurface undergoes very slow biodegradation. In water cis-1,2-DCE is lost mainly though volatilization (half-life about 3 hours). Losses that occur through biodegradation, adsorption to sediment and bioconcentration should not be significant. In the atmosphere cis-1,2-DCE is lost mainly by reaction with photochemically generated hydroxyl radicals, in the air Cis-1,2-DCE has a half-life of about 8 days.

trans-1,2-Dichloroethene (trans 1,2-DCE)

Trans-1,2-DCE that is released at the soil surface either evaporates or leaches into the groundwater. Trans-1,2-DCE that leaches into the subsurface undergoes very slow biodegradation. In water trans-1,2-DCE is lost mainly though volatilization (half-life about 3 hours). Losses that occur through biodegradation, adsorption to sediment and bioconcentration should not be significant. In the atmosphere trans-1,2-DCE is lost mainly by reaction with photochemically generated hydroxyl radicals, in the air trans-1,2-DCE has a half-life of about 3.6 days.

4-Methyl-2-pentanone (MIBK)

When released on to soil MIBK may be removed by direct photolysis, volatilization and aerobic biodegradation. MIBK is readily percolated through the soil. In water MIBK is primarily lost though volatilization (half-life of 15-33 hours) and direct photolysis, aerobic biodegradation maybe of minor importance. MIBK is not expected to undergo chemical oxidation, chemical hydrolysis, bioaccumulate or adsorb significantly to sediment. In the atmosphere MIBK will react with photochemically generated hydroxyl radicals, undergo direct photolysis or react with nitrogen oxides. When degraded nitrogen oxides MIBK may produce acetone, peroxyacetylnitrate and methyl nitrate.

Tetrachloroethylene (PCE)

When released to soil, PCE is subject to evaporation and to leaching into the groundwater. In anaerobic soil and groundwater with acclimated bacterial populations biodegradation may be an important process. When released to water PCE will undergo rapid volatilization. It is not expected to undergo significant biodegradation, bioaccumulation, or adsorb to sediment. PCE is not expected to hydrolyze in soil or water. In the atmosphere PCE will be subject mainly to photooxidation, with some

washout expected with rain. The half-live of PCE is expected to be about 2 months.

Trichloroethylene (TCE)

TCE released to atmosphere will react rapidly, with a half-life of about 5 days. The reactions TCE undergoes in air produce phosgene, dichloroacetyl chloride and formyl chloride. TCE is not subject to direct photolysis. When released to water TCE is removed primarily by volatilization (half-life of minutes to hours). Other losses from biodegradation, hydrolysis and photooxidation will be slow in comparison to volatilization. Releases on to soil will partially evaporate and some will leach into the groundwater, where it will have a long residence time.

Trichlorofluoromethane

On the land surface or in water the main loss of trichlorofluoromethane will be through evaporation. In water trichlorofluoromethane bioaccumulation in fish or other aquatic biota is unlikely, nor will it sorb significantly to soils or sediments. On land it can leach into the subsurface, where it has a long persistence time. In the atmosphere it has a half-life of between 52 and 207 years, as it must diffuse from the troposphere to the stratosphere. Very slow interaction with ozone in the stratosphere will degrade trichlorofluoromethane. Trichlorofluoromethane can be transported over great distances and is found evenly spread through out the atmosphere.

1,1,2-Trichloro-1,2,2-trifluoroethane

When released to soil 1,1,2-Trichloro-1,2,2-trifluoroethane rapidly volatilizes, though a fraction will leach down to the groundwater. When released to surface water all 1,1,2-Trichloro-1,2,2-trifluoroethane is expected to be volatilized with a half-life of about 4 hours. In the atmosphere the dominate removal mechanism s photolysis in the stratosphere with a half-life between 80 and 140 years after diffusion out of the troposphere. The persistence of 1,1,2-Trichloro-1,2,2-trifluoroethane is indicated with its distribution around the globe.

Dichlorodifluoromethane

Dichlorodifluoromethane, when released onto land, either volatilizes or leaches into the subsurface, there are no known processes that degrade dichlorodifluoromethane. Dichlorodifluoromethane is also stable in water and the only loss is volatilization into the atmosphere. The water surfaces (oceans/lake) will come to an equilibrium with dichlorodifluoromethane and can transport it long distances. Dichlorodifluoromethane is very stable in the troposphere and slowly diffuses into the stratosphere where it is lost to photolysis. The degradation of dichlorodifluoromethane in the atmosphere produces chlorine atoms that attack ozone.

Methyl Acetate

When released onto soil methyl acetate is very mobile and has the potential to leach into

groundwater. Rapid volatilization is expected to occur from both wet and dry soils. Hydrolysis is not expected to account for a significant loss from soil except under very basic conditions (pH>9). If released into water methyl acetate is expected to rapidly volatize into the atmosphere. Some data indicates that methyl acetate will biodegrade in water under both aerobic and anaerobic conditions. Methyl acetate will not significantly adsorb to sediment or suspended solids, nor should it bioaccumulate in fish. Hydrolysis in water should only occur at significant rates at a ph of greater than nine. In the atmosphere methyl acetate is expected to undergo a slow reaction with photochemically generated hydroxyl radicals with half-lives in the range of 50 to 100 days. Some research has shown that the photooxidation of methyl acetate will be much faster.

Methylene Chloride

When released to the atmosphere methylene chloride will react with photochemically generated hydroxyl radicals and degrade over a few months, it will not undergo direct photolysis. Releases to surface water will primarily be losses to evaporation. Biodegradation is possible in surface water but would be a slow process. Methylene chloride is not expected to adsorb to sediment or organic suspended solids, nor is it expected to bioaccumulate in aquatic organisms. Releases to surface soil will evaporate rapidly, though a fraction of the mass is expected to percolate down toward the groundwater. The rate of biodegradation or final transport fate is still uncertain for methylene chloride in the subsurface. Hydrolysis is not an important process under normal environmental conditions.

Pesticides

Pesticides are persistent and immobile contaminants in environmental media. Typically, pesticides are insoluble in water so, whether they are sprayed, dusted, or applied directly to soil, pesticides ultimately accumulate in soil. Pesticides travel at various rates through soil, primarily due to their affinity for soil/sediment particles. The soil sorption coefficient (K_d) is the distribution of a pesticide between soil and water. In general, the K_d values are higher for high organic carbon soils (i.e.; clays) than for nonorganic soils (i.e.; sands). Thus, soils (clays) with a high K_d adsorb more pesticides than nonorganic soils (sands).

A discussion of the pesticides detected is provided as below.

Chlordane

Technical chlordane, commonly used as an insecticide, is a complex mixture of many chlorinated components, having different persistence patterns in the environment. Chlordane is expected to be relatively immobile in the typical subsurface environment when present at low concentrations. Bulk quantities of the liquid chemical (e.g., from a spill, heavy spray application, or improper disposal) could be transported through the unsaturated zone. However, most studies have shown that proper application of chlordane to soil surfaces does not result in rapid transport through the soil. Estimates for the unsaturated zone using the Mackay's equilibrium model indicate that almost all of the chlordane is expected to be associated with the stationary phase with little available for transport,

dispersion, and diffusion. In saturated deep soils, the percentage of the chlordane in the soil-water phase is expected to be small with little available for transport with flowing groundwater.

Due to chlordane's extensive use as an insecticide, numerous studies have indicated that chlordane is quite persistent in soils and transport through leaching is low. Chlordane has been reported to be susceptible to photolysis and biodegradation. Evidence of the microbial degradation has been presented in several studies with results indicating slow degradation in soils with the half-life for degradation of chlordane in natural soils to be on the order of 2 to 4 years.

4,4"-DDT/4,4"-DDE/4,4"-DDD

DDT and its metabolites are expected to be highly immobile in the subsurface environment when present at low dissolved concentrations. Bulk quantities of these pesticides dissolved in an organic solvent could be transported through the unsaturated zone as a result of a spill or improper disposal. However, the extremely low solubility of these pesticides and their strong tendency to sorb to soils results in a very slow transport rate in soils.

Based on Mackay's Equilibrium Model, due to their strong tendency to sorb to soils, virtually all of these pesticides partition to the soil particles in the unsaturated zone with negligible amount associated with the soil-water or soil-gas phases. Even in saturated environments, which is assumed to contain no soil-air and a smaller organic carbon fraction, almost all of the DDT, DDE, and DDD is retained on the soil.

The rate at which DDT and its metabolites degrade in the subsurface environment is dependent on the conditions under which they are present. The pH strongly affects the rate of aqueous hydrolysis. DDT has been found to undergo abiotic, reductive dehalogenation to DDD in the presence of porphyrin. Dehydrochlorination of DDT to DDE (removal of a hydrogen and chlorine atom to form a double bond) has also been observed in model systems containing reduced porphyrins and in the natural environment. The half-life for the decomposition of DDT in aerobic soils has been reported to be in the range of 10 to 14 years compared to half-lives of 28 to 33 days in moist soils incubated under anaerobic conditions.

DDE is the major degradation product of DDT in aerobic soil and is quite resistant to further hydrolysis. The biological degradation of DDE in aquatic environments is believed to occur very slowly. Under anaerobic conditions, DDD is the major metabolite of DDT. As was the case for DDE, in aquatic systems, biodegradation is believed to be slow.

Endrin (Aldehyde and Ketone)

Endrin and other formulations such as endrin ketone and endrin aldehyde have been used as insecticides on cotton and grains, and as avicides and rodenticides. If endrin is released to the soil, it will be expected to persist for extremely long periods of time. Biodegradation may be enhanced somewhat in moist soils or under anaerobic conditions. Endrin aldehyde will be expected to strongly

sorb to soil and be immobile in soil. If endrin aldehyde is released to water, it will not hydrolyze or biodegrade. It will be subject to photoisomerization to ketoendrin based upon experiments on solid endrin. Endrin will sorb to sediment and will significantly bioconcentrate in aquatic organisms. Fate and transport data for endrin aldehyde obtained from *Handbook of Environmental Fate and Exposure Data for Organic Chemicals, Volume III, Pesticides,* Philip H. Howard, 1991.

Dieldrin

Dieldrin has been used as an insecticide for corn and for termite control. If dieldrin is released to the soil, it will persist for long periods of time and is highly immobile. Due to its low water solubility and strong adsorption to soil, dieldrin is not expected to leach into groundwater. Dieldrin may adsorb onto dust particles and become suspended in the air or reach surface water through soil runoff. When released into water, it is subject to photorearrange to photodieldrin (water half-life of four months). It will also adsorb to sediments and bioconcentrate in aquatic organisms. Fate and transport data for dieldrin was obtained from *Handbook of Environmental Fate and Exposure Data for Organic Chemicals, Volume III, Pesticides,* Philip H. Howard, 1991.

Aldrin

Aldrin has been classified as moderately persistent with a half-life of 20-100 days. Biodegradation in soil is slow but Aldrin is not expected to leach into groundwater. In soil Aldrin decomposes to dieldrin. Aldrin residues in water will volatize and photooxidation are expected to be significant. Photolysis has been observed in water and bioaccumulation will be significant as will be absorption to sediments. Vapor phase aldrin is expected to react with photochemically generated hydroxyl radicals with an estimated half-life of 36.46 minutes. Most aldrin in the atmosphere is expected to adsorb to particulates. Though aldrin can undergo direct photolysis in the atmosphere, the rate of photolysis will be slow compared to reaction with hydroxyl radicals.

Endosulfan

Release of endosulfan to soils will most likely result in biodegradation and hydrolysis. Endosulfan on the surface may photolyze. Volatilization and leaching are not expect to be significant due to the high soil sorption coefficients. When released to water endosulfan isomers are expected to hydrolyze readily under alkaline conditions, and more slowly under neutral or acidic conditions, half-lives in water of between 35.4 and 37.5 for neutral conditions, and 150.6-187.3 days for acidic conditions. Volatilization, biodegradation and bioconcentration are expected to be significant as well. Photolysis and oxidation could also be important. Endosulfan released into the air will react which photochemically generated hydroxyl radicals with an estimated half life of 1.23 hours.

Heptachlor

Volatilization of heptachlor from surface soils, especially moist soil will be rapid, volatilization of heptachlor incorporated into soils will be slower. Hydrolysis in moist soils will be significant.

Heptachlor degrades to 1-hydroxychlordene, heptachlor epoxide and other unidentified metabolites. Biodegradation of heptachlor will also be significant. Heptachlor is expected to sorb strongly to soil sediments and therefore to resist leaching into groundwater. Release of heptachlor to water results in hydrolysis to 1-hydroxychlordene with a half-life of approximately 1 day, as well as volatilization to the atmosphere. Hydrolysis will dominate over adsorption to sediments, biodegradation, photolysis and bioconcentration. In air the vapor phase will react with photochemically generated hydroxyl radicals and ozone with half-lives approximately 6 and 1.5 hours respectively. Direct photolysis may also occur.

BHC (alpha, beta, delta, and gamma (Lindane))

When released into water Lindane is not expected to volatize significantly. Lindane may hydrolyze significantly in basic waters, but not in neutral or acidic waters. At a pH of 9.3 the half-life of lindane in water is approximately 4 days. Transport into sediment will be slow, primarily from diffusion rather than from settling. Lindane released to soil will either volatilize or leach slowly to the groundwater. Lindane reacts with photochemically produced hydroxyl radicals and has a half-life in the atmosphere of approximately 2.3 days. Lindane may slowly biodegrade under aerobic conditions and may rapidly degrade while under anaerobic conditions. Photolysis is considered the primary fate, though lindane is reported to photo-degrade in water. Lindane will bioconcentrate slightly in fish.

Polychlorinated Biphenyls (PCBs)

Aroclor-1260

Aroclor-1260 is expected to be highly immobile in the soil/groundwater system due to sorption. Estimates from Mackay's equilibrium model indicate that approximately 99 percent of the Aroclor is expected to sorb to the soil in the unsaturated zone. Less than one percent is expected to partition to the soil-water phase and the remaining portion is available to migrate by bulk transport, dispersion, and diffusion. In saturated deep soils, sorption is expected to be the most significant fate process and Aroclor-1260 is not expected to leach into the groundwater. The tendency of PCBs to adsorb to sediment and suspended particles increases with the degree of chlorination and the organic content of the sediments.

SVOCs

Numerous SVOCs were detected at the site with PAHs being the primary contaminant detected above EPA RBCs. A discussion of each of the detected SVOCs is provided below.

Polynuclear Aromatic Hydrocarbons

Numerous PAHs including acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, carbazole, chrysene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, 2-methylnaphthalene, dibenzofuran,

dibenzo(a,h)anthracene, phenanthrene, naphthalene and pyrene were detected in site soils, sediment, and groundwater samples. Fate and transport characteristics are similar for this class of compounds; therefore, PAHs will be discussed as a class of compounds rather than individually.

PAHs tend to strongly sorb to most soils, although lower molecular weight PAHs will leach in soils with low organic carbon content. Estimates from Mackay's equilibrium model indicate that 90 to 99 percent of PAHs are expected to sorb to the soil in the unsaturated zone. A small portion will be present in the soil-water phase and available for bulk transport, dispersion, and diffusion. In saturated soils, a higher percentage is expected to be present in the soil-water phase and transported with flowing groundwater.

Lower molecular weight PAHs may volatilize from shallow soils and surface water but higher molecular weight PAHs have limited volatility. Since PAHs have very low solubilities in water, these compounds will be readily sorbed and deposited onto sediment.

The major fate process for PAHs in soil and water is biodegradation; but PAHs in surface water may also photo degrade. PAHs under normal environmental conditions are not expected to undergo hydrolysis, and are not susceptible to oxidation or reduction reactions in the subsurface environment. Most PAHs are reported to be readily susceptible to aerobic biodegradation. However, the rate of biodegradation is dependent upon each PAH and the environmental conditions.

Phthalates

Phthalates detected at the site included bis(2-ethylhexyl)phthalate (DEHP), detected in 27 of 30 samples of soil, and di-n-octyl phthalate. Di-n-octylphthalate was only detected in 6 of 30 soil samples and not detected in groundwater samples, the discussion for phthalates will focus on DEHP. DEHP may move through the subsurface environment when present at low concentrations (dissolved in water and sorbed on soil) or as a separate organic phase (from spills or improper waste disposal). In the unsaturated zone, equilibrium models (Mackay's Equilibrium Partitioning Model) indicate nearly all of DEHP would sorb onto the soil particles. A small portion will be in the soil-water phase and thus can migrate by bulk transport, dispersion, and diffusion. In saturated soils, a much higher fraction is likely to be present in the soil-water phase and transported with flowing groundwater. The extent of sorption is still very strong and groundwaters underlying DEHP-contaminated sites may not be affected unless the phthalates are mobilized by complexation with other chemical species.

The persistence of DEHP is not well documented. In most cases, it should be assumed that these compounds would persist for years. DEHP that has been released into the air, or that enters surface waters with significant sunlight exposure is not expected to be degraded by direct photolysis.

DEHP has been found to be biodegradable in several studies. The ease of degradability is however, less than that of most other phthalate esters. Therefore, biodegradation in typical subsurface environments should be assumed to be of minimal importance.

3-3'-Dichlorobenzidine

If 3-3'-dichlorobenzidine is released into water it will rapidly and strongly adsorb to sediment and particulate matter, some of the compound will be irreversibly adsorbed to the sediment. The compound will undergo very rapid photooxidation near the surface of water, with a half-life of about 90 seconds, forming 3-chlorobenzidine, benzidine and other water insoluble substances. Redox and free radical reactions could be important. When released onto soil 3-3'-dichlorobenzidine will adsorb strongly, and may under go slow mineralization. The compound may under go reactions with other soil components. If released into the air it will likely be adsorbed to particulates and rapidly photo-degrade.

2,4-Dinitrotoluene

When released to soil 2,4-Dinitrotoluene may biodegrade in both aerobic and anaerobic conditions. It will not bioconcentrate significantly in fish and shows a tendency to partition to suspended sediment and sediment organic matter. The volatilization from surface waters will not be significant, the most important removal process in water will be photolysis with listed half-lives between 2.7 and 9.3 hours. In the atmosphere 2,4-Dinitrotoluene is estimated to have a half-life of about 8 hours.

2,6-Dinitrotoluene

Information for 2,6-dinitrotoluene released into soil is unavailable; it is expected to be slightly mobile. 2,6-Dinitrotoluene will have a slight tendency to adsorb to sediments, suspended solids and biota when released into water. Volatilization from water is slow and hydrolysis is probably not significant. Photolysis is probably the most significant removal mechanism for 2,6-Dinitrotoluene in water. In the atmosphere the estimated half-life is 8 hours based upon reaction with photochemically generated hydroxyl radicals.

1-1'-Biphenyl

1-1'-Biphenyl released onto soil can volatize, but a significant portion will adsorb to organics present in the soil. The main loss from soil is through biodegradation, in one study 9.1% of the biphenyl was biodegraded in 2 days. In the atmosphere 1-1'-Biphenyl reacted with hydroxyl radicals with an estimated half-life of 2.2 days. It is also subject to considerable photolysis with a half-life estimated at 2 hours. 1-1'-Biphenyl can react very slowly with ozone, but it is not expected to be a significant loss. In water 1-1'-Biphenyl can volatilize into the atmosphere, but also shows strong tendency to adsorb to organic suspended solids as well as sediment. The main losses from water are hydrolysis, with a half-life of about 40 hours and biodegradation with a half-life measured in hours. Biphenyl does bioaccumulate in aquatic animals.

Table 5-2 summarizes the potential transport pathways of organic and inorganic contaminants in soil, sediment, water, air, and biological systems, and identifies the applicable reactions and processes.

5.2 POTENTIAL PATHWAYS OF CONTAMINANT TRANSPORT

This section discusses the potential transport pathways by which groups of contaminants can migrate between and within environmental media (i.e., air, surface water, soil, sediment, and groundwater) at the 80th DRS.

5.2.1 On-site Deposition of Windblown Dust

Wind can act as a contaminant transport agent by eroding soil and exposed sediment and blowing it off-site. The net transport is influenced by: wind velocity, the grain size/density of the soil/sediment particles and the amount of vegetative cover over the site. The 80th DRS is covered partially (approximately 60%) by asphalt, which would limit the amount of windblown dust. However, the remainder of the site (northern portion) consists of vegetative cover and some bare sands, which would do little to inhibit windblown dust. Thus, there appears to be insufficient ground cover on the northern portion of the site where sampling was conducted to effectively limit this transportation mechanism.

5.2.2 Soil/Sediment Transport by Storm Water Runoff

Water can erode exposed soil/sediment particles during precipitation events. This is influenced by site topography, amount and rate of precipitation, soil/sediment particle size/density, cohesion of soil/sediment, and vegetative cover. Similar to windblown transport, asphalt cover at the site limits the surface area of soil/sediment subject to erosion by storm water runoff. Although the high permeability of the soil present in the unpaved portion of the site reduces the volume of storm water runoff, other factors (e.g., storm intensity, storm water conveyances, topography, etc.) make storm water runoff potentially a significant transport mechanism.

5.2.3 Soil/Surface Water to Air Transport

The primary mechanism of contaminant transport from soil and surface water to air is volatilization. Volatile soil contaminants can migrate up through soil pore spaces and diffuse into the atmosphere. Nonvolatile contaminants such as PCBs and metals can be transported to air only if adhered to airborne particulate matter.

5.2.4 Surface Water to Sediment Transport

Some important mechanisms that control contaminant migration from surface water to sediment are:

- **Seepage**: Contaminated storm water can flow through sediment under hydraulic head, potentially transporting dissolved contaminants to sediment.

- **Gravity Settling**: Gravity settling is a mechanism for separating particles with sorbed metals and organic chemicals from surface water.

- **Adsorption**: Depending on the chemistry of the surface water and sediment and the physical interactions between surface water and sediments, adsorption can be a mechanism for transporting contaminants in water to sediment.

- **Dissolution/Precipitation.** The chemical process by which a material is dissolved in a liquid solvent such as water. Precipitation is the reverse process of dissolution.

5.2.5 Sediment to Surface Water Transport

The primary mechanisms for transporting contaminants from sediment to surface water are desorption, dissolution, and ion exchange. This process is influenced by the physical and chemical properties of the contaminant, the sediment particle, the surface water and turbulence during transport. However, these mechanisms are considered minor for the compounds of concern relative to other transport mechanisms.

5.2.6 Soil/Vadose Zone to Groundwater Transport

The primary mechanism of contaminant transport from the soil/vadose zone to groundwater is through dissolution and transport of constituents via infiltration of rainwater. This mechanism can effectively transport soluble contaminants. Because of the high annual precipitation (44.68 in/yr) at Fort Story and the highly permeable soils present at the site, infiltration rates can be very high. Fort Story contains mostly sandy, course sandy, and sandy gravel soils allowing for fast infiltration, with little runoff. Some areas at Fort Story have significantly reduced the potential for infiltration due to localized impermeable features (i.e. pavement and buildings).

5.2.7 Groundwater to Soil/Vadose Zone Transport

There are several mechanisms of contaminant transport from groundwater to the vadose zone. VOCs in groundwater can volatilize into the unsaturated pore space in the vadose zone. At the capillary fringe, groundwater contaminants can be transported to unsaturated soil via precipitation, adsorption, and ion exchange.

5.2.8 Groundwater to Surface Water Transport

Organic contaminants associated with groundwater are either in a dissolved state or as an immiscible phase on top of or at the bottom of the aquifer. Subsurface transport of immiscible contaminants is governed by several processes: advection, dispersion, and retardation. Advection most strongly influences the transport of dissolved organic contaminants along the hydraulic gradient present as a result of the hydrogeologic framework of the site. Dispersion and spreading during transport results in dilution of contaminants hydraulically downgradient of the source area. Generally speaking, dispersion is greater along the direction of groundwater flow than it is transverse to the flow direction. Retardation of dissolved contaminants occurs as a result of adsorption, partitioning, ion exchange, and other processes that occur along the groundwater flow path. As a result of retardation, contaminants are distributed between the aqueous phase and aquifer sediments, contaminant concentrations in the aqueous phase decrease, and migration of the aqueous phase is

reduced relative to groundwater flow.

5.3 FATE AND TRANSPORT CONCEPTUAL MODEL

The conceptual fate and transport model presented in this section provides a qualitative analysis of the environmental mechanisms, site characteristics, and physical/chemical properties of contaminants that have influenced, or currently influence, contaminant fate and transport at the 80th DRS. Evaluating the site conditions and contaminant properties resulted in identification of the potential contaminant pathways presented in **Table 5-3.**

Discharge of compounds from groundwater in the Columbia aquifer through the Yorktown confining unit to the underlying Yorktown-Eastover aquifer was considered to be unlikely based on the following considerations:

- The estimated vertical hydraulic gradient between the Columbia and Yorktown-Eastover aquifers and groundwater flow simulations (Harsh and Laczniak, 1990) for these aquifers indicate that the potential for groundwater flow is from the Yorktown-Eastover aquifer upward through the Yorktown confining unit to the Columbia aquifer. Thus, contaminants are most likely to migrate along the horizontal groundwater gradient in the Columbia aquifer to discharge points such creeks or streams.

- The Yorktown confining unit has a very low hydraulic conductivity that has been measured to be approximately 10^{-5} to 10^{-6} cm/sec by geotechnical studies.

Migration of the majority of the contaminants (primarily PAHs, pesticides, and metals) is more likely to occur by transport of soil/sediment by storm water or surface water rather than by vertical infiltration based on the physical and chemical properties of the identified compounds, the identified concentrations, and the established groundwater flow regime.

5.4 SITE FATE AND TRANSPORT

This section discusses the fate and transport for the 80th DRS. **Table 5-2** presents the transport mechanisms applicable to the individual transport pathways and the transport pathways identified for the site are presented in **Table 5-3.** Based on the fate and transport properties of the general type of chemical(s) present at the site and the site conditions, a conceptual model for the site is presented. A graphical presentation of the conceptual model for the site is presented on **Figure 5-1**.

The possible transport pathways identified for the site that are considered to be minor pathways due to mitigating site conditions or contaminant properties include the following:

- Volatilization of VOCs from shallow groundwater to shallow soils. The VOCs in site groundwater are all in the low (six or less) part-per-billion range, and therefore would not be a significant contributor of vapor when view with respect to COPC mass.

- Migration, enhanced by infiltrating rainwater, of SVOCs, pesticides, and metals through the vadose zone to groundwater. SVOCs, pesticides, and inorganics strongly adsorb to soil/sediments and are not readily leached to groundwater due to their low aqueous solubility.

- Migration of VOCs, pesticides, SVOCs and inorganics adsorbed to sediment/soil and transported along with windblown dust/sand. Ground cover at the site should limit the amount of transport by wind.

- Leaching of sediment/soil contaminants to surface water. Due to the low solubility of pesticides, SVOCS, and most inorganics, it is very unlikely that these compounds would be readily leached from soil.

The major transport pathways identified for the site include:

- Migration of SVOCs, pesticides, and inorganics adsorbed to soil/sediments by storm runoff into the wetlands and beach/coastal areas.

- Bulk transport, dispersion, or diffusion of VOCs from soil to groundwater.

Soils

Soil samples results for the site indicate that VOCs, SVOCs, pesticides and inorganics were present.

Most VOCs were infrequently detected, and all that were detected had concentration several orders of magnitude less than the associated EPA risk screening criteria. Because of the infrequent detection and low concentrations detected (several were estimated concentration), migration of VOCs is not a significant concern at the site.

Of the detected SVOCs, PAHs were detected most frequently. PAHs strongly adsorb to soil, especially the fine fraction (silt and clay), and remains in the soil column at the source area but they can slowly leach to groundwater or surface water. Sandy soils, such as those at the site can lack sufficient organics to hold PAHs in place. Leaching of PAHs from soil to groundwater is increased in environments with a high annual precipitation rate and high infiltration rate similar to the site conditions observed at the site. Biodegradation is an important fate process for PAHs under aerobic conditions but not anaerobic conditions. There were multiple detection throughout the soil column that were above the EPA risk screening criteria. Most of the detections above the EPA risk screening criteria were found in the surface soil (less than 6 inches). PAHs were found above the industrial and residential EPA criteria. These constituents are most likely bound to the surface soil, but remain available for transport.

Of the remaining SVOCs that were detected in most surface and subsurface soil samples on-site and downgradient of the site, phthalates were also frequently detected. Typically, phthalates and other SVOCs strongly sorb to soil, are relatively immobile, and would biodegrade over time. As there is a lack of organics to help bind the phthalates and other SVOCs, they can potentially be available for transport offsite by leaching toward the groundwater or by surface runoff. The phthalates and other

SVOCs were found throughout the soil column, both shallow (less than 6 inches) and deep soil. This indicates that they are available for both surface run off and possible further leaching into the subsurface. However, as none of the phthalates and SVOCs (excluding the PAHs discussed above) were detected above the RBC screening criteria, migration of SVOCs is not a significant concern at the site.

Numerous metals were detected on-site and downgradient of the site. Some soil samples exceeded the residential EPA RBCs for arsenic (8 of 30) and iron (6 of 30) and 1 sample exceeded the RBCs for aluminum. None of the samples collected exceeded the EPA RBCs for industrial soils. Arsenic can be transported adsorbed to soils/sediment particles (especially silts and clays) that are windborne. Arsenic in soil typically occurs predominately as an insoluble form, which is most likely in this case given the soil conditions of the site (sandy). Arsenic is relatively immobile and in the presence of iron, calcium and aluminum tends to form insoluble complexes that remain in the soils. It is expected that arsenic would be adsorbed to silts and clays in an insoluble form that would be unavailable for leaching to groundwater. However, a change in pH in the soil column can make arsenic more soluble and increase the potential for leaching to groundwater and surface water.

In general, pesticides were detected in soil samples throughout the soil column. Pesticides are persistent and relatively immobile compounds. These compounds would not be expected to significantly leach to groundwater. The compounds can migrate adsorbed to soil/sediment particles when transported by storm water runoff or surface water. There was one detection of a pesticide (Aldrin) that was found to be above the EPA risk screening criteria. The sample was detected in the surface soil.

Groundwater

Overall, VOCs were detected infrequently, with two constituents detected above EPA criteria for tap water RBCs. Three detections for both tetrachloroethene (MW-7, MW-8, MW-9) and trichloroethene (MW-5, MW-7, MW-8) exceeded screening criteria. However, only tetrachloroethene at MW-8 exceeded the EPA's MCL criteria. PCE and TCE resist adsorption to soil and are identified as compounds that can leach into, and migrate in, groundwater. PCE can be biodegraded in to TCE. Confining layers in the subsurface restrict vertical migration.

Bis(2-ethylhexyl) phthalate (BEHP) was the only SVOC detected at the site. It was detected at in the sample from MW-8 above the EPA risk screening criteria RBC. BEHP's long persistence in the subsurface and ability to migrate through the soil at low concentrations could indicate that BEHP could be transported in site groundwater. AS BEHP was detected in only one sample location of 10, indicates that BEHP contamination is not wildly spread.

Numerous metals were detected in groundwater; however, the constituents most frequently detected over the RBCs were arsenic, iron and manganese. Dissolved phase inorganics will be transported with flowing groundwater, but most likely will not migrate as rapidly as the organics. Precipitation of the metals onto soil particles in the saturated zone may occur and impact dissolved inorganic concentrations available for migration.

6.1 INTRODUCTION

This human health risk assessment (HHRA) presents an assessment of potential human health risks associated with constituents detected at the 80th DRS at Fort Story, Virginia. The objectives of the assessment are (1) to provide an analysis of baseline risk, currently and in the future, in the absence of any major action to control or mitigate site contamination, and (2) to assist in determining the need for remediation. It provides a basis for comparing a variety of remedial alternatives, and determining, which will be the most protective of human health.

The HHRA presents an assessment of potential human health risks associated with exposure to constituents detected at or migrating from the site. The HHRA follows guidance provided in the following documents:

- *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A)*, EPA, 1989a
- *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part B)*, EPA, 1989b
- *Risk Assessment Guidance for Superfund, Volume I: Human Health. Supplemental Guidance. "Standard Default Exposure Factors"*, EPA, 1991a
- *Selecting Exposure Routes and Contaminants of Concern by Risk-based Screening*, EPA Region III, 1993a
- *Human Health Evaluation Manual. Supplemental Guidance: Standard Default Exposure Factors.* U.S. Environmental Protection Agency, 1995.
- *Assessing Dermal Exposure from Soil.* U.S. Environmental Protection Agency, Region III, 1995.
- *Risk-Based Concentration Table*, EPA Region III, April 2003.
- *Exposure Factors Handbook*, EPA, 1997
- *Guidance for Data Usability in Risk Assessment, Part 2*, EPA, 1992a
- *RAGS; Part E, Supplemental Guidance for Dermal Risk Assessment, Final Report,* USEPA, 2004.
- *Soil Screening Levels* and *Supplements* (EPA, 1996 and 2001b).
- *Virginia Voluntary Remediation Program Risk Assessment Guidance,* VDEQ, June 2003.

- *Updated Dermal Exposure Assessment Guidance.* U.S. Environmental Protection Agency, Region III, 2003.

- *Groundwater Resources of the Four Cities Area, Virginia.* Commonwealth of Virginia State Water Control Board (SWCB), 1981.

- *Arsenic in ground water of the United States.* USGS, et al, 2003. http://co.water.usgs.gov/trace/arsenic/

6.1.1 Objectives

The goal of the HHRA process is to provide a framework for developing the risk information necessary to assist decision-making at the site. Specific objectives include:

- Provide an analysis of baseline human health risks and help determine the need for remedial action at the site.

- Provide a basis for determining levels of chemicals that can remain at the site and still be adequately protective of public and Fort Story personnel health.

- Provide a basis for comparing potential health impacts of various remedial alternatives at the site.

- Provide a consistent process for evaluating and documenting public health threats at the site.

6.1.2 HHRA Components

There are four components to the HHRA process: (1) hazard identification; (2) exposure assessment; (3) toxicity assessment; and (4) risk characterization. Each step is described briefly as follows:

- **Hazard identification** involves gathering and analyzing the site data relevant to the human health evaluation and identifying the chemicals of potential concern (COPC) at the site that are the focus of the risk assessment process. The selection of such chemicals is based on a number of parameters, including the frequency of detection and concentration in each environmental medium, environmental fate and transport characteristics, intrinsic toxicity and the likelihood of human exposure via significant exposure routes.

- **Exposure assessments** are conducted to estimate the magnitude of actual and/or potential human exposures, the frequency and duration of these exposures, and the pathways by which humans are exposed. In the exposure assessment, reasonable maximum estimates of exposure are developed for both current and future land-use assumptions. Conducting an exposure assessment involves analyzing constituent releases, identifying exposed

populations, identifying all potential pathways of exposure, estimating exposure point concentrations for specific pathways and estimating contaminant intakes for specific pathways. The results of this assessment are pathway-specific intakes for current and future exposures to individual substances.

- **Toxicity assessments** consider the types of adverse health effects associated with chemical exposures, the relationship between magnitude of exposure and adverse effects and related uncertainties such as the weight of evidence of a particular chemical's carcinogenicity in humans. Qualitative and quantitative toxicity data for each COPC are summarized, and appropriate guidance levels with which to characterize risks are identified.

- **Risk characterization** summarizes and combines outputs of the exposure and toxicity assessments to characterize baseline risk, both in quantitative expressions and qualitative statements. The likelihood and magnitude of adverse health risks are estimated in this step, in the form of noncancer hazard quotients and cancer risks.

The selection of COPCs will be made based on the methodology established in to EPA Region III's guidance document entitled *Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening*. The process includes the following steps:

- Data Quality Evaluation which includes assessing the appropriateness of the analytical methods and qualifiers, the significance of blank contamination, and if special analysis is required for TICs.

- Reducing the data set using a risk-based concentration screen such as comparing data to EPA Region III Risk Based Concentrations (RBCs) and USEPA Maximum Contaminant Levels (MCLs). The risk-based screen will be used as follows:

    - The maximum concentration of each chemical in each medium will be compared against the EPA RBC/MCL. If the concentration exceeds the RBC/MCL, the constituent will be retained for the risk assessment. If the constituent concentration is lower than the RBC/MCL than the constituent is dropped for that medium. However, if no screening criteria is available, the constituent will be retained for further analysis. If no toxicity values are available for this compound, then the chemical will be evaluated qualitatively.

    - If a specific constituent does not exceed its risk-based concentration for any medium, it is dropped from the risk assessment.

    - If no constituent in a specific medium exceeds its risk-based concentration, the medium is dropped from the risk assessment.

    - All constituents and exposure routes that are dropped are kept on a sub-list and considered for re-inclusion, based on special properties.

- Consideration of re-including eliminated chemicals based on factors such as ARAR exceedances, special exposure routes, and historical information for the site or area.

- Further reductions in the data set based on evaluations of essentiality, frequency of detection and comparison to background; however, it should be noted that the frequency of detection and comparison to background assessments will be discussed after the quantitative risk assessment in the uncertainty section. In other words, chemicals will not be eliminated based on their infrequent detection or comparison to background, but their significance will be discussed in the uncertainty section. A summary of the background metals data for soils was presented in Section 3.1.4 while the source of the background data, the Montgomery Watson Fort Story PA/SI, is presented in **Appendix J**.

6.2 DATA QUALITY EVALUATION

Prior to the initiation of the hazard identification process, a data quality evaluation will be conducted to determine if analytical methods, quantitation limits, and qualifiers are appropriate, to assess any blank contamination, to assess duplicates and state how they will be utilized in the risk assessment, and assess sampling methodologies. In addition, a comparison of inorganic concentrations to background and assessment of essential nutrients will also be conducted. This information is provided in the following subsections.

6.2.1 Evaluation of Analytical Methods

All analytical data collected at the site during the performance of the Site Inspection Report were analyzed using appropriate SW-846 methods as follows:

- Volatile Organic Compounds (VOCs) SW846 Method 8260B
- Semi Volatile Organic Compounds (SVOCs) SW846 Method 8270C
- Polychlorinated Biphenyls (PCBs)/Pesticides SW846 Method 8081A/8082
- Metals (Total and Dissolved) SW846 Method 6010B/7470A/7471A
- Total Dissolved Solids (TDS) SW846 Method 160.1
- Total Suspended Solids (TSS) SW846 Method 160.2
- Total Organic Carbon (TOC) Lloyd Kahn Method

6.2.2 Data Quality

URS Corporation performed manual data validation of all soil and groundwater analytical results for the RI. The validation was performed in accordance with *Region III Modifications to the National Functional Guidelines for Organic Data Review (September 1994), Region III Modifications to the Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analysis (April 1993), and Region III Innovative Approaches to Data Validation (June 1995).*

2003 Sampling Event Data

Based on the data validation results, the data generated for the site were considered acceptable. However, two major problems associated with severe QC exceedences from the analytical methods were encountered, which have a serious effect on the usability of some of the data. The major problems and their overall impact on the data usability are discussed below.

- *Major Problem 1*: The VOC continuing calibrations (CCAL) associated with the groundwater samples (plus field QC blank) exhibited a low (i.e., <0.05) relative response factor for acetone. The non-detect acetone results for all groundwater samples (except GW-MW-117) and field QC blanks were rejected ("R"), while the detected acetone result for GW-MW-117 was qualified as biased low ("L").
    - *Impact on RI Outcome: Minimal.* The Method Detection Limit and Sample Quantitation Limit for Acetone are two to three orders of magnitude below screening criteria. Furthermore, acetone was not a target constituent of concern prior to beginning the investigation.
- *Major Problem 2*: The SVOC CCAL associated with several soil and groundwater samples exhibited a low (i.e., <0.05) relative response factor for atrazine. The non-detect atrazine results for all affected soil, groundwater, and equipment rinsate blank samples were rejected ("R").
    - *Impact on RI Outcome: Minimal.* Atrazine was not a target constituent of concern prior to beginning the investigation, and there is no reason to suspect its presence.

In addition, several minor problems were also identified and are summarized in the QCS/AR Report for the 80th DRS. However, no data was rejected for the minor problems.

2004 Sampling Event Data

Based on the data validation results, the data generated for the site were considered acceptable. However, one major problem associated with severe QC exceedences from the analytical methods was encountered, which have a serious effect on the usability of some of the data. The major problem and its overall impact on the data usability are discussed below.

- *Major Problem*: The VOC continuing calibration (CCAL) performed on 6/23/04 exhibited a low (i.e., <0.05) relative response factor for acetone. The non-detect acetone results for all groundwater samples (except for MW-03 and MW-07 which were not associated with this CCAL) were rejected ("R").
    - *Impact on RI Outcome: Minimal.* The Method Detection Limit and Sample Quantitation Limit for Acetone are two to three orders of magnitude below screening

criteria. Furthermore, acetone was not a target constituent of concern prior to beginning the investigation.

In addition, several minor problems were also identified and are summarized in the QCS/AR Report for the 80th DRS. However, no data was rejected for the minor problems.

6.2.3 Statistical Evaluation Data

The 95th percent Upper Confidence Limit (UCL) of the arithmetic mean was calculated for COPCs in the onsite soils and groundwater. A detailed description of the methodology used to calculate background and on-site data is provided in **Section 6.4.5**. The statistical analysis of each metal is also provided in **Appendix D**.

6.2.4 Evaluation of Essential Nutrients

A screening process to reduce the list of chemicals of potential concern is the evaluation of essential human nutrients. Chemicals that are essential nutrients, present at low concentrations (e.g., only slightly above background), and are toxic only at very high doses need not be considered further in the quantitative risk assessment. Chemicals typically considered as essential nutrients include calcium, iron, magnesium, potassium, and sodium. Nutritional requirements, typical intakes, and toxic levels for the five identified essential nutrients are presented below.

Calcium

Calcium is the most abundant mineral in the human body. Ninety nine percent of the body's calcium is located in the teeth and bones. Calcium is needed to form bones and teeth and is also required for blood clotting, transmission of signals in nerve cells, and muscle contraction. The important of calcium for preventing osteoporosis is probably its most well-known role. The National Academy of Sciences has established guidelines for calcium that are 25 to 50 percent higher than previous recommendations. For ages 19 to 50, calcium intake is recommended to be 1,000 mg daily; for adults over age 51, the recommendation is 1,200 mg daily.

Constipation, bloating, and gas are sometimes reported with the use of calcium supplements. People with hyperparathyroidism or chronic kidney disease should not supplement with calcium without consulting a physician. High doses of calcium can inhibit the absorption of iron, zinc, phosphorus, and magnesium. Toxicity data for high-level consumption or exposure to calcium is not well defined. However, for safety sake, the upper limit is set at 2,500 mg daily.

Iron

Iron is part of hemoglobin, the oxygen-carrying component of the blood. Iron-deficient people tire easily because their bodies are starved for oxygen. Iron is also part of myoglobin, which helps muscle cells store oxygen. Without enough iron, ATP (the fuel the body runs on) cannot be properly

synthesized. As a result, some iron-deficient people become fatigued even when their hemoglobin levels are normal. If a physician diagnoses iron deficiency, iron supplementation is essential. A common recommended amount for an adult is 100 mg daily. The recommended daily intake for the average person (without an iron deficiency) is 10 mg for children ages 1 to 10: 12 mg for males ages 11 to 18: 10 mg for males ages 19 and over; 15 mg for females ages 11 to 50; and 10 mg for females ages 51 and over.

Iron (ferrous sulfate) is the leading cause of accidental poisonings in children. Death in children has occurred from ingesting as little as 200 mg to as much as 5.85 grams of iron. Some researchers have linked excess iron to diabetes, cancer, heart disease, systemic lupus, and increased risk of infection.

Magnesium

Magnesium is needed for bone, protein, and fatty acid formation, making new cells, activating B vitamins, relaxing muscles, clotting blood, and forming ATP. Insulin secretion and function also require magnesium. Magnesium also acts in a way related to calcium channel blocker drugs and this may be responsible for the fact that under certain circumstances, magnesium has been found to potentially improve vision in people with glaucoma and to lower blood pressure. Most people do not consume enough magnesium. Many doctors recommended 250 to 350 mg daily for adults.

Taking too much magnesium often leads to diarrhea. For some people, this can happen with amounts as low as 350 to 500 mg per day. Problems that are more serious can develop with excessive magnesium intake from laxatives.

Potassium

Potassium is needed to regulate water balance, levels of acidity, blood pressure, and neuromuscular function, including a critical role in transmission of electrical impulses in the heart. Potassium is also required for carbohydrate and protein metabolism. The recommended daily dose of potassium for ages 4 to adults is 3,500 mg.

High potassium intake (several hundred milligrams at one time in tablet form) can produce stomach irritation. However, a diet rich in potassium from food is unlikely to be a problem for healthy individuals because excesses are typically eliminated from your body. However, individuals with kidney disease may have to watch the amount of potassium in their diet.

Sodium

Sodium is the principal cation in the extracellular fluid and assists in regulating the membrane potential across cells. A comprehensive review of the evidence suggests that, as part of a overall healthy diet, no more than 2,400 mg of sodium should be consumed daily. A diet high in sodium increases the risk of heart disease-related mortality in overweight individuals.

With the exception of Iron, none of the essential nutrients will be carried forward and evaluated further in this HHRA, as they are not considered hazardous to human health. Iron, however, will be carried forward into this report and evaluated further due to its potentially health affects in children.

6.3 HAZARD IDENTIFICATION

Twenty-two groundwater, ten surface soil, and twenty subsurface soil samples were collected from this site and analyzed for TCL VOCs, TCL SVOCs, TCL organochlorine pesticides/PCBs, and TAL metals. The data are presented in **Tables 4-3 through 4-7**.

Also provided are the Hazard Assessment tables (**Tables 6-1 through 6-3**), which contain a summary of the data including the frequency and the range of detections for each chemical with detections over the method detection limit. Also included in **Tables 6-1 through 6-3** is a comparison of the detections with selected screening criteria [i.e., EPA Region III RBCs and USEPA drinking water Maximum Contaminant Levels (MCLs)], and the USEPA weight-of-evidence classification for known or suspected human carcinogens, to facilitate the hazard identification.

The EPA Region III RBCs for industrial soils, residential soils and tap water for non-carcinogenic compounds have been adjusted to a hazard quotient of 0.1 by dividing them by a factor of ten. The RBCs were established for single contaminant exposure situations, however, because multiple contaminants have been detected for each matrix (groundwater and soil), the RBCs have been adjusted. Chemicals of potential concern (COPCs) are identified on the hazard identification tables through the following two annotations:

- **Yes** indicates that the maximum concentration of the compound exceeded the screening criteria and will be retained for further quantitative analysis, and

- **Qual** indicates that the compound was detected but no screening criteria are available and it will be evaluated qualitatively in the risk assessment.

Emphasis is given in the ensuing evaluation to chemical contamination in the soil throughout the site, and groundwater underlying the site as these environmental media are regarded as having the greatest potential for human contact. Chemicals and metals in subsurface soils are discussed in the context of the potential for exposure from future excavation of these soils and potential degradation of groundwater from leaching.

6.3.1 Surface Soils

Surface soil samples were collected from 10 locations at the site and site periphery to evaluate potential exposure to surface soils. Surface soil analytical data were compared to EPA Region III RBCs for industrial and residential soils, as shown in **Tables 4-3 through 4-6**.

Surface (0-.5 feet bgs) soil samples were from various locations around the site. The locations are summarized on **Table 2-2**.

VOCs

Twenty-one VOCs were detected in Site surface soil samples. Of these 21 compounds, the three most common compounds detected were methylene chloride (detected in 9 of 10 samples), toluene (detected in 8 of 10 samples), and acetone (detected in 6 of 10 samples); however, the EPA Region III RBCs for all the detected VOCs were not exceeded in the samples and therefore, they have not been selected as COPCs.

SVOCs

Twenty-three SVOCs were detected in surface soil samples from the site. Of these 23 constituent detections, the more frequently detected compounds included: bis(2-EH)phthalate detected in 8 of 10 samples; as well as benzo(a)pyrene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, and fluoranthene each detected in 7 of 10 samples. Of these detected constituents, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenzo(a,h)anthracene exceeded both EPA Residential and Industrial Soil RBCs in several samples; and indeno(1,2,3-cd)pyrene exceeded the Residential Soil RBC; therefore, these five SVOCs are retained as COPCs.

Pesticides

Eleven pesticides were detected in surface soil samples from the site. Of these 11 constituent detections, the more frequently detected compounds included: endrin ketone, detected in 5 of 10 samples; as well as endosulfan sulfate and 4,4'-DDT each detected in 3 of 10 samples. Of these detected constituents, only aldrin exceeded the EPA Residential Soil RBC in 1 of 10 samples; and is therefore retained as a COPC.

PCBs

No PCBs were detected in surface soil samples.

Inorganics

Twenty inorganic constituents were detected in surface soil samples from the site. However, only three of these inorganic constituent's (arsenic, iron, and vanadium) concentrations exceeded screening criteria; and are discussed below.

- Arsenic exceeded the residential soil criteria in 7 of 10 samples, but did not exceed the industrial screening criteria. Arsenic will be retained as a COPC at this time.

- Iron exceeded the residential RBC of 2,300 mg/kg in 6 of the 10 surface soil samples

collected at the site. Iron will be retained as a COPC at this time.

- Vanadium exceeded the residential RBC of 7.8 mg/kg in 3 of the 10 surface soil samples collected at the site. Vanadium will be retained as a COPC at this time.

6.3.2 Combined Surface and Subsurface Soils

Thirty soil samples were collected from 10 soil borings at the site to evaluate potential exposure to surface and subsurface soils (i.e., future excavation activities for development would potentially involve subsurface soils becoming exposed to the surface). Surface/subsurface soil analytical data were compared to EPA Region III RBCs for industrial and residential soils, as shown in **Table 6-2**.

Surface (0-0.5 feet bgs) and subsurface (1-3 feet and 4-6 feet bgs) soil samples were from the following 10 borings around the site. The locations are summarized on **Table 2-2**.

VOCs

Twenty-one VOCs were detected in Site soil samples. Of these 21 compounds, the three most common compounds detected were toluene (detected in 28 of 30 samples), methylene chloride (detected in 26 of 30 samples), and acetone (detected in 26 of 30 samples); however, the EPA Region III RBCs for all the detected VOCs were not exceeded in the samples and therefore, they have not been selected as COPCs.

SVOCs

Twenty-six SVOCs were detected in soil samples from the site. Of these 26 constituent detections, the more frequently detected compounds included: bis(2-EH)phthalate, detected in 27 out of 30 samples; fluoranthene, detected in 21 of 30 samples; as well as benzo(g,h,i)perylene, phenanthrene, and pyrene, each detected in 20 of 30 samples. Of these detected constituents, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenzo(a,h)anthracene exceeded both EPA Residential and Industrial Soil RBCs in several samples; and indeno(1,2,3-cd)pyrene exceeded the Residential Soil RBC; therefore, these five SVOCs are retained as COPCs.

Pesticides

Sixteen pesticides were detected in soil samples from the site. Of these 16 constituent detections, the more frequently detected compounds included: endrin ketone, detected in 17 of 30 samples; 4,4'-DDT, detected in 8 of 30 samples; as well as endosulfan sulfate, detected in 7 of 30 samples. Of these detected constituents, only aldrin exceeded the EPA Residential Soil RBC in 1 of 30 samples; and is therefore retained as a COPC.

PCBs

Only one PCB (Aroclor 1260) was detected in 2 of the 30 soil samples obtained from the site. However, the concentrations of Aroclor 1260 did not exceed the screening criteria, and therefore it was not retained as a COPC.

Inorganics

Twenty-two inorganic constituents were detected in soil samples from the site. However, only three of these inorganic constituent's (arsenic, iron, and vanadium) concentrations exceeded screening criteria; and are discussed below.

- Arsenic exceeded the residential soil criteria in 8 of 30 samples, but did not exceed the industrial screening criteria. Arsenic will be retained as a COPC at this time.
- Iron exceeded the residential RBC of 2,300 mg/kg in 6 of the 30 soil samples collected at the site. Iron will be retained as a COPC at this time.
- Vanadium exceeded the residential RBC of 7.8 mg/kg in 3 of the 30 surface soil samples collected at the site. Vanadium will be retained as a COPC at this time.

6.3.3 Groundwater

Groundwater quality data are summarized in **Table 6-3** along with EPA Maximum Contaminant Levels (MCLs) and Action Levels, and EPA RBC for Tap Water. Groundwater samples were collected from 10 monitoring wells in 2003 and from 12 monitoring wells (10 existing and 2 new wells) in 2004 to assess the lateral and vertical extent of contamination in the Columbia Aquifer (water table aquifer). The groundwater samples were analyzed for VOCs, SVOCs, pesticides, PCBs, as well as total and dissolved metals.

Several constituents were detected in the groundwater samples collected at the site. **Table 6-3** provides the analytical results for the groundwater samples collected at the site. A combined VOC dataset (2003 plus 2004 data) of 22 samples for the VOCs is presented in **Table 6-3**. Only those constituents detected are presented.

VOCs

Five VOCs were detected in groundwater samples from the site: cis 1,2-dichloroethene ([cis 1,2-DCE] detected in 3 of 22 samples), tetrachloroethene ([PCE] detected in 7 of 22 samples), toluene (detected in 10 of 22 samples), trichloroethene ([TCE] detected in 5 of 22 samples), and 1,2,4-trichlorobenzene (detected in 1 of 22 samples). PCE and TCE were both detected above both their EPA RBCs and MCLs while cis 1,2-DCE was detected above its RBC only. Therefore, cis 1,2-DCE, PCE, and TCE will be retained as COPCs for further evaluation.

Semivolatile Organic Compounds

Bis(2-ethylhexyl)phthalate was detected in one of ten samples at a concentration above its RBC. Therefore, bis(2-ethylhexyl)phthalate will be retained as a COPC for further evaluation.

Pesticides

No pesticides were detected over the detection limit in the groundwater samples collected.

Polychlorinated Biphenyls

No polychlorinated biphenyls (PCBs) were detected over the detection limit.

Total Metals

- Total metals were detected in all the groundwater samples collected at the site. A summary of the total metal results detected above EPA screening criteria is discussed below.
  Total antimony exceeded its MCL of 6 ug/l in 1 out of 10 samples while it exceeded its EPA tap water RBC of 1.5 ug/l in 8 out of 10 samples. Thus, total antimony is retained as a COPC.

- Total arsenic exceeded the EPA RBC of 0.045 ug/l in 3 of 10 samples but did not exceed its MCL of 10 ug/l in any samples. No other samples exceeded the detection limit for arsenic. However, to maintain a conservative approach, total arsenic will be retained as a COPC at this time.

- Total iron was detected in all groundwater samples. While total iron has no primary MCL, the EPA RBC of 1,100 ug/l was exceeded in 4 of 10 samples. Thus, total iron is retained as a COPC.

- Total manganese was detected in all groundwater samples, and it exceeded the EPA RBC of 73 ug/l in 2 of the 10 samples. Thus, to maintain a conservative approach, total manganese will be retained as a COPC at this time.

- Total vanadium was detected in 9 of 10 groundwater samples, and it exceeded the EPA RBC of 3.7 ug/l in 3 of the 10 samples. Thus, to maintain a conservative approach, total vanadium will be retained as a COPC at this time.

Dissolved Metals

Dissolved metals were detected in all the groundwater samples collected at the site. A summary of the dissolved metal results detected above EPA screening criteria is discussed below.

- Dissolved arsenic exceeded the EPA RBC of 0.045 ug/l in 2 of 10 samples but did not exceed its MCL in any samples. In addition, no other samples exceeded the detection limit for arsenic. Thus, dissolved arsenic will be retained as a COPC at this time.

- Dissolved iron was detected in all groundwater samples, and while dissolved iron has no primary MCL, the EPA RBC of 1,100 ug/l was exceeded in 3 out of 10 samples. Thus, dissolved iron will be retained as a COPC at this time.

- Dissolved manganese was detected in all groundwater samples, and it exceeded the EPA RBC of 73 ug/l in 2 of the 10 samples. Thus, to maintain a conservative approach, dissolved manganese will be retained as a COPC at this time.

- Dissolved vanadium was detected in 10 of 10 groundwater samples, and it exceeded the EPA RBC of 3.7 ug/l in only 1 of the 10 samples. Thus, to maintain a conservative approach, dissolved vanadium will be retained as a COPC at this time.

The detections of total and dissolved metal above the EPA MCLs or RBCs are presented on **Table 6-3.**

6.3.4 Chemicals of Potential Concern

COPC identified during the hazard identification are provided in **Table 6-1** (surface soil), **6-2** (combined soil), and **6-3** (groundwater). Potential risk associated with the COPC will be further evaluated in the exposure assessment section.

6.4 EXPOSURE ASSESSMENT

The objective of the exposure assessment is to estimate the type and magnitude of exposures to the COPCs that are present at or migrating from the site.

6.4.1 Potentially Exposed Populations

As part of the exposure assessment, it is important to characterize the potentially exposed populations at or near the site with regard to the current situation and potential future conditions.

Current Situation

The 80th DRS area contains a 50-foot by 70-foot concrete pad surrounded by asphalt on the west, south, and east sides. The north side is bordered by sand that was used as the DRS staging area. Over time, this staging area apparently became contaminated with by-products (primarily petroleum products) of the washing and maintenance operations. A 1,000 gallon used oil UST, 250-gallon antifreeze aboveground storage tank (AST), and a former drum storage area were located west of

the wash pad. While Fort Story has numerous residential dwellings, there are no residential sites within one mile of the 80th DRS. Additionally; the land use in the immediate vicinity is best classified as industrial usage.

Soil

The majority of the site is covered with asphalt pavement; however, smaller portions of the site consist of bare sandy soil. Thus, there is a potential for a site worker to contact soil; therefore, in keeping with the conservative nature of this document, the Fort Story Site Worker will be retained for further evaluation. Furthermore, it will be assumed that the worker will be exposed to surface soils only in order to reflect current site conditions.

During construction, both surface and subsurface soils would be disturbed exposing the construction worker to the constituents present in the soils, therefore, a construction worker exposure scenario will be retained for further evaluation.

Groundwater

At present, there are no potable wells or irrigation wells in the immediate vicinity of the site. As discussed in Section 3.1.5, there are several off-post residential communities that may be utilizing groundwater as potable water; however they are located over 1 mile west of the site and groundwater at the site flows northward towards the Chesapeake Bay. Under the current situation, because there are no nearby drinking water wells and groundwater does not appear to be impacting any surface water, exposure to contaminated groundwater from residential populations will not be evaluated.

Because there are no buildings located over the groundwater plume, vapor intrusion is not a reasonable exposure scenario at this site and will not be evaluated further for current land use.

During construction, there is the potential for exposing the construction worker to the constituents present in the groundwater; therefore, a construction worker exposure scenario will be retained for further evaluation.

Future Land Use

Based on master planning issues for Fort Story, as well as its unique location and subsequent training environs, the facility is expected to remain government property The potential for future development of the land as commercial, residential, or recreational properties is not expected as the base will remain open and the area will continued to identified as industrial usage; however, If development of the site occurred in the future, commercial/industrial worker exposure to groundwater would be possible via inhalation only, where indirect exposure to VOC vapors could occur through migration from groundwater into structures. This scenario has been retained to maintain a conservative approach.

If land use conditions change in the future, possible exposure scenarios (e.g., residential exposure to soils and groundwater if residential development was planned) will be re-evaluated.

The 95th UCL for the detected VOCs with hits above EPA RBCs for tap water including cis 1,2-DCE (3.1 µg/L), PCE (2.9 µg/L), and TCE (2.5 µg/L) were all below these compounds respective MCLs. Based on the low concentrations of VOCs detected at the site, it is highly unlikely that a risk would result from vapor intrusion; therefore, an assessment of the potential for vapor intrusion into buildings that may be constructed at the site in the future is not warranted at this time.

Figure 6-1 presents a conceptual site model that demonstrates the current and potential future uses of the site and shows the complete exposure pathways.

Potential Exposed Populations Summary

The following potentially exposed populations to the contaminated media at the site have been identified:

- Fort Story Site Workers exposure (adults only) to contaminated surface soils during Site maintenance. Identified as a current and future land use population.
- Construction worker exposure (adults only) to contaminated surface/subsurface soils. Identified as a current and future land use population.
- Construction worker exposure (adults only) to contaminated groundwater. Identified as a current and future land use population.
- Commercial/industrial worker exposure to vapors in structured from groundwater via volatization.

However, for this HHRA, as the exposure scenarios are so similar, site industrial workers and Fort Story site workers will be considered as the same receptor population. This scenario will consider exposure to surface soils at the site only. As the COPC exposure concentrations in surface soils are greater than, or equal to, the exposure concentrations of the combined surface/subsurface data set, this is a conservative assumption.

Because only industrial exposure scenarios (site and construction worker) are to be evaluated for site soils, several originally identified COPCs including indeno(1,2,3-cd)pyrene, aldrin, aluminum, arsenic, iron, and vanadium will not be retained because they only exceeded the residential soil RBCs and did not exceed the industrial soil RBCs.

6.4.2 Exposure Pathways

The potential exposure pathways of concern at the site include:

Industrial Site Workers (Adults)

- Ingestion of chemicals in surface/subsurface soil
- Dermal contact with chemicals in surface/subsurface soil
- Inhalation of particulates from surface/subsurface soil

Construction Workers (Adults)

- Ingestion of chemicals in surface/subsurface soil
- Dermal contact with chemicals in surface/subsurface soil
- Inhalation of particulates from surface/subsurface soil
- Ingestion of chemicals in groundwater
- Dermal contact with chemicals in groundwater
- Inhalation of volatile chemicals in groundwater

Commercial/Industrial Workers (Adults)

- **Inhalation of volatile chemicals in groundwater**

6.4.3 Data Limitations and Uncertainties

The limitations and uncertainties associated with the analytical data for the site were reviewed during data validation to ensure that appropriate and reliable data are selected for use in estimating human exposure.

Samples and their duplicates are not considered as separate sampling events. Rather a chemical-specific value representing the maximum value of the sample and its duplicate is used. This may result in a conservative estimate of exposure. However, since relatively few duplicate samples were collected, the overall impact on risk estimates should be minimal.

For purposes of this HHRA, if a COPC was not detected in a sample, it is assumed to be present at 1/2 the sample quantitation limit (SQL). Adjusting non-detects by assigning values at 1/2 the chemical-specific SQL is a highly conservative approach that assumes a chemical is present at concentrations typically greater than the method detection limit (MDL), even though the constituent has not been detected above the MDL. This approach would tend to greatly overestimate the risk.

In this evaluation, data which were qualified by indicating that the numerical values are estimated quantities (those organics with a "J" qualifier and those metals with a "B" qualifier) are treated in this evaluation the same as data without this qualifier.

6.4.4 Estimates of Constituent Intake

Evaluation of the exposure pathways described above involves the estimation of several parameters

such as skin surface area available for contact; skin permeability factors; exposure time, frequency, and duration; soil-to-skin adherence factors; ingestion rates; as well as the constituent concentrations in the specific media of concern. **Table 6-4** represents a general equation for calculating chemical intakes (chronic daily intakes or CDI) and defines the intake variables in terms of chemical-related, population-related, and evaluation-determined parameters.

6.4.5 Estimates of Reasonable Maximum Exposures

The USEPA recommends that estimates of constituent intake be developed to portray reasonable maximum exposures (RME), which might be expected to occur under current and future site conditions. Accordingly, the highest exposure that might reasonably be expected to occur at the site, one that is well above the average case of exposure but within the range of possibility, should be considered.

The sample data obtained are only "snapshots" of contamination over the site and its surroundings. In order to determine the constituent concentrations to which one might be exposed over many years, it is necessary to evaluate the entire data set in order to develop "representative" concentrations. In many instances, environmental data sets are skewed such that the normal distribution is not a suitable model for estimating parameters such as means, proportions, confidence limits, etc. The USEPA (USEPA 1989a) recommends that the upper confidence limit [i.e., the upper confidence limit (UCL)] on the mean of all the data should be used for evaluating RMEs. The 95th UCL of the arithmetic mean will be calculated and used as the reasonable concentration.

Three types of confidence limits are available: parametric, log-normal, and non-parametric. The type of confidence limit that will be applied depends upon the data distribution of the constituent being evaluated (e.g., normal [parametric], log-normal, and non-normal [non-parametric]). Statistical limits for each constituent data set were employed as detailed below by the following procedures.

1. Initially, all data sets are assumed normally distributed, and the following steps were completed.

    - The assumption of normality of the data was tested using the Shapiro-Wilk Test of Normality.

    - If the data set was determined to be normally distributed (by passing the normality test), a Parametric Confidence Limit was calculated using the ProUCL data program.

2. If the data set initially failed the Test of Normality, the following steps were followed.

    - All data was converted to natural logarithms.

    - The log-adjusted data was then tested for normality using the Shapiro-Wilk Test of Normality.

    - If the log-adjusted data was determined to be normally distributed (by passing the normality test), the data set was said to be log-normally distributed.

- A lognormal confidence limit was applied to the lognormal data sets using the ProUCL program, selecting the highest calculated UCL from three different methods (95% H-UCL, 95% Chebyshev, and 99% Chebyshev) as the final UCL.

3. If the data set was neither normally distributed nor log-normally distributed the following steps were followed.

- The data set was said to be distribution-free (non-parametric or non-normal).
- A non-parametric confidence limit was applied to the distribution-free data sets.
- The ProUCL data program was utilized to determine the 95th percentile non-parametric UCL using five different methodologies (CLT, Jacknife, Standard Bootstrap, Bootstrap t, and Chebyshev). The highest of the five 95th non-parametric UCLs calculated was then selected as the final UCL established (provided this value was less than the maximum, if not, the second highest UCL was selected as the final UCL).

As described previously, for all samples in which the COPC is not detected, a value of 1/2 the SQL for that chemical was assigned. Depending upon the number of non-detects and variability in measured concentrations, the UCL on the mean concentration may exceed the maximum detected value. Since exposure to chemicals having concentrations greater than the maximum detected value is not feasible, the maximum concentration is used to determine the exposure when the UCL concentration is greater than the maximum concentration. This approach is also consistent with USEPA guidance (USEPA, 1989a) and may be considered a conservative approach to exposure assessment. As reported in the USEPA document, "Supplemental Guidance to RAGS: Calculating the Concentration Term", data sets with fewer than 10 samples per exposure area provide poor estimates of the mean concentration, however, EPA Region III has stated through reviews of previous risk assessments conducted at USACE sites that UCL calculations can be conducted for data sets of three samples or greater. The calculated UCLs are provided in **Appendix D**.

Soil Exposure Estimations

Only surface soil data (0- to 0.5-foot depth) was utilized for the site worker exposures while a combination of surface (0- to 0.5-foot depth) and subsurface (data from 1- to 6-foot depth) were combined and used to estimate exposures for the construction worker population (both current and future) identified in **Sections 6.4.1 and 6.4.2**, as if the site were developed, surface and subsurface soils could be mingled and brought to the surface. Additionally, COPCs in both surface and subsurface soils were selected based on detections greater than the EPA RBCs for industrial soils since only industrial and construction workers were identified as potentially exposed populations. The COPCs in soils include benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenzo(a,h)anthracene. The estimated exposure concentrations for surface soils and combined surface/subsurface soils are summarized in the following tables:

SUMMARY OF SURFACE SOIL EXPOSURE ESTIMATIONS		
COPC	**95 Percentile UCL or Maximum**	**Estimated Exposure Concentration (mg/kg) (Surface Soil)**
Benzo(a)anthracene	UCL	4.83
Benzo(a)pyrene	UCL	4.81
Benzo(b)fluoranthene	UCL	6.24
Dibenzo(a,h)anthracene	UCL	1.03
SUMMARY OF COMBINED SOIL EXPOSURE ESTIMATIONS		
COPC	**95 Percentile UCL or Maximum**	**Estimated Exposure Concentration (mg/kg) (Combined Soils)**
Benzo(a)anthracene	UCL	3.42
Benzo(a)pyrene	UCL	3.32
Benzo(b)fluoranthene	UCL	4.41
Dibenzo(a,h)anthracene	UCL	0.55

Groundwater Exposure Estimations

As previously stated, the Construction Worker (Adult) Population has been determined to have a potential for exposure to groundwater through ingestion, contact, and inhalation of volatiles. The Commercial/Industrial Worker (Adult) population in potential future structures has been determined to have a potential exposure to groundwater through inhalation of volatiles only. Therefore, exposure estimations will only be calculated for these populations.

The construction worker's exposure to groundwater would be best represented by total inorganics groundwater data. Therefore, this HHRA will apply total (unfiltered) inorganics data for exposure of future construction workers.

Data from monitoring wells MW-1 through MW-3 and MW-5 through MW-11 have been used to calculate exposure concentrations. Furthermore, in keeping with USEPA Region III Guidance, COPCs in groundwater were selected based on detections greater than the EPA RBCs and/or MCLs for Tap/Drinking Water. The COPCs in groundwater greater than the screening criteria include tetrachloroethene, trichloroethene, bis(2-ethylhexyl) phthalate, total antimony, total arsenic, total iron and total manganese. The estimated exposure concentrations are summarized below:

SUMMARY OF GROUNDWATER EXPOSURE ESTIMATIONS		
COPC	95 Percentile UCL or Maximum	Estimated Exposure Concentration (mg/l)
Cis 1,2-DCE	UCL	0.0031
PCE	UCL	0.0029
TCE	UCL	0.0025
Bis(2-ethylhexyl) phthalate	UCL	0.0050
Total Antimony	UCL	0.0044
Total Arsenic	UCL	0.0052
Total Iron	UCL	2.63
Total Manganese	UCL	0.089
Total Vanadium	UCL	0.0035

6.4.6 Parameters and Assumptions in Assessing Exposures

Fort Story/Industrial Site Worker (Adults)

Soils

Tables 6-5, 6-6, and 6-7 present the parameters and assumptions used in assessing exposures for Fort Story site workers to chemicals in soil through ingestion, dermal contact, and inhalation of soil particulates. The following summarizes the assumptions made for exposure to chemicals in soil through ingestion, dermal contact, and inhalation of soil particulates:

Ingestion

- In evaluating inadvertent ingestion of soil (as might result from hand-to-mouth behavior), an ingestion rate of 100 mg/day of soil per day for outdoor site workers (such as groundskeepers) has been assumed (EPA, 2001b).

- The "fraction ingested" (FI) is defined as the fraction ingested from a particular source. For this analysis, it is assumed that 100 percent of the incidental exposure is presumed to come from this scenario as per VDEQ Voluntary Remediation Program (VRP) exposure factors.

- The exposure frequency (EF) for site workers is assumed to be 250 days/year (VDEQ, 2003).

- For workers on the site, an exposure duration (ED) of 25 years is assumed (USEPA, 1995).

- The average body weight (BW) of an American adult is approximately 70 kg (USEPA, 1991).

- The averaging time (AT) selected depends upon the type of toxic effect being assessed as described as follows:

  - When evaluating exposures for potential long-term non-cancer health effects, intakes are calculated by averaging over the period of exposure. This, in effect, is equal to the exposure duration multiplied by 365 days/year.
  - When evaluating potential carcinogenic risks, intakes are calculated by prorating the total cumulative dose over a lifetime. For calculation purposes, this is equal to 70 years multiplied by 365 days/year.

This distinction is consistent with the hypothesis that the mechanism of action for each of these effects is different. The approach for carcinogens is based on the assumption that a high dose received over a short period of time is equivalent to a corresponding low dose spread over a lifetime.

Dermal Contact

The value recommended by VDEQ (2003) for available skin surface area is 800 cm^2/day.

- The value cited as the 50th percentile for skin surface area for males and females with exposed hands, forearms, feet, lower legs, and head exposed is 3,300 cm^2 (VDEQ, 2003).

- The soil to skin adherence factor (AF) used is 0.20 mg/cm^2 based on VDEQ (2003) recommendation.

- For the dermal contact with soil pathway, the absorption factor (ABS) is 13% for PAHs (USEPA, Region III, 1995).

- The exposure frequency, exposure duration, body weight, and averaging time values are the same as those used for the ingestion pathway.

Inhalation of Soil Particulates

- For the evaluation of inhalation of soil particulates, the constituent concentration in air is calculated using the methodology for the Particulate Emission Factor as provided in *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (EPA, 2001c), using default parameters. All calculations are provided in **Appendix E**.

- An inhalation rate (IR) of 1.6 m^3/hour for site workers is assumed in evaluating the inhalation of chemicals in air due to soil particulate suspension (USEPA, 1997).

- Exposure time (ET) for the inhalation pathway is estimated as 8 hours/day for adults based

upon a standard work day.

- The exposure frequency, exposure duration, body weight and averaging time values are the same as those used for the ingestion pathway.

Construction Workers (Adults)

Soils

Tables 6-8, 6-9, and 6-10 present the parameters and assumptions used in assessing exposures for potential future construction workers to chemicals in soil through ingestion, dermal contact, and inhalation of particulates. The following summarizes the assumptions made for exposure to chemicals in soil through ingestion, dermal contact, and inhalation of soil particulates:

Ingestion

- In evaluating inadvertent ingestion of soil (as might result from hand-to-mouth behavior), a conservative ingestion rate of 480 mg of soil/day is assumed, as per VDEQ, 2003.

- The "fraction ingested" (FI) is defined as the fraction ingested from a particular source. For this analysis, it is assumed that 50 percent of the incidental exposure is presumed to come from this scenario (VDEQ, 2003).

- The exposure frequency (EF) for construction workers is assumed to be 125 days/year (VDEQ VRP Exposure Factors).

- For workers on the site, an exposure duration (ED) of one year is assumed based upon professional judgment.

- The average body weight (BW) of an American adult is approximately 70 kg (USEPA, 1991).

- The averaging time (AT) selected depends upon the type of toxic effect being assessed as described as follows:

    - When evaluating exposures for potential long-term non-cancer health effects, intakes are calculated by averaging over the period of exposure. This, in effect, is equal to the exposure duration multiplied by 365 days/year.

    - When evaluating potential carcinogenic risks, intakes are calculated by prorating the total cumulative dose over a lifetime. For calculation purposes, this is equal to 70 years multiplied by 365 days/year.

This distinction is consistent with the hypothesis that the mechanism of action for each of these effects is different. The approach for carcinogens is based on the assumption that a high dose received over a short period of time is equivalent to a corresponding low dose spread over a lifetime.

Dermal Contact

- The value cited as the 50th percentile for skin surface area for males and females with exposed hands, forearms, feet, lower legs, and head is 3,300 cm^2 (VDEQ, 2003).

- The soil to skin adherence factor (AF) used is 0.90 mg/cm^2 based upon the 95th percentile for construction workers doing utilities-related work (VDEQ VRP Factors). This is a reasonable assumption as the individual workers mostly likely to be in intimate contact with soil for the most prolonged period would utilities workers.

- For the dermal contact with soil pathway, the absorption factor (ABS) is 13% for PAHs (USEPA, Region III, 1995).

- The exposure frequency, exposure duration, body weight and averaging time values are the same as those used for the ingestion pathway.

Inhalation of Soil Particulates

- For the evaluation of inhalation of soil particulates, the constituent concentration in air is calculated using the methodology for the Particulate Emission Factor (PEF) as provided in *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (EPA, 2001c). The PEF is calculated using default parameters and assumptions regarding vehicular traffic on the site during construction. Dust generated by vehicular traffic would be the greatest source of airborne constituents in this case, as most constituents are confirmed to the surface (or near surface) soils. In addition, site activities such as excavation, grading, bull dozing, and wind erosion of exposed soils may generate soil particulate emissions. All calculations are provided in **Appendix E**.

- An inhalation rate (IR) of 2.5 m^3/hour for construction workers is assumed in evaluating the inhalation of chemicals in air due to soil particulate suspension (VDEQ, 2003).

- Exposure time (ET) for the inhalation pathway is estimated as 4 hours/day for adults based VDEQ, 2003.

The exposure frequency, exposure duration, body weight and averaging time values are the same as those used for the ingestion pathway.

Groundwater

Tables 6-11, 6-12, and 6-13 present the parameters and assumptions used in assessing exposures for potential future construction workers to chemicals in groundwater through ingestion, dermal contact, and inhalation of volatiles. The following summarizes the assumptions made for exposure to chemicals in groundwater through incidental ingestion, dermal contact, and inhalation of vapors from groundwater:

Incidental Ingestion

- In evaluating inadvertent ingestion of groundwater, an ingestion rate of 0.02 liters/day based on VDEQ, 2003.
- The exposure frequency (EF) for construction workers is assumed to be 125 days/year (VDEQ VRP Exposure Factors).
- For workers on the site, an exposure duration (ED) of one year is assumed based upon professional judgment.
- The average body weight (BW) of an American adult is approximately 70 kg (USEPA, 1991).
- The averaging time (AT) selected depends upon the type of toxic effect being assessed as described as follows:
    - When evaluating exposures for potential long-term non-cancer health effects, intakes are calculated by averaging over the period of exposure. This, in effect, is equal to the exposure duration multiplied by 365 days/year.
    - When evaluating potential carcinogenic risks, intakes are calculated by prorating the total cumulative dose over a lifetime. For calculation purposes, this is equal to 70 years multiplied by 365 days/year.

This distinction is consistent with the hypothesis that the mechanism of action for each of these effects is different. The approach for carcinogens is based on the assumption that a high dose received over a short period of time is equivalent to a corresponding low dose spread over a lifetime.

Dermal Contact

- The value cited as the 50th percentile for skin surface area for males with exposed hands, forearms, feet, lower legs, and head is 3,300 cm^2 (VDEQ, 2003).
- It is assumed that the event frequency will be once per day based upon USEPA Guidance (1992b).

- Since the calculated exposure is designed to be the absorbed dose, not the amount of chemical that comes into contact with the skin, a permeability constant (PC) is necessary to access exposure through dermal contact. The PC reflects movement across the skin to the underlying skin layers and into the bloodstream. PCs for the COPC were obtained from USEPA, 2001 Appendix B, and are summarized above.

- The exposure frequency, exposure duration, body weight and averaging time values are the same as those used for the ingestion pathway.

Inhalation of Vapors Volatized from Groundwater

- For the evaluation of inhalation of airborne VOCs from the groundwater, the contaminant concentration in air is calculated using a model developed by VDEQ (VDEQ, 2002, Table 3.8) for the Voluntary Remediation Program. In order to estimate the air concentration, this approach applies a combination of a vadose zone model to estimate volatilization of gases from contaminated groundwater into a trench and a box model to estimate dispersion of the contaminants from the air inside the trench into the atmosphere. For this model, it is assumed that a trench three feet wide by eight feet long is excavated to a depth of 6 feet.

- The concentration in air for the chemicals of potential concern is presented below. All concentration-in-air calculations are provided in **Appendix E**.

COPC Concentrations in Air	
COPC	**Air Concentration (mg/m^3)**
Cis 1,2-DCE	3.90E-02
PCE	3.79E-02
TCE	2.90E-02
Bis(2-ethylhexyl)phthalate	6.09E-05

- An inhalation rate (IR) of 2.5 m^3/hour for construction workers is assumed in evaluating the inhalation of chemicals in air due to soil particulate suspension (VDEQ, 2003).

- Exposure time (ET) for the inhalation pathway is estimated as 4 hours/day for adults based VDEQ, 2003.

The exposure frequency, exposure duration, body weight and averaging time values are the same as those used for the ingestion pathway.

Commercial/Industrial Workers (Adults)

Johnson and Ettinger (1991) Model for Subsurface Vapor Intrusion into Buildings was used to calculate the exposure to groundwater in indoor air. This model was used to account for inter-media transfer, specifically, from groundwater to indoor air. More information about the model can be found at the EPA web site:

http://www.epa.gov/superfund/programs/risk/airmodel/johnson_ettinger.htm

Input parameters used for the model are as follows:

- Chemical
- Initial chemical concentration in groundwater
- Depth below grade to water table – 4 ft bgs (495 cm)
- Soil type directly above water table – sand
- Average soil/groundwater temperature – 18 degrees Celsius
- Vadose zone soil type – sand

Input parameters were based on results from field investigations conducted at the site; an average temperature for shallow groundwater temperature was used (USEPA 1995). Default values were used for all other input parameters. Exposure medium concentrations are as follows for the three VOCs that exceeded screening criteria:

- TCE 8.55E-01 ug/m^3
- PCE 1.58E+00 ug/m^3
- Cis 1,2-DCE 4.13E-01 ug/m^3

Documentation of the model inputs for the VOC are provided in **Appendix G**. In addition, spreadsheets for the intermediate calculations and results have been included.

6.5 TOXICITY ASSESSMENT

The toxicity assessment, also termed the dose-response assessment, serves to characterize the relationship between the magnitude of exposure and the potential that an adverse effect will occur. It involves (1) determining whether exposure to a chemical can cause an increase in the incidence of a particular adverse health effect and (2) characterizing the nature and strength of the evidence of causation. The toxicity information is then quantitatively evaluated and the relationship between the dose of the constituent received and the incidence of adverse effects in the exposed population is evaluated. The USEPA and other regulatory agencies have performed toxicity assessments for numerous chemicals and the guidance they provide is used when available. These include verified reference doses (RfDs) for the evaluation of noncarcinogenic effects from chronic exposure and cancer potency slopes (CPSs) for the evaluation of cancer risk from lifetime exposure. Each of these are discussed below.

Sources of toxicological guidance information, in order of preference, include: (1) IRIS (Integrated Risk Information System) which is a USEPA database containing current health risk and regulatory

information for many chemicals; (2) USEPA Health Effects Summary Tables (HEAST) which are tabular presentations of toxicity data; and (3) USEPA National Center for Environmental Assessment.

The inherent toxicity of the COPC for the HHRA is briefly summarized in **Appendix F**.

6.5.1 Non-Carcinogenic Effects

The potential for non-cancer health effects associated with chemical exposure is evaluated by comparing an estimated intake (such as chronic daily intake or CDI) over a specified time period with an RfD derived for a similar exposure period. The RfD is an estimate of a daily exposure level for the human population, including sensitive subpopulations, which are likely to be without an appreciable risk of deleterious effects during a lifetime. RfDs often have an uncertainty spanning perhaps an order of magnitude or greater. Chronic RfDs, used in this report, are specifically developed to be protective of long-term exposure to a chemical.

The RfDs for the COPC used for the characterization of chronic non-cancer risk via oral exposure routes are presented in **Table 6-14**, along with the confidence level of the chronic RfD, the critical effect, the basis and source of the RfD and any uncertainty of modifying factors used in the derivation of the RfD.

The ratio of the estimate of the CDI to the health-protective criterion (CDI/RfD) is called the hazard quotient (USEPA, 1989a). The hazard quotient assumes that there is a level of exposure (i.e., the RfD) below which it is unlikely for even sensitive subpopulations to experience adverse health effects. If the hazard quotient exceeds 1.0, there may be concern for potential non-cancer effects. The greater the hazard quotient above 1.0, then the greater is the level of concern.

RfDs for oral exposure are available for most chemicals. For dermal exposure, however, RfDs are not available. In their absence, the oral RfDs are used and adjusted to reflect absorbed dose. This allows for comparison between exposure estimated as absorbed doses and toxicity values expressed as absorbed doses.

The GI absorption values (ABS_{GI}) identified for the COPCs were obtained from Exhibit 4-1 in the EPA RAGs Part E guidance document and are presented as follows:

- Antimony (metallic) – 15%
- Arsenic (arsenite) – 95%
- Benz[a]anthracene – 89%
- Benzo[a]pyrene – 89%
- Benzo[b]fluoranthene – 89%
- Bis(2-ethylhexyl)phthalate – 100%
- Dibenzo(a,h)anthracene – 89%
- Cis 1,2-DCE – 100%
- Iron – 100%

- Manganese – 4%
- Tetrachloroethylene – 100%
- Trichloroethylene – 100%
- Vanadium – 2.6%

The oral RfDs are multiplied by the ABS_{GI} to come up with the RfD_{ABS} values. The calculated RfD_{ABS} values are presented in **Table 6-14.** It should be noted that no adjustment was made for arsenic, all PAHs, bis(2-ethylhexyl)phthalate, all VOCs, and iron because Exhibit 4-1 in RAGS Part E suggests no adjustment is needed because of their high absorption factors.

Except for a few COPCs, reference doses for inhalation exposure, referred to as RfD_i, are typically not available. The RfD_is were available for the following constituents (in mg/kg/d):

- Manganese – 1.43×10^{-5}
- PCE – 8.0×10^{-2}
- TCE – 1.0×10^{-2}

6.5.2 Carcinogenic Effects

Regardless of the mechanism of effect, risk assessment methods generally derive from the hypothesis that thresholds for cancer induction by carcinogens do not exist and that the dose-response relationship is linear at low doses. Such risk assessment methods require extrapolation from high dose animal studies to evaluate low dose exposures to humans. In the absence of adequate information to the contrary, a linearized, multistage, non-threshold low dose extrapolation model is recommended by the USEPA as the most appropriate method for assessing chemical carcinogens. The USEPA emphasizes that this procedure leads to a plausible upper limit to the risk that is consistent with some proposed mechanisms of carcinogenesis.

Through application of this approach, the USEPA has derived estimates of incremental excess cancer risk from lifetime exposure to potential carcinogens. This is accomplished by establishing the carcinogenic potency of the chemical through critical evaluation of the various test data and the fitting of those dose-response data to a low dose extrapolation model. The CPS (which describes the dose-response relationship at low doses) is expressed as a function of intake [i.e., per (mg/kg-day)-1]. This expression incorporates standard pharmacological considerations such as body weight. CPSo data for the COPC are presented in **Table 6-15** and are used to estimate finite, upper limits of risk at low dose levels administered over a lifetime. The weight-of-evidence classification for carcinogenicity, the type of cancer associated with each COPC and the basis and source of the CPSo are also presented in **Table 6-15**.

To arrive at an estimate of incremental cancer risk, the following equation is used (USEPA, 1989a):

Risk = CDI x CPS
where:

Risk = a unitless probability (e.g., 2×10^{-5} or 2 in 100,000) of an individual developing cancer
CDI = chronic daily intake averaged over 70 years (mg/kg-day)
CPS = Cancer Potency Slope expressed in $(mg/kg\text{-}day)^{-1}$

This linear equation is valid only at low risk levels (i.e., below estimated risks of 0.01). This approach does not necessarily give a realistic prediction of risk. The true value of the risk at trace ambient concentrations is unknown, and may be as low as zero.

As with RfDs, there are no assigned CPS values for dermal exposure. In their absence, CPS factors for oral exposures (denoted as CPSo) are used and adjusted to reflect absorbed dose. This allows for comparison between exposures estimated as absorbed doses and toxicity values expressed as absorbed doses. The same ABS_{GI} values used to adjust RfDs are applied in adjusting CPSo values. The CPSs are divided by the ABS_{GI} values previously stated to come up with the adjusted CPSs. The adjusted CPS values are presented in **Table 6-15**.

Except for a few COPCs, cancer potency slope factors for inhalation exposure, referred to as CPS_i, are typically not available. The CPS_is were available for the following constituents (in $[mg/kg/d]^{-1}$):

- Arsenic – $1.51 \times 10^{+1}$
- Benzo(a)pyrene - 3.1×10^{0}
- PCE – 2.0×10^{-2}
- TCE – 4.0×10^{-1}

6.5.3 Mixtures

The USEPA has also developed guidelines to evaluate the overall potential for noncancer and cancer effects posed by multiple chemicals. This approach assumes that subthreshold exposures to several chemicals at the same time could result in an adverse health effect. It assumes that the magnitude of the adverse effect will be proportional to the sum of the ratios of the subthreshold exposures to acceptable exposures. The hazard index is equal to the sum of the hazard quotients. When the hazard index exceeds 1.0, there may be concern for potential health effects. Generally, hazard indices are only used in the evaluation of a mixture of chemicals that induce the same effect by the same mechanism of action. In this evaluation, the hazard quotients of a mixture of chemicals that can have different effects are used as a screening-level approach, as recommended by the USEPA (USEPA, 1989a). This approach is likely to overestimate the potential for effects.

For the assessment of carcinogenic risks, the individual risks associated with exposure to each constituent are summed. This represents an approximation of the precise equation for combining risks, which accounts for the joint probabilities of the same individual developing cancer as a consequence of exposure to two or more carcinogens. This additive approach assumes independence of action by the constituents involved (i.e., that there are no synergistic or antagonistic chemical interactions and all chemicals produce the same effect, i.e., cancer).

6.6 RISK CHARACTERIZATION

The final step in the human health evaluation is the characterization of risk. Here the toxicity and exposure assessments are summarized and combined into quantitative and qualitative expressions of risk. Potential noncarcinogenic effects are characterized by comparing intakes and toxicity values, while carcinogenic risks are characterized by estimating the probability that an individual will develop cancer over a lifetime of exposure.

6.6.1 Use of Surrogate Constituents

Typically, constituents that do not have risk screening criteria and no, or minimal, toxicity data are identified as COPCs and retained for qualitative assessment. However, in the case of this HHRA, the VDEQ permits the use of "surrogate constituents" (i.e., constituents that are closely related to the particular constituent in question, and thus expected to have similar health impacts) that allows constituents to be evaluated with respect to COPC status in the absence of chemical-specific screening data. Thus, use of surrogates decreases the need to evaluate potential COPCs in only the qualitative manner. As shown in **Tables 6-1 to 6-3**, the following provides the constituents for which a no chemical-specific screening data, as well as the surrogate substitution:

- *Constituent*: Acenaphthylene – *Surrogate*: Pyrene
- *Constituent*: Benzo(g,h,I)perylene – *Surrogate*: Pyrene
- *Constituent*: Phenanthrene – *Surrogate*: Pyrene
- *Constituent*: Endosulfan I – *Surrogate*: Endosulfan
- *Constituent*: Endosulfan II – *Surrogate*: Endosulfan
- *Constituent*: Endosulfan Sulfate – *Surrogate*: Endosulfan

6.6.2 Quantitative Risk Assessment

Potential non-cancer health effects are presented. Carcinogenic risks are similarly presented for the COPC, for each pathway of concern and for each potentially exposed population. The cumulative impact of exposure from the various pathways evaluated is estimated for each potentially exposed population.

The USEPA (1989a) recommends absorption efficiency adjustments to ensure that the site exposure estimate (CDI) and the toxicity criteria (RfD and CPS) are both expressed as absorbed doses or both expressed as intakes (administered doses). All CDI calculations are provided in **Appendix G**. As indicated in the following tables, the oral RfD's and CPS's have been adjusted for absorption to match the absorbed dose for dermal exposure.

Fort Story/Future Industrial Site Workers

Non-cancer Effects

Table 6-16 presents the chemical-specific hazard quotients for each pathway involving Fort Story and potential future industrial; site worker exposures to surface soils. In addition, the total pathway hazard, also referred to as the hazard index, which is the sum of the chemical-specific hazard quotients for each pathway, is presented in **Table 6-16**. The total exposure hazard incorporates all the appropriate exposure pathways for the Fort Eustis/Industrial site workers.

To assess the overall potential for adverse non-cancer effects posed by the chemicals of potential concern, the hazard quotients for the chemicals are summed for each of the pathways through which on-site exposure may occur.

As shown in **Table 6-16**, the four PAHs do not have identified non-cancer effects, and therefore, no hazard index was calculated.

Cancer Risks

Table 6-17 presents estimated chemical-specific and total pathway cancer risks calculated for ingestion and inhalation of, and dermal contact with chemicals in surface soils. The estimated total exposure cancer risks are also noted in this table, incorporating all the appropriate exposure pathways for Fort Story/Future Industrial site workers.

The estimated cancer risk for ingestion of, dermal contact with, and inhalation of chemicals in soils is about 3.29 in one hundred thousand (3.29×10^{-5}). This value is at the mid range of the USEPA Superfund target risk level of 10^{-4} to 10^{-6}. Exposure to (ingestion, dermal contact, and inhalation) soil with benzo(a)pyrene accounts for approximately 70% of the risk for site workers.

Construction Workers

Non-cancer Effects

Table 6-18 presents the chemical-specific hazard quotients for each pathway involving construction workers exposures to soils (surface/subsurface combined) and groundwater. In addition, the total pathway hazard, also referred to as the hazard index, which is the sum of the chemical-specific hazard quotients for each pathway, is presented in **Table 6-18**. The total exposure hazard incorporates all the appropriate exposure pathways for the construction workers. To assess the overall potential for adverse non-cancer effects posed by the chemicals of potential concern, the hazard quotients for the chemicals are summed for each of the pathways through which on-site exposure may occur.

As shown in **Table 6-18**, the total exposure hazard index for all exposures associated with soil and

groundwater is 0.275, which is less than the criterion of 1.0. Thus, adverse non-carcinogen health effects in this population are unlikely.

Cancer Risks

Table 6-19 presents estimated chemical-specific and total pathway cancer risks calculated for ingestion and inhalation of, and dermal contact with chemicals in soils (surface/subsurface combined) and groundwater. The estimated total exposure cancer risks are also noted in this table, incorporating all the appropriate exposure pathways for construction workers. The estimated cancer risk is about 1.02 in one hundred thousand (1.02×10^{-5}). This value is at the mid-range of the USEPA Superfund target risk level of 10^{-4} to 10^{-6}. The summary of risk is presented as follows:

- Approximately 15% of the risk is associated with soil exposure (Total Soil Exposure Risk $=1.49 \times 10^{-6}$).
  - Approximately 71% of the soil exposure risk is associated with exposure (ingestion, dermal, and inhalation) to benzo(a)pyrene.

- Approximately 85% of the risk is associated with groundwater exposure (Total Groundwater Exposure Risk $= 8.76 \times 10^{-6}$).
  - Approximately 93% of the groundwater exposure risk is associated with inhalation of TCE vapors from groundwater.

Commercial/Industrial Workers

Non-cancer Effects

The total exposure hazard incorporates all the appropriate exposure pathways for the commercial/industrial workers. To assess the overall potential for adverse non-cancer effects posed by the chemicals of potential concern, the hazard quotients for the chemicals are summed for the inhalation pathway only through which on-site exposure may occur.

The total exposure hazard index for inhalation of VOCs in structures associated with groundwater is 0.02, which is much less than the criterion of 1.0. Thus, adverse non-carcinogen health effects in this population are unlikely.

Cancer Risks

The estimated cancer risk is about 3.1 in one hundred thousand (3.1×10^{-5}). Approximately 90 percent of the risk is associated with TCE concentrations in groundwater. This value is at the mid-range of the USEPA Superfund target risk level of 10^{-4} to 10^{-6}. It should be noted that the 95th UCL concentrations for these three VOCs are all less than their respective MCL.

6.6.3 Uncertainty

Some uncertainty is inherent in the process of conducting predictive, quantitative health risk assessments. Environmental sampling and analysis, fate and transport modeling and human exposure modeling are all prone to uncertainty, as are the available toxicity values used to characterize risk. Such uncertainty is generally related to the limitations of the sampling in terms of the number and distribution of samples and analytical information in terms of systematic or random errors used to characterize a site, the estimation procedures and the input variables and assumptions used in the assessment.

There are uncertainties in every step of the risk assessment process; uncertainties that relate to this human health evaluation may be noted. Selection of the COPCs provides uncertainty since the selection process relies heavily on professional judgment. If different COPCs were chosen or if some were excluded the estimates of risk would be affected.

Additional uncertainties are inherent in the exposure assessment for individual chemicals and exposure routes. There is also some uncertainty in the derivation of health effects criteria in the toxicity assessment. In most cases, the criteria are derived from the extrapolation from laboratory animal data to the human condition. This may have the effect of either overestimating or underestimating the risk.

For this site, the only identified uncertainty that may influence the results of the HHRA included that the site was generally small in size (estimated at less than 1 acre); therefore, the estimates of receptor exposure to site media is likely a significant overestimation.

6.6.4 Human Health Risk Assessment Summary

A summary of the non-carcinogenic and carcinogenic risk (adjusted as discussed in Section 6.6.3) is provided in the following table:

Human Health Risk Assessment Summary					
Exposed Population	**Exposure Pathway**	**Non-Cancer Effects**		**Cancer Effects**	
		PHI	**TEHI**	**TPR**	**TER**
Fort Story/Future Industrial Site Workers	Ingestion of Soil	N/A	N/A	1.77×10^{-5}	3.29×10^{-5}
	Dermal Contact with Soil	N/A		1.52×10^{-5}	
	Inhalation of Soil Particulates	N/A		4.90×10^{-10}	
Commercial/Industrial Workers inside Structures	Inhalation of Vapors from GW	0.02	0.02	3.1×10^{-5}	3.1×10^{-5}

Human Health Risk Assessment Summary					
Exposed Population	Exposure Pathway	Non-Cancer Effects		Cancer Effects	
		PHI	TEHI	TPR	TER
Construction Workers	Ingestion of Soil	N/A	0.275	5.70×10^{-7}	1.02×10^{-5}
	Dermal Contact with Soil	N/A		9.16×10^{-7}	
	Inhalation of Soil Particulates	N/A		1.59×10^{-9}	
	Ingestion of Groundwater	0.00512		1.60×10^{-8}	
	Dermal Contact with GW	0.104		9.45×10^{-8}	
	Inhalation of Vapors from GW	0.165		8.65×10^{-6}	

For Non-Carcinogens:
PHI – Pathway Hazard Index indicates non-carcinogenic risk for specific exposure pathways
TEHI – Total Exposure Hazard Index indicates non-carcinogenic risk for exposed population
Criterion of 1.0 is used to determine if adverse health effects are possible or unlikely.
N/A – Not applicable because non-cancer effects were not identified for this population.
For Carcinogens:
TPR – Total Pathway Risk indicates carcinogenic risk for specific exposure pathways
TER – Total Exposure Risk indicates carcinogenic risk for exposed population
USEPA Remediation goal of 10^{-4} to 10^{-6} used to assess carcinogenic risk.
Bolded and underlined text indicates value exceeds the non-cancer criterion of 1.0 or above the carcinogenic risk level of 10^{-4}.

Finally, the above summary of potentially exposed populations was based on a conservative approach rather than a more reasonable estimation of risk. Additional factors that affect the conclusions drawn from the risk characterization results include the following:

- The exceedences of the industrial soil RBCs for the PAHs is limited to a small portion of the site in the interior area near the former location of the storage tanks.

- The majority of the risk associated with construction and potential future commercial/industrial worker exposure to contaminated groundwater is associated with TCE; however, the 95th UCL utilized in the risk calculations was only 2.5 µg/L which is lower than the USEPA drinking water MCL of 5 µg/L. The estimated cancer risk associated with the other groundwater COPCs combined was in the 10^{-7} range.

- The cancer risk established for the site workers (3.29×10^{-5}), commercial/industrial workers (3.1×10^{-5}) and construction workers (1.02×10^{-5}) is within the EPA Superfund target risk level range. As quoted in Section 300.430(e)(2)(i)(A)(2) of the National Contingency Plan (NCP), "for known or suspected carcinogens, acceptable exposure levels are generally concentrations that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6};" therefore, the concentrations in soil and groundwater fall within the acceptable range based on carcinogenic risk.

Based on the limited soil area impacted by the PAHs, the relatively low concentration of TCE (and other constituents) in groundwater, and the calculated cancer risks for site and construction workers which is within the acceptable range per NCP guidance, no additional action is warranted at the site based on the potentially exposed populations.

The purpose of this Screening Level Ecological Risk Assessment (SLERA) is: 1) evaluate adverse effects or stressors on ecosystems and components of ecosystems at the 80th Division Reserve Site (DRS) and 2) identify which contaminants at the site, if any, could potentially pose a risk to the assessment endpoint(s) utilizing the limited data collected during the confirmation sampling phase of the project. This SLERA was conducted following the procedures contained in the *Ecological Risk Assessment Guidance for Superfund: Process for Design and Conducting Ecological Risk Assessments* (USEPA, 1997) and the *Guidelines for Ecological Risk Assessment* (USEAP, 1998).

According to current USEPA guidance, the following steps were completed for the risk assessment at the 80th DRS:

- Problem Formulation
  - Qualitative characterization of natural resources
  - Identification of chemicals of potential concern (COPC)
  - Identification of potential exposure pathways
  - Identification of assessment and measurement endpoints
  - Development of conceptual ecological site model
  - Define risk management goals

- Exposure assessment providing quantitative or qualitative exposure scenarios for selected ecological receptors

- Ecological effects assessment summarizing toxicity reference values for selected ecological receptors

- Characterization of risk

- Estimation of risk uncertainty

7.1 PROBLEM FORMULATION

Problem formulation is the first phase of ecological risk assessment and establishes the goals, breadth, and focus of the assessment (USEPA, 1997). The process involves a series of interrelated steps to identify potential stressors, pathways, and ecological effects. Ecological endpoints appropriate for the site are then derived, and an ecological conceptual site model is formulated. This model is a set of working hypotheses regarding the potential pathways and effects of site-related stressors on ecosystems of concern.

Problem formulation is based on information collected during the Remedial Investigation. This phase of the ecological risk assessment is presented in four parts: ecosystems of concern; potential stressors, exposure pathways, and ecological effects; ecological endpoints; and, the conceptual model.

7.1.1 Site Description

The 80th DRS is located north of DaNang Road and east of Hospital Road, on the Fort Story Army Base, Virginia Beach, Virginia. The site contains a 50-foot by 70-foot concrete pad surrounded by asphalt on the west, south, and east sides. The north side is bordered by sand that was used as the 80th DRS staging area. Over time, this staging area apparently became contaminated with by-products (primarily petroleum products) of the washing and maintenance operations. A 1,000-gallon used-oil underground storage tank (UST), 250-gallon antifreeze aboveground storage tank (AST), and a former drum storage area were located west of the wash pad. The location of the 80th DRS is provided on **Figure 1-1**.

The 80th DRS area is at an elevation of approximately 10 feet above mean sea level (AMSL) and is generally devoid of topographic features. The asphalt area on the south half of the site is flat. The north half of the site is located in a sandy flat area with low sand ridges. This sandy area located north of the asphalt and concrete pads comprises an area of approximately 0.2 acres. The entire 80th DRS staging area is located within a relatively undisturbed portion of the Ft. Story Base providing habitat for local flora and fauna. As shown in **Figure 7-1**, the area of ecological concern for the site is the small area in the central portion of the site where the detections of organics and metals exceeded BTAG limits. This area is only approximately 120 feet wide and 60 feet long which equates to about 0.20 acres. Other areas with BTAG exceedences include the areas at SB-1 and SB-2 which are upgradient of the former source areas (UST and AST) at the site.

7.1.2 Flora and Fauna

A southeastern evergreen forest community covers most of Fort Story. This forest type is the northernmost extension of a vegetation type in which long-needled pines dominate. This forest type extends along the Gulf and Atlantic coastal plains from eastern Texas to the James River. The southeastern evergreen forest south of the James River is characterized by Loblolly Pine (*Pinus taeda*) interspersed with various oaks (*Quacus spp.*) and other hardwoods. This forest community is a mosaic of plant assemblages controlled largely by soils and drainage patterns. The indicator species of the southeastern evergreen forest was historically Longleaf Pine (*Pinus palustris*). Loblolly Pine now predominates in this area since it rapidly colonizes old fields, out competes Longleaf Pine and has been extensively planted.

Wildlife found at Fort Story is typical of that found in the Virginia Beach and Seashore State Park area. Common mammal species found at the installation include Muskrat (*Ondontra zibethicus*), Eastern Cottontail (*Sylvilagus floridanus*), Raccoon (*Procyon lotor*), Opossum (*Didelphis virginiana*), and Squirrel (*Scuirus spp.*). Some White-tailed Deer (*Odocoileus virginianus*) may take temporary residence in and around the cypress swamp.

Common species of birds include seagulls (*Larus spp.*), European Starling (*Sturnus vulgaris*), Robin (*Turdus migratorius*), American Crow (*Corvus brachyrhynchos*), and Blue jay (*Cyanocitta cristata*).

Typical species of amphibians and reptiles found within the installation include common species of

frogs, turtles, and snakes, such as the Green Frog (*Hyla cinerea*), Eastern Box Turtle (*Terrapene carolina carolina*), and Copperhead Snake (*Agkistrodon contorix contorix*).

7.1.2.1 Threatened and Endangered Species

According to the Virginia Department of Conservation and Recreation, Division of Natural Heritage study conducted for Virginia Beach, several threatened and endangered species may occur in the vicinity of Fort Story where suitable habitat exists. These species are the Federal threatened Bald Eagle (*Haliaeetus leucocephalus*) the Federal threatened Dismal Swamp Shrew (*Sorex longirostris fisheri*), the State Endangered Chicken Turtle (*Deirochelys reticularia*), and the State threatened Eastern Glass Lizard (*Ophisaurus ventralis*). Terrestrial and semi-aquatic species are expected to utilize the habitats adjacent to the Reserve Site. The 80th DRS site is not located within designated critical habitat for any protected species.

An ongoing study by Old Dominion University on the Chicken Turtle at Seashore State Park and a portion of Fort Story has recorded no incidence of the turtle on the installation. No confirmed occurrences of the other species have ever been documented, (Horne Engineering and Environmental Services, 1995).

Given the habitat associated with the project area, it is unlikely that any threatened or endangered species will use the 80th DRS with any exclusivity or frequency.

7.1.3 Previous Investigations

A summary of previous investigations and studies conducted at this site is provided below.

Final Site Assessment Report, Montgomery-Watson, May 1994

Montgomery Watson conducted an investigation from February to May 1994 to evaluate the presence of possible soil contamination in the LARC staging area of the site and around the existing concrete pad. Elevated levels of total petroleum hydrocarbons (TPH), heavy oils and lead were detected in the shallow soils adjacent to the former drum storage area, tank area, and wash pad area. Based on the limited vertical extent of contaminated soil, excavation of soil and off-site treatment and disposal was feasible.

Site Characterization Report, Environmental Restoration Company (ERC), June 1994

ERC conducted a site characterization of the site in 1994. Based on the site characterization, two areas of soil contamination and one area of groundwater contamination were identified at the site. TPH and lead contamination was discovered in the shallow soil of the LARC staging area. These contaminants are most likely the result of discharging bilge water and sandblasting. TCE and PCE were detected in monitoring well MW-4.

Removal Action Final Report, IT Corporation, August 1995.

From April through July 1995, IT Corporation completed a removal action of contaminated soil from the LARC staging area and from the tank area. Approximately 3,500 tons of TPH-contaminated soils and 30 tons of PCE-contaminated soil were excavated from the site and transported off-site for thermal desorption. Significant quantities of contaminated soils remained in both areas. The areas were backfilled with clean fill.

7.1.4 Potential Stressors and Exposure Pathways

The second step in problem formulation involves the identification of the interrelationships between potential stressors, exposure pathways, and ecological effects for the identified ecosystems of concern. Chemical and/or physical stressors are identified, potential pathways for migration of contaminants in the on-site soils to the ecosystems of concern are discussed, and potential ecological effects are summarized.

Chemical analyses were performed on soils as outlined in Section 1 of this report. The conclusions derived from this study focus on identifying potential adverse impacts to species, habitats, and populations in the ecosystem surrounding the 80th DRS site, based only on these limited soils data. Sample results are provided in **Appendix K**. **Figure 2-1** shows the soil sample locations.

Potential Stressors

No physical stressors have been identified on the site. Potential chemical stressors, however, are present in the soils. Chemical stressors and affected media are screened to identify chemicals of potential concern (COPCs). All analytical data were compared to USEPA *Region III Biological Technical Assistance Group (BTAG) Fauna/Flora Screening Levels* (screening levels) (USEPA, 1995) and NOAA's *Screening Quick Reference Tables* (SquiRT) (NOAA, 1999). The SquiRT background geometric mean soils values were used, when applicable.

Chemicals were retained for consideration as a COPC if they met any of the following criteria:

1) The detected or estimated media concentration exceeded the selected screening level.
2) Undetected parameters ("U"-flagged) were retained as COPCs if ½ the method detection limit (MDL) was greater than the screening value. Consistent with laboratory protocol, the MDL was estimated as 10 percent of the PQL (practical quantification limit), which is the value in the laboratory reports and flagged with the "U".
3) Parameters that had no screening values were retained for consideration as final COPCs.

As noted in **Table 7-1,** an environmental effects quotient (EEQ) was calculated for each detected contaminant by dividing the maximum detected concentration by the lowest screening criteria. If the EEQ was equal to or greater than one, then the constituent was identified as a COPC.

Subsurface data was considered as the existence of burrowing animals and the possibility of other turbation of soil could lead to a potentially complete pathway for biota to be exposed to the subsurface soils. Groundwater sample results were not screened for COCPs as there are no pathways for groundwater interact with biota. The site contains no surface water areas that would allow a direct contact exposure to terrestrial receptors.

VOCs

A total of 10 volatile organic compounds (VOCs) were retained as COPCs. Of these compounds only Tetrachloroethylene had BTAG or SQuiRT screening values available. The remaining compounds were retained as COPCs in accordance to the above referenced protocol. These included: 1,1,2-trichloro-1,2,2-trifluoethane, 2-Hexanone, Carbon disulfide, Acetone, 1,3-Dichlorobenzene, 2-Butanone (MEK), Dichlorodifluoromethane, Trichlorofluoromethane and Methyl acetate.

SVOCs

A total of 24 semi-volatile compounds were retained as COPCs. Many of these COPCs had EPA BTAG or NOAA SQuiRT screening values including: Acenaphthene, Acenaphthylene, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(g,h,i)perylene, Benzo(k)fluoranthene, Chrysene, Dibenzo(a,h)anthracene, Dibenzofuran, Fluoranthene, Fluorene, Indeno(1,2,3-cd)pyrene, Naphthalene, Phenanthrene and Pyrene. The remaining compounds were retained as COPCs in accordance with protocol, these COCPs were: 1,1'-Biphenyl, 2,4-trinitrotoluene, 2,6-Dinitrotoluene, 2-Methylnaphthalene, 3,3'-Dichlorobenzidine, bis(2-Ethylhexyl)phthalate, Carbazole, Di-n-octylphthalate

Metals

Six metals were retained as COPCs: Aluminum, Calcium, Chromium, Lead, Potassium and Sodium. Three of these did not have screening values but were retained according to the above-referenced protocol.

Pesticides

There were no pesticides with BTAG or SQuiRT screening values that were detected with EEQ values equal to or greater than one. Those pesticides that were detected that have no screening values were retained as per above. The pesticides that were retained as COPCs include: alpha-BHC, beta-BHC, delta-BHC, Endosulfan I, Endosulfan II, Endosulfan sulfate, Endrin aldehyde, Endrin ketone and Heptachlor.

PCBs

Aroclor-1260 was detected, but was not found to be above the BTAG screening level and thus was not retained as a COPC.

Exposure Pathways

Several ecologically relevant migration pathways for contaminants exist at the 80th DRS. The media of concern on this site is the soil. Aquatic exposure or surface water exposure pathways for COPCs at the 80th DRS are not complete and, therefore, will not be assessed in this ERA. Types of receptors and the exposure routes are summarized below:

- root uptake from contaminated soil by plants;
- contact and absorption, incidental ingestion, and feeding on contaminated soils by invertebrates;
- incidental ingestion of contaminated soil by wildlife; and
- bioaccumulation from vegetation or animal prey at the base of the food chain by wildlife.

Based on these pathways, the following general classes of ecological receptors potentially might be exposed to contaminants at the 80th DRS.

- Uptake of COPCs by terrestrial plant and invertebrates from site soil;
- Birds that forage or nest on the Reserve Site;
- Small insectivorous mammals;
- Small herbivorous mammals that feed on the 80th DRS; and
- Other higher trophic level birds and mammals (e.g., carnivores) that feed within the vicinity of the 80th DRS.

These potential exposure pathways are shown in **Figure 7-1**.

7.1.5 Assessment and Measurement Endpoints

An assessment endpoint is a measurable character of a receptor or population of receptors that can be used to assess a COPCs impact on that receptor, i.e., reduced growth or reproduction of receptor populations. Based on the COPCs, the affected media, and the potential routes of exposure the assessment endpoints include: 1) Uptake of COPCs into food chain, 2) survival and reproduction of upper-trophic avian species, and 3) survival and reproduction of upper-trophic mammalian species.

The 80th DRS comprises a small 0.2-acre site that is located within a much larger undisturbed portion of the Ft. Story Base. The site is comprised on sandy soil and minimal groundcover that does not provide a highly productive habitat for the surrounding ecosystem. Based on these site characteristics, the assessment endpoints for this SLERA will focus on risks to upper-trophic populations rather than individual receptors or local invertebrate and plant populations. The goal of this SLERA will be to determine whether COPCs in site soils pose a risk to the surrounding populations by uptake and concentration through the food chain.

A measurement endpoint is a quantifiable expression of observations that can be compared to a reference site or value to detect adverse responses to a site contaminant (USEPA, 1997).

Measurement endpoints selected to measure the potential risk to the receptors or endpoint species are comprised of toxicity reference values (TRVs) obtained directly from the literature or calculated from published references. If the total exposure concentrations exceed these TRVs, there is a potential risk of adverse effects to individual receptors that could indicate a large risk to the overall ecosystem surrounding the site. The comparison of TRVs to estimated exposures is conducted in the Ecological Effects Assessment section of this report.

7.1.6 Ecological Conceptual Site Model

Following USEPA guidance (USEPA, 1997), a conceptual model was developed to evaluate how chemical stressors from the 80th Division Reserve Site may affect ecological components of the natural environment. This model illustrates the relationship between the ecosystem at risk, including the assessment endpoint species, and the chemical stressors. In addition, the contaminated media, exposure routes, and environmental transport are identified in the conceptual site model.

Following is a brief description of the endpoint species initially identified as potential species of concern for this assessment. The descriptions include the habitat and dietary requirements for each of these species. These receptors were identified based on the potential for exposure (i.e., potential site presence and food habitats) and susceptibility to adverse effects of the site contaminants. Also listed are the primary metabolic assumptions used for developing the exposure estimates (e.g., body weight and food consumption). A comparison of the typical home range for these species as compared to the 0.20 acre area of ecological concern for the site will be made to assess the acceptability of the initially identified species.

- **American Robin (*Turdus migratorius*).** The American robin occurs throughout most of the continental United States during the breeding season and winters in the southern half of the United States and in Mexico and Central America. Robins forage on the ground in open areas, along habitat edges, or the edges of streams. They forage by hopping along the ground in search of ground-dwelling invertebrates and by searching for fruit and foliage-dwelling insects in shrubs and low tree branches. Foraging home ranges of 0.4 to 2.0 acres have been measured.

  The robin has been identified to represent the songbird community and avian omnivores at the 80th DRS. Although other small bird species are known to occur at the 80th DRS, the robin represents herbivorous and insectivorous small birds in the vicinity. Measurement endpoints for the robin are derived from avian toxicity data taken from published dose-response studies that relate contaminant exposure or uptake to effects on individual organisms. Select assumptions are listed below.

  - Body Weight = 0.077 kg
  - Food Consumption = 0.068 kg/d (dry weight)
  - Diet Consists of 68% fruit; 32% invertebrates
  - Contaminant concentration in invertebrates is equal to Exposure Point Concentrations

- **Red-tailed Hawk (*Buteo jamaciencis*).** The Red-tailed Hawk is the most widespread and familiar member of the American buteos (large soaring hawks) and represents avian predators. It is a year round resident in Virginia. They nest in the month of March in tall trees. The red-tailed hawk is usually found in grasslands or marsh- shrub habitats, but is a very adaptable bird, being equally at home in deserts and forests, and at varying heights above sea level. The Red-tailed Hawk is an opportunistic hunter. As an avian predator, the red-tailed hawk has a large home range varying from approximately 148 acres to over 6,000 acres. Measurement endpoints for the red-tailed hawk are derived from avian toxicity data taken from published dose-response studies that relate contaminant exposure or uptake effects on individual organisms. Select assumptions are listed below.

  - Body Weight= 1 kg
  - Food Consumption = 1.1 kg/d (dry weight)
  - Diet Consists of 100% small mammals and small rodents, with muskrats, snakes, lizards, and small raccoons included

- **Short-tailed Shrew (*Blarina brevicauda*).** The short-tailed shrew ranges throughout the north-central and eastern United States and into southern Canada. They occur in a wide variety of habitats, preferring those that are cool and moist and areas with abundant cover. The short-tailed shrew is primarily carnivorous, concentrating on insects, earthworms, slugs, and snails when available and represents mammalian omnivores. However, it will also eat plants, fungi, millipedes, and small mammals.

  The home range for shrews varies significantly in different portions of the country and times of year. The home range can vary from 0.07 acre to over 5.4 acres. The *Wildlife Exposure Handbook* (USEPA, 1993) states that the shrew's home range can vary from 0.07 acres to 0.17 acres during non-breeding winter months in highly productive habitats. In lower productivity habitats, the shrew's home range in non-breeding winter months can vary between 0.25 and 0.54 acres. The year-round, average home range for shrews was reported to be approximately 1 acre. The small site size, sandy soil type, and minimal vegetative under story at the 80th DRS site would be consistent with a higher estimated year-round home range. Evaluations of area use factors in this risk assessment will assume approximately 0.5 acres for the shrew's year-round home range. The AUF associated with incidental soil ingestion was 1.0 assuming that a shrew could locate its borough within the impacted 0.2 acres.

  The short-tailed shrew is an important prey species for many raptors and carnivorous mammals (USEPA, 1993). As a carnivorous species, it represents the small mammals using the 80th DRS. Measurement endpoints for the shrew are derived from mammalian toxicity data taken from published dose-response studies that relate contaminant exposure or uptake effects on individual organisms. Select assumptions are listed below.

  - Body Weight= 0.017 kg
  - Food Consumption = 0.0024 kg/d (dry weight)

- Diet consists of 100% invertebrates
- Contaminant concentration in food is equal to Exposure Point Concentrations

- **Eastern Cottontail (*Sylvilagus floridanus*).** The eastern cottontail is the most widely distributed of the medium-sized rabbits. The eastern cottontail measures 35 to 43 cm in length and weighs 0.7 to 1.8 kg. During the growing season, cottontails eat herbaceous plants (e.g., grasses, clover, timothy, alfalfa). During the winter in areas where herbaceous plants are not available, they consume woody vines, shrubs, and trees (e.g., birch, maple, and apple). Measurement endpoints for the eastern cottontail are derived from mammalian toxicity data taken from published dose-response studies that relate contaminant exposure or uptake effects on individual organisms. The typical home range for this species has been identified at 3 to 20 acres. Select assumptions are listed below.

  - Body Weight= 1.8 kg
  - Food Consumption = 0.31 kg/d (dry weight)
  - Diet consists of 100% herbs
  - Contaminant concentration in food is equal to Exposure Point Concentrations

- **Grey Fox (*Urocyon cinereoargenteus*).** Grey foxes are present throughout the United States, except in the northwest and northern prairies. Grey foxes prey on small mammals but will also eat insects, fruits, acorns, birds, and eggs. The home range of this species varies between 141 and 8,447 acres. This species is similar in size and habits of the red fox (*Vulpes vulpes*) (USEPA, 1993). Measurement endpoints for the fox are derived from mammalian toxicity data taken from published dose-response studies that relate contaminant exposure or uptake to effects on individual organisms. Select assumptions are listed below.

  - Body Weight= 4.5 kg
  - Food Consumption = 0.31 kg/d (dry weight)
  - Diet consists of 85% mammals and birds; 15% vegetable matter
  - Contaminant concentration in food is equal to Exposure Point Concentrations

7.1.7 Risk Management Goal

Following USEPA guidance (USEPA 1998), the risk management goal for the 80th DRS SLERA is to protect the ecosystem surrounding the site by evaluating uptake of COPCs from soil into the food chain. The management goals will be addressed by evaluation of the assessment endpoints presented in Section 7.1.5.

7.2 EXPOSURE ASSESSMENT

This section includes site-specific information pertinent to the assessment of potential ecological exposures to contaminants at the 80th DRS. General discussions of ecosystems of concern,

pathways and COPC are provided in the following sections.

7.2.1 Exposure Point Concentrations (EPCs)

Exposure media of ecological concern at the 80th DRS in this SLERA is focused on surface soils. The maximum exposure case is considered for invertebrates because they are either immobile or have limited mobility. In this case, the maximum value best represents the exposure received by the most exposed individual and therefore is a conservative estimate of the exposure experienced by the population.

Wildlife may be exposed to contaminants through ingestion of food, soil, and water. In this assessment, exposure through food and soil was estimated using exposure models. Because no surface water is present on the 80th DRS, exposure to contaminated drinking water was not considered in the exposure modeling. Exposure estimates were calculated using soils and soil-biota uptake factors for plant and invertebrates, i.e., earthworms, based on the maximum surface soil concentrations identified in the Problem Formulation effort of this SLERA (i.e., plant uptake factors-PUFs and earthworm uptake factors-EUFs).

PUFs and EUFs were derived from published sources, when available. Using these uptake factors, tissue levels in potential food items of the applicable receptor organisms were calculated. Where uptake factors were not available, invertebrate tissue concentrations were assumed to be equal to the soil concentration. Concentrations in the prey species of the gray fox and the red-tailed hawk were assumed to be equal to the maximum concentrations in soils of the respective COPCs. Earthworm and plant uptake factors are provided in **Table 7-2**.

In instances where uptake values were not available, the conservative estimate of 100 percent uptake was used (i.e., concentration of the contaminant in the organism equaled concentration in the environment).

7.2.2 Exposure Scenarios and Pathways

The wildlife scenarios are summarized previously in the conceptual model and include ingestion of contaminated surface soil by all of the wildlife, ingestion of contaminants by uptake of soil by terrestrial invertebrates, followed by predation by terrestrial predators. Plant uptake from contaminated soils was also another exposure route with consumption by birds, omnivores, and herbivores.

The exposure parameters were derived or obtained from published sources. The ingestion rate of food, normalized to body weight of the respective receptors was estimated according to the following equation provided in the *Wildlife Exposure Factors Handbook* (USEPA, 1993):

$$\mathbf{NIR_f = NFMR\ (kcal/g\text{-}day)/ME_{avg}\ (kcal/g\ wet\ wt)}$$

Where: NIR_f = Ingestion rate of food, normalized to body weight

NFMR = Field metabolic rate, normalized to body weight
ME_{avg} = Average metabolizable energy

$$ME_{avg} \text{ (kcal/g wet wt)} = \square (P_k \times ME_k \text{ (kcal/g wet wt)})$$

Where: P_k = Proportion of diet of food type k
ME_k = Metabolizable energy of food type k

$$ME_k = GE_k \text{ (kcal/g wet wt)} \times AE \text{ (in percent)}$$

Where: GE_k = Gross Energy of food type k
AE = Assimilation Efficiency

Where soil ingestion rates were unknown, ingestion rates for species with similar foraging habits were utilized. The USEPA (1993) gives estimates of soil in diet for various invertebrate-consuming species. It was assumed that the use of the high end of this range would be appropriate for the short-tailed shrew, American robin, red-tailed hawk, and gray fox. Therefore, a conservative soil ingestion rate of 10 percent was used in the exposure calculations for these organisms.

7.2.3 Exposure Estimates

Dietary exposure and exposure from ingestion of soil for each wildlife receptor species were calculated using the following equations derived from the *Wildlife Exposure Factors Handbook* (USEPA, 1993).

The following equations were used to estimate exposure to contaminants in soils via ingestion:

$$EE_{soil/sediment} = (C \times FS \times IR_{total}\text{(dry weight)} \times FR) / BW$$

Where: $EE_{soil/sediment}$ = Estimated exposure through ingestion (mg/kg BW-day)

C = Contaminant concentration in media in the area of concern (mg/kg dry wt)

FS = Fraction of media in diet (as percentage of diet on a dry-weight basis divided by 100; unit less)

IR_{total} = Food ingestion rate on a dry-weight basis (kg/day)

FR = Fraction of total food intake from the area of concern (unit less)

BW = Body weight (kg)

The food ingestion rate on a dry-weight basis was estimated based on body weight:

Birds: IR_{total} (kg/day) = $0.0582\ BW^{0.651}$ (kg)

Mammals: IR_{total} (kg/day) = $0.0687\ BW^{0.822}$ (kg)

Values for NIRf, IR, soil ingestion, and body weights are provided in **Table 7-3**. Estimates of exposure to contaminants via dietary sources were made for the receptors using the following equations:

Where: $$EE_{diet} = \sum_{k=1}^{M} (C_k \times FR_k \times NIR_k)$$

Where: EE_{diet} = Estimated exposure through diet (e.g., in mg/kg BW-day)

C_k = Contaminant concentration in the kth type of food (e.g., in mg/kg wet weight)

FR_k = Fraction of intake of the kth food type that is contaminated (unit less).

NIR = Normalized ingestion rate of the kth food type on a wet weight basis (e.g., in g/g-day).

M = Number of contaminated food types

No estimates were calculated to account for contaminated water uptake because this is usually incidental and no samples were collected to represent these values.

The estimated maximum exposure (expressed as daily dosage) through ingestion of soil and food for each of the avian receptors is given in **Table 7-4** and mammalian receptors is given in **Table 7-5**. Full exposure calculations are provided in **Appendix H**.

For the initial analysis, all selected receptor species were assumed to feed in the contaminated areas year-round 100 percent of the time and ingest incidental amounts of contaminated soils. This is especially conservative since the site is very small at 0.2 acres and relatively unattractive to ecological receptors due to location, surrounding habitat, and large portion of the site being capped by concrete and asphalt. The robin is migratory and actually only spends 75 percent of the year in this region. Exposure from ingestion and diet was calculated for COPCs in each media and for each receptor. These exposure estimates were summed together to obtain the total exposure. An additional analysis was performed to look at actual potential area use by receptor species as described in USEPA guidelines (USEPA 1997). Area use factors (AUFs) were derived for each species by taking the ratio of the species-specific home ranges and the impacted portion of the 80th DRS site (0.2 acres). Home ranges for individual species were based on lower-end estimates presented in the Wildlife Factors Handbook (USEPA 1993). Home ranges and AUFs for receptor species at the 80th DRS are summarized in **Table 7-3**.

7.3 ECOLOGICAL EFFECTS ASSESSMENT

7.3.1 Ecological Effects Summaries

Toxicity profiles summarizing the potential adverse ecological effects of each COPC were derived from the literature, and are included as **Appendix I**. The profiles provide discussions of the acute and chronic toxicity of the COPCs to plants and animals. Effects on growth, reproduction, and survival of aquatic and terrestrial species are given, where available. Also included are significant fate and transport characteristics of the chemicals. These summaries, in addition to established criteria, were used to identify the critical effects of COPCs.

7.3.2 Toxicity Reference Values

TRVs were obtained from literature or derived receptor organisms as described below.

Terrestrial Plants - Phytotoxicity screening values included USEPA Region III BTAG Screening Criteria (USEPA, 1995) for flora and other published phytotoxicity values are provided in **Table 7-1**. These values were used as TRVs to assess potential risks to terrestrial plants.

Terrestrial Invertebrates – Invertebrate toxicity screening values included USEPA Region III BTAG Draft Screening Criteria (USEPA, 1995) for faunas and other published invertebrate toxicity values are provided in **Table 7-1**. These values were used as TRVs to assess potential risks to terrestrial invertebrates.

Terrestrial Wildlife - TRVs for mammals and birds chosen as receptor species were derived based on methodology presented by Opresko et al. (1994) and (Sample et al., 1996), respectively. This general method is based on USEPA methodology for deriving human toxicity values from animal data. In this method, experimentally derived No Observed Adverse Effect Levels (NOAELs) are used to estimate NOAELs for wildlife by adjusting the dose according to differences in body size. NOAELs for laboratory species, obtained from the literature, were converted to mammalian receptor species NOAELs as follows:

$$NOAEL_r = NOAEL_t \, (bw_t / bw_r)^{1/4}$$

Bird TRVs are represented as follows:

$$NOAEL_r = NOAEL_t \, (bw_t/bw_r)^0 = NOAEL_t \, (1) = NOAEL_t$$

Where: $NOAEL_r$ = receptor species NOAEL
$NOAEL_t$ = test species NOAEL

bw_r = receptor body weight
bw_t = test species body weight

The test species and receptor species TRVs (NOAELs) are provided for each of the COPC in **Table 7-6**. As shown, NOAELS were not available for all receptors. Quantitative risk characterization cannot be performed in these cases.

7.4 RISK CHARACTERIZATION

In this section, the ecological risks posed by contaminants identified in various media at the 80th DRS are identified and summarized. As presented in the previous section, TRVs for COPCs in terrestrial habitats on the 80th DRS were obtained from the literature or calculated, where necessary. In addition, exposure estimates were calculated based on the food chain model developed for the 80th DRS and shown in **Figure 7-1**.

In this section, the exposure estimates are divided by the TRVs for each of the receptor species to calculate a hazard quotient (HQ) for each COPC. An HQ equal to or greater than one indicates that the COPC may have the potential to pose a risk to the species investigated. An HQ less than one indicates that the COPC is unlikely to pose a risk to the species investigated under the assumptions presented. The complete calculations are contained in **Appendix H**. A summary of the conservative risk characterization is provided in Section 7.4.1, and the effects of site- and species-specific area use factors are presented in Section 7.4.2.

7.4.1 Characterization

As outlined above in Section 7.3.2, quantitative assessment was performed for each selected receptor organism and each COPC that had a TRV (i.e., NOAEL). The complete exposure calculations are contained in **Appendix H**. Summaries of the HQs for avian and mammalian species are summarized in **Table 7-7** and **Table 7-8**, respectively. Based on the standard exposure assessment assumptions, aluminum was the only COPC with a hazard quotient above 1 for both avian species, while a total of nine COPCs had HQ values above 1 in mammalian species. Eight SVOC compounds including benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, fluoranthene, phenanthrene, and pyrene, had HQs ranging from 2 to 7 in shrews, foxes, and rabbits. Aluminum had HQ values ranging from 1,000 in foxes to 3,000 in rabbits. As previously stated, these HQ values were derived using the extremely conservative assumption that 100 percent of each receptor's life would be spent on the 0.2-acre 80th DRS site, which is highly unlikely to occur.

7.4.2 Area Use Based Risk Characterization

Species-specific AUF values derivations were presented in Section 7.2. These AUFs were applied to exposure equations as presented in Section 7.2 in the form of fraction intake (FR) in each of the

exposure equations. A summary of the COPC intakes for avian and mammalian receptors are presented in **Table 7-9** and **7-10**, respectively. The calculations supporting these tables are presented in **Appendix H**. Each of the COPCs derived in the more conservative approach presented in the previous section are highlighted in bold print in **Table 7-9** through **Table 7-12** to draw attention to the impacts on calculation of HQ values by applying AUFs.

Table 7-11 and **Table 7-12** provide revised HQ values for avian and mammalian species, respectively, following the application of species specific AUFs. No COPCs were identified for the red-tailed hawk, while aluminum remained a COPC for the American robin. For mammalian species, aluminum also remained as a COPC for the short-tailed shrew, the gray fox, and the eastern cottontail; however, only pyrene remained as a COPC among the SVOCs in the shrew with an HQ value of 3. The risk of exposure to aluminum and pyrene in site soil to ecological receptors will be discussed in more detail in Section 7.5 – Uncertainty Analysis.

7.5 UNCERTAINTY ANALYSIS

Uncertainty in the risk estimates may arise during any stage in the SLERA process. Assumptions made regarding potential effects of stressors, ecosystems or the species residing within those ecosystems, and exposure parameters. These uncertainties could potentially lead to overestimating or underestimating the potential risks to ecological receptors. Generally, care was taken to fully assess and incorporate field observations into the decision process during problem formulation to minimize these uncertainties. Major areas of uncertainty are presented below along with analysis as to whether potential risk is likely to be overestimated or underestimated.

7.5.1 Exposure Assessment Uncertainty

Uncertainties associated with the exposure assessment include the use of the maximum concentration for individual COPCs as the source concentration term, the aerial extent of site soil impacted by COPCs, and routes of exposure. The use of the maximum concentration will lead to an overestimation of potential risk.

Uncertainties in exposure pathways are also inherent in the ERA process. Exposure of receptor species to COPCs in soil is limited to the ingestion route of exposure through ingestion of food web vectors and incidental ingestion of soil. Inhalation and dermal exposure to COPCs in site sediment are not accounted for in the SLERA exposure model. The limited exposure routes for COPCs in soil could result in an underestimation of potential risk.

The aerial extents of COPCs in soil at the 80th DRS site were based information developed for the remedial investigation. The certainty of delineating lateral and vertical extents of impacts could lead to overestimation or underestimation of potential risk.

7.5.2 Area Use Factors

Aerial extents of soil impacted by COPCs only extend over approximately 0.2 acres of the site. COPCs are not equally co-distributed and exposure to individual COPCs are likely to be in very localized areas within the impacted area. The assumption that all receptors will be simultaneously exposed to the maximum concentration of all COPCs is likely to lead to an overestimation of potential risk.

AUFs were used to develop alternative HQs for chemical exposure at the site based on conservative estimates of home ranges for indicator species with the exception of the shrew. These home range assumptions could lead to an overestimation of potential risk.

The home range for the shrew was not based on the minimum range published. The minimum reported home range, varying from 0.07 to 0.17 acres, was for non-breeding winter months in highly productive habitats with high prey densities (USEPA 1993). These conditions do not exist at the 80th DRS site. Text presented in the *Wildlife Exposure Handbook* (USEPA 1993) indicated that shrew home ranges in habitats with low prey densities could range from approximately 2.5 to 5.4 acres. The year-round average home range for the shrew is approximately 1 acre. The AUF used to evaluate potential exposures of COPCs represents a lower-end estimate for areas likely to have low prey densities such as the 80th DRS site. An AUF value of 1 was used for incidental soil ingestion since a shrew could locate its borough within the 0.2-acre site. The AUF selection for the shrew at this site is based on conservative assumptions and would likely lead to an overestimation of potential risk.

7.5.3 COPC Concentrations in Biota

Concentrations of COPCs in soil invertebrates and plants are estimated based on published life history and exposure factors rather than directly measured data. The literature values for invertebrate and plant uptake values were used rather than field data. The COPC concentrations in field collected tissue samples are typically lower than those modeled by published uptake factors. Similar trends may be likely for invertebrates and plants at the 80th DRS site; however, there are no data to draw any conclusion. COPC concentrations on invertebrates, therefore, could be overestimated or underestimated.

COPC concentrations in prey were assumed to be equal to the maximum reported concentrations in site soil samples. Limited uptake models are available to estimate concentrations of COPCs in upper-trophic species based on soil concentrations. A bioaccumulation model prepared by the Oak Ridge National Laboratories (Sample *et.al.*, 1998) looked at uptake by small animals of trace metals and two organic compounds. These studies indicated that maximum uptake factor for aluminum in small animals is 0.093. The same study looked at uptake of two bioaccumulative organic compounds (tetrachlorodibenzo-p-dioxin; TCDD and tetrachlorodibenzo-furan; TCDF). The maximum uptake factor in small animals for TCDD was 2.2, while the maximum uptake factor for TCDF was 0.16. The organic COPCs at the 80th DRS site are not bioaccumulative as are the dioxin

compounds. The assumption, therefore, that prey concentrations are equal to the maximum reported soil concentrations will likely overestimate risk to predator populations.

7.5.4 Exposure to COPCs in Surface Water

The exposure assessment model has all terrestrial receptors receiving COPC dose only in food, which is the dominant pathway. The dose of COPCs associated with the potential COPC migration to surface water such as ponded storm water and subsequent ingestion of such surface water, therefore, could be underestimated.

7.5.5 Toxicity Reference Values (TRVs)

The TRVs used in this risk assessment are based on NOAEL endpoints. The application of NOAEL TRVs ensures that concentrations of COPCs associated with HQs below unity are protective of ecological receptors. The approach, however, does not account for the uncertainty of whether an adverse effect is likely to occur at HQ values above unity. A risk assessment that focuses on HQ associated with NOAEL TRVs would lead to overestimation of risk.

Risk assessments that focus on the NOAEL TRVs provide a sound estimate of exposure levels that are not going to respond in an adverse impact to ecological receptors; however, the threshold for adverse impacts are not represented by the NOAEL TRVs. Estimates of potential risk can also be generated using TRVs based on the lowest observable adverse effect level (LOAEL) to determine at what exposure levels adverse impacts might be expected. The threshold exposure, therefore, would exist between the NOAEL-based HQ and the LOAEL-based HQ. Generally, LOAEL-based TRVs are approximately 10x the NOAEL TRVs. As a result, NOAEL-based HQs that are below 10 do not represent a threshold exposure above which an adverse impact might be expected. The HQ for pyrene in the short-tailed shrew is 3. This NOAEL-based HQ, therefore, indicates that soil concentrations of pyrene at the 80th DRS site are not likely to result in adverse impacts to shrew populations at Ft. Story.

7.5.6 Uncertainty in Hazard Quotient Analysis

The hazard quotient method is the approach stipulated by the USEPA Region IIII risk assessment guidelines for evaluating risk posed to ecological receptors from COPCs in environmental media. The hazard quotient method has inherent limitations that influence the interpretation of potential ecological risks from potential COPC exposures from environmental media (Tannenbaum *et al.*, 2003). Limitations of the hazard quotient method include:

- Hazard quotients for ecological risk assessments are not a direct measure of risk as presented in human health-based risk assessments.
- Hazard quotients are not a population-based measure as assumed in the ERA process.
- Hazard quotients are not linearly scaled, so extrapolation of results is limited.

- Extremely low concentrations of COPCs in the environment can trigger a hazard quotient value greater than unity.

7.5.7 Uncertainty Associated with Exposure to Aluminum

The only HQ values significantly above unity are for aluminum for several species. The concentrations of aluminum in soil samples range up to 8,500 mg/kg. These concentrations are consistent naturally occurring concentrations in many soils types. Aluminum is the most commonly occurring metallic element, comprising eight percent of the earth's crust (Press and Siever, 1974). Typical range for aluminum in soils is from 1 percent to 30 percent (10,000 mg/kg to 300,000 mg/kg), with naturally occurring concentrations varying over several orders of magnitude.

The USEPA recognized that due to the ubiquitous nature of aluminum, the variability of aluminum concentrations in naturally occurring soil, and the availability of conservative screening benchmarks, aluminum is often identified as a COPC for ecological risk assessments (USEPA, 2003). In soil, aluminum toxicity is directly related to the soluble fraction. The USEPA states that comparisons of total aluminum concentrations to soluble-based screening values are inappropriate. Insoluble aluminum oxides are consistently less toxic than soluble forms. Potential ecological risks, therefore, are based on pH. The USEPA states that aluminum should only be identified as a COPC at sites where soil pH is less than 5.5 (USEPA, 2003). As a result, the site-specific risk from aluminum in soil at the 80th DRS site is significantly overestimated. In keeping with USEPA guidelines for ecological risk assessments for aluminum, aluminum is not considered a COPC at the 80th DRS site.

7.6 SUMMARY OF RISKS

This screening level ecological risk assessment (SLERA) was completed in accordance with USEPA guidelines. The results of the SLERA and conclusions for chemicals of potential concern (COPCs) are summarized below.

7.6.1 Volatile Organic Compounds (VOCs)

A total of 21 VOCs were detected, 12 of these compounds had screening values. Only one compound, Tetrachloroethylene, had an EEQ of greater than one based on BTAG criteria. Nine compounds were retained as COPCs due to lack of screening values. There were no TRVs available to assess direct contact with plants or invertebrates for these initial ten COPCs. Five TRVs were available for mammalian receptors: 2-Butanone, Acetone, Carbon disulfide, Tetrachloroethylene and Trichlorofluoromethane. There were no avian TRVs available for VOCs. No hazard quotients for VOCs indicate these compounds present a potential risk to ecological receptors at the 80th DRS site.

7.6.2 Semi-volatile Compounds (SVOC)

All 24 SVOCs were initially retained as COPCs, either for exceeding the BTAG values or because they lacked TRV criteria. Seven of these SVOCs are polyaromatic hydrocarbons (PAH) and two are

phthalates. Of the initial COPCs, 16 that had screening criteria available were retained. This included seven PAHs. No phthalates were retained. Of the initial COPCs, only fluorene had a non-BTAG TRV available. Though fluorene did not exceed the invertebrate TRV, it was retained as a COPC for exceeding the BTAG screening value.

Mammalian TRV data was available for 11 of the COPCs. Avian TRV data was only available for bis(2-Ethylhexyl)phthalate. After completing the initial exposure assessment, eight COPCs were determined to have a HQ above one for mammalian species: Benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, fluoranthene, phenanthrene and pyrene. No COPCs were found to have an HQ greater than one for avian species. Using area use factors (AUFs) were used to refine the risk characterization. Only one COPC, pyrene, was identified for shrew populations. The HQ for pyrene in shrews was 3 using a NOAEL-based TRV. Due to the minimal NOAEL-based HQ for one indicator species, pyrene is not considered to pose a risk to ecological receptors at the 80th DRS and has not been retained as a COPC in this SLERA

7.6.3 Metals

Six metals were initially retained as COPCs. Three of these did not have screening values. Mammalian and avian TRV data was available for three COPC metals. After completing the initial exposure assessment, aluminum was found to have an HQ equal to or greater than one for all avian and mammalian species. Aluminum toxicity in a soil matrix is related to its solubility and, therefore, soil pH. For sites with soil pH above 5.5, USEPA guidelines do not recommend including aluminum as a COPC for ecological receptors. The soil conditions at the 80th DRS are consistent with elimination of aluminum as a COPC.

7.6.4 Conclusions

As stated in Section 7.1, the assessment endpoints at the 80th DRS site do not include vegetation or soil invertebrates due to the small size of the impacted site, the lack of endangered species on the site, and the type of soil and vegetation on the site. The appropriate evaluation of risk posed by COPCs in soil at this site was to determine the risk posed to the overall ecosystem at Fort Story. The assessment endpoints for this SLERA, therefore, were to evaluate: 1) Uptake of COPCs into food chain, 2) survival and reproduction of upper-trophic avian species, and 3) survival and reproduction of upper-trophic mammalian species.

Based on the results of this SLERA, COPCs in soil at the 80th DRS site are not likely to accumulate in the food chain of the ecosystem surrounding the site and, therefore, do not pose a risk to upper-trophic avian or mammalian species. There is ample habitat at Fort Story surrounding the site to maintain a healthy, diverse ecosystem. As a result, the management goal for the 80th DRS site of protecting the ecosystem surrounding the site by evaluating uptake of COPCs from soil into the food chain can be achieved without establishing COPCs based on ecological endpoints.

Based on the combination of the low HQ value for pyrene, the elimination of aluminum as a COPC, and a conservative risk assessment approach, the conclusion of this risk characterization is that

concentrations of COPCs in soils at the 80th DRS do not pose a risk to upper trophic receptors. There is no evidence that remediation decisions should be based on existing adverse effects to ecological receptors. No further ecological risk assessment is recommended for this site.

7.7 REFERENCES

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A summary of the nature and extent of contamination, fate and transport characteristics and the risk assessment for the 80th DRS is provided in the following sections.

8.1 NATURE AND EXTENT OF CONTAMINATION

8.1.1 Soil

A summary of the nature and extent of soil contamination is provided as follows:

VOCs

- Acetone, methylene chloride, and toluene were detected in more than 85 percent of the surface and subsurface soil samples collected at the site. Many other VOCs including carbon disulfide, 1,4-dichlorobenzene, trans 1,2-DCE, ethylbenzene, MIBK, PCE, trichlorofluoromethane, 1,1,2-trichloro-1,2,2-trifluoroethane, and xylenes were detected frequently (in greater than 20 percent of the samples) throughout the site. Concentrations of these compounds varied from surface to deeper depths with no apparent trends.

- The lateral extent of VOC contamination was not defined because VOCs were detected in all of the surface soil samples collected in this area. However, concentrations were several orders of magnitude lower than EPA screening criteria.

SVOCs

- SVOCs were detected in all soil samples collected from the site. The primary SVOCs detected were PAHs, which are constituents of petroleum hydrocarbons. Bis(2-ethylhexyl)phthalate was the only SVOC detected in two of the soil borings, while only bis(2-ethylhexyl)phthalate, fluorene, phenanthrene, and pyrene were detected one of the borings indicating minimal downgradient migration of SVOCs in soils since these 3 borings are located directly downgradient of the former UST and AST, asphalted, and drum storage areas of the site.

- Although PAHs were detected throughout the site, the areas with the highest concentrations were centered on the former UST/AST area and the former drum storage area with lower concentrations in areas generally upgradient of these areas.

Pesticides

- Endrin ketone, DDT, and endosulfan sulfate were detected in site soil samples. Aldrin was the only pesticide detected above an EPA RBC for residential soils (38 ug/kg) in one sample on-site at a concentration of 73 ug/kg. Pesticides were detected in all soil samples at the site with little variation in location (upgradient, on-site, or downgradient) or with depth.

- Due to past widespread application of these pesticides, their presence at these low concentrations is expected at the site.

PCBs

- Aroclor-1260 was the only PCB detected at the site and it was detected in only 2 of 30 soil samples and at concentrations lower than EPA RBCs. Due to infrequent detection, there is not pattern to its distribution at the site.

Inorganics

- Metals were detected in soil samples throughout the site as would be expected since the majority of them are naturally occurring in various concentrations. Only three metals (arsenic, iron, and vanadium) concentrations exceeded EPA RBCs for residential soils, none exceeded industrial RBCs. Arsenic exceeded the RBC in 8 of 30 samples and iron exceeded the RBC in 6 of 30 samples while vanadium exceeded the RBC in 3 of 30 samples

- In general, concentrations of metals typically were similar for soil samples collected from the surface and subsurface depths.

8.1.2 Groundwater

A summary of the nature and extent of ground water contamination is provided as follows:

VOCs/SVOCs

- Several VOCs and bis(2-ethylhexyl)phthalate were detected at concentrations greater than the EPA RBCs at the site.

- Other than toluene, which was detected in all 10 wells at the site, no other organics were detected in wells that are upgradient/cross-gradient of the former AST/UST and drum storage areas.

- The highest concentrations of organics were detected in the central portions of the site near the former UST/AST (assumed source area) and drum area, with some organics detected in downgradient wells as well.

- The lateral distribution of PCE, TCE, and cis 1,2-DCE implies these compounds have migrated with groundwater from the former UST area downgradient to the north/northwest in that these compounds have been detected in downgradient wells MW-5, MW-6, and MW-9.

- Bis(2-ethylhexyl)phthalate was detected in only one well on-site and its apparent distribution is limited to the former UST area.

Inorganics

Although most metals were detected in total and dissolved phase throughout the site, the distribution pattern will focus on those metals that exceeded EPA RBCs and/or MCLs:

- Total antimony concentrations are consistent across the site with detections in 8 of 10 wells across the site. The concentrations in the upgradient wells are greater than the concentrations in the central-site and downgradient wells. This indicates that the antimony concentrations detected at the site are probably naturally occurring levels and not influenced by the past operations at the former UST/AST and drum storage areas.

- Total arsenic was detected in only 3 of 10 wells with concentrations greatest in one central-site well and in two downgradient wells. Based on the low concentrations and infrequent detection, no discernible pattern is present and it is unclear if these concentrations are solely related to natural levels or are influenced by former site activities.

- Total iron was detected in all 10 wells with concentrations greatest in one central-site well (MW-7) and in three downgradient wells (MW-9, MW-10, and MW-11). These concentrations were the only total iron detects above the EPA RBC. Dissolved iron was also detected in all 10 wells with concentrations greatest in the same wells as the total iron concentrations. The highest concentrations of total and dissolved iron were present in downgradient wells MW-10 and MW-11 which are the least-impacted wells in relation to identified contaminants of concern for the site (VOCs and SVOCs from the former UST and drum storage areas). Based location of the highest iron concentrations (downgradient wells), it is unclear if these concentrations are solely related to natural levels or are influenced by former site activities.

- Total and dissolved manganese were detected in all 10 wells with concentrations greatest in two downgradient wells. These concentrations were the only total or dissolved manganese detects above the EPA RBC. The highest concentrations of total and dissolved manganese were present in two downgradient wells, which are the least-impacted wells in relation to identified contaminants of concern for the site (VOCs and SVOCs from the former UST and drum storage areas). Based location of the highest manganese concentrations (downgradient wells), it is unclear if these concentrations are solely related to natural levels or are influenced by former site activities.

- Total vanadium concentrations are fairly consistent across the site with detections in 9 of 10 wells across the site. The concentrations (1.2 to 4.2 µg/L) in the upgradient wells (MW-1 and MW-2) are consistent with the concentrations (1.1 to 6.3 µg/L) in the central-site wells (MW-3, MW-7, and MW-8) and greater than the concentrations (0.65 to 2.3 µg/L) in the downgradient wells. This indicates that the vanadium concentrations detected at the site are probably naturally occurring levels and not influenced by the past operations at the former UST/AST and drum storage areas.

8.2 FATE AND TRANSPORT

A summary of the fate and transport for the site contaminants is provided in the following sections.

8.2.1 Transport Pathways

The possible transport pathways identified for the site that are considered to be minor pathways due to mitigating site conditions or contaminant properties include the following:

- Volatilization of VOCs from shallow groundwater to shallow soils. The VOCs in site groundwater are all in the low (7.5 or less) part-per-billion range, and therefore would not be a significant contributor of vapor when view with respect to COPC mass.

- Migration, enhanced by infiltrating rainwater, of SVOCs, pesticides, and metals through the vadose zone to groundwater. SVOCs, pesticides, and inorganics strongly adsorb to soil/sediments and are not readily leached to groundwater due to their low aqueous solubility.

- Migration of VOCs, pesticides, SVOCs and inorganics adsorbed to sediment/soil and transported along with windblown dust/sand. Ground cover at the site should limit the amount of transport by wind.

- Leaching of sediment/soil contaminants to surface water. Due to the low solubility of pesticides, SVOCS, and most inorganics, it is very unlikely that these compounds would be readily leached from soil.

The major transport pathways identified for the site include:

- Migration of SVOCs, pesticides, and inorganics adsorbed to soil/sediments by storm runoff into the wetlands and beach/coastal areas.

- Bulk transport, dispersion, or diffusion of VOCs from soil to groundwater.

8.2.2 Fate and Transport of Contaminants in Specific Media

Soils

Soil samples results for the site indicate that VOCs, SVOCs, pesticides and inorganics were present.

Most VOCs were infrequently detected, and all that were detected had concentration several orders of magnitude less than the associated EPA risk screening criteria. Because of the infrequent detection and low concentrations detected (several were estimated concentration), migration of VOCs is not a significant concern at the site.

Of the detected SVOCs, PAHs were detected most frequently. PAHs strongly adsorb to soil, especially the fine fraction (silt and clay), and remains in the soil column at the source area but they can slowly leach to groundwater or surface water. Sandy soils, such as those at the site can lack sufficient organics to hold PAHs in place. Leaching of PAHs from soil to groundwater is increased in environments with a high annual precipitation rate and high infiltration rate similar to the site conditions observed at the site. Biodegradation is an important fate process for PAHs under aerobic

conditions but not anaerobic conditions. There was multiple detection throughout the soil column that was above the EPA risk screening criteria. Most of the detections above the EPA risk screening criteria were found in the surface soil (less than 6 inches). PAHs were found above the industrial and residential EPA criteria. These constituents are most likely bound to the surface soil, but remain available for transport.

Numerous metals were detected on-site and downgradient of the site. Some soil samples exceeded the residential EPA RBCs for arsenic, iron, and aluminum. None of the samples collected exceeded the EPA RBCs for industrial soils. Arsenic can be transported adsorbed to soils/sediment particles (especially silts and clays) that are windborne. Arsenic in soil typically occurs predominately as an insoluble form. Arsenic is relatively immobile and in the presence of iron, calcium, and aluminum, and tends to form insoluble complexes that remain in the soils. It is expected that arsenic would be adsorbed to silts and clays in an insoluble form that would be unavailable for leaching to groundwater.

In general, pesticides were detected in soil samples throughout the soil column. Pesticides are persistent and relatively immobile compounds. These compounds would not be expected to significantly leach to groundwater. The compounds can migrate adsorbed to soil/sediment particles when transported by storm water runoff or surface water. There was one detection of a pesticide (Aldrin) that was found to be above the EPA risk screening criteria. The sample was detected in the surface soil.

Groundwater

Overall, VOCs were detected infrequently, with two constituents detected above EPA criteria for tap water RBCs. Three detections for both tetrachloroethene (MW-7, MW-8, and MW-9) and trichloroethene (MW-5, MW-7, and MW-8) exceeded screening criteria. However, only tetrachloroethene at MW-8 exceeded the EPA's MCL criteria. PCE and TCE resist adsorption to soil and are identified as compounds that can leach into, and migrate in, groundwater. PCE can be biodegraded in to TCE. Confining layers in the subsurface restrict vertical migration.

Bis(2-ethylhexyl) phthalate (BEHP) was the only SVOC detected at the site. It was detected at in the sample from MW-8 above the EPA risk screening criteria RBC. BEHP's long persistence in the subsurface and ability to migrate through the soil at low concentrations could indicate that BEHP could be transported in site groundwater. AS BEHP was detected in only one sample location of 10, indicates that BEHP contamination is not wildly spread.

Numerous metals were detected in groundwater; however, the constituents most frequently detected over the RBCs were arsenic, iron and manganese. Dissolved phase inorganics will be transported with flowing groundwater, but most likely will not migrate as rapidly as the organics. Precipitation of the metals onto soil particles in the saturated zone may occur and impact dissolved inorganic concentrations available for migration.

8.3 RISK ASSESSMENT

8.3.1 Human Health Risk Assessment

A summary of the non-carcinogenic and carcinogenic risk is provided in the following table:

Human Health Risk Assessment Summary					
Exposed Population	**Exposure Pathway**	**Non-Cancer Effects**		**Cancer Effects**	
		PHI	**TEHI**	**TPR**	**TER**
Fort Story/Future Industrial Site Workers	Ingestion of Soil	N/A	N/A	1.77×10^{-5}	3.29×10^{-5}
	Dermal Contact with Soil	N/A		1.52×10^{-5}	
	Inhalation of Soil Particulates	N/A		4.90×10^{-10}	
Commercial/Industrial Workers inside Structures	Inhalation of Vapors from GW	0.02	0.02	3.1×10^{-5}	3.1×10^{-5}
Construction Workers	Ingestion of Soil	N/A	0.275	5.70×10^{-7}	1.02×10^{-5}
	Dermal Contact with Soil	N/A		9.16×10^{-7}	
	Inhalation of Soil Particulates	N/A		1.59×10^{-9}	
	Ingestion of Groundwater	0.00512		1.60×10^{-8}	
	Dermal Contact with GW	0.104		9.45×10^{-8}	
	Inhalation of Vapors from GW	0.165		8.65×10^{-6}	

For Non-Carcinogens:
PHI – Pathway Hazard Index indicates non-carcinogenic risk for specific exposure pathways
TEHI – Total Exposure Hazard Index indicates non-carcinogenic risk for exposed population
Criterion of 1.0 is used to determine if adverse health effects are possible or unlikely.
N/A – Not applicable because non-cancer effects were not identified for this population.
For Carcinogens:
TPR – Total Pathway Risk indicates carcinogenic risk for specific exposure pathways
TER – Total Exposure Risk indicates carcinogenic risk for exposed population
USEPA Remediation goal of 10^{-4} to 10^{-6} used to assess carcinogenic risk.
Bolded and underlined text indicates value exceeds the non-cancer criterion of 1.0 or above the carcinogenic risk level of 10^{-4}.

Finally, the above summary of potentially exposed populations was based on a conservative approach rather than a more reasonable estimation of risk. Additional factors that affect the conclusions drawn from the risk characterization results include the following:

- The exceedences of the industrial soil RBCs for the PAHs is limited to a small portion of the site in the interior area near the former location of the storage tanks.

- The majority of the risk associated with construction worker and commercial/industrial worker exposure to contaminated groundwater is associated with TCE; however, the 95th UCL utilized in the risk calculations was only 2.5 µg/L which is lower than the USEPA drinking water MCL of 5 µg/L. The estimated cancer risk associated with the other groundwater COPCs combined was in the 10^{-7} range.

- The cancer risk established for the site workers (3.29×10^{-5}), commercial/industrial workers (3.1×10^{-5}) and construction workers (1.02×10^{-5}) is within the EPA Superfund target risk level range. As quoted in Section 300.430(e)(2)(i)(A)(2) of the National Contingency Plan (NCP), "for known or suspected carcinogens, acceptable exposure levels are generally concentrations that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6};" therefore, the concentrations in soil and groundwater fall within the acceptable range based on carcinogenic risk.

8.3.2 Ecological Risk Assessment

This screening level ecological risk assessment (SLERA) was completed in accordance with USEPA guidelines. The results of the SLERA and conclusions for chemicals of potential concern (COPCs) are summarized below.

VOCs

A total of 21 VOCs were detected, 12 of these compounds had screening values. Only one compound, Tetrachloroethylene, had an EEQ of greater than one based on BTAG criteria. Nine compounds were retained as COPCs due to lack of screening values. There were no TRVs available to assess direct contact with plants or invertebrates for these initial ten COPCs. Five TRVs were available for mammalian receptors: 2-Butanone, Acetone, Carbon disulfide, Tetrachloroethylene and Trichlorofluoromethane. There were no avian TRVs available for VOCs. No hazard quotients for VOCs indicate these compounds present a potential risk to ecological receptors at the 80th DRS site.

SVOCs

All 24 SVOCs were initially retained as COPCs, either for exceeding the BTAG values or because they lacked TRV criteria. Seven of these SVOCs are polyaromatic hydrocarbons (PAH) and two are phthalates. Of the initial COPCs, 16 that had screening criteria available were retained. This included seven PAHs. No phthalates were retained. Of the initial COPCs, only fluorene had a non-BTAG TRV available. Though fluorene did not exceed the invertebrate TRV, it was retained as a COPC for exceeding the BTAG screening value.

Mammalian TRV data was available for 11 of the COPCs. Avian TRV data was only available for bis(2-Ethylhexyl)phthalate. After completing the initial exposure assessment, eight COPCs were determined to have a HQ above one for mammalian species: Benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, fluoranthene, phenanthrene and pyrene. No

COPCs were found to have an HQ greater than one for avian species. Using area use factors (AUFs) were used to refine the risk characterization. Only one COPC, pyrene, was identified for shrew populations. The HQ for pyrene in shrews was 3 using a NOAEL-based TRV. Due to the minimal NOAEL-based HQ for one indicator species, pyrene is not considered to pose a risk to ecological receptors at the 80th DRS and has not been retained as a COPC in this SLERA

Metals

Six metals were initially retained as COPCs. Three of these did not have screening values. Mammalian and avian TRV data was available for three COPC metals. After completing the initial exposure assessment, aluminum was found to have an HQ equal to or greater than one for all avian and mammalian species. Aluminum toxicity in a soil matrix is related to its solubility and, therefore, soil pH. For sites with soil pH above 5.5, USEPA guidelines do not recommend including aluminum as a COPC for ecological receptors. The soil conditions at the 80th DRS are consistent with elimination of aluminum as a COPC.

Conclusions

As stated in Section 7.1, the assessment endpoints at the 80th DRS site do not include vegetation or soil invertebrates due to the small size of the impacted site, the lack of endangered species on the site, and the type of soil and vegetation on the site. The appropriate evaluation of risk posed by COPCs in soil at this site was to determine the risk posed to the overall ecosystem at Fort Story. The assessment endpoints for this SLERA, therefore, were to evaluate: 1) Uptake of COPCs into food chain, 2) survival and reproduction of upper-trophic avian species, and 3) survival and reproduction of upper-trophic mammalian species.

Based on the results of this SLERA, COPCs in soil at the 80th DRS site are not likely to accumulate in the food chain of the ecosystem surrounding the site and, therefore, do not pose a risk to upper-trophic avian or mammalian species. There is ample habitat at Fort Story surrounding the site to maintain a healthy, diverse ecosystem. As a result, the management goal for the 80th DRS site of protecting the ecosystem surrounding the site by evaluating uptake of COPCs from soil into the food chain can be achieved without establishing COPCs based on ecological endpoints.

Based on the combination of the low HQ value for pyrene, the elimination of aluminum as a COPC, and a conservative risk assessment approach, the conclusion of this risk characterization is that concentrations of COPCs in soils at the 80th DRS do not pose a risk to upper trophic receptors. There is no evidence that remediation decisions should be based on existing adverse effects to ecological receptors. No further ecological risk assessment is recommended for this site.

8.4 RECOMMENDATIONS

The recommendations for the site are based on the nature and extent of contamination, fate and transport characteristics and the results of the human health and ecological risk assessments.

A feasibility (FS) study is not recommended for the 80th DRS site based on the results of the risk assessment that indicated no or minimal potential risks for the identified potentially exposed human and ecological populations. Typically, the results of the risk assessment are the triggers for performance of a FS and since no potential current or future risk was identified, the FS is not warranted.

However, although no current or future risk was identified for site groundwater, there are concentrations of several contaminants are above EPA MCLs for drinking water including several VOCs. Since the site cannot currently be considered as unrestricted land use (because of the MCL exceedences primarily), it is recommended that a Decision Document (DD) be prepared for the site which will include a requirement for long term monitoring (LTM) and land use controls at the site to assess any migration potential or increases in contaminant concentrations and to ensure that the anticipated land use (continued industrial usage) is continued. A public comment period will be established for public participation in review of the draft DD.

Compliance with Virginia Antidegradation policy is the long range objective for the site. Because no current or planned potable use of the site groundwater is anticipated, state and federal groundwater protection standards and MCLs are not applicable at this time. Based on the previous removal action at the site which included the removal of petroleum- and PCE-contaminated soils (the source of the groundwater contamination) and the relatively low concentrations of VOCs currently in groundwater, it is reasonable to assume that continued decreases in contaminant concentrations through natural processes will occur with eventual reduction to levels that satisfy the requirements of the Virginia Antidegradation policy.

Tables

Remedial Investigation Report
80th Division Reserve Site
Fort Story, Virginia

MOVING TO PROTECT OUR WORLD

USATC ENVIRONMENTAL

Table 2-1
Analytical Methods and Parameters

ANALYSES WITH PARAMETERS		METHODS (PREP)
TAL METALS		Water:
Aluminum	Magnesium	6010 (3005)
Antimony	Manganese	7470A for mercury
Arsenic	Mercury	
Barium	Nickel	
Beryllium	Potassium	Solids:
Cadmium	Selenium	6010 (3050)
Calcium	Silver	7471A for mercury
Chromium	Sodium	
Cobalt	Thallium	
Copper	Vanadium	
Iron	Zinc	
Lead	Cyanide	
TCL SVOCs		SW-846 8270C
Phenol	Dibenz(a,h)anthracene	Water: (3520)
bis(2-chloroethyl)ether	Benzo(g,h,i)perylene	Solids: (3550)
2-Chlorophenol	Acenaphthene	
1,3-Dichlorobenzene	Indeno(1,2,3-cd)pyrene	
1,4-Dichlorobenzene	2,4-Dinitrophenol	
Benzyl alcohol	4-Nitrophenol	
1,2-Dichlorobenzene	Dibenzofuran	
2-Methylphenol (o-cresol)	2,4-Dinitrotoluene	
bis(2-chloroisopropyl)ether	2,6-Dinitrotoluene	
3-/4-Methylphenol(m&p-cresol)	Diethylphthalate	
N-Nitroso-di-n-propylamine	4-Chlorophenyl-phenyl ether	
Hexachloroethane	Fluorene	
Nitrobenzene	4-Nitroaniline	
Isophorone	4,6-Dinitro-2-methylphenol	
2-Nitrophenol	N-Nitrosodiphenylamine	
2,4-Dimethylphenol	4-Bromophenyl-phenyl ether	
Benzoic acid	Hexachlorobenzene	
bis(2-Chloroethoxy)methane	Pentachlorophenol	
2,4-Dichlorophenol	Phenanthrene	
1,2,4-Trichlorobenzene	Anthracene	
Naphthalene	Di-n-butylphthalate	
4-Chloroaniline	Fluoranthene	
Hexachlorobutadiene	Pyrene	
4-Chloro-3-methylphenol	Butylbenzylphthalate	
2-Methylnaphthalene	3,3'-Dichlorobenzidine	
Hexachlorocyclopentadiene	Benzo(a)anthracene	
2,4,6-Trichlorophenol	bis(2-ethylhexy)phthalate	
2,4,5-Trichlorophenol	Chrysene	
2-Chloronaphthalene	Di-n-octylphthalate	
2-Nitroaniline	Benzo(b)fluoranthene	
Dimethylphthalate	Benzo(k)fluoranthene	
Acenaphthylene	Benzo(a)pyrene	
3-Nitroaniline		

Table 2-1
Analytical Methods and Parameters

ANALYSES WITH PARAMETERS		METHODS (PREP)
TCL VOCs		SW-846 8260B
Acetone	1,2-Dichloroethane	Water: (5030)
Benzene	1,1-Dichloroethene	Solids: (5035)
Bromoform	cis 1,2-Dichloroethene	
Bromochloroemethane	trans 1,2-Dichloroethene	
Bromodichloroemethane	1,2-Dichloropropane	
Bromomethane	cis 1,3-Dichloropropene	
2-Butanone (MEK)	trans 1,3-Dichloropropene	
Carbon disulfide	Ethylbenzene	
Carbon tetrachloride	2-Hexanone	
Chlorobenzene	Methylene chloride	
Chloroethane	4-Methyl-2-pentanone (MIBK)	
Chloroform	Styrene	
Chloromethane	1,1,2,2-Tetrachloroethane	
Dibromochloromethane	Tetrachloroethene	
1,2-Dibromo-3-chloropropane	Toluene	
1,2-Dichlorobenzene	1,1,1-Trichloroethane	
1,3-Dichlorobenzene	1,1,2-Trichloroethane	
1,4-Dichlorobenzene	Trichloroethene	
1,2-Dibromoethane	Vinyl chloride	
1,1-Dichloroethane	Xylenes	
TCL PESTICIDES		SW-846 8081A
Aldrin	Endosulfan sulfate	Water: (3520)
alpha-BHC	Endrin	Solids: (3550)
beta-BHC	Endrin aldehyde	
delta-BHC	Endrin Keytone	
gamma-BHC (Lindane)	Heptachlor	
4,4'-DDD	Heptachlor epoxide	
4,4'-DDE	Methoxychlor	
4,4'-DDT	Toxaphene	
Dieldrin	alpha-Chlordane	
Endosulfan I	gamma-Chlordane	
Endosulfan II		
TCL PCBs		SW-846 8082
Aroclor 1016	Aroclor 1248	Water: (3520)
Aroclor 1221	Aroclor 1254	Solids: (3550)
Aroclor 1232	Aroclor 1260	
Aroclor 1242		
MISCELLANEOUS PARAMETERS		
TSS		160.2
TDS		160.1
Total Organic Carbon		Lloyd Kahn Method (soil)

TABLE 2-2
SUMMARY OF FIELD INVESTIGATIONS

Location	Soil Borings/ Soil Samples	Monitoring Wells Installed	Groundwater Samples
Upgradient of Former UST/AST Area	1 / 3 (SB-2)	0	2 (MW-1, MW-2)
Adjacent to Former UST/AST Area	4 / 12 (SB-3, SB-4, SB-5, MW-7)	1 (MW-7)	1 (MW-7)
Cross-gradient from Former UST/AST Area	2 / 6 (SB-1, MW-8)	3 (MW-8, MW-12, MW-13)	4 (MW-3, MW-8, MW-12, and MW-13)
Downgradient to Former UST/AST Area	3 / 9 (MW-9, MW-10, MW-11)	3 (MW-9, MW-10, MW-11)	5 (MW-5, MW-6, MW-9, MW-10, and MW-11)

TABLE 3-1
AVERAGE TEMPERATURE AND PRECIPITATION DATA
FORT STORY AREA (1941 - 1970) (NOAA, 1982)

Month	Temperature (F)			Precipitation (inches)
	Daily Min	Daily Max	Daily Mean	
January	32.2	48.8	40.5	3.35
February	32.7	50.0	41.4	3.31
March	38.9	57.3	48.1	3.42
April	47.9	67.7	57.8	2.71
May	57.2	76.2	66.7	3.34
June	65.5	83.5	74.5	3.62
July	69.9	86.6	78.3	5.70
August	68.9	84.9	76.9	5.92
September	63.9	79.6	71.8	4.20
October	53.3	70.1	61.7	3.06
November	42.6	60.5	51.6	2.94
December	34.0	50.6	42.3	3.11
Annual	50.6	68.0	59.3	44.68

TABLE 3-2
GROUNDWATER ELEVATIONS
80th DIVISION RESERVE SITE, FORT STORY

WELL NO.	ASPHALT/ CONCRETE ELEVATION (1)	TOC ELEVATION	DEPTH TO WATER	HIGH TIDE - ELEVATION (1/20/03)	DEPTH TO WATER	TRANSITIONAL TIDE - ELEVATION (1/20/03)	DEPTH TO WATER	LOW TIDE - ELEVATION (1/20/03)
	ft msl (2)	ft msl	ft TOC (3)	ft msl	ft TOC	ft msl	ft TOC	ft msl
MW-1	10.4	10.2	3.1	7.0	3.1	7.1	3.2	7.0
MW-2	10.6	10.1	3.1	7.0	3.1	7.1	3.1	7.0
MW-3	10.6	10.3	3.3	7.0	3.3	7.0	3.3	7.0
MW-5	13.3	15.6	8.7	7.0	8.7	7.0	8.7	7.0
MW-6	12.6	14.4	7.5	6.9	7.5	6.9	7.5	6.9
MW-7	10.7	13.5	6.5	7.0	6.5	7.0	6.5	7.0
MW-8	10.3	9.9	2.9	7.0	2.9	7.0	2.9	7.0
MW-9	13.9	16.6	9.7	6.9	9.6	7.0	9.7	7.0
MW-10	10.8	13.5	6.5	7.0	6.5	7.0	6.5	7.0
MW-11	11.1	13.5	6.5	7.0	6.5	7.0	6.5	7.0

Notes:

(1) Elevations are based on NAVD 88.

(2) msl - Mean Sea Level

(3) TOC - Top of PVC Casing

TABLE 3-3
SUMMARY OF MONITORING WELLS
80th DRS, FORT STORY

WELL NO.	Northing(1)	Easting	RIM ELEV.	ASPHALT/ CONCRETE ELEV2	TOC ELEV	CAP ELEV	STICK-UP (approx.)	RISER LENGTH	SCREEN LENGTH	SCREEN INTERVAL	FILTER PACK LENGTH	TOTAL DEPTH
			ft msl (3)	ft msl	ft TOC (4)	ft msl	ft	ft	ft	ft msl	ft	ft
MW-1	3505405.156	12204858.91	N/A	10.4	10.2	N/A	0	5.0	10	5.2 - -4.8	11	15
MW-2	3505414.968	12204936.3	10.6	10.6	10.1	N/A	0	4.0	10	6.1 - -3.9	11	14
MW-3	3505482.337	12204969.44	10.6	10.6	10.3	N/A	0	3.5	10	6.8 - -3.2	11	13.5
MW-5	3505484.04	12204758.89	N/A	13.3	15.6	15.8	2.3	3.0	10	10.3 - 0.3	11	13
MW-6	3505579.11	12204833.04	N/A	12.6	14.4	15.2	1.8	3.5	10	9.1 - -0.9	11	13.5
MW-7	3505463.62	12204859.05	N/A	10.7	13.5	13.8	3.0	4.0	10	6.5 - -3.5	11	14
MW-8	3505406.08	12204742.43	10.3	10.3	9.9	N/A	0	4.0	10	5.9 - -4.1	11	14
MW-9	3505517.81	12204821.20	N/A	13.9	16.6	17.0	3.0	4.0	10	9.6 - -0.4	12	14
MW-10	3505537.914	12204915.73	N/A	10.8	13.5	13.8	2.9	4.0	10	6.6 - -3.4	11	14
MW-11	3505596.236	12204952.06	N/A	11.1	13.5	13.8	2.6	4.0	10	6.9 - -3.1	11	14
MW-12	N/A	N/A	N/A	N/A	N/A	N/A	0.0	0.0	10	N/A - N/A	12	18
MW-13	N/A	N/A	N/A	N/A'	N/A	NA/	0.0	0.0	10	N/A - N/A	12	20

NOTES:

(1) Coordinates are on the Virginia State Plane Coordinate System, South Zone, NAD 83/94

(2) Elevations are based on NAVD 88

(3) msl - Mean Sea Level

(4) TOC - Top of PVC Casing

TABLE 4-1
CHEMICAL-SPECIFIC ARARs AND TBC FOR SOIL

Parameters	TBC Criteria				Hazard Effects [3]
	EPA Region III BTAG Screening Levels [1]		EPA Region III Risk-Based Concentration Table [2]		
	Flora (ug/kg)	Fauna (ug/kg)	Ind. Soils (mg/kg)	Res. Soils (mg/kg)	
VOLATILE ORGANIC COMPOUNDS					
Acetone	---	---	92,000,000	7,000,000	N
2-Butanone (MEK)	---	---	61,000,000	470,000	N
Carbon Disulfide	---	---	10,000,000	780,000	N
Chlorobenzene	---	100	2,000,000	160,000	N
1,2-Dichlorobenzene	100	100	9,200,000	700,000	N
1,3-Dichlorobenzene	---	---	310,000	23,000	N
1,4-Dichlorobenzene	100	100	120,000	27,000	C
Dichlorodifluoromethane	---	---	20,000,000	1,600,000	N
1,2-Dichloroethane	---	870,000	31,000	7,000	C
Trans-1,2-dichlorothene	300	300	2,000,000	160,000	N
Ethylbenzene	100	100	10,000,000	780,000	N
2-Hexanone	---	---	4,100,000	310,000	N
Methyl acetate	---	---	100,000,000	7,800,000	N
Methylene chloride	300	300	380,000	85,000	C
4-Methyl-2-pentanone (MIBK)	---	100,000	---	---	N
Tetrachloroethene	300	300	5,300	1,200	C
Toluene	100	100	8,200,000	630,000	N
Trichloroethene	300	300	7,200	1,600	C
Trichlorofluoromethane	---	---	31,000,000	2,300,000	N
1,1,2-trichloro-1,2,2-trifluoethane	---	---	3,100,000,000	230,000,000	N
Xylene (total)	100	100	20,000,000	1,600,000	N
SEMIVOLATILE ORGANIC COMPOUNDS					
Acenaphthene	100	100	6,100,000	470,000	N
Acenaphthylene	100	100	---	---	N
Anthracene	100	100	31,000,000	2,300,000	N
Benzo(a)anthracene	100	100	3,900	220	C
Benzo(a)pyrene	---	100	390	22	C
Benzo(b)fluoranthene	100	100	3,900	220	C
Benzo(g,h,i)perylene	100	100	---	---	N
Benzo(k)fluoranthene	100	100	39,000	2,200	C
1,1'-Biphenyl	---	---	5,100,000	39,000	N
Bis(2-ethylhexyl)phthalate	---	---	200,000	46,000	C
Carbazole	---	---	140,000	32,000	C
2-Chloronaphthalene	---	---	8,200,000	630,000	N
2-Chlorophenol	100	100	510,000	39,000	N
Chrysene	100	100	390,000	22,000	C
Dibenzo(a,h)anthracene	100	100	390	22	C
Dibenzofuran	---	---	200,000	16,000	N
3,3'-Dichlorobenzidine	---	---	6,400	1,400	N
2,4-Dinitrotoluene	---	---	200,000	16,000	N
2,6-Dinitrotoluene	---	---	100,000	7,800	N

TABLE 4-1
CHEMICAL-SPECIFIC ARARs AND TBC FOR SOIL

Parameters	TBC Criteria				Hazard Effects [3]
	EPA Region III BTAG Screening Levels [1]		EPA Region III Risk-Based Concentration Table [2]		
	Flora (ug/kg)	Fauna (ug/kg)	Ind. Soils (mg/kg)	Res. Soils (mg/kg)	
SEMIVOLATILE ORGANIC COMPOUNDS (Continued)					
Di-n-octyl phthalate	---	---	2,000,000	160,000	N
Fluoranthene	100	100	4,100,000	310,000	N
Fluorene	100	100	4,100,000	310,000	N
Indeno(1,2,3-cd)pyrene	100	100	3,900	220	C
2-Methylnaphthalene	---	---	410,000	31,000	N
N-Nitrosodiphenylamine	---	---	580,000	130,000	N
Naphthalene	100	100	2,000,000	160,000	N
Phenanthrene	100	100	---	---	N
Pyrene	100	100	3,100,000	230,000	N
PESTICIDES					
Aldrin	100	100	170	38	C
alpha-BHC	---	---	450	100	C
beta-BHC	---	---	1,600	350	C
delta-BHC	---	---	450	100	C
gamma-BHC (Lindane)	100	100	2,200	490	C
Chlordane (alpha)	100	100	8,200	1,800	C
Chlordane (gamma)	100	100	8,200	1,800	C
4,4'-DDD	100	100	12,000	2,700	C
4,4'-DDE	100	100	8,400	1,900	C
4,4'-DDT	100	100	8,400	1,900	C
Dieldrin	100	100	180	40	C
Endosulfan I	---	---	610,000	47,000	N
Endosulfan II	---	---	610,000	47,000	N
Endosulfan sulfate	---	---	610,000	47,000	N
Endrin	100	100	31,000	2,300	N
Endrin aldehyde	---	---	31,000	2,300	N
Endrin ketone	---	---	31,000	2,300	N
Heptachlor	---	---	640	140	C
Heptachlor epoxide	100	100	310	70	C
Methoxychlor	100	100	510,000	39,000	N
Toxaphene	---	---	2,600	580	C
PCBs					
Aroclor-1016	100	---	41,000	550	C
Aroclor-1221	100	---	1,400	320	C
Aroclor-1232	100	---	1,400	320	C
Aroclor-1242	100	---	1,400	320	C
Aroclor-1248	100	---	1,400	320	C
Aroclor-1254	100	---	1,400	320	C
Aroclor-1260	100	---	1,400	320	C

TABLE 4-1
CHEMICAL-SPECIFIC ARARs AND TBC FOR SOIL

Parameters	TBC Criteria				Hazard Effects [3]
	EPA Region III BTAG Screening Levels [1]		EPA Region III Risk-Based Concentration Table [2]		
	Flora (mg/kg)	Fauna (mg/kg)	Ind. Soils (mg/kg)	Res. Soils (mg/kg)	
INORGANICS					
Aluminum	1	-	---	---	N
Antimony	0.48	150	41	3.1	N
Arsenic	328	-	1.9	0.43	C
Barium	-	440	20,000	1,600	N
Beryllium	0.02	-	200	16	N
Cadmium	2.5	-	100	7.8	N
Calcium	---	---	---	---	
Chromium (as Cr VI)	0.02	0.0075	310	23	N
Cobalt	100	200	---	---	N
Copper	15	---	4,100	310	N
Iron	3260	12	31,000	2,300	N
Lead	2	0.01	400	400	C
Magnesium	---	---	---	---	
Manganese	---	330	2,000	160	N
Mercury	0.058	0.058	31	2.3	N
Nickel	2	20.9	2,000	160	N
Potassium	---	---	---	---	
Selenium	1.8	---	510	39	N
Silver	0.0000098	0.0000098	510	39	N
Sodium	---	---	---	---	
Thallium	0.001	---	7.2	0.55	N
Vanadium	0.5	58	100	7.8	N
Zinc	10	150	31,000	2,300	N

Notes:

(1) EPA Region III BTAG Screening Levels for Ecological risks (August 1995)

(2) EPA Region III Risk-based Concentration Table for Industrial and Residential Soils (Oct 2006) (Non-carcinogens adjusted to a Hazard Index of 0.1)

(3) Hazard Effects: C - carcinogenic effects, N - noncarcinogenic effects

(4) EPA Standards for Lead in Soil, OPPT Lead Programs, 1/2/2001

(5) Per EPA Region III correspondence, mercuric chloride RBCs utilized for mercury.

TABLE 4-2
CHEMICAL-SPECIFIC ARARs AND TBC FOR GROUNDWATER

Parameters	ARARs				TBC Criteria		Hazard Effects [8]
	EPA MCLs [1] (ug/l)	EPA Secondary MCLs [2] (ug/l)	Virginia GW Stds [3] (ug/l)	Va GW Protection Levels [4] (ug/l)	Virginia Groundwater Criteria [5] (ug/l)	EPA Region III RBC Table [6] for Tap Water (ug/l)	
VOLATILE ORGANIC COMPOUNDS							
Cis 1,2-DCE	70	-	-	-	-	6.1	N
Tetrachloroethene	5	-	-	5	-	0.10	C
Toluene	1,000	-	-	100	-	230	N
1,2,4-trichlorobenzene	70	-	-	-	-	6.1	N
Trichloroethene	5	-	-	-	-	0.026	C
SEMIVOLATILE ORGANIC COMPOUNDS							
Bis(2-ethylhexyl)phthalate	6	-	-	-	-	4.8	C
INORGANICS							
Aluminum	-	50 - 200	-	-	-	---	N
Antimony	6	-	-	-	-	1.5	N
Arsenic	10	-	50	50	-	0.045	C
Barium	2,000	-	1,000	1,000	-	730	N
Beryllium	4	-	-	-	-	7.3	N
Cadmium	5	-	0.4	0.4	-	1.8	N
Calcium	-	-	-	-	-	-	N
Chromium (as Cr VI)	100	-	50	50	-	11	N
Cobalt	-	-	-	-	-	---	N
Copper	1,300	-	1,000	1,000	-	150	N
Iron	-	300	-	-	300	1,100	N
Lead	15 [7]	-	50	50	-	-	C
Magnesium	-	-	-	-	-	-	N
Manganese	-	50	-	-	50	73	N
Mercury	2	-	0.05	0.05	-	1.1	N
Nickel	100	-	-	-	-	73	N
Potassium	-	-	-	-	-	-	N
Selenium	50	-	-	10	-	18	N
Silver	-	-	-	-	-	18	N
Sodium	-	-	-	-	-	-	N
Thallium	2	-	-	-	-	0.26	N
Vanadium	-	-	-	-	-	3.7	N
Zinc	-	5,000	50	50	-	1,100	N

Notes:
(1) U.S. EPA Maximum Contaminant Levels for Drinking Water (40 CFR 141)
(2) U.S. EPA Secondary Maximum Contaminant Levels for Drinking Water (40 CFR 143)
(3) Virginia Groundwater Quality Standards
(4) Virginia Groundwater Protection Levels from Solid Waste Regulations
(5) Virginia Water Quality Criteria for Groundwater
(6) EPA Region III Risk-based Concentration Table for Tap Water (Oct 2006) - Noncarcinogens adjusted to a HQ of 0.1
(7) USEPA action level for drinking water
(8) Hazard Effects: C - carcinogenic effects, N - noncarcinogenic effects

TABLE 4-3
SOIL RESULTS - VOLATILE ORGANICS
80th Division Reserve Site, Fort Story, VA

Compound	Soil Results (ug/kg)									EPA RBCs (1)	
	Boring MW-7			Boring MW-8			Boring MW-9			Industrial Soils	Residential Soils
	0 to 6 in.	1 to 3 ft	4 to 6 ft	0 to 6 in.	1 to 3 ft	4 to 6 ft	0 to 6 in.	1 to 3 ft	4 to 6 ft		
Acetone	**18 B**	**14 JB**	**19 B**	**15 J**	**14 JB**	**28 B**	**44**	**28**	**5 J**	92,000,000	7,000,000
2-Butanone (MEK)	16 U	17 U	16 U	16 U	16 U	14 U	16 U	14 U	16 U	61,000,000	4,700,000
Carbon Disulfide	**1 JB**	**0.8 JB**	**0.9 JB**	6 U	6 U	**0.9 JB**	**2 J**	6 U	6 U	10,000,000	780,000
Chlorobenzene	**0.5 J**	**0.5 J**	**0.5 J**	6 U	**0.5 J**	**0.5 J**	6 U	6 U	6 U	2,000,000	160,000
1,2-Dichlorobenzene	**0.3 J**	7 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	9,200,000	700,000
1,3-Dichlorobenzene	**0.5 J**	7 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	310,000	23,000
1,4-Dichlorobenzene	**0.5 J**	**0.4 J**	**0.3 J**	6 U	**0.4 J**	**0.3 J**	6 U	6 U	6 U	120,000	27,000
Dichlorodifluoromethane	7 U	7 U	**0.6 J**	**0.6 JB**	6 U	6 U	6 U	6 U	6 U	20,000,000	1,600,000
1,2-Dichloroethane	7 U	7 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	31,000	7,000
Trans-1,2-dichlorothene	**0.9 JB**	**0.7 JB**	**0.8 JB**	6 U	**0.8 JB**	**0.7 JB**	6 U	6 U	6 U	2,000,000	160,000
Ethylbenzene	**0.7 J**	**0.5 J**	6 U	6 U	**0.7 J**	**0.6 J**	6 U	6 U	6 U	10,000,000	780,000
2-Hexanone	16 U	17 U	16 U	16 U	16 U	14 U	16 U	14 U	16 U	4,100,000	310,000
Methyl acetate	7 U	7 U	6 U	6 U	6 U	6 U	**6 J**	6 U	6 U	100,000,000	7,800,000
Methylene chloride	**6 JB**	**6 JB**	**7 B**	**5 JB**	**8 B**	**7 B**	**4 JB**	**4 JB**	**4 JB**	380,000	85,000
4-Methyl-2-pentanone	**10 J**	**7 J**	**10 J**	16 U	**14 J**	**8 J**	16 U	14 U	16 U	---	---
Tetrachloroethene	**9 B**	**2 JB**	**5 JB**	**29**	6 U	**3 JB**	6 U	6 U	6 U	5,300	1,200
Toluene	**3 JB**	**3 JB**	**3 JB**	**2 JB**	**4 JB**	**3 JB**	**0.7 JB**	**0.7 JB**	**0.9 JB**	8,200,000	630,000
Trichloroethene	**0.8 JB**	**1 JB**	**0.7 JB**	6 U	**0.7 JB**	**0.7 JB**	6 U	6 U	6 U	7,200	1,600
Trichlorofluoromethane	**2 JB**	**2 JB**	**2 JB**	6 U	**2 JB**	**2 JB**	6 U	6 U	6 U	31,000,000	2,300,000
1,1,2-trichloro-1,2,2-trifluoethane	**2 J**	**1 J**	**2 J**	**2 JB**	**2 J**	**1 J**	6 U	6 U	6 U	3,100,000,000	230,000,000
Xylene (total)	**7 J**	**5 J**	**5 J**	**1 J**	**6 J**	**5 J**	19 U	17 U	19 U	20,000,000	1,600,000

Notes:

(1) EPA Risk-based Concentrations for Industrial and Residential Soils (Oct 2006)
(Non-carcinogens adjusted to a Hazard Index of 0.1)

550 Bolded text indicates analyte was detected.

Data Qualifiers:

U Not detected

J Analyte present. Reported value between detection and quantitation limits

B Analyte present in associated method blank

TABLE 4-3
SOIL RESULTS - VOLATILE ORGANICS
80th Division Reserve Site, Fort Story, VA

Compound	Soil Results (ug/kg)									EPA RBCs (1)	
	Boring MW-10			Boring MW-11			Boring SB-1			Industrial Soils	Residential Soils
	0 to 6 in.	1 to 3 ft	4 to 6 ft	0 to 6 in.	1 to 3 ft	4 to 6 ft	0 to 6 in.	1 to 3 ft	4 to 6 ft		
Acetone	**57 B**	**16 J**	**18**	14 U	**25**	**16 B**	13 U	**9 J**	**16**	92,000,000	7,000,000
2-butanone (MEK)	**5 J**	16 U	16 U	14 U	16 U	15 U	13 U	13 U	16 U	61,000,000	4,700,000
Carbon Disulfide	**1 JB**	**6 J**	**2 J**	5 U	**1 J**	6 U	5 U	5 U	6 U	10,000,000	780,000
Chlorobenzene	9 U	7 U	7 U	5 U	6 U	6 U	5 U	5 U	6 U	2,000,000	160,000
1,2-Dichlorobenzene	9 U	7 U	7 U	5 U	6 U	6 U	5 U	5 U	6 U	9,200,000	700,000
1,3-Dichlorobenzene	9 U	7 U	7 U	5 U	6 U	6 U	5 U	5 U	6 U	310,000	23,000
1,4-Dichlorobenzene	**0.4 J**	7 U	7 U	5 U	6 U	6 U	5 U	5 U	6 U	120,000	27,000
Dichlorodifluoromethane	9 U	7 U	7 U	5 U	6 U	**0.6 J**	5 U	5 U	6 U	20,000,000	1,600,000
1,2-Dichloroethane	**3 J**	7 U	7 U	5 U	6 U	6 U	5 U	5 U	6 U	31,000	7,000
Trans-1,2-dichlorothene	**1 JB**	7 U	7 U	5 U	6 U	**0.9 JB**	5 U	5 U	6 U	2,000,000	160,000
Ethylbenzene	**0.7 J**	7 U	7 U	5 U	6 U	**0.6 J**	5 U	5 U	6 U	10,000,000	780,000
2-Hexanone	**230**	16 U	16 U	14 U	16 U	15 U	13 U	13 U	16 U	4,100,000	310,000
Methyl acetate	**69**	7 U	7 U	5 U	6 U	6 U	5 U	5 U	6 U	100,000,000	7,800,000
Methylene chloride	**10 B**	**6 JB**	**7 B**	**4 JB**	**7 B**	**8 B**	**8 B**	**6 B**	**6 JB**	380,000	85,000
4-Methyl-2-pentanone	**11 J**	16 U	**5 J**	14 U	16 U	**16**	13 U	13 U	16 U	---	---
Tetrachloroethene	9 U	7 U	7 U	5 U	6 U	**2 JB**	5 U	5 U	6 U	5,300	1,200
Toluene	**4 JB**	**2 JB**	**3 JB**	**1 JB**	**2 JB**	**3 JB**	**0.8 JB**	**2 JB**	**2 JB**	8,200,000	630,000
Trichloroethene	**1 JB**	7 U	7 U	5 U	6 U	**0.5 JB**	5 U	5 U	6 U	7,200	1,600
Trichlorofluoromethane	**3 JB**	7 U	**0.8 J**	5 U	6 U	**2 JB**	5 U	5 U	6 U	31,000,000	2,300,000
1,1,2-trichloro-1,2,2-trifluoethane	**2 J**	**2 JB**	**1 JB**	5 U	**1 JB**	**2 J**	5 U	5 U	6 U	3,100,000,000	230,000,000
Xylene (total)	**6 J**	**3 J**	**2 J**	16 U	**1 J**	**7 J**	15 U	16 U	19 U	20,000,000	1,600,000

Notes:

(1) EPA Risk-based Concentrations for Industrial and Residential Soils (Oct 2006)
(Non-carcinogens adjusted to a Hazard Index of 0.1)

550 Bolded text indicates analyte was detected.

Data Qualifiers:

U Not detected

J Analyte present. Reported value between detection and quantitation limits

B Analyte present in associated method blank

TABLE 4-3
SOIL RESULTS - VOLATILE ORGANICS
80th Division Reserve Site, Fort Story, VA

Compound	Soil Results (ug/kg)												EPA RBCs (1)	
	Boring SB-2			Boring SB-3			Boring SB-4			Boring SB-5			Ind. Soils	Res. Soils
	0 to 6 in.	1 to 3 ft	4 to 6 ft	0 to 6 in.	1 to 3 ft	4 to 6 ft	0 to 6 in.	1 to 3 ft	4 to 6 ft	0 to 6 in.	1 to 3 ft	4 to 6 ft		
Acetone	13 U	**13 J**	**20**	13 U	**13**	**8 J**	**17**	**15**	**16**	**14**	**12 J**	**15**	92,000,000	7,000,000
2-butanone (MEK)	13 U	14 U	16 U	13 U	13 U	15 U	14 U	14 U	15 U	13 U	13 U	15 U	61,000,000	4,700,000
Carbon Disulfide	5 U	5 U	6 U	5 U	5 U	6 U	5 U	5 U	6 U	5 U	5 U	6 U	10,000,000	780,000
Chlorobenzene	5 U	5 U	6 U	5 U	5 U	6 U	5 U	5 U	6 U	5 U	5 U	6 U	2,000,000	160,000
1,2-Dichlorobenzene	5 U	5 U	6 U	5 U	5 U	6 U	5 U	5 U	6 U	5 U	5 U	6 U	9,200,000	700,000
1,3-Dichlorobenzene	5 U	5 U	6 U	5 U	5 U	6 U	5 U	5 U	6 U	5 U	5 U	6 U	310,000	23,000
1,4-Dichlorobenzene	5 U	5 U	6 U	5 U	5 U	6 U	5 U	5 U	6 U	5 U	5 U	6 U	120,000	27,000
Dichlorodifluoromethane	5 U	5 U	6 U	5 U	5 U	6 U	5 U	5 U	6 U	5 U	5 U	6 U	20,000,000	1,600,000
1,2-Dichloroethane	5 U	5 U	6 U	5 U	5 U	6 U	5 U	5 U	6 U	5 U	5 U	6 U	31,000	7,000
Trans-1,2-dichlorothene	5 U	5 U	6 U	5 U	5 U	6 U	5 U	5 U	6 U	5 U	5 U	6 U	2,000,000	160,000
Ethylbenzene	5 U	5 U	6 U	5 U	5 U	6 U	5 U	5 U	6 U	5 U	5 U	6 U	10,000,000	780,000
2-Hexanone	**13**	14 U	16 U	13 U	13 U	15 U	14 U	14 U	15 U	13 U	13 U	15 U	4,100,000	310,000
Methyl acetate	**5**	5 U	6 U	5 U	5 U	6 U	5 U	5 U	6 U	5 U	5 U	6 U	100,000,000	7,800,000
Methylene chloride	5 U	**5 JB**	**6 JB**	5 U	5 U	6 U	**5 JB**	**5 JB**	**7 B**	**5 JB**	**4 JB**	**7 B**	380,000	85,000
4-Methyl-2-pentanone	13 U	14 U	16 U	13 U	13 U	15	14 U	14 U	15 U	13 U	13 U	15 U	---	---
Tetrachloroethene	5 U	5 U	6 U	**5**	**9**	**18**	**120**	**5 J**	**13**	**26**	5 U	**3 J**	5,300	1,200
Toluene	5 U	**3 JB**	**2 JB**	5 U	**1 J**	6 U	**2 JB**	**2 JB**	**2 JB**	**2 JB**	**2 JB**	**2 JB**	8,200,000	630,000
Trichloroethene	5 U	5 U	6 U	5 U	5 U	6 U	5 U	5 U	6 U	5 U	5 U	6 U	7,200	1,600
Trichlorofluoromethane	5 U	5 U	6 U	5 U	5 U	6 U	5 U	5 U	6 U	5 U	5 U	6 U	31,000,000	2,300,000
1,1,2-trichloro-1,2,2-trifluoethane	5 U	**1 J**	6 U	5 U	5 U	6 U	5 U	5 U	**0.8 J**	5 U	**0.7 J**	**0.8 J**	3,100,000,000	230,000,000
Xylene (total)	15 U	16 U	19 U	15 U	16 U	18 U	3 J	16 U	19 U	16 U	16 U	19 U	20,000,000	1,600,000

Notes:

(1) EPA Risk-based Concentrations for Industrial and Residential Soils (Oct 2006)
(Non-carcinogens adjusted to a Hazard Index of 0.1)

550 Bolded text indicates analyte was detected.

Data Qualifiers:

U Not detected

J Analyte present. Reported value between detection and quantitation limits

B Analyte present in associated method blank

TABLE 4-4
SOIL RESULTS - SEMIVOLATILE ORGANICS
80th Division Reserve Site, Fort Story, VA

Compound	Soil Results (ug/kg)									EPA RBCs (1)	
	Boring MW-7			Boring MW-8			Boring MW-9			Industrial Soils	Residential Soils
	0 to 6 in.	1 to 3 ft.	4 to 6 ft.	0 to 6 in.	1 to 3 ft.	4 to 6 ft.	0 to 6 in.	1 to 3 ft.	4 to 6 ft.		
Acenaphthene	350 U	360 U	410 U	**960 J**	380 U	**54 J**	360 U	350 U	360 U	6,100,000	470,000
Acenaphthylene	350 U	**54 J**	410 U	**2200**	**41 J**	**130 J**	360 U	350 U	360 U	---	---
Anthracene	350 U	**32 J**	410 U	**2500**	**46 J**	**160 J**	360 U	350 U	360 U	31,000,000	2,300,000
Benzo(a)anthracene	350 U	**140 JB**	410 U	**3900 B**	**91 JB**	**300 JB**	360 U	350 U	360 U	3,900	220
Benzo(a)pyrene	**28 JB**	**160 JB**	410 U	**3900 B**	**82 JB**	**270 JB**	360 U	350 U	360 U	390	22
Benzo(b)fluoranthene	350 U	**150 JB**	410 U	**6600 B**	**110 JB**	**340 JB**	360 U	350 U	360 U	3,900	220
Benzo(g,h,i)perylene	**27 J**	**100 J**	410 U	**2900**	**60 J**	**160 J**	360 U	350 U	360 U	---	---
Benzo(k)fluoranthene	**36 JB**	**190 JB**	410 U	**4100 B**	**86 JB**	**310 JB**	360 U	350 U	360 U	39,000	2,200
1,1'-Biphenyl	350 U	360 U	410 U	**470 J**	380 U	**62 J**	360 U	350 U	360 U	5,100,000	39,000
Bis(2-ethylhexyl)phthalate	**150 J**	**340 J**	**320 J**	1100 U	**220 J**	**420**	**40 J**	**110 J**	**880**	200,000	46,000
Carbazole	350 U	360 U	410 U	**480 J**	380 U	380 U	360 U	350 U	360 U	140,000	32,000
Chrysene	**34 JB**	**170 JB**	410 U	**4900 B**	**110 JB**	**350 JB**	360 U	350 U	360 U	390,000	22,000
Dibenzo(a,h)anthracene	350 U	**30 J**	410 U	**1200**	**32 J**	**73 J**	360 U	350 U	360 U	390	22
Dibenzofuran	350 U	360 U	410 U	**790 J**	380 U	**86 J**	360 U	350 U	360 U	200,000	16,000
3,3'-Dichlorobenzidine	350 U	360 U	410 U	1100 U	380 U	380 U	360 U	350 U	360 U	6,400	1,400
2,4-Dinitrotoluene	350 U	360 U	410 U	1100 U	380 U	380 U	360 U	350 U	360 U	200,000	16,000
2,6-Dinitrotoluene	350 U	360 U	410 U	1100 U	380 U	380 U	360 U	350 U	360 U	100,000	7,800
Di-n-octyl phthalate	270 J	360 U	**42 J**	1100 U	380 U	380 U	360 U	350 U	360 U	---	---
Fluoranthene	**28 JB**	**190 JB**	410 U	**7600 B**	**180 JB**	**600 B**	360 U	350 U	360 U	4,100,000	310,000
Fluorene	350 U	**36 J**	410 U	**1600**	380 U	**48 J**	360 U	350 U	360 U	4,100,000	310,000
Indeno(1,2,3-cd)pyrene	**29 J**	**94 J**	410 U	**3200**	**64 J**	**170 J**	360 U	350 U	360 U	3,900	220
2-Methylnaphthalene	350 U	360 U	410 U	**2400**	**42 J**	**190 J**	360 U	350 U	360 U	410,000	31,000
N-Nitrosodiphenylamine	350 U	360 U	410 U	1100 U	380 U	380 U	360 U	350 U	360 U	580,000	130,000
Naphthalene	350 U	360 U	410 U	**1200**	380 U	**72 J**	360 U	350 U	360 U	2,000,000	160,000
Phenanthrene	350 U	**96 JB**	410 U	**12000 B**	**320 JB**	**1200 B**	360 U	350 U	360 U	---	---
Pyrene	**43 JB**	**440 B**	410 U	**12000 B**	**320 JB**	**810 B**	360 U	350 U	360 U	3,100,000	230,000

Notes:

(1) EPA Risk-based Concentrations for Industrial and Residential Soils (April 25, 2003)
(Non-carcinogens adjusted to a Hazard Index of 0.1)

Data Qualifiers:

U Not detected
J Analyte present. Reported value between detection and quantitation limits
D Sample diluted due to exceedance of calibration range in original sample
B Analyte present in associated method blank

550	Bolded text indicates analyte was detected.
200	Yellow shaded box indicates analyte detected above EPA RBC for residential soils only
800	Pink shaded box indicates analyte detected above EPA RBC for both residential and industrial soils

TABLE 4-4
SOIL RESULTS - SEMIVOLATILE ORGANICS
80th Division Reserve Site, Fort Story, VA

Compound	Soil Results (ug/kg)									EPA RBCs (1)	
	Boring MW-10			Boring MW-11			Boring SB-1			Industrial Soils	Residential Soils
	0 to 6 in.	1 to 3 ft.	4 to 6 ft.	0 to 6 in.	1 to 3 ft.	4 to 6 ft.	0 to 6 in.	1 to 3 ft.	4 to 6 ft.		
Acenaphthene	370 U	360 U	390 U	360 U	340 U	390 U	**49 J**	**85 J**	410 U	6,100,000	470,000
Acenaphthylene	370 U	360 U	390 U	360 U	340 U	390 U	**81 J**	**140 J**	**36 J**	---	---
Anthracene	370 U	360 U	390 U	360 U	340 U	390 U	**76 J**	**150 J**	**33 J**	31,000,000	2,300,000
Benzo(a)anthracene	370 U	360 U	390 U	360 U	340 U	390 U	**210 J**	**340 J**	**93 J**	3,900	220
Benzo(a)pyrene	370 U	360 U	390 U	360 U	340 U	390 U	**170 J**	**270 J**	**72 J**	390	22
Benzo(b)fluoranthene	370 U	360 U	390 U	360 U	340 U	390 U	**240 J**	**300 J**	**110 J**	3,900	220
Benzo(g,h,i)perylene	370 U	360 U	390 U	360 U	340 U	390 U	**140 J**	**190 J**	**64 J**	---	---
Benzo(k)fluoranthene	370 U	360 U	390 U	360 U	340 U	390 U	**210 J**	**360**	**91 J**	39,000	2,200
1,1'-Biphenyl	370 U	360 U	390 U	360 U	340 U	390 U	330 U	**26 J**	410 U	5,100,000	39,000
Bis(2-ethylhexyl)phthalate	**130 J**	360 U	**610**	**45 J**	**310 J**	**270 J**	**84 J**	**290 J**	**390 J**	200,000	46,000
Carbazole	370 U	360 U	390 U	360 U	340 U	390 U	330 U	350 U	410 U	140,000	32,000
Chrysene	370 U	360 U	390 U	360 U	340 U	390 U	**210 J**	**340 J**	**92 J**	390,000	22,000
Dibenzo(a,h)anthracene	370 U	360 U	390 U	360 U	340 U	390 U	**46 J**	**67 J**	410 U	390	22
Dibenzofuran	370 U	360 U	390 U	360 U	340 U	390 U	**30 J**	**54 J**	410 U	200,000	16,000
3,3'-Dichlorobenzidine	370 U	360 U	390 U	360 U	340 U	390 U	330 U	350 U	410 U	6,400	1,400
2,4-Dinitrotoluene	370 U	360 U	390 U	360 U	340 U	390 U	330 U	350 U	410 U	200,000	16,000
2,6-Dinitrotoluene	370 U	360 U	390 U	360 U	340 U	390 U	330 U	350 U	410 U	100,000	7,800
Di-n-octyl phthalate	370 U	360 U	390 U	360 U	340 U	390 U	**280 J**	**32 J**	410 U	---	---
Fluoranthene	370 U	360 U	**42 JB**	360 U	340 U	390 U	**370**	**620**	**150 J**	4,100,000	310,000
Fluorene	370 U	360 U	390 U	360 U	340 U	390 U	**94 J**	**170 J**	**28 J**	4,100,000	310,000
Indeno(1,2,3-cd)pyrene	370 U	360 U	390 U	360 U	340 U	390 U	150 J	**200 J**	**65 J**	3,900	220
2-Methylnaphthalene	370 U	360 U	390 U	360 U	340 U	390 U	**34 J**	**75 J**	410 U	410,000	31,000
N-Nitrosodiphenylamine	370 U	360 U	390 U	360 U	340 U	390 U	330 U	350 U	410 U	580,000	130,000
Naphthalene	370 U	360 U	390 U	360 U	340 U	390 U	330 U	350 U	410 U	2,000,000	160,000
Phenanthrene	370 U	360 U	**74 JB**	360 U	340 U	390 U	**390**	**810**	**150 J**	---	---
Pyrene	370 U	360 U	**61 JB**	360 U	340 U	390 U	740 U	**1200**	**330 J**	3,100,000	230,000

Notes:

(1) EPA Risk-based Concentrations for Industrial and Residential Soils (April 25, 2003)
(Non-carcinogens adjusted to a Hazard Index of 0.1)

Data Qualifiers:

U Not detected
J Analyte present. Reported value between detection and quantitation limits
D Sample diluted due to exceedance of calibration range in original sample
B Analyte present in associated method blank

550	Bolded text indicates analyte was detected.
200	Yellow shaded box indicates analyte detected above EPA RBC for residential soils only
800	Pink shaded box indicates analyte detected above EPA RBC for both residential and industrial soils

TABLE 4-4
SOIL RESULTS - SEMIVOLATILE ORGANICS
80th Division Reserve Site, Fort Story, VA

Compound	Soil Results (ug/kg)												EPA RBCs (1)	
	Boring SB-2			Boring SB-3			Boring SB-4			Boring SB-5			Industrial Soils	Residential Soils
	0 to 6 in.	1 to 3 ft.	4 to 6 ft.	0 to 6 in.	1 to 3 ft.	4 to 6 ft.	0 to 6 in.	1 to 3 ft.	4 to 6 ft.	0 to 6 in.	1 to 3 ft.	4 to 6 ft.		
Acenaphthene	340 U	360 U	410 U	**560**	350 U	400 U	**240 J**	360 U	**68 J**	1100 U	350 U	410 U	6,100,000	470,000
Acenaphthylene	**250 J**	360 U	**33 J**	**1700**	**130 J**	**32 J**	**1400**	**150 J**	**450**	**900 J**	**21 J**	**74 J**	---	---
Anthracene	**150 J**	360 U	410 U	**2000**	**120 J**	400 U	**1100 J**	**110 J**	**360 J**	**750 J**	350 U	**69 J**	31,000,000	2,300,000
Benzo(a)anthracene	**320 J**	360 U	**45 J**	**5600 D**	**420**	**83 J**	**4300**	**510**	**1500**	**3300**	**76 J**	**280 J**	3,900	220
Benzo(a)pyrene	**430**	360 U	**49 J**	**5500 D**	**330 J**	**58 J**	**4000**	**450**	**1400**	**3200**	**65 J**	**260 J**	390	22
Benzo(b)fluoranthene	**750**	360 U	**90 J**	**6500 D**	**660**	**80 J**	**5100**	**570**	**2000**	**3400**	**69 J**	**300 J**	3,900	220
Benzo(g,h,i)perylene	**550**	**26 J**	**58 J**	**3700**	**270 J**	**56 J**	**2500**	**310 J**	**900**	**1900**	**56 J**	**180 J**	---	---
Benzo(k)fluoranthene	**500**	360 U	**62 J**	**4100**	**680**	**79 J**	**3600**	**460**	**1300**	**3200**	**79 J**	**250 J**	39,000	2,200
1,1'-Biphenyl	340 U	360 U	410 U	**250 J**	350 U	400 U	**120 J**	360 U	410 U	**85 J**	350 U	410 U	5,100,000	39,000
Bis(2-ethylhexyl)phthalate	**91 J**	**130 J**	**180 J**	**200 J**	**160 J**	**260 J**	1100 U	**96 J**	**260 J**	**190 J**	**90 J**	**470**	200,000	46,000
Carbazole	340 U	360 U	410 U	**490**	350 U	400 U	**150 J**	360 U	**48 J**	**120 J**	350 U	410 U	140,000	32,000
Chrysene	**410**	360 U	**50 J**	**6000 D**	**450**	**97 J**	**5000**	**570**	**1800**	**3700**	**86 J**	**320 J**	390,000	22,000
Dibenzo(a,h)anthracene	**160 J**	360 U	410 U	**1500**	**110 J**	400 U	**910 J**	**110 J**	**350 J**	**680 J**	350 U	**64 J**	390	22
Dibenzofuran	340 U	360 U	410 U	390	350 U	400 U	300 J	360 U	**73 J**	**230 J**	350 U	410 U	200,000	16,000
3,3'-Dichlorobenzidine	340 U	360 U	410 U	**290 J**	350 U	400 U	1100 U	360 U	**41 J**	1100 U	350 U	410 U	6,400	1,400
2,4-Dinitrotoluene	340 U	360 U	**130 J**	340 U	350 U	400 U	1100 U	360 U	410 U	1100 U	350 U	410 U	200,000	16,000
2,6-Dinitrotoluene	340 U	360 U	**51 J**	340 U	350 U	400 U	1100 U	360 U	410 U	1100 U	350 U	410 U	100,000	7,800
Di-n-octyl phthalate	**210 J**	360 U	410 U	**24 J**	350 U	**43 J**	1100 U	360 U	410 U	1100 U	350 U	410 U	---	---
Fluoranthene	**530**	**37 J**	**95 J**	**9800 D**	**660**	**150 J**	**6300**	**750**	**2300**	**4500**	**120 J**	**420**	4,100,000	310,000
Fluorene	25 J	360 U	410 U	**1400**	**80 J**	400 U	**500 J**	**46 J**	**140 J**	**67 J**	350 U	410 U	4,100,000	310,000
Indeno(1,2,3-cd)pyrene	**520**	**25 J**	**55 J**	**3600**	**260 J**	**52 J**	**2600**	**310 J**	**950**	**2000**	**49 J**	**160 J**	3,900	220
2-Methylnaphthalene	340 U	360 U	410 U	**1000**	**51 J**	400 U	**510 J**	360 U	**94 J**	**490 J**	350 U	**49 J**	410,000	31,000
N-Nitrosodiphenylamine	340 U	360 U	**150 J**	340 U	350 U	400 U	1100 U	360 U	410 U	1100 U	350 U	410 U	580,000	130,000
Naphthalene	340 U	360 U	410 U	**340 J**	350 U	400 U	**190 J**	360 U	**31 J**	**120 J**	350 U	410 U	2,000,000	160,000
Phenanthrene	**410**	**29 J**	**70 J**	**9500 D**	**530**	**120 J**	**4500**	**440**	**1400**	**3700**	**120 J**	**400 J**	---	---
Pyrene	**920**	**50 J**	**130 J**	**16000 D**	**1000**	**220 J**	**11000**	**1400**	**4000**	**8200**	**210 J**	**780**	3,100,000	230,000

Notes:

(1) EPA Risk-based Concentrations for Industrial and Residential Soils (April 25, 2003)
(Non-carcinogens adjusted to a Hazard Index of 0.1)

Data Qualifiers:

U Not detected
J Analyte present. Reported value between detection and quantitation limits
D Sample diluted due to exceedance of calibration range in original sample
B Analyte present in associated method blank

550	Bolded text indicates analyte was detected.
200	Yellow shaded box indicates analyte detected above EPA RBC for residential soils only
800	Pink shaded box indicates analyte detected above EPA RBC for both residential and industrial soils

TABLE 4-5
SOIL RESULTS - PESTICIDES AND PCBs
80 Division Reserve Site, Fort Story, VA

	Soil Samples									EPA RBCs (1)	
	Boring MW-7			Boring MW-8			Boring MW-9			Industrial Soils	Residential Soils
	0 to 6 in.	1 to 3 ft.	4 to 6 ft.	0 to 6 in.	1 to 3 ft.	4 to 6 ft.	0 to 6 in.	1 to 3 ft.	4 to 6 ft.		
Pesticides (ug/kg)											
Aldrin	0.87 U	0.9 U	1 U	0.88 U	**0.98 P**	0.94 U	0.9 U	0.89 U	0.91 U	170	38
alpha-BHC	0.87 U	0.9 U	1 U	0.88 U	0.95 U	0.94 U	0.9 U	0.89 U	0.91 U	450	100
beta-BHC	1.8 U	1.8 U	2.1 U	1.8 U	2 U	1.9 U	1.8 U	1.8 U	1.9 U	1,600	350
delta-BHC	0.87 U	0.9 U	1 U	0.88 U	0.95 U	0.94 U	0.9 U	0.89 U	0.91 U	450	100
gamma-BHC (Lindane)	0.87 U	0.9 U	1 U	0.88 U	0.95 U	0.94 U	0.9 U	0.89 U	0.91 U	2,200	490
Chlordane (gamma)	0.87 U	0.9 U	1 U	0.88 U	0.95 U	0.94 U	0.9 U	0.89 U	0.91 U	8,200	1,800
4,4'-DDD	3.5 U	3.6 U	4.1 U	3.5 U	3.8 U	**4.3**	**2.7 JP**	3.5 U	**6.4 P**	12,000	2,700
4,4'-DDE	1.8 U	1.8 U	2.1 U	1.8 U	2 U	1.9 U	**1.7 J**	**2.6**	1.9 U	8,400	1,900
4,4'-DDT	**4.3 J**	5.4 U	6.3 U	5.3 U	5.7 U	5.7 U	**8.8 P**	5.4 U	**7.3**	8,400	1,900
Dieldrin	1.8 U	1.8 U	2.1 U	**27 EP**	2 U	**16 EP**	1.8 U	1.8 U	1.9 U	180	40
Endosulfan I	1.8 U	1.8 U	2.1 U	1.8 U	2 U	1.9 U	1.8 U	1.8 U	1.9 U	610,000	47,000
Endosulfan II	3.5 U	3.6 U	4.1 U	**18 P**	3.8 U	3.8 U	3.6 U	3.5 U	3.6 U	610,000	47,000
Endosulfan sulfate	3.5 U	3.6 U	4.1 U	3.5 U	3.8 U	3.8 U	3.6 U	3.5 U	3.6 U	610,000	47,000
Endrin	3.5 U	3.6 U	4.1 U	3.5 U	3.8 U	3.8 U	3.6 U	3.5 U	3.6 U	31,000	2,300
Endrin aldehyde	3.5 U	3.6 U	4.1 U	3.5 U	3.8 U	3.8 U	3.6 U	3.5 U	3.6 U	31,000	2,300
Endrin ketone	8.7 U	9 U	10 U	**52**	9.5 U	**5.5 JP**	9 U	8.9 U	9.1 U	31,000	2,300
Heptachlor	0.87 U	0.9 U	1 U	0.88 U	0.95 U	0.94 U	0.9 U	0.89 U	0.91 U	640	140
PCBs (ug/kg)											
Aroclor-1016	68 U	71 U	81 U	69 U	75 U	74 U	71 U	70 U	71 U	41,000	550
Aroclor-1221	89 U	92 U	110 U	90 U	98 U	97 U	92 U	91 U	93 U	1,400	320
Aroclor-1232	68 U	71 U	81 U	69 U	75 U	74 U	71 U	70 U	71 U	1,400	320
Aroclor-1242	47 U	49 U	56 U	48 U	52 U	51 U	49 U	48 U	49 U	1,400	320
Aroclor-1248	47 U	49 U	56 U	48 U	52 U	51 U	49 U	48 U	49 U	1,400	320
Aroclor-1254	47 U	49 U	56 U	48 U	52 U	51 U	49 U	48 U	49 U	1,400	320
Aroclor-1260	68 U	71 U	**21 J**	69 U	75 U	74 U	71 U	**67 J**	71 U	1,400	320

Notes:
(1) EPA Risk-based Concentrations for Industrial and Residential Soils (April 25, 2003)
(Non-carcinogens adjusted to a Hazard Index of 0.1)

Data Qualifiers:
- U Not detected
- J Analyte present. Reported value between detection and quantitation limits
- D Sample diluted due to exceedance of calibration range in original sample
- B Analyte present in associated method blank
- E Exceeded calibration range of instrument
- P Greater than 25% difference for detected levels in two GC columns

550	Bolded text indicates analyte was detected.
200	Yellow shaded box indicates analyte detected above EPA RBC for residential soils only
800	Pink shaded box indicates analyte detected above EPA RBC for both residential and industrial soils

TABLE 4-5
SOIL RESULTS - PESTICIDES AND PCBs
80 Division Reserve Site, Fort Story, VA

	Soil Samples									EPA RBCs (1)	
	Boring MW-10			Boring MW-11			Boring SB-1			Industrial Soils	Residential Soils
	0 to 6 in.	1 to 3 ft.	4 to 6 ft.	0 to 6 in.	1 to 3 ft.	4 to 6 ft.	0 to 6 in.	1 to 3 ft.	4 to 6 ft.		
Pesticides (ug/kg)											
Aldrin	0.93 U	0.91 U	0.98 U	0.91 U	0.86 U	0.97 U	0.84 U	**11 E**	1 U	170	38
alpha-BHC	0.93 U	0.91 U	0.98 U	0.91 U	0.86 U	0.98 U	0.84 U	0.87 U	1 U	450	100
beta-BHC	1.9 U	**2.4 P**	2 U	**3.7 P**	1.8 U	2 U	1.7 U	**100 EP**	2.1 U	1,600	350
delta-BHC	0.93 U	0.91 U	0.98 U	**1.3**	0.86 U	0.98 U	0.84 U	0.87 U	1 U	450	100
gamma-BHC (Lindane)	0.93 U	0.91 U	**0.37 J**	0.91 U	0.86 U	0.98 U	0.84 U	0.87 U	1 U	2,200	490
Chlordane (gamma)	0.93 U	0.91 U	0.98 U	0.91 U	0.86 U	0.98 U	0.84 U	0.87 U	1 U	8,200	1,800
4,4'-DDD	3.7 U	3.6 U	**0.42 J**	3.6 U	3.4 U	**0.88 J**	3.3 U	6.9 U	4.1 U	12,000	2,700
4,4'-DDE	1.9 U	1.9 U	2 U	**3.1 P**	**1.6 J**	2 U	1.7 U	3.6 U	2.1 U	8,400	1,900
4,4'-DDT	5.6 U	5.5 U	**3 JP**	5.5 U	**1.7 J**	**1.3 JP**	5.1 U	11 U	6.3 U	8,400	1,900
Dieldrin	1.9 U	1.9 U	2 U	1.9 U	1.8 U	2 U	1.7 U	3.6 U	2.1 U	180	40
Endosulfan I	1.9 U	1.9 U	2 U	1.9 U	1.8 U	2 U	1.7 U	3.6 U	2.1 U	610,000	47,000
Endosulfan II	3.7 U	3.6 U	3.9 U	3.6 U	3.4 U	3.9 U	3.3 U	6.9 U	4.1 U	610,000	47,000
Endosulfan sulfate	3.7 U	3.6 U	3.9 U	3.6 U	3.4 U	3.9 U	3.3 U	**6.7**	4.1 U	610,000	47,000
Endrin	3.7 U	3.6 U	3.9 U	3.6 U	3.4 U	3.9 U	3.3 U	3.5 U	4.1 U	31,000	2,300
Endrin aldehyde	3.7 U	3.6 U	3.9 U	**0.97 J**	3.4 U	3.9 U	3.3 U	3.5 U	**0.88 JP**	31,000	2,300
Endrin ketone	9.3 U	9.1 U	9.8 U	9.1 U	8.6 U	9.8 U	**4.2 J**	**11**	**1.1 JP**	31,000	2,300
Heptachlor	0.93 U	0.91 U	0.98 U	0.91 U	0.86 U	0.98 U	0.84 U	0.87 U	1 U	640	140
PCBs (ug/kg)											
Aroclor-1016	73 U	71 U	76 U	71 U	68 U	76 U	66 U	140 U	81 U	41,000	550
Aroclor-1221	96 U	93 U	100 U	93 U	89 U	100 U	86 U	180 U	110 U	1,400	320
Aroclor-1232	73 U	71 U	76 U	71 U	68 U	76 U	66 U	140 U	81 U	1,400	320
Aroclor-1242	51 U	49 U	53 U	49 U	47 U	53 U	45 U	95 U	56 U	1,400	320
Aroclor-1248	51 U	49 U	53 U	49 U	47 U	53 U	45 U	95 U	56 U	1,400	320
Aroclor-1254	51 U	49 U	53 U	49 U	47 U	53 U	45 U	95 U	56 U	1,400	320
Aroclor-1260	73 U	71 U	76 U	71 U	68 U	76 U	66 U	140 U	81 U	1,400	320

Notes:
(1) EPA Risk-based Concentrations for Industrial and Residential Soils (April 25, 2003)
(Non-carcinogens adjusted to a Hazard Index of 0.1)

Data Qualifiers:
U Not detected
J Analyte present. Reported value between detection and quantitation limits
D Sample diluted due to exceedance of calibration range in original sample
B Analyte present in associated method blank
E Exceeded calibration range of instrument
P Greater than 25% difference for detected levels in two GC columns

550	Bolded text indicates analyte was detected.
200	Yellow shaded box indicates analyte detected above EPA RBC for residential soils only
800	Pink shaded box indicates analyte detected above EPA RBC for both residential and industrial soils

TABLE 4-5
SOIL RESULTS - PESTICIDES AND PCBs
80 Division Reserve Site, Fort Story, VA

	Soil Samples												EPA RBCs (1)	
	Boring SB-2			Boring SB-3			Boring SB-4			Boring SB-5			Ind.	Res.
	0 to 6 in.	1 to 3 ft.	4 to 6 ft.	0 to 6 in.	1 to 3 ft.	4 to 6 ft.	0 to 6 in.	1 to 3 ft.	4 to 6 ft.	0 to 6 in.	1 to 3 ft.	4 to 6 ft.	Soils	Soils
Pesticides (ug/kg)														
Aldrin	0.86 U	0.9 U	1 U	86 U	**15 E**	1 U	**36**	0.91 U	1 U	**73 E**	0.88 U	1 U	170	38
alpha-BHC	0.86 U	0.9 U	1 U	86 U	**1.7 J**	1 U	4.6 U	0.91 U	1 U	88 U	**0.74 J**	**0.53 J**	450	100
beta-BHC	1.8 U	1.8 U	2.1 U	180 U	3.6 U	2 U	9.3 U	1.9 U	2.1 U	180 U	1.8 U	2.1 U	1,600	350
delta-BHC	0.86 U	0.9 U	1 U	86 U	1.7 U	1 U	4.6 U	0.91 U	1 U	88 U	**0.66 J**	1 U	450	100
gamma-BHC (Lindane)	0.86 U	**0.39 J**	1 U	86 U	1.7 U	1 U	4.6 U	0.91 U	1 U	88 U	0.88 U	1 U	2,200	490
Chlordane (gamma)	0.86 U	0.9 U	1 U	86 U	**1.7 U**	1 U	4.6 U	0.91 U	1 U	88 U	0.88 U	1 U	8,200	1,800
4,4'-DDD	3.4 U	3.6 U	4.1 U	340 U	6.9 U	4 U	18 U	3.6 U	4.1 U	350 U	3.5 U	4.1 U	12,000	2,700
4,4'-DDE	1.8 U	1.8 U	2.1 U	180 U	3.6 U	2 U	9.3 U	1.9 U	2.1 U	180 U	1.8 U	2.1 U	8,400	1,900
4,4'-DDT	**2.4 J**	**0.91 J**	6.3 U	520 U	11 U	6 U	27 U	5.5 U	6.2 U	530 U	5.3 U	6.2 U	8,400	1,900
Dieldrin	1.8 U	1.8 U	2.1 U	180 U	3.6 U	2 U	9.3 U	1.9 U	**7.1 P**	180 U	1.8 U	2.1 U	180	40
Endosulfan I	1.8 U	1.8 U	2.1 U	180 U	**0.9 JP**	2 U	9.3 U	1.9 U	2.1 U	180 U	1.8 U	2.1 U	610,000	47,000
Endosulfan II	3.4 U	3.6 U	4.1 U	340 U	6.9 U	4 U	18 U	3.6 U	4.1 U	350 U	3.5 U	4.1 U	610,000	47,000
Endosulfan sulfate	3.4 U	3.6 U	4.1 U	**69 EP**	**5.7**	4 U	**25**	3.6 U	**13**	**110 JD**	**0.8 J**	4.1 U	610,000	47,000
Endrin	3.4 U	3.6 U	4.1 U	340 U	6.9 U	4 U	18 U	3.6 U	4.1 U	350 U	3.5 U	4.1 U	31,000	2,300
Endrin aldehyde	3.4 U	3.6 U	4.1 U	340 U	10 U	4 U	18 U	3.6 U	4.1 U	350 U	3.5 U	4.1 U	31,000	2,300
Endrin ketone	**16**	**1.6 J**	**1.9 JP**	**110 EP**	**14**	**1.5 JP**	**31 JP**	**6.9 J**	**7.3 J**	**110**	**4.2 JP**	**7.1 J**	31,000	2,300
Heptachlor	0.86 U	0.9 U	1 U	86 U	1.7 U	1 U	4.6 U	0.91 U	1 U	88 U	**1 P**	1 U	640	140
PCBs (ug/kg)														
Aroclor-1016	81 U	67 U	71 U	6700 U	140 U	78 U	360 U	71 U	80 U	6900 U	69 U	80 U	41,000	550
Aroclor-1221	110 U	88 U	92 U	8800 U	180 U	100 U	470 U	93 U	100 U	9000 U	90 U	100 U	1,400	320
Aroclor-1232	81 U	67 U	71 U	6700 U	140 U	78 U	360 U	71 U	80 U	6900 U	69 U	80 U	1,400	320
Aroclor-1242	56 U	46 U	49 U	4600 U	95 U	54 U	250 U	49 U	56 U	4800 U	48 U	56 U	1,400	320
Aroclor-1248	56 U	46 U	49 U	4600 U	95 U	54 U	250 U	49 U	56 U	4800 U	48 U	56 U	1,400	320
Aroclor-1254	56 U	46 U	49 U	4600 U	95 U	54 U	250 U	49 U	56 U	4800 U	48 U	56 U	1,400	320
Aroclor-1260	81 U	67 U	71 U	6700 U	140 U	78 U	360 U	71 U	80 U	6900 U	69 U	80 U	1,400	320

Notes:
(1) EPA Risk-based Concentrations for Industrial and Residential Soils (April 25, 2003)
(Non-carcinogens adjusted to a Hazard Index of 0.1)

Data Qualifiers:
U Not detected
J Analyte present. Reported value between detection and quantitation limits
D Sample diluted due to exceedance of calibration range in original sample
B Analyte present in associated method blank
E Exceeded calibration range of instrument
P Greater than 25% difference for detected levels in two GC columns

550	Bolded text indicates analyte was detected.
200	Yellow shaded box indicates analyte detected above EPA RBC for residential soils only
800	Pink shaded box indicates analyte detected above EPA RBC for both residential and industrial soils

TABLE 4-6
SOIL RESULTS - METALS
80th Division Reserve Site, Fort Story, VA

Compound	Soil Samples (mg/kg)									EPA RBCs	
	Boring MW-7			Boring MW-8			Boring MW-9			Industrial Soils	Residential Soils
	0 to 6 in.	1 to 3 ft.	4 to 6 ft.	0 to 6 in.	1 to 3 ft.	4 to 6 ft.	0 to 6 in.	1 to 3 ft.	4 to 6 ft.		
Aluminum	**1200 N***	**292 N***	**163 N***	**6930 N***	**236 N***	**328 N***	**889 N***	**488 N***	**284 N***	---	---
Antimony	**0.42 B***	**0.77 B***	**0.57 B***	**0.51 B***	0.4 U*	0.41 U*	**0.56 B***	**0.5 B***	0.4 U*	41	3.1
Arsenic	**0.63 B***	0.25 U*	0.31 U*	**1 B***	0.27 U*	0.28 U*	**0.81 B***	**0.43 B***	0.27 U*	1.9	0.43
Barium	**5.3 ***	**2.2 ***	**1 B***	**15.8 ***	**1.2 ***	**2 ***	**8.3 ***	**3.5 ***	**2.6 ***	20,000	1,600
Beryllium	**0.05 B***	**0.02 B***	0.01 U*	**0.11 B***	0.01 U*	0.01 U*	**0.06 B***	**0.03 B***	**0.02 B***	200	16
Cadmium	0.04 U*	0.04 U*	0.05 U*	0.04 U*	0.04 U*	0.04 U*	0.04 U*	0.04 U*	0.04 U*	100	7.8
Calcium	**247 ***	**96.4 B***	**41.5 B***	**574 ***	**38.6 B***	**78.5 B***	**3060 ***	**261 ***	**97.3 B***	---	---
Chromium	**4.2 ***	**4.6 ***	**1.9 ***	**9.8 ***	**2.6 ***	**5 ***	**2.7 ***	**2.4 ***	**4.8 ***	310	23
Cobalt	**0.8 ***	**0.2 B***	**0.08 B***	**0.93 ***	**0.07 B***	**0.15 B***	**0.71 ***	**0.36 B***	**0.25 B***	---	---
Copper	**6.3 ***	**2.6 ***	**0.28 B***	**1.3 ***	0.15 U*	0.16 U*	0.15 U*	**0.28 B***	**0.3 B***	4,100	310
Iron	**2,070 ***	**1,190 ***	**715 ***	**10100 ***	**952 ***	**1,250 ***	**2,390 ***	**1,330 ***	**1,380 ***	31,000	2,300
Lead	**21.2 N***	**9.6 N***	**1.5 N***	**6.3 N***	**0.65 N***	**0.84 N***	**8.3 N***	**5.4 N***	**2.1 N***	400	400
Magnesium	**151 *E**	**45.3 B*E**	**30 B*E**	**504 *E**	**36.5 B*E**	**69.4 B*E**	**265 *E**	**86.4 B*E**	**54.7 B*E**	---	---
Manganese	**13.3 ***	**8.8 ***	**3.7 ***	**69.1 ***	**4.1 ***	**8.2 ***	**33.7 ***	**13.1 ***	**11.6 ***	2,000	160
Mercury	**0.035**	**0.017 B**	0.018 U	**0.034**	0.017 U	0.017 U	**0.02 B**	**0.023 B**	0.018 U	31	2.3
Nickel	**0.73 ***	**0.39 B***	**0.15 B***	**3.7 ***	0.19 B*	**0.45 B***	**1.4 ***	**0.62 ***	**0.66 ***	2,000	160
Potassium	**169 ***	**61.3 B***	**45.8 B***	**494 ***	56.5 B*	**102 B***	**274 ***	**87.9 B***	**70.2 B***	---	---
Selenium	0.32 U*	0.33 U*	0.41 U*	**0.69 ***	0.35 U*	0.37 U*	0.35 U*	0.33 U*	0.36 U*	510	39
Silver	0.07 U*	0.07 U*	0.09 U*	0.07 U*	0.07 U*	0.08 U*	0.07 U*	0.07 U*	0.08 U*	510	39
Sodium	**133 B***	**65.7 B***	**51.7 B***	**77 B***	**51.4 B***	**61.1 B***	**84.5 B***	**62.4 B***	**54.9 B***	---	---
Thallium	0.49 UN*	0.51 UN*	0.64 UN*	0.53 UN*	0.55 UN*	0.57 UN*	0.54 UN*	0.51 UN*	0.55 UN*	7.2	0.55
Vanadium	**3.9 ***	**1.2 B***	**1.2 B***	**17.6 ***	**1.5 B***	**1.9 B***	**4.1 ***	**2.3 ***	**1.5 B***	100	7.8
Zinc	**81.8 *E**	**16.5 *E**	**3.6 *E**	**10.6 *E**	**1.1 B*E**	**2.3 *E**	**11 *E**	**5.1 *E**	**5.4 *E**	31,000	2,300

Notes:
(1) EPA Risk-based Concentrations for Industrial and Residential Soils (April 25, 2003)
(Non-carcinogens adjusted to a Hazard Index of 0.1)

Data Qualifiers:
U Not detected
B Analyte present. Reported value between detection and quantitation limits
E Estimated value, serial dilution results not within 10 percent
N Sample spike recovery is outside of control limits
* Sample and duplicate results are not within control limits

550	Bolded text indicates analyte was detected.
200	Yellow shaded box indicates analyte detected above EPA RBC for residential soils only
800	Pink shaded box indicates analyte detected above EPA RBC for both residential and industrial soils

TABLE 4-6
SOIL RESULTS - METALS
80th Division Reserve Site, Fort Story, VA

Compound	Soil Samples (mg/kg)									EPA RBCs	
	Boring MW-10			Boring MW-11			Boring SB-1			Industrial Soils	Residential Soils
	0 to 6 in.	1 to 3 ft.	4 to 6 ft.	0 to 6 in.	1 to 3 ft.	4 to 6 ft.	0 to 6 in.	1 to 3 ft.	4 to 6 ft.		
Aluminum	**395 N***	**1140**	**299 N***	**739**	**314 N***	**216 N***	**424**	**313**	**135**	---	---
Antimony	**0.47 B**	**0.74 B**	**0.51 B***	**2.1**	**0.71 B***	**0.5 B***	**0.46 B**	0.39 U	0.45 U	41	3.1
Arsenic	**0.51 B**	**1.2**	0.29 U*	**0.56 B**	0.25 U*	0.29 U*	0.24 U	**0.34 B**	0.3 U	1.9	0.43
Barium	**2.2 ***	**4.3**	**2.1 ***	**11.6**	**2.9 ***	**1.9 ***	**1.6**	**2**	**1 B**	20,000	1,600
Beryllium	**0.02 B**	**0.04 B**	0.01 U*	**0.05 B**	**0.02 B***	**0.01 B***	**0.01 B**	**0.02 B**	0.01 U	200	16
Cadmium	0.04 U	0.04 U	0.05 U*	0.04 U	0.04 U*	0.05 U*	0.04 U	0.04 U	0.05 U	100	7.8
Calcium	**70.1 B***	**269**	**118 ***	**110**	**77.7 B***	**88.9 B***	**44 B**	**67.1 B**	**25 B**	---	---
Chromium	**1.8**	**4.6**	**6.3 ***	**6**	**5.1 ***	**2.2 ***	**1**	**2.2**	**1.6**	310	23
Cobalt	**0.30 B**	**0.54 B**	**0.14 B***	**0.48 B**	**0.27 B***	**0.16 B***	**0.17 B**	**0.21 B**	0.07 U	---	---
Copper	**4.3**	**0.39 B**	**0.4 B***	**14.4**	**22.2 ***	**0.97 ***	0.14 U	0.15 U	0.17 U	4,100	310
Iron	**810**	**1,510**	**867 ***	**1,900**	**1,270 ***	**734 ***	**760**	**1,030**	**335**	31,000	2,300
Lead	**5 N***	**2.6 N***	**1.4 N***	**33.9 N***	**33.6 N***	**2.6 N***	**0.84 N***	**0.85 N***	**0.5 N***	400	400
Magnesium	**50.7 B*E**	**91.7 BE**	**45.5 B*E**	**84.3 BE**	**51.2 B*E**	**32.1 B*E**	**55.5 BE**	**81.2 BE**	**20.8 BE**	---	---
Manganese	**3.4**	**4.7**	**6.6 ***	**8**	**13.9 ***	**5.4 ***	**6.3**	**8**	**2.5**	2,000	160
Mercury	**0.021 B**	0.018 U	**0.02 B**	0.016 U	**0.018 B**	**0.02 B**	0.016 U	0.015 U	0.02 U	31	2.3
Nickel	**0.32 B**	**0.79**	**0.39 B***	**0.66**	**0.54 ***	**0.23 B***	**0.13 B**	**0.16 B**	**0:14 B**	2,000	160
Potassium	**96.7 B***	**157**	**74.2 B***	**111**	**58.4 B***	**53.7 B***	**64.9 B**	**94.4 B**	**39.7 B**	---	---
Selenium	0.37 U*	0.36 U	0.38 U*	**0.37 B**	0.33 U*	0.38 U*	0.32 U	0.35 U	0.4 U	510	39
Silver	0.08 U*	0.08 U	0.08 U*	0.07 U	0.07 U*	0.08 U*	0.07 U	0.07 U	0.08 U	510	39
Sodium	**59.6 B***	**57.2 B**	**67 B***	**127 B**	**95.2 B***	**59.7 B***	**44.5 B**	**49.7 B**	**61.7 B**	---	---
Thallium	0.571 U	0.56 UN	0.58 UN*	0.54 UN	0.51 UN*	0.58 UN*	0.5 UN	0.53 UN	0.62 UN	7.2	0.55
Vanadium	**2 B***	**3.6**	**1.3 B***	**2.9**	**1.6 B***	**0.99 B***	**1.4 B**	**1.6 B**	**0.76 B**	100	7.8
Zinc	**6.3**	**5.4**	**6.5 *E**	**66.3**	**42.7 *E**	**5.9 *E**	**1.8 B**	**2.6**	**1.6 B**	31,000	2,300

Notes:
(1) EPA Risk-based Concentrations for Industrial and Residential Soils (April 25, 2003)
(Non-carcinogens adjusted to a Hazard Index of 0.1)

Data Qualifiers:
U Not detected
B Analyte present. Reported value between detection and quantitation limits
E Estimated value, serial dilution results not within 10 percent
N Sample spike recovery is outside of control limits
* Sample and duplicate results are not within control limits

550	Bolded text indicates analyte was detected.
200	Yellow shaded box indicates analyte detected above EPA RBC for residential soils only
800	Pink shaded box indicates analyte detected above EPA RBC for both residential and industrial soils

TABLE 4-6
SOIL RESULTS - METALS
80th Division Reserve Site, Fort Story, VA

	Soil Samples (mg/kg)												EPA RBCs	
	Boring SB-2			Boring SB-3			Boring SB-4			Boring SB-5			Ind.	Res.
Compound	0 to 6 in.	1 to 3 ft.	4 to 6 ft.	0 to 6 in.	1 to 3 ft.	4 to 6 ft.	0 to 6 in.	1 to 3 ft.	4 to 6 ft.	0 to 6 in.	1 to 3 ft.	4 to 6 ft.	Soils	Soils
Aluminum	**1,970**	**225**	**142**	**1760**	**216**	**184**	**8,530**	**272**	**293**	**5,350**	**204**	**276**	---	---
Antimony	**0.35 B**	**0.49 B**	0.45 U	**0.47 B**	**0.44 B**	**0.64 B**	0.38 U	0.39 U	**0.45 B**	0.39 U	**0.43 B**	0.44 U	41	3.1
Arsenic	**0.35 B**	0.27 U	0.3 U	**0.41 B**	**0.41 B**	0.28 U	**0.92 B**	0.26 U	0.3 U	**0.67 B**	0.25 U	0.3 U	1.9	0.43
Barium	**5.1**	**2.2**	**1.3**	**4.6**	**1.4**	**0.98 B**	**14.1**	**2**	**1.7**	**10.7**	**1.3**	**1.4**	20,000	1,600
Beryllium	**0.04 B**	**0.02 B**	0.01 U	**0.04 B**	**0.02 B**	**0.01 B**	**0.12 B**	**0.03 B**	0.01 U	**0.08 B**	0.01 U	0.01 U	200	16
Cadmium	0.04 U	0.04 U	0.05 U	0.04 U	0.04 U	0.04 U	0.04 U	**0.11 B**	0.05 U	0.04 U	0.04 U	0.05 U	100	7.8
Calcium	**61.2 B**	**41.1 B**	**64.7 B**	**92.9 B**	**20.5 B**	**18.2 B**	**182**	**71.6 B**	**49.9 B**	**174**	**31.7 B**	**48.6 B**	---	---
Chromium	**3**	**1.4**	**1.4**	**3.1**	**2**	**1.4**	**10**	**1.5**	**2.7**	**6.4**	**2.6**	**1.7**	310	23
Cobalt	**0.35 B**	**0.17 B**	0.07 U	**0.3 B**	**0.22 B**	**0.1 B**	**0.73**	**0.22 B**	**0.09 B**	**0.59**	**0.09 B**	0.07 U	---	---
Copper	**0.38 B**	0.15 U	0.17 U	0.13 U	0.14 U	0.16 U	**1.0**	0.15 U	0.17 U	**0.41 B**	0.14 U	0.17 U	4,100	310
Iron	**2,650**	**769**	**395**	**2,640**	**910**	**619**	**9,060**	**756**	**696**	**5,970**	**843**	**730**	31,000	2,300
Lead	**2.7 N***	**1.1 N***	**0.66 N***	**2.6 N***	**0.86 N***	**0.75 N***	**6.9 N***	**0.71 N***	**0.72 N***	**4.6 N***	**0.71 N***	**0.79 N***	400	400
Magnesium	**114 E**	**40.6 BE**	**22.1 BE**	**129 E**	**36 BE**	**25.3 BE**	**337 E**	**44.2 BE**	**41.2 BE**	**266 E**	**34.6 BE**	**41.3 BE**	---	---
Manganese	**11**	**5.5**	**1.9**	**13.4**	**9.2**	**2.4**	**24.1**	**10.8**	**6.5**	**22**	**5**	**4.1**	2,000	160
Mercury	0.017 U	0.016 U	0.019 U	0.015 U	0.015 U	0.02 U	**0.02 B**	0.018 U	0.019 U	**0.032 B**	0.015 U	0.02 U	31	2.3
Nickel	**0.84**	**0.21 B**	0.12 U	**0.69**	**0.35 B**	0.11 U	**2.3**	**0.31 B**	**0.31 B**	**1.5**	**0.15 B**	0.12 U	2,000	160
Potassium	**161**	**63.5 B**	**62.7 B**	**173**	**59.8 B**	**56.2 B**	**445**	**50.1 B**	**58.6 B**	**361**	**43.1 B**	**55.9 B**	---	---
Selenium	0.32 U	0.35 U	0.4 U	**0.42 B**	0.32 U	0.37 U	**0.74**	0.35 U	0.39 U	**0.74**	0.33 U	0.4 U	510	39
Silver	0.07 U	0.07 U	0.08 U	0.07 U	0.07 U	0.08 U	0.07 U	**0.09 B**	0.08 U	0.07 U	0.07 U	0.08 U	510	39
Sodium	**51.3 B**	**52.2 B**	**77.7 B**	**50.3 B**	**48.1 B**	**56.7 B**	**68.5 B**	**49.9 B**	**58.3 B**	**76 B**	**48.6 B**	**51.4 B**	---	---
Thallium	0.49 UN	0.54 UN	0.62 UN	0.49 UN	0.5 UN	0.57 UN	0.53 UN	0.54 UN	0.61 UN	0.53 UN	0.5 UN	0.61 UN	7.2	0.55
Vanadium	**5.3**	**1.2 B**	**0.89 B**	**5**	**1.2 B**	**1.3 B**	**19.4**	**1.1 B**	**1 B**	**13.3**	**1.3 B**	**1.4 B**	100	7.8
Zinc	**4.1**	**5.3**	**15.8**	**3.9**	**1.6 B**	**1.5 B**	**8.7**	**3.5**	**2.9**	**6.8**	**1.7 B**	**1.3 B**	31,000	2,300

Notes:
(1) EPA Risk-based Concentrations for Industrial and Residential Soils (April 25, 2003)
(Non-carcinogens adjusted to a Hazard Index of 0.1)

Data Qualifiers:
U Not detected
B Analyte present. Reported value between detection and quantitation limits
E Estimated value, serial dilution results not within 10 percent
N Sample spike recovery is outside of control limits
* Sample and duplicate results are not within control limits

550	Bolded text indicates analyte was detected.
200	Yellow shaded box indicates analyte detected above EPA RBC for residential soils only
800	Pink shaded box indicates analyte detected above EPA RBC for both residential and industrial soils

TABLE 4-7
GROUNDWATER RESULTS
80th Division Reserve Site, Fort Story, VA

Compound	Monitoring Well I.D. and Groundwater Results										EPA Screening Criteria	
	MW-1	MW-2	MW-3	MW-5	MW-6	MW-7	MW-8	MW-9	MW-10	MW-11	Tap Water RBCs (1)	MCLs (2)
VOCs (ug/L)												
cis-1,2-Dichloroethene	5 U	5 U	5 U	5 U	5 U	0.7 J	5 U	5 U	5 U	5 U	6.1	70
Tetrachloroethene	5 U	5 U	5 U	0.3 J	5 U	4 J	6	0.8 J	5 U	5 U	0.1	5
Toluene	0.5 JB	0.5 JB	1 JB	0.3 JB	0.3 JB	0.2 JB	0.4 JB	0.3 JB	0.4 JB	0.4 JB	230	1,000
1,2,4-Trichlorobenzene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	0.2 JB	5 U	6.1	70
Trichloroethene	5 U	5 U	5 U	0.9 J	5 U	3 J	0.8 J	5 U	5 U	5 U	0.026	5
SVOCs (ug/L)												
Bis(2-ethylhexyl) phthalate	10 U	10 U	10 U	10 U	10 U	10 U	8 J	10 U	10 U	10 U	4.8	6
PESTICIDES/PCBs (ug/L)												
No pesticides or PCBs detected												
TOTAL METALS (ug/L)												
Aluminum	93.6 B	890	227	56.5 B	112	212	778	284	953	168	---	---
Antimony	5.1 B	6.4 B	3.1 B	2.5 B	3 B	2.3 U	4 B	2.3 U	2.8 B	4.6 B	1.5	6
Arsenic	3.7 U	3.7 U	3.7 U	3.7 U	3.7 U	3.7 U	6 B	3.7 U	4.9 B	4.8 B	0.045	10
Barium	5.2 BE	15.7 E	9.3 BE	7.8 BE	18.4 E	12.8 E	8.8 BE	30.8 E	10.8 E	13.1 E	730	2,000
Beryllium	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	7.3	4
Cadmium	0.4 U	1.1 B	0.4 U	0.4 U	0.41 B	0.4 U	0.4 U	0.71 B	0.4 U	0.4 U	1.8	5
Calcium	13,000	20,900	10,200	11,100	7,970	10,100	11,200	12,600	26,700	24,000	---	---
Chromium	1.8 B	6.6	1.9 B	1.3 B	1 B	2.1 B	2.8 B	2.2 B	4.4 B	2.2 B	11	100
Cobalt	0.59 B	0.5 U	0.5 U	0.5 U	0.5 U	0.53 B	0.5 U	0.5 U	0.5 U	0.5 U	73	---
Copper	1.5 U	1.9 B	1.5 U	1.5 U	1.5 U	1.5 U	4.2 B	1.5 U	1.5 U	1.5 U	150	1,300
Iron	650	972	292	802	884	1,390	1,020	1,120	3,240	5,130	1,100	---
Lead	1.1 U	4	1.1 U	1.1 U	1.8 B	1.1 U	1.2 B	1.1 U	1.3 B	1.1 U	---	15 (3)
Magnesium	1,280	2,700	1,130	1,620	2,090	1,210	1,260	1,460	3,160	2,970	---	---
Manganese	19.6	17.2	36.2	20	10.6	17.2	52	26.7	122	165	73	---
Mercury	0.11 B	0.12 B	0.11 B	0.1 B	0.1 U	0.13 B	0.1 U	0.1 U	0.12 B	0.1 U	1.1 (4)	2
Nickel	1 U	2.5 B	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	73	---
Potassium	1,130	2,380	1,110	1,040	1,480	2,170	1,580	2,040	4,920	2,270	---	---
Selenium	2.6 U	2.6 U	2.6 U	2.6 U	2.6 U	2.6 U	2.6 B	2.6 U	2.6 U	3.5 B	18	50
Silver	0.7 U	0.7 U	0.7 U	0.7 U	0.7 U	0.7 U	0.7 U	0.7 U	0.7 U	0.7 U	18	---
Sodium	4,140	4,970	3,620	4,870	11,700	3,160	7,150	7,740	4,840	4,010	---	---
Thallium	4.4 U	4.4 U	4.4 U	4.4 U	4.4 U	4.4 U	4.4 U	4.4 U	4.4 U	4.4 U	0.26	2
Vanadium	1.2 B	4.2 B	1.9 B	0.88 B	0.65 B	1.1 B	6.3 B	0.4 U	4.6 B	2.3 B	3.7	---
Zinc	309 *	173 *	76.6 *	134 *	86.7 *	177 *	11.7 B*	100 *	12 B*	6.8 B*	1,100	---

TABLE 4-7
GROUNDWATER RESULTS
80th Division Reserve Site, Fort Story, VA

Compound	Monitoring Well I.D. and Groundwater Results										EPA Screening Criteria	
	MW-1	MW-2	MW-3	MW-5	MW-6	MW-7	MW-8	MW-9	MW-10	MW-11	Tap Water RBCs (1)	MCLs (2)
DISSOLVED METALS (ug/L)												
Aluminum	**37.9** B	**86.2** B	**207**	**39.1** B	**60.7** B	**73.3** B	**63.6** B	**98.5** B	**124**	**85.7** B	---	---
Antimony	2.3 U	2.3 U	2.3 U	2.3 U	2.3 U	2.3 U	2.3 U	2.3 U	2.3 U	2.3 U	1.5	6
Arsenic	3.7 U	3.7 U	3.7 U	**5.4** B	3.7 U	3.7 U	**5** B	3.7 U	3.7 U	3.7 U	0.045	10
Barium	**4.9** B	**11.5**	**8.8** B	**7.7** B	**17.9**	**12.2**	**6.7** B	**28.2**	**8.6** B	**13**	730	2,000
Beryllium	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	7.3	4
Cadmium	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	**0.98** B	0.4 U	0.4 U	1.8	5
Calcium	**13600**	**20800**	**10400**	**11400**	**8190**	**10400**	**10900**	**12800**	**27500**	**25200**	---	---
Chromium	0.6 U	**0.81** B	**1.2** B	0.6 U	0.6 U	0.6 U	**0.85** B	0.6 U	**0.78** B	0.6 U	11	100
Cobalt	**0.53** B	0.5 U	0.5 U	0.5 U	0.5 U	**0.65** B	0.5 U	**1.1** B	0.5 U	0.5 U	73	---
Copper	1.5 U	1.5 U	**2.1** B	1.5 U	1.5 U	1.5 U	1.5 U	**2.1** B	1.5 U	1.5 U	150	1,300
Iron	**484**	**81.6** B	**247**	**885**	**419**	**1,170**	**355**	**1,010**	**2,170**	**4,650**	1,100	---
Lead	**1.3** B	1.1 U	**1.4** B	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	**1.2** B	---	15 (3)
Magnesium	**1,330**	**2,720**	**1,150**	**1,700**	**2,160**	**1,260**	**1,190**	**1,530**	**3,260**	**3,100**	---	---
Manganese	**18.9**	**13.8**	**37.2**	**21.7**	**9.7** B	**16.9**	**48.5**	**28**	**123**	**167**	73	---
Mercury	0.1 U	**0.11** B	**0.13** B	0.1 U	**0.11** B	0.1 U	**0.12** B	0.1 U	**0.12** B	0.1 U	1.1 (4)	2
Nickel	1 U	1 U	**1.5** B	1 U	1 U	1 U	**2.2** B	**1.9** B	1 U	1 U	73	---
Potassium	**1,340**	**2,630**	**1,250**	**1,200**	**1,670**	**2,410**	**1,730**	**2,320**	**5,520**	**2,670**	---	---
Selenium	2.6 U	**10.3**	**3.1** B	**3.7** B	2.6 U	**3.6** B	2.6 U	2.6 U	**3.8** B	**3** B	18	50
Silver	0.7 UN	0.7 UN	0.7 UN	0.7 UN	0.7 UN	0.7 UN	0.7 UN	0.7 UN	0.7 UN	0.7 UN	18	---
Sodium	**4,010**	**4,860**	**3,560**	**4,740**	**11,900**	**2,930**	**7,400**	**8,570**	**4,860**	**4,100**	---	---
Thallium	4.4 U	4.4 U	4.4 U	4.4 U	4.4 U	4.4 U	4.4 U	4.4 U	4.4 U	4.4 U	0.26	2
Vanadium	**1.1** B	**1.5** B	**1.7** B	**0.79** B	**0.48** B	**1** B	**4.8** B	**0.55** B	**2.2** B	**2** B	3.7	---
Zinc	**299**	**27**	**79.7**	**133**	**88.2**	**158**	**3.6** B	**97.7**	**4.4** B	**4.9** B	1,100	---
MISCELLANEOUS (mg/L)												
Total Dissolved Solids	**52**	**75**	**68**	**53**	**71**	**45**	**50**	**80**	**106**	**99**	---	---
Total Suspended Solids	1 U	**9.6**	**2.4**	1 U	**2.1**	**2.2**	**21.6**	**5.2**	**16.8**	**2.4**	---	---

Notes:

(1) EPA Risk-based Concentrations for Tap Water - April 25, 2003 EPA RBC Table (Non-carcinogens adjusted to a Hazard Index of 0.1)

(2) EPA Maximum Contaminant Levels (MCLs) - Only primary drinking water standards presented. Secondary MCLs for aesthetics only and are not presented in table.

(3) EPA Action Level of 15 ug/L presented.

(4) EPA RBC for tap water for mercuric chloride used for mercury.

550	Bolded text indicates analyte was detected.
800	Shaded box indicates analyte detected above EPA screening criteria

Data Qualifiers:

Organics:

U	Not detected
J	Analyte present. Reported value between detection and quantitation limits
B	Analyte present in associated method blank

Inorganics:

U	Not detected
B	Analyte present. Reported value between detection and quantitation limits.
N	Spike recovery is outside of control limits.
E	Estimated value. Serial dilution not within 10 percent.
*	Sample and duplicate sample not within control limits.

TABLE 4-8
GROUNDWATER RESULTS - JUNE 2004
80th Division Reserve Site, Fort Story, VA

Compound	Monitoring Well I.D. and Groundwater Results														EPA Screening Criteria	
	MW-1	MW-1D	MW-2	MW-3	MW-5	MW-6	MW-6 (dup)	MW-7	MW-8	MW-9	MW-10	MW-11	MW-12	MW-13	Tap Water RBCs (1)	MCLs (2)
VOCs (ug/L)																
cis-1,2-Dichloroethene	5 U	5 U	5 U	5 U	5 U	5 U	**1.9 J**	5 U	5 U	**11**	5 U	5 U	5 U	5 U	6.1	70
Tetrachloroethene	5 U	5 U	5 U	5 U	**2.1 J**	5 U	**1.2 J**	5 U	5 U	**6.5**	5 U	5 U	5 U	5 U	0.1	5
Trichloroethene	5 U	5 U	5 U	5 U	5 U	5 U	**1.5 J**	5 U	5 U	**28**	5 U	5 U	5 U	5 U	0.026	5

Notes:

(1) EPA Risk-based Concentrations for Tap Water - October 2004 EPA RBC Table (Non-carcinogens adjusted to a Hazard Index of 0.1)

(2) EPA Maximum Contaminant Levels (MCLs) - Only primary drinking water standards presented.Secondary MCLs for aesthetics only and are not presented in table.

Data Qualifiers:

Organics:

U Not detected

J Analyte present. Reported value between detection and quantitation limits

550	Bolded text indicates analyte was detected.
800	Shaded box indicates analyte detected above EPA screening criteria

TABLE 5-1
CHEMICAL PROPERTIES OF ORGANIC COMPOUNDS

COMPOUNDS	CHEMICAL PARAMETER							
	CAS No.	Vp (mm Hg)	Sw (mg/L)	Log Kow	Koc (ml/g)	Spec. Density	Kh (atm x m^3/mol)	MI
VOLATILE ORGANIC COMPOUNDS (VOCs)								
Acetone	67-64-1	231	misible	-0.24	1.981	0.79	3.67E-05	SM
2-Butanone (MEK)	78-93-3	9.06E+01	239000	0.29	165.5	0.805	1.05E-05	VM
Carbon Disulfide	75-15-0	2.97E+02	2100	1.7-4.16	1	1.2632	1.40E-03	EM
Chlorobenzene	108-90-7	1.20E+01	498	2.84	2.84	1.1066	3.45E-03	VM
Dichlorobenzene (o, m & p)	25321-22-6	1.74E+00	80	3.43	434	1.306	0.0012-0.0018	SM
Dichlorodifluoromethane	75-71-8	4.85E+03	280	2.16	48.64	1.329	2.25E-01	VM
1,2-Dichloroethane (1,2-DCA)	107-06-2	7.89E+01	5100	1.48	43.79	1.253	9.97E-04	VM
cis 1,2-Dichloroethene (1,2-DCE)	156-59-2	2.01E+02	3500	2.09	43.79	1.284	3.37E-03	VM
trans 1,2-Dichloroethene (1,2-DCE)	156-60-5	2.01E+02	3500	2.09	43.79	1.257	6.72E-03	VM
Ethylbenzene	100-41-4	7.00E+00	152	3.15	2.83	0.867	7.90E-03	IM
2-Hexanone	591-78-6	1.16E+01	0.0027	1.38	13.02	0.811	9.57E-05	SM
Methylene Acetate	79-20-9	2.16E+02	243000	0.18	3.324	0.932	1.15E-04	EM
Methylene chloroide	75-09-2	4.35E+02	13000	1.25	23.74	1.3255	2.68E-03	EM
4-Methyl-2-pentanone (MIBK)	108-10-1	1.45E+01	20400	1.19	10.91	0.7978	9.40E-05	VM
Tetrachloroethele (PCE)	127-18-4	1.85E+01	206	3.4	106.8	1.623	1.49E-02	VM
Toluene	108-88-3	2.84E+01	526	2.73	268	0.867	5.94E-03	VM
1,2,4-Trichlorobenzene	120-82-1	4.60E-01	49	4.02	717.6	1.4634	1.42E-03	SM
Trichloroethylene (TCE)	79-01-6	6.90E+01	1280	2.42	67.7	1.462	1.03E-02	VM
Trichloroflouromthane	75-69-4	8.03E+02	110	2.53	48.64	1.494	9.70E-02	VM
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	3.63E+02	170	3.16	224.7	1.575	5.26E-01	VM
Xylenes	1330-20-7	9.00E+00	0.3	3.16	2.84	0.87	7.00E-03	IM

TABLE 5-1
CHEMICAL PROPERTIES OF ORGANIC COMPOUNDS

COMPOUNDS	CHEMICAL PARAMETER							
	CAS No.	Vp (mm Hg)	Sw (mg/L)	Log Kow	Koc (ml/g)	Spec. Density	Kh (atm x m^3/mol)	MI
PESTICIDES								
Aldrin	309-00-2	1.20E-04	0.017	6.5	106000		4.96E-04	VIM
BHC (alpha, beta, delta, and gamma (Lindar	58-89-9	3.52E-05	8	4.14	3380	1.87	5.57E-05	IM
Chlordane (alpha & gamma)	5103-71-9	9.75E-06	0.056 - 0.10	8.69 - 9.65	5.48 - 6.00	1.63	1.34E-03	VIM
DDD	72-54-8	4.68E-06	0.020 - 0.090	5.061 - 6.217	5.38	1.476	2.16E-05	VIM
DDE	72-55-9	1.57E-05	0.04	5.69 - 6.956	5.386 - 6.00	NA	1.22E-03	VIM
DDT	50-29-3	1.70E-10	0.0012 - 0.0055	4.89 - 6.914	5.146 - 6.26	1.56	1.29E-05	VIM
Dieldrin	60-57-1	3.75E-06	0.17	4.32	10600	1.75	5.80E-05	VIM
Endosulfan I	115-29-7	1.00E-05	0.47 - 0.51	3.83	3.4605	NA	1.12E-05	VIM
Endrin aldehyde	53494-70-5	NA	NA	NA	NA	NA	NA	--
Heptachlor	76-44-8	4.00E-04	0.18	6.1	52400	1.58	1.48E-03	VIM
PCBs								
Aroclor-1260	11096-82-5	4.00E-05	0.000008	6.1 - 9.3	207000	1.58	3.40E-04	VIM

TABLE 5-1
CHEMICAL PROPERTIES OF ORGANIC COMPOUNDS

COMPOUNDS	CHEMICAL PARAMETER							
	CAS No.	Vp (mm Hg)	Sw (mg/L)	Log Kow	Koc (ml/g)	Spec. Density	Kh (atm x m^3/mol)	MI
SEMIVOLATILE ORGANIC COMPOUNDS (SVOCs)								
PAHs								
Phthalates								
1,1'-Biphenyl	92-52-4	8.93E-03	6.94	3.98	6250	0.992	3.00E-04	IM
3,3'-Dichlorobenzidine	91-94-1	4.16E-06	3.1	3.51	7489		4.50E-08	VIM
2,4-Dinitrotoluene	121-14-2	1.47E-04	270	1.98	363.8	1.512	8.67E-07	SM
2,6-Dinitortoluene	606-20-2	5.97E-04	352.4	2.1	371.4	1.2833	2.17E-07	SM
N-Nitrosodiphenyamine	1116-54-7	4.65E-06	1000000	-1.28	1	1.28	---	VM

NOTES:
EM = Extremely Mobile
VM = Very Mobile
SM = Slightly Mobile
IM = Immobile
VIM = Very Immobile

CHEMICAL PARAMETERS ABBREVIATIONS:
Vp = Vapor Pressure
Sw = Aqueous Solubility
Log Kow = Octanol/Water partition coefficient
Log Koc = Organic carbon adsorption coefficient
Spec. Density. = Specific density in water (at 20°c with respect to water at 4°c)
Kh = Henry's law constant
MI = Mobility Index (from Ford and Gurba, 1984; and Dragun, 1988)

TABLE 5-2
FATE AND TRANSPORT MECHANISMS AND PATHWAYS

Mechanisms	Pathways						
	S to Air	SW to Air	SW to Sed	Sed to SW	S/VZ to GW	GW to S/VZ	GW
ORGANICS							
Volatilization	X	X		X		X	X
Hydrolysis				X	X		
Biodegradation							X
Advection							X
Dispersion							X
Diffusion							X
Desorption/Adsorption			X	X	X	X	X
Partitioning			X	X		X	X
Solubility				X	X	X	X

S to Air - Soil to Air
SW to Air - Surface Water to Air
SW to Sed - Surface Water to Sediment
Sed to SW - Sediment to Surface Water
S/VZ to GW - Soil/Vadose Zone to Groundwater
GW to S/VZ - Groundwater to Soil/Vadose Zone
GW - Groundwater

TABLE 5-3
TRANSPORT PATHWAYS

Transport Pathways	80 DRS Fort Story Pathway Present?
S to Air	**Yes**
SW to Air	**No**
SW to Sed	**No**
Sed to SW	**No**
S/VZ to GW	**Yes**
GW to S/VZ	**Yes** (through fluctuating water table)
GW	**Yes** (Horizontal but not vertical)

S to Air - Soil to Air

SW to Air - Surface Water to Air

SW to Sed - Surface Water to Sediment

Sed to SW - Sediment to Surface Water

S/VZ to GW - Soil/Vadose Zone to Groundwater

GW to S/VZ - Groundwater to Soil/Vadose Zone

GW - Groundwater

TABLE 6-1
Hazard Assessment for Surface Soils
80th DRS, Fort Story, Virginia

Compound	Range of Detection	Frequency of Detection	EPA Region III Industrial Soil RBCs[1]	EPA Region III Residential Soil RBCs[1]	EPA Carcinogen Class[2]	Potential Concern?[3]
VOCs (ug/kg)						
Acetone	14 - 44	6/10	92,000,000	7,000,000	D	
2-Butanone (MEK)	5	1/10	61,000,000	4,700,000	D	
Carbon Disulfide	1 - 2	3/10	10,000,000	780,000	Not Assigned	
Chlorobenzene	0.5	1/10	2,000,000	160,000	D	
1,2-Dichlorobenzene	0.3	1/10	9,200,000	700,000	D	
1,3-Dichlorobenzene	0.5	1/10	310,000	23,000	D	
1,4-Dichlorobenzene	0.4 - 0.5	2/10	120,000	27,000	Not Assigned	
Dichlorodifluoromethane	0.6	1/10	20,000,000	1,600,000	Not Assigned	
1,2-Dichloroethane	3	1/10	31,000	7,000	B2	
Trans-1,2-dichlorothene	0.9 - 1	2/10	2,000,000	160,000	Not Assigned	
Ethylbenzene	0.7	2/10	10,000,000	780,000	D	
2-Hexanone	13 - 230	2/10	4,100,000	310,000	Not Assigned	
Methyl acetate	5 - 69	3/10	100,000,000	7,800,000	D	
Methylene chloride	4 - 10	9/10	380,000	85,000	B2	
4-Methyl-2-pentanone (MIBK)	10	1/10	---	---	Not Assigned	
Tetrachloroethene	5 - 120	5/10	5,300	1,200	C-B2	
Toluene	0.7 - 4	8/10	8,200,000	630,000	D	
Trichloroethene	0.8 - 1.0	2/10	7,200	1,600	B2	
Trichlorofluoromethane	2 - 3	2/10	31,000,000	2,300,000	Not Assigned	
1,1,2-trichloro-1,2,2-trifluoethane	1 - 2	4/10	3,100,000,000	230,000,000	Not Assigned	
Xylene (total)	1 - 7	3/10	20,000,000	1,600,000	D	

TABLE 6-1
Hazard Assessment for Surface Soils
80th DRS, Fort Story, Virginia

Compound	Range of Detection	Frequency of Detection	EPA Region III Industrial Soil RBCs[1]	EPA Region III Residential Soil RBCs[1]	EPA Carcinogen Class[2]	Potential Concern?[3]
SVOCs (ug/kg)						
Acenaphthene	**49 - 960**	**4/10**	**6,100**	**470**	**Not Assigned**	**Yes**
Acenaphthylene [4]	81 - 2,200	6/10	3,100,000	230,000	D	
Anthracene	**76 - 2,500**	**6/10**	**31,000**	**2,300**	**D**	**Yes**
Benzo(a)anthracene	**210 - 5,600**	**6/10**	**3,900**	**870**	**B2**	**Yes**
Benzo(a)pyrene	**28 - 5,500**	**7/10**	**390**	**87**	**B2**	**Yes**
Benzo(b)fluoranthene	**240 - 6,800**	**6/10**	**3,900**	**870**	**B2**	**Yes**
Benzo(g,h,i)perylene [4]	27 - 3,700	7/10	3,100,000	230,000	D	
Benzo(k)fluoranthene	36 - 4,100	7/10	39,000	8,700	B2	
1,1'-Biphenyl	85 - 470	4/10	5,100,000	39,000	D	
Bis(2-ethylhexyl)phthalate	40 - 200	8/10	200,000	46,000	B2	
Carbazole	120 - 490	4/10	140,000	32,000	----	
Chrysene	34 - 6,000	8/10	390,000	87,000	B2	
Dibenzo(a,h)anthracene	46 - 1,500	6/10	390,000	87,000	B2	
Dibenzofuran	30 - 790	3/10	200,000	16,000	D	
3,3'-Dichlorobenzidine	290	1/10	6,400	1,400	B2	
Di-n-octyl phthalate	24 - 280	3/10	2,000,000	160,000	----	
Fluoranthene	370 -9,800	7/10	4,100,000	310,000	D	
Fluorene	67 - 1,600	5/10	4,100,000	310,000	D	
Indeno(1,2,3-cd)pyrene	**29 - 3,600**	**6/10**	**3,900**	**870**	**B2**	**Yes**
2-Methylnaphthalene	34 - 2,400	5/10	2,000,000	160,000	----	
Naphthalene	120 - 1,200	4/10	2,000,000	160,000	Not Assigned	
Phenanthrene [4]	390 - 12,000	6/10	3,100,000	230,000	D	
Pyrene	43 - 16,000	6/10	3,100,000	230,000	D	

TABLE 6-1
Hazard Assessment for Surface Soils
80th DRS, Fort Story, Virginia

Compound	Range of Detection	Frequency of Detection	EPA Region III Industrial Soil RBCs[1]	EPA Region III Residential Soil RBCs[1]	EPA Carcinogen Class[2]	Potential Concern?[3]
Pesticides/PCBs (ug/kg)						
Aldrin	**36 - 76**	**2/10**	**170**	**38**	**B2**	**Yes**
beta-BHC	3.7	1/10	1,600	350	C	
delta-BHC	1.3	1/10	450	100	D	
4,4'-DDD	2.7	1/10	12,000	2,700	B2	
4,4'-DDE	1.7 - 3.1	2/10	8,400	1,900	B2	
4,4'-DDT	2.4 - 8.8	3/10	8,400	1,900	B2	
Dieldrin	27	1/10	180	40	B2	
Endosulfan II [5]	18	1/10	610,000	47,000	B2	
Endosulfan sulfate [5]	25 - 110	3/10	610,000	47,000	B2	
Endrin aldehyde	0.97	1/10	31,000	2,300	D	
Endrin ketone	4.2 - 110	5/10	31,000	2,300	D	

TABLE 6-1
Hazard Assessment for Surface Soils
80th DRS, Fort Story, Virginia

Compound	Range of Detection	Frequency of Detection	EPA Region III Industrial Soil RBCs[1]	EPA Region III Residential Soil RBCs[1]	EPA Carcinogen Class[2]	Potential Concern?[3]
SVOCs (ug/kg)						
Acenaphthene	49 - 960	4/10	6,100,000	470,000	Not Assigned	
Acenaphthylene [4]	81 - 2,200	6/10	3,100,000	230,000	D	
Anthracene	76 - 2,500	6/10	31,000,000	2,300,000	D	
Benzo(a)anthracene	**210 - 5,600**	**6/10**	**3,900**	**220**	**B2**	**Yes**
Benzo(a)pyrene	**28 - 5,500**	**7/10**	**390**	**22**	**B2**	**Yes**
Benzo(b)fluoranthene	**240 - 6,800**	**6/10**	**3,900**	**220**	**B2**	**Yes**
Benzo(g,h,i)perylene [4]	27 - 3,700	7/10	3,100,000	230,000	D	
Benzo(k)fluoranthene	36 - 4,100	7/10	39,000	2,200	B2	
1,1'-Biphenyl	85 - 470	4/10	5,100,000	39,000	D	
Bis(2-ethylhexyl)phthalate	40 - 200	8/10	200,000	46,000	B2	
Carbazole	120 - 490	4/10	140,000	32,000	----	
Chrysene	34 - 6,000	8/10	390,000	22,000	B2	
Dibenzo(a,h)anthracene	**46 - 1,500**	**6/10**	**390**	**22**	**B2**	**Yes**
Dibenzofuran	30 - 790	3/10	200,000	16,000	D	
3,3'-Dichlorobenzidine	290	1/10	6,400	1,400	B2	
Di-n-octyl phthalate	24 - 280	3/10	2,000,000	160,000	----	
Fluoranthene	370 -9,800	7/10	4,100,000	310,000	D	
Fluorene	67 - 1,600	5/10	4,100,000	310,000	D	
Indeno(1,2,3-cd)pyrene	**29 - 3,600**	**6/10**	**3,900**	**220**	**B2**	**Yes**
2-Methylnaphthalene	34 - 2,400	5/10	410,000	31,000	D	
Naphthalene	120 - 1,200	4/10	2,000,000	160,000	Not Assigned	
Phenanthrene [4]	390 - 12,000	6/10	3,100,000	230,000	D	
Pyrene	43 - 16,000	6/10	3,100,000	230,000	D	

TABLE 6-1
Hazard Assessment for Surface Soils
80th DRS, Fort Story, Virginia

Compound	Range of Detection	Frequency of Detection	EPA Region III Industrial Soil RBCs[1]	EPA Region III Residential Soil RBCs[1]	EPA Carcinogen Class[2]	Potential Concern?[3]
Pesticides/PCBs (ug/kg)						
Aldrin	**36 - 76**	**2/10**	**170**	**38**	**B2**	**Yes**
beta-BHC	3.7	1/10	1,600	350	C	
delta-BHC	1.3	1/10	450	100	D	
4,4'-DDD	2.7	1/10	12,000	2,700	B2	
4,4'-DDE	1.7 - 3.1	2/10	8,400	1,900	B2	
4,4'-DDT	2.4 - 8.8	3/10	8,400	1,900	B2	
Dieldrin	27	1/10	180	40	B2	
Endosulfan II [5]	18	1/10	610,000	47,000	B2	
Endosulfan sulfate [5]	25 - 110	3/10	610,000	47,000	B2	
Endrin aldehyde	0.97	1/10	31,000	2,300	D	
Endrin ketone	4.2 - 110	5/10	31,000	2,300	D	

TABLE 6-1
Hazard Assessment for Surface Soils
80th DRS, Fort Story, Virginia

Compound	Range of Detection	Frequency of Detection	EPA Region III Industrial Soil RBCs[1]	EPA Region III Residential Soil RBCs[1]	EPA Carcinogen Class[2]	Potential Concern?[3]
Metals (mg/kg)						
Aluminum	395 - 8,530	10/10	---	---	D	
Antimony	0.35 - 2.1	8/10	41	3.10	Not Assigned	
Arsenic	**0.35 - 1.0**	**9/10**	**1.9**	**0.43**	**A**	**Yes**
Barium	1.6 - 15.8	10/10	20,000	1,600	Not Assigned	
Beryllium	0.01 - 0.12	10/10	200	16	B2	
Calcium	44 - 3060	10/10	---	---	---	
Chromium (as Cr VI)	1 - 10	10/10	310	23	A	
Cobalt	0.17 - 0.93	10/10	2,000	160	---	
Copper	0.38 - 14.4	7/10	4,100	310	D	
Iron	**760 - 10,100**	**10/10**	**31,000**	**2,300**	---	**Yes**
Lead [6]	0.84 - 33.9	10/10	400	400	B2	
Magnesium	50.7 - 504	10/10	---	---	---	
Manganese	3.4 - 69.1	10/10	2,000	160	D	
Mercury	0.02 - 0.035	6/10	31	2.3	D	
Nickel	0.13 - 3.7	10/10	2,000	160	B2	
Potassium	64.9 - 494	10/10	---	---	---	
Selenium	0.37 - 0.74	5/10	510	39	D	
Sodium	44.5 - 133	10/10	---	---	---	
Vanadium	**2 - 19.4**	**10/10**	**100**	**7.8**	**Not Assigned**	**Yes**
Zinc	1.8 - 81.8	10-Oct	31,000	2,300	D	

Notes:

(1) EPA Region III RBC Criteria for Industrial and Residential Soils (April 2003). Non-carcinogenic RBCs have been adjusted to a hazard quotient of 0.1.

(2) Weight of Evidence Classification:

A= Human carcinogen

B1= Probable human carcinogen, limited human data

B2= Probable human carcinogen, sufficient evidence in animals or no evidence in humans

C= Possible human carcinogen

D= Not classified as to carcinogenicity

(3) Potential Concern - Yes indicates that the chemical will be evaluated quantitatively while Qual 'indicates that the compound has no screening criteria available and it will be evaluated qualitatively.

(4) RBC for pyrene used as a surrogate.

(5) RBC for endosulfan used as a surrogate.

(6) USEPA Lead standard for children playing in exposed soil

TABLE 6-2
Hazard Assessment for Combined Surface/Subsurface Soils
80th DRS, Fort Story, Virginia

Compound	Range of Detection	Frequency of Detection	EPA Region III Industrial Soil RBCs[1]	EPA Region III Residential Soil RBCs[1]	EPA Carcinogen Class[2]	Potential Concern?[3]
VOCs (ug/kg)						
Acetone	5 - 57	26/30	92,000,000	7,000,000	D	
2-Butanone (MEK)	5	1/30	61,000,000	4,700,000	D	
Carbon Disulfide	0.8 - 6	9/30	10,000,000	780,000	Not Assigned	
Chlorobenzene	0.5	5/30	2,000,000	160,000	D	
1,2-Dichlorobenzene	0.3	1/30	9,200,000	700,000	D	
1,3-Dichlorobenzene	0.5	1/30	310,000	23,000	D	
1,4-Dichlorobenzene	0.3 - 0.5	6/30	120,000	27,000	Not Assigned	
Dichlorodifluoromethane	0.6	3/30	20,000,000	1,600,000	Not Assigned	
1,2-Dichloroethane	3	1/ 30	31,000	7,000	B2	
Trans-1,2-dichlorothene	0.7 - 1	7/30	2,000,000	160,000	Not Assigned	
Ethylbenzene	0.5 - 0.7	6/30	10,000,000	780,000	D	
2-Hexanone	13 - 230	2/30	4,100,000	310,000	Not Assigned	
Methyl acetate	5 - 69	3/30	100,000,000	7,800,000	D	
Methylene chloride	4 - 10	26/30	380,000	85,000	B2	
4-Methyl-2-pentanone (MIBK)	5 - 16	8/30	---	---	Not Assigned	
Tetrachloroethene	2 - 120	14/30	5,300	1,200	C-B2	
Toluene	0.7 - 5	28/30	8,200,000	630,000	D	
Trichloroethene	0.5 - 1	7/30	7,200	1,600	B2	
Trichlorofluoromethane	0.8 - 3	8/30	31,000,000	2,300,000	Not Assigned	
1,1,2-trichloro-1,2,2-trifluoethane	0.7 - 2	15/30	3,100,000,000	230,000,000	Not Assigned	
Xylene (total)	1 - 7	11/30	20,000,000	1,600,000	D	

TABLE 6-2
Hazard Assessment for Combined Surface/Subsurface Soils
80th DRS, Fort Story, Virginia

Compound	Range of Detection	Frequency of Detection	EPA Region III Industrial Soil RBCs[1]	EPA Region III Residential Soil RBCs[1]	EPA Carcinogen Class[2]	Potential Concern?[3]
SVOCs (ug/kg)						
Acenaphthene	49 - 960	7/30	6,100,000	470,000	Not Assigned	
Acenaphthylene [4]	21 - 2,200	18/30	3,100,000	230,000	D	
Anthracene	32 - 2,500	15/30	31,000,000	2,300,000	D	
Benzo(a)anthracene	**45 - 5,600**	**18/30**	**3,900**	**220**	**B2**	**Yes**
Benzo(a)pyrene	**28 - 5,500**	**19/30**	**390**	**22**	**B2**	**Yes**
Benzo(b)fluoranthene	**69 - 6,800**	**18/30**	**3,900**	**220**	**B2**	**Yes**
Benzo(g,h,i)perylene [4]	26 - 3,700	20/30	3,100,000	230,000	D	
Benzo(k)fluoranthene	36 - 4,100	19/30	39,000	2,200	B2	
1,1'-Biphenyl	26 - 470	6/30	5,100,000	39,000	D	
Bis(2-ethylhexyl)phthalate	40 - 880	27/30	200,000	46,000	B2	
Carbazole	48 - 490	5/30	140,000	32,000	----	
Chrysene	34 - 6,000	19/30	390,000	22,000	B2	
Dibenzo(a,h)anthracene	**30 - 1,500**	**14/30**	**390**	**22**	**B2**	**Yes**
Dibenzofuran	30 - 790	6/30	200,000	16,000	D	
3,3'-Dichlorobenzidine	41 - 290	2/30	6,400	1,400	B2	
2,4-Dinitrotoluene	130	1/30	200,000	16,000	B2	
2,6-Dinitrotoluene	51	1/30	100,000	7,800	B2	
Di-n-octyl phthalate	24 - 280	6/30	2,000,000	160,000	----	
Fluoranthene	28 - 9,800	21/30	4,100,000	310,000	D	
Fluorene	28 - 1,600	12/30	4,100,000	310,000	D	
Indeno(1,2,3-cd)pyrene	**25 - 3,600**	**19/30**	**3,900**	**220**	**B2**	**Yes**
2-Methylnaphthalene	34 - 2,400	11/30	410,000	31,000	----	
N-Nitrosodiphenylamine	150	1/30	580,000	130,000	---	
Naphthalene	31 - 1,200	6/30	2,000,000	160,000	Not Assigned	
Phenanthrene [4]	29 - 12,000	20/30	3,100,000	230,000	D	
Pyrene	43 - 16,000	20/30	3,100,000	230,000	D	

TABLE 6-2
Hazard Assessment for Combined Surface/Subsurface Soils
80th DRS, Fort Story, Virginia

Compound	Range of Detection	Frequency of Detection	EPA Region III Industrial Soil RBCs[1]	EPA Region III Residential Soil RBCs[1]	EPA Carcinogen Class[2]	Potential Concern?[3]
Pesticides/PCBs (ug/kg)						
Aldrin	**0.98 - 73**	**5/30**	**170**	**38**	**B2**	**Yes**
alpha-BHC	0.53 - 1.7	3/30	450	100	B2	
beta-BHC	2.4 - 100	3/30	1,600	350	C-B2	
delta-BHC	0.66	1/30	450	100	D	
gamma-BHC (Lindane)	0.37 - 0.39	2/30	2,200	490	Not Assigned	
Chlordane (gamma)	1.7	1/30	8,200	1,800	B2	
4,4'-DDD	0.42 - 6.4	5/30	12,000	2,700	B2	
4,4'-DDE	1.6 - 3.1	4/30	8,400	1,900	B2	
4,4'-DDT	0.91 - 8.8	8/30	8,400	1,900	B2	
Dieldrin	7.1 - 27	3/30	180	40	B2	
Endosulfan I [5]	0.9	1/30	610,000	47,000	B2	
Endosulfan II [5]	18	1/30	610,000	47,000	B2	
Endosulfan sulfate [5]	0.8 - 110	7/30	610,000	47,000	B2	
Endrin aldehyde	0.88 - 0.97	2/30	31,000	2,300	B2	
Endrin ketone	1.1 - 110	17/30	31,000	2,300	B2	
Heptachlor	1	1/30	640	140	B2	
Aroclor-1260	21 - 67	2/30	1,400	320	Not Assigned	

TABLE 6-2
Hazard Assessment for Combined Surface/Subsurface Soils
80th DRS, Fort Story, Virginia

Compound	Range of Detection	Frequency of Detection	EPA Region III Industrial Soil RBCs(1)	EPA Region III Residential Soil RBCs(1)	EPA Carcinogen Class(2)	Potential Concern?(3)
Metals (mg/kg)						
Aluminum	135 - 8,530	30/30	---	---	D	
Antimony	0.35 - 2.1	20/30	41	3	Not Assigned	
Arsenic	**0.35 - 1.2**	**13/30**	**1.9**	**0.43**	**A**	**Yes**
Barium	0.98 - 15.8	30/30	20,000	1,600	Not Assigned	
Beryllium	0.01 - 0.12	21/30	200	16	B2	
Cadmium	0.11	1/30	100	8	B1	
Calcium	18.2 - 3,060	30/30	---	---	---	
Chromium (as Cr VI)	1.0 - 10	30/30	310	23	A	
Cobalt	0.07 - 0.93	27/30	---	---	---	
Copper	0.28 - 6.3	15/30	4,100	310	D	
Iron	**335 - 10,100**	**30/30**	**31,000**	**2,300**	**---**	**Yes**
Lead (6)	0.5 - 33.9	30/30	400	400	B2	
Magnesium	20.8 - 504	30/30	---	---	---	
Manganese	1.9 - 69.1	30/30	2,000	160	D	
Mercury	0.017 - 0.035	11/30	31	2.3	D	
Nickel	0.13 - 3.7	26/30	2,000	160	B2	
Potassium	39.7 - 494	29/30	---	---	---	
Selenium	0.37 - 0.74	5/30	510	39	D	
Silver	0.09	1/30	510	39	D	
Sodium	44.5 - 133	30/30	---	---	---	
Vanadium	**0.76 - 19.4**	**30/30**	**100**	**7.8**	**Not Assigned**	**Yes**
Zinc	1.1 - 81.8	30/30	31,000	2,300	D	

Notes:

(1) EPA Region III RBC Criteria for Industrial and Residential Soils (April 2003). Non-carcinogenic RBCs have been adjusted to a hazard quotient of 0.1.

(2) Weight of Evidence Classification:

A= Human carcinogen

B1= Probable human carcinogen, limited human data

B2= Probable human carcinogen, sufficient evidence in animals or no evidence in humans

C= Possible human carcinogen

D= Not classified as to carcinogenicity

(3) Potential Concern - Yes indicates that the chemical will be evaluated quantitatively while Qual indicates that the compound has no screening criteria available and it will be evaluated qualitatively.

(4) RBC for pyrene used as a surrogate.

(5) RBC for endosulfan used as a surrogate.

(6) USEPA Lead standard for children playing in exposed soil

TABLE 6-3
Hazard Assessment for Groundwater
80th DRS, Fort Story, Virginia

Parameters	Range of Detection	Frequency of Detection	USEPA RBCs [1]	USEPA MCLs [2]	EPA Carcinogen Class[3]	Potential Concern?[4]
VOCs (ug/l)						
cis 1, 2-DCE	**0.7 - 11.0**	**3/22**	**6.1 [5]**	**70**	**D**	**Yes**
PCE	**0.30 - 6.3**	**7/22**	**0.1**	**5**	**C-B2**	**Yes**
Toluene	0.2 - 1.0	10/22	230	1000	D	
TCE	**0.8 - 7.5**	**5/22**	**0.026**	**5**	**B2**	**Yes**
1,2,4-Trichlorobenzene	0.2	1/22	6.1	70	D	
SVOCs (ug/l)						
Bis(2-ethylhexyl) phthalate	**5**	**1/10**	**4.8**	**6**	**B2**	**Yes**
Pesticides/PCBs (ug/l)						
No pesticides or PCBs detected						
Metals (ug/l), Total						
Aluminum	56.5 - 953	10/10	---	---	D	
Antimony	**2.5 - 6.4**	**8/10**	**1.5**	**6**	**Not Assigned**	**Yes**
Arsenic	**4.8 - 6.0**	**3/10**	**0.045**	**10**	**A**	**Yes**
Barium	5.2 - 30.8	10/10	730	2,000	Not Assigned	
Cadmium	0.41 - 1.1	3/10	1.8	5	B1	
Calcium	7,970 - 26,700	10/10	---	---	---	
Chromium	1.0 - 6.6	10/10	11	100	A	
Cobalt	0.53 - 0.59	2/10	73	---	---	
Copper	1.9 - 4.2	2/10	150	1,300	D	
Iron	**292 - 5,130**	**10/10**	**1,100**	**---**	---	**Yes**
Lead [6]	1.2 - 4	4/10	---	15	B2	
Magnesium	1,130 - 3,160	10/10	---	---	---	
Manganese	**10.6 - 165**	**10/10**	**73**	**---**	**D**	**Yes**
Mercury [7]	0.10 - 0.13	6/10	1.1	2	C	
Nickel	2.5	1/10	73	---	B2	
Potassium	1,040 - 4,920	10/10	---	---	---	
Selenium	2.6 - 3.5	2/10	18.0	50	D	
Sodium	3,160 - 11,700	10/10	---	---	---	
Vanadium	**0.65 - 6.3**	**9/10**	**3.7**	**---**	**Not Assigned**	**Yes**
Zinc	6.8 - 309	10/10	1,100	---	D	

TABLE 6-3
Hazard Assessment for Groundwater
80th DRS, Fort Story, Virginia

Parameters	Range of Detection	Frequency of Detection	USEPA RBCs (1)	USEPA MCLs (2)	EPA Carcinogen Class(3)	Potential Concern?(4)
Metals (ug/l), Dissolved						
Aluminum	37.9 - 207	10/10	---	---	D	
Arsenic	**5.0 - 5.4**	**2/10**	**0.045**	**10**	**A**	**Yes**
Barium	4.9 - 28.2	10/10	730	2,000	Not Assigned	
Cadmium	0.98	1/10	1.8	5	B1	
Calcium	8,190 - 27,500	10/10	---	---	---	
Chromium	0.78 - 1.2	4/10	11	100	A	
Cobalt	0.53 - 1.1	3/10	73	---	---	
Copper	2.1	2/10	150	1,300	D	
Iron	**81.6 - 4,650**	**10/10**	**1,100**	**---**	**---**	**Yes**
Lead (5)	1.2 - 1.3	2/10	---	15	B2	
Magnesium	1,150 - 3,260	10/10	---	---	---	
Manganese	**9.7 - 167**	**10/10**	**73**	**---**	**D**	**Yes**
Mercury (6)	0.11 - 0.13	5/10	1.1	2	C	
Nickel	1.5 - 2.2	3/10	73	---	B2	
Potassium	1,200 - 5,520	10/10	---	---	---	
Selenium	3.0 - 10.3	6/10	18	50	D	
Sodium	2,930 - 11,900	10/10	---	---	---	
Vanadium	**0.48 - 4.8**	**10/10**	**3.7**	**---**	**Not Assigned**	**Yes**
Zinc	3.6 - 299	10/10	1,100	---	D	

Notes:

(1) EPA Region III RBC Criteria for Industrial and Residential Soils (May 2002). Non-carcinogenic RBCs have been adjusted to a hazard quotient of 0.1.

(2) EPA MCLs (July 2002)

(3) Weight of Evidence Classification:

A= Human carcinogen

B1= Probable human carcinogen, limited human data

B2= Probable human carcinogen, sufficient evidence in animals or no

C= Possible human carcinogen

D= Not classified as to carcinogenicity

(4) Potential Concern - **Yes** indicates that the chemical will be evaluated quantitatively while **Qual** indicates that the compound has no screening criteria available and it will be evaluated qualitatively.

(5) Total 1,2-DCE tap water RBC value used for cis 1,2-DCE

(6) At the tap Action Limit. Applicable only to drinking water.

(7) EPA RBC for tap water for mercuric chloride used for mercury.

TABLE 6-4
GENERIC EQUATION FOR CALCULATING CHEMICAL INTAKES

$$I = [(C \times CR \times EFD)/BW] \times 1/AT$$

Where:

I = intake; the amount of chemical at the exchange boundary (mg/kg body weight-day)

C = chemical concentration; the "average" concentration contacted over the exposure period (e.g., mg/kg for soil or sediment)

CR = contact rate; the amount of contaminated medium contacted per unit time or event (e.g., grams/day)

EFD = exposure frequency and duration; describes how long and how often exposure occurs; often calculated using two terms (EF and ED)

EF = exposure frequency (day/year)

ED = exposure durations (years)

BW = body weight; the average body weight over the exposure period (kg)

AT = averaging time; time period over which exposure is averaged (days)

TABLE 6-5
FORT STORY/FUTURE INDUSTRIAL SITE WORKER EXPOSURE:
INGESTION OF CHEMICALS IN SOIL

EQUATION:

Intake (mg/kg-day) = (CS x IR x CF x FI x EF x ED)/(BW x AT)

Where:

CS = Chemical concentration in soil (mg/kg)
IR = Ingestion rate (mg soil/day)
CF = Conversion factor (10^{-6} kg/mg)
FI = Fraction ingested from contaminated source (unitless)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged - days)

Variable values:

CS = 95th percentile UCL on the mean of the measured concentrations in site samples, except when it exceeds the maximum detected concentration

IR = 100 mg/day

CF = 10^{-6} kg/mg

FI = 1.0

EF = 250 days per year

ED = 25 years

BW = 70 kg

AT = period of exposure for noncarcinogenic effects is equal to ED x 365 days/year; for carcinogenic effects - 70 x 365 days/year

TABLE 6-6
FORT STORY/FUTURE INDUSTRIAL SITE WORKER EXPOSURE:
DERMAL CONTACT WITH CHEMICALS IN SOIL

EQUATION:

Absorbed Dose (mg/kg-day) = (CS x CF x SA x AF x ABS x EF x ED)/(BW x AT)

Where:

CS = Chemical concentration in soil (mg/kg)
CF = Conversion factor (10^{-6} kg/mg)
SA = Skin surface area available for contact (cm^2)
AF = Soil to skin adherence factor (mg/cm^2)
ABS = Absorption factor (unitless)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged - days)

Variable values:

CS = 95th percentile UCL on the mean of the measured concentrations in site samples, except when it exceeds the maximum detected concentration

CF = 10^{-6} kg/mg

SA = 3,300 cm^2

AF = 0.20 mg/cm^2

ABS = PAHs - 0.13

EF = 250 days/year

ED = 25 years

BW = 70 kg

AT = period of exposure for noncarcinogenic effects is equal to ED x 365 days/year; for carcinogenic effects - 70 x 365 days/year

TABLE 6-7
FORT STORY/FUTURE INDUSTRIAL SITE WORKER EXPOSURE:
INHALATION OF SOIL PARTICULATES

EQUATION:

Intake (mg/kg-day) = (CA x IR x ET x EF x ED)/(BW x AT)

Where:

CA = Chemical concentration in air (mg/m^3)
IR = Inhalation rate (m^3/hour)
ET = Exposure Time (hours/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged - days)

Variable values:

CA = Derived from Particulate Emission Factor calculations and 95th percentile UCL on the mean of the measured concentrations in site soil samples

IR = 1.6 m^3/hour

ET = 8 hours/day

EF = 250 days/year

ED = 25 years

BW = 70 kg for adults

AT = period of exposure for noncarcinogenic effects is equal to ED x 365 days/year; for carcinogenic effects - 70 x 365 days/year

TABLE 6-8
CONSTRUCTION WORKER EXPOSURE:
INGESTION OF CHEMICALS IN SOIL

EQUATION:

Intake (mg/kg-day) = (CS x IR x CF x FI x EF x ED)/(BW x AT)

Where:

CS = Chemical concentration in soil (mg/kg)
IR = Ingestion rate (mg soil/day)
CF = Conversion factor (10^{-6} kg/mg)
FI = Fraction ingested from contaminated source (unitless)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged - days)

Variable values:

CS = 95th percentile UCL on the mean of the measured concentrations in site samples, except when it exceeds the maximum detected concentration

IR = 480 mg/day

CF = 10^{-6} kg/mg

FI = 0.5

EF = 125 days per year

ED = 1 year

BW = 70 kg

AT = period of exposure for noncarcinogenic effects is equal to ED x 365 days/year; for carcinogenic effects - 70 x 365 days/year

TABLE 6-9
CONSTRUCTION WORKER EXPOSURE:
DERMAL CONTACT WITH CHEMICALS IN SOIL

EQUATION:

Absorbed Dose (mg/kg-day) = (CS x CF x SA x AF x ABS x EF x ED)/(BW x AT)

Where:

CS = Chemical concentration in soil (mg/kg)
CF = Conversion factor (10^{-6} kg/mg)
SA = Skin surface area available for contact (cm^2)
AF = Soil to skin adherence factor (mg/cm^2)
ABS = Absorption factor (unitless)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged - days)

Variable values:

CS = 95th percentile UCL on the mean of the measured concentrations in site samples, except when it exceeds the maximum detected concentration

CF = 10^{-6} kg/mg

SA = 3,300 cm^2

AF = 0.90 mg/cm^2

ABS = PAHs - 0.13

EF = 125 days/year

ED = 1 year

BW = 70 kg

AT = period of exposure for noncarcinogenic effects is equal to ED x 365 days/year; for carcinogenic effects - 70 x 365 days/year

TABLE 6-10
CONSTRUCTION WORKER EXPOSURE:
INHALATION OF SOIL PARTICULATES

EQUATION:

Intake (mg/kg-day) = (CA x IR x ET x EF x ED)/(BW x AT)

Where:

CA = Chemical concentration in air (mg/m^3)
IR = Inhalation rate (m^3/hour)
ET = Exposure Time (hours/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged - days)

Variable values:

CA = Derived from Particulate Emission Factor calculations and 95th percentile UCL on the mean of the measured concentrations in site soil samples

IR = 2.5 m^3/hour

ET = 4 hours/day

EF = 125 days/year

ED = 1 year

BW = 70 kg for adults

AT = period of exposure for noncarcinogenic effects is equal to ED x 365 days/year; for carcinogenic effects - 70 x 365 days/year

TABLE 6-11
CONSTRUCTION WORKER EXPOSURE
INGESTION OF CHEMICALS IN GROUNDWATER

EQUATION:

Intake (mg/kg-day) = (CW x IR x EF x ED)/(BW x AT)

Where:

CW = Chemical concentration in water (mg/l)
IR = Ingestion rate (liters/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged - days)

Variable values:

CW = 95th percentile UCL on the mean of the measured concentrations in site samples, except when it exceeds the maximum detected concentration

IR = 0.02 liters per day for adults

EF = 125 days/year

ED = 1 year

BW = 70 kg

AT = period of exposure for noncarcinogenic effects is equal to ED x 365 days/year; for carcinogenic effects – 70 x 365 days/year

TABLE 6-12
CONSTRUCTION EXPOSURE
DERMAL CONTACT WITH CHEMICALS IN GROUNDWATER

EQUATION:

Absorbed Dose (mg/kg-day) = (CW x SA x PC x ET x EF x ED x CF)/(BW x AT)

Where:

CW = Chemical concentration in water (mg/l)
SA = Skin surface area available for contact (cm^2)
PC = Chemical-specific dermal permeability coefficient (cm/hr)
ET = Exposure time (hours/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged - days)

Variable values:

CW = 95th percentile UCL on the mean of the measured concentrations in site samples, except when it exceeds the maximum detected concentration

SA = 3,300 cm^2;

PC = Chemical-specific values estimated from the octanol/water coefficient

ET = 4 hours/day

EF = 125 days/year

ED = 1 year

CF = 0.001 (1 liter/1000 cm^3)

BW = 70 kg

AT = period of exposure for noncarcinogenic effects is equal to ED x 365 days/year; for carcinogenic effects - 70 x 365 days/year

TABLE 6-13
CONSTRUCTION EXPOSURE
INHALATION OF AIRBORNE CHEMICALS VOLATIZED FROM GROUNDWATER

EQUATION:

Intake (mg/kg-day) = (CA x IR x ET x EF x ED)/(BW x AT)

Where:

CA = Chemical concentration in air (mg/m^3)
IR = Inhalation rate (m^3/hour)
ET = Exposure time (hours/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged - days)

Variable values:

CA = 95th percentile UCL on the mean of the measured concentrations in site samples, except when it exceeds the maximum detected concentration

IR = 2.5 m^3/hour for adults

ET = 4 hours/day

EF = 125 days/year

ED = 1 year

BW = 70 kg

AT = period of exposure for noncarcinogenic effects is equal to ED x 365 days/year; for carcinogenic effects - 70 x 365 days/year

TABLE 6-14
TOXICITY VALUES: NON-CARCINOGENIC EFFECTS - ORAL ROUTE
80th DRS, FORT STORY, VIRGINIA

COPC	Chronic RfDo (mg/kg-day)	RfD_{ABS} (1) (mg/kg-day)	Chronic RfDi (mg/kg-day)	Confidence Level	Critical Effect	RfD Basis	Uncertainty Factor	Modifying Factors
VOCs								
cis 1,2-DCE	9.00E-03	9.00E-03	----	Low	Decreased hematocrit	NOAEL (2)	3000	1
PCE	1.00E-02	1.00E-02	8.00E-02	Medium	Hepatoxtocity and Weight Gain	NOAEL	1000	1
TCE	3.00E-04	3.00E-04	1.00E-02	---	Kidney, liver, developing fetus	NOAEL	---	---
SVOCs								
Benz[a]anthracene	----	----	----	----	----	----	----	----
Benzo(a)pyrene	----	----	----	----	----	----	----	----
Benzo(b)fluoranthene	----	----	----	----	----	----	----	----
Bis(2-ethylhexyl) phthalate	2.00E-02	2.00E-02	----	Medium	Increased Relative Weight	NOAEL	1000	1
Dibenzo(a,h)anthracene	----	----	----	----	----	----	----	----
Metals								
Antimony	4.00E-04	6.00E-05	----	Low	Longevity, blood glucose	NOAEL	1000	1
Arsenic	3.00E-04	3.00E-04	----	Medium	Hyperpigmentation, keratosis and possible vascular complications	NOAEL	3	1
Iron	3.00E-01	3.00E-01	----	----	----	EPA-NCEA(3)	----	----
Manganese	1.40E-01	5.60E-03	1.43E-05	Medium	Central nervous system effects	NOAEL	1	1
Vanadium	1.00E-03	2.60E-05	----	----	----	NOAEL	100	1

Notes:

(1) RfD adjusted for dermal exposures by using GI absorption values (ABS_{GI})

(RfD_{ABS} = RfDo x ABS_{GI})

(2) NOAEL - No Observed Adverse Effect Level

(3) Environmental Protection Agency - National Center for Environmental Assessment Provisional Value

TABLE 6-15
TOXICITY VALUES: CARCINOGENIC EFFECTS FOR ORAL ROUTES
80th DRS, FORT STORY, VIRGINIA

COPC	CPSo $(mg/kg\text{-}day)^{-1}$	CPS_{ABS}[1] $(mg/kg\text{-}day)^{-1}$	CPSi $(mg/kg\text{-}day)^{-1}$	Weight of Evidence Class	Type of Cancer	SF Basis	SF Source
VOCs							
cis 1,2-DCE	----	----	----	D	----	----	----
Tetrachloroethylene	5.40E-01	5.40E-01	2.00E-02	C-B2	Liver, renal, leukemia	Oral	RAIS(2)
Trichloroethene	4.00E-01	4.00E-01	4.00E-01	B2	Liver, lung	Oral	RAIS[2]
SVOCs							
Benzo[a]anthracene	7.30E-01	7.30E-01	----	B2	Hepatomas, pulmonary adenomas and forestomach papillomas	Oral	RAIS[2]
Benzo(a)pyrene	7.30E+00	7.30E+00	3.10E+00	B2	Carcinomas, Squamous Cell Papillomas	Oral, diet	RAIS[2]
Benzo(b)fluoranthene	7.30E-01	7.30E-01	----	B2	Skin, lung, thorax, liver	Oral	RAIS[2]
Bis(2-ethylhexyl) phthalate	1.40E-02	1.40E-02	---	B2	Carcinoma and adenoma	Oral, Diet	RAIS[2]
Dibenzo(a,h)anthracene	7.30E+00	7.30E+00	---	B2			
Metals							
Antimony	----	----	----	----	----	----	----
Arsenic	1.50E+00	1.50E+00	1.51E+01	A	Skin	Oral	RAIS[2]
Iron	----	----	----	----	----	----	----
Manganese	----	----	----	----	----	----	----
Vanadium	----	----	----	----	----	----	----

Notes:
(1) CPS adjusted for dermal exposures by using GI absorption factors
($CPS_{ABS} = CPSo/ABS_{GI}$)
(2) RAIS - Risk Assessment Information System, June 2003 (developed from EPA Integrated Risk Information System (IRIS) and Health Effects Assessment Summary Tables (HEAST))

TABLE 6-16
CHRONIC HAZARD INDEX ESTIMATES (NONCANCER EFFECTS)
FORT STORY/FUTURE INDUSTRIAL SITE WORKERS
80th DRS, FORT STORY, VIRGINIA

Exposure Pathway	COPC	CDI (mg/kg-day)	RfD Adjusted For Absorption	RfD (mg/kg-day)	Hazard Quotient	Pathway Hazard Index
Ingestion of COPC in Surface Soil	Benzo(a)anthracene	4.73E-06	No	----	----	
	Benzo(a)pyrene	4.71E-06	No	----	----	
	Benzo(b)fluoranthene	6.11E-06	No	----	----	
	Dibenzo(a,h)anthracene	1.01E-06	No	----	----	0.00E+00
Dermal Contact with COPC in Surface Soil	Benzo(a)anthracene	4.05E-06	No	----	----	
	Benzo(a)pyrene	4.04E-06	No	----	----	
	Benzo(b)fluoranthene	5.24E-06	No	----	----	
	Dibenzo(a,h)anthracene	8.65E-07	No	----	----	0.00E+00
Inhalation of COPC in Site Soil Particulates	Benzo(a)anthracene	4.45E-10	No	----	----	
	Benzo(a)pyrene	4.43E-10	No	----	----	
	Benzo(b)fluoranthene	5.75E-10	No	----	----	
	Dibenzo(a,h)anthracene	9.49E-11	No	----	----	0.00E+00
					Total Exposure Hazard Index	**0.00E+00**

Notes:
CDI = Chronic Daily Intake
RfD = Reference dose
Hazard Quotient = CDI/RfD

TABLE 6-17
CANCER RISK ESTIMATES
FORT STORY/FUTURE INDUSTRIAL SITE WORKERS
80th DRS, FORT STORY, VIRGINIA

Exposure Pathway	COPC	CDI (mg/kg-day)	CPS Adjusted For Absorption	CPS $(mg/kg\text{-}day)^{-1}$	Chemical-Specific Risk	Total Pathway Risk
Ingestion of COPC in Surface Soil	Benzo(a)anthracene	1.69E-06	No	7.30E-01	1.23E-06	
	Benzo(a)pyrene	1.68E-06	No	7.30E+00	1.23E-05	
	Benzo(b)fluoranthene	2.18E-06	No	7.30E-01	1.59E-06	
	Dibenzo(a,h)anthracene	3.60E-07	No	7.30E+00	2.63E-06	1.77E-05
Dermal Contact with COPC in Surface Soil	Benzo(a)anthracene	1.45E-06	No	7.30E-01	1.06E-06	
	Benzo(a)pyrene	1.44E-06	No	7.30E+00	1.05E-05	
	Benzo(b)fluoranthene	1.87E-06	No	7.30E-01	1.37E-06	
	Dibenzo(a,h)anthracene	3.09E-07	No	7.30E+00	2.26E-06	1.52E-05
Inhalation of COPC in Site Soil Particulates	Benzo(a)anthracene	1.59E-10	No	---	----	
	Benzo(a)pyrene	1.58E-10	No	3.10E+00	4.90E-10	
	Benzo(b)fluoranthene	2.05E-10	No	---	----	
	Dibenzo(a,h)anthracene	3.39E-11	No	---	0.00E+00	4.90E-10
					Total Exposure Risk	**3.29E-05**

Notes:
CDI = Chronic Daily Intake
CPS - Cancer Potency Slope
Chemical-specific Risk = CDI X CPS

TABLE 6-18
CHRONIC HAZARD INDEX ESTIMATES (NONCANCER EFFECTS)
CONSTRUCTION WORKERS
80th DRS, FORT STORY, VIRGINIA

Exposure Pathway	COPC	CDI (mg/kg-day)	RfD Adjusted For Absorption	RfD (mg/kg-day)	Hazard Quotient	Pathway Hazard Index
Ingestion of COPC in Combined Surface/Subsurface	Benzo(a)anthracene	4.02E-06	No	----	----	
	Benzo(a)pyrene	3.90E-06	No	----	----	
	Benzo(b)fluoranthene	5.18E-06	No	----	----	
	Dibenzo(a,h)anthracene	6.46E-07	No	----	----	0.00E+00
Dermal Contact with COPC in Combined	Benzo(a)anthracene	6.46E-06	No	----	----	
	Benzo(a)pyrene	6.27E-06	No	----	----	
	Benzo(b)fluoranthene	8.33E-06	No	----	----	
	Dibenzo(a,h)anthracene	1.04E-06	No	----	----	0.00E+00
Inhalation of COPC in Site Soil Particulates	Benzo(a)anthracene	3.70E-08	No	----	----	
	Benzo(a)pyrene	3.59E-08	No	----	----	
	Benzo(b)fluoranthene	4.77E-08	No	----	----	
	Dibenzo(a,h)anthracene	5.97E-09	No	----	----	0.00E+00
					Total Soil Exposure Hazard Index	**0.00E+00**
Ingestion of COPC in Groundwater	cis 1,2-DCE	3.42E-07	No	9.00E-03	3.80E-05	
	PCE	4.31E-07	No	1.00E-02	4.31E-05	
	TCE	2.94E-07	No	3.00E-04	9.80E-04	
	Bis(2-ethylhexyl)phthalate	4.89E-07	No	2.00E-02	2.45E-05	
	Total Antimony	4.31E-07	No	4.00E-04	1.08E-03	
	Total Arsenic	5.09E-07	No	3.00E-04	1.70E-03	
	Total Iron	2.57E-04	No	3.00E-01	8.57E-04	
	Total Manganese	8.71E-06	No	1.40E-01	6.22E-05	
	Total Vanadium	3.42E-07	No	1.00E-03	3.42E-04	5.12E-03
Dermal Contact with COPC in Groundwater	cis 1,2-DCE	7.46E-06	No	9.00E-03	8.29E-04	
	PCE	9.38E-06	No	1.00E-02	9.38E-04	
	TCE	2.32E-06	No	3.00E-04	7.73E-03	
	Bis(2-ethylhexyl)phthalate	8.07E-06	Yes	2.00E-02	4.04E-04	
	Total Antimony	2.84E-07	Yes	6.00E-05	4.73E-03	
	Total Arsenic	3.36E-07	Yes	3.00E-04	1.12E-03	
	Total Iron	1.70E-04	Yes	3.00E-01	5.67E-04	
	Total Manganese	5.75E-06	Yes	5.60E-03	1.03E-03	
	Total Vanadium	2.26E-06	Yes	2.60E-05	8.69E-02	1.04E-01
Inhalation of COPC Vapors from Groundwater	cis 1,2-DCE	1.91E-03	No	---	---	
	PCE	1.85E-03	No	8.00E-02	2.31E-02	
	TCE	1.42E-03	No	1.00E-02	1.42E-01	
	Bis(2-ethylhexyl)phthalate	2.98E-06	No	---	----	1.65E-01
					Total Groundwater Exposure Hazard Index	**2.75E-01**
					Total Exposure Hazard Index	**2.75E-01**

Notes:
CDI = Chronic Daily Intake
RfD = Reference dose
Hazard Quotient = CDI/RfD

TABLE 6-19
CANCER RISK ESTIMATES
CONSTRUCTION WORKERS
80th DRS, FORT STORY, VIRGINIA

Exposure Pathway	COPC	CDI (mg/kg-day)	CPS Adjusted For Absorption	CPS $(mg/kg\text{-}day)^{-1}$	Chemical-Specific Risk	Total Pathway Risk
Ingestion of COPC in Combined Surface/Subsurface	Benzo(a)anthracene	5.74E-08	No	7.30E-01	4.19E-08	
	Benzo(a)pyrene	5.57E-08	No	7.30E+00	4.07E-07	
	Benzo(b)fluoranthene	7.40E-08	No	7.30E-01	5.40E-08	
	Dibenzo(a,h)anthracene	9.23E-09	No	7.30E+00	6.74E-08	5.70E-07
Dermal Contact with COPC in Combined	Benzo(a)anthracene	9.23E-08	No	7.30E-01	6.74E-08	
	Benzo(a)pyrene	8.96E-08	No	7.30E+00	6.54E-07	
	Benzo(b)fluoranthene	1.19E-07	No	7.30E-01	8.69E-08	
	Dibenzo(a,h)anthracene	1.48E-08	No	7.30E+00	1.08E-07	9.16E-07
Inhalation of COPC in Site Soil Particulates	Benzo(a)anthracene	5.28E-10	No	----	----	
	Benzo(a)pyrene	5.13E-10	No	3.10E+00	1.59E-09	
	Benzo(b)fluoranthene	6.81E-10	No	----	----	
	Dibenzo(a,h)anthracene	8.53E-11	No	----	----	1.59E-09
					Total Soil Exposure Risk	**1.49E-06**
Ingestion of COPC in Groundwater	cis 1,2-DCE	4.89E-09	No	---	---	
	PCE	6.15E-09	No	5.40E-01	3.32E-09	
	TCE	4.19E-09	No	4.00E-01	1.68E-09	
	Bis(2-ethylhexyl)phthalate	6.99E-09	No	1.40E-02	9.79E-11	
	Total Antimony	6.15E-09	No	----	----	
	Total Arsenic	7.27E-09	No	1.50E+00	1.09E-08	
	Total Iron	3.68E-06	No	----	----	
	Total Manganese	1.24E-07	No	----	----	
	Total Vanadium	4.89E-09	No	----	----	1.60E-08
Dermal Contact with COPC in Groundwater	cis 1,2-DCE	1.07E-07	No	---	---	
	PCE	1.34E-07	No	5.40E-01	7.24E-08	
	TCE	3.32E-08	No	4.00E-01	1.33E-08	
	Bis(2-ethylhexyl)phthalate	1.15E-07	No	1.40E-02	1.61E-09	
	Total Antimony	4.06E-09	Yes	----	----	
	Total Arsenic	4.80E-09	Yes	1.50E+00	7.20E-09	
	Total Iron	2.43E-06	Yes	----	----	
	Total Manganese	8.21E-08	Yes	----	----	
	Total Vanadium	3.23E-09	Yes	----	----	9.45E-08
Inhalation of COPC Vapors from Groundwater	cis 1,2-DCE	2.73E-05	No	---	---	
	PCE	2.65E-05	No	2.00E-02	5.30E-07	
	TCE	2.03E-05	No	4.00E-01	8.12E-06	
	Bis(2-ethylhexyl)phthalate	4.26E-08	No	---	---	8.65E-06
					Total Groundwater Exposure Risk	**8.76E-06**
					Total Exposure Risk	**1.02E-05**

Notes:
CDI = Chronic Daily Intake
CPS - Cancer Potency Slope
Chemical-specific Risk = CDI X CPS

TABLE 7-1
PHYTOTOXICITY AND INVERTEBRATE VALUES
80th DRS, FT. STORY, VIRGINIA

Compound	Squirt	Soil BTAG (ug/kg)		Maximum Detected or PQL[1]	Value Used in Exposure Calcs [1]	Min Screening Level	EEQ	COPC	No Screening Value
		Flora	Fauna						
VOCs									
1,1,2-trichloro-1,2,2-trifluoroethane	--	--	--	2.0 J	2.0	0.00E+00	N/A	Y	X
1,2-Dichlorobenzene	--	1.00E+02	1.00E+02	0.3 J	0.3	1.00E+02	0.00	N	
1,2-Dichloroethane	--	--	8.70E+05	3.0 J	3.0	8.70E+05	0.00	N	
1,3-Dichlorobenzene	--	--	--	0.5 J	0.5	0.00E+00	N/A	Y	X
1,4-Dichlorobenzene		1.00E+02	1.00E+02	0.5 J	0.5	1.00E+02	0.01	N	
2-Butanone (MEK)	--	--	--	5.0 J	5.0	0.00E+00	N/A	Y	X
2-Hexanone	--	--	--	230.0	230.0	0.00E+00	N/A	Y	X
4-Methyl-2-pentanone (MIBK)	--	--	1.00E+05	14.0	14.0	1.00E+05	0.00	N	
Acetone	--	--	--	57.0 B	57.0	0.00E+00	N/A	Y	X
Carbon disulfide	--	--	--	6.0 J	6.0	0.00E+00	N/A	Y	X
Chlorobenzene	1.00E+02	--	1.00E+02	0.5 J	0.5	1.00E+02	0.01	N	
Dichlorodifluoromethane	--	--	--	0.6 J	0.6	0.00E+00	N/A	Y	X
Ethylbenzene	1.00E+06	--	--	0.7 J	0.7	1.00E+06	0.00	N	
Methyl acetate	--	--	--	69.0	69.0	0.00E+00	N/A	Y	X
Methylene chloride (Dichloromethane)	1.00E+02	3.00E+02	3.00E+02	10.0 B	10.0	1.00E+02	0.10	N	
Tetrachloroethylene	5.00E+00	3.00E+02	3.00E+02	120.0	120.0	5.00E+00	24.00	Y	
Toluene	3.00E+05	1.00E+02	1.00E+02	4.0	4.0	1.00E+02	0.04	N	
Trans-1,2-Dichloroethylene	1.00E+02	--	--	1.0 JB	1.0	1.00E+02	0.01	N	
Trichloroethylene	6.50E+01	--	3.00E+02	1.0 J	1.0	6.50E+01	0.02	N	
Trichlorofluoromethane		--	--	3.0 J	3.0	0.00E+00	N/A	Y	X
Xylenes, Total	1.00E+02	--	1.00E+02	7.0 J	7.0	1.00E+02	0.07	N	

TABLE 7-1
PHYTOTOXICITY AND INVERTEBRATE VALUES
80th DRS, FT. STORY, VIRGINIA

Compound	Squirt	Soil BTAG (ug/kg)		Maximum Detected or PQL[1]	Value Used in Exposure Calcs [1]	Min Screening Level	EEQ	COPC	No Screening Value
		Flora	Fauna						
SVOCs									
1,1'-Biphenyl	--	--	--	470.0 J	470.0	0.00E+00	N/A	Y	X
2,4-Dinitrotoluene	--	--	--	1.10E+03 U	55.0	0.00E+00	N/A	Y	X
2,6-Dinitrotoluene	--	--	--	1.10E+03 U	55.0	0.00E+00	N/A	Y	X
2-Methylnaphthalene	--	--	--	2,400.0	2,400.0	0.00E+00	N/A	Y	X
3,3'-Dichlorobenzidine	--	--	--	2.90E+02 J	290.0	0.00E+00	N/A	Y	X
Acenaphthene	--	1.00E+02	1.00E+02	960.0 J	960.0	1.00E+02	9.60	Y	
Acenaphthylene	--	100	100	2,200.0	2,200.0	1.00E+02	22.00	Y	
Benzo(a)anthracene	1.00E+02	1.00E+02	1.00E+02	5.60E+03 D	5,600.0	1.00E+02	56.00	Y	
Benzo(a)pyrene	--	--	1.00E+02	5.50E+03 D	5,500.0	1.00E+02	55.00	Y	
Benzo(b)fluoranthene	1.00E+02	1.00E+02	1.00E+02	6.80E+03 D	6,800.0	1.00E+02	68.00	Y	
Benzo(g,h,i)perylene	--	1.00E+02	1.00E+02	3.70E+03	3,700.0	1.00E+02	37.00	Y	
Benzo(k)fluoranthene	1.00E+02	1.00E+02	1.00E+02	4.10E+03	4,100.0	1.00E+02	41.00	Y	
bis(2-Ethylhexyl)phthalate	--	--	--	3.40E+02	340.0	0.00E+00	N/A	Y	X
Carbazole	--	--	--	4.90E+02 J	490.0	0.00E+00	N/A	Y	X
Chrysene	--	1.00E+02	1.00E+02	6.00E+03 D	6,000.0	1.00E+02	60.00	Y	
Dibenzo(a,h)anthracene	1.00E+02	1.00E+02	1.00E+02	1.50E+03	1,500.0	1.00E+02	15.00	Y	
Dibenzofuran	1.00E+02	--	--	7.90E+02 J	790.0	1.00E+02	7.90	Y	
Di-n-octylphthalate	--	--	--	2.80E+02 J	280.0	0.00E+00	N/A	Y	X
Fluoranthene	--	1.00E+02	1.00E+02	9.80E+03 D	9,800.0	1.00E+02	98.00	Y	
Fluorene	--	1.00E+02	1.00E+02	1.60E+03	1,600.0	1.00E+02	16.00	Y	
Indeno(1,2,3-cd)pyrene	--	1.00E+02	1.00E+02	3.60E+03	3,600.0	1.00E+02	36.00	Y	
Naphthalene	1.00E+02	1.00E+02	1.00E+02	1.50E+02 J	150.0	1.00E+02	1.50	Y	
Phenanthrene	1.00E+02	1.00E+02	1.00E+02	1.20E+04 B	12,000.0	1.00E+02	120.00	Y	
Pyrene	1.00E+02	1.00E+02	1.00E+02	1.60E+04 D	16,000.0	1.00E+02	160.00	Y	
N-Nitrosodiphenylamine	--	--	--	1.10E+03 U	55.0	0.00E+00	N/A	Y	X

TABLE 7-1
PHYTOTOXICITY AND INVERTEBRATE VALUES
80th DRS, FT. STORY, VIRGINIA

Compound	Squirt	Soil BTAG (ug/kg)		Maximum Detected or PQL[1]	Value Used in Exposure Calcs [1]	Min Screening Level	EEQ	COPC	No Screening Value
		Flora	Fauna						
Metals									
Aluminum	4.70E+07	1.00E+03	--	8.53E+06	8,530,000.0	1.00E+03	8,530.00	Y	
Antimony	4.80E+02	4.80E+02	--	2.10E+03 B	2,100.0	4.80E+02	4.38	Y	
Arsenic	5.20E+03	3.30E+05	--	1.00E+03	1,000.0	5.20E+03	0.19	N	
Barium	4.40E+05	4.40E+05	4.40E+05	1.58E+04	15,800.0	4.40E+05	0.04	N	
Beryllium	--	2.00E+01	--	1.20E+02 B	120.0	2.00E+01	6.00	Y	
Cadmium	--	2.50E+03	--	4.00E+01 U	2.00E+01	2.50E+03	0.00	N	
Calcium	--	--	--	3.06E+06	3,060,000.0	0.00E+00	N/A	Y	X
Chromium	3.70E+04	2.00E+01	7.50E+00	1.00E+04	10,000.0	7.50E+00	1,333.33	Y	
Cobalt	6.70E+03	1.00E+05	1.00E+05	9.30E+02	930.0	6.70E+03	0.14	N	
Copper	1.70E+04	1.50E+04		1.44E+04	14,400.0	1.50E+04	0.96	N	
Iron	1.80E+07	3.26E+06	1.20E+04	1.01E+07	10,100,000.0	1.20E+04	841.67	Y	
Lead	1.60E+04	2.00E+03	1.00E+01	3.39E+04 N	33,900.0	1.00E+01	3,390.00	Y	
Magnesium	--	4400000	4400000	5.04E+05	504,000.0	4.40E+06	0.11	N	
Manganese	3.30E+05	3.30E+05	3.30E+05	6.91E+04	69,100.0	3.30E+05	0.21	N	
Mercury	5.80E+01	5.80E+01	5.80E+01	3.50E+02 B	350.0	5.80E+01	6.03	Y	
Nickel	1.30E+04	2.00E+03	--	3.70E+03	3,700.0	2.00E+03	1.85	Y	
Potassium	--	--	--	4.94E+05	494,000.0	0.00E+00	N/A	Y	X
Selenium	2.60E+02	1.80E+03	1.80E+03	7.40E+02	740.0	2.60E+02	2.85	Y	
Silver	--	9.80E+03	--	9.00E+02 U	4.50E+02	9.80E+03	0.00	N	
Sodium	--	--	--	1.33E+05 B	133,000.0	0.00E+00	N/A	Y	X
Thallium	--	1.00E+00	--	6.40E+02 U	3.20E+02	1.00E+00	32.00	Y	
Vanadium	5.80E+04	5.00E+02	5.80E+04	1.94E+04	19,400.0	5.00E+02	38.80	Y	
Zinc	4.80E+04	1.00E+04	--	8.18E+04	81,800.0	1.00E+04	8.18	Y	

TABLE 7-1
PHYTOTOXICITY AND INVERTEBRATE VALUES
80th DRS, FT. STORY, VIRGINIA

Compound	Squirt	Soil BTAG (ug/kg)		Maximum Detected or PQL[1]	Value Used in Exposure Calcs [1]	Min Screening Level	EEQ	COPC	No Screening Value
		Flora	Fauna						
TCL Pesticides									
4,4'-DDD	--	100	1.00E+02	2.7 P	2.7	1.00E+02	0.03	N	
4,4'-DDE	--	100	1.00E+02	3.1 P	3.1	1.00E+02	0.03	N	
4,4'-DDT	--	100	1.00E+02	8.80E+00 P	8.8	1.00E+02	0.09	N	
Aldrin	--	1.00E+02	1.00E+02	7.30E+01 E	73.0	1.00E+02	0.73	N	
alpha-BHC	--	--	--	1.70E+00 J	1.7	0.00E+00	N/A	Y	X
beta-BHC	--	--	--	1.00E+02 EP	100.0	0.00E+00	N/A	Y	X
delta-BHC	--	--	--	1.30E+00	1.3	0.00E+00	N/A	Y	X
Dieldrin	--	100	1.00E+02	27.00 EP	27.0	1.00E+02	0.27	N	
Endosulfan I	--	--	--	0.90 JP	0.9	0.00E+00	N/A	Y	X
Endosulfan II	--	--	--	18.0 P	18.0	0.00E+00	N/A	Y	X
Endosulfan sulfate	--	--	--	110.0 JD	110.0	0.00E+00	N/A	Y	X
Endrin	--	100	1.00E+02	4.1 U	4.1	1.00E+02	0.00	N	
Endrin aldehyde	--	--	--	1.0 J	1.0	0.00E+00	N/A	Y	X
Endrin ketone	--	--	--	110.0 EP	110.0	0.00E+00	N/A	Y	X
gamma-BHC (Lindane)	--	100	100	3.90E-01 J	0.4	1.00E+02	0.00	N	
gamma-Chlordane	--	--	100	1.7 U	0.85	1.00E+02	0.00	N	
Heptachlor	--	--	--	1.0 P	1.0	0.00E+00	N/A	Y	X

TABLE 7-1
PHYTOTOXICITY AND INVERTEBRATE VALUES
80th DRS, FT. STORY, VIRGINIA

Compound	Squirt	Soil BTAG (ug/kg)		Maximum Detected or PQL[1]	Value Used in Exposure Calcs [1]	Min Screening Level	EEQ	COPC	No Screening Value
		Flora	Fauna						
TCL PCBs									
Aroclor-1260	5.00E+02	100	--	67.0 J	67.0	1.00E+02	0.67	N	

[1]Parameters that had no screening values were retained for consideration as final COPCs. Undetected parameters ("U"-flagged) were retained as COPCs if ½ the method detection limit (MDL) was greater than the screening value. Consistent with laboratory protocol, the MDL was estimated as 10 percent of the PQL (practical quantification limit), which is value in the laboratory reports and flagged with the "U". Parameters flagged with "J", "E", or "N", although estimated to be present, are not necessarily accurate; however, they were handled as being present at the concentrations noted.

[2] Efroymson, R.A., M.E. Wioll, G. W. Suter II, and A.C. Wooten. 1997. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision.

[3] Invert Tox Ref: Efroymson, R.A., M.E. Will, and G. W. Suter II. 1997. Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision.

[4] FL=Flora; FA=Fauna; Sceening against BTAG values only.

NOTES:
This table contains COPCs with published toxicity screening values and/or COPCs that were detected above PQL or at estimated concentrations that have BTAG screening values.

TABLE 7-2
COMPREHENSIVE PLANT AND EARTHWORM UPTAKE FACTORS
80th DRS, FT. STORY, VIRGINIA

COPC	Plant Uptake Factor (PUF)	Reference	Earthworm Uptake Factor (EUF)	Reference
1,1,2-trichloro-1,2,2-trifluoethane	0.57	(a)	1	(d)
1,1'-Biphenyl	0.19	(a)	1	(d)
1,3-Dichlorobenzene	0.35	(a)	1	(d)
2,4-Dinitrotoluene	2.76	(a)	1	(d)
2,6-Dinitrotoluene	2.35	(a)	1	(d)
2-Butanone (MEK)	26.41	(a)	1	(d)
2-Hexanone	6.16	(a)	1	(d)
2-Methylnaphthalene	0.19	(a)	1	(d)
3,3'-Dichlorobenzidine	0.36	(a)	1	(d)
Acenaphthene	0.21	(a)	1	(d)
Acenaphthylene	0.20	(a)	1	(d)
Acetone	53.6	(a)	1	(d)
alpha-BHC	0.15	(a)	1	(d)
beta-BHC	0.16	(a)	4.2	(e)
Benzo(a)anthracene	0.019	(a)	0.38	(e)
Benzo(a)pyrene	0.012	(a)	0.86	(e)
Benzo(b)fluoranthene	0.012	(a)	0.96	(e)
Benzo(g,h,i)perylene	0.002	(a)	0.44	(e)
Benzo(k)fluoranthene	0.012	(a)	0.93	(e)
bis(2-Ethylhexyl)phthalate	0.0015	(a)	1	(d)
Carbazole	0.48	(a)	1	(d)
Carbon disulfide	2.92	(a)	1	(d)
Chrysene	0.012	(a)	0.37	(e)
delta-BHC	0.15	(a)	1	(d)
Dibenz(a,h)anthracene	0.0076	(a)	0.38	(e)
Dibenzofuran	0.16	(a)	1	(d)
Dichlorodifluoromethane	2.17	(a)	1	(d)
Di-n-octylphthalate	0.0008	(a)	1	(d)
Endosulfan I	0.34	(a)	1	(d)
Endosulfan II	0.34	(a)	1	(d)
Endosulfan sulfate	0.34	(a)	1	(d)
Endrin aldehyde	0.020	(b)	9	(f)

TABLE 7-2
COMPREHENSIVE PLANT AND EARTHWORM UPTAKE FACTORS
80th DRS, FT. STORY, VIRGINIA

COPC	Plant Uptake Factor (PUF)	Reference	Earthworm Uptake Factor (EUF)	Reference
Endrin ketone	1	(d)	1	(d)
Fluoranthene	0.042	(a)	0.32	(e)
Fluorene	0.14	(a)	1	(d)
Heptachlor	0.11	(a)	3.5	(b)
Indeno(1,2,3-cd)pyrene	0.012	(a)	0.75	(e)
Methyl acetate	30.59	(a)	1	(d)
Naphthalene	0.44	(a)	1	(d)
Phenanthrene	0.089	(a)	0.29	(e)
Pyrene	0.043	(a)	0.74	(e)
N-Nitrosodiphenylamine	0.60	(a)	1	(d)
Tetrachloroethylene	0.41	(a)	1	(d)
Trichlorofluoromethane	1.33	(a)	1	(d)
Aluminum	1	(d)	1	(d)
Calcium	1	(d)	1	(d)
Chromium	0.0075	(c)	0.306	(g)
Lead	0.045	(c)	0.266	(g)
Potassium	1	(d)	1	(d)
Sodium	1	(d)	1	(d)

Notes:

[a]Calculated as PUF = $38.9(K_{ow})^{-0.58}$, from Travis and Hattemer-Frey, 1988.

[b]Jorgensen et al., 1991.

[c]Baes et al., 1984.

[d]Assumed to equal soil or sediment concentration (EUF=1) since earthworm uptake information was not found for this chemical.

[e]Beyer, 1990.

[f]Gish, 1970.

[g]Sample et al., 1998.

Table 7-3
Exposure factors for Ecological Receptors[1]
80th DRS, Ft. Story, Virginia

Receptor	NIR_f (g/g-day)	IR (kg/day) (dw)	Soil Ingestion (%)	Body Weight (kg)	Home Range (acres)	Area Use Factor (based on 0.2 acre site)
American Robin	1.22	0.068	10	0.077	0.4 - 2.0	0.5
Red-Tailed Hawk	0.11	0.12	1.0	1	148 - 6,000	0.0014
Eastern Cottontail	0.205[2]	0.081	6.3 (Jackrabbit)	1.23	3 - 20	0.07
Gray Fox	0.08	0.064	2.8	4.5	141 - 8,447	0.0014
Short-tailed Shrew	0.56	0.5	10[3]	0.017	0.5	0.4

Notes:
[1] Reference: USEPA, 1993 (unless otherwise noted)
NIR_f = Ingestion rate of food, normalized to body weight.
IR = Daily ingestion rate of food.
[2] = Estimated using the following equasion: $NIRf = NFMR/ME_{avg}$
Where: NFMR = Free-living metabolic rate normalized to body weight (e.g., in kcal/g-day
ME_{avg} = Average metablizable energy of the total diet on a wet-weight basis (e.g., in kcal/g wet weight)
Source: (USEPA, 1993)
[3] = Estimated

TABLE 7-4
AVIAN TOTAL EXPOSURE SUMMARY
80th DRS, FT. STORY, VIRGINIA

Compound	Robin	Red-tailed Hawk
1,1,2-trichloro-1,2,2-trifluoethane	1.30E-03	2.22E-04
1,3-Dichlorobenzene	2.58E-04	5.56E-05
2-Butanone (MEK)	8.37E-02	5.56E-04
2-Hexanone	9.50E-01	2.56E-02
Acetone	1.92E+00	6.34E-03
Carbon disulfide	1.27E-02	6.67E-04
Dichlorodifluoromethane	9.89E-04	6.67E-05
Methyl acetate	1.33E+00	7.67E-03
Tetrachloroethylene	6.63E-02	1.33E-02
Trichlorofluoromethane	3.38E-03	3.34E-04
1,1'-Biphenyl	1.95E-01	5.23E-02
2,4-Dinitrotoluene	2.62E-01	1.45E-02
2,6-Dinitrotoluene	8.98E-02	5.67E-03
2-Methylnaphthalene	9.98E-01	2.67E-01
3,3'-Dichlorobenzidine	1.51E-01	3.22E-02
Acenaphthene	4.11E-01	1.07E-01
Acenaphthylene	9.29E-01	2.45E-01
Benzo(a)anthracene	7.17E-01	6.23E-01
Benzo(a)pyrene	1.45E+00	6.12E-01
Benzo(b)fluoranthene	1.99E+00	7.56E-01
Benzo(g,h,i)perylene	4.56E-01	4.11E-01
Benzo(k)fluoranthene	1.20E+00	4.56E-01
bis(2-Ethylhexyl)phthalate	1.02E-01	3.78E-02
Carbazole	2.92E-01	5.45E-02
Chrysene	7.25E-01	6.67E-01
Dibenzo(a,h)anthracene	1.81E-01	1.67E-01
Dibenzofuran	3.14E-01	8.78E-02
Di-n-octylphthalate	8.35E-02	3.11E-02
Fluoranthene	1.22E+00	1.09E+00
Fluorene	2.97E-01	1.78E-01
Indeno(1,2,3-cd)pyrene	8.35E-01	4.00E-01
Naphthalene	8.57E-02	1.67E-02
Phenanthrene	1.74E+00	1.33E+00
Pyrene	3.97E+00	1.78E+00
Aluminum	7.85E+03	9.49E+02
Calcium	2.82E+03	3.40E+02
Chromium	9.93E-01	1.11E+00
Lead	3.76E+00	3.77E+00
Potassium	4.55E+02	5.49E+01
Sodium	1.22E+02	1.48E+01
alpha-BHC	6.65E-04	1.89E-04
beta-BHC	1.33E-01	1.11E-02
delta-BHC	5.08E-04	1.45E-04
Endosulfan I	4.58E-04	1.00E-04
Endosulfan II	9.17E-03	2.00E-03
Endosulfan sulfate	5.60E-02	1.22E-02
Endrin aldehyde	2.57E-03	1.08E-04
Endrin ketone	1.01E-01	1.22E-02
Heptachlor	1.10E-03	1.11E-04

TABLE 7-5
MAMMALIAN TOTAL EXPOSURE SUMMARY
80th DRS, FT. STORY, VIRGINIA

Compound	Short-tailed Shrew	Gray Fox	Rabbit
1,1,2-trichloro-1,2,2-trifluoethane	1.22E-03	1.62E-04	2.44E-04
1,3-Dichlorobenzene	3.05E-04	3.93E-05	3.84E-05
2-Butanone (MEK)	3.05E-03	1.96E-03	2.71E-02
2-Hexanone	1.40E-01	3.41E-02	2.92E-01
Acetone	3.48E-02	4.09E-02	6.27E-01
Carbon disulfide	3.66E-03	6.57E-04	3.62E-03
Dichlorodifluoromethane	3.66E-04	6.03E-05	2.70E-04
Methyl acetate	4.21E-02	3.05E-02	4.33E-01
Tetrachloroethylene	7.32E-02	9.52E-03	1.07E-02
Trichlorofluoromethane	1.83E-03	2.71E-04	8.33E-04
1,1'-Biphenyl	2.87E-01	3.60E-02	2.07E-02
2,4-Dinitrotoluene	7.93E-02	1.40E-02	7.42E-02
2,6-Dinitrotoluene	3.11E-02	5.23E-03	2.48E-02
2-Methylnaphthalene	1.46E+00	1.84E-01	1.06E-01
3,3'-Dichlorobenzidine	1.77E-01	2.28E-02	2.29E-02
Acenaphthene	5.86E-01	7.38E-02	4.62E-02
Acenaphthylene	1.34E+00	1.69E-01	1.01E-01
Benzo(a)anthracene	1.47E+00	4.18E-01	5.04E-02
Benzo(a)pyrene	2.92E+00	4.10E-01	4.16E-02
Benzo(b)fluoranthene	4.00E+00	5.07E-01	5.14E-02
Benzo(g,h,i)perylene	1.01E+00	2.75E-01	2.04E-02
Benzo(k)fluoranthene	2.41E+00	3.06E-01	3.10E-02
bis(2-Ethylhexyl)phthalate	2.07E-01	2.53E-02	1.84E-03
Carbazole	2.99E-01	3.93E-02	5.07E-02
Chrysene	1.54E+00	4.47E-01	4.54E-02
Dibenzo(a,h)anthracene	3.94E-01	1.12E-01	9.99E-03
Dibenzofuran	4.82E-01	6.03E-02	2.99E-02
Di-n-octylphthalate	1.71E-01	2.08E-02	1.47E-03
Fluoranthene	2.25E+00	7.34E-01	1.34E-01
Fluorene	3.67E-01	1.22E-01	5.41E-02
Indeno(1,2,3-cd)pyrene	1.69E+00	2.68E-01	2.72E-02
Naphthalene	9.15E-02	1.20E-02	1.43E-02
Phenanthrene	2.55E+00	9.06E-01	2.80E-01
Pyrene	7.43E+00	1.20E+00	2.23E-01
Aluminum	5.20E+03	7.37E+02	1.79E+03
Calcium	1.87E+03	2.64E+02	6.43E+02
Chromium	2.21E+00	7.45E-01	6.64E-02
Lead	6.74E+00	2.54E+00	4.86E-01
Potassium	3.01E+02	4.27E+01	1.04E+02
Sodium	8.11E+01	1.15E+01	2.79E+01
alpha-BHC	1.04E-03	1.30E-04	6.09E-05
beta-BHC	2.40E-01	7.63E-03	3.79E-03
delta-BHC	7.93E-04	9.91E-05	4.66E-05
Endosulfan I	5.49E-04	7.06E-05	6.73E-05
Endosulfan II	1.10E-02	1.41E-03	1.35E-03
Endosulfan sulfate	6.71E-02	8.63E-03	8.23E-03
Endrin aldehyde	4.94E-03	7.24E-05	8.92E-06
Endrin ketone	6.71E-02	9.50E-03	2.31E-02
Heptachlor	2.01E-03	7.57E-05	2.77E-05

TABLE 7-6
TOXICITY REFERENCE VALUES (TRVs) / NOAELs FOR MAMMALS AND BIRDS
80th DRS, Fort Story, Virginia

COPC	Mammal TRVs[1] (mg/kg-day)				Bird TRVs [2] (mg/kg-day)	
	Test Species	Short-tailed Shrew	Cottontail Rabbit	Gray Fox	Test Species	Receptor Species
1,1,2-trichloro-1,2,2-trifluoethane	NA	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	NA	NA	NA	NA	NA	NA
2-Butanone (MEK)	1771 (r)	3,384	848	813	NA	NA
2-Hexanone	NA	NA	NA	NA	NA	NA
Acetone	10 (r) [a]	19.1	4.80	2.58	NA	NA
Carbon disulfide	42.5 (gp) [b][3]	102	25.6	24.5	NA	NA
Dichlorodifluoromethane	NA	NA	NA	NA	NA	NA
Methyl acetate	NA	NA	NA	NA	NA	NA
Tetrachloroethylene	1.4 (m)	1.59	0.40	0.38	NA	NA
Trichlorofluoromethane	450 (r)	860	216	207	NA	NA
1,1'-Biphenyl	NA	NA	NA	NA	NA	NA
2,4-Dinitrotoluene	NA	NA	NA	NA	NA	NA
2,6-Dinitrotoluene	NA	NA	NA	NA	NA	NA
2-Methylnaphthalene	NA	NA	NA	NA	NA	NA
3,3'-Dichlorobenzidine	NA	NA	NA	NA	NA	NA
Acenaphthene	NA	NA	NA	NA	NA	NA
Acenaphthylene	NA	NA	NA	NA	NA	NA
Benzo(a)anthracene	1 (m) [a][4]	1.14	0.28	0.27	NA	NA
Benzo(a)pyrene	1 (m) [a]	1.14	0.28	0.27	NA	NA
Benzo(b)fluoranthene	1 (m) [a][4]	1.14	0.28	0.27	NA	NA
Benzo(g,h,i)perylene	1 (m) [a][4]	1.14	0.28	0.27	NA	NA
Benzo(k)fluoranthene	1 (m) [a][4]	1.14	0.28	0.27	NA	NA
bis(2-Ethylhexyl)phthalate	18.3 (m) [a]	20.8	5.21	5.00	1.1 (rd) [a]	1.1
Carbazole	NA	NA	NA	NA	NA	NA
Chrysene	1 (m) [a][4]	1.14	0.28	0.27	NA	NA
Dibenzo(a,h)anthracene	NA	NA	NA	NA	NA	NA
Dibenzofuran	NA	NA	NA	NA	NA	NA
Di-n-octylphthalate	NA	NA	NA	NA	NA	NA
Fluoranthene	1 (m) [a][4]	1.14	0.28	0.27	NA	NA
Fluorene	NA	NA	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	1 (m) [a][4]	1.14	0.28	0.27	NA	NA
Naphthalene	NA	NA	NA	NA	NA	NA
Phenanthrene	1 (m) [a][4]	1.14	0.28	0.27	NA	NA
Pyrene	1 (m) [a][4]	1.14	0.28	0.27	NA	NA
Aluminum	1.93 (m) [a]	2.19	0.55	0.53	109.7 (rd) [a]	109.7
Calcium	NA	NA	NA	NA	NA	NA
Chromium	2,737 (r) [a]	5,230	1,311	1,257	1 (bd) [a]	1

TABLE 7-6
TOXICITY REFERENCE VALUES (TRVs) / NOAELs FOR MAMMALS AND BIRDS
80th DRS, Fort Story, Virginia

COPC	Mammal TRVs[1] (mg/kg-day)				Bird TRVs [2] (mg/kg-day)	
	Test Species	Short-tailed Shrew	Cottontail Rabbit	Gray Fox	Test Species	Receptor Species
Lead	8 (r) [a]	15.3	3.83	3.67	3.85 (k) [a]	3.85
Potassium	NA	NA	NA	NA	NA	NA
Sodium	NA	NA	NA	NA	NA	NA
alpha-BHC	1.6 (r) [5]	3.06	0.77	0.73	0.36 (jq) [5]	0.36
beta-BHC	0.4 (r)	0.76	0.19	0.18	0.36 (jq) [5]	0.36
delta-BHC	1.6 (r) [5]	3.06	0.77	0.73	0.36 (jq) [5]	0.36
Endosulfan I	0.15 (r) [a]	0.29	0.07	0.07	10 (gp) [a]	10
Endosulfan II	0.15 (r) [a]	0.29	0.07	0.07	10 (gp) [a]	10
Endosulfan sulfate	0.15 (r) [a]	0.29	0.07	0.07	10 (gp) [a]	10
Endrin aldehyde	0.092 (m) [a]	0.10	0.03	0.03	0.3 (m) [a]	0.3
Endrin ketone	NA	NA	NA	NA	NA	NA
Heptachlor	0.1 (mk) [a]	0.29	0.07	0.07	41.6 (m) [d][2]	41.6

Notes:

- = Not Applicable

NA = Not Available

[1]Mammal TRVs represent NOAELs for laboratory species converted to receptor species NOAELs as follows (Sample et al., 1996):

$$NOAEL_r = NOAEL_t\ (bw_t/bw_r)^{1/4}$$

Where: $NOAEL_r$ = receptor NOAEL
$NOAEL_t$ = test species NOAEL
bw_r = receptor body weight
bw_t = test species body weight

Body weights of test and receptor species (kg):

rat (r) = 0.2	muskrat = 1.2
mouse (m) = 0.025	raccoon = 5.8
guinea pig (gp) = 0.5	deer mouse = 0.02
mink (mk) = 1	red fox = 4.5
dog (d) = 10	

[2]Bird TRVs are represented as follows (Sample et al., 1996): $NOAEL_r = NOAEL_t\ (bw_t/bw_r)^0 = NOAEL_t\ (1) = NOAEL_t$
(pe = pelican, bq = bobwhite quail, jq = Japanese quail, m = mallard, bb = blackbird, bo = barn owl, gp = gray partridge, ph= pheasant, c =chicks, k = kestrel, md = mallard duckling)

[3]Value represents an oral LD_{50} divided by an Uncertainty Factor of 50 (5 for extrapolation from LD_{50} to acute LOAEL (USEPA, 1986) and 10 for extrapolation from acute LOAEL to chronic NOAEL (Newell et al., 1987).

[4]Value is for benzo(a)pyrene.

[5]Mixed Isomers of BHC

References:

[a]Sample et al., 1996.
[b]Lewis, 1992.
[c]Heaton, 1992.
[d]Hudson et al., 1984.

TABLE 7-7
AVIAN HQ[1] SUMMARY
80th DRS, FT. STORY, VIRGINIA

Compound	Robin	Red-tailed Hawk
1,1,2-trichloro-1,2,2-trifluoethane	NA	NA
1,3-Dichlorobenzene	NA	NA
2-Butanone (MEK)	NA	NA
2-Hexanone	NA	NA
Acetone	NA	NA
Carbon disulfide	NA	NA
Dichlorodifluoromethane	NA	NA
Methyl acetate	NA	NA
Tetrachloroethylene	NA	NA
Trichlorofluoromethane	NA	NA
1,1'-Biphenyl	NA	NA
2,4-Dinitrotoluene	NA	NA
2,6-Dinitrotoluene	NA	NA
2-Methylnaphthalene	NA	NA
3,3'-Dichlorobenzidine	NA	NA
Acenaphthene	NA	NA
Acenaphthylene	NA	NA
Benzo(a)anthracene	NA	NA
Benzo(a)pyrene	NA	NA
Benzo(b)fluoranthene	NA	NA
Benzo(g,h,i)perylene	NA	NA
Benzo(k)fluoranthene	NA	NA
bis(2-Ethylhexyl)phthalate	9E-02	3E-02
Carbazole	NA	NA
Chrysene	NA	NA
Dibenzo(a,h)anthracene	NA	NA
Dibenzofuran	NA	NA
Di-n-octylphthalate	NA	NA
Fluoranthene	NA	NA
Fluorene	NA	NA
Indeno(1,2,3-cd)pyrene	NA	NA
Naphthalene	NA	NA
Phenanthrene	NA	NA
Pyrene	NA	NA
Aluminum	**7E+01**	**9E+00**
Calcium	NA	NA
Chromium	1E+00	1E+00
Lead	1E+00	1E+00
Potassium	NA	NA
Sodium	NA	NA
alpha-BHC	2E-03	5E-04
beta-BHC	4E-01	3E-02
delta-BHC	1E-03	4E-04
Endosulfan I	5E-05	1E-05
Endosulfan II	9E-04	2E-04
Endosulfan sulfate	6E-03	1E-03
Endrin aldehyde	9E-03	4E-04
Endrin ketone	NA	NA
Heptachlor	3E-05	3E-06

[1] Hazard Quotient (HQ) = Total Exposure / NOAEL

TABLE 7-8
MAMMALIAN HQ[1] SUMMARY
80th DRS, FT. STORY, VIRGINIA

Compound	Short-tailed Shrew	Gray Fox	Rabbit
1,1,2-trichloro-1,2,2-trifluoethane	NA	NA	NA
1,3-Dichlorobenzene	NA	NA	NA
2-Butanone (MEK)	9E-07	2E-06	3E-05
2-Hexanone	NA	NA	NA
Acetone	2E-03	2E-02	1E-01
Carbon disulfide	4E-05	3E-05	1E-04
Dichlorodifluoromethane	NA	NA	NA
Methyl acetate	NA	NA	NA
Tetrachloroethylene	5E-02	2E-02	3E-02
Trichlorofluoromethane	2E-06	1E-06	4E-06
1,1'-Biphenyl	NA	NA	NA
2,4-Dinitrotoluene	NA	NA	NA
2,6-Dinitrotoluene	NA	NA	NA
2-Methylnaphthalene	NA	NA	NA
3,3'-Dichlorobenzidine	NA	NA	NA
Acenaphthene	NA	NA	NA
Acenaphthylene	NA	NA	NA
Benzo(a)anthracene	1E+00	**2E+00**	2E-01
Benzo(a)pyrene	**3E+00**	**2E+00**	1E-01
Benzo(b)fluoranthene	**4E+00**	**2E+00**	2E-01
Benzo(g,h,i)perylene	9E-01	1E+00	7E-02
Benzo(k)fluoranthene	**2E+00**	1E+00	1E-01
bis(2-Ethylhexyl)phthalate	1E-02	5E-03	4E-04
Carbazole	NA	NA	NA
Chrysene	1E+00	**2E+00**	2E-01
Dibenzo(a,h)anthracene	NA	NA	NA
Dibenzofuran	NA	NA	NA
Di-n-octylphthalate	NA	NA	NA
Fluoranthene	**2E+00**	**3E+00**	5E-01
Fluorene	NA	NA	NA
Indeno(1,2,3-cd)pyrene	1E+00	1E+00	1E-01
Naphthalene	NA	NA	NA
Phenanthrene	**2E+00**	**3E+00**	1E+00
Pyrene	**7E+00**	**4E+00**	8E-01
Aluminum	**2E+03**	**1E+03**	**3E+03**
Calcium	NA	NA	NA
Chromium	4E-04	6E-04	5E-05
Lead	4E-01	7E-01	1E-01
Potassium	NA	NA	NA
Sodium	NA	NA	NA
alpha-BHC	3E-04	2E-04	8E-05
beta-BHC	3E-01	4E-02	2E-02
delta-BHC	3E-04	1E-04	6E-05
Endosulfan I	2E-03	1E-03	9E-04
Endosulfan II	4E-02	2E-02	2E-02
Endosulfan sulfate	2E-01	1E-01	1E-01
Endrin aldehyde	5E-02	3E-03	3E-04
Endrin ketone	NA	NA	NA
Heptachlor	7E-03	1E-03	4E-04

[1] Hazard Quotient (HQ) = Total Exposure / NOAEL

TABLE 7-9
AVIAN EXPOSURE ASSUMING AREA USE FACORS SUMMARY
80th DRS, FT. STORY, VIRGINIA

Compound	Robin	Red-tailed Hawk
1,1,2-trichloro-1,2,2-trifluoethane	6.52E-04	2.22E-07
1,3-Dichlorobenzene	1.29E-04	5.56E-08
2-Butanone (MEK)	4.18E-02	5.56E-07
2-Hexanone	4.75E-01	2.56E-05
Acetone	9.59E-01	6.34E-06
Carbon disulfide	6.35E-03	6.67E-07
Dichlorodifluoromethane	4.95E-04	6.67E-08
Methyl acetate	6.67E-01	7.67E-06
Tetrachloroethylene	3.32E-02	1.33E-05
Trichlorofluoromethane	1.69E-03	3.34E-07
1,1'-Biphenyl	9.77E-02	5.23E-05
2,4-Dinitrotoluene	1.31E-01	1.45E-05
2,6-Dinitrotoluene	4.49E-02	5.67E-06
2-Methylnaphthalene	4.99E-01	2.67E-04
3,3'-Dichlorobenzidine	7.56E-02	3.22E-05
Acenaphthene	2.06E-01	1.07E-04
Acenaphthylene	4.64E-01	2.45E-04
Benzo(a)anthracene	3.59E-01	6.23E-04
Benzo(a)pyrene	7.26E-01	6.12E-04
Benzo(b)fluoranthene	9.97E-01	7.56E-04
Benzo(g,h,i)perylene	2.28E-01	4.11E-04
Benzo(k)fluoranthene	6.01E-01	4.56E-04
bis(2-Ethylhexyl)phthalate	5.08E-02	3.78E-05
Carbazole	1.46E-01	5.45E-05
Chrysene	3.62E-01	6.67E-04
Dibenzo(a,h)anthracene	9.07E-02	1.67E-04
Dibenzofuran	1.57E-01	8.78E-05
Di-n-octylphthalate	4.17E-02	3.11E-05
Fluoranthene	6.12E-01	1.09E-03
Fluorene	1.49E-01	1.78E-04
Indeno(1,2,3-cd)pyrene	4.18E-01	4.00E-04
Naphthalene	4.29E-02	1.67E-05
Phenanthrene	8.72E-01	1.33E-03
Pyrene	1.99E+00	1.78E-03
Aluminum	**3.92E+03**	**9.49E-01**
Calcium	1.41E+03	3.40E-01
Chromium	4.96E-01	1.11E-03
Lead	1.88E+00	3.77E-03
Potassium	2.27E+02	5.49E-02
Sodium	6.12E+01	1.48E-02
alpha-BHC	3.32E-04	1.89E-07
beta-BHC	6.67E-02	1.11E-05
delta-BHC	2.54E-04	1.45E-07
Endosulfan I	2.29E-04	1.00E-07
Endosulfan II	4.58E-03	2.00E-06
Endosulfan sulfate	2.80E-02	1.22E-05
Endrin aldehyde	1.29E-03	1.08E-07
Endrin ketone	5.06E-02	1.22E-05
Heptachlor	5.49E-04	1.11E-07

Note: BOLD represents COPCs that had HQs above 1 in initial analysis.

TABLE 7-10
MAMMALIAN EXPOSURE ASSUMING AREA USE FACTORS SUMMARY
80th DRS, FT. STORY, VIRGINIA

Compound	Short-tailed Shrew	Gray Fox	Rabbit
1,1,2-trichloro-1,2,2-trifluoethane	4.88E-04	2.27E-07	1.71E-05
1,3-Dichlorobenzene	1.22E-04	5.50E-08	2.69E-06
2-Butanone (MEK)	1.22E-03	2.74E-06	1.90E-03
2-Hexanone	5.61E-02	4.78E-05	2.04E-02
Acetone	1.39E-02	5.73E-05	4.39E-02
Carbon disulfide	1.46E-03	9.19E-07	2.54E-04
Dichlorodifluoromethane	1.46E-04	8.44E-08	1.89E-05
Methyl acetate	1.68E-02	4.26E-05	3.03E-02
Tetrachloroethylene	2.93E-02	1.33E-05	7.49E-04
Trichlorofluoromethane	7.32E-04	3.80E-07	5.83E-05
1,1'-Biphenyl	1.15E-01	5.05E-05	1.45E-03
2,4-Dinitrotoluene	3.17E-02	1.96E-05	5.20E-03
2,6-Dinitrotoluene	1.24E-02	7.33E-06	1.74E-03
2-Methylnaphthalene	5.86E-01	2.58E-04	7.40E-03
3,3'-Dichlorobenzidine	7.08E-02	3.20E-05	1.60E-03
Acenaphthene	2.34E-01	1.03E-04	3.24E-03
Acenaphthylene	5.37E-01	2.37E-04	7.10E-03
Benzo(a)anthracene	5.89E-01	5.85E-04	3.53E-03
Benzo(a)pyrene	1.17E+00	5.74E-04	2.91E-03
Benzo(b)fluoranthene	1.60E+00	7.10E-04	3.60E-03
Benzo(g,h,i)perylene	4.06E-01	3.86E-04	1.43E-03
Benzo(k)fluoranthene	9.64E-01	4.28E-04	2.17E-03
bis(2-Ethylhexyl)phthalate	8.30E-02	3.54E-05	1.29E-04
Carbazole	1.20E-01	5.50E-05	3.55E-03
Chrysene	6.17E-01	6.26E-04	3.18E-03
Dibenzo(a,h)anthracene	1.58E-01	1.56E-04	6.99E-04
Dibenzofuran	1.93E-01	8.44E-05	2.10E-03
Di-n-octylphthalate	6.83E-02	2.92E-05	1.03E-04
Fluoranthene	8.98E-01	1.03E-03	9.41E-03
Fluorene	1.47E-01	1.70E-04	3.79E-03
Indeno(1,2,3-cd)pyrene	6.77E-01	3.76E-04	1.91E-03
Naphthalene	3.66E-02	1.67E-05	1.00E-03
Phenanthrene	1.02E+00	1.27E-03	1.96E-02
Pyrene	2.97E+00	1.68E-03	1.56E-02
Aluminum	2.08E+03	1.03E+00	1.25E+02
Calcium	7.47E+02	3.70E-01	4.50E+01
Chromium	8.85E-01	1.04E-03	4.65E-03
Lead	2.70E+00	3.56E-03	3.40E-02
Potassium	1.21E+02	5.98E-02	7.27E+00
Sodium	3.25E+01	1.61E-02	1.96E+00
alpha-BHC	4.15E-04	1.81E-07	4.27E-06
beta-BHC	9.61E-02	1.07E-05	2.65E-04
delta-BHC	3.17E-04	1.39E-07	3.26E-06
Endosulfan I	2.20E-04	9.89E-08	4.71E-06
Endosulfan II	4.39E-03	1.98E-06	9.42E-05
Endosulfan sulfate	2.68E-02	1.21E-05	5.76E-04
Endrin aldehyde	1.97E-03	1.01E-07	6.25E-07
Endrin ketone	2.68E-02	1.33E-05	1.62E-03
Heptachlor	8.04E-04	1.06E-07	1.94E-06

Note: BOLD represents COPCs that had HQs above 1 in initial analysis.

TABLE 7-11
AVIAN HQ[1] SUMMARY ASUMMING AREA USE FACTORS
80th DRS, FT. STORY, VIRGINIA

Compound	Robin	Red-tailed Hawk
1,1,2-trichloro-1,2,2-trifluoethane	NA	NA
1,3-Dichlorobenzene	NA	NA
2-Butanone (MEK)	NA	NA
2-Hexanone	NA	NA
Acetone	NA	NA
Carbon disulfide	NA	NA
Dichlorodifluoromethane	NA	NA
Methyl acetate	NA	NA
Tetrachloroethylene	NA	NA
Trichlorofluoromethane	NA	NA
1,1'-Biphenyl	NA	NA
2,4-Dinitrotoluene	NA	NA
2,6-Dinitrotoluene	NA	NA
2-Methylnaphthalene	NA	NA
3,3'-Dichlorobenzidine	NA	NA
Acenaphthene	NA	NA
Acenaphthylene	NA	NA
Benzo(a)anthracene	NA	NA
Benzo(a)pyrene	NA	NA
Benzo(b)fluoranthene	NA	NA
Benzo(g,h,i)perylene	NA	NA
Benzo(k)fluoranthene	NA	NA
bis(2-Ethylhexyl)phthalate	5E-02	3E-05
Carbazole	NA	NA
Chrysene	NA	NA
Dibenzo(a,h)anthracene	NA	NA
Dibenzofuran	NA	NA
Di-n-octylphthalate	NA	NA
Fluoranthene	NA	NA
Fluorene	NA	NA
Indeno(1,2,3-cd)pyrene	NA	NA
Naphthalene	NA	NA
Phenanthrene	NA	NA
Pyrene	NA	NA
Aluminum	**4E+01**	9E-03
Calcium	NA	NA
Chromium	5E-01	1E-03
Lead	5E-01	1E-03
Potassium	NA	NA
Sodium	NA	NA
alpha-BHC	9E-04	5E-07
beta-BHC	2E-01	3E-05
delta-BHC	7E-04	4E-07
Endosulfan I	2E-05	1E-08
Endosulfan II	5E-04	2E-07
Endosulfan sulfate	3E-03	1E-06
Endrin aldehyde	4E-03	4E-07
Endrin ketone	NA	NA
Heptachlor	1E-05	3E-09

Note: BOLD represents COPCs that had HQs above 1 in initial analysis.

[1] Hazard Quotient (HQ) = Total Exposure / NOAEL

TABLE 7-12
MAMMALIAN HQ[1] SUMMARY ASSUMING AREA USE FACTORS
80th DRS, FT. STORY, VIRGINIA

Compound	Short-tailed Shrew	Gray Fox	Rabbit
1,1,2-trichloro-1,2,2-trifluoethane	NA	NA	NA
1,3-Dichlorobenzene	NA	NA	NA
2-Butanone (MEK)	4E-07	3E-09	2E-06
2-Hexanone	NA	NA	NA
Acetone	7E-04	2E-05	9E-03
Carbon disulfide	1E-05	4E-08	1E-05
Dichlorodifluoromethane	NA	NA	NA
Methyl acetate	NA	NA	NA
Tetrachloroethylene	2E-02	3E-05	2E-03
Trichlorofluoromethane	9E-07	2E-09	3E-07
1,1'-Biphenyl	NA	NA	NA
2,4-Dinitrotoluene	NA	NA	NA
2,6-Dinitrotoluene	NA	NA	NA
2-Methylnaphthalene	NA	NA	NA
3,3'-Dichlorobenzidine	NA	NA	NA
Acenaphthene	NA	NA	NA
Acenaphthylene	NA	NA	NA
Benzo(a)anthracene	5E-01	2E-03	1E-02
Benzo(a)pyrene	1E+00	2E-03	1E-02
Benzo(b)fluoranthene	1E+00	3E-03	1E-02
Benzo(g,h,i)perylene	4E-01	1E-03	5E-03
Benzo(k)fluoranthene	8E-01	2E-03	8E-03
bis(2-Ethylhexyl)phthalate	4E-03	7E-06	2E-05
Carbazole	NA	NA	NA
Chrysene	5E-01	2E-03	1E-02
Dibenzo(a,h)anthracene	NA	NA	NA
Dibenzofuran	NA	NA	NA
Di-n-octylphthalate	NA	NA	NA
Fluoranthene	8E-01	4E-03	3E-02
Fluorene	NA	NA	NA
Indeno(1,2,3-cd)pyrene	6E-01	1E-03	7E-03
Naphthalene	NA	NA	NA
Phenanthrene	9E-01	5E-03	7E-02
Pyrene	**3E+00**	6E-03	5E-02
Aluminum	**9E+02**	**2E+00**	**2E+02**
Calcium	NA	NA	NA
Chromium	2E-04	8E-07	4E-06
Lead	2E-01	1E-03	9E-03
Potassium	NA	NA	NA
Sodium	NA	NA	NA
alpha-BHC	1E-04	2E-07	6E-06
beta-BHC	1E-01	6E-05	1E-03
delta-BHC	1E-04	2E-07	4E-06
Endosulfan I	8E-04	1E-06	7E-05
Endosulfan II	2E-02	3E-05	1E-03
Endosulfan sulfate	9E-02	2E-04	8E-03
Endrin aldehyde	2E-02	4E-06	2E-05
Endrin ketone	NA	NA	NA
Heptachlor	3E-03	2E-06	3E-05

Note: BOLD represents COPCs that had HQs above 1 in initial analysis.

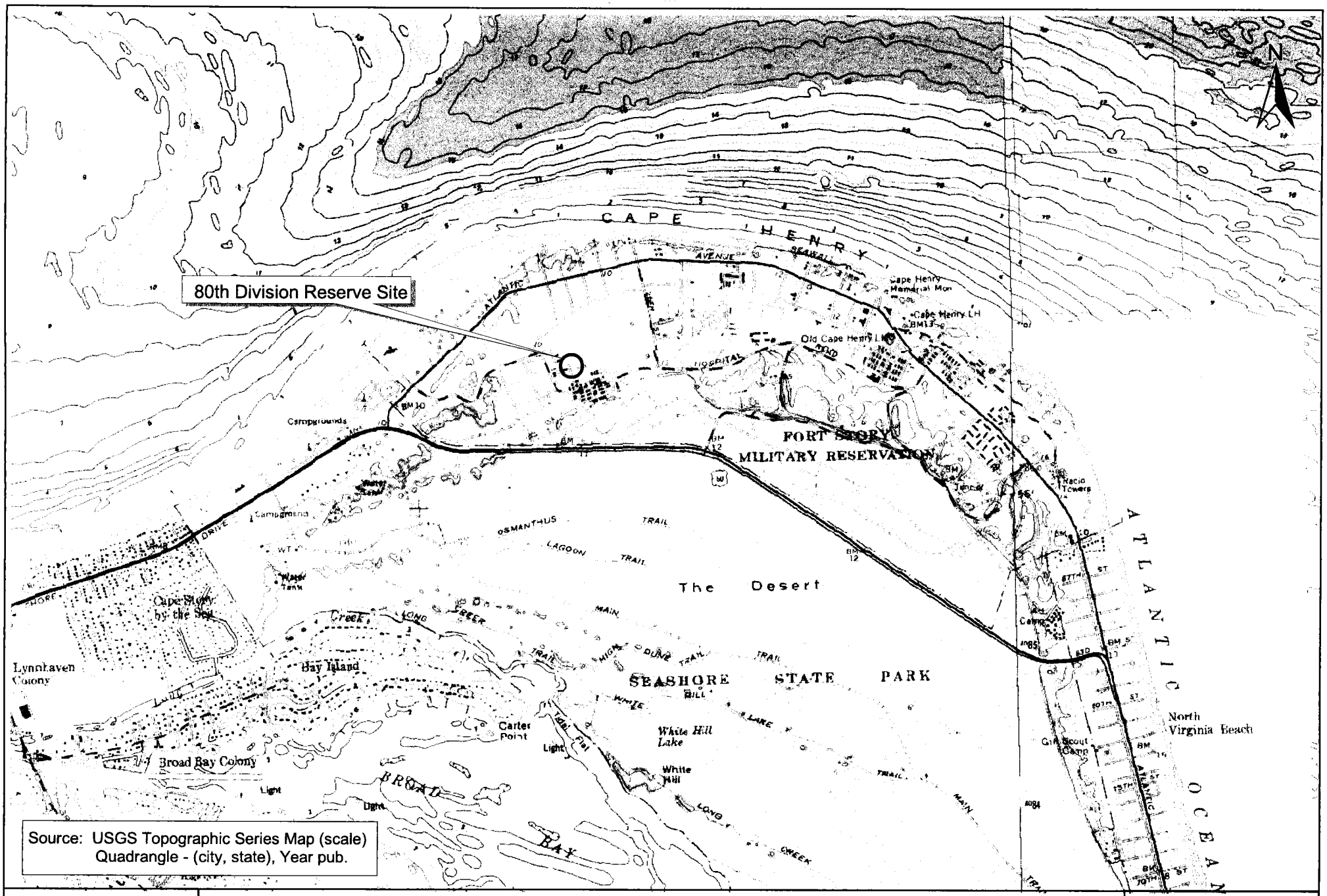
[1] Hazard Quotient (HQ) = Total Exposure / NOAEL

Figures

Remedial Investigation Report
80th Division Reserve Site
Fort Story, Virginia

MOVING TO PROTECT OUR WORLD

USATC ENVIRONMENTAL



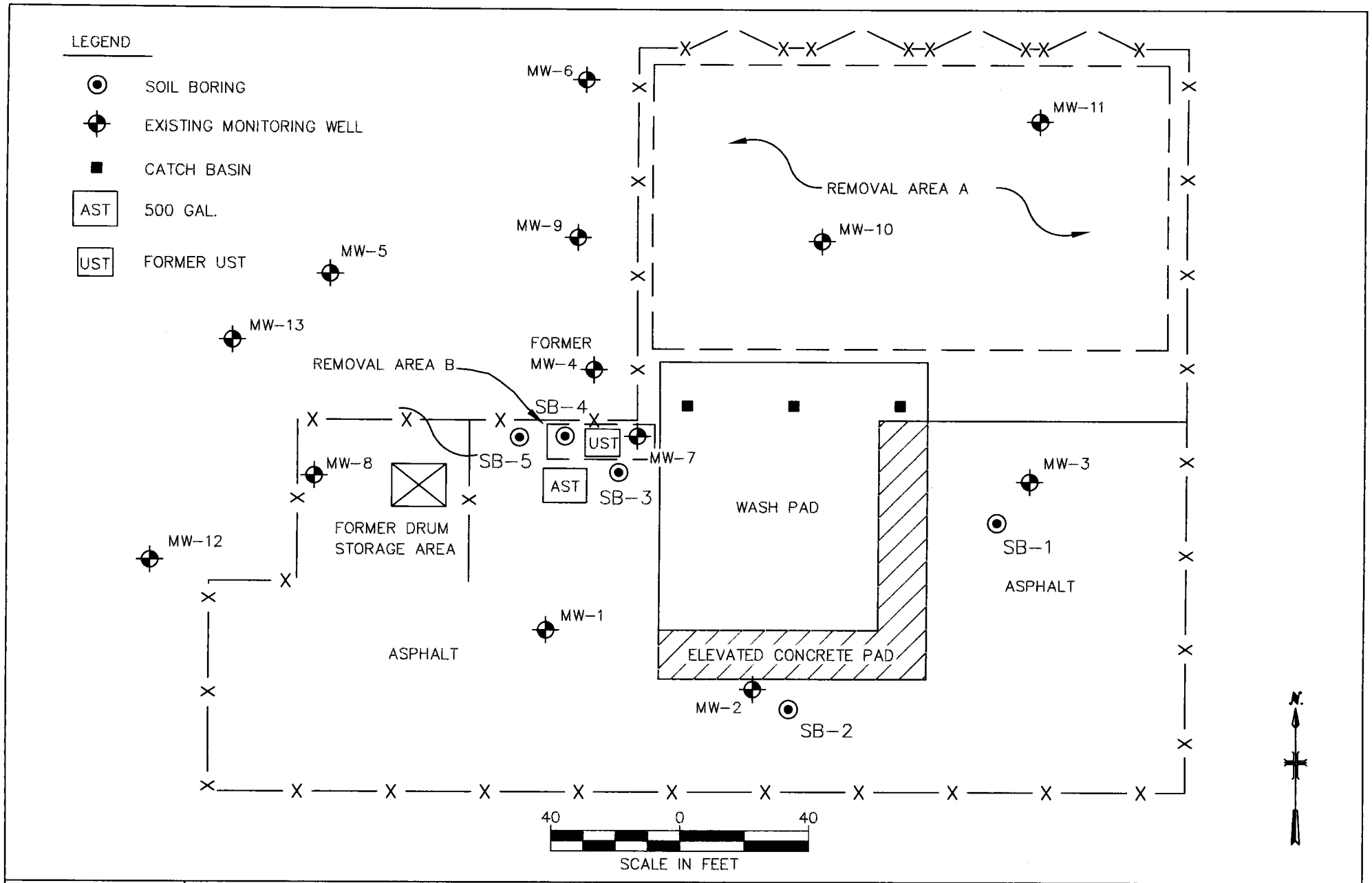
Source: USGS Topographic Series Map (scale)
Quadrangle - (city, state), Year pub.

MALCOLM PIRNIE

Fort Story
80th Division Reserve Site
SITE LOCATION

April 2004

Figure 1-1

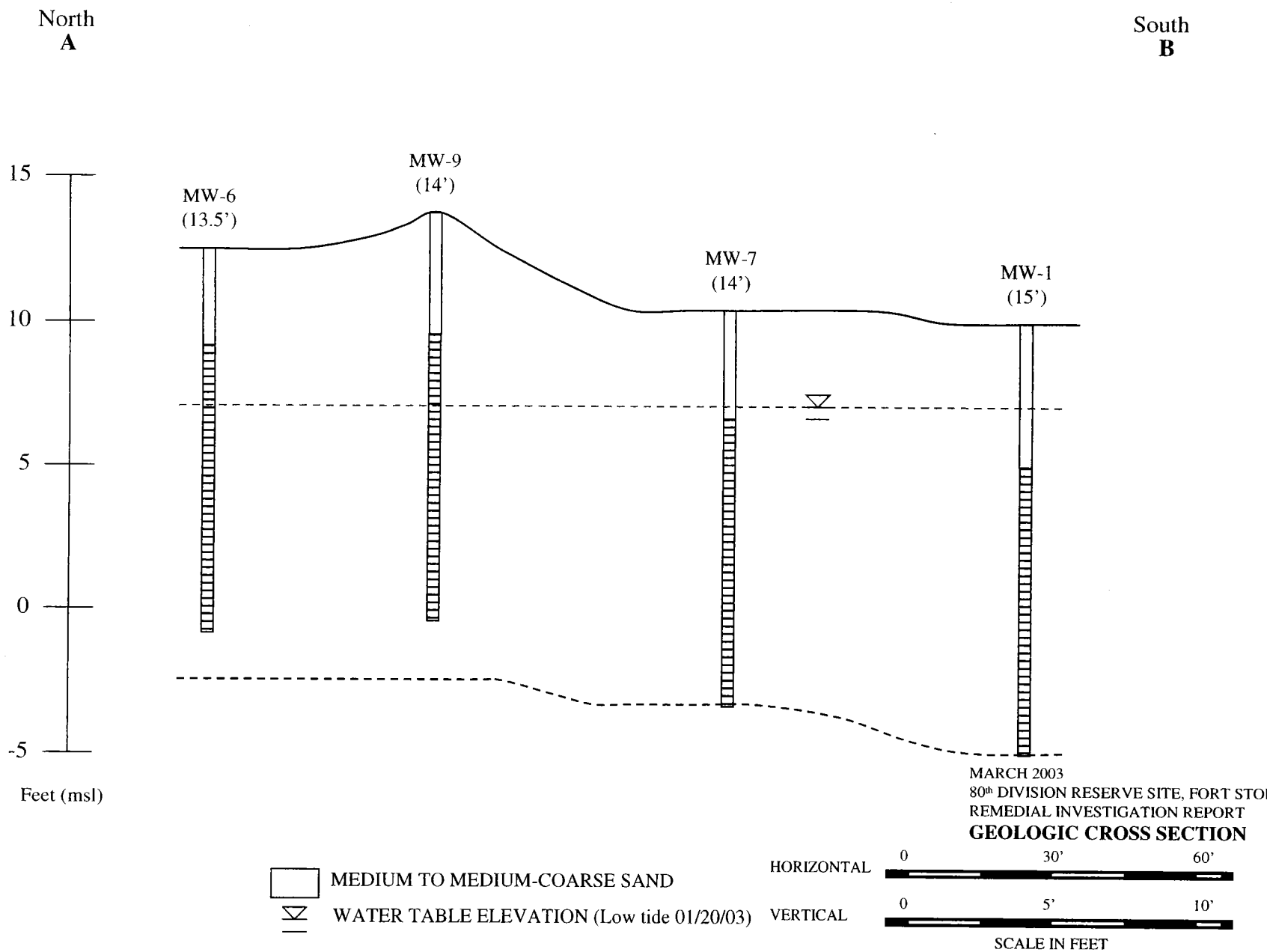


MALCOLM PIRNIE

FORT STORY, VIRGINIA BEACH, VIRGINIA
80th DIVISION RESERVE SITE
SAMPLE LOCATION MAP

MALCOLM PIRNIE, INC.
May 2005
FIGURE 2-1

Figure 3-1

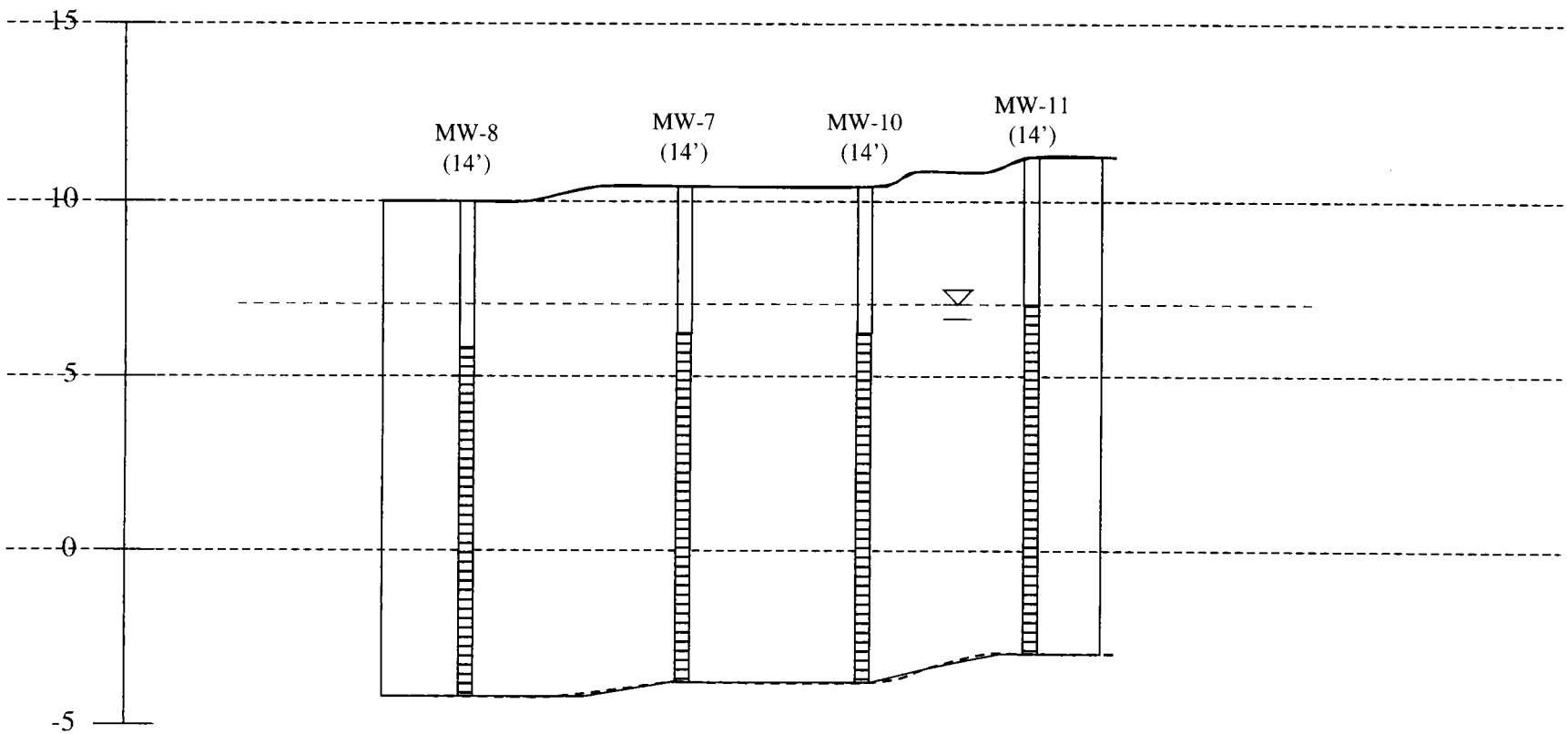


MARCH 2003
80th DIVISION RESERVE SITE, FORT STORY
REMEDIAL INVESTIGATION REPORT
GEOLOGIC CROSS SECTION

Figure 3-2

West
A

Northeast
B



Feet (msl)

MARCH 2003
80th DIVISION RESERVE SITE, FORT STORY
REMEDIAL INVESTIGATION REPORT
GEOLOGIC CROSS SECTION

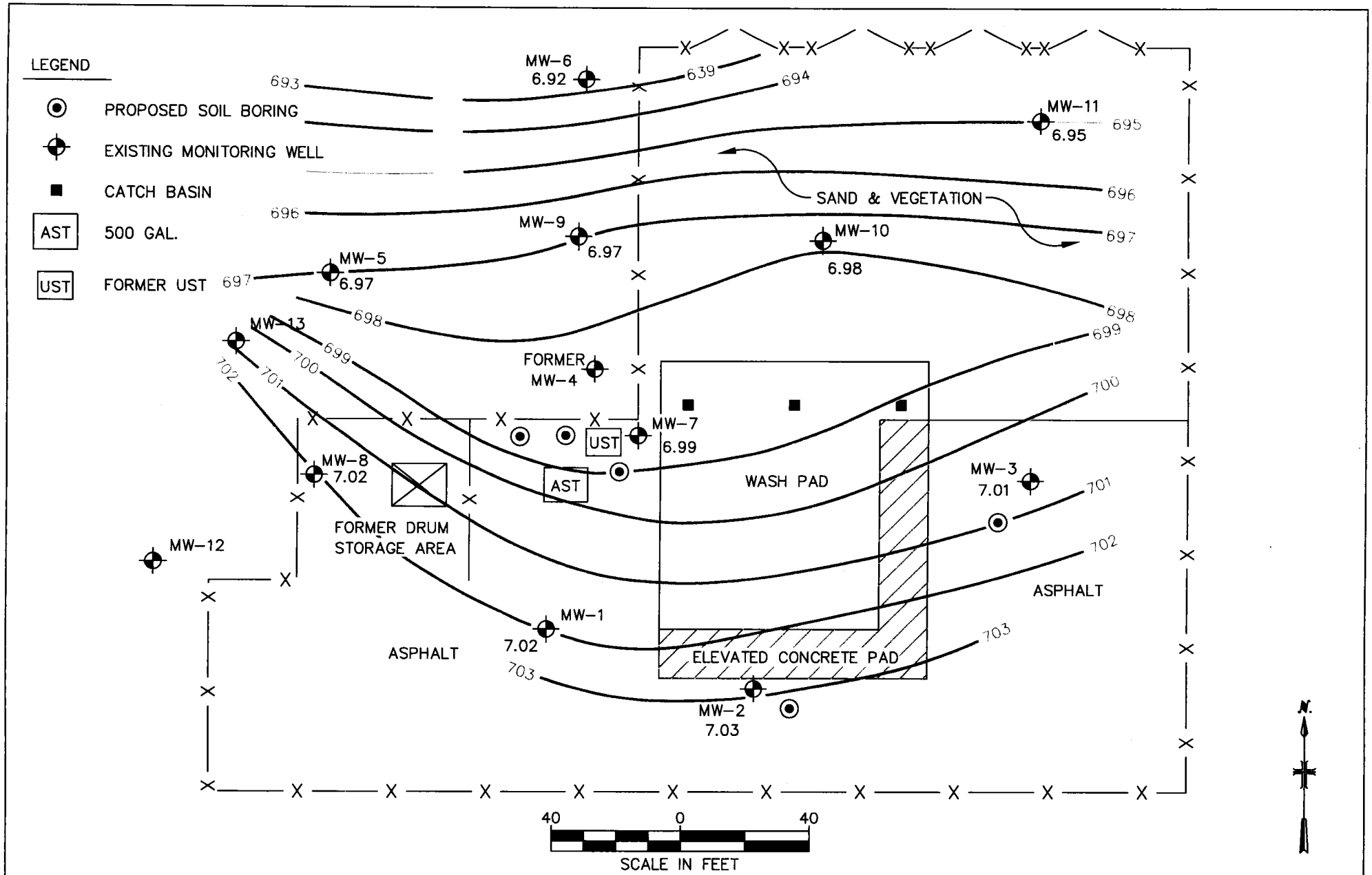
MEDIUM TO MEDIUM-COARSE SAND

WATER TABLE ELEVATION (Low tide 01/20/03)

HORIZONTAL 0 80' 160'

VERTICAL 0 5' 10'

SCALE IN FEET

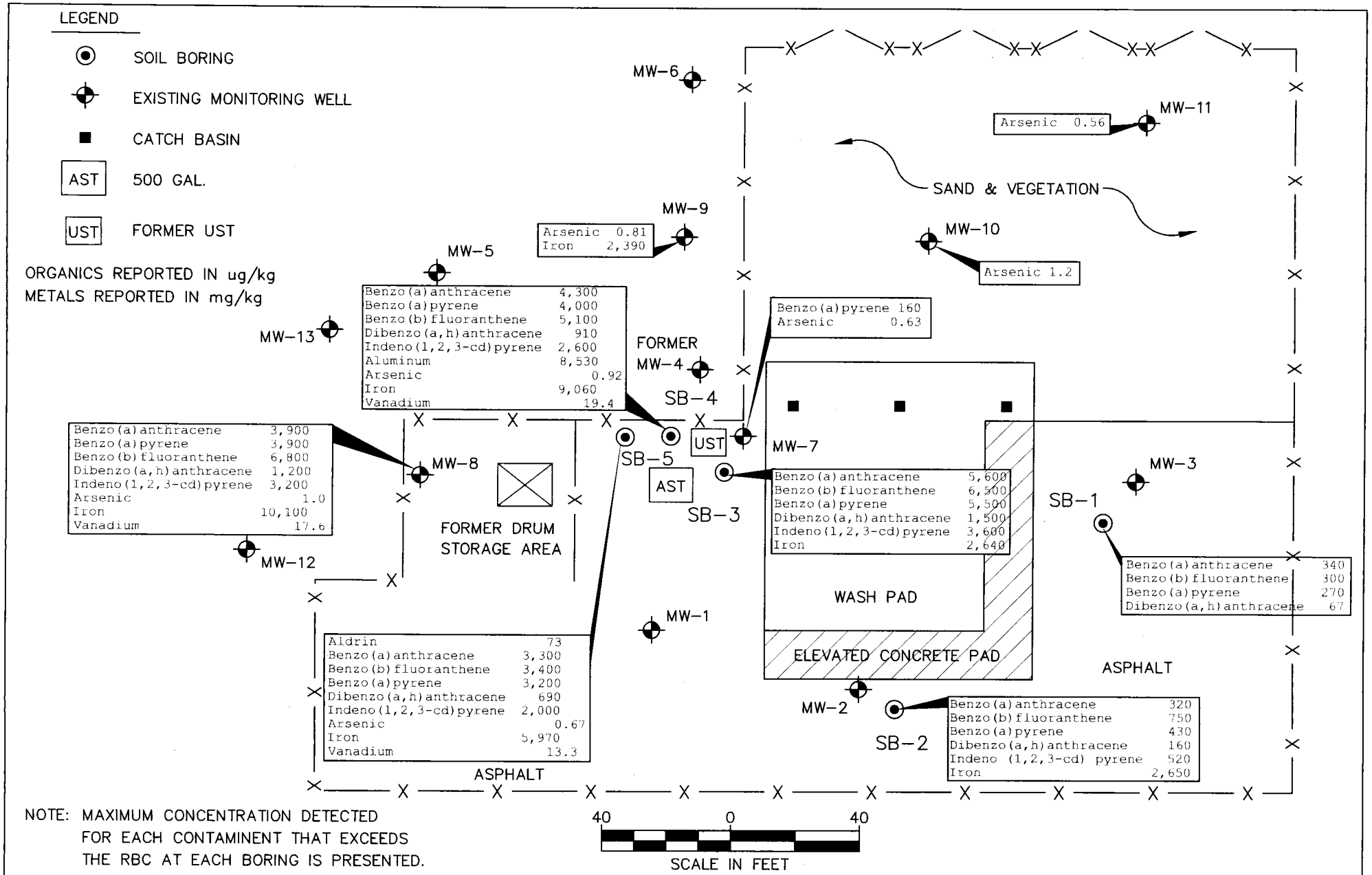


MALCOLM PIRNIE

FORT STORY, VIRGINIA
80th DIVISION RESERVE SITE – REMEDIAL INVESTIGATION REPORT
GROUNDWATER CONTOUR MAP

MALCOLM PIRNIE, INC.

MAY 2005
FIGURE 3-3

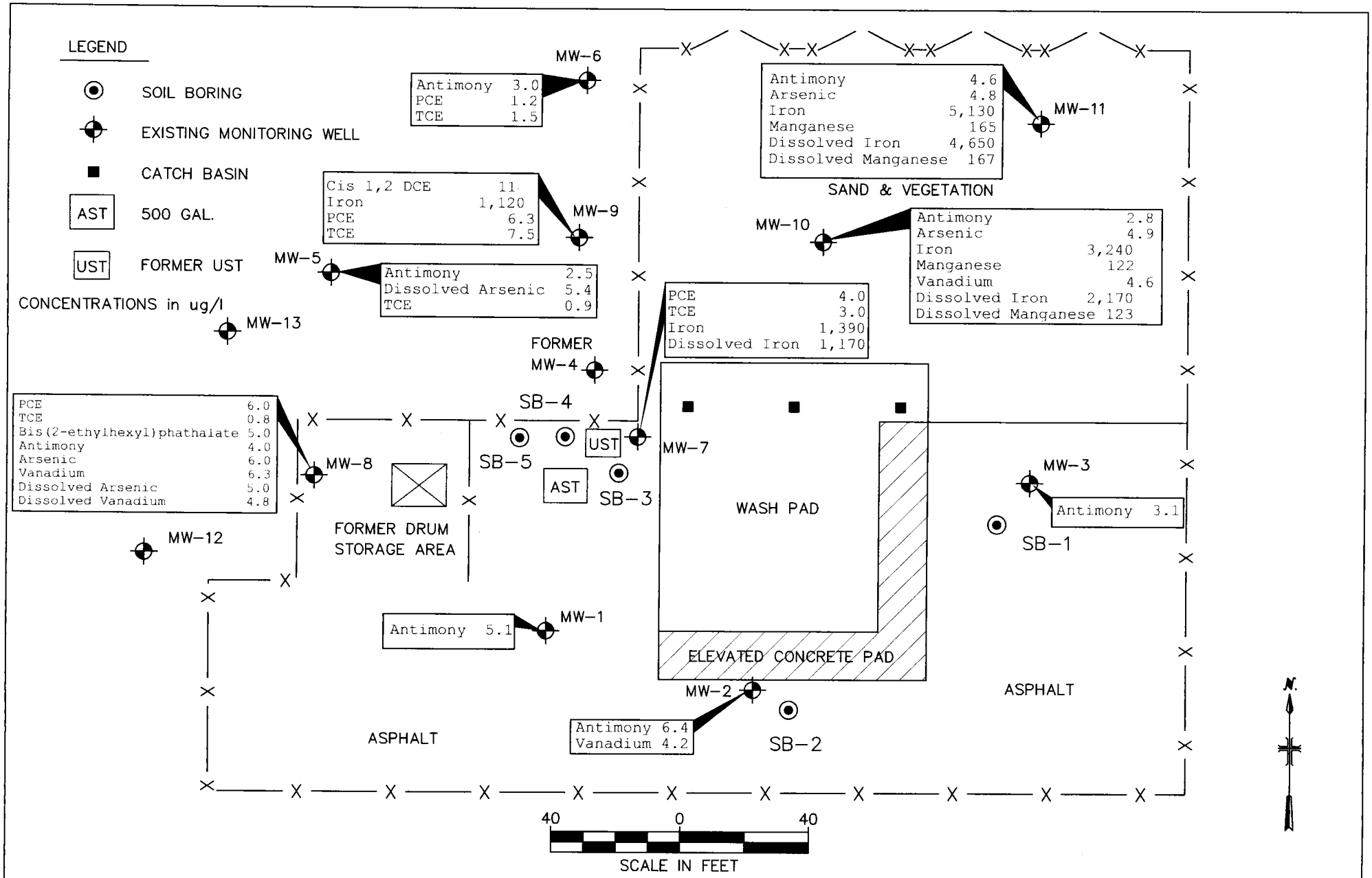


NOTE: MAXIMUM CONCENTRATION DETECTED FOR EACH CONTAMINENT THAT EXCEEDS THE RBC AT EACH BORING IS PRESENTED.

MALCOLM PIRNIE

FORT STORY, VIRGINIA BEACH, VIRGINIA
80th DIVISION RESERVE SITE
SOIL DETECTIONS ABOVE RBCs

MALCOLM PIRNIE, INC.
JANUARY 2007
FIGURE 4-1



MALCOLM PIRNIE

FORT STORY, VIRGINIA BEACH, VIRGINIA
80th DIVISION RESERVE SITE
GROUNDWATER DETECTIONS ABOVE RBCs AND/OR MCLs

MALCOLM PIRNIE, INC.
JANUARY 2007
FIGURE 4-2

80th Division Reserve Site Transport Pathways

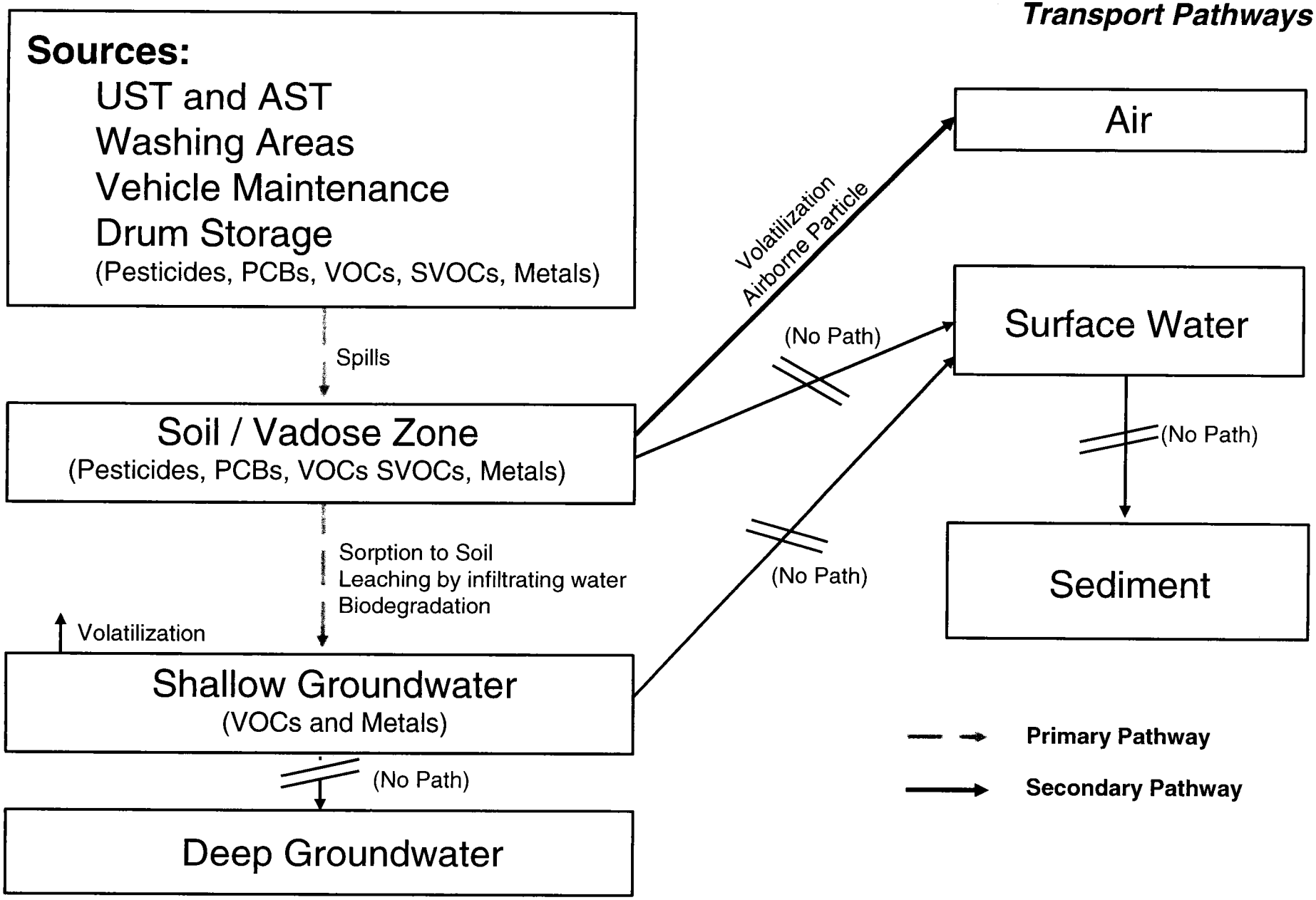
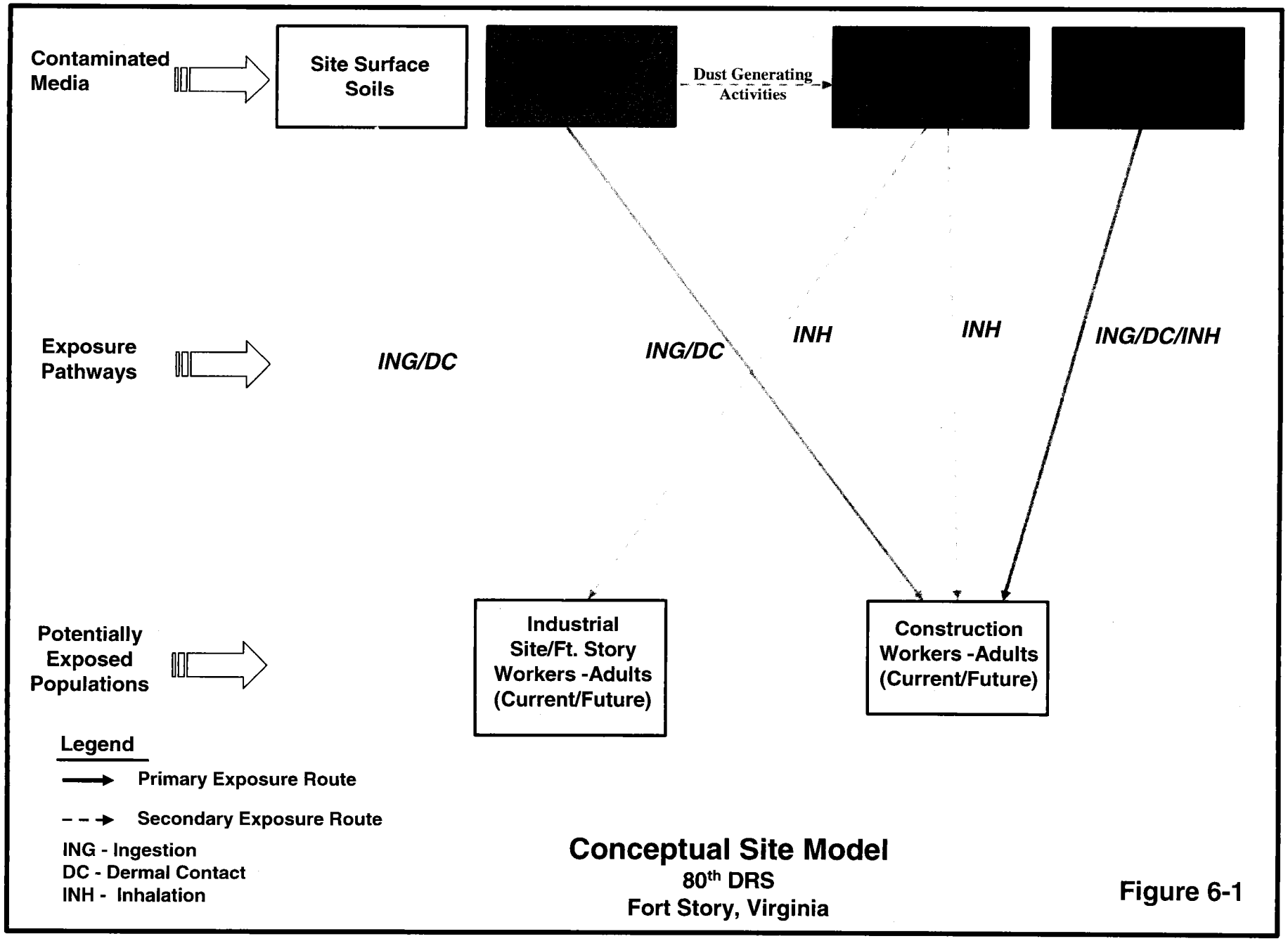


Figure 5-1

0285-917



Conceptual Site Model
80th DRS
Fort Story, Virginia

Figure 6-1

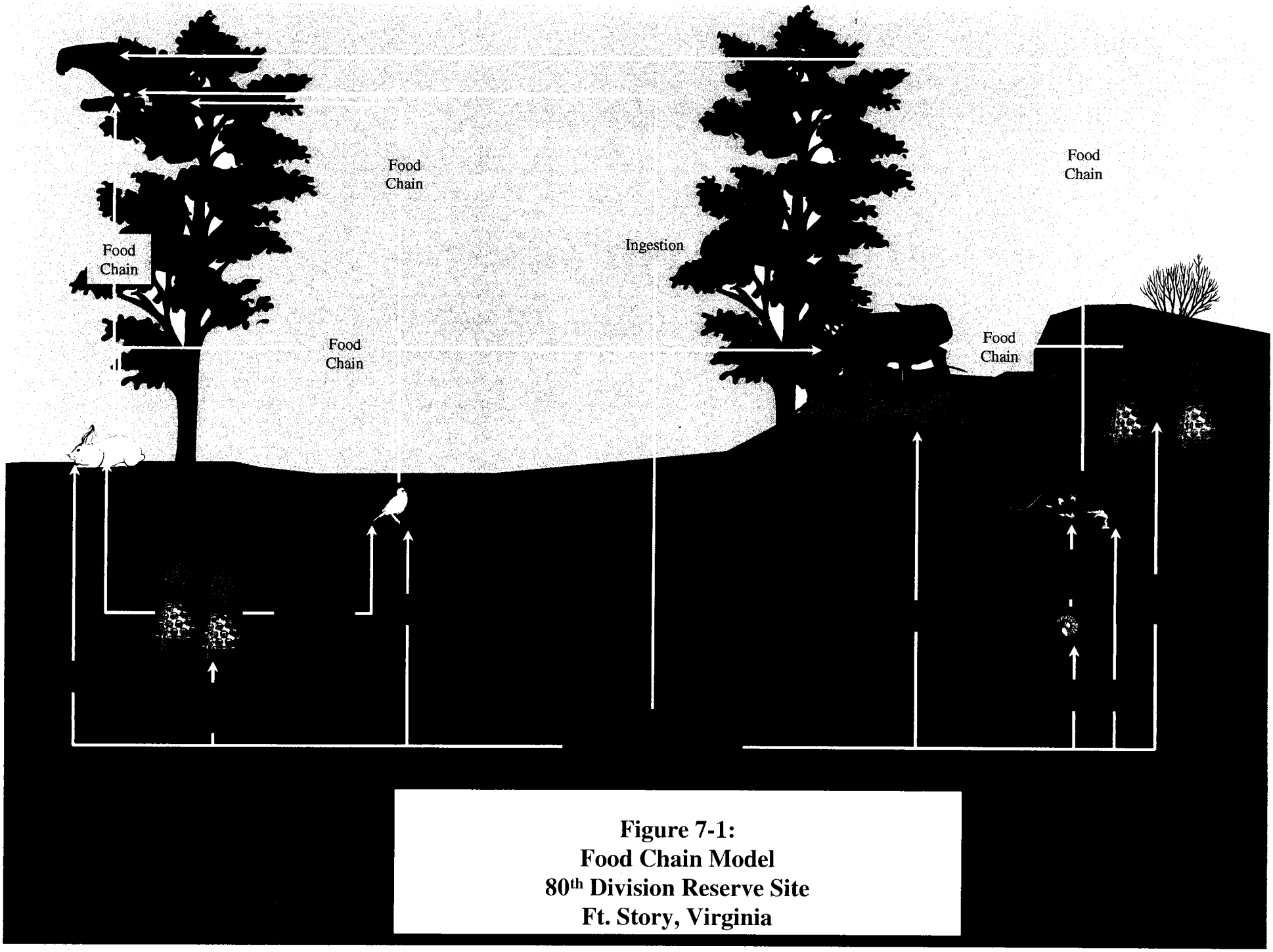


Figure 7-1:
Food Chain Model
80th Division Reserve Site
Ft. Story, Virginia

Appendix A
References

Remedial Investigation Report
80th Division Reserve Site
Fort Story, Virginia

MOVING TO PROTECT OUR WORLD

USATC ENVIRONMENTAL

APPENDIX A
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Appendix B
Sampling Forms

Remedial Investigation Report
80th Division Reserve Site
Fort Story, Virginia

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Groundwater Sampling Logs

Remedial Investigation Report
80th Division Reserve Site
Fort Story, Virginia

0285-917

MALCOLM PIRNIE

701 Town Center Drive, Suite 600, Newport News, VA 23606

GROUNDWATER MONITORING WELL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917 DATE: 01/07/2003

PROJECT NAME: 80th DRS SAMPLERS: GTP / CMP

SITE LOCATION: Fort Story, 80th Division Reserve Site

SITE CONTACT: Joanna Bateman WEATHER CONDITIONS:

WELL IDENTIFICATION NUMBER: MW-01 High of 35°F, windy

WELL HEADSPACE READING: PID MODEL/LAMP:

DEPTH TO WATER (Before Purging): 2.94 FEET FROM TOP OF CASING

WELL DEPTH: 11.49 FEET FROM TOP OF CASING

HEIGHT OF WATER IN WELL: 8.55 FEET

WELL VOLUME: 1.4 GAL PURGE VOLUME: 4.2-7 GAL

PURGE START TIME: 10:55 PURGE FINISH TIME: 11:20

WELL EVACUATION DEVICE: Grundfos

SAMPLE COLLECTION DEVICE: Grundfos

SAMPLING START TIME: 11:20 SAMPLING FINISH TIME: 11:

SAMPLE APPEARANCE: Clear

FIELD PARAMETERS	FIRST	SECOND	THIRD	FOURTH	FIFTH
temperature (degrees C)	13.3	15.7	16.3	16.1	16.3
specific conductivity (umhos/cm)	0.131	0.129	0.134	0.137	0.138
pH (SU)	5.03	4.56	4.41	4.35	4.38
dissolved oxygen (mg/l)	0.45	0.34	0.12	0.33	0.45
turbidity	655	16	4	2	1
volume purged (gallons)	0	1	2	3	4.2

ANALYSIS REQUIRED: VOCs, SVOCs, Pest/PCBs, TL / Diss metals, TSS, TDS

LABORATORY: CompuChem CONTACT: Rodney Ralmonde

NOTES (continued on back):

Casing Diameter (in)	Casing Volume (Gal per Ft)
2.0	0.1632
4.0	0.6528
6.0	1.4687

MALCOLM PIRNIE

701 Town Center Drive, Suite 600, Newport News, VA 23606

GROUNDWATER MONITORING WELL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917 DATE: 01/07/2003

PROJECT NAME: 80th DRS SAMPLERS: GTP / CMP

SITE LOCATION: Fort Story, 80th Division Reserve Site

SITE CONTACT: Joanna Bateman WEATHER CONDITIONS:

WELL IDENTIFICATION NUMBER: MW-02 High of 35°F, windy

WELL HEADSPACE READING: PID MODEL/LAMP:

DEPTH TO WATER (Before Purging): 2.9 FEET FROM TOP OF CASING

WELL DEPTH: 11.45 FEET FROM TOP OF CASING

HEIGHT OF WATER IN WELL: 8.55 FEET

WELL VOLUME: 1.7 GAL PURGE VOLUME: 4.2 GAL

PURGE START TIME: 13:00 PURGE FINISH TIME: 13:20

WELL EVACUATION DEVICE: Grundfos

SAMPLE COLLECTION DEVICE: Grundfos

SAMPLING START TIME: 13:20 SAMPLING FINISH TIME: 13:

SAMPLE APPEARANCE: Clear

FIELD PARAMETERS	FIRST	SECOND	THIRD	FOURTH	FIFTH
temperature (degrees C)	14.4	15.1	15.2	15.2	15.6
specific conductivity (umhos/cm)	0.222	0.206	0.220	0.212	205.000
pH (SU)	5.37	4.96	4.85	4.79	4.71
dissolved oxygen (mg/l)	1.69	2.14	1.85	1.80	0.64
turbidity	451	103	43	19	12
volume purged (gallons)	0	2	3.5	4.5	5

ANALYSIS REQUIRED: VOCs, SVOCs, Pest/PCBs, TL / Diss metals, TSS, TDS

LABORATORY: CompuChem CONTACT: Rodney Ralmonde

NOTES (continued on back): GW-MW-02-->13:30, fuel-like odor

Casing Diameter (in)	Casing Volume (Gal per Ft)
2.0	0.1632
4.0	0.6528
6.0	1.4687

MALCOLM PIRNIE

701 Town Center Drive, Suite 600, Newport News, VA 23606

GROUNDWATER MONITORING WELL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917 DATE: 01/14/2003

PROJECT NAME: 80th DRS SAMPLERS: GTP / CMP

SITE LOCATION: Fort Story, 80th Division Reserve Site

SITE CONTACT: Joanna Bateman WEATHER CONDITIONS: 38°F, windy

WELL IDENTIFICATION NUMBER: MW-03

WELL HEADSPACE READING: PID MODEL/LAMP:

DEPTH TO WATER (Before Purging): 3.25 FEET FROM TOP OF CASING

WELL DEPTH: 11.95 FEET FROM TOP OF CASING

HEIGHT OF WATER IN WELL: 8.7 FEET

WELL VOLUME: 1.40 GAL PURGE VOLUME: 4.3 GAL

PURGE START TIME: 9:20 PURGE FINISH TIME: 9:45

WELL EVACUATION DEVICE: Grundfos

SAMPLE COLLECTION DEVICE: Grundfos

SAMPLING START TIME: 9:45 SAMPLING FINISH TIME: 9:5

SAMPLE APPEARANCE: Clear

FIELD PARAMETERS	FIRST	SECOND	THIRD	FOURTH	FIFTH
temperature (degrees C)	13.3	15.3	15.7	16.0	16.1
specific conductivity (umhos/cm)	0.142	0.089	0.077	0.076	0.077
pH (SU)	4.43	4.64	5.06	5.09	5.09
dissolved oxygen (mg/l)	3.23	2.18	3.07	3.26	3.16
turbidity	473	101	38	18	6
volume purged (gallons)	0	1	2	3	4.5

ANALYSIS REQUIRED: VOCs, SVOCs, Pest/PCBs, TL / Diss metals, TSS, TDS

LABORATORY: CompuChem CONTACT: Rodney Ralmonde

NOTES (continued on back):

Casing Diameter (in)	Casing Volume (Gal per Ft)
2.0	0.1632
4.0	0.6528
6.0	1.4687

MALCOLM PIRNIE

701 Town Center Drive, Suite 600, Newport News, VA 23606

GROUNDWATER MONITORING WELL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917 DATE: 01/09/2003

PROJECT NAME: 80th DRS SAMPLERS: GTP / TYJ

SITE LOCATION: Fort Story, 80th Division Reserve Site

SITE CONTACT: Joanna Bateman WEATHER CONDITIONS: High 65°F, windy

WELL IDENTIFICATION NUMBER: MW-05

WELL HEADSPACE READING: PID MODEL/LAMP:

DEPTH TO WATER (Before Purging): 8.49 FEET FROM TOP OF CASING

WELL DEPTH: 14.92 FEET FROM TOP OF CASING

HEIGHT OF WATER IN WELL: 6.43 FEET

WELL VOLUME: 1.05 GAL PURGE VOLUME: 3.2-6.2 GAL

PURGE START TIME: 9:40 PURGE FINISH TIME: 10:00

WELL EVACUATION DEVICE: Grundfos

SAMPLE COLLECTION DEVICE: Grundfos

SAMPLING START TIME: 10:00 SAMPLING FINISH TIME: 10:

SAMPLE APPEARANCE: Clear

FIELD PARAMETERS	FIRST	SECOND	THIRD	FOURTH	FIFTH
temperature (degrees C)	15.0	16.7	17.0	17.1	
specific conductivity (umhos/cm)	0.210	0.141	0.135	0.137	
pH (SU)	5.2	5.3	5.5	5.8	
dissolved oxygen (mg/l)	11.1	11.2	10.4	11.4	
turbidity	200	2	0	0	
volume purged (gallons)	0	1	2	3.5	

ANALYSIS REQUIRED: VOCs, SVOCs, Pest/PCBs, TL / Diss metals, TSS, TDS

LABORATORY: CompuChem CONTACT: Rodney Ralmonde

NOTES (continued on back):

Casing Diameter (in)	Casing Volume (Gal per Ft)
2.0	0.1632
4.0	0.6528
6.0	1.4687

MALCOLM PIRNIE

701 Town Center Drive, Suite 600, Newport News, VA 23606

GROUNDWATER MONITORING WELL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917 DATE: 01/09/2003

PROJECT NAME: 80th DRS SAMPLERS: GTP / TYJ

SITE LOCATION: Fort Story, 80th Division Reserve Site

SITE CONTACT: Joanna Bateman WEATHER CONDITIONS: High 65°F, windy

WELL IDENTIFICATION NUMBER: MW-06

WELL HEADSPACE READING: PID MODEL/LAMP:

DEPTH TO WATER (Before Purging): 4.35 FEET FROM TOP OF CASING

WELL DEPTH: 14.37 FEET FROM TOP OF CASING

HEIGHT OF WATER IN WELL: 7.02 FEET

WELL VOLUME: 1.15 GAL PURGE VOLUME: 3.4-6.0 GAL

PURGE START TIME: 10:35 PURGE FINISH TIME: 11:00

WELL EVACUATION DEVICE: Grundfos

SAMPLE COLLECTION DEVICE: Grundfos

SAMPLING START TIME: 11:00 SAMPLING FINISH TIME: 11:

SAMPLE APPEARANCE: Clear with some rust-colored particles

FIELD PARAMETERS	FIRST	SECOND	THIRD	FOURTH	FIFTH
temperature (degrees C)	15.1	15.8	15.8	16.0	
specific conductivity (umhos/cm)	0.202	0.201	0.197	0.194	
pH (SU)	6.07	5.7	5.6	5.7	
dissolved oxygen (mg/l)	11.82	12.5	12.3	12.6	
turbidity	196	213	6	2	
volume purged (gallons)	0	1	2	3.5	

ANALYSIS REQUIRED: VOCs, SVOCs, Pest/PCBs, TL / Diss metals, TSS, TDS

LABORATORY: CompuChem CONTACT: Rodney Ralmonde

NOTES (continued on back):

Casing Diameter (in)	Casing Volume (Gal per Ft)
2.0	0.1632
4.0	0.6528
6.0	1.4687

MALCOLM PIRNIE

701 Town Center Drive, Suite 600, Newport News, VA 23606

GROUNDWATER MONITORING WELL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917 DATE: 01/08/2003

PROJECT NAME: 80th DRS SAMPLERS: GTP / TYJ

SITE LOCATION: Fort Story, 80th Division Reserve Site

SITE CONTACT: Joanna Bateman WEATHER CONDITIONS:

WELL IDENTIFICATION NUMBER: MW-07 57°F, windy

WELL HEADSPACE READING: PID MODEL/LAMP:

DEPTH TO WATER (Before Purging): 7.29 FEET FROM TOP OF CASING

WELL DEPTH: 17.32 FEET FROM TOP OF CASING

HEIGHT OF WATER IN WELL: 10.03 FEET

WELL VOLUME: 1.64 GAL PURGE VOLUME: 4.9-8.2 GAL

PURGE START TIME: 13:50 PURGE FINISH TIME: 14:10

WELL EVACUATION DEVICE: Grundfos

SAMPLE COLLECTION DEVICE: Grundfos

SAMPLING START TIME: 14:10 SAMPLING FINISH TIME: 14:

SAMPLE APPEARANCE: Clear

FIELD PARAMETERS	FIRST	SECOND	THIRD	FOURTH	FIFTH
temperature (degrees C)	15.7	17.6	17.8	17.6	
specific conductivity (umhos/cm)	0.110	0.112	0.118	0.118	
pH (SU)	8.66	7.42	7.14	6.79	
dissolved oxygen (mg/l)	8.71	7.88	7.37	7.68	
turbidity	-10*	-10*	-10*	148	
volume purged (gallons)	0	2	4	5	

ANALYSIS REQUIRED: VOCs, SVOCs, Pest/PCBs, TL / Diss metals, TSS, TDS

LABORATORY: CompuChem CONTACT: Rodney Ralmonde

NOTES (continued on back): -10* - Turbidity not reading properly

Casing Diameter (in)	Casing Volume (Gal per Ft)
2.0	0.1632
4.0	0.6528
6.0	1.4687

MALCOLM PIRNIE

701 Town Center Drive, Suite 600, Newport News, VA 23606

GROUNDWATER MONITORING WELL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917 DATE: 01/07/2003

PROJECT NAME: 80th DRS SAMPLERS: GTP / CMP

SITE LOCATION: Fort Story, 80th Division Reserve Site

SITE CONTACT: Joanna Bateman WEATHER CONDITIONS:

WELL IDENTIFICATION NUMBER: MW-08 High of 35°F, windy

WELL HEADSPACE READING: PID MODEL/LAMP:

DEPTH TO WATER (Before Purging): 2.72 FEET FROM TOP OF CASING

WELL DEPTH: 14 FEET FROM TOP OF CASING

HEIGHT OF WATER IN WELL: 11.28 FEET

WELL VOLUME: 1.8 GAL PURGE VOLUME: 5.5-9.2 GAL

PURGE START TIME: 9:55 PURGE FINISH TI A 1:20

WELL EVACUATION DEVICE: Grundfos

SAMPLE COLLECTION DEVICE: Grundfos

SAMPLING START TIME: 10:20 SAMPLING FINISH TIME: 10:

SAMPLE APPEARANCE: Clear, yellow tint

FIELD PARAMETERS	FIRST	SECOND	THIRD	FOURTH	FIFTH
temperature (degrees C)	14.6	15.5	15.4	16.5	16.1
specific conductivity (umhos/cm)	0.234	0.180	0.170	0.155	0.150
pH (SU)	3.57	3.62	3.75	4.00	4.08
dissolved oxygen (mg/l)	0.31	0.46	0.60	0.63	0.61
turbidity	280	220	80	42	28
volume purged (gallons)	0	1	2.5	3.5	5.5

ANALYSIS REQUIRED: VOCs, SVOCs, Pest/PCBs, TL / Diss metals, TSS, TDS

LABORATORY: CompuChem CONTACT: Rodney Ralmonde

NOTES (continued on back):

Casing Diameter (in)	Casing Volume (Gal per Ft)
2.0	0.1632
4.0	0.6528
6.0	1.4687

MALCOLM PIRNIE

701 Town Center Drive, Suite 600, Newport News, VA 23606

GROUNDWATER MONITORING WELL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917 DATE: 01/09/2003

PROJECT NAME: 80th DRS SAMPLERS: GTP / TYJ

SITE LOCATION: Fort Story, 80th Division Reserve Site

SITE CONTACT: Joanna Bateman WEATHER CONDITIONS:

WELL IDENTIFICATION NUMBER: MW-09 High 65°F, windy

WELL HEADSPACE READING: PID MODEL/LAMP:

DEPTH TO WATER (Before Purging): 9.49 FEET FROM TOP OF CASING

WELL DEPTH: 17.45 FEET FROM TOP OF CASING

HEIGHT OF WATER IN WELL: 7.96 FEET

WELL VOLUME: 1.30 GAL PURGE VOLUME: 3.9-6.5 GAL

PURGE START TIME: 13:00 PURGE FINISH TIME: 13:30

WELL EVACUATION DEVICE: Grundfos

SAMPLE COLLECTION DEVICE: Grundfos

SAMPLING START TIME: 13:30 SAMPLING FINISH TIME: 13:

SAMPLE APPEARANCE: Clear with some rust-colored particles

FIELD PARAMETERS	FIRST	SECOND	THIRD	FOURTH	FIFTH
temperature (degrees C)	16.2	17.9	18.0	17.9	
specific conductivity (umhos/cm)	0.144	0.163	0.178	0.178	
pH (SU)	6.1	6.2	5.8	5.8	
dissolved oxygen (mg/l)	11.2	11.5	11.5	11.5	
turbidity	787	60	17	11	
volume purged (gallons)	0	2	3	4	

ANALYSIS REQUIRED: VOCs, SVOCs, Pest/PCBs, TL / Diss metals, TSS, TDS

LABORATORY: CompuChem CONTACT: Rodney Ralmonde

NOTES (continued on back):

Casing Diameter (in)	Casing Volume (Gal per Ft)
2.0	0.1632
4.0	0.6528
6.0	1.4687

MALCOLM PIRNIE

701 Town Center Drive, Suite 600, Newport News, VA 23606

GROUNDWATER MONITORING WELL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917 DATE: 01/08/2003

PROJECT NAME: 80th DRS SAMPLERS: GTP / TYJ

SITE LOCATION: Fort Story, 80th Division Reserve Site

SITE CONTACT: Joanna Bateman WEATHER CONDITIONS: 57°F, windy

WELL IDENTIFICATION NUMBER: MW-10

WELL HEADSPACE READING: PID MODEL/LAMP:

DEPTH TO WATER (Before Purging): 6.27 FEET FROM TOP OF CASING

WELL DEPTH: 18.75 FEET FROM TOP OF CASING

HEIGHT OF WATER IN WELL: 12.48 FEET

WELL VOLUME: 2 GAL PURGE VOLUME: 6-10 GAL

PURGE START TIME: 9:40 PURGE FINISH TIME: 10:00

WELL EVACUATION DEVICE: Grundfos

SAMPLE COLLECTION DEVICE: Grundfos

SAMPLING START TIME: 10:00 SAMPLING FINISH TIME: 10:

SAMPLE APPEARANCE: Clear

FIELD PARAMETERS	FIRST	SECOND	THIRD	FOURTH	FIFTH
temperature (degrees C)	14.5	15.2	15.9	15.9	16.0
specific conductivity (umhos/cm)	0.506	0.350	0.295	0.277	0.268
pH (SU)	4.95	5.44	5.51	5.70	5.71
dissolved oxygen (mg/l)	0.15	0.57	0.73	1.44	0.80
turbidity	999	-10*	-10*	653	-10*
volume purged (gallons)	0	1.5	2	4	6

ANALYSIS REQUIRED: VOCs, SVOCs, Pest/PCBs, TL / Diss metals, TSS, TDS

LABORATORY: CompuChem CONTACT: Rodney Ralmonde

NOTES (continued on back): -10* - Turbidity not reading properly (-10 reading, but water is fairly clear)

Casing Diameter (in)	Casing Volume (Gal per Ft)
2.0	0.1632
4.0	0.6528
6.0	1.4687

MALCOLM PIRNIE

701 Town Center Drive, Suite 600, Newport News, VA 23606

GROUNDWATER MONITORING WELL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917 DATE: 01/08/2003

PROJECT NAME: 80th DRS SAMPLERS: GTP / TYJ

SITE LOCATION: Fort Story, 80th Division Reserve Site

SITE CONTACT: Joanna Bateman WEATHER CONDITIONS:

WELL IDENTIFICATION NUMBER: MW-11 50°F, sunny

WELL HEADSPACE READING: PID MODEL/LAMP:

DEPTH TO WATER (Before Purging): 6.28 FEET FROM TOP OF CASING

WELL DEPTH: 18.25 FEET FROM TOP OF CASING

HEIGHT OF WATER IN WELL: 11.97 FEET

WELL VOLUME: 1.95 GAL PURGE VOLUME: 5.9-9.8 GAL

PURGE START TIME: 10:40 PURGE FINISH TIME: 11:00

WELL EVACUATION DEVICE: Grundfos

SAMPLE COLLECTION DEVICE: Grundfos

SAMPLING START TIME: 11:00 SAMPLING FINISH TIME: 11:

SAMPLE APPEARANCE:

FIELD PARAMETERS	FIRST	SECOND	THIRD	FOURTH	FIFTH
temperature (degrees C)	13.9	15.8	16.0	16.3	16.2
specific conductivity (umhos/cm)	0.245	0.250	0.250	0.253	0.252
pH (SU)	8.28	7.70	7.12	6.98	6.90
dissolved oxygen (mg/l)	7.66	7.63	7.27	7.78	7.23
turbidity	236	10	10	10	10
volume purged (gallons)	0	1	2	4	6

ANALYSIS REQUIRED: VOCs, SVOCs, Pest/PCBs, TL / Diss metals, TSS, TDS

LABORATORY: CompuChem CONTACT: Rodney Ralmonde

NOTES (continued on back): MW-11MS/MSD sampled at 11:10, finished at 11:30

Casing Diameter (in)	Casing Volume (Gal per Ft)
2.0	0.1632
4.0	0.6528
6.0	1.4687

Soil Sampling Logs

Remedial Investigation Report
80th Division Reserve Site
Fort Story, Virginia

0285-917

Malcolm Pirnie

701 Town Center Drive, Suite 600, Newport News, VA 23606

office: (757) 873-8700 fax: (757)873-8723

SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 3 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: High of 38°F, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - MW07 -0***

SAMPLE START TIME: 9:30

SAMPLE COLLECTION TIME (on sample bottle): 9:30

PREVIOUS SAMPLE ID: ---

DUPLICATE SAMPLE ID (if collected):

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 0 - 6"

DEPTH TO GROUNDWATER: 6 ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING:

PID MODEL / LAMP: 2.2

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

Malcolm Pirnie

701 Town Center Drive, Suite 600, Newport News, VA 23606

office: (757) 873-8700 fax: (757)873-8723

SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 10 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: High of 38°F, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - MW07 - 1***

SAMPLE START TIME: 9:30

SAMPLE COLLECTION TIME (on sample bottle): 9:35 (VOCs only)

PREVIOUS SAMPLE ID: SS - MW07 -0

DUPLICATE SAMPLE ID (if collected):

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 1 - 3ft

DEPTH TO GROUNDWATER: 6 ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING:

PID MODEL / LAMP: 2.2

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

Malcolm Pirnie

701 Town Center Drive, Suite 600, Newport News, VA 23606

office: (757) 873-8700 fax: (757)873-8723

SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 4 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: High of 38°F, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - MW07 - 4***

SAMPLE START TIME: 9:30

SAMPLE COLLECTION TIME (on sample bottle): 9:40

PREVIOUS SAMPLE ID: SS - MW07 - 1

DUPLICATE SAMPLE ID (if collected): —

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collectec —

SAMPLE COLLECTION DEPTH: 4 - 6ft

DEPTH TO GROUNDWATER: 6 ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING:

PID MODEL / LAMP: 3.2

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

Malcolm Pirnie

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office: (757) 873-8700 fax: (757)873-8723

SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 3 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: High of 38°F, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - MW08 -0***

SAMPLE START TIME:

SAMPLE COLLECTION TIME (on sample bottle): 11:30

PREVIOUS SAMPLE ID: SS - MW07 - 4

DUPLICATE SAMPLE ID (if collected): —

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collectec —

SAMPLE COLLECTION DEPTH: 0 - 6"

DEPTH TO GROUNDWATER: 6 ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING:

PID MODEL / LAMP: 2.6

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

Malcolm Pirnie

701 Town Center Drive, Suite 600, Newport News, VA 23606

office: (757) 873-8700 fax: (757)873-8723

SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 10 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: High of 38°F, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - MW08 - 1***

SAMPLE START TIME:

SAMPLE COLLECTION TIME (on sample bottle): 11:35

PREVIOUS SAMPLE ID: SS - MW08 -0

DUPLICATE SAMPLE ID (if collected): —

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collectec —

SAMPLE COLLECTION DEPTH: 1 - 3ft

DEPTH TO GROUNDWATER: 6 ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING:

PID MODEL / LAMP: 6.3

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

Malcolm Pirnie

701 Town Center Drive, Suite 600, Newport News, VA 23606

office: (757) 873-8700 fax: (757)873-8723

SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 4 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: High of 38°F, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - MW08 - 4***

SAMPLE START TIME:

SAMPLE COLLECTION TIME (on sample bottle): 11:40

PREVIOUS SAMPLE ID: SS - MW08 - 1

DUPLICATE SAMPLE ID (if collected): —

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collectec —

SAMPLE COLLECTION DEPTH: 4 - 6ft

DEPTH TO GROUNDWATER: 6 ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING:

PID MODEL / LAMP: 4.4

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

Malcolm Pirnie

701 Town Center Drive, Suite 600, Newport News, VA 23606

office: (757) 873-8700 fax: (757)873-8723

SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 10 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: Between 34 - 40°, rainy

SAMPLE IDENTIFICATION NUMBER: ***SS - MW09 -0***

SAMPLE START TIME: 10:15

SAMPLE COLLECTION TIME (on sample bottle): 10:15

PREVIOUS SAMPLE ID:

DUPLICATE SAMPLE ID (if collected):

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 0 - 6"

DEPTH TO GROUNDWATER: 6 ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: >1000

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

Malcolm Pirnie

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office: (757) 873-8700 fax: (757)873-8723

SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 10 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: Between 34 - 40°, rainy

SAMPLE IDENTIFICATION NUMBER: ***SS - MW09 - 1***

SAMPLE START TIME: 10:15

SAMPLE COLLECTION TIME (on sample bottle): 10:20

PREVIOUS SAMPLE ID: SS - MW09 -0

DUPLICATE SAMPLE ID (if collected):

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 1 - 3ft

DEPTH TO GROUNDWATER: 6 ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING:

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

Malcolm Pirnie

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SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 4 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: Between 34 - 40°, rainy

SAMPLE IDENTIFICATION NUMBER: ***SS - MW09 - 4***

SAMPLE START TIME: 10:15

SAMPLE COLLECTION TIME (on sample bottle): 10:25

PREVIOUS SAMPLE ID: SS - MW09 - 1

DUPLICATE SAMPLE ID (if collected):

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 4 - 6ft

DEPTH TO GROUNDWATER: 6 ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING:

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

Malcolm Pirnie

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SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 3 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: High of 38°, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - MW10 - 0***

SAMPLE START TIME: 13:30

SAMPLE COLLECTION TIME (on sample bottle): 13:30

PREVIOUS SAMPLE ID: SS - MW08 - 4

DUPLICATE SAMPLE ID (if collected): SS - MW10MS/MSD - 0 and SS - MW10MS/MSD - 0 (two- M.S and MSD)

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 0 - 6"

DEPTH TO GROUNDWATER: 5ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: not working

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES: PID needs to be recharged: no reading

Malcolm Pirnie

701 Town Center Drive, Suite 600, Newport News, VA 23606

office: (757) 873-8700 fax: (757)873-8723

SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 3 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: High of 38°, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - MW10 - 1***

SAMPLE START TIME: 13:30

SAMPLE COLLECTION TIME (on sample bottle): 13:30

PREVIOUS SAMPLE ID: SS - MW10 - 0

DUPLICATE SAMPLE ID (if collected): SS - MW10MS/MSD - 1 and SS - MW10MS/MSD - 1 (two - M.S and MSD)

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 1 - 3ft

DEPTH TO GROUNDWATER: 5ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: not working

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES: PID needs to be recharged: no reading

Malcolm Pirnie

701 Town Center Drive, Suite 600, Newport News, VA 23606

office: (757) 873-8700 fax: (757)873-8723

SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 3 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: High of 38°, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - MW10 - 4***

SAMPLE START TIME: 13:30

SAMPLE COLLECTION TIME (on sample bottle): 13:40

PREVIOUS SAMPLE ID: SS - MW10 - 1

DUPLICATE SAMPLE ID (if collected): SS - MW10MS/MSD - 4 (duplicate)

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 4 - 6ft

DEPTH TO GROUNDWATER: 5ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: not working

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES: PID needs to be recharged: no reading

Malcolm Pirnie

701 Town Center Drive, Suite 600, Newport News, VA 23606

office: (757) 873-8700 fax: (757)873-8723

SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 5 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: High of 38°, windy

SAMPLE IDENTIFICATION NUMBER: SS - MW11 - 0

SAMPLE START TIME: 9:20

SAMPLE COLLECTION TIME (on sample bottle): 9:20

PREVIOUS SAMPLE ID:

DUPLICATE SAMPLE ID (if collected):

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 0 - 6"

DEPTH TO GROUNDWATER: 5ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: not working

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES: PID needs to be recharged: no reading

Malcolm Pirnie

701 Town Center Drive, Suite 600, Newport News, VA 23606

office: (757) 873-8700 fax: (757)873-8723

SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 3 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: High of 38°, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - MW11 - 1***

SAMPLE START TIME: 14:50

SAMPLE COLLECTION TIME (on sample bottle): 14:50

PREVIOUS SAMPLE ID: SS - MW10 - 4

DUPLICATE SAMPLE ID (if collected): SS - MW11D - 1

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 1 - 3ft

DEPTH TO GROUNDWATER: 5ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: not working

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES: PID needs to be recharged: no reading

Malcolm Pirnie

701 Town Center Drive, Suite 600, Newport News, VA 23606

office: (757) 873-8700 fax: (757)873-8723

SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 3 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: High of 38°, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - MW11 - 4***

SAMPLE START TIME: 14:50

SAMPLE COLLECTION TIME (on sample bottle): 14:55

PREVIOUS SAMPLE ID: SS - MW11 - 1

DUPLICATE SAMPLE ID (if collected): SS - MW11D - 4

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 4 - 6ft

DEPTH TO GROUNDWATER: 5ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: not working

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES: PID needs to be recharged: no reading

Malcolm Pirnie

701 Town Center Drive, Suite 600, Newport News, VA 23606

office: (757) 873-8700 fax: (757)873-8723

SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 4 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: Between 34 - 40°, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - SB01 -0***

SAMPLE START TIME: 11:55

SAMPLE COLLECTION TIME (on sample bottle): 11:55

PREVIOUS SAMPLE ID: SS - SB02 - 4

DUPLICATE SAMPLE ID (if collected):

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 0 - 6"

DEPTH TO GROUNDWATER: 5 ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: 14.7

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

Malcolm Pirnie

701 Town Center Drive, Suite 600, Newport News, VA 23606

office: (757) 873-8700 fax: (757)873-8723

SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 4 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: Between 34 - 40°, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - SB01 - 1***

SAMPLE START TIME: 11:55

SAMPLE COLLECTION TIME (on sample bottle): 12:00

PREVIOUS SAMPLE ID: SS - SB01 -0

DUPLICATE SAMPLE ID (if collected):

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 1 - 3ft

DEPTH TO GROUNDWATER: 5 ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: 52

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

Malcolm Pirnie

701 Town Center Drive, Suite 600, Newport News, VA 23606

office: (757) 873-8700 fax: (757)873-8723

SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 4 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: Between 34 - 40°, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - SB01 - 4***

SAMPLE START TIME: 11:55

SAMPLE COLLECTION TIME (on sample bottle): 12:05

PREVIOUS SAMPLE ID: SS - SB01 - 1

DUPLICATE SAMPLE ID (if collected):

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 4 - 6ft

DEPTH TO GROUNDWATER: 5 ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: 29.9

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

Malcolm Pirnie

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SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 4 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: Between 34 - 40°, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - SB02 -0***

SAMPLE START TIME: 11:15

SAMPLE COLLECTION TIME (on sample bottle): 11:15

PREVIOUS SAMPLE ID: SS - SB03 - 4

DUPLICATE SAMPLE ID (if collected):

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 0 - 6"

DEPTH TO GROUNDWATER: 5 ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: 38.3

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

Malcolm Pirnie

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SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 4 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: Between 34 - 40°, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - SB02 - 1***

SAMPLE START TIME: 11:15

SAMPLE COLLECTION TIME (on sample bottle): 11:20

PREVIOUS SAMPLE ID: SS - SB02 -0

DUPLICATE SAMPLE ID (if collected):

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 1 - 3ft

DEPTH TO GROUNDWATER: 5 ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: 17.5

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

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SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 4 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: Between 34 - 40°, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - SB02 - 4***

SAMPLE START TIME: 11:15

SAMPLE COLLECTION TIME (on sample bottle): 11:20

PREVIOUS SAMPLE ID: SS - SB02 - 1

DUPLICATE SAMPLE ID (if collected):

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 4 - 6ft

DEPTH TO GROUNDWATER: 5 ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: 48.9

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

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SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 4 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: Between 34 - 40°, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - SB03 -0***

SAMPLE START TIME: 10:45

SAMPLE COLLECTION TIME (on sample bottle): 10:45

PREVIOUS SAMPLE ID: SS - SB05 - 4

DUPLICATE SAMPLE ID (if collected):

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 0 - 6"

DEPTH TO GROUNDWATER: 4 ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: 10.2

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

Malcolm Pirnie

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SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 4 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: Between 34 - 40°, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - SB03 - 1***

SAMPLE START TIME: 10:45

SAMPLE COLLECTION TIME (on sample bottle): 10:50

PREVIOUS SAMPLE ID: SS - SB03 -0

DUPLICATE SAMPLE ID (if collected):

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 1 - 3ft

DEPTH TO GROUNDWATER: 4 ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: 25.7

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

Malcolm Pirnie

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SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 4 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: Between 34 - 40°, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - SB03 - 4***

SAMPLE START TIME: 10:45

SAMPLE COLLECTION TIME (on sample bottle): 10:55

PREVIOUS SAMPLE ID: SS - SB03 - 1

DUPLICATE SAMPLE ID (if collected):

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 4 - 6ft

DEPTH TO GROUNDWATER: 4 ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: 48.8

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

Malcolm Pirnie

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SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 4 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: Between 34 - 40°, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - SB04 -0***

SAMPLE START TIME: 9:45

SAMPLE COLLECTION TIME (on sample bottle): 9:45

PREVIOUS SAMPLE ID:

DUPLICATE SAMPLE ID (if collected):

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 0 - 6"

DEPTH TO GROUNDWATER: 5 ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: 2.1

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

Malcolm Pirnie

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SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 4 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: Between 34 - 40°, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - SB04 - 1***

SAMPLE START TIME: 9:45

SAMPLE COLLECTION TIME (on sample bottle): 9:50

PREVIOUS SAMPLE ID: SS - SB04 -0

DUPLICATE SAMPLE ID (if collected):

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 1 - 3ft

DEPTH TO GROUNDWATER: 5 ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: 2.2

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

Malcolm Pirnie

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SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 4 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: Between 34 - 40°, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - SB04 - 4***

SAMPLE START TIME: 9:45

SAMPLE COLLECTION TIME (on sample bottle): 9:55

PREVIOUS SAMPLE ID: SS - SB04 - 1

DUPLICATE SAMPLE ID (if collected):

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 4 - 6ft

DEPTH TO GROUNDWATER: 5 ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: 8.4

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

Malcolm Pirnie

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SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 4 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: Between 34 - 40°, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - SB05 -0***

SAMPLE START TIME: 10:10

SAMPLE COLLECTION TIME (on sample bottle): 10:10

PREVIOUS SAMPLE ID: SS - SB04 - 4

DUPLICATE SAMPLE ID (if collected):

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 0 - 6"

DEPTH TO GROUNDWATER: 5ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: 7.2

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

Malcolm Pirnie

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office: (757) 873-8700 fax: (757)873-8723

SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 4 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: Between 34 - 40°, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - SB05 - 1***

SAMPLE START TIME: 10:10

SAMPLE COLLECTION TIME (on sample bottle): 10:15

PREVIOUS SAMPLE ID: SS - SB05 -0

DUPLICATE SAMPLE ID (if collected):

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 1 - 3ft

DEPTH TO GROUNDWATER: 5ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: 12.6

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

Malcolm Pirnie

701 Town Center Drive, Suite 600, Newport News, VA 23606

office: (757) 873-8700 fax: (757)873-8723

SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 4 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: Between 34 - 40°, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - SB05 - 4***

SAMPLE START TIME: 10:10

SAMPLE COLLECTION TIME (on sample bottle): 10:15

PREVIOUS SAMPLE ID: SS - SB05 - 1

DUPLICATE SAMPLE ID (if collected):

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 4 - 6ft

DEPTH TO GROUNDWATER: 5ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: 6.3

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

Malcolm Pirnie

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SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 4 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: Between 34 - 40°, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - SB01 -0***

SAMPLE START TIME: 11:55

SAMPLE COLLECTION TIME (on sample bottle): 11:55

PREVIOUS SAMPLE ID: SS - SB02 - 4

DUPLICATE SAMPLE ID (if collected):

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 0 - 6"

DEPTH TO GROUNDWATER: 5 ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: 14.7

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

Malcolm Pirnie

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SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 4 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: Between 34 - 40°, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - SB01 - 1***

SAMPLE START TIME: 11:55

SAMPLE COLLECTION TIME (on sample bottle): 12:00

PREVIOUS SAMPLE ID: SS - SB01 -0

DUPLICATE SAMPLE ID (if collected):

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 1 - 3ft

DEPTH TO GROUNDWATER: 5 ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: 52

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

Malcolm Pirnie

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SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 4 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: Between 34 - 40°, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - SB01 - 4***

SAMPLE START TIME: 11:55

SAMPLE COLLECTION TIME (on sample bottle): 12:05

PREVIOUS SAMPLE ID: SS - SB01 - 1

DUPLICATE SAMPLE ID (if collected):

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 4 - 6ft

DEPTH TO GROUNDWATER: 5 ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: 29.9

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

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SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 4 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: Between 34 - 40°, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - SB02 -0***

SAMPLE START TIME: 11:15

SAMPLE COLLECTION TIME (on sample bottle): 11:15

PREVIOUS SAMPLE ID: SS - SB03 - 4

DUPLICATE SAMPLE ID (if collected):

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 0 - 6"

DEPTH TO GROUNDWATER: 5 ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: 38.3

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

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SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 4 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: Between 34 - 40°, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - SB02 - 1***

SAMPLE START TIME: 11:15

SAMPLE COLLECTION TIME (on sample bottle): 11:20

PREVIOUS SAMPLE ID: SS - SB02 -0

DUPLICATE SAMPLE ID (if collected):

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 1 - 3ft

DEPTH TO GROUNDWATER: 5 ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: 17.5

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

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SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 4 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: Between 34 - 40°, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - SB02 - 4***

SAMPLE START TIME: 11:15

SAMPLE COLLECTION TIME (on sample bottle): 11:20

PREVIOUS SAMPLE ID: SS - SB02 - 1

DUPLICATE SAMPLE ID (if collected):

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 4 - 6ft

DEPTH TO GROUNDWATER: 5 ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: 48.9

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

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SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 4 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: Between 34 - 40°, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - SB03 -0***

SAMPLE START TIME: 10:45

SAMPLE COLLECTION TIME (on sample bottle): 10:45

PREVIOUS SAMPLE ID: SS - SB05 - 4

DUPLICATE SAMPLE ID (if collected):

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 0 - 6"

DEPTH TO GROUNDWATER: 4 ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: 10.2

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

Malcolm Pirnie

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SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 4 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: Between 34 - 40°, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - SB03 - 1***

SAMPLE START TIME: 10:45

SAMPLE COLLECTION TIME (on sample bottle): 10:50

PREVIOUS SAMPLE ID: SS - SB03 -0

DUPLICATE SAMPLE ID (if collected):

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 1 - 3ft

DEPTH TO GROUNDWATER: 4 ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: 25.7

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

Malcolm Pirnie

701 Town Center Drive, Suite 600, Newport News, VA 23606

office: (757) 873-8700 fax: (757)873-8723

SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 4 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: Between 34 - 40°, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - SB03 - 4***

SAMPLE START TIME: 10:45

SAMPLE COLLECTION TIME (on sample bottle): 10:55

PREVIOUS SAMPLE ID: SS - SB03 - 1

DUPLICATE SAMPLE ID (if collected):

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 4 - 6ft

DEPTH TO GROUNDWATER: 4 ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: 48.8

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

Malcolm Pirnie

701 Town Center Drive, Suite 600, Newport News, VA 23606

office: (757) 873-8700 fax: (757)873-8723

SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 4 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: Between 34 - 40°, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - SB04 -0***

SAMPLE START TIME: 9:45

SAMPLE COLLECTION TIME (on sample bottle): 9:45

PREVIOUS SAMPLE ID:

DUPLICATE SAMPLE ID (if collected):

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 0 - 6"

DEPTH TO GROUNDWATER: 5 ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: 2.1

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

Malcolm Pirnie

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office: (757) 873-8700 fax: (757)873-8723

SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 4 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: Between 34 - 40°, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - SB04 - 1***

SAMPLE START TIME: 9:45

SAMPLE COLLECTION TIME (on sample bottle): 9:50

PREVIOUS SAMPLE ID: SS - SB04 -0

DUPLICATE SAMPLE ID (if collected):

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 1 - 3ft

DEPTH TO GROUNDWATER: 5 ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: 2.2

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

Malcolm Pirnie

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SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 4 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: Between 34 - 40°, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - SB04 - 4***

SAMPLE START TIME: 9:45

SAMPLE COLLECTION TIME (on sample bottle): 9:55

PREVIOUS SAMPLE ID: SS - SB04 - 1

DUPLICATE SAMPLE ID (if collected):

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 4 - 6ft

DEPTH TO GROUNDWATER: 5 ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: 8.4

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

Malcolm Pirnie

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SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 4 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: Between 34 - 40°, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - SB05 -0***

SAMPLE START TIME: 10:10

SAMPLE COLLECTION TIME (on sample bottle): 10:10

PREVIOUS SAMPLE ID: SS - SB04 - 4

DUPLICATE SAMPLE ID (if collected):

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 0 - 6"

DEPTH TO GROUNDWATER: 5ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: 7.2

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

Malcolm Pirnie

701 Town Center Drive, Suite 600, Newport News, VA 23606

office: (757) 873-8700 fax: (757)873-8723

SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 4 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: Between 34 - 40°, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - SB05 - 1***

SAMPLE START TIME: 10:10

SAMPLE COLLECTION TIME (on sample bottle): 10:15

PREVIOUS SAMPLE ID: SS - SB05 -0

DUPLICATE SAMPLE ID (if collected):

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 1 - 3ft

DEPTH TO GROUNDWATER: 5ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: 12.6

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

Malcolm Pirnie

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SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 4 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: Between 34 - 40°, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - SB05 - 4***

SAMPLE START TIME: 10:10

SAMPLE COLLECTION TIME (on sample bottle): 10:15

PREVIOUS SAMPLE ID: SS - SB05 - 1

DUPLICATE SAMPLE ID (if collected):

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 4 - 6ft

DEPTH TO GROUNDWATER: 5ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: 6.3

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

Malcolm Pirnie

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office: (757) 873-8700 fax: (757)873-8723

SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 3 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: High of 38°F, windy

SAMPLE IDENTIFICATION NUMBER: *SS - MW07 -0*

SAMPLE START TIME: 9:30

SAMPLE COLLECTION TIME (on sample bottle): 9:30

PREVIOUS SAMPLE ID: —

DUPLICATE SAMPLE iD (if collected):

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 0 - 6"

DEPTH TO GROUNDWATER: 6 ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING:

PID MODEL / LAMP: 2.2

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

Malcolm Pirnie

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SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 10 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: High of 38°F, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - MW07 - 1***

SAMPLE START TIME: 9:30

SAMPLE COLLECTION TIME (on sample bottle): 9:35 (VOCs only)

PREVIOUS SAMPLE ID: SS - MW07 -0

DUPLICATE SAMPLE ID (if collected):

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 1 - 3ft

DEPTH TO GROUNDWATER: 6 ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING:

PID MODEL / LAMP: 2.2

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

Malcolm Pirnie

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SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 4 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: High of 38°F, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - MW07 - 4***

SAMPLE START TIME: 9:30

SAMPLE COLLECTION TIME (on sample bottle): 9:40

PREVIOUS SAMPLE ID: SS - MW07 - 1

DUPLICATE SAMPLE ID (if collected): —

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collectec —

SAMPLE COLLECTION DEPTH: 4 - 6ft

DEPTH TO GROUNDWATER: 6 ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING:

PID MODEL / LAMP: 3.2

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

Malcolm Pirnie

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SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 3 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: High of 38°F, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - MW08 -0***

SAMPLE START TIME:

SAMPLE COLLECTION TIME (on sample bottle): 11:30

PREVIOUS SAMPLE ID: SS - MW07 - 4

DUPLICATE SAMPLE ID (if collected): —

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collectec —

SAMPLE COLLECTION DEPTH: 0 - 6"

DEPTH TO GROUNDWATER: 6 ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING:

PID MODEL / LAMP: 2.6

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

Malcolm Pirnie

701 Town Center Drive, Suite 600, Newport News, VA 23606

office: (757) 873-8700 fax: (757)873-8723

SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 10 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: High of 38°F, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - MW08 - 1***

SAMPLE START TIME:

SAMPLE COLLECTION TIME (on sample bottle): 11:35

PREVIOUS SAMPLE ID: SS - MW08 -0

DUPLICATE SAMPLE ID (if collected): —

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collectec —

SAMPLE COLLECTION DEPTH: 1 - 3ft

DEPTH TO GROUNDWATER: 6 ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING:

PID MODEL / LAMP: 6.3

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

Malcolm Pirnie

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SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 4 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: High of 38°F, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - MW08 - 4***

SAMPLE START TIME:

SAMPLE COLLECTION TIME (on sample bottle): 11:40

PREVIOUS SAMPLE ID: SS - MW08 - 1

DUPLICATE SAMPLE ID (if collected): —

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collectec —

SAMPLE COLLECTION DEPTH: 4 - 6ft

DEPTH TO GROUNDWATER: 6 ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING:

PID MODEL / LAMP: 4.4

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

Malcolm Pirnie

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SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 10 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: Between 34 - 40°, rainy

SAMPLE IDENTIFICATION NUMBER: ***SS - MW09 -0***

SAMPLE START TIME: 10:15

SAMPLE COLLECTION TIME (on sample bottle): 10:15

PREVIOUS SAMPLE ID:

DUPLICATE SAMPLE ID (if collected):

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 0 - 6"

DEPTH TO GROUNDWATER: 6 ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: >1000

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

Malcolm Pirnie

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SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 10 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: Between 34 - 40°, rainy

SAMPLE IDENTIFICATION NUMBER: ***SS - MW09 - 1***

SAMPLE START TIME: 10:15

SAMPLE COLLECTION TIME (on sample bottle): 10:20

PREVIOUS SAMPLE ID: SS - MW09 -0

DUPLICATE SAMPLE ID (if collected):

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 1 - 3ft

DEPTH TO GROUNDWATER: 6 ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING:

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

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SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 4 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: Between 34 - 40°, rainy

SAMPLE IDENTIFICATION NUMBER: ***SS - MW09 - 4***

SAMPLE START TIME: 10:15

SAMPLE COLLECTION TIME (on sample bottle): 10:25

PREVIOUS SAMPLE ID: SS - MW09 - 1

DUPLICATE SAMPLE ID (if collected):

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 4 - 6ft

DEPTH TO GROUNDWATER: 6 ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING:

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES:

Malcolm Pirnie

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SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 3 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: High of 38°, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - MW10 - 0***

SAMPLE START TIME: 13:30

SAMPLE COLLECTION TIME (on sample bottle): 13:30

PREVIOUS SAMPLE ID: SS - MW08 - 4

DUPLICATE SAMPLE ID (if collected): SS - MW10MS/MSD - 0 and SS - MW10MS/MSD - 0 (two- M.S and MSD)

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 0 - 6"

DEPTH TO GROUNDWATER: 5ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: not working

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES: PID needs to be recharged: no reading

Malcolm Pirnie

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SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 3 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: High of 38°, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - MW10 - 1***

SAMPLE START TIME: 13:30

SAMPLE COLLECTION TIME (on sample bottle): 13:30

PREVIOUS SAMPLE ID: SS - MW10 - 0

DUPLICATE SAMPLE ID (if collected): SS - MW10MS/MSD - 1 and SS - MW10MS/MSD - 1 (two - M.S and MSD)

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 1 - 3ft

DEPTH TO GROUNDWATER: 5ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: not working

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES: PID needs to be recharged: no reading

Malcolm Pirnie

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SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 3 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: High of 38°, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - MW10 - 4***

SAMPLE START TIME: 13:30

SAMPLE COLLECTION TIME (on sample bottle): 13:40

PREVIOUS SAMPLE ID: SS - MW10 - 1

DUPLICATE SAMPLE ID (if collected): SS - MW10MS/MSD - 4 (duplicate)

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 4 - 6ft

DEPTH TO GROUNDWATER: 5ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: not working

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES: PID needs to be recharged: no reading

Malcolm Pirnie

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SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 5 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: High of 38°, windy

SAMPLE IDENTIFICATION NUMBER: SS - MW11 - 0

SAMPLE START TIME: 9:20

SAMPLE COLLECTION TIME (on sample bottle): 9:20

PREVIOUS SAMPLE ID:

DUPLICATE SAMPLE ID (if collected):

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 0 - 6"

DEPTH TO GROUNDWATER: 5ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: not working

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES: PID needs to be recharged: no reading

Malcolm Pirnie

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SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 3 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: High of 38°, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - MW11 - 1***

SAMPLE START TIME: 14:50

SAMPLE COLLECTION TIME (on sample bottle): 14:50

PREVIOUS SAMPLE ID: SS - MW10 - 4

DUPLICATE SAMPLE ID (if collected): SS - MW11D - 1

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 1 - 3ft

DEPTH TO GROUNDWATER: 5ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: not working

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES: PID needs to be recharged: no reading

Malcolm Pirnie

701 Town Center Drive, Suite 600, Newport News, VA 23606

office: (757) 873-8700 fax: (757)873-8723

SOIL SAMPLE COLLECTION LOGS

PROJECT NUMBER: 0285-917

DATE: 12 / 3 /02

PROJECT NAME: 80th Division Reserve Site

SAMPLERS: Gerlyn Perlas

Tina Jung

SITE CONTACT: Joanna Bateman

WEATHER CONDITIONS: High of 38°, windy

SAMPLE IDENTIFICATION NUMBER: ***SS - MW11 - 4***

SAMPLE START TIME: 14:50

SAMPLE COLLECTION TIME (on sample bottle): 14:55

PREVIOUS SAMPLE ID: SS - MW11 - 1

DUPLICATE SAMPLE ID (if collected): SS - MW11D - 4

DECON METHOD: see SAP

EQUIPMENT BLANK IDENTIFICATION NUMBER (if collected):

SAMPLE COLLECTION DEPTH: 4 - 6ft

DEPTH TO GROUNDWATER: 5ft

SAMPLE COLLECTION DEVICE: Hollow stem auger

SAMPLE TYPE (g - grab / c - composite): g-VOC, c- all others

ORGANIC VAPOR READING: not working

PID MODEL / LAMP:

SAMPLE APPEARANCE: sand

SAMPLE ANALYSIS INFORMATION

ANALYSIS REQUIRED: VOCs SVOCs Pest/PCBs Metals TOC pH

LABORATORY: CompuChem

CONTACT: Rodney Ralmonde

NOTES: PID needs to be recharged: no reading

Daily Quality Control Reports

Remedial Investigation Report
80th Division Reserve Site
Fort Story, Virginia

0285-917

FIGURE 2

Date 12 / 03 / 02

MALCOLM PIRNIE, INC.
DAILY QUALITY CONTROL REPORT

Day	S	M	T	W	TH	F	S
			X				

USACE PM: _____
Fort Story Rep: Joanna Bateman
Malcolm Pirnie PM: _ Tony Pace

Project: ____ 80th Division Reserve Site
Malcolm Pirnie Job No. _____ 0285-917
USACE Contract No. DACA31-00-D-0043
Delivery Order No. _____

Weather	Bright Sun	Clear	Overcast	Rain	Snow
Temperature	< 32	32 - 50	50 - 70	70-85	>85
Wind	Still	Moderate	High	REPORT NO.	
Humidity	Dry	Moderate	Humid		

SUBCONTRACTORS ON-SITE:

Fishburne Drilling

EQUIPMENT ON SITE:

Drill rig

PID

WORK PERFORMED (INCLUDING SAMPLING):

WELL INSTALLATION

SOIL SAMPLING

SOIL CHARACTERIZATION

FIGURE 2 (CONT.)

Project: _____ 80th Division Reserve Site

Report No. _____

Malcolm Pirnie Project No. _____ 0285-917

Date 12 / 03 / 02

QUALITY CONTROL ACTIVITIES (INCLUDING FIELD CALIBRATIONS):

PID: 0.0 fresh air
99.3 isobutylene

HEALTH AND SAFETY LEVELS AND ACTIVITIES:

Level D

PROBLEMS ENCOUNTERED/CORRECTIVE ACTION TAKEN:

- Drill rig had to avoid fence, overhead utility lines
- PID failed @ MW09 ~ will recharge
  no odors detected as samples were collected
- ~~may have to use an ATV to install MW09~~

SPECIAL NOTES:

TOMORROW'S EXPECTATIONS:

- Finish MWs & SBs

BY Gerlyn T. Perlas TITLE Engineer

FIGURE 2

Date 12 / 4 / 02

MALCOLM PIRNIE, INC.
DAILY QUALITY CONTROL REPORT

Day	S	M	T	W	TH	F	S
				X			

USACE PM: _____
Fort Story Rep: Joanna Patterson
Malcolm Pirnie PM: _ Tony Pace

Project: ____ 80th Division Reserve Site
Malcolm Pirnie Job No. _____ 0285-917
USACE Contract No. DACA31-00-D-0043
Delivery Order No. _____

Weather	Bright Sun	Clear	Overcast	Rain	Snow
Temperature	< 32	32 - 50	50 - 70	70-85	>85
Wind	Still	Moderate	High	REPORT NO.	
Humidity	Dry	Moderate	Humid		

SUBCONTRACTORS ON-SITE:

Fishburne Drilling

EQUIPMENT ON SITE:

Drill rig

PID

WORK PERFORMED (INCLUDING SAMPLING):

SOIL SAMPLING

SOIL CHARACTERIZATION

FIGURE 2 (CONT.)

Project: _____ 80th Division Reserve Site

Report No. _____

Malcolm Pirnie Project No. _____ 0285-917

Date 12 / 4 / 02

QUALITY CONTROL ACTIVITIES (INCLUDING FIELD CALIBRATIONS):

PID fresh air: 0.0 ppm
Isobutylene: 100 ppm

HEALTH AND SAFETY LEVELS AND ACTIVITIES:

Level D

PROBLEMS ENCOUNTERED/CORRECTIVE ACTION TAKEN:

- Sand was too loose in area surrounding MW80 location. Will have to use an ATV to install well. Fishburne will arrange to use ATV.

SPECIAL NOTES:

TOMORROW'S EXPECTATIONS:

Finish well installations, developing

BY Gerlyn T. Perlas TITLE Engineer

FIGURE 2

Date 12 / 5 / 02

MALCOLM PIRNIE, INC.
DAILY QUALITY CONTROL REPORT

Day	S	M	T	W	TH	F	S
					X		

USACE PM: _____
Fort Story Rep: _____
Malcolm Pirnie PM: _ Tony Pace

Project: ____ 80th Division Reserve Site
Malcolm Pirnie Job No. _____ 0285-917 / 0285-900
USACE Contract No. DACA31-00-D-0043
Delivery Order No. _____

Weather	Bright Sun	Clear	Overcast	Rain	Snow
Temperature	< 32	32 - 50	50 - 70	70-85	>85
Wind	Still	Moderate	High	REPORT NO.	
Humidity	Dry	Moderate	Humid		

SUBCONTRACTORS ON-SITE:

Fishburne Drilling

EQUIPMENT ON SITE:

Drill rig

PID

WORK PERFORMED (INCLUDING SAMPLING):

Well Development

Well Installation

& Soil Characterization

FIGURE 2 (CONT.)

Project: _____ 80th Division Reserve Site

Report No. _____

Malcolm Pirnie Project No. _____ 0285-917/0285-900

Date 12 / 5 / 02

QUALITY CONTROL ACTIVITIES (INCLUDING FIELD CALIBRATIONS):

PID Fresh air : 0.0ppm
Isobutylene : 100ppm

HEALTH AND SAFETY LEVELS AND ACTIVITIES:

Level D

PROBLEMS ENCOUNTERED/CORRECTIVE ACTION TAKEN:

- Drillers did not arrive until 12 pm (original driller called in sick)
- Drill rig not functioning when mobed @ GMW-6. Fishbaugh will arrange to bring another drill rig to finish installations

SPECIAL NOTES:

TOMORROW'S EXPECTATIONS:

Finish installing monitoring wells

BY Gerlyn T. Perlas TITLE Engineer

FIGURE 2

Date 12 / 6 / 02

MALCOLM PIRNIE, INC.
DAILY QUALITY CONTROL REPORT

Day	S	M	T	W	TH	F	S
						X	

Weather	Bright Sun	Clear	Overcast	Rain	Snow
Temperature	< 32	32 - 50	50 - 70	70-85	>85
Wind	Still	Moderate	High	REPORT NO.	
Humidity	Dry	Moderate	Humid		

USACE PM: _____
Fort Story Rep: Joanna Bateman
Malcolm Pirnie PM: _ Tony Pace

Project: ____ 80th Division Reserve Site / LARC GO
Malcolm Pirnie Job No. _____ 0285-917
USACE Contract No. DACA31-00-D-0043
Delivery Order No. _____

SUBCONTRACTORS ON-SITE:

Fishburne Drilling

EQUIPMENT ON SITE:

Drill rig

PID

WORK PERFORMED (INCLUDING SAMPLING):

SOIL CHARACTERIZATION

WELL INSTALLATION

FIGURE 2 (CONT.)

Project: _____ 80th Division Reserve Site /Larc 60 Report No. _____

Malcolm Pirnie Project No. _____ 0285-917 Date 12 / 6 / 02

QUALITY CONTROL ACTIVITIES (INCLUDING FIELD CALIBRATIONS):
PID: Fresh air – 0.0 ppm
Isobutylene – 101 ppm

HEALTH AND SAFETY LEVELS AND ACTIVITIES:
Level D

PROBLEMS ENCOUNTERED/CORRECTIVE ACTION TAKEN:

SPECIAL NOTES:

TOMORROW'S EXPECTATIONS:
Develop wells

BY Gerlyn T. Perlas TITLE Engineer

FIGURE 2

Date 12 / 9 / 02

MALCOLM PIRNIE, INC.
DAILY QUALITY CONTROL REPORT

Day	S	M	T	W	TH	F	S
		X					

USACE PM: _____
Fort Story Rep: Mana Bateman
Malcolm Pirnie PM: Tony Pace

Project: ____ ~~80th Division Reserve Site~~ LARC 60 maint. Area
Malcolm Pirnie Job No. _____ 0285-~~917~~ 900
USACE Contract No. DACA31-00-D-0043
Delivery Order No. _____

Weather	Bright Sun	Clear	Overcast	Rain	Snow
Temperature	< 32	32 - 50	50 - 70	70-85	>85
Wind	Still	Moderate	High	REPORT NO.	
Humidity	Dry	Moderate	Humid		

SUBCONTRACTORS ON-SITE:

Fishburne Drilling

EQUIPMENT ON SITE:

~~Drill rig~~ Submersible pump
Water level indicator (Solinst 101)

WORK PERFORMED (INCLUDING SAMPLING):

Developed monitoring wells

FIGURE 2 (CONT.)

Project: _____ ~~80th Division Reserve Site~~ LARC 60 MAINT. AREA Report No. _____

Malcolm Pirnie Project No. _____ 0285-~~97~~ 900 Date 12 / 9 / 02

QUALITY CONTROL ACTIVITIES (INCLUDING FIELD CALIBRATIONS):
Horiba U-10 pH: 3.97
Cond: 4.49
Turb: Ø
HEALTH AND SAFETY LEVELS AND ACTIVITIES:
Level D
PROBLEMS ENCOUNTERED/CORRECTIVE ACTION TAKEN:
SPECIAL NOTES:
TOMORROW'S EXPECTATIONS:
Install MW-Ø9 @ 80th DIVISION Reserve Site

BY Gerlyn T. Perlas TITLE Engineer

FIGURE 2

Date 12 / 10 / 02

MALCOLM PIRNIE, INC.
DAILY QUALITY CONTROL REPORT

Day	S	M	T	W	TH	F	S
			X				

Weather	Bright Sun	Clear	Overcast	Rain	Snow
Temperature	< 32	32 - 50	50 - 70	70-85	>85
Wind	Still	Moderate	High	REPORT NO.	
Humidity	Dry	Moderate	Humid		

USACE PM: _____
Fort Story Rep: Joanna Bateman
Malcolm Pirnie PM: _ Tony Pace

Project: ____ ~~80th Division Reserve Site~~ ok
Malcolm Pirnie Job No. _____ 0285-917
USACE Contract No. DACA31-00-D-0043
Delivery Order No. _____

SUBCONTRACTORS ON-SITE:

Fishburne Drilling

EQUIPMENT ON SITE:

Drill rig - ATV

WORK PERFORMED (INCLUDING SAMPLING):

well installation
soil characterization
well development

FIGURE 2 (CONT.)

Project: _____ 80th Division Reserve Site

Malcolm Pirnie Project No. _____ 0285-917

Report No. _____

Date 12 / 10 / 02

QUALITY CONTROL ACTIVITIES (INCLUDING FIELD CALIBRATIONS):

Horiba U-10 pH: 4
cond: 4.49
turb: 0

PID freshair: 0.0 ppm
Isobutylene: 100 ppm

HEALTH AND SAFETY LEVELS AND ACTIVITIES:

Level D

PROBLEMS ENCOUNTERED/CORRECTIVE ACTION TAKEN:

SPECIAL NOTES:

TOMORROW'S EXPECTATIONS:

BY Gerlyn T. Perlas TITLE Engineer

FIGURE 2

Date 01/13/03

MALCOLM PIRNIE, INC.
DAILY QUALITY CONTROL REPORT

Day	S	M	T	W	TH	F	S
		X					

USACE PM: _____
Fort Eustis Rep: JOANNH BATEMAN
Malcolm Pirnie PM: TONY PACE

Project: GARC 60
Malcolm Pirnie Job No. 0285-900
USACE Contract No. DACA31-00-D-0043
Delivery Order No. _____

Weather	Bright Sun	Clear	Overcast	Rain	Snow
Temperature	< 32	32 - 50	50 - 70	70-85	>85
Wind	Still	Moderate	High	REPORT NO.	
Humidity	Dry	Moderate	Humid		

SUBCONTRACTORS ON-SITE:

EQUIPMENT ON SITE:

WELL WIZARD CONTROL PUMP / GENERATOR, SUMMSTION

WORK PERFORMED (INCLUDING SAMPLING):

GW Sampling

FIGURE 2 (CONT.)

Project: LARC 60

Malcolm Pirnie Project No. 0285900

Report No.

Date 1/13/03

QUALITY CONTROL ACTIVITIES (INCLUDING FIELD CALIBRATIONS):

HORIBA U-10: pH: 3.99
Cond: 4.57
TURB: 0

HEALTH AND SAFETY LEVELS AND ACTIVITIES:

Level D

PROBLEMS ENCOUNTERED/CORRECTIVE ACTION TAKEN:

well wizard pump not working -- air is not coming out of pump control.
call Gurley Curry (equipment manager @ NEW) and well wizard GEO Helpline.
-- suggest pulling control box to thaw out in case of frozen tubing.
may also be timing switches.

SPECIAL NOTES:

TOMORROW'S EXPECTATIONS:

BY Jenelyn Perlas TITLE Engineer

FIGURE 2

Date 1/14/03

MALCOLM PIRNIE, INC.
DAILY QUALITY CONTROL REPORT

Day	S	M	T	W	TH	F	S
			X				

USACE PM: _____
Fort Eustis Rep: JOANNA BATCMAN
Malcolm Pirnie PM: TONY PACE

Project: LARC 60
Malcolm Pirnie Job No. 0285-900
USACE Contract No. DACA31-00-D-0043
Delivery Order No. _____

Weather	Bright Sun	Clear	Overcast	Rain	Snow
Temperature	< 32	32 - 50	50 - 70	70-85	>85
Wind	Still	Moderate	High	REPORT NO.	
Humidity	Dry	Moderate	Humid		

SUBCONTRACTORS ON-SITE:

EQUIPMENT ON SITE:

generator, HORIBA U-10, Grundfos, SOLINIST WT

WORK PERFORMED (INCLUDING SAMPLING):

GW sampling

FIGURE 2 (CONT.)

Project: LARC 60

Malcolm Pirnie Project No. 0285900

Report No.

Date 1/14/03

QUALITY CONTROL ACTIVITIES (INCLUDING FIELD CALIBRATIONS):
HORIBA U-10: pH: 3.99
cond: 4.57
turb: Ø

HEALTH AND SAFETY LEVELS AND ACTIVITIES:
Level D

PROBLEMS ENCOUNTERED/CORRECTIVE ACTION TAKEN:

SPECIAL NOTES:

TOMORROW'S EXPECTATIONS:

BY Gerlyn Perlar TITLE Engineer

FIGURE 2

Date 1/15/03

MALCOLM PIRNIE, INC.
DAILY QUALITY CONTROL REPORT

Day	S	M	T	W	TH	F	S
				X			

USACE PM: _____
Fort Eustis Rep: JOANNA BATEMAN
Malcolm Pirnie PM: TONY PACE

Project: LARC 60
Malcolm Pirnie Job No. 0285900
USACE Contract No. DACA31-00-D-0043
Delivery Order No. _____

Weather	Bright Sun	Clear	Overcast	Rain	Snow
Temperature	< 32	32 - 50	50 - 70	70-85	>85
Wind	Still	Moderate	High	REPORT NO.	
Humidity	Dry	Moderate	Humid		

SUBCONTRACTORS ON-SITE:

EQUIPMENT ON SITE:

HORIBA U-10, Grundfos well wizard, solinst 107

WORK PERFORMED (INCLUDING SAMPLING):

GW Sampling

FIGURE 2 (CONT.)

Project: LARC 60

Malcolm Pirnie Project No. 0285900

Report No.

Date 1/15/03

QUALITY CONTROL ACTIVITIES (INCLUDING FIELD CALIBRATIONS):

HORIBA U-10: pH: 3.99
turb: 0
cond: 4.51

HEALTH AND SAFETY LEVELS AND ACTIVITIES:

Level D

PROBLEMS ENCOUNTERED/CORRECTIVE ACTION TAKEN:

SPECIAL NOTES:

TOMORROW'S EXPECTATIONS:

BY Gerlyn Porlas TITLE Engineer

FIGURE 2

Date 1/28/03

MALCOLM PIRNIE, INC.
DAILY QUALITY CONTROL REPORT

Day	S	M	T	W	TH	F	S
		X					

Weather	Bright Sun	Clear	Overcast	Rain	Snow
Temperature	< 32	32 - 50	50 - 70	70-85	>85
Wind	Still	Moderate	High	REPORT NO.	
Humidity	Dry	Moderate	Humid		

USACE PM: _____
Fort Eustis Rep: Joanna Bateman
Malcolm Pirnie PM: Tony Pace

Project: LARC 68
Malcolm Pirnie Job No. 0285900
USACE Contract No. DACA31-00-D-0043
Delivery Order No. _____

SUBCONTRACTORS ON-SITE:

EQUIPMENT ON SITE:

HORIBA U-10, WEL Wizard Control Box, SOLINST 101

WORK PERFORMED (INCLUDING SAMPLING):

GW Sampling

FIGURE 2 (CONT.)

Project: _____ Report No. _____

Malcolm Pirnie Project No. _____ Date 1/20/03

QUALITY CONTROL ACTIVITIES (INCLUDING FIELD CALIBRATIONS):

U-10 pH: 4
turb Ø
cond: 4.49

HEALTH AND SAFETY LEVELS AND ACTIVITIES:

Level D

PROBLEMS ENCOUNTERED/CORRECTIVE ACTION TAKEN:

- Federal Holiday -- gate to enter LARC 60 was locked.
MPI signed out keys to gate @ Ft. Story headquarters.

SPECIAL NOTES:

~~FINISH~~

TOMORROW'S EXPECTATIONS:

FINISH sampling wells.

BY Gerlyn Perlas TITLE Engineer

FIGURE 2

Date 1/21/03

MALCOLM PIRNIE, INC.
DAILY QUALITY CONTROL REPORT

Day	S	M	T	W	TH	F	S
			X				

USACE PM: _____
Fort Eustis Rep: Joanna Bateman
Malcolm Pirnie PM: Tony Pace

Project: LARC 6B
Malcolm Pirnie Job No. 0285 900
USACE Contract No. DACA31-00-D-0043
Delivery Order No. _____

Weather	Bright Sun	Clear	Overcast	Rain	Snow
Temperature	< 32	32 - 50	50 - 70	70-85	>85
Wind	Still	Moderate	High	REPORT NO.	
Humidity	Dry	Moderate	Humid		

SUBCONTRACTORS ON-SITE:

EQUIPMENT ON SITE:

Honda U-10, well wizard control Box/compressor, Generator, Grundfos, Solinist 101

WORK PERFORMED (INCLUDING SAMPLING):

GW Sampling

FIGURE 2 (CONT.)

Project: LARC 60

Malcolm Pirnie Project No. 0285900

Report No.

Date 1/21/03

QUALITY CONTROL ACTIVITIES (INCLUDING FIELD CALIBRATIONS):

U-10 pH 4
cond 4.48
turb. 1

HEALTH AND SAFETY LEVELS AND ACTIVITIES:

Level D

PROBLEMS ENCOUNTERED/CORRECTIVE ACTION TAKEN:

- well wizard control box not functioning properly -- may be due to cold weather. Control box was placed inside truck in heat to "thaw out."
- 6MW-1 located in locked fenced area -- MPI asked several Ft. Story personnel. Gary Longmeyer (DPW) was able to track down keys to open fence.

SPECIAL NOTES:

TOMORROW'S EXPECTATIONS:

BY Jerlyn Perlas TITLE Engineer

FIGURE 2

Date 1/7/03

MALCOLM PIRNIE, INC.
DAILY QUALITY CONTROL REPORT

Day	S	M	T	W	TH	F	S
			X				

USACE PM: _____
Fort ~~Eustis~~ Story Rep: Joanna Batoman
Malcolm Pirnie PM: TONY PACE

Project: 80 DRS
Malcolm Pirnie Job No. 0285917
USACE Contract No. DACA31-00-D-0043
Delivery Order No. _____

Weather	Bright Sun	Clear	Overcast	Rain	Snow
Temperature	< 32	32 - 50	50 - 70	70-85	>85
Wind	Still	Moderate	High	REPORT NO.	
Humidity	Dry	Moderate	Humid		

SUBCONTRACTORS ON-SITE:

EQUIPMENT ON SITE:

Horiba U-10
SOLINIST 101, Generator, Grundfos

WORK PERFORMED (INCLUDING SAMPLING):

GW Sampling

FIGURE 2 (CONT.)

Project: 80 DRS

Report No.

Malcolm Pirnie Project No. 0285917

Date 1/7/03

QUALITY CONTROL ACTIVITIES (INCLUDING FIELD CALIBRATIONS):

Horiba: pH 3.8
COND 4.47
TURB 0

HEALTH AND SAFETY LEVELS AND ACTIVITIES:

Level D

PROBLEMS ENCOUNTERED/CORRECTIVE ACTION TAKEN:

SPECIAL NOTES:

TOMORROW'S EXPECTATIONS:

Resume GW monitoring

BY Jerlyn Perlas TITLE Engineer

FIGURE 2

Date 1/8/03

MALCOLM PIRNIE, INC.
DAILY QUALITY CONTROL REPORT

Day	S	M	T	W	TH	F	S
				X			

Weather	Bright Sun	Clear	Overcast	Rain	Snow
Temperature	< 32	32 - 50	50 - 70	70-85	>85
Wind	Still	Moderate	High	REPORT NO.	
Humidity	Dry	Moderate	Humid		

USACE PM: _____
Fort Eustis Rep: Joanna Bateman
Malcolm Pirnie PM: Tony Pace

Project: 80 DRS
Malcolm Pirnie Job No. 0285917
USACE Contract No. DACA31-00-D-0043
Delivery Order No. _____

SUBCONTRACTORS ON-SITE:

EQUIPMENT ON SITE:

Horiba U-10, Grundfos, Generator, Solinist 101

WORK PERFORMED (INCLUDING SAMPLING):

GW monitoring

FIGURE 2 (CONT.)

Project: 80 TDRS

Report No.

Malcolm Pirnie Project No. 0285917

Date 1/8/03

QUALITY CONTROL ACTIVITIES (INCLUDING FIELD CALIBRATIONS):

HORIBA U-10: pH : 3.75
Cond: 4.59
TURB: 2

HEALTH AND SAFETY LEVELS AND ACTIVITIES:

Level D

PROBLEMS ENCOUNTERED/CORRECTIVE ACTION TAKEN:

SPECIAL NOTES:

TOMORROW'S EXPECTATIONS:

PM8h sampling

BY Gerlyn Perlas TITLE Engineer

FIGURE 2

Date 01/09/03

MALCOLM PIRNIE, INC.
DAILY QUALITY CONTROL REPORT

Day	S	M	T	W	TH	F	S
					X		

Weather	Bright Sun	Clear	Overcast	Rain	Snow
Temperature	< 32	32 - 50	50 - 70	70-85	>85
Wind	Still	Moderate	High	REPORT NO.	
Humidity	Dry	Moderate	Humid		

USACE PM: _____
Fort Eustis Rep: Joanna Bateman
Malcolm Pirnie PM: Tony Pace

Project: 80 DRS
Malcolm Pirnie Job No. 0285917
USACE Contract No. DACA31-00-D-0043
Delivery Order No. _____

SUBCONTRACTORS ON-SITE:

EQUIPMENT ON SITE:

Generator, Horiba U-10, Grundfos, Solinist 101

WORK PERFORMED (INCLUDING SAMPLING):

GW sampling

FIGURE 2 (CONT.)

Project: 80 DRS

Report No.

Malcolm Pirnie Project No. 0285917

Date 01/09/03

QUALITY CONTROL ACTIVITIES (INCLUDING FIELD CALIBRATIONS):

HORIBA U-10

pH: 3.99

Cond: 4.51

Turb: 0

HEALTH AND SAFETY LEVELS AND ACTIVITIES:

Level D

PROBLEMS ENCOUNTERED/CORRECTIVE ACTION TAKEN:

cannot locate MW03. may be beneath pile of scrap metal.
will await further instructions from T. Pace.

SPECIAL NOTES:

TOMORROW'S EXPECTATIONS:

BY Geralyn Perlas TITLE Engineer

Daily Sampling Notes

Remedial Investigation Report
80th Division Reserve Site
Fort Story, Virginia

MOVING TO PROTECT OUR WORLD

USATC ENVIRONMENTAL

0285-917

MALCOLM PIRNIE

701 Town Center Drive, Suite 600
Newport News, Virginia 23606
(757) 873-8700
(757) 873-8723 (FAX)

DAILY NOTES

PROJECT: 80 DRS GW sampling PROJECT NO: 0285017 PAGE 1 OF 1

PERSONNEL: GTP / CMP LOCATION: Ft. Story DATE: 1/7/03

WEATHER: 35; windy OTHER:

TIME:	LOG ENTRY
0730	CMP picks up truck & meets GTP @ FT. SMY 0830
0900	arrive on site SODRS to set up @ MW05
0950	Begin purging MW08 (yellow tint)
1020	Begin sampling MW08
1040	Finish sampling MW08, Decon, MOB TO MW01
1055	Begin purging MW01
1120	Sample MW01
1130	FINISH Sampling MW01
1145	cleanup/decon and break for lunch (buy supplies)
1240	Return to site and set up @ MW02
1300	Begin purging MW02
1320	Sample MW02
1330	Sample MW02D
	pack up / decon / pack coolers
1445	Leave site

gep 1/7/03

SIGNATURE:	CHECKED BY:	TITLE:	DATE:

MALCOLM PIRNIE

Date 12/ 0 /02

Page 1 of 1

DAILY NOTES

Project Name	80th Division Reserve Site
Site Location	Fort Story, VA
Project Number	0285-917
Personnel On Site	GTP and TYJ

TIME	LOG ENTRY
0715	TYJ picks up truck @ MPI office to meet GTP @ Ft. Story
0830	meet @ Ft. Story
0845	arrive @ 80 DRS to set up @ MW10
0940	Begin purging MW10
1000	sample MW10
1010	Finish sampling MW10 ; Decon & set up @ MW11
1040	Begin purging MW11
1100	Start sampling MW11
1110	sample MW11 MS/MSD
1130	Finish sampling MW11 MS/MSD ; Clean up / decon
1200	Leave site / Ft. Story to buy needed supplies (ice, bags, etc)
	and break for lunch
1330	Return to site to set up @ MW07
1350	Begin purging MW07
1410	sample MW07
1420	FINISH sampling MW07 ; Decon, prepare for ER sampling
1500	Sample ER-SS-010803
1520	FINISH sampling ER SS 010803 ; ~~Decon~~, pack up & clean site & pack samp coole
1600	Leave site / Ft. Story to buy more ice and finish packing
	coolers
1650	Finish packing coolers -- TYJ will return to office to
	add COCs & tape coolers to ~~send off to Compuchem~~
	GTP 01/08/03

Signature:	Checked by:	Title:	Date:

ER 1500

MALCOLM PIRNIE

701 Town Center Drive, Suite 600
Newport News, Virginia 23606
(757) 873-8700
(757) 873-8723 (FAX)

DAILY NOTES

PROJECT: 80 DRS PROJECT NO: 0285917 PAGE 1 OF 1

PERSONNEL: GTP/TJJ LOCATION: Ft Story DATE: 01/09/03

WEATHER: 65, windy OTHER:

TIME:	LOG ENTRY
0715	TJJ picks up truck @ office to meet GTP @ Ft. Story
0830	Meet @ site (GTP/TJJ) to finish GW sampling; set up/decon
0940	Begin purging MW05
1000	Sample MW05
1010	Finish sampling; decon & set up @ MW06
1035	Begin purging MW06
1100	Begin sampling MW06
1110	Finish sampling MW06; Decon
1130	Look for MW03 in asphalt area again -- cannot find well --
	may be located under pile of scrap metal -- will wait for
	instructions fr. Tony Pace to sample well.
1200	Break for lunch
~~1300~~ 1245	Return to site to set up @ MW09
1300	Begin purging MW09
1330	Sample MW09
1340	Finish sampling; decon, prepare for Equipment Rinsate
1420	Sample ER-SS-010903
1440	Finish sampling, cleanup/decon
1455	Leave site to buy more ice and pack coolers

SIGNATURE: [signature] 01/09/03 CHECKED BY: TITLE: DATE:

MALCOLM PIRNIE

Date 01/12/03

Page 1 of 2

DAILY NOTES

Project Name	LARC 60
Site Location	Fort Story, VA
Project Number	0285-900
Personnel On Site	GTP/CMP

TIME	LOG ENTRY
0900	GTP Receives voicemail fr. T. Pace regarding LARC 60 sampling
	questions -- unclear weather sampling team needed to
	wait for well wizard pumps for 6MW-1 & 6MW-3D b/f
	sampling (no -- use Grundfos); unclear which wells to
	sample for sulfate/TDS/TOC (MW-117, 6MW-3S, 6MW-5S).
	unclear whether need to sample for both total & dissolved metals
	(yes). M80 -- take readings @ 80 DRS during low, high, transitional.
	GTP informs CMP ~~-- CMP to~~ on voicemail
0830	CMP returns call -- will gather needed supplies & meet GTP
	@ Ft Story
1000	meet @ Ft Story
1015	arrive @ 80 DRS to discuss when to take readings -- will wait
	till later in week
1030	arrive @ LARC 60 to begin setup @ MW-118
	well wizard compressor not functioning properly. (no air discharge)
	- Call Garey Curry
	- Call well wizard QED helpline -- possible causes -- frozen tubing,
	timing switches) -- suggest "thawing out" control box
note	J. Bateman notifies Gary Longmeyer about moving scrap
	metal @ 80 DRS to locate MW03
1200	Break for lunch - leave site
1300	arrive on site to try well wizard again @ MW-118.
	Still not functioning properly -- will move to well w/
	no pump & use Grundfos to sample.

Signature:	Checked by:	Title:	Date:

MALCOLM PIRNIE

Date 01/13/03

Page 2 of 2

DAILY NOTES

Project Name	LARC 60
Site Location	Fort Story, VA
Project Number	0285-900
Personnel On Site	GTP/CMP

TIME	LOG ENTRY
1315	Set up @ 6MW-3D using non-dedicated equipment.
1345	Begin purging 6MW-3D
1430	Sample 6MW-3D
1440	Finish sampling 6MW-3D
	clean up @ Site
1500	Leave Site to return to office
NOTE	J. Bateman notified by G. Longmeyer that well was not
	found under scrap metal @ SDRS.

GTP 01/13/03

Signature:	Checked by:	Title:	Date:

MALCOLM PIRNIE

Date 01/17/03

Page 1 of 2

DAILY NOTES

Project Name	LARC 60
Site Location	Fort Story, VA
Project Number	0285-900
Personnel On Site	GTP/CMP

TIME	LOG ENTRY
0830	Meet @ Ft. Story LARC 80 DRS (GTP/CMP) to locate
	MW03
0900	Locate MW03 under brush/grass - will sample to
	finish 80 DRS sampling -- set up @ MW03
0920	Begin purging MW03
0945	Sample MW03
0955	Finish sampling MW03 -- decon/cleanup.
1090	Set up @ MW-118 @ LARC 60
	Ft. Story personnel questions MPI identification -- not
	authorized to be @ site & in motorpool (location of MW118).
	Must go to Ft Story headquarters for authorization.
	Headquarters questions Dan Musel (J. Bateman not in
	office). D. Musel identifies MPI personnel for authorization
80	to continue.
1045	Stop by DPW to ask about locked fence which would
	prevent access to GMW-1 -- need to call personnel
	in charge of that area.
1055	Setup @ MW-118
1100	Begin purging MW-118
1120	Sample MW118
1130	Sample MW-118D
1140	Cleanup area
1200	Break for lunch
1300	Return to site to setup @ MW-117 (map does not

Signature:	Checked by:	Title:	Date:

MALCOLM PIRNIE

DAILY NOTES

Date 01/10/03

Page 1 of 2

Project Name	LARC 60
Site Location	Fort Story, VA
Project Number	0285-900
Personnel On Site	GTP/CMP

TIME	LOG ENTRY
	correctly represent locations of MW-117 & 6MW-2.
	(6MW-2 does not have pump -- identified well by
	checking well depth -- deep well) - will come back
	to well @ later time.
1330	Begin purging 6MW-2 MW-117
1345	Sample MW-117
1355	Finish MW-117
1400	Begin purging 6MW-6
1420	Begin sampling 6MW-6 (1420 on bottle labels)
1445	Finish sampling ; begin cleanup @ well
	Pack coolers for shipping
1545	Finish packing coolers; return to office to ship
	coolers & gather tomorrow's supplies.

GP 1/14/03

Signature:	Checked by:	Title:	Date:

MALCOLM PIRNIE

Date 01/15/03

Page 1 of

DAILY NOTES

Project Name	LARC 60
Site Location	Fort Story, VA
Project Number	0285-900
Personnel On Site	GTP/CMP

TIME	LOG ENTRY
0830	CMP picks up fieldtruck to meet GTP
0945	Meet @ site to setup @ 6MW-5D
1020	Begin purging 6MW-5D
1230	Sample 6MW-5D
1240	Finish sampling, clean up site and break for lunch
1330	Return to site to set up @ 6MW-5S
1350	Purge 6MW-5S
1425	Sample 6MW-5S
1445	Begin purging 6MW-7
1515	Sample 6MW-7. clean up
1530	Pack coolers for shipping and leave site

Signature: | Checked by: | Title: | Date:

MALCOLM PIRNIE

Date 1/10/2003

Page 1 of 2

DAILY NOTES

Project Name	80th Division Reserve Site / LARC 60
Site Location	Fort Story, VA
Project Number	0285-917 / 900
Personnel On Site	GTP and ~~TJJ~~ CMP

TIME	LOG ENTRY
0800	CMP picks up field truck/equipment
0915	meet @ Ft. Story (CMP, GTP)
0930	Check water levels @ 80DRS (high tide)
	MW-08 2.94
	MW-01 3.14
	MW-02 3.11
	MW-03 3.32
	MW-11 6.50
	MW-10 6.49
	MW-7 6.50
	MW-5 8.67
	MW-6 7.51
	MW-9 9.68
1000	Fence @ LARC 60 locked -- MLK Holiday -- will find personnel to
	unlock gate
	DPW - closed
	Headquarters -- sign out key
1025	arrive @ site to set up @ MW-115
1120	Sample MW-115
1200	Sample GMW-35
1230	Check water levels @ 80DRS (transition)
	MW01 3.12 MW04 — MW07 6.51 MW10 6.49
	MW02 3.09 MW05 8.66 MW08 2.92 MW11 6.49
	MW03 3.30 MW06 7.51 MW09 9.64

Signature:	Checked by:	Title:	Date:

MALCOLM PIRNIE

Date 02/ 4/ 02

Page 1 of 2

DAILY NOTES

Project Name	~~80th Division Reserve Site~~ LARC 60
Site Location	Fort Story, VA
Project Number	0285-917 / 900
Personnel On Site	GTP and ~~TXJ~~ CMP

TIME	LOG ENTRY
1330	Set up @ 6MW-8
1420	Sample 6MW-8
1435	Set up / find 6MW-4
1510	Sample 6MW-4
1520	Sample 6MW-4D
1525	pack samples for shipment
1535	CMP leaves site to drop off samples
	GTP takes water level measurements @ SODRS (Low tide)
	MW01 3.15
	MW02 3.11
	MW03 3.32
	MW05 8.66
	MW06 7.52
	MW07 6.53
	MW08 2.91
	MW09 9.65
	MW10 6.50
	MW11 6.51
1615	Pack up / leave site

Signature:	Checked by:	Title:	Date:

MALCOLM PIRNIE

Date 01/-/03

Page 1 of

DAILY NOTES

Project Name	LARC 60
Site Location	Fort Story, VA
Project Number	0285-900
Personnel On Site	GTP/~~CMP~~ ARL

TIME	LOG ENTRY
0830	Meet @ Ft. Story East gate (ARL/GTP)
0845	Set up @ GMW-9 & LARC 60
0920	Sample GMW-9
0935	Sample GMW-9D
0950	Begin purging GMW-2 using generator (no well wizard
	pump installed)
1030	Sample GMW-2
*	NOTE J. Bateman requests that labels be put on
	sides of all drums used for monitoring wells.
	(Tops of drums already labeled)
1100	Break for lunch
1200	Return to site to begin labeling drums sides
1245	Begin purging GMW-1
1300	C. Pianta arrives to drop off extra sample containers
1320	Sample GMW-1
1340	Sample GMW-1MS/MSD
*	NOTE: Control box not functioning well due to
	cold temps -- placed inside of truck to warm up.
1400	Resume labeling drums @ LARC 60 & 80 DRS
1530	Leave site to buy more tape
1550	Return to site to resume labeling
1710	Finish labeling drums. Leave site to send out samples
	JEP
	1/21/03

Signature:	Checked by:	Title:	Date:

HW
Bill Barnes
422-7404

Bldg. 878
1011 → 4123 x302

MALCOLM PIRNIE

DAILY NOTES

Date 12 / 3 / 02

Project Name	80th Division Reserve Site
Site Location	Fort Story, VA
Project Number	0285-917
Personnel On Site	GTP and TYJ

weather: 35°, windy

TIME	LOG ENTRY
0830	TYJ & GTP meet @ Ft. Story East gate
0900	meet Fishburne @ gate Tim (Driller) Terry (Helper)
0915	Begin drilling MW-7 (drill through asphalt)
0930	SS - MW 07 - 0"
0935	SS - MW07 - 1'
0940	SS - MW07 - 4'
	- Begin installing well casing, grout, sand, etc.
1055	Finish installing well casing, filter, bentonite -- still need to grout
1115	Begin drilling MW08
1130	SS - MW08 - 0" } collect
1135	SS - MW08 - 1' }
1140	SS - MW08 - 4' }
	Finish installing boring & install well
~~1250~~ 1300	Begin drilling MW10
1330	SS MW10 - 0
1332	MW10 MS/MSD - 0
1335	MW10 - 1'
1337	MW10 MS/MSD - 1'
1340	MW10 - 4'
1342	MW10 MS/MSD - 4'
	Finish installing boring & install well, sand, casing, etc.
1440	Begin drilling MW11
1450	SS - MW11 - 1' (will hand auger 0' sample)
1452	SS - MW11D - 1'

Signature:	Checked by:	Title:	Date:

MALCOLM PIRNIE

Date 12 / 3 / 02

Page 1 of 2

DAILY NOTES

Project Name	80th Division Reserve Site
Site Location	Fort Story, VA
Project Number	0285-917
Personnel On Site	GTP and TYJ

TIME	LOG ENTRY
1455	SS - MW11-4'
1457	SS - MW11D-4'
1530	Drill next to MW08
1535	Collect MW08-0" (Already collected VOCs)
1540	- Clean up @ site & buy ice to pack samples
1545	leave site.

Signature:	Checked by:	Title:	Date:

MALCOLM PIRNIE

Date 12 / 4 / 02

Page 1 of 3

DAILY NOTES

Project Name	80th Division Reserve Site
Site Location	Fort Story, VA
Project Number	0285-917
Personnel On Site	GTP and TYJ

WEATHER: 38°, SUNNY

TIME	LOG ENTRY
0830	meet @ Site (GTP/TYJ) To Begin setup/decon
0900	Fishburne arrives to set up
0920	Drillers mob To SB04 (difficult spot to drill -- avoid concrete slab & fence & overhead utilities)
0945	collect SS - SB04 - 0"
0950	" SS - SB04 - 1'
0955	" SS - SB04 - 4'
	Hand auger in borehole for more sample volume for 0"
1005	Begin drilling SB05
1010	Collect SS-SB05-0"
1015	" SS - SB05 - 1'
1020	" SS - SB05 - 4'
	Hand auger in borehole for more sample volume for 0"
1035	Begin drilling SB03
1045	Collect SS-SB03 - 0"
1050	" SS-SB03 - 1'
1055	" SS-SB03 4'
	Hand auger in borehole for more sample volume for 0"
1100	Begin drilling SB02
1115	SB02 - 0" (collect)
1120	SB02 - 1' "
1125	SB02 - 4' "
	Hand auger in borehole for more sample volume for 0"
1145	Begin drilling SB01

Signature:	Checked by:	Title:	Date:

MALCOLM PIRNIE

Date 12 / 4 / 02

Page 1 of 3

DAILY NOTES

Project Name	80th Division Reserve Site
Site Location	Fort Story, VA
Project Number	0285-917
Personnel On Site	GTP and TYJ

TIME	LOG ENTRY
11:55	SB01-0"
12:00	SB01 1'
12:05	SB01 4'
	Hand auger for more sample vol.
12:30	lunch (fishburne attempts to install flush mount padding MW08)
13:00	return from lunch; get permission to enter
	fenced off area where MW-09 is to be situated
	* Concrete cutter not functioning -- will have to finish MW08 pad later.
13:30	move all MPI and Fishburne vehicles
	into fenced area.
13:40	GTP - go to East gate to meet 3rd Fishburne employee Eric M
13:50	- equipment Rinsate ER-SS-120402 taken
	- Fishburne drill rig stuck in sand as
	backing into area of MW-09.
	- drill rig pulled out by other Fishburne truck
	~~[illegible]~~
14:00	- Drill rig + trucks return to main area to
	develop wells and pour concrete base for
	new wells.
14 10	Install concrete pad @ MW-07
14:20 pm	- MW-11 - develop well

Signature:	Checked by:	Title:	Date:

MALCOLM PIRNIE

Date 12 / 4 / 02

Page 1 of 3

DAILY NOTES

Project Name	80th Division Reserve Site
Site Location	Fort Story, VA
Project Number	0285-917
Personnel On Site	GTP and TYJ

TIME	LOG ENTRY
~~1155~~ 1445	Begin developing @ MW-10
for ~~1200~~	Install pad @ MW-11
~~1205~~ 1505	Begin developing @ MW-07
	* patch up holes in asphalt area
1545	FINISH DEVELOPING MW-07

Signature:	Checked by:	Title:	Date:

MALCOLM PIRNIE

Date 12 / 5 / 02

DAILY NOTES

Project Name	80th Division Reserve Site / LARC 60 Maint. area
Site Location	Fort Story, VA
Project Number	0285-917 / 0285-900
Personnel On Site	GTP and TYJ

WEATHER: 40°, rain

TIME	LOG ENTRY
0845	TYJ & GTP meet @ Ft Story 80th Div Reserve Site
~~09~~	Set up for sample collection for MW-01
0920	Collect SS - MW11 - 0'
0940	GTP calls Fishburne -- Drillers have not arrived
	Drillers were supposed to meet @ 9:00 @ site.
	Paxton arranging to have another driller meet on site b/c
	Tim (original driller) called in sick (hospital). Eric to meet
	MPI for well development. Roland to inspect pathway to
	MW-09.
1115	Call Paxton again to confirm arrival time of drillers.
1150	Fishburne arrives (Rollen - Head Driller, Jeremy, Terry, Eric)
	Eric to develop wells at 80DRS & finish padding wells
1225	Set up @ LARC 60 site to begin drilling 6MW-9
	(Rollen, Jeremy, Tony)
1240	Begin drilling 6MW-9
	Well fell x 2' -- pull well up to correct position
	Fill w/ sand & bentonite -- will grout after bentonite is set
80DRS →	* Eric: developed MW-8 (45 min), MW-1 (25 min), MW-2 (20 min)
	MW-2 odor (fuel-like) present, all wells clear purge water
1345	Move to 6MW-6 -- Drill rig not starting.
	Fishburne attempts to fix rig -- If rig cannot be fixed
1	today, will use different rig to finish wells tomorrow.
1430	Eric finishes up concrete pad for MW-8 @ 80DRS
1530	Eric moves to fenced area to develop MW-4 & 6

Signature:	Checked by:	Title:	Date:

MALCOLM PIRNIE

Date 12 / 5 / 02

Page 1 of 2

DAILY NOTES

Project Name	80th Division Reserve Site
Site Location	Fort Story, VA
Project Number	0285-917
Personnel On Site	GTP and TYJ

TIME	LOG ENTRY
1700	FINISH Developing MW-4&6.
1715	Cleanup & leave site

GTP 12/5/02

Signature:	Checked by:	Title:	Date:

MALCOLM PIRNIE

Date 12 / 6 / 02

Page 1 of 1

DAILY NOTES

Project Name	80th Division Reserve Site
Site Location	Fort Story, VA
Project Number	0285-917
Personnel On Site	GTP and TYJ

TIME	LOG ENTRY
0830	TYJ & GTP arrive @ site on Ft. Story (LARC 60)
	Set up
0849	Fishburne arrives to set up @ 6MW-6
0910	Begin drilling 6MW-6
1000	Finish @ 6MW-6
1015	mob to 6MW-5S, Begin drilling
1035	GTP picks up Greg (Fishburne fr. Gate)
1100	FINISH DRILLING 6MW-5S -- continue grouting as rig mobs
	to 6MW-5D (next to 6MW-5S), Begin drilling 5D
1315	FINISH INSTALLING Borings. Begin installing filter, grout
1400	FINISH @ 6MW-5D, mob to 6MW-7
	(avoid overhead utilities & underground utilities)
14~~05~~	Begin drilling 6MW-~~5D~~ 7
1450	FINISH installing boring @ 6MW-~~5D~~ 7. Begin installing
	filter, grout, etc. as Rolton mobs to
	6MW-8
1500	Begin drilling 6MW-8
1525	FINISH drilling 6MW-8. Begin installing filter, concrete, bent.
1600	TYJ leaves site to return to MPI office
	Fishburne cleans up at site & finishes well.
1430	Leave site
	~~to GP rubber~~

Signature:	Checked by:	Title:	Date:

MALCOLM PIRNIE

Date 12/4/02

Page 1 of

DAILY NOTES

Project Name	~~80th Division Reserve Site~~ LARC 60
Site Location	Fort Story, VA
Project Number	~~0285-917~~ 0285-903
Personnel On Site	GTP and TYJ

TIME	LOG ENTRY
0900	TYJ & GTP meet @ LARC 60 maint. area
	Fishburne arrives (Eric N.) To Develop wells
	(ATV will be brought out tomorrow to finish MW-09
	@ the 80D.R site
0930	Set up @ 6MW-9
0950	Begin developing → water purged until clear
1022	Finish developing well; mob to next well
1030	Begin developing 6MW-6 → purge until clear
1052	Finish developing; mob to next well
1100	Begin developing 6MW-5S → purge until clear
1120	Finish developing; mob to next well
1122	Begin developing 6MW-5D → purge until clear
1210	Finish developing; mob to next well
1225	Begin developing 6MW-7 → purge water clear
1245	Finish developing; mob to next well
	Break for Lunch (≈ 30 min)
1325	Begin developing 6MW-8 → purge water clear
1340	Finish developing; Fishburne demobs
1400	TYJ & GTP take water level readings / well measurements
	@ 80 DRS.
1500	TYJ & GTP leave site to return to MPI office
	yes 12/9/02

Signature:	Checked by:	Title:	Date:

MALCOLM PIRNIE

Date 12/ 4/02

Page 1 of 1

DAILY NOTES

Project Name	80th Division Reserve Site
Site Location	Fort Story, VA
Project Number	0285-917
Personnel On Site	GTP and ~~TXO~~ ARL

TIME	LOG ENTRY
0845	GTP & ARL meet @ Ft. Story
0915	Fishburne arrives w/ ATV (Jeremy - driller)
0930	Arrive @ 80DRS to finish installing last well MW09
	GTP informs Chief Slicker of work to be done inside
	compound
1010	Begin drilling MW09 (loose sand)
1015	Collect SS-MW09-0"
1020	-1'
1025	-4'
1100	Fishburne finishes well; begins demobing
	* wait ≈ 1 hour b/f developing
1200	Begin developing MW09 (Eric-Fishburne) + purge clear
1225	Finish developing; Fishburne begins demobing
1230	collect ~~SS-MW09 MS/MSD~~ ER-SS-121002
1300	Cleanup & Leave site

GTP 12/10/02

Signature:	Checked by:	Title:	Date:

Appendix C
Boring and Well Data

Remedial Investigation Report
80th Division Reserve Site
Fort Story, Virginia

MOVING TO PROTECT OUR WORLD

USATC ENVIRONMENTAL

Boring Logs

Remedial Investigation Report
80th Division Reserve Site
Fort Story, Virginia

0285-917

MALCOLM PIRNIE

Project:	80th Division Reserve Site	**Boring:** SB-01	Page 1 of 1
Date:	4-Dec-02	**Project Number:**	0285-917
Location:	Fort Story, VA	**Drilling Contractor:**	Fishburne Drilling
Inspector:	Tina Jung	**Driller:**	Tim Donahue
Elevation:		**Drilling Equipment:**	Hollow stem auger

Scale	SPT Sample No.	SPT Sample Blows	Sample Type	Sample Depth	Rec.	Sample Description	USCS	Remarks/ PID
1' 2'		6 8 7			45	Top-3": Silty clay, with gravel, stiff, 10YR6/8 Remainder: Medium-coarse sand, well sorted, clean, loose, 10YR7/4	SP	11:55AM 14.7
3' 4'		9 8 9 9				Medium-coarse sand, well sorted, clean, loose, 10YR7/4 Bottom 2": Medium-coarse sand, well sorted, clean, loose, 10YR5/1	SP	52
5' 6'		4 6 9 9			70	Top-6": Medium-coarse sand, well sorted, 10YR4/3 Remainder: Medium-coarse sand, well sorted, 10YR5/2	SP	12:03PM WET 29.9
7' 8'		4 4 5 4			75	Medium-coarse sand, well sorted, 10YR5/2	SP	39.7
9' 10'								
11' 12'								
13' 14'								
15' 16'								
17' 18'								
19' 20'								

Notes:

Malcolm Pirnie Inc. 701 Town Center Drive Suite 600 Newport News, VA 23606 757-873-8700 FAX: 757-873-8723

MALCOLM PIRNIE

Project:	80th Division Reserve Site	**Boring:** SB-02	Page 1 of 1
Date:	4-Dec-02	**Project Number:**	0285-917
Location:	Fort Story, VA	**Drilling Contractor:**	Fishburne Drilling
Inspector:	Tina Jung	**Driller:**	Tim Donahue
Elevation:		**Drilling Equipment:**	Hollow stem auger

Scale	SPT Sample No.	SPT Sample Blows	Sample Type	Sample Depth	Rec.	Sample Description	USCS	Remarks/ PID
1' 2'		7 7 10			45	Medium-coarse sand, well sorted, clean, 10YR6/6	SP	11:12AM 38.3
3' 4'		6 4 3 4			55	Medium-coarse sand, well sorted, clean, 10YR6/6 Bottom 7": Medium-coarse sand, well sorted, clean, 10YR6/6, moist	SP	17.5
5' 6'		4 6 9 9			75	Top-3": Medium-coarse sand, well sorted, clean, 10YR5/3 Next 3": Medium-coarse sand, well sorted, clean, 10YR4/1 Remainder: Medium-coarse sand, well sorted, clean, 10YR5/2	SP	48.9
7' 8'		4 4 5 7			70	Medium-coarse sand, well sorted, clean, 10YR5/2	SP	39.2
9' 10'								
11' 12'								
13' 14'								
15' 16'								
17' 18'								
19' 20'								

Notes:

MALCOLM PIRNIE

Project:	80th Division Reserve Site	**Boring:** SB-03	Page 1 of 1
Date:	4-Dec-02	**Project Number:**	0285-917
Location:	Fort Story, VA	**Drilling Contractor:**	Fishburne Drilling
Inspector:	Tina Jung	**Driller:**	Tim Donahue
Elevation:		**Drilling Equipment:**	Hollow stem auger

Scale	SPT Sample No.	SPT Sample Blows	Sample Type	Sample Depth	Rec.	Sample Description	USCS	Remarks/ PID
1' 2'		6 8 8			45	Top-2": Silty clay, stiff, gravel, 7.5YR5/8 Remainder: Medium sand, well sorted, clean, loose, dry, 10YR6/4	SP	10:40AM 10.2
3' 4'		10 11 10 12			65	Top-5": Medium-coarse sand, well sorted, clean, loose, dry, 10YR7/4 Next: Medium-coarse sand, well sorted, clean, moist, 3" black staining at bottom Bottom 3": Fine sand, well sorted, clean	SP	25.7
5' 6'		5 6 5 5			80	Medium-coarse sand, well sorted, clean, 10YR6/2, wet Half point: Medium-coarse sand, well sorted, clean, 7.5YR5/6	SP	WET 48.8
7' 8'		4 3 2 2			80	Medium-coarse sand, well sorted, 7.5YR5/4 Half point: Medium-coarse sand, well sorted, clean, 10YR6/2	SP	10:54AM 15.6
9' 10'								
11' 12'								
13' 14'								
15' 16'								
17' 18'								
19' 20'								

Notes:

Malcolm Pirnie Inc. 701 Town Center Drive Suite 600 Newport News, VA 23606 757-873-8700 FAX: 757-873-8723

MALCOLM PIRNIE

Project:	80th Division Reserve Site	**Boring:** SB-04	Page 1 of 1
Date:	4-Dec-02	**Project Number:**	0285-917
Location:	Fort Story, VA	**Drilling Contractor:**	Fishburne Drilling
Inspector:	Tina Jung	**Driller:**	Tim Donahue
Elevation:		**Drilling Equipment:**	Hollow stem auger

Scale	SPT Sample No.	SPT Sample Blows	Sample Type	Sample Depth	Rec.	Sample Description	USCS	Remarks/ PID
1' 2'		6 8 10			50	Top-5": clay, stiff, medium plasticity, with minor gravel, 7.5YR5/8 Remainder: Medium sand, well sorted, clean, loose, dry 10YR7/3	SP	9:38AM 2.1
3' 4'		9 7 6 7			70	Top-3": Medium sand, well sorted, clean, loose, dry, 10YR7/3, black staining Next: same, but moist Bottom 6": Medium sand, well sorted, clean, grey	SP	2.2
5' 6'		5 5 6 6			60	Top-3": Medium sand mainly, poorly sorted, pebbles (1.5cm diam), 10YR4/1 Next: Medium-coarse sand, well sorted, 10YR5/1 Bottom half: Medium-coarse sand, well sorted, 10YR6/3	SP	WET 8.4
7' 8'		5 6 7 7			80	Medium-coarse sand, well sorted, clean, 10YR4/1	SP	
9' 10'								
11' 12'								
13' 14'								
15' 16'								
17' 18'								
19' 20'								

Notes:

MALCOLM PIRNIE

Project:	80th Division Reserve Site	**Boring:** SB-05	Page 1 of 1
Date:	4-Dec-02	**Project Number:**	0285-917
Location:	Fort Story, VA	**Drilling Contractor:**	Fishburne Drilling
Inspector:	Tina Jung	**Driller:**	Tim Donahue
Elevation:		**Drilling Equipment:**	Hollow stem auger

Scale	SPT Sample No.	SPT Sample Blows	Sample Type	Sample Depth	Rec.	Sample Description	USCS	Remarks/ PID
1' 2'		7 8 8 7			45	Silty clay, pebbles, stiff, 10YR6/8 Bottom half: Medium-coarse sand, well sorted, clean, dry, 10YR6/4	SP	7.2
3' 4'		7 7 9 7			60	Medium-coarse sand, well sorted, clean, dry, 10YR6/4	SP	12.6
5' 6'		4 4 3 4			60	Medium-coarse sand, well sorted, clean, dry, 10YR6/4	SP	6.3
7' 8'		3 3 2 2			80	Medium-coarse sand, well sorted, clean, dry, 10YR6/4	SP	10.2
9' 10'								
11' 12'								
13' 14'								
15' 16'								
17' 18'								
19' 20'								

Notes:

MALCOLM PIRNIE

Project:	80th Division Reserve Site	**Boring:** MW-07	Page 1 of 1
Date:	3-Dec-02	**Project Number:**	0285-917
Location:	Fort Story, VA	**Drilling Contractor:**	Fishburne Drilling
Inspector:	Tina Jung	**Driller:**	Tim Donahue
Elevation:		**Drilling Equipment:**	Hollow stem auger

Scale	SPT Sample No.	SPT Sample Blows	Sample Type	Sample Depth	Rec.	Sample Description	USCS	Remarks/ PID
1' 2'		0 2 3 5			30	Medium sand, well sorted, 10YR7/3	SP	9:30AM 2.2
3' 4'		6 3 3 5			60	Medium sand, well sorted, 10YR7/3 At top 2": black staining Bottom 3": Black staining, then changes to 2.5YR6/1 grey sand	SP	2
5' 6'		4 5 3 5			70	Medium sand, well sorted, clean, brown, 10YR6/4 black asphalt chunk in upper 2"	SP	WET 3.2
7' 8'		4 4 5 7			?	Medium sand, well sorted, clean, brown, 10YR6/4	SP	10:00AM 3.6
9' 10'		7 10 12 14			90	Medium sand, well sorted, clean, brown, 10YR6/4	SP	10:18AM
11' 12'		11 11 11 13			55	Medium sand, well sorted, clean, brown, 10YR6/4	SP	10:22AM
13' 14'								
15' 16'								
17' 18'								
19' 20'								

Notes:

MALCOLM PIRNIE

Project:	80th Division Reserve Site	**Boring:** MW-08	Page 1 of 1
Date:	3-Dec-02	**Project Number:**	0285-917
Location:	Fort Story, VA	**Drilling Contractor:**	Fishburne Drilling
Inspector:	Tina Jung	**Driller:**	Tim Donahue
Elevation:		**Drilling Equipment:**	Hollow stem auger

Scale	SPT Sample No.	SPT Sample Blows	Sample Type	Sample Depth	Rec.	Sample Description	USCS	Remarks/ PID
1' 2'		0 8 12 14			30	Top-3": Asphalt Remainder: Medium sand, well sorted, clean, 5Y8/1 Bottom 2": Medium sand, well sorted, clean, 10YR7/8	SP	11:25AM 2.6
3' 4'		13 8 9 8			50	Medium sand, well sorted, clean, 10YR6/8	SP	6.3
5' 6'		10 12 14 10			100	Top-8": Silt to gravel, poorly sorted, dark grey Next: Medium sand, well sorted, clean, 10YR6/6 Bottom 2": Coarse to medium sand	SW SP	WET 4.4
7' 8'		7 7 8 7			95	Top -3": Medium-coarse sand, well sorted, black staining Medium-coarse sand, well sorted, 2.5Y6/2	SP	11:37AM 1.5
9' 10'		3 4 6 6			45	Medium-coarse sand, well sorted, 2.5Y6/2 Bottom 4": Medium sand, well sorted, 2.5Y6/2	SP	4.9
11' 12'		6 6 7 6			75	Medium-coarse sand, with gravel (3%), 2.5Y6/2	SP	11:55AM 10.2
13' 14'								
15' 16'								
17' 18'								
19' 20'								

Notes:

MALCOLM PIRNIE

Project:	80th Division Reserve Site	**Boring:** MW-09	Page 1 of 1
Date:	10-Dec-02	**Project Number:**	0285-917
Location:	Fort Story, VA	**Drilling Contractor:**	Fishburne Drilling
Inspector:	Allen Long	**Driller:**	Jeremy
Elevation:		**Drilling Equipment:**	Hollow stem auger

Scale	SPT Sample No.	SPT Sample Blows	Sample Type	Sample Depth	Rec.	Sample Description	USCS	Remarks/ PID
1' 2'		1 2 4 4			18"	Coarse to fine sand, moist, light brown, 10YR3/6	SP	>1000
3' 4'		5 8 11 12			24"	Coarse to medium sand, moist, yellowish orange, 10YR10/6	SP	>1000
5' 6'		5 6 7 5			12"	Coarse to medium sand, moist, yellowish orange, 10YR7/6	SP	>1000
7' 8'		3 5 6 6			14"	Coarse to medium sand, greenish grey, 10YR7/1, wet	SP	WET >1000
9' 10'		5 6 8 10			14"	Medium to fine sand, yellowish orange, 10YR6/6	SP	>1000
11' 12'		1 3 5 4			18"	Medium to fine sand, light brown, 10YR5/4	SP	>1000
13' 14'		5 4 6 7			18"	Medium to fine sand, light brown, 10YR5/4	SP	>1000
15' 16'		1 1 2 2			14"	Medium to fine sand, light grey, 10YR7/1	SP	>1000
17' 18'								
19' 20'								

Notes:

MALCOLM PIRNIE

Project:	80th Division Reserve Site	**Boring:** MW-10	Page 1 of 1
Date:	3-Dec-02	**Project Number:**	0285-917
Location:	Fort Story, VA	**Drilling Contractor:**	Fishburne Drilling
Inspector:	Tina Jung	**Driller:**	Tim Donahue
Elevation:		**Drilling Equipment:**	Hollow stem auger

Scale	SPT Sample No.	SPT Sample Blows	Sample Type	Sample Depth	Rec.	Sample Description	USCS	Remarks/ PID
1' 2'		4 5 5 7			65	Medium sand, well sorted, clean, 10YR6/6	SP	12:58PM
3' 4'		8 8 11 14			95	Medium sand, well sorted, clean, 10YR6/6 Bottom 6": Medium sand, well sorted, clean, 10YR6/1	SP	
5' 6'		12 14 14 16			100	Medium-coarse sand, well sorted, clean, 10YR6/1	SP	WET
7' 8'		10 12 12 14			100	Medium-coarse sand, well sorted, clean, 10YR6/1	SP	
9' 10'		8 7 8 8			90	Medium-coarse sand, well sorted, clean, 10YR6/1		
11' 12'		9 10 10 12			97	Medium-coarse sand, well sorted, clean, 10YR6/1	SP	
13' 14'								
15' 16'								
17' 18'								
19' 20'								

Notes:

Malcolm Pirnie Inc. 701 Town Center Drive Suite 600 Newport News, VA 23606 757-873-8700 FAX: 757-873-8723

MALCOLM PIRNIE

Project:	80th Division Reserve Site	**Boring:** MW-11	Page 1 of 1
Date:	3-Dec-02	**Project Number:**	0285-917
Location:	Fort Story, VA	**Drilling Contractor:**	Fishburne Drilling
Inspector:	Tina Jung	**Driller:**	Tim Donahue
Elevation:		**Drilling Equipment:**	Hollow stem auger

Scale	SPT Sample No.	SPT Sample Blows	Sample Type	Sample Depth	Rec.	Sample Description	USCS	Remarks/ PID
1' 2'		6 8 8 10			55	Medium sand, well sorted, clean, 10YR6/3	SP	2:30PM
3' 4'		15 15 13 11			55	Medium sand, well sorted, clean, 10YR6/3 Bottom 4": Medium-coarse sand, well sorted, clean, 10YR6/3	SP	
5' 6'		10 10 10 12			80	Medium-coarse sand, well sorted, clean, 10YR6/3 Bottom 6 to 4": silt mixed with medium sand (approx 40% medium sand), dark grey to grey, 2.5Y4/1 to 2.5Y6/1 Bottom 4": Medium sand, 2.5Y6/1	S.M SP	WET
7' 8'		8 7 7 6			65	Top-3": Medium sand to gravel, 10YR5/4 Next: silty and medium sand, dark grey, 2.5Y4/1 Bottom 8": medium-coarse sand, 10YR6/1	S.M SP	
9' 10'		7 7 8 9			45	Medium-coarse sand, well sorted, clean, 10YR5/4	SP	
11' 12'		8 9 8 8			65	Medium-coarse sand, well sorted, clean, 10YR5/4	SP	
13' 14'								
15' 16'								
17' 18'								
19' 20'								

Notes:

Water Level Measurments

Remedial Investigation Report
80th Division Reserve Site
Fort Story, Virginia

0285-917

GROUNDWATER LEVEL MEASUREMENT SHEET

PROJECT INFORMATION			
Site Name	80th Division Reserve Site	Date	Dec 9-10, 2002
Project Name	Fort Story, VA	Personnel	Gerlyn Perlas, Tina Jung
Project No.	0285-917	Equipment Type	Water level tape
WEATHER CONDITIONS			
Temp. Range	34-40	Precipitaton	10-Dec-02
Pressure		Humidity	

WELL DATA

Well or Piezometer I.D.	Measurement Date/Time	Elevation of Reference Point (ft)	Water Level Indicator Reading (ft)	Adjusted Depth (ft)	Groundwater Elevation (ft)
MW- 07	12/09/2002 (14:00)		6.11	3.02	3.09
MW- 08	12/09/2002 (14:00)		2.51	0	2.51
MW- 09	12/10/2002		9.28	3	6.28
MW- 10	12/09/2002 (14:00)		6.1	2.91	3.19
MW- 11	12/09/2002 (14:00)		3.1	2.6	0.5

GROUNDWATER LEVEL MEASUREMENT SHEET

PROJECT INFORMATION				
Site Name	Fort Story - 80th Division Reserve Site	Date	01/20/2003	HIGH TIDE
Project Name	80th DRS	Personnel	GTP / CMP	
Project No.	0285-917	Equipment Type	Solinst 101	

WEATHER CONDITIONS			
Temp. Range	42°F, windy	Precipitaton	
Pressure		Humidity	

WELL DATA

Well or Piezometer I.D.	Measurement Date/Time	Elevation of Reference Point (ft)	Water Level Indicator Reading (ft)	Adjusted Depth (ft)	Groundwater Elevation (ft)
MW-01	1/20/03 9:33	10.17	3.14		7.03
MW-02	1/20/03 9:36	10.14	3.11		7.03
MW-03	1/20/03 9:40	10.33	3.32		7.01
MW-05	1/20/03 9:53	15.63	8.67		6.96
MW-06	1/20/03 9:57	14.44	7.51		6.93
MW-07	1/20/03 9:49	13.52	6.50		7.02
MW-08	1/20/03 9:30	9.93	2.94		6.99
MW-09	1/20/03 9:55	16.62	9.68		6.94
MW-10	1/20/03 9:43	13.48	6.49		6.99
MW-11	1/20/03 9:46	13.46	6.50		6.96

GROUNDWATER LEVEL MEASUREMENT SHEET

PROJECT INFORMATION			
Site Name	Fort Story - 80th Division Reserve Site	Date	01/20/2003 TRANSITIONAL
Project Name	80th DRS	Personnel	GTP / CMP
Project No.	0285-917	Equipment Type	Solinst 101
WEATHER CONDITIONS			
Temp. Range	42°F, windy	Precipitaton	
Pressure		Humidity	

WELL DATA

Well or Piezometer I.D.	Measurement Date/Time	Elevation of Reference Point (ft)	Water Level Indicator Reading (ft)	Adjusted Depth (ft)	Groundwater Elevation (ft)
MW-01	1/20/03 12:33	10.17	3.12		7.05
MW-02	1/20/03 12:36	10.14	3.09		7.05
MW-03	1/20/03 12:39	10.33	3.30		7.03
MW-05	1/20/03 12:58	15.63	8.66		6.97
MW-06	1/20/03 13:06	14.44	7.51		6.93
MW-07	1/20/03 12:48	13.52	6.51		7.01
MW-08	1/20/03 12:30	9.93	2.92		7.01
MW-09	1/20/03 13:03	16.62	9.64		6.98
MW-10	1/20/03 12:45	13.48	6.49		6.99
MW-11	1/20/03 12:42	13.46	6.49		6.97

GROUNDWATER LEVEL MEASUREMENT SHEET

PROJECT INFORMATION				
Site Name	Fort Story - 80th Division Reserve Site	Date	01/20/2003	LOW TIDE
Project Name	80th DRS	Personnel	GTP / CMP	
Project No.	0285-917	Equipment Type	Solinst 101	

WEATHER CONDITIONS			
Temp. Range	42°F, windy	Precipitaton	
Pressure		Humidity	

WELL DATA

Well or Piezometer I.D.	Measurement Date/Time	Elevation of Reference Point (ft)	Water Level Indicator Reading (ft)	Adjusted Depth (ft)	Groundwater Elevation (ft)
MW-01	1/20/03 15:40	10.17	3.15		7.02
MW-02	1/20/03 15:45	10.14	3.11		7.03
MW-03	1/20/03 15:55	10.33	3.32		7.01
MW-05	1/20/03 16:10	15.63	8.66		6.97
MW-06	1/20/03 16:15	14.44	7.52		6.92
MW-07	1/20/03 16:05	13.52	6.53		6.99
MW-08	1/20/03 15:35	9.93	2.91		7.02
MW-09	1/20/03 16:12	16.62	9.65		6.97
MW-10	1/20/03 15:58	13.48	6.50		6.98
MW-11	1/20/03 16:00	13.46	6.51		6.95

(LOW TIDE)

entered computer

GROUNDWATER LEVEL MEASUREMENT SHEET

PROJECT INFORMATION			
Site Name	80 DRS	Date	1/20/03
Project Name	80 DRS	Personnel	GTP
Project No.	0285-917	Equipment Type	SOLINIST 101

WEATHER CONDITIONS			
Temp. Range	42', WINDY	Precipitaton	
Pressure		Humidity	

WELL DATA

Well or Piezometer I.D.	Measurement Date/Time	Elevation of Reference Point (ft)	Water Level Indicator Reading (ft)	Adjusted Depth (ft)	Groundwater Elevation (ft)
MW01	01/20/03 1540	10.17	3.15		7.02
MW02	1545	10.14	3.11		7.03
MW03	1555	10.33	3.32		7.01
MW05	1610	15.63	8.66		6.97
MW06	1615	14.44	7.52		6.92
MW07	1605	13.52	6.53		6.99
MW08	1535	9.93	2.91		7.02
MW09	1612	16.62	9.65		6.97
MW10	1558	13.48	6.50		6.98
MW11	1500	13.46	6.51		6.95

enter computer

(HIGH TIDE)

GROUNDWATER LEVEL MEASUREMENT SHEET

PROJECT INFORMATION			
Site Name	80 DRS	Date	1/20/03
Project Name	80 DRS	Personnel	GTP/CMP
Project No.	0285-917	Equipment Type	SOLINIST 101

WEATHER CONDITIONS			
Temp. Range	42 ~~30's~~, WINDY	Precipitaton	
Pressure		Humidity	

WELL DATA

Well or Piezometer I.D.	Measurement Date/Time	Elevation of Reference Point (ft)	Water Level Indicator Reading (ft)	Adjusted Depth (ft)	Groundwater Elevation (ft)
MW01	1/20/03 0933	10.17	3.14		7.03
MW02	0936	10.14	3.11		7.03
MW03	0940	10.33	3.32		7.01
MW05	0953	15.63	8.67		6.96
MW06	0957	14.44	7.51		6.93
MW07	0949	13.52	6.50		7.02
MW08	0930	9.93	2.94		6.99
MW09	0955	16.62	9.68		6.94
MW10	0943	13.48	6.49		6.99
MW11	0946	13.46	6.50		6.96

(TRANSITIONAL)

GROUNDWATER LEVEL MEASUREMENT SHEET

PROJECT INFORMATION			
Site Name	80 DRS	Date	1/20/03
Project Name	80 DRS	Personnel	GTP / CMP
Project No.	0285-917	Equipment Type	SOLINIST 101

WEATHER CONDITIONS			
Temp. Range	42°, WINDY	Precipitaton	
Pressure		Humidity	

WELL DATA

Well or Piezometer I.D.	Measurement Date/Time	Elevation of Reference Point (ft)	Water Level Indicator Reading (ft)	Adjusted Depth (ft)	Groundwater Elevation (ft)
MW01	1/20/03 1233	10.17	3.12		7.05
MW02	1236	10.14	3.09		7.05
MW03	1239	10.33	3.30		7.03
MW05	1258	15.63	8.66		6.97
MW06	1306	14.44	7.51		6.93
MW07	1298	13.52	6.51		7.01
MW08	1280	9.93	2.92		7.01
MW09	1303	16.62	9.64		6.98
MW10	1245	13.48	6.49		6.99
MW11	1242	13.46	6.49		6.97

Well Construction Logs

Remedial Investigation Report
80th Division Reserve Site
Fort Story, Virginia

0285-917

MALCOLM PIRNIE

WELL CONSTRUCTION LOG

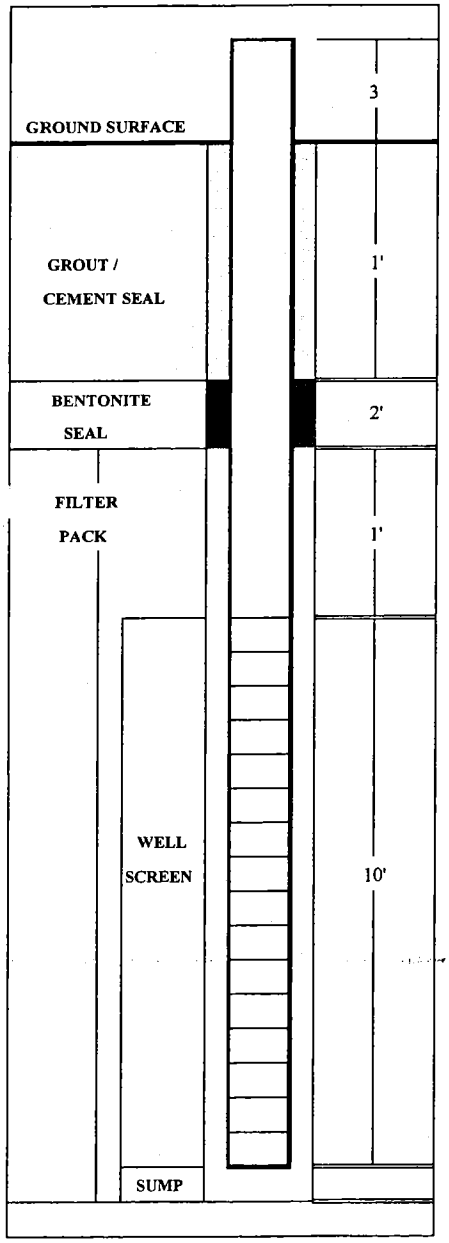
WELL ID: MW-07

BORING ID:

Malcolm Pirnie Inc. 701 Town Center Drive Suite 600 Newport News, VA 23606 757-873-8700 FAX: 757-873-8723

PROJECT NAME 80th DIVISION RESERVE SITE		PROJECT NO: 0285917	ELEVATIONS
LOCATION FORT STORY			GROUND:
NORTHING:		DRILLING INFORMATION	WELL:
EASTING:		COMPANY: FISHBURNE	SECURITY CASING:

INSTALLATION	DATE	TIME		
STARTED:	12/03/02	0915	DRILLER: TIM	FLUIDS:
COMPLETED:	12/03/02	1015	EQUIPMENT: DRILL RIG	BORE HOLE DIAMETER 4.25"
MPI PERSONNEL:			METHOD: HOLLOW STEM AUGER	SAMPLE INTERVAL CONTINUOUS
			EQUIPMENT DECON. STEAM CLEAN	SAMPLE METHOD: SPLIT SPOON-2FT.



WELL CONSTRUCTION DATA

PROTECTIVE CASING:

Locking Cap (Y/N): Y *Protective Posts (#):* 0

Protective outer casing: METAL

Pad: CONCRETE

WELL MATERIALS:

Screen

Type: PVC

Diameter: 2" *Slot Type:* WIRE WRAPPED *Slot Size:* 0.01

Joint: FLUSH THREAD *Length:* 10'

Riser

Type: PVC

Diameter: 2" *Length:* 3.02'

TOTAL DEPTH OF WELL: 17'

INITIAL WATER LEVEL: 6.11'

FILTER PACK:

Material: SAND

Amount used: 1 BAG

Total thickness: 11'

BENTONITE:

Type: BENTONITE HOLE PLUG

Size: 3/8"

Amount used: 1 BAG

GROUT:

Type: CEMENT

Amount used: 1 BAG

WELL DEVELOPMENT

Method: PUMP AND SURGE

Development Time: ~25 MIN

NOTES:

MALCOLM PIRNIE

WELL CONSTRUCTION LOG

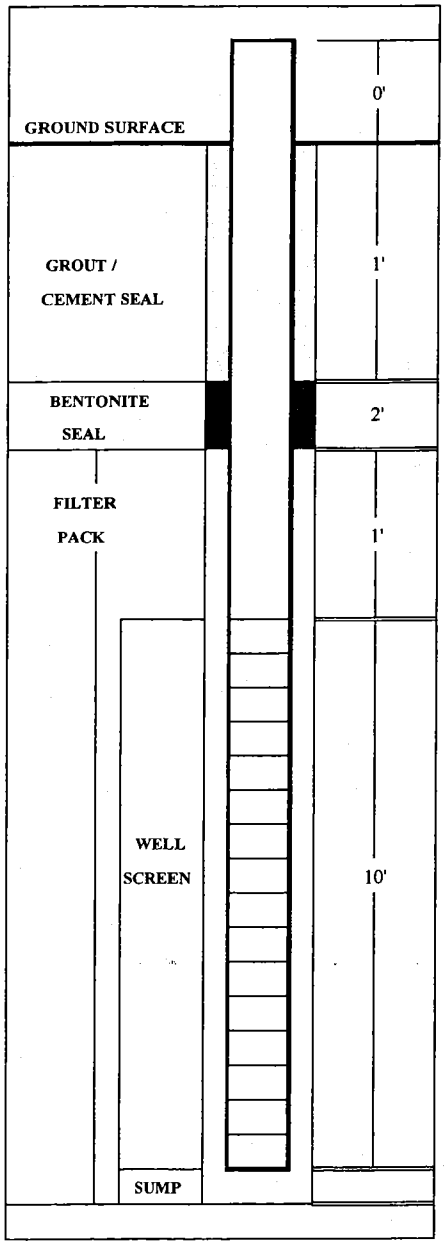
WELL ID: MW-08

BORING ID:

Malcolm Pirnie Inc. 701 Town Center Drive Suite 600 Newport News, VA 23606 757-873-8700 FAX: 757-873-8723

PROJECT NAME 80th DIVISION RESERVE SITE		PROJECT NO: 0285917	ELEVATIONS
LOCATION FORT STORY			GROUND:
NORTHING:		DRILLING INFORMATION	WELL:
EASTING:		COMPANY: FISHBURNE	SECURITY CASING:

INSTALLATION	DATE	TIME		
STARTED:	12/03/02	1115	DRILLER: TIM	FLUIDS:
COMPLETED:	12/03/02	1215	EQUIPMENT: DRILL RIG	BORE HOLE DIAMETER 4.25"
MPI PERSONNEL:			METHOD: HOLLOW STEM AUGER	SAMPLE INTERVAL CONTINUOUS
			EQUIPMENT DECON. STEAM CLEAN	SAMPLE METHOD: SPLIT SPOON-2FT.



WELL CONSTRUCTION DATA

PROTECTIVE CASING:

Locking Cap (Y/N): Y *Protective Posts (#):* 0

Protective outer casing:

Pad: CONCRETE

WELL MATERIALS:

Screen

Type: PVC

Diameter: 2" *Slot Type:* WIRE WRAPPED *Slot Size:* 0.01

Joint: FLUSH THREAD *Length:* 10'

Riser

Type: N/A

Diameter: N/A *Length:* N/A

TOTAL DEPTH OF WELL: 14'

INITIAL WATER LEVEL: 2.51

FILTER PACK:

Material: SAND

Amount used: 1 BAG

Total thickness: 11'

BENTONITE:

Type: BENTONITE HOLE PLUG

Size: 3/8"

Amount used: 1 BAG

GROUT:

Type: CEMENT

Amount used: 1 BAG

WELL DEVELOPMENT

Method: PUMP AND SURGE

Development Time: ~25 MIN

NOTES:

MALCOLM PIRNIE

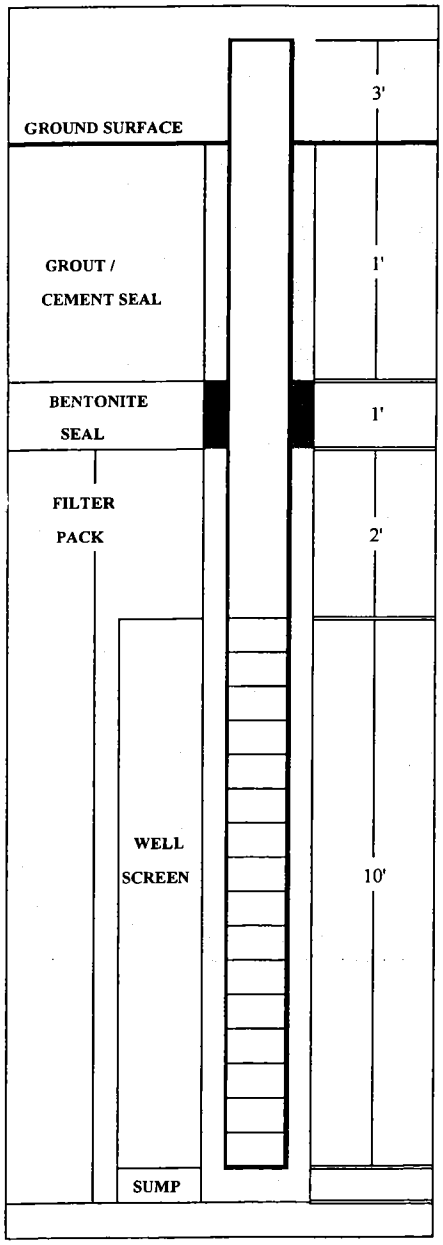
WELL CONSTRUCTION LOG

WELL ID: MW-09

BORING ID:

Malcolm Pirnie Inc. 701 Town Center Drive Suite 600 Newport News, VA 23606 757-873-8700 FAX: 757-873-8723

PROJECT NAME 80th DIVISION RESERVE SITE			PROJECT NO: 0285917	ELEVATIONS
LOCATION FORT STORY				GROUND:
NORTHING:			DRILLING INFORMATION	WELL:
EASTING:			COMPANY: FISHBURNE	SECURITY CASING:
INSTALLATION	DATE	TIME	DRILLER: JEREMY	FLUIDS:
STARTED:	12/10/02	1010	EQUIPMENT: DRILL RIG-ATV	BORE HOLE DIAMETER 4.25"
COMPLETED:	12/10/02	1100	METHOD: HOLLOW STEM AUGER	SAMPLE INTERVAL CONTINUOUS
MPI PERSONNEL:			EQUIPMENT DECON. STEAM CLEAN	SAMPLE METHOD: SPLIT SPOON-2FT.



WELL CONSTRUCTION DATA

PROTECTIVE CASING:

Locking Cap (Y/N): Y *Protective Posts (#):* 0

Protective outer casing: METAL

Pad: CONCRETE

WELL MATERIALS:

Screen

Type: PVC

Diameter: 2" *Slot Type:* WIRE WRAPPED *Slot Size:* 0.01

Joint: FLUSH THREAD *Length:* 10'

Riser

Type: PVC

Diameter: 2" *Length:* 3'

TOTAL DEPTH OF WELL: 17.75'

INITIAL WATER LEVEL: 9.28'

FILTER PACK:

Material: SAND

Amount used: 1 BAG

Total thickness: 12'

BENTONITE:

Type: BENTONITE HOLE PLUG

Size: 3/8"

Amount used: 1 BAG

GROUT:

Type: CEMENT

Amount used: 1 BAG

WELL DEVELOPMENT

Method: PUMP AND SURGE

Development Time: ~25 MIN

NOTES:

MALCOLM PIRNIE

WELL CONSTRUCTION LOG

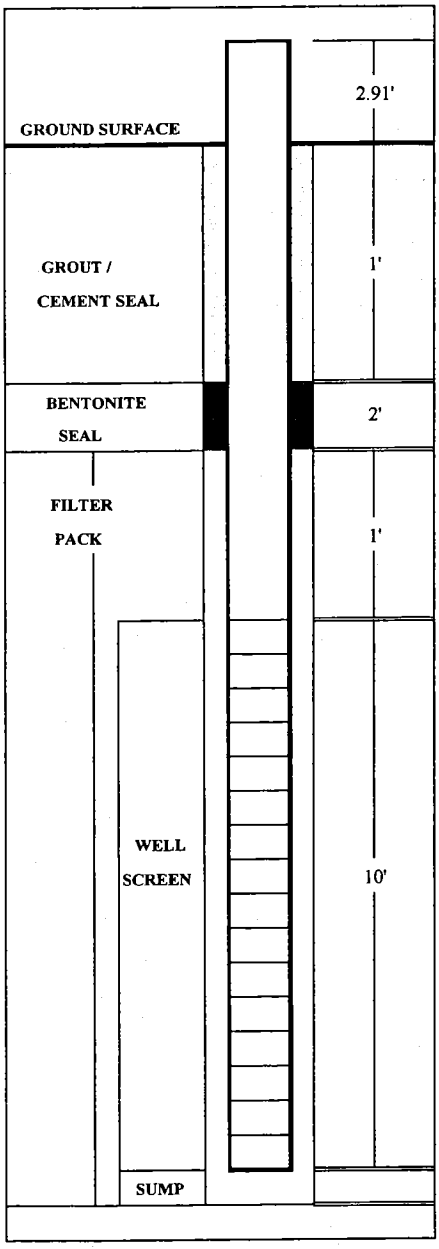
WELL ID: MW-10

BORING ID:

Malcolm Pirnie Inc. 701 Town Center Drive Suite 600 Newport News, VA 23606 757-873-8700 FAX: 757-873-8723

PROJECT NAME 80th DIVISION RESERVE SITE		PROJECT NO: 0285917	ELEVATIONS
LOCATION FORT STORY			GROUND:
NORTHING:		DRILLING INFORMATION	WELL:
EASTING:		COMPANY: FISHBURNE	SECURITY CASING:

INSTALLATION	DATE	TIME		
STARTED:	12/03/02	1300	DRILLER: TIM	FLUIDS:
COMPLETED:	12/03/02	1400	EQUIPMENT: DRILL RIG	BORE HOLE DIAMETER 4.25"
MPI PERSONNEL:			METHOD: HOLLOW STEM AUGER	SAMPLE INTERVAL CONTINUOUS
			EQUIPMENT DECON. STEAM CLEAN	SAMPLE METHOD: SPLIT SPOON-2FT.



WELL CONSTRUCTION DATA

PROTECTIVE CASING:

Locking Cap (Y/N): Y *Protective Posts (#):* 0

Protective outer casing: METAL

Pad: CONCRETE

WELL MATERIALS:

Screen

Type: PVC

Diameter: 2" *Slot Type:* WIRE WRAPPED *Slot Size:* 0.01

Joint: FLUSH THREAD *Length:* 10'

Riser

Type: PVC

Diameter: 2" *Length:* 2.91'

TOTAL DEPTH OF WELL: 16.91'

INITIAL WATER LEVEL: 6.1'

FILTER PACK:

Material: SAND

Amount used: 1 BAG

Total thickness: 11'

BENTONITE:

Type: BENTONITE HOLE PLUG

Size: 3/8"

Amount used: 1 BAG

GROUT:

Type: CEMENT

Amount used: 1 BAG

WELL DEVELOPMENT

Method: PUMP AND SURGE

Development Time: ~25 MIN

NOTES:

MALCOLM PIRNIE

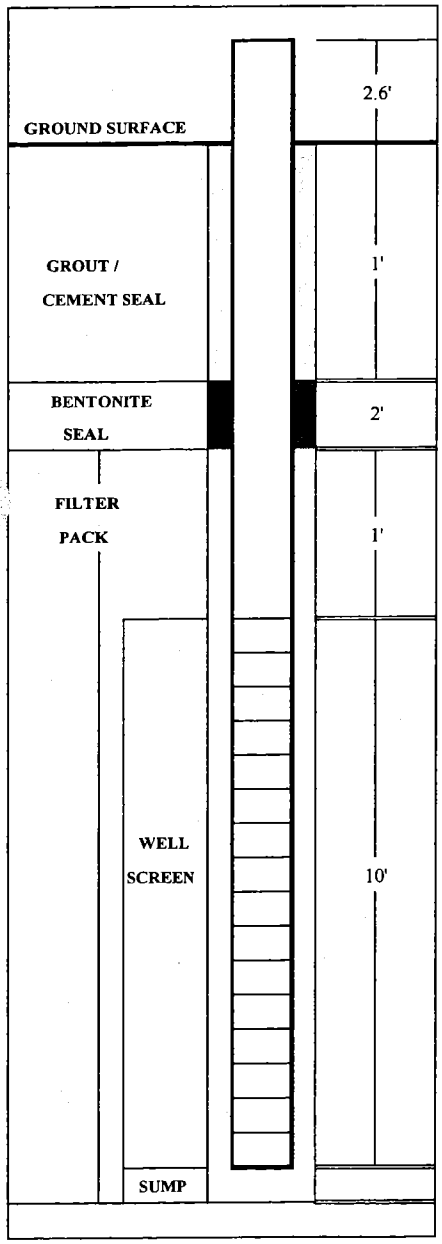
WELL CONSTRUCTION LOG

WELL ID: MW-11

BORING ID:

Malcolm Pirnie Inc. 701 Town Center Drive Suite 600 Newport News, VA 23606 757-873-8700 FAX: 757-873-8723

PROJECT NAME 80th DIVISION RESERVE SITE			PROJECT NO: 0285917	ELEVATIONS
LOCATION FORT STORY				GROUND:
NORTHING:			DRILLING INFORMATION	WELL:
EASTING:			COMPANY: FISHBURNE	SECURITY CASING:
INSTALLATION	DATE	TIME	DRILLER: TIM	FLUIDS:
STARTED:	12/03/02	1440	EQUIPMENT: DRILL RIG	BORE HOLE DIAMETER 4.25"
COMPLETED:	12/03/02	1540	METHOD: HOLLOW STEM AUGER	SAMPLE INTERVAL CONTINUOUS
MPI PERSONNEL:			EQUIPMENT DECON. STEAM CLEAN	SAMPLE METHOD: SPLIT SPOON-2FT.



WELL CONSTRUCTION DATA

PROTECTIVE CASING:

Locking Cap (Y/N): Y *Protective Posts (#):* 0

Protective outer casing: METAL

Pad: CONCRETE

WELL MATERIALS:

Screen

Type: PVC

Diameter: 2" *Slot Type:* WIRE WRAPPED *Slot Size:* 0.01

Joint: FLUSH THREAD *Length:* 10'

Riser

Type: PVC

Diameter: 2" *Length:* 2.6'

TOTAL DEPTH OF WELL: 16.6'

INITIAL WATER LEVEL: 6.1'

FILTER PACK:

Material: SAND

Amount used: 1 BAG

Total thickness: 11'

BENTONITE:

Type: BENTONITE HOLE PLUG

Size: 3/8"

Amount used: 1 BAG

GROUT:

Type: CEMENT

Amount used: 1 BAG

WELL DEVELOPMENT

Method: PUMP AND SURGE

Development Time: ~25 MIN

NOTES:

Appendix D
UCL Exposure Calculations

Remedial Investigation Report
80th Division Reserve Site
Fort Story, Virginia

MOVING TO PROTECT OUR WORLD

USATC ENVIRONMENTAL

UCL Calculations
80th DRS Fort Story, Virginia
Surface Soils

Benzo(a)anthracene (ug/kg)	
MW-7	175
MW-8	3900
MW-9	180
MW-10	185
MW-11	180
SB-1	210
SB-2	320
SB-3	5600
SB-4	4300
SB-5	3300

From ProUCL

Raw Statistics	
Number of Valid Samples	10
Number of Unique Samples	9
Minimum	175
Maximum	5600
Mean	1835
Median	265
Standard Deviation	2174.445012
Variance	4728211.111
Coefficient of Variation	1.184983658
Skewness	0.734841807

Gamma Statistics	
k hat	0.621295499
k star (bias corrected)	0.501573516
Theta hat	2953.506025
Theta star	3658.486626
nu hat	12.42590998
nu star	10.03147032
Approx.Chi Square Value (.05)	3.960596016
Adjusted Level of Significance	0.0267
Adjusted Chi Square Value	3.324558506

Log-transformed Statistics	
Minimum of log data	5.164785974
Maximum of log data	8.630521877
Mean of log data	6.525378579
Standard Deviation of log data	1.578020182
Variance of log data	2.490147695

RECOMMENDATION

Data are Non-parametric (0.05)

Use 99% Chebyshev (Mean, Sd) UCL

Recommended UCL exceeds the maximum observation
Consider using 95% or 97.5% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.7505425
Shapiro-Wilk 5% Critical Value	0.842
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	3095.4848

Gamma Distribution Test	
A-D Test Statistic	1.3126377
A-D 5% Critical Value	0.7672767
K-S Test Statistic	0.3307359
K-S 5% Critical Value	0.2784872
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	4647.7217
Adjusted Gamma UCL	5536.9

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.7359958
Shapiro-Wilk 5% Critical Value	0.842
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	23831.357
95% Chebyshev (MVUE) UCL	6272.1475
97.5% Chebyshev (MVUE) UCL	8161.8066
99% Chebyshev (MVUE) UCL	11873.676

95% Non-parametric UCLs	
CLT UCL	2966.0341
Adj-CLT UCL (Adjusted for skewness)	3136.7691
Mod-t UCL (Adjusted for skewness)	3122.116
Jackknife UCL	3095.4848
Standard Bootstrap UCL	2881.1424
Bootstrap-t UCL	3293.1883
Hall's Bootstrap UCL	2755.4792
Percentile Bootstrap UCL	2987.5
BCA Bootstrap UCL	3058.5
95% Chebyshev (Mean, Sd) UCL	**4832.2656**
97.5% Chebyshev (Mean, Sd) UCL	6129.1848
99% Chebyshev (Mean, Sd) UCL	8676.7315

UCL = 4832 ug/kg

UCL Calculations
80th DRS Fort Story, Virginia
Surface Soils

Benzo(a)pyrene (ug/kg)	
MW-7	28
MW-8	3900
MW-9	180
MW-10	185
MW-11	180
SB-1	170
SB-2	430
SB-3	5500
SB-4	4000
SB-5	3200

From ProUCL

Raw Statistics	
Number of Valid Samples	10
Number of Unique Samples	9
Minimum	28
Maximum	5500
Mean	1777.3
Median	307.5
Standard Deviation	2119.372446
Variance	4491739.567
Coefficient of Variation	1.192467477
Skewness	0.742287899

Gamma Statistics	
k hat	0.547368259
k star (bias corrected)	0.449824448
Theta hat	3246.991346
Theta star	3951.09694
nu hat	10.94736518
nu star	8.996488959
Approx.Chi Square Value (.05)	3.324069822
Adjusted Level of Significance	0.0267
Adjusted Chi Square Value	2.752972161

Log-transformed Statistics	
Minimum of log data	3.33220451
Maximum of log data	8.612503371
Mean of log data	6.338424861
Standard Deviation of log data	1.830508366
Variance of log data	3.350760878

RECOMMENDATION
Assuming gamma distribution (0.05)

Use Approximate Gamma UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.769306
Shapiro-Wilk 5% Critical Value	0.842
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	3005.86

Gamma Distribution Test	
A-D Test Statistic	0.866437
A-D 5% Critical Value	0.773197
K-S Test Statistic	0.270137
K-S 5% Critical Value	0.279927
Data follow approximate gamma distibution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	**4810.206**
Adjusted Gamma UCL	5808.072

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.867294
Shapiro-Wilk 5% Critical Value	0.842
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	63373.14
95% Chebyshev (MVUE) UCL	7897.854
97.5% Chebyshev (MVUE) UCL	10373.01
99% Chebyshev (MVUE) UCL	15234.98

95% Non-parametric UCLs	
CLT UCL	2879.688
Adj-CLT UCL (Adjusted for skewness)	3047.785
Mod-t UCL (Adjusted for skewness)	3032.08
Jackknife UCL	3005.86
Standard Bootstrap UCL	2813.028
Bootstrap-t UCL	3133.294
Hall's Bootstrap UCL	2644.769
Percentile Bootstrap UCL	2857
BCA Bootstrap UCL	2935
95% Chebyshev (Mean, Sd) UCL	4698.653
97.5% Chebyshev (Mean, Sd) UCL	5962.725
99% Chebyshev (Mean, Sd) UCL	8445.75

UCL = 4810 ug/kg

UCL Calculations
80th DRS Fort Story, Virginia
Surface Soils

Benzo(b)fluoranthene (ug/kg)	
MW-7	175
MW-8	6800
MW-9	180
MW-10	185
MW-11	180
SB-1	240
SB-2	750
SB-3	6500
SB-4	5100
SB-5	3400

From ProUCL

Raw Statistics	
Number of Valid Samples	10
Number of Unique Samples	9
Minimum	175
Maximum	6800
Mean	2351
Median	495
Standard Deviation	2819.33286
Variance	7948637.778
Coefficient of Variation	1.19920581
Skewness	0.786923595

Gamma Statistics	
k hat	0.590838972
k star (bias corrected)	0.480253947
Theta hat	3979.087557
Theta star	4895.326766
nu hat	11.81677943
nu star	9.605078935
Approx.Chi Square Value (.05)	3.695656902
Adjusted Level of Significance	0.0267
Adjusted Chi Square Value	3.086005884

Log-transformed Statistics	
Minimum of log data	5.164785974
Maximum of log data	8.824677891
Mean of log data	6.714452951
Standard Deviation of log data	1.661404263
Variance of log data	2.760264124

RECOMMENDATION
Data are Non-parametric (0.05)

Use 99% Chebyshev (Mean, Sd) UCL

Recommended UCL exceeds the maximum observation
Consider using 95% or 97.5% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.755004
Shapiro-Wilk 5% Critical Value	0.842
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	3985.314

Gamma Distribution Test	
A-D Test Statistic	1.030291
A-D 5% Critical Value	0.769716
K-S Test Statistic	0.291476
K-S 5% Critical Value	0.27908
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	6110.291
Adjusted Gamma UCL	7317.4

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.778787
Shapiro-Wilk 5% Critical Value	0.842
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	41497.82
95% Chebyshev (MVUE) UCL	8682.983
97.5% Chebyshev (MVUE) UCL	11337.07
99% Chebyshev (MVUE) UCL	16550.52

95% Non-parametric UCLs	
CLT UCL	3817.471
Adj-CLT UCL (Adjusted for skewness)	4054.532
Mod-t UCL (Adjusted for skewness)	4022.291
Jackknife UCL	3985.314
Standard Bootstrap UCL	3743.712
Bootstrap-t UCL	4446.505
Hall's Bootstrap UCL	3537.473
Percentile Bootstrap UCL	3786
BCA Bootstrap UCL	3904
95% Chebyshev (Mean, Sd) UCL	**6237.182**
97.5% Chebyshev (Mean, Sd) UCL	7918.736
99% Chebyshev (Mean, Sd) UCL	11221.82

UCL = 6237 ug/kg

UCL Calculations
80th DRS Fort Story, Virginia
Surface Soils

Dibenzo(a,h)anthracene (ug/kg)	
MW-7	175
MW-8	1200
MW-9	180
MW-10	185
MW-11	180
SB-1	46
SB-2	160
SB-3	1500
SB-4	910
SB-5	690

From ProUCL

Raw Statistics	
Number of Valid Samples	10
Number of Unique Samples	9
Minimum	46
Maximum	1500
Mean	522.6
Median	182.5
Standard Deviation	518.5940823
Variance	268939.8222
Coefficient of Variation	0.992334639
Skewness	0.986425358

Gamma Statistics	
k hat	1.105908229
k star (bias corrected)	0.840802427
Theta hat	472.5527727
Theta star	621.5491098
nu hat	22.11816458
nu star	16.81604854
Approx.Chi Square Value (.05)	8.53963504
Adjusted Level of Significance	0.0267
Adjusted Chi Square Value	7.536237095

Log-transformed Statistics	
Minimum of log data	3.828641396
Maximum of log data	7.313220387
Mean of log data	5.742830413
Standard Deviation of log data	1.124443061
Variance of log data	1.264372197

RECOMMENDATION
Assuming gamma distribution (0.05)

Use Approximate Gamma UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.805953
Shapiro-Wilk 5% Critical Value	0.842
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	823.2192

Gamma Distribution Test	
A-D Test Statistic	0.745691
A-D 5% Critical Value	0.746355
K-S Test Statistic	0.323309
K-S 5% Critical Value	0.273193
Data follow approximate gamma distibution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	**1029.092**
Adjusted Gamma UCL	1166.108

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.889472
Shapiro-Wilk 5% Critical Value	0.842
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	2071.081
95% Chebyshev (MVUE) UCL	1412.997
97.5% Chebyshev (MVUE) UCL	1792.189
99% Chebyshev (MVUE) UCL	2537.037

95% Non-parametric UCLs	
CLT UCL	792.3459
Adj-CLT UCL (Adjusted for skewness)	847.0062
Mod-t UCL (Adjusted for skewness)	831.7451
Jackknife UCL	823.2192
Standard Bootstrap UCL	775.3061
Bootstrap-t UCL	936.3274
Hall's Bootstrap UCL	791.7921
Percentile Bootstrap UCL	786.6
BCA Bootstrap UCL	822.5
95% Chebyshev (Mean, Sd) UCL	1237.433
97.5% Chebyshev (Mean, Sd) UCL	1546.741
99% Chebyshev (Mean, Sd) UCL	2154.318

UCL = 1029 ug/kg

UCL Calculations
80th DRS Fort Story, Virginia
Combined Surface/Subsurface Soils

Benzo(a)anthracene (ug/kg)	
MW-7	175
	140
	205
MW-8	3900
	91
	300
MW-9	180
	175
	180
MW-10	185
	180
	195
MW-11	180
	170
	195
SB-1	210
	340
	93
SB-2	320
	180
	45
SB-3	5600
	420
	83
SB-4	4300
	510
	1500
SB-5	3300
	76
	280

From ProUCL

Raw Statistics	
Number of Valid Samples	30
Number of Unique Samples	24
Minimum	45
Maximum	5600
Mean	790.2667
Median	190
Standard Deviation	1447.793
Variance	2096104
Coefficient of Variation	1.832031
Skewness	2.377054

Gamma Statistics	
k hat	0.617855
k star (bias corrected)	0.578292
Theta hat	1279.049
Theta star	1366.553
nu hat	37.07131
nu star	34.69751
Approx.Chi Square Value (.05)	22.22039
Adjusted Level of Significance	0.041
Adjusted Chi Square Value	21.64393

Log-transformed Statistics	
Minimum of log data	3.806662
Maximum of log data	8.630522
Mean of log data	5.676633
Standard Deviation of log data	1.239688
Variance of log data	1.536827

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.526911
Shapiro-Wilk 5% Critical Value	0.927
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	1239.396

Gamma Distribution Test	
A-D Test Statistic	4.118423
A-D 5% Critical Value	0.79908
K-S Test Statistic	0.320373
K-S 5% Critical Value	0.167818
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	1234.015
Adjusted Gamma UCL	1266.881

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.824366
Shapiro-Wilk 5% Critical Value	0.927
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	1183.428
95% Chebyshev (MVUE) UCL	1320.824
97.5% Chebyshev (MVUE) UCL	1631.243
99% Chebyshev (MVUE) UCL	2241

95% Non-parametric UCLs	
CLT UCL	1225.05
Adj-CLT UCL (Adjusted for skewness)	1347.626
Mod-t UCL (Adjusted for skewness)	1258.516
Jackknife UCL	1239.396
Standard Bootstrap UCL	1196.775
Bootstrap-t UCL	1505.986
Hall's Bootstrap UCL	1199.543
Percentile Bootstrap UCL	1242.6
BCA Bootstrap UCL	1345.533
95% Chebyshev (Mean, Sd) UCL	1942.453
97.5% Chebyshev (Mean, Sd) UCL	2441.005
99% Chebyshev (Mean, Sd) UCL	**3420.313**

RECOMMENDATION
Data are Non-parametric (0.05)

Use 99% Chebyshev (Mean, Sd) UCL

UCL = 3420 ug/kg

UCL Calculations
80th DRS Fort Story, Virginia
Combined Surface/Subsurface Soils

	Benzo(a)pyrene (ug/kg)
MW-7	28
	160
	205
MW-8	3900
	82
	270
MW-9	180
	175
	180
MW-10	185
	180
	195
MW-11	180
	170
	195
SB-1	170
	270
	72
SB-2	430
	180
	49
SB-3	5500
	330
	58
SB-4	4000
	450
	1400
SB-5	3200
	65
	260

From ProUCL

Raw Statistics	
Number of Valid Samples	30
Number of Unique Samples	23
Minimum	28
Maximum	5500
Mean	757.3
Median	182.5
Standard Deviation	1409.519
Variance	1986745
Coefficient of Variation	1.861243
Skewness	2.396198

Gamma Statistics	
k hat	0.582454
k star (bias corrected)	0.546431
Theta hat	1300.188
Theta star	1385.902
nu hat	34.94725
nu star	32.78586
Approx.Chi Square Value (.05)	20.6941
Adjusted Level of Significance	0.041
Adjusted Chi Square Value	20.13947

Log-transformed Statistics	
Minimum of log data	3.332205
Maximum of log data	8.612503
Mean of log data	5.564267
Standard Deviation of log data	1.320121
Variance of log data	1.742719

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.527385
Shapiro-Wilk 5% Critical Value	0.927
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	1194.556

Gamma Distribution Test	
A-D Test Statistic	3.700526
A-D 5% Critical Value	0.802105
K-S Test Statistic	0.316625
K-S 5% Critical Value	0.168227
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	1199.798
Adjusted Gamma UCL	1232.84

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.862438
Shapiro-Wilk 5% Critical Value	0.927
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	1254.124
95% Chebyshev (MVUE) UCL	1355.039
97.5% Chebyshev (MVUE) UCL	1684.792
99% Chebyshev (MVUE) UCL	2332.528

95% Non-parametric UCLs	
CLT UCL	1180.59
Adj-CLT UCL (Adjusted for skewness)	1300.886
Mod-t UCL (Adjusted for skewness)	1213.32
Jackknife UCL	1194.556
Standard Bootstrap UCL	1170.653
Bootstrap-t UCL	1461.799
Hall's Bootstrap UCL	1151.741
Percentile Bootstrap UCL	1194.9
BCA Bootstrap UCL	1354.1
95% Chebyshev (Mean, Sd) UCL	1879.027
97.5% Chebyshev (Mean, Sd) UCL	2364.399
99% Chebyshev (Mean, Sd) UCL	**3317.819**

RECOMMENDATION
Data are Non-parametric (0.05)

Use 99% Chebyshev (Mean, Sd) UCL

UCL = 3318 ug/kg

UCL Calculations
80th DRS Fort Story, Virginia
Combined Surface/Subsurface Soils

Benzo(b)fluoranthene (ug/kg)	
MW-7	175
	150
	205
MW-8	6800
	110
	340
MW-9	180
	175
	180
MW-10	185
	180
	195
MW-11	180
	170
	195
SB-1	240
	300
	110
SB-2	750
	180
	90
SB-3	6500
	660
	80
SB-4	5100
	570
	2000
SB-5	3400
	69
	300

From ProUCL

Raw Statistics	
Number of Valid Samples	30
Number of Unique Samples	22
Minimum	69
Maximum	6800
Mean	992.3
Median	190
Standard Deviation	1881.551
Variance	3540236
Coefficient of Variation	1.896152
Skewness	2.413574

Gamma Statistics	
k hat	0.567949
k star (bias corrected)	0.533376
Theta hat	1747.164
Theta star	1860.412
nu hat	34.07694
nu star	32.00258
Approx.Chi Square Value (.05)	20.07199
Adjusted Level of Significance	0.041
Adjusted Chi Square Value	19.52649

Log-transformed Statistics	
Minimum of log data	4.234107
Maximum of log data	8.824678
Mean of log data	5.803194
Standard Deviation of log data	1.302135
Variance of log data	1.695556

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.521222
Shapiro-Wilk 5% Critical Value	0.927
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	1575.989

Gamma Distribution Test	
A-D Test Statistic	4.081414
A-D 5% Critical Value	0.803344
K-S Test Statistic	0.319477
K-S 5% Critical Value	0.168395
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	1582.113
Adjusted Gamma UCL	1626.312

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.807223
Shapiro-Wilk 5% Critical Value	0.927
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	1531.709
95% Chebyshev (MVUE) UCL	1667.844
97.5% Chebyshev (MVUE) UCL	2070.691
99% Chebyshev (MVUE) UCL	2862.007

95% Non-parametric UCLs	
CLT UCL	1557.345
Adj-CLT UCL (Adjusted for skewness)	1719.091
Mod-t UCL (Adjusted for skewness)	1601.218
Jackknife UCL	1575.989
Standard Bootstrap UCL	1553.696
Bootstrap-t UCL	1971.184
Hall's Bootstrap UCL	1562.635
Percentile Bootstrap UCL	1558.3
BCA Bootstrap UCL	1741.633
95% Chebyshev (Mean, Sd) UCL	2489.681
97.5% Chebyshev (Mean, Sd) UCL	3137.599
99% Chebyshev (Mean, Sd) UCL	**4410.308**

RECOMMENDATION
Data are Non-parametric (0.05)

Use 99% Chebyshev (Mean, Sd) UCL

UCL = 4410 ug/kg

UCL Calculations
80th DRS Fort Story, Virginia
Combined Surface/Subsurface Soils

	Dibenzo(a,h)anthracene (ug/kg)
MW-7	175
	30
	205
MW-8	1200
	32
	73
MW-9	180
	175
	180
MW-10	185
	180
	195
MW-11	180
	170
	195
SB-1	46
	67
	205
SB-2	160
	180
	205
SB-3	1500
	110
	200
SB-4	910
	110
	350
SB-5	690
	175
	64

From ProUCL

Raw Statistics	
Number of Valid Samples	30
Number of Unique Samples	20
Minimum	30
Maximum	1500
Mean	277.5667
Median	180
Standard Deviation	344.0269
Variance	118354.5
Coefficient of Variation	1.239439
Skewness	2.578204

Gamma Statistics	
k hat	1.233611
k star (bias corrected)	1.132472
Theta hat	225.0034
Theta star	245.0981
nu hat	74.01665
nu star	67.94831
Approx.Chi Square Value (.05)	49.9725
Adjusted Level of Significance	0.041
Adjusted Chi Square Value	49.08325

Log-transformed Statistics	
Minimum of log data	3.401197
Maximum of log data	7.31322
Mean of log data	5.168858
Standard Deviation of log data	0.918141
Variance of log data	0.842982

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.592805
Shapiro-Wilk 5% Critical Value	0.927
Data not normal at 5% significance level	
95% UCL (Assuming Normal Distribution)	
Student's-t UCL	384.2896
Gamma Distribution Test	
A-D Test Statistic	2.484962
A-D 5% Critical Value	0.769663
K-S Test Statistic	0.337538
K-S 5% Critical Value	0.163893
Data do not follow gamma distribution at 5% significance level	
95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	377.4114
Adjusted Gamma UCL	384.249
Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.892962
Shapiro-Wilk 5% Critical Value	0.927
Data not lognormal at 5% significance level	
95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	399.3185
95% Chebyshev (MVUE) UCL	479.6072
97.5% Chebyshev (MVUE) UCL	573.4517
99% Chebyshev (MVUE) UCL	757.791
95% Non-parametric UCLs	
CLT UCL	380.8806
Adj-CLT UCL (Adjusted for skewness)	412.472
Mod-t UCL (Adjusted for skewness)	389.2172
Jackknife UCL	384.2896
Standard Bootstrap UCL	379.4345
Bootstrap-t UCL	481.9032
Hall's Bootstrap UCL	409.9988
Percentile Bootstrap UCL	381.5667
BCA Bootstrap UCL	420.8333
95% Chebyshev (Mean, Sd) UCL	**551.351**
97.5% Chebyshev (Mean, Sd) UCL	669.8177
99% Chebyshev (Mean, Sd) UCL	902.5226

RECOMMENDATION
Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

UCL = 551 ug/kg

UCL Calculations
80th DRS Fort Story, Virginia
Groundwater

cis 1,2-DCE (ug/l)		
	2003	*2004*
MW-1	2.5	2.5
MW-2	2.5	2.5
MW-3	2.5	2.5
MW-5	2.5	2.5
MW-6	2.5	1.9
MW-7	0.7	2.5
MW-8	2.5	2.5
MW-9	2.5	11
MW-10	2.5	2.5
MW-11	2.5	2.5
MW-12		2.5
MW-13		2.5

From ProUCL:

Raw Statistics	
Number of Valid Samples	22
Number of Unique Samples	4
Minimum	0.7
Maximum	11
Mean	2.777273
Median	2.5
Standard Deviation	1.879192
Variance	3.531364
Coefficient of Variation	0.676632
Skewness	4.309134

Gamma Statistics	
k hat	4.782763
k star (bias corrected)	4.160871
Theta hat	0.580684
Theta star	0.667474
nu hat	210.4416
nu star	183.0783
Approx.Chi Square Value (.05)	152.775
Adjusted Level of Significance	0.0386
Adjusted Chi Square Value	150.7106

Log-transformed Statistics	
Minimum of log data	-0.356675
Maximum of log data	2.397895
Mean of log data	0.9133
Standard Deviation of log data	0.430432
Variance of log data	0.185272

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.326024
Shapiro-Wilk 5% Critical Value	0.911
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	3.46668

Gamma Distribution Test	
A-D Test Statistic	5.960744
A-D 5% Critical Value	0.746483
K-S Test Statistic	0.483116
K-S 5% Critical Value	0.185982
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	3.328153
Adjusted Gamma UCL	3.373741

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.46909
Shapiro-Wilk 5% Critical Value	0.911
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	3.276118
95% Chebyshev (MVUE) UCL	3.84265
97.5% Chebyshev (MVUE) UCL	4.327531
99% Chebyshev (MVUE) UCL	5.279986

95% Non-parametric UCLs	
CLT UCL	3.436275
Adj-CLT UCL (Adjusted for skewness)	3.829571
Mod-t UCL (Adjusted for skewness)	**3.528026**
Jackknife UCL	3.46668
Standard Bootstrap UCL	N/R
Bootstrap-t UCL	N/R
Hall's Bootstrap UCL	N/R
Percentile Bootstrap UCL	N/R
BCA Bootstrap UCL	N/R
95% Chebyshev (Mean, Sd) UCL	4.523644
97.5% Chebyshev (Mean, Sd) UCL	5.279301
99% Chebyshev (Mean, Sd) UCL	6.763642

RECOMMENDATION
Data are Non-parametric (0.05)

Use Student's-t UCL
or Modified-t UCL

UCL = 3.5 ug/l

UCL Calculations
80th DRS Fort Story, Virginia
Groundwater

PCE (ug/l)		
	2003	2004
MW-1	2.5	2.5
MW-2	2.5	2.5
MW-3	2.5	2.5
MW-5	0.3	2.1
MW-6	2.5	1.2
MW-7	4	2.5
MW-8	6	2.5
MW-9	0.8	6.3
MW-10	2.5	2.5
MW-11	2.5	2.5
MW-12		2.5
MW-13		2.5

From ProUCL:

Raw Statistics	
Number of Valid Samples	22
Number of Unique Samples	8
Minimum	0.3
Maximum	6.3
Mean	2.645455
Median	2.5
Standard Deviation	1.346151
Variance	1.812121
Coefficient of Variation	0.508854
Skewness	1.430674

Gamma Statistics	
k hat	3.658772
k star (bias corrected)	3.190151
Theta hat	0.723044
Theta star	0.829257
nu hat	160.986
nu star	140.3667
Approx.Chi Square Value (.05)	113.9847
Adjusted Level of Significance	0.0386
Adjusted Chi Square Value	112.2113

Log-transformed Statistics	
Minimum of log data	-1.203973
Maximum of log data	1.84055
Mean of log data	0.830005
Standard Deviation of log data	0.618783
Variance of log data	0.382893

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.710625
Shapiro-Wilk 5% Critical Value	0.911
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	3.139308

Gamma Distribution Test	
A-D Test Statistic	2.921063
A-D 5% Critical Value	0.747562
K-S Test Statistic	0.345639
K-S 5% Critical Value	0.186351
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	3.257749
Adjusted Gamma UCL	3.309236

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.704483
Shapiro-Wilk 5% Critical Value	0.911
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	3.685938
95% Chebyshev (MVUE) UCL	4.420321
97.5% Chebyshev (MVUE) UCL	5.143399
99% Chebyshev (MVUE) UCL	6.563746

95% Non-parametric UCLs	
CLT UCL	3.117528
Adj-CLT UCL (Adjusted for skewness)	3.211067
Mod-t UCL (Adjusted for skewness)	3.153898
Jackknife UCL	3.139308
Standard Bootstrap UCL	3.10437
Bootstrap-t UCL	3.413916
Hall's Bootstrap UCL	5.989901
Percentile Bootstrap UCL	3.140909
BCA Bootstrap UCL	3.2
95% Chebyshev (Mean, Sd) UCL	3.89646
97.5% Chebyshev (Mean, Sd) UCL	**4.437771**
99% Chebyshev (Mean, Sd) UCL	5.501071

RECOMMENDATION
Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

UCL = 4.4 ug/l

UCL Calculations
80th DRS Fort Story, Virginia
Groundwater

TCE (ug/l)		
	2003	2004
MW-1	2.5	2.5
MW-2	2.5	2.5
MW-3	2.5	2.5
MW-5	0.9	2.5
MW-6	2.5	1.5
MW-7	3	2.5
MW-8	0.8	2.5
MW-9	2.5	7.5
MW-10	2.5	2.5
MW-11	2.5	2.5
MW-12		2.5
MW-13		2.5

From ProUCL:

Raw Statistics	
Number of Valid Samples	22
Number of Unique Samples	6
Minimum	0.8
Maximum	7.5
Mean	2.554545
Median	2.5
Standard Deviation	1.227358
Variance	1.506407
Coefficient of Variation	0.48046
Skewness	3.114579

Gamma Statistics	
k hat	6.057323
k star (bias corrected)	5.261627
Theta hat	0.421728
Theta star	0.485505
nu hat	266.5222
nu star	231.5116
Approx.Chi Square Value (.05)	197.2837
Adjusted Level of Significance	0.0386
Adjusted Chi Square Value	194.928

Log-transformed Statistics	
Minimum of log data	-0.223144
Maximum of log data	2.014903
Mean of log data	0.853064
Standard Deviation of log data	0.422874
Variance of log data	0.178822

RECOMMENDATION
Data are Non-parametric (0.05)

Use Student's-t UCL
or Modified-t UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.504553
Shapiro-Wilk 5% Critical Value	0.911
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	3.004818

Gamma Distribution Test	
A-D Test Statistic	4.220601
A-D 5% Critical Value	0.745847
K-S Test Statistic	0.396806
K-S 5% Critical Value	0.185799
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	2.997748
Adjusted Gamma UCL	3.033976

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.630367
Shapiro-Wilk 5% Critical Value	0.911
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	3.06322
95% Chebyshev (MVUE) UCL	3.587544
97.5% Chebyshev (MVUE) UCL	4.034277
99% Chebyshev (MVUE) UCL	4.911796

95% Non-parametric UCLs	
CLT UCL	2.98496
Adj-CLT UCL (Adjusted for skewness)	3.170624
Mod-t UCL (Adjusted for skewness)	**3.033778**
Jackknife UCL	3.004818
Standard Bootstrap UCL	2.982675
Bootstrap-t UCL	3.228681
Hall's Bootstrap UCL	5.080487
Percentile Bootstrap UCL	3.013636
BCA Bootstrap UCL	3.240909
95% Chebyshev (Mean, Sd) UCL	3.695154
97.5% Chebyshev (Mean, Sd) UCL	4.188696
99% Chebyshev (Mean, Sd) UCL	5.158164

UCL = 3 ug/l

UCL Calculations
80th DRS Fort Story, Virginia
Groundwater

Bis(2-ethylhexyl) phthalate (ug/l)	
MW-1	5
MW-2	5
MW-3	5
MW-5	5
MW-6	5
MW-7	5
MW-8	5
MW-9	5
MW-10	5
MW-11	5

From ProUCL

Summary Statistics for	**UCL Calculations**
Number of Samples	10
Minimum	5
Maximum	5
Mean	5
Median	5
Standard Deviation	0
Variance	0
Coefficient of Variation	0
Skewness	0
Test for Normality, Raw Data	
N	10
Mean	5
Stdv	0
Slope	0
Intercept	0
Correlation, R	0
Shapiro-Wilk Statistic	0
Critical Value (0.05)	0.842
Data not Normal	
Test for Normality, Log-Adjusted Data	
N	10
Mean	1.6094
Stdv	0
Slope	0
Intercept	0.9487
Correlation, R	0
Shapiro-Wilk Statistic	0
Critical Value (0.05)	0.842
Data ar Lognormal	
95% Non-parametric UCL	
CLT	5
Jackknife	5
Standard Bootstrap	5
Bootstrap t	0
Chebyshev (Mean, Std)	5
Raw Statistics	
Number of Valid Samples	10
Number of Unique Samples	1
Minimum	5
Maximum	5
Mean	5
Median	5

Data contains constant observations with no distinct values. There is no need to calculate lognormal statistics.

UCL = 5 ug/l

UCL Calculations
80th DRS Fort Story, Virginia
Groundwater

Tt Antimony (ug/l)	
MW-1	5.1
MW-2	6.4
MW-3	3.1
MW-5	2.5
MW-6	3
MW-7	2.3
MW-8	4
MW-9	2.3
MW-10	2.8
MW-11	4.6

From ProUCL

Raw Statistics	
Number of Valid Samples	10
Number of Unique Samples	9
Minimum	2.3
Maximum	6.4
Mean	3.61
Median	3.05
Standard Deviation	1.377961
Variance	1.898778
Coefficient of Variation	0.381707
Skewness	1.024521

Gamma Statistics	
k hat	8.532216
k star (bias corrected)	6.039218
Theta hat	0.423102
Theta star	0.59776
nu hat	170.6443
nu star	120.7844
Approx.Chi Square Value (.05)	96.40091
Adjusted Level of Significance	0.0267
Adjusted Chi Square Value	92.6196

Log-transformed Statistics	
Minimum of log data	0.832909
Maximum of log data	1.856298
Mean of log data	1.223963
Standard Deviation of log data	0.356568
Variance of log data	0.127141

RECOMMENDATION
Data are normal (0.05)

Use Student's-t UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.878649
Shapiro-Wilk 5% Critical Value	0.842
Data are normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	**4.408778**

Gamma Distribution Test	
A-D Test Statistic	0.428663
A-D 5% Critical Value	0.726349
K-S Test Statistic	0.224783
K-S 5% Critical Value	0.266865
Data follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	4.523105
Adjusted Gamma UCL	4.707767

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.918006
Shapiro-Wilk 5% Critical Value	0.842
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	4.617293
95% Chebyshev (MVUE) UCL	5.386304
97.5% Chebyshev (MVUE) UCL	6.159319
99% Chebyshev (MVUE) UCL	7.677758

95% Non-parametric UCLs	
CLT UCL	4.326744
Adj-CLT UCL (Adjusted for skewness)	4.477592
Mod-t UCL (Adjusted for skewness)	4.432307
Jackknife UCL	4.408778
Standard Bootstrap UCL	4.305673
Bootstrap-t UCL	4.765649
Hall's Bootstrap UCL	4.444832
Percentile Bootstrap UCL	4.31
BCA Bootstrap UCL	4.43
95% Chebyshev (Mean, Sd) UCL	5.509389
97.5% Chebyshev (Mean, Sd) UCL	6.331256
99% Chebyshev (Mean, Sd) UCL	7.945655

UCL = 4.4 ug/l

UCL Calculations
80th DRS Fort Story, Virginia
Groundwater

Tt Arsenic (ug/l)	
MW-1	1.85
MW-2	1.85
MW-3	1.85
MW-5	1.85
MW-6	1.85
MW-7	1.85
MW-8	6
MW-9	1.85
MW-10	4.9
MW-11	4.8

From ProUCL

Raw Statistics	
Number of Valid Samples	10
Number of Unique Samples	4
Minimum	1.85
Maximum	6
Mean	2.865
Median	1.85
Standard Deviation	1.664173
Variance	2.769472
Coefficient of Variation	0.580863
Skewness	1.180215

Gamma Statistics	
k hat	4.096969
k star (bias corrected)	2.934545
Theta hat	0.699297
Theta star	0.976301
nu hat	81.93939
nu star	58.69091
Approx.Chi Square Value (.05)	42.07419
Adjusted Level of Significance	0.0267
Adjusted Chi Square Value	39.63995

Log-transformed Statistics	
Minimum of log data	0.615186
Maximum of log data	1.791759
Mean of log data	0.925591
Standard Deviation of log data	0.503169
Variance of log data	0.253179

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.647399
Shapiro-Wilk 5% Critical Value	0.842
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	3.82969

Gamma Distribution Test	
A-D Test Statistic	1.976948
A-D 5% Critical Value	0.729396
K-S Test Statistic	0.443564
K-S 5% Critical Value	0.267782
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	3.996499
Adjusted Gamma UCL	4.241919

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.631884
Shapiro-Wilk 5% Critical Value	0.842
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	4.158975
95% Chebyshev (MVUE) UCL	4.819143
97.5% Chebyshev (MVUE) UCL	5.682181
99% Chebyshev (MVUE) UCL	7.377453

95% Non-parametric UCLs	
CLT UCL	3.730617
Adj-CLT UCL (Adjusted for skewness)	3.940482
Mod-t UCL (Adjusted for skewness)	3.862425
Jackknife UCL	3.82969
Standard Bootstrap UCL	N/R
Bootstrap-t UCL	N/R
Hall's Bootstrap UCL	N/R
Percentile Bootstrap UCL	N/R
BCA Bootstrap UCL	N/R
95% Chebyshev (Mean, Sd) UCL	**5.158904**
97.5% Chebyshev (Mean, Sd) UCL	6.151479
99% Chebyshev (Mean, Sd) UCL	8.101199

RECOMMENDATION
Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

UCL = 5.2 ug/l

UCL Calculations
80th DRS Fort Story, Virginia
Groundwater

Tt Iron (ug/l)	
MW-1	650
MW-2	972
MW-3	292
MW-5	802
MW-6	884
MW-7	1390
MW-8	1020
MW-9	1120
MW-10	3240
MW-11	5130

From ProUCL

Raw Statistics	
Number of Valid Samples	10
Number of Unique Samples	10
Minimum	292
Maximum	5130
Mean	1550
Median	996
Standard Deviation	1486.742
Variance	2210401
Coefficient of Variation	0.959188
Skewness	1.980031

Gamma Statistics	
k hat	1.738594
k star (bias corrected)	1.283682
Theta hat	891.525
Theta star	1207.464
nu hat	34.77188
nu star	25.67365
Approx.Chi Square Value (.05)	15.1265
Adjusted Level of Significance	0.0267
Adjusted Chi Square Value	13.73729

Log-transformed Statistics	
Minimum of log data	5.676754
Maximum of log data	8.542861
Mean of log data	7.031654
Standard Deviation of log data	0.802035
Variance of log data	0.64326

RECOMMENDATION

Data follow gamma distribution (0.05)

Use Approximate Gamma UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.720366
Shapiro-Wilk 5% Critical Value	0.842
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	2411.836

Gamma Distribution Test	
A-D Test Statistic	0.699793
A-D 5% Critical Value	0.737488
K-S Test Statistic	0.257754
K-S 5% Critical Value	0.270495
Data follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	**2630.758**
Adjusted Gamma UCL	2896.798

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.931425
Shapiro-Wilk 5% Critical Value	0.842
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	3225.349
95% Chebyshev (MVUE) UCL	3222.832
97.5% Chebyshev (MVUE) UCL	3967.846
99% Chebyshev (MVUE) UCL	5431.28

95% Non-parametric UCLs	
CLT UCL	2323.326
Adj-CLT UCL (Adjusted for skewness)	2637.875
Mod-t UCL (Adjusted for skewness)	2460.899
Jackknife UCL	2411.836
Standard Bootstrap UCL	2273.704
Bootstrap-t UCL	4802.201
Hall's Bootstrap UCL	7450.497
Percentile Bootstrap UCL	2371
BCA Bootstrap UCL	2609.4
95% Chebyshev (Mean, Sd) UCL	3599.332
97.5% Chebyshev (Mean, Sd) UCL	4486.08
99% Chebyshev (Mean, Sd) UCL	6227.924

UCL = 2631 ug/l

UCL Calculations
80th DRS Fort Story, Virginia
Groundwater

Tt Manganese (ug/l)	
MW-1	19.6
MW-2	17.2
MW-3	36.2
MW-5	20
MW-6	10.6
MW-7	17.2
MW-8	52
MW-9	26.7
MW-10	122
MW-11	165

From ProUCL

Raw Statistics	
Number of Valid Samples	10
Number of Unique Samples	9
Minimum	10.6
Maximum	165
Mean	48.65
Median	23.35
Standard Deviation	52.34109
Variance	2739.589
Coefficient of Variation	1.07587
Skewness	1.735617

Gamma Statistics	
k hat	1.365245
k star (bias corrected)	1.022338
Theta hat	35.63462
Theta star	47.58699
nu hat	27.30491
nu star	20.44677
Approx.Chi Square Value (.05)	11.17964
Adjusted Level of Significance	0.0267
Adjusted Chi Square Value	10.00853

Log-transformed Statistics	
Minimum of log data	2.360854
Maximum of log data	5.105945
Mean of log data	3.475687
Standard Deviation of log data	0.895472
Variance of log data	0.801871

RECOMMENDATION
Assuming gamma distribution (0.05)

Use Approximate Gamma UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.715802
Shapiro-Wilk 5% Critical Value	0.842
Data not normal at 5% significance level	
95% UCL (Assuming Normal Distribution)	
Student's-t UCL	78.99114

Gamma Distribution Test	
A-D Test Statistic	0.79493
A-D 5% Critical Value	0.741666
K-S Test Statistic	0.232272
K-S 5% Critical Value	0.271829
Data follow approximate gamma distibution	
at 5% significance level	
95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	**88.97741**
Adjusted Gamma UCL	99.3887

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.89653
Shapiro-Wilk 5% Critical Value	0.842
Data are lognormal at 5% significance level	
95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	114.4522
95% Chebyshev (MVUE) UCL	104.897
97.5% Chebyshev (MVUE) UCL	130.4444
99% Chebyshev (MVUE) UCL	180.6272

95% Non-parametric UCLs	
CLT UCL	75.87513
Adj-CLT UCL (Adjusted for skewness)	85.58195
Mod-t UCL (Adjusted for skewness)	80.50521
Jackknife UCL	78.99114
Standard Bootstrap UCL	74.01339
Bootstrap-t UCL	157.171
Hall's Bootstrap UCL	213.9063
Percentile Bootstrap UCL	77.96
BCA Bootstrap UCL	82.91
95% Chebyshev (Mean, Sd) UCL	120.7972
97.5% Chebyshev (Mean, Sd) UCL	152.0154
99% Chebyshev (Mean, Sd) UCL	213.3374

UCL = 89.0 ug/l

UCL Calculations
80th DRS Fort Story, Virginia
Groundwater

Tt Vanadium (ug/l)	
MW-1	1.2
MW-2	4.2
MW-3	1.9
MW-5	0.88
MW-6	0.65
MW-7	1.1
MW-8	6.3
MW-9	0.2
MW-10	4.6
MW-11	2.3

From ProUCL

Raw Statistics	
Number of Valid Samples	10
Number of Unique Samples	10
Minimum	0.2
Maximum	6.3
Mean	2.333
Median	1.55
Standard Deviation	2.023419
Variance	4.094223
Coefficient of Variation	0.867303
Skewness	0.999851

Gamma Statistics	
k hat	1.366505
k star (bias corrected)	1.02322
Theta hat	1.707276
Theta star	2.280057
nu hat	27.33009
nu star	20.4644
Approx.Chi Square Value (.05)	11.19269
Adjusted Level of Significance	0.0267
Adjusted Chi Square Value	10.02081

Log-transformed Statistics	
Minimum of log data	-1.609438
Maximum of log data	1.84055
Mean of log data	0.438603
Standard Deviation of log data	1.043097
Variance of log data	1.088051

RECOMMENDATION
Data are normal (0.05)

Use Student's-t UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.877514
Shapiro-Wilk 5% Critical Value	0.842
Data are normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	**3.505938**

Gamma Distribution Test	
A-D Test Statistic	0.221266
A-D 5% Critical Value	0.741644
K-S Test Statistic	0.155203
K-S 5% Critical Value	0.271822
Data follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	4.265592
Adjusted Gamma UCL	4.764431

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.960699
Shapiro-Wilk 5% Critical Value	0.842
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	8.104977
95% Chebyshev (MVUE) UCL	6.226546
97.5% Chebyshev (MVUE) UCL	7.847552
99% Chebyshev (MVUE) UCL	11.0317

95% Non-parametric UCLs	
CLT UCL	3.385478
Adj-CLT UCL (Adjusted for skewness)	3.601651
Mod-t UCL (Adjusted for skewness)	3.539656
Jackknife UCL	3.505938
Standard Bootstrap UCL	3.324195
Bootstrap-t UCL	3.830607
Hall's Bootstrap UCL	3.465934
Percentile Bootstrap UCL	3.373
BCA Bootstrap UCL	3.6
95% Chebyshev (Mean, Sd) UCL	5.12209
97.5% Chebyshev (Mean, Sd) UCL	6.328932
99% Chebyshev (Mean, Sd) UCL	8.699538

UCL = 3.51 ug/l

Appendix E
Human Uptake Calculations

Remedial Investigation Report
80th Division Reserve Site
Fort Story, Virginia

MOVING TO PROTECT OUR WORLD

USATC ENVIRONMENTAL

CONSTRUCTION WORKER CONCENTRATION-IN-AIR CALCULATIONS
80th DRS, Fort Story, Virginia

Exposure point concs. (inhalation) for construction workers in a trench: Groundwater 6 ft deep	Molecular Weight MWi g/mol	Henry's Law Constant Hi atm-m3/mol	Gas-Phase Mass Transfer Coefficient KiG cm/s	Liquid-Phase Mass Transfer Coefficient KiL cm/s	Overall Mass Transfer Coefficient Ki cm/s	Groundwater Concentration Cgw ug/L	Volatilization Factor VF L/m3	Concentration of Contaminant in Trench Ctrench ug/m3	Concentration of Contaminant in Trench Ctrench mg/m3
VOCs									
cis-1,2-Dichloroethene	96.94	4.08E-03	4.74E-01	1.15E-03	1.13E-03	3.50E+00	1.11E+01	3.90E+01	3.90E-02
PCE	165.83	1.84E-02	3.96E-01	8.79E-04	8.76E-04	4.40E+00	8.62E+00	3.79E+01	3.79E-02
TCE	131.39	1.03E-02	4.28E-01	9.87E-04	9.82E-04	3.00E+00	9.66E+00	2.90E+01	2.90E-02
SVOCs									
bis-(2-Ethylhexyl)phthalate	390.56	1.02E-07	2.97E-01	5.72E-04	1.24E-06	5.00E+00	1.22E-02	6.09E-02	6.09E-05

COPC Concentrations in Site Air from Particulate Emissions
Site Worker Scenario
80th DRS, Fort Story, Virginia

Particulate Emission Factor

$PEF = Q/C_w \times ((3600sec/h)/(0.036 \times (1-V) \times (U_m/U_t)^3 \times F(x))$

PEF = 1.36E+09 m^3/kg

Obtained from USEPA (2001), where (all values are defaults):

PEF =	----	= Particulate Emission Factor (m^3/kg) for generation of dust via wind.
Q/C_{wind} =	93.77	= Inverse of mean conc. at center of a 0.5-acre-square source (g/m^2-s per kg/m^3)
V =	0.50	= Fraction of vegetative cover (unitless)
U_m =	5	= Mean annual windspeed (m/s)
U_t =	11.32	= Equivalent threshold value of windspeed at 7 m (m/s)
F(x) =	0.194	= Function dependent on U_m/U_t derived using Cowherd et al. (1985) (unitless)

COPC Concentrations in Air

$COPC_A = COPC_S * (1/PEF)$

Benzo(a)anthracene$_A$ =	3.55E-09	mg/m^3
Benzo(a)pyrene$_A$ =	3.54E-09	mg/m^3
Benzo(b)fluoranthene$_A$ =	4.59E-09	mg/m^3
Dibenzo(a,h)anthracene$_A$ =	7.58E-10	mg/m^3

Derived from USEPA (2001), where:

$COPC_A$ =	----	= COPC concentration in air due to dust generation/Particulate emission (mg/m^3).
PEF =	1.36E+09	= Particulate Emission Factor (m^3/kg).
$COPC_S$ =	-----	= 95th % UCL COPC concentration in site soils (mg/kg), as provided below.
Benzo(a)anthracene$_S$ =	4.83	= 95th % UCL Benzo(a)anthracene concentration in site soils (mg/kg).
Benzo(a)pyrene$_S$ =	4.81	= 95th % UCL Benzo(a)pyrene concentration in site soils (mg/kg).
Benzo(b)fluoranthene$_S$ =	6.24	= 95th % UCL Benzo(b)fluoranthene concentration in site soils (mg/kg).
Dibenzo(a,h)anthracene$_S$ =	1.03	= 95th % UCL Dibenzo(a,h)anthracene concentration in site soils (mg/kg).

COPC Concentrations in Site Air from Particulate Emissions
Construction Worker Scenario
80th DRS, Fort Story, Virginia

Particulate Emission Factor for Road Travel

$$PEF_{road} = Q/C_{sr} \times F_D^{-1} \times ((T \times A_R)/(556 \times (W/3)^{0.4} \times (365-p)/365 \times VKT)$$

Obtained from USEPA (2001), where:

PEF_{road} =	----	= Particulate Emission Factor (m^3/kg) for generation of dust via vehicle traffic.
Q/C_{sr} =	23.02	= Default Value, Inverse of 1-h average air concentration along a straight road segment bisecting a 0.5-acre square site (g/m^2 -s per kg/m^3)
F_d =	0.185	= Default Value, Dispersion correction factor (unitless)
T =	3,456,000	= Total time over which construction occurs (seconds), assumed 5 days/week for 6 months
A_R =	840	= Surface area of contaminated road segment (m^2), assumes 2 roads totaling 240 m in length, each 3.5 m wide.
W =	9.6	= Mean vehicle weight (tons), assumes 40 trucks per day at 20 tons each and 60 cars per day at 2 tons each. Assumption based upon professional judgement of traffic at a medium to larger scale construction site.
p=	130	= Number of days with at least 0.01 inches of precipitation.
VKT =	2,400	= Sum of fleet vehicle kilometers traveled during the exposure duration (km), assumes each vehicle travels road twice per day.

$$\boxed{PEF_{road} = 264{,}037 \ m^3/kg}$$

Particulate Emission Factor for Construction Activities

$$PEF_{const.} = Q/C_{sa} \times F_D^{-1} [(M_{wind} + M_{excav} + M_{doz} + M_{grade})/(A_c \times T)]^{-1}$$

Obtained from USEPA (2001), where:

PEF =	----	= Particulate Emission Factor (m^3/kg) for generation of dust via construction activities.
Q/C_{sa} =	see below	= Inverse of 1-h ave. air concentration at the center of the square emmission source (g/m^2-s per kg/m^3).
F_D =	see below	= Dispersion Factor (unitless)
M_{wind} =	see below	= Unit mass emitted from wind erosion (g)
M_{excav} =	see below	= Unit mass emitted from excavation (g)
M_{doz} =	see below	= Unit mass emitted from bull dozing (g)
M_{grade} =	see below	= Unit mass emitted from grading (g)
A_c =	5,000	= Areal extent of site soil contamination (m^2)
T =	3,456,000	= Total time over which construction occurs (seconds), assumed 5 days/week for 4.5 months

$$Q/C_{sa} = A \times \exp[(\ln A_c - B)^2/C]$$

Q/C_{sa} =	11.80	g/m^2-s per kg/m^3

A =	2.4538	Default, Constant (unitless)
B =	17.566	Default, Constant (unitless)
C =	189.04	Default, Constant (unitless)
Ac =	1.4	= Areal extent of site soil contamination (acres)

$F_D = 0.1852 + (5.3537/t_c) + (-9.6318/t_c^2)$

F_D =	0.191	

t_c =	960	= Duration of construction (hrs)

$M_{wind} = 0.036 \times (1-V) \times (U_m/U_t)^3 \times F(x) \times A \times ED \times 8{,}760 hr/yr$

M_{wind} =	14,793	g

V =	0	= Default, Fraction of vegetative cover (unitless)
U_m =	4.69	= Default, Mean windspeed during construction (m/s)
U_t =	11.32	= Default, Equivalent threshold value of windspeed at 7m (m/s)
F(x) =	0.194	= Default, Function dependent on U_m/U_t (unitless)
A =	5,000	= Areal extent of site soil contamination (m^2)
ED =	0.68	= Duration that soil is exposed, equals 2x total construction duration (yr) to allow for revegetation of site.

$M_{excav} = 0.35 \times 0.0016\ [(U_m/2.2)^{1.3}/(M/2)^{1.4}] \times D_{soil} \times A_{soil} \times d_{excav} \times N_A \times 10^3$ g/kg

M_{excav} =	703	g

U_m =	4.69	= Default, Mean windspeed during construction (m/s)
M =	12	= Default, Gravimetric soil moisture content (%)
D_{soil} =	1.68	= Default, Insitu soil density (Mg/m^3)
A_{excav} =	1430	= Areal extent of excavation (m^2), assumes 25% of site is excavated in some form. Assumption based upon professional judgement.
d_{excav} =	1.2	= Average depth of excavation (m). Assumption based upon professional judgement.
N_A =	2	= Default, Number of times soil is dumped from excavator (unitless)

$M_{doz} = 0.75 \times (0.45 \times s^{1.5})/M^{1.4} \times VKT/S \times 1000$ g/kg

M_{doz} =	11,320	g

s =	6.9	= Default, Soil silt content (%).
M =	12	= Default, Gravimetric soil moisture content (%)
VKT =	684	= Sum of dozing distance (km), assumes dozer operating continuously for 4 hrs/d for 1 wk at average speed. Assumption based upon professional judgement.
S =	11.4	= Default, Average dozing speed (kph)

$M_{grade} = 0.60 \times 0.0056(S)^2 \times VKT \times 1000$ g/kg

M_{grad} =	224,009	g

S =	11.4	= Default, Average grading speed (kph)
VKT =	513	= Sum of grading distance (km), assumes grader operating continuously for 4 hrs/d for 2 wk at average speed. Assumption based upon professional judgement.

$PEF_{const.}$ = 4.3E+06 m^3/kg

Total Site Particulate Emission Factor for All Activities

$PEF_{Total} = PEF_{road} + PEF_{const.}$

PEF_{total} =	4.5E+06	m^3/kg

COPC Concentrations in Air

$COPC_A = COPC_S * (1/PEF_{total})$

$Benzo(a)anthracene_A$ =	7.56E-07	mg/m^3
$Benzo(a)pyrene_A$ =	7.34E-07	mg/m^3
$Benzo(b)fluoranthene_A$ =	9.75E-07	mg/m^3
$Dibenzo(a,h)anthacene_A$ =	1.22E-07	mg/m^3

Derived from USEPA (2001), where:

$COPC_A$ =	----	= COPC concentration in air due to dust generation/Particulate emission (mg/m^3).
PEF_{Total} =	4,524,812	= Particulate Emission Factor (m^3/kg).
$COPC_S$ =	-----	= 95th % UCL COPC concentration in site soils (mg/kg), as provided below.
$Benzo(a)anthracene_S$ =	3.42	= 95th % UCL Benzo(a)anthracene concentration in site soils (mg/kg).
$Benzo(a)pyrene_S$ =	3.32	= 95th % UCL Benzo(a)pyrene concentration in site soils (mg/kg).
$Benzo(b)fluoranthene_S$ =	4.41	= 95th % UCL Benzo(b)fluoranthene concentration in site soils (mg/kg).
$Dibenzo(a,h)anthracene_S$ =	0.55	= 95th % UCL Dibenzo(a,h)anthracene concentration in site soils (mg/kg).

Appendix F
Human Toxicity Data

Remedial Investigation Report
80th Division Reserve Site
Fort Story, Virginia

MOVING TO PROTECT OUR WORLD
USATC ENVIRONMENTAL

HHRA Toxicological Profiles
For Chemicals of Potential Concern
80th Division Reserve Site, Fort Story, VA

Aluminum

Aluminum is a silver-white flexible metal with a vast number of uses. It makes up about 8% of the earth's crust. The aluminum content of seawater ranges from 3 to 2400 ppb. Aluminum metal is used as a structural material in the construction, automotive, and aircraft industries, in the production of metal alloys, and in the electrical industry in power lines, insulated cables and wiring. Other uses of aluminum metal include cooking utensils, decorations, fencing, highway signs, cans, food packaging, foil, and dental crowns and dentures. Aluminum powder is used in paints and fireworks, and natural aluminum minerals are used in water purification, sugar refining, and in the brewing and paper industries. Aluminum borate is used in the production of glass and ceramics, and aluminum chloride is used to make rubber, lubricants, wood preservatives, and cosmetics. Aluminum chlorohydrate is the active ingredient in antiperspirants and deodorants, while aluminum hydroxide is used as a pharmaceutical to lower plasma phosphorus levels of patients with kidney failure. Until recently, aluminum has existed in forms not available to humans and most other species. However, acid rain has increased the availability of aluminum to biological systems and has resulted in destructive effects on fish and plant species. It is unknown if humans are susceptible to this increased bioavailability. It is poorly absorbed and efficiently eliminated; however, when absorption does occur, aluminum is distributed mainly in bone, liver, testes, kidneys, and brain. Aluminum may be involved in Alzheimer's disease (dialysis dementia) and in Amyotrophic Lateral Sclerosis and Parkinsonism-Dementia Syndromes of Guam. Aluminum content of brain, muscle, and bone increases in Alzheimer's patients. Neurofibrillary tangles are found in patients suffering from aluminum encephalopathy and Alzheimer's disease. Symptoms of "dialysis dementia" include speech disorders, dementia, convulsions, and myoclonus. Neurological effects have also been observed in rats orally exposed to aluminum compounds.

The respiratory system appears to be the primary target following inhalation exposure to aluminum. Alveolar proteinosis has been observed in guinea pigs, rats, and hamsters exposed to aluminum powders. Rats and guinea pigs exposed to aluminum chlorohydrate exhibited an increase in alveolar macrophages, increased relative lung weight, and multifocal granulomatous pneumonia. Male rats exposed to aluminum (as aluminum chloride) via gavage for 6 months exhibited decreased spermatozoa counts and sperm motility, and testicular histological and histochemical changes. Male rats exposed to drinking water containing aluminum (as aluminum potassium sulfate) for a lifetime exhibited increases in unspecified malignant and nonmalignant tumors and similarly exposed female mice exhibited an increased incidence of leukemia. Rats and guinea pigs exposed via inhalation to aluminum chlorohydrate developed lung granulomas while granulomatous foci developed in similarly exposed male hamsters.

Antimony

Antimony is a naturally occurring silvery-white metal that is found in the earth's crust. Antimony ores are mined and then mixed with other metals to form antimony alloys or combined with oxygen to form antimony oxide. Little antimony is currently mined in the United States. It is brought into this country from other countries for processing. However, there are companies in the United States that produce antimony as a by-product of smelting lead and other metals. Antimony is used in lead storage batteries, solder, sheet and pipe metal, bearings, castings, and pewter. Antimony oxide is added to textiles and plastics to prevent them from catching fire. It is also used in paints, ceramics, and fireworks, and as enamels for plastics, metal, and glass.

Metallic antimony and a few trivalent antimony compounds are the most significant regarding exposure potential and toxicity. Antimony is a common urban air pollutant, occurring at an average concentration of 0.001 $\mu g/m^3$. Exposure to antimony may occur via inhalation and by ingestion of contaminated food.

Acute oral and inhalation exposure of humans and animals to high doses of antimony or antimony-containing compounds (antimonials) may cause gastrointestinal disorders (vomiting, diarrhea), respiratory difficulties, and death at extremely high doses. Subchronic and chronic oral exposure may affect hematologic parameters. Long-term oral exposure to high doses of antimony or antimonials has been shown to adversely affect longevity in animals. Long-term occupational exposure of humans has resulted in electrocardiac disorders, respiratory disorders, and possibly increased mortality. Antimony levels for these occupational exposure evaluations ranged from 2.2 to 11.98 mg Sb/m^3. Based on limited data, occupational exposure of women to metallic antimony and several antimonials has reportedly caused alterations in the menstrual cycle and an increased incidence of spontaneous abortions.

The Department of Health and Human Services, the International Agency for Research on Cancer, and the Environmental Protection Agency (EPA) have not classified antimony as to its human carcinogenicity.

Arsenic

Arsenic is a naturally occurring element widely distributed in the earth's crust. In the environment, arsenic is combined with oxygen, chlorine, and sulfur to form inorganic arsenic compounds. Arsenic in animals and plants combines with carbon and hydrogen to form organic arsenic compounds. Inorganic arsenic compounds are mainly used to preserve wood. Organic arsenic compounds are used as pesticides, primarily on cotton plants. Arsenic cannot be destroyed in the environment. It can only change its form. Arsenic in air will settle to the ground or is washed out of the air by rain. Many arsenic compounds can dissolve in water. Fish and shellfish can accumulate arsenic, but the arsenic in fish is mostly in a form that is not harmful. The toxicity of inorganic arsenic depends on its valence state and also on the physical and chemical properties of the compound in which it occurs.

Water soluble inorganic arsenic compounds are absorbed through the gastrointestinal tract and lungs; distributed primarily to the liver, kidney, lung, spleen, aorta, and skin; and excreted mainly in the urine at rates as high as 80%. Symptoms of acute inorganic arsenic poisoning in humans are nausea, anorexia, vomiting, epigastric and abdominal pain, and diarrhea. Dermatitis (exfoliative erythroderma), muscle cramps, cardiac abnormalities, hepatotoxicity, bone marrow suppression and hematologic abnormalities (anemia), vascular lesions, and peripheral neuropathy (motor dysfunction, paresthesia) have also been reported. Oral doses as low as 20-60 g/kg/day have been reported to cause toxic effects in some individuals. Severe exposures can result in acute encephalopathy, congestive heart failure, stupor, convulsions, paralysis, coma, and death. The acute lethal dose to humans has been estimated to be about 0.6 mg/kg/day.

General symptoms of chronic arsenic poisoning in humans are weakness, general debility and lassitude, loss of appetite and energy, loss of hair, hoarseness of voice, loss of weight, and mental disorders. Primary target organs are the skin (hyperpigmentation and hyperkeratosis), nervous system (peripheral neuropathy), and vascular system. Anemia, leukopenia, hepatomegaly, and portal hypertension have also been reported. In addition, possible reproductive effects include a high male to female birth ratio.

Epidemiological studies have revealed an association between arsenic concentrations in drinking water and increased incidences of skin cancers, as well as cancers of the liver, bladder, respiratory and gastrointestinal tracts. Occupational exposure studies have shown a clear correlation between exposure to arsenic and lung cancer mortality. Several studies have shown that inorganic arsenic can increase the risk of lung cancer, skin cancer, bladder cancer, liver cancer, kidney cancer, and prostate cancer. The World Health Organization (WHO), the Department of Health and Human Services (DHHS), and the EPA have determined that inorganic arsenic is a human carcinogen and is classified: A; human carcinogen.

Bis(2-ethylhexyl)phthalate

Bis(2-ethylhexyl)phthalate or di(2-ethylhexyl)phthalate (DEHP) is a clear oily liquid and is practically insoluble in water. Bis(2-ethylhexyl)phthalate is primarily used in the plastics industry as a plasticizer with such varied applications as wire insulation, food packaging and biomedical applications such as tubing and blood containers. Other uses include vacuum pump oil and as a dielectric fluid in capacitors. The combined annual production of dioctyl phthalates in the United States exceeds 300 million pounds. The wide-spread uses of bis(2-ethylhexyl)phthalate have made the compound, along with other phthalic acid esters, ubiquitous in the environment. It has been detected in ground water, surface water, drinking water, air, soil, plants, fish and animals.

There is no evidence that DEHP causes serious health effects in humans. Most of what we know about the health effects of DEHP comes from high exposures to rats and mice. Brief exposure to very high levels of

DEHP in food or water damaged sperm, but the effect reversed when DEHP was removed from the diet. Longer exposures to high doses affected the ability of both males and females to reproduce and caused birth defects. High levels of DEHP damaged the livers of rats and mice. Long exposures of rats to DEHP caused kidney damage similar to the damage seen in the kidneys of long-term dialysis patients. Whether or not DEHP contributes to human kidney damage, is unclear at present. Health effects from skin contact with products containing DEHP do not cause harmful effects because it cannot be taken up easily through the skin.

There is no direct evidence in any study on humans exposed to bis(2-ethylhexyl)phthalate that it causes cancer. Bis(2-ethylhexyl)phthalate is known to induce the proliferation of peroxisomes, which has been associated with carcinogenesis. Dose-dependent, statistically-significant increases in the incidences of hepatocellular carcinomas and combined carcinomas and adenomas were seen in mice and rats exposed to bis(2-ethylhexyl)phthalate in their diet. An increased incidence of neoplastic nodules and hepatocellular carcinomas was also reported in exposed rats.

Based on U.S. EPA guidelines, bis(2-ethylhexyl)phthalate was assigned to weight-of-evidence Group B2, probable human carcinogen, on the basis of an increased incidence of liver tumors in rats and mice.

Manganese

Manganese is a silver-colored, naturally occurring metal that is found in many types of rocks and makes up about 0.10% of the earth's crust. Manganese is not found alone but combines with other substances such as oxygen, sulfur, or chlorine. Manganese can also be combined with carbon to make organic manganese compounds, including pesticides (e.g., maneb or mancozeb) and methylcyclopentadienyl manganese tricarbonyl (MMT), a fuel additive in some gasolines. Manganese is an essential trace element and is necessary for good health. Normal nutritional requirements of manganese are satisfied through the diet, which is the normal source of the element, with minor contributions from water and air. The National Research Council recommends a dietary allowance of 2-5 mg/day for a safe and adequate intake of manganese for an adult human. Manganese can be found in several food items, including grains, cereals, and tea.

Manganese can elicit a variety of serious toxic responses upon prolonged exposure to elevated concentrations, either orally or by inhalation. The central nervous system is the primary target. Initial symptoms are headache, insomnia, disorientation, anxiety, lethargy, and memory loss. These symptoms progress with continued exposure and eventually include motor disturbances, tremors, and difficulty in walking, symptoms similar to those seen with Parkinsonism. These motor difficulties are often irreversible. Some individuals exposed to very high levels of manganese for long periods of time at work developed mental and emotional disturbances and slow and clumsy body movements. This combination of symptoms is a disease called "manganism."

There are no human cancer data available for manganese. Some conflicting data exist on possible carcinogenesis following injections of manganese chloride and manganese sulfate in mice. However, the EPA weight-of-evidence classification is D, not classifiable as to human carcinogenicity, based on no evidence in humans and inadequate evidence in animals.

Tetrachloroethylene

Tetrachloroethylene is a manufactured organic chemical that is widely used for dry cleaning of fabrics and for metal-degreasing. It is also used to make other chemicals and is used in some consumer products. Other names for tetrachloroethylene include perchloroethylene, PCE, and tetrachloroethene. It is a nonflammable liquid at room temperature that evaporates easily into the air and has a sharp, sweet odor.

Tetrachloroethylene is rapidly absorbed by the lungs and the digestive tract, but not through the skin. High concentrations of tetrachloroethylene in the air can cause dizziness, headache, sleepiness, confusion, nausea, difficulty in speaking and walking, unconsciousness, and death. Acute exposure to high concentrations of the chemical (estimated to be greater than 1500 ppm for a 30-minute exposure) may be fatal to humans. Irritation may result from repeated or extended skin contact with Tetrachloroethylene. These symptoms occur almost entirely in work (or hobby) environments due to accidental exposure to high concentrations or intention use of tetrachloroethylene to get a "high". In industry, most workers are exposed to levels lower than those causing obvious nervous system effects. The health effects of breathing air or drinking water with low levels of tetrachloroethylene are not known. Results from some studies suggest that women who work in dry cleaning industries where exposures to tetrachloroethylene can be quite high may have more menstrual problems and spontaneous abortions than women who are not exposed. It is not known, however, if tetrachloroethylene was responsible for these problems because other possible causes were not considered. Results of animal studies, conducted with amounts much higher than those that most humans are exposed to, show that tetrachloroethylene can cause liver and kidney damage.

Epidemiology studies of dry cleaning and laundry workers have demonstrated excesses in mortality due to various types of cancer, including liver cancer, but the data are regarded as inconclusive because of various confounding factors. The tenuous finding of an excess of liver tumors in humans is strengthened by the results of carcinogenicity bioassays, in which tetrachloroethylene, administered either orally or by inhalation, induced hepatocellular tumors in mice. The chemical also induced mononuclear cell leukemia and renal tubular cell tumors in rats. Although U.S. EPA's Science Advisory Board recommended a weight-of-evidence classification of C-B2 continuum (C = possible human carcinogen; B2 = probable human carcinogen), the agency has not adopted a current position on the weight-of-evidence classification. The Department of Health and Human Services (DHHS) has determined that tetrachloroethylene may reasonably be anticipated to be a carcinogen.

Trichloroethene

Trichloroethene (TCE), also known as trichlorothylene, is a colorless, highly volatile liquid that is miscible with water and a number of organic solvents. TCE is a man-made chemical and is not known to occur naturally. It is mainly used as a solvent in industrial degreasing and cleaning of metals, but it is also used as a solvent for waxes, fats, resins, oils, and in numerous other applications. Prior to 1977, TCE had been used as an anesthetic, grain fumigant, disinfectant, and extractant of spice oleoresins in food and of caffeine in the production of decaffeinated coffee. The evaluation of the toxicity of TCE is complicated by the presence or absence of other chemicals. Industrial grade TCE usually contains stabilizers that are known to be toxic such as triethylamine, triethanolamine, epichlorohydrin, or stearates. In the absence of stabilizers, TCE readily decomposes. These decomposition products are also toxic.

Human and animal data indicate that exposure to TCE can result in toxic effects on a number of organs and systems, including the liver, kidney, blood, skin, immune system, reproductive system, nervous system, and cardiovascular system. Breathing small amounts of TCE may cause headaches, lung irritation, dizziness, poor coordination, and difficulty concentrating. Breathing large amounts of TCE may cause impaired heart function, unconsciousness, and death. Breathing it for long periods may cause nerve, kidney, and liver damage. Drinking large amounts of TCE may cause nausea, liver damage, unconsciousness, impaired heart function, or death. Drinking small amounts of TCE for long periods may cause liver and kidney damage, impaired immune system function, and impaired fetal development in pregnant women, although the extent of some of these effects is not yet clear. Skin contact with TCE for short periods may cause skin rashes.

Epidemiologic studies have been inadequate to determine if a correlation exists between exposure to TCE and increased cancer risk in humans. Some human studies with exposure over long periods to high levels of TCE in drinking water or in workplace air have found evidence of increased cancer; however, these results are inconclusive because the cancer could have been caused by other chemicals. Some studies with mice and rats have suggested that high levels of TCE may cause liver or lung cancer. Although U.S. EPA's Science Advisory Board recommended a weight-of-evidence classification of C-B2 continuum (C = possible human carcinogen; B2 = probable human carcinogen), the agency has not adopted a current position on the weight-of-evidence classification. In an earlier evaluation, TCE was assigned to weight-of-evidence Group B2, probable human carcinogen. The International Agency for Research on Cancer (IARC) has determined that TCE is not classifiable as to human carcinogenicity

Benzo[a]anthracene

Benz[a]anthracene is a polycyclic aromatic hydrocarbon (PAH) containing four aromatic rings two of which share carbons with only one other ring. It is soluble in alcohol, ether and benzene but practically insoluble in water. There is no commercial application for benz[a]anthracene, however, it is a ubiquitous contaminant formed during the incomplete combustion of organic material. Benz[a]anthracene is found in various kinds of smoke and flue gases, tobacco smoke, automobile exhaust, roasted coffee and in charcoal broiled, barbecued or smoked meats. It is also found in creosote, coal tar, petroleum asphalt, and a variety of foods, including vegetable oils and baker's yeast. It is an atmospheric contaminant near power plants and busy highways, and tends to bind to particulate matter in the atmosphere. In general, there is a region in the structure of PAH's that is known to react with DNA, which may account for both their toxicity and carcinogenicity.

The toxic effects of benz[a]anthracene and similar PAHs are primarily directed toward tissues that contain proliferating cells. Animal studies indicate that exposure to PAH's with distinct chemical structure can damage the hematopoietic system leading to progressive anemia as well as agranulocytosis. The lymphoid system can also be affected resulting in lymphopenia. Toxic effects have been observed in the rapidly dividing cells of the intestinal epithelium, spermatogonia and resting spermatocytes in the testis and primary oocytes of the ovary. Most of these effects have occurred following both oral and parenteral exposure. Epithelial proliferation and cell hyperplasia in the respiratory tract have been reported following subchronic inhalation exposure.

The primary concern with benz[a]anthracene exposure is its potential carcinogenicity. There is no unequivocal, direct evidence of the carcinogenicity of the compound to humans, however, benz[a]anthracene and other known carcinogenic PAHs are components of coal tar, soot, coke oven emissions and tobacco smoke. There is adequate evidence of its carcinogenic properties in animals. Oral exposures of mice to benz[a]anthracene have resulted in hepatomas, pulmonary adenomas and forestomach papillomas. The EPA weight-of-evidence classification is: B2, probable human carcinogen, for both oral and inhalation exposure based on adequate animal evidence and no human evidence.

Benzo[a]pyrene

Benzo[a]pyrene is one of many chemicals known as polycyclic aromatic hydrocarbons (PAH). It exists as yellowish plates and needles. Benzo[a]pyrene is practically insoluble in water but is soluble in benzene, toluene, xylene and sparingly soluble in alcohol and methanol. No current commercial production or use of benzo[a]pyrene is known. It occurs ubiquitously in products of incomplete combustion and in fossil fuels. It has been identified in surface water, tap water, rain water, groundwater, waste water, and sewage sludge. Benzo[a]pyrene is primarily released to the air and removed from the atmosphere by photochemical

oxidation and dry deposition to land or water. Biodegradation is the most important transformation process in soil or sediment.

No data are available on the systemic (non-carcinogenic) effects of benzo[a]pyrene in humans. Benzo[a]pyrene is readily absorbed following inhalation, oral, and dermal routes of administration. Following inhalation exposure, benzo[a]pyrene is rapidly distributed to several tissues in rats. The metabolism of benzo[a]pyrene is complex and includes the formation of a proposed ultimate carcinogen, benzo[a]pyrene 7,8 diol-9,10-epoxide. Dietary administration of doses as low as 10 mg/kg during gestation caused reduced fertility and reproductive capacity in mice offspring, and treatment by gavage with 120 mg/kg/day during gestation caused stillbirths, resorptions, and malformations.

Numerous epidemiological studies have shown a clear association between exposure to various mixtures of PAHs containing benzo[a]pyrene (e.g., coke oven emissions, roofing tar emissions, and cigarette smoke) and increased risk of lung cancer and other tumors. However, each of the mixtures also contained other potentially carcinogenic PAHs; therefore, it is not possible to evaluate the contribution of benzo[a]pyrene to the carcinogenicity of these mixtures. Based on United States Environmental Protection Agency (EPA) guidelines, benzo[a]pyrene was assigned to weight-of-evidence group B2, probable human carcinogen.

Benzo[b]fluoranthene

Benzo[b]fluoranthene is a polycyclic aromatic hydrocarbon (PAH) with one five-membered carbon ring and four six-membered carbon rings. It is a crystalline solid with. Benzo[b]fluoranthene is virtually insoluble in water and is slightly soluble in benzene and acetone. There is no commercial production or known use of this compound. Benzo[b]fluoranthene is found in fossil fuels and occurs ubiquitously in products of incomplete combustion. It has been detected in mainstream cigarette smoke; urban air; gasoline engine exhaust; emissions from burning coal and from oil-fired heating; broiled and smoked food; oils and margarine; and in soils, groundwater, and surface waters at hazardous waste sites.

No absorption data were available for benzo[b]fluoranthene; however, by analogy to structurally-related PAHs, primarily benzo[a]pyrene, it would be expected to be absorbed from the gastrointestinal tract, lungs, and skin. No data were found concerning the acute, subchronic, chronic, developmental, or reproductive toxicity of benzo[b]fluoranthene in humans.

No long-term oral or inhalation bioassays were available to assess the carcinogenicity of benzo[b]fluoranthene in humans. Benzo[b]fluoranthene was tested for carcinogenicity in animals in dermal application, lung implantation, subcutaneous (s.c.) injection, and intraperitoneal (i.p.) injection studies. Dermal applications of 0.01-0.5% solutions of benzo[b]fluoranthene for life produced a high incidence of skin papillomas and carcinomas in mice. Sarcomas and carcinomas of the lungs and thorax were seen in rats receiving single lung implants of 0.1-1 mg benzo[b]fluoranthene. Newborn mice receiving 0.5 umol

benzo[b]fluoranthene via i.p. injection developed liver and lung tumors and mice administered three s.c. injections of 0.6 mg benzo[b]fluoranthene developed injection site sarcomas.

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

Appendix G
CDI Calculations

Remedial Investigation Report
80th Division Reserve Site
Fort Story, Virginia

MOVING TO PROTECT OUR WORLD

USATC ENVIRONMENTAL

CDI CALCULATIONS FOR SURFACE SOIL - INGESTION
80th DRS, FORT STORY VIRGINIA

COPC	Conc (mg/kg)	IR (mg/day)	CF (kg/mg)	FI	EF (days/yr)	ED (yrs)	BW (kg)	CDI (mg/kg-day)
Non-Carcinogenic: Ingestion of Chemicals in Surface Soil - Ft Story/Industrial Worker Population (Adults)								
Benzo(a)anthracene	4.83	100	1.00E-06	1	250	25	70	4.73E-06
Benzo(a)pyrene	4.81	100	1.00E-06	1	250	25	70	4.71E-06
Benzo(b)fluoranthene	6.24	100	1.00E-06	1	250	25	70	6.11E-06
Dibenzo(a,h)anthracene	1.03	100	1.00E-06	1	250	25	70	1.01E-06
Carcinogenic: Ingestion of Chemicals in Surface Soil - Ft Story/Industrial Worker Population (Adults)								
Benzo(a)anthracene	4.83	100	1.00E-06	1	250	25	70	1.69E-06
Benzo(a)pyrene	4.81	100	1.00E-06	1	250	25	70	1.68E-06
Benzo(b)fluoranthene	6.24	100	1.00E-06	1	250	25	70	2.18E-06
Dibenzo(a,h)anthracene	1.03	100	1.00E-06	1	250	25	70	3.60E-07

CDI CALCULATIONS FOR SURFACE SOIL - DERMAL CONTACT
80 DRS, FORT STORY VIRGINIA

COPC	Conc (mg/kg)	CF (kg/mg)	SA (cm^2)	AF (mg/cm^2)	ABS	EF (days/yr)	ED (yrs)	BW (kg)	CDI (mg/kg-day)
Non-Carcinogenic: Dermal Contact with Chemicals in Surface Soil - Ft Story/Industrial Worker Population (Adults)									
Benzo(a)anthracene	4.83	1.00E-06	3300	0.2	0.13	250	25	70	4.05E-06
Benzo(a)pyrene	4.81	1.00E-06	3300	0.2	0.13	250	25	70	4.04E-06
Benzo(b)fluoranthene	6.24	1.00E-06	3300	0.2	0.13	250	25	70	5.24E-06
Dibenzo(a,h)anthracene	1.03	1.00E-06	3300	0.2	0.13	250	25	70	8.65E-07
Carcinogenic: Dermal Contact with Chemicals in Surface Soil - Ft Story/Industrial Worker Population (Adults)									
Benzo(a)anthracene	4.83	1.00E-06	3300	0.2	0.13	250	25	70	1.45E-06
Benzo(a)pyrene	4.81	1.00E-06	3300	0.2	0.13	250	25	70	1.44E-06
Benzo(b)fluoranthene	6.24	1.00E-06	3300	0.2	0.13	250	25	70	1.87E-06
Dibenzo(a,h)anthracene	1.03	1.00E-06	3300	0.2	0.13	250	25	70	3.09E-07

CDI CALCULATIONS FOR SURFACE SOIL - INHALATION OF SOIL PARTICULATES
80th DRS, FORT STORY, VIRGINIA

COPC	Conc (mg/m^3)	IR (m^3/hour)	ET (hours)	EF (days/yr)	ED (yrs)	BW (kg)	CDI (mg/kg-day)
Non-Carcinogenic: Inhalation of Chemicals in Surface Soil - Fort Story/Future Industrial Site Workers (Adults)							
Benzo(a)anthracene	3.55E-09	1.6	8.0	250	25	70	4.45E-10
Benzo(a)pyrene	3.54E-09	1.6	8.0	250	25	70	4.43E-10
Benzo(b)fluoranthene	4.59E-09	1.6	8.0	250	25	70	5.75E-10
Dibenzo(a,h)anthracene	7.58E-10	1.6	8.0	250	25	70	9.49E-11
Carcinogenic: Inhalation of Chemicals in Surface Soil - Fort Story/Future Industrial Site Workers (Adults)							
Benzo(a)anthracene	3.55E-09	1.6	8.0	250	25	70	1.59E-10
Benzo(a)pyrene	3.54E-09	1.6	8.0	250	25	70	1.58E-10
Benzo(b)fluoranthene	4.59E-09	1.6	8.0	250	25	70	2.05E-10
Dibenzo(a,h)anthracene	7.58E-10	1.6	8.0	250	25	70	3.39E-11

CDI CALCULATIONS FOR COMBINED SURFACE/SUBSURFACE SOIL - INGESTION
80th DRS, FORT STORY VIRGINIA

COPC	Conc (mg/kg)	IR (mg/day)	CF (kg/mg)	FI	EF (days/yr)	ED (yrs)	BW (kg)	CDI (mg/kg-day)
Non-Carcinogenic: Ingestion of Chemicals in Combined Soil - Construction Worker Population (Adults)								
Benzo(a)anthracene	3.42	480	1.00E-06	0.5	125	1	70	4.02E-06
Benzo(a)pyrene	3.32	480	1.00E-06	0.5	125	1	70	3.90E-06
Benzo(b)fluoranthene	4.41	480	1.00E-06	0.5	125	1	70	5.18E-06
Dibenzo(a,h)anthracene	0.55	480	1.00E-06	0.5	125	1	70	6.46E-07
Carcinogenic: Ingestion of Chemicals in Combined Soil - Construction Worker Population (Adults)								
Benzo(a)anthracene	3.42	480	1.00E-06	0.5	125	1	70	5.74E-08
Benzo(a)pyrene	3.32	480	1.00E-06	0.5	125	1	70	5.57E-08
Benzo(b)fluoranthene	4.41	480	1.00E-06	0.5	125	1	70	7.40E-08
Dibenzo(a,h)anthracene	0.55	480	1.00E-06	0.5	125	1	70	9.23E-09

CDI CALCULATIONS FOR COMBINED SURFACE/SUBSURFACE SOIL - DERMAL CONTACT
80 DRS, FORT STORY VIRGINIA

COPC	Conc (mg/kg)	CF (kg/mg)	SA (cm2)	AF (mg/cm2)	ABS	EF (days/yr)	ED (yrs)	BW (kg)	CDI (mg/kg-day)
Non-Carcinogenic: Dermal Contact with Chemicals in Soil - Construction Worker Population (Adults)									
Benzo(a)anthracene	3.42	1.00E-06	3300	0.9	0.13	125	1	70	6.46E-06
Benzo(a)pyrene	3.32	1.00E-06	3300	0.9	0.13	125	1	70	6.27E-06
Benzo(b)fluoranthene	4.41	1.00E-06	3300	0.9	0.13	125	1	70	8.33E-06
Dibenzo(a,h)anthracene	0.55	1.00E-06	3300	0.9	0.13	125	1	70	1.04E-06
Carcinogenic: Dermal Contact with Chemicals in Soil - Construction Worker Population (Adults)									
Benzo(a)anthracene	3.42	1.00E-06	3300	0.9	0.13	125	1	70	9.23E-08
Benzo(a)pyrene	3.32	1.00E-06	3300	0.9	0.13	125	1	70	8.96E-08
Benzo(b)fluoranthene	4.41	1.00E-06	3300	0.9	0.13	125	1	70	1.19E-07
Dibenzo(a,h)anthracene	0.55	1.00E-06	3300	0.9	0.13	125	1	70	1.48E-08

CDI CALCULATIONS FOR COMBINED SURFACE/SUBSURFACE SOIL - INHALATION OF SOIL PARTICULATES
80th DRS, FORT STORY, VIRGINIA

COPC	Conc (mg/m^3)	IR (m^3/hour)	ET (hours)	EF (days/yr)	ED (yrs)	BW (kg)	CDI (mg/kg-day)
Non-Carcinogenic: Inhalation of Chemicals in Combined Surface/Subsurface Soil - Construction Workers (Adults)							
Benzo(a)anthracene	7.56E-07	2.5	4.0	125	1	70	3.70E-08
Benzo(a)pyrene	7.34E-07	2.5	4.0	125	1	70	3.59E-08
Benzo(b)fluoranthene	9.75E-07	2.5	4.0	125	1	70	4.77E-08
Dibenzo(a,h)anthracene	1.22E-07	2.5	4.0	125	1	70	5.97E-09
Carcinogenic: Inhalation of Chemicals in Combined Surface/Subsurface Soil - Construction Workers (Adults)							
Benzo(a)anthracene	7.56E-07	2.5	4.0	125	1	70	5.28E-10
Benzo(a)pyrene	7.34E-07	2.5	4.0	125	1	70	5.13E-10
Benzo(b)fluoranthene	9.75E-07	2.5	4.0	125	1	70	6.81E-10
Dibenzo(a,h)anthracene	1.22E-07	2.5	4.0	125	1	70	8.53E-11

CDI CALCULATIONS FOR GROUNDWATER - INGESTION
80th DRS, FORT STORY VIRGINIA

COPC	Conc (mg/l)	IR (liters/day)	EF (days/yr)	ED (yrs)	BW (kg)	CDI (mg/kg-day)
Non-Carcinogenic: Construction Worker Population Ingestion of Chemicals in Groundwater						
cis 1,2-DCE	0.0035	0.02	125	1	70	3.42E-07
PCE	0.0044	0.02	125	1	70	4.31E-07
TCE	0.003	0.02	125	1	70	2.94E-07
Bis(2-ethylhexyl)phthalate	0.005	0.02	125	1	70	4.89E-07
Total Antimony	0.0044	0.02	125	1	70	4.31E-07
Total Arsenic	0.0052	0.02	125	1	70	5.09E-07
Total Iron	2.63	0.02	125	1	70	2.57E-04
Total Manganese	0.089	0.02	125	1	70	8.71E-06
Total Vanadium	0.0035	0.02	125	1	70	3.42E-07
Carcinogenic: Construction Worker Population Ingestion of Chemicals in Groundwater						
cis 1,2-DCE	0.0035	0.02	125	1	70	4.89E-09
Tetrachloroethene	0.0044	0.02	125	1	70	6.15E-09
Trichloroethene	0.003	0.02	125	1	70	4.19E-09
Bis(2-ethylhexyl)phthalate	0.005	0.02	125	1	70	6.99E-09
Total Antimony	0.0044	0.02	125	1	70	6.15E-09
Total Arsenic	0.0052	0.02	125	1	70	7.27E-09
Total Iron	2.63	0.02	125	1	70	3.68E-06
Total Manganese	0.089	0.02	125	1	70	1.24E-07
Total Vanadium	0.0035	0.02	125	1	70	4.89E-09

CDI CALCULATIONS FOR GROUNDWATER - DERMAL CONTACT
80 DRS, FORT STORY VIRGINIA

COPC	Conc (mg/l)	SA (cm^2)	PC (cm/hour)	ET (hours/day)	EF (days/yr)	ED (yrs)	CF (1 L/1000 cm^3)	BW (kg)	CDI (mg/kg-day)
Non-Carcinogenic: Construction Worker Dermal Contact with Chemicals in Groundwater									
cis 1,2-DCE	0.0035	3300	3.30E-02	4	125	1	0.001	70	7.46E-06
PCE	0.0044	3300	3.30E-02	4	125	1	0.001	70	9.38E-06
TCE	0.003	3300	1.20E-02	4	125	1	0.001	70	2.32E-06
Bis(2-ethylhexyl)phthalate	0.005	3300	2.50E-02	4	125	1	0.001	70	8.07E-06
Total Antimony	0.0044	3300	1.00E-03	4	125	1	0.001	70	2.84E-07
Total Arsenic	0.0052	3300	1.00E-03	4	125	1	0.001	70	3.36E-07
Total Iron	2.63	3300	1.00E-03	4	125	1	0.001	70	1.70E-04
Total Manganese	0.089	3300	1.00E-03	4	125	1	0.001	70	5.75E-06
Total Vanadium	0.0035	3300	1.00E-03	4	125	1	0.001	70	2.26E-07
Carcinogenic: Construction Worker Dermal Contact with Chemicals in Groundwater									
cis 1,2-DCE	0.0035	3300	3.30E-02	4	125	1	0.001	70	1.07E-07
PCE	0.0044	3300	3.30E-02	4	125	1	0.001	70	1.34E-07
TCE	0.003	3300	1.20E-02	4	125	1	0.001	70	3.32E-08
Bis(2-ethylhexyl)phthalate	0.005	3300	2.50E-02	4	125	1	0.001	70	1.15E-07
Total Antimony	0.0044	3300	1.00E-03	4	125	1	0.001	70	4.06E-09
Total Arsenic	0.0052	3300	1.00E-03	4	125	1	0.001	70	4.80E-09
Total Iron	2.63	3300	1.00E-03	4	125	1	0.001	70	2.43E-06
Total Manganese	0.089	3300	1.00E-03	4	125	1	0.001	70	8.21E-08
Total Vanadium	0.0035	3300	1.00E-03	4	125	1	0.001	70	3.23E-09

CDI CALCULATIONS FOR GROUNDWATER - INHALATION OF VAPORS
80th DRS, FORT STORY, VIRGINIA

COPC	Conc (mg/m^3)	IR (m^3/hour)	ET (hours)	EF (days/yr)	ED (yrs)	BW (kg)	CDI (mg/kg-day)
Non-Carcinogenic: Construction Worker Inhalation of Volatilized Chemicals from Groundwater (Adults)							
cis 1,2-DCE	3.90E-02	2.5	4.0	125	1	70	1.91E-03
PCE	3.79E-02	2.5	4.0	125	1	70	1.85E-03
TCE	2.90E-02	2.5	4.0	125	1	70	1.42E-03
Bis(2-ethylhexyl)phthalate	6.09E-05	2.5	4.0	125	1	70	2.98E-06
Carcinogenic: Construction Worker Inhalation of Volatilized Chemicals from Groundwater (Adults)							
cis 1,2-DCE	3.90E-02	2.5	4.0	125	1	70	2.73E-05
PCE	3.79E-02	2.5	4.0	125	1	70	2.65E-05
TCE	2.90E-02	2.5	4.0	125	1	70	2.03E-05
Bis(2-ethylhexyl)phthalate	6.09E-05	2.5	4.0	125	1	70	4.26E-08

Summary Groundwater to Indoor Air Exposure

Source: http://www.epa.gov/oswer/riskassessment/airmodel/johnson_ettinger.htm
3-Phase System Models and Soil Gas Models:
Excel zip file (ZIP 282K)
GW-SREEN-Feb04.xls

COC	EPC	unit	Infinite Source Bldg Concen	unit
cis 1,2-DCE	3.1	µg/L	4.13E-01	µg/m^3
PCE	2.9	µg/L	1.58E+00	µg/m^3
TCE	2.5	µg/L	8.55E-01	µg/m^3

parameters (changed from default)		
depth below grade to bottom of enclosed spa	15	cm
depth below grade to water table	123	cm
avg soil/GW temp	18	celsius
soil type directly above water table	sand	
vadose zone soil type	sand	
exposure frequency	250	days/year

RESULTS SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (µg/L)	Indoor exposure groundwater conc., noncarcinogen (µg/L)	Risk-based indoor exposure groundwater conc., (µg/L)	Pure component water solubility, S (µg/L)	Final indoor exposure groundwater conc., (µg/L)
NA	NA	NA	1.47E+06	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
2.8E-05	1.5E-02

MESSAGE SUMMARY BELOW:

MESSAGE: Risk/HQ or risk-based groundwater concentration is based on a route-to-route extrapolation.

END

DATA ENTRY SHEET

GW-SCREEN
Version 3.1; 02/04

Reset to Defaults

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

YES [ ]

OR

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

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (µg/L)	Chemical
156592	3.10E+00	cis-1,2-Dichloroethylene

MORE ↓

ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER SCS soil type directly above water table	ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Average vapor flow rate into bldg. (Leave blank to calculate) Q_{soil} (L/m)
15	123	S	18	5

MORE ↓

ENTER Vadose zone SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined vandose zone soil vapor permeability, k_v (cm^2)	ENTER Vadose zone SCS soil type (Lookup Soil Parameters)	ENTER Vadose zone soil dry bulk density, ρ_b^v (g/cm^3)	ENTER Vadose zone soil total porosity, n^v (unitless)	ENTER Vadose zone soil water-filled porosity, θ_w^v (cm^3/cm^3)
S			S	1.66	0.375	0.054

MORE ↓

ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)	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)
1.0E-05	1	70	30	30	250

Used to calculate risk-based groundwater concentration.

END

CHEMICAL PROPERTIES SHEET

ABC

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-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)
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

END

INTERMEDIATE CALCULATIONS SHEET

Source-building separation, L_T (cm)	Vadose zone soil air-filled porosity, θ_a^V (cm^3/cm^3)	Vadose zone effective total fluid saturation, S_{te} (cm^3/cm^3)	Vadose zone soil intrinsic permeability, k_i (cm^2)	Vadose zone soil relative air permeability, k_{rg} (cm^2)	Vadose zone soil effective vapor permeability, k_v (cm^2)	Thickness of capillary zone, L_{cz} (cm)	Total porosity in capillary zone, n_{cz} (cm^3/cm^3)	Air-filled porosity in capillary zone, $\theta_{a,cz}$ (cm^3/cm^3)	Water-filled porosity in capillary zone, $\theta_{w,cz}$ (cm^3/cm^3)	Floor-wall seam perimeter, X_{crack} (cm)
108	0.321	0.003	1.01E-07	0.998	1.00E-07	17.05	0.375	0.122	0.253	4,000

Bldg. ventilation rate, $Q_{building}$ (cm^3/s)	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. groundwater temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. groundwater temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. groundwater temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Vadose zone effective diffusion coefficient, D^{eff}_V (cm^2/s)	Capillary zone effective diffusion coefficient, D^{eff}_{cz} (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)
1.69E+04	1.00E+06	4.00E-04	15	7,653	2.98E-03	1.25E-01	1.78E-04	1.19E-02	4.78E-04	2.49E-03

Diffusion path length, L_d (cm)	Convection path length, L_p (cm)	Source vapor conc., C_{source} ($\mu g/m^3$)	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., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
108	15	3.87E+02	0.10	8.33E+01	1.19E-02	4.00E+02	1.11E+76	1.07E-03	4.13E-01	NA	3.5E-02

END

RESULTS SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (µg/L)	Indoor exposure groundwater conc., noncarcinogen (µg/L)	Risk-based indoor exposure groundwater conc., (µg/L)	Pure component water solubility, S (µg/L)	Final indoor exposure groundwater conc., (µg/L)
NA	NA	NA	3.50E+06	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	8.1E-03

MESSAGE SUMMARY BELOW:

MESSAGE: Risk/HQ or risk-based groundwater concentration is based on a route-to-route extrapolation.

END

DATA ENTRY SHEET

GW-SCREEN
Version 3.1; 02/04

Reset to Defaults

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

YES [ ]

OR

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

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_w (µg/L)	Chemical
127184	2.90E+00	Tetrachloroethylene

MORE ↓

ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER SCS soil type directly above water table	ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Average vapor flow rate into bldg. (Leave blank to calculate) Q_{soil} (L/m)
15	123	S	18	5

MORE ↓

ENTER Vadose zone SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined vandose zone soil vapor permeability, k_v (cm^2)	ENTER Vadose zone SCS soil type (Lookup Soil Parameters)	ENTER Vadose zone soil dry bulk density, ρ_b^v (g/cm^3)	ENTER Vadose zone soil total porosity, n^v (unitless)	ENTER Vadose zone soil water-filled porosity, θ_w^v (cm^3/cm^3)
S			S	1.66	0.375	0.054

MORE ↓

ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)	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)
1.0E-05	1	70	30	30	250

Used to calculate risk-based groundwater concentration.

END

CHEMICAL PROPERTIES SHEET

ABC

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)
7.20E-02	8.20E-06	1.84E-02	25	8,288	394.40	620.20	1.55E+02	2.00E+02	5.9E-06	6.0E-01

END

INTERMEDIATE CALCULATIONS SHEET

Source-building separation, L_T (cm)	Vadose zone soil air-filled porosity, θ_a^v (cm^3/cm^3)	Vadose zone effective total fluid saturation, S_{te} (cm^3/cm^3)	Vadose zone soil intrinsic permeability, k_i (cm^2)	Vadose zone soil relative air permeability, k_{rg} (cm^2)	Vadose zone soil effective vapor permeability, k_v (cm^2)	Thickness of capillary zone, L_{cz} (cm)	Total porosity in capillary zone, n_{cz} (cm^3/cm^3)	Air-filled porosity in capillary zone, $\theta_{a,cz}$ (cm^3/cm^3)	Water-filled porosity in capillary zone, $\theta_{w,cz}$ (cm^3/cm^3)	Floor-wall seam perimeter, X_{crack} (cm)
108	0.321	0.003	1.01E-07	0.998	1.00E-07	17.05	0.375	0.122	0.253	4,000

Bldg. ventilation rate, $Q_{building}$ (cm^3/s)	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. groundwater temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. groundwater temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. groundwater temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Vadose zone effective diffusion coefficient, D^{eff}_V (cm^2/s)	Capillary zone effective diffusion coefficient, D^{eff}_{cz} (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)
1.69E+04	1.00E+06	4.00E-04	15	9,472	1.25E-02	5.23E-01	1.78E-04	1.16E-02	4.62E-04	2.42E-03

Diffusion path length, L_d (cm)	Convection path length, L_p (cm)	Source vapor conc., C_{source} ($\mu g/m^3$)	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., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
108	15	1.52E+03	0.10	8.33E+01	1.16E-02	4.00E+02	5.42E+77	1.04E-03	1.58E+00	5.9E-06	6.0E-01

END

RESULTS SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (µg/L)	Indoor exposure groundwater conc., noncarcinogen (µg/L)	Risk-based indoor exposure groundwater conc., (µg/L)	Pure component water solubility, S (µg/L)	Final indoor exposure groundwater conc., (µg/L)
NA	NA	NA	2.00E+05	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
2.7E-06	1.8E-03

MESSAGE SUMMARY BELOW:

END

DATA ENTRY SHEET

GW-SCREEN
Version 3.1; 02/04

Reset to Defaults

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

YES [ ]

OR

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

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (µg/L)	Chemical
79016	2.50E+00	Trichloroethylene

MORE ↓

ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER SCS soil type directly above water table	ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Average vapor flow rate into bldg. (Leave blank to calculate) Q_{soil} (L/m)
15	123	S	18	5

MORE ↓

ENTER Vadose zone SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined vandose zone soil vapor permeability, k_v (cm^2)	ENTER Vadose zone SCS soil type (Lookup Soil Parameters)	ENTER Vadose zone soil dry bulk density, ρ_b^v (g/cm^3)	ENTER Vadose zone soil total porosity, n^v (unitless)	ENTER Vadose zone soil water-filled porosity, θ_w^v (cm^3/cm^3)
S			S	1.66	0.375	0.054

MORE ↓

ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)	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)
1.0E-05	1	70	30	30	250

Used to calculate risk-based groundwater concentration.

END

CHEMICAL PROPERTIES SHEET

ABC

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)
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

END

INTERMEDIATE CALCULATIONS SHEET

Source-building separation, L_T (cm)	Vadose zone soil air-filled porosity, θ_a^V (cm^3/cm^3)	Vadose zone effective total fluid saturation, S_{te} (cm^3/cm^3)	Vadose zone soil intrinsic permeability, k_i (cm^2)	Vadose zone soil relative air permeability, k_{rg} (cm^2)	Vadose zone soil effective vapor permeability, k_v (cm^2)	Thickness of capillary zone, L_{cz} (cm)	Total porosity in capillary zone, n_{cz} (cm^3/cm^3)	Air-filled porosity in capillary zone, $\theta_{a,cz}$ (cm^3/cm^3)	Water-filled porosity in capillary zone, $\theta_{w,cz}$ (cm^3/cm^3)	Floor-wall seam perimeter, X_{crack} (cm)
108	0.321	0.003	1.01E-07	0.998	1.00E-07	17.05	0.375	0.122	0.253	4,000

Bldg. ventilation rate, $Q_{building}$ (cm^3/s)	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. groundwater temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. groundwater temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. groundwater temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Vadose zone effective diffusion coefficient, D^{eff}_V (cm^2/s)	Capillary zone effective diffusion coefficient, D^{eff}_{cz} (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)
1.69E+04	1.00E+06	4.00E-04	15	8,458	7.29E-03	3.05E-01	1.78E-04	1.28E-02	5.08E-04	2.66E-03

Diffusion path length, L_d (cm)	Convection path length, L_p (cm)	Source vapor conc., C_{source} ($\mu g/m^3$)	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., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
108	15	7.63E+02	0.10	8.33E+01	1.28E-02	4.00E+02	7.02E+70	1.12E-03	8.55E-01	1.1E-04	4.0E-02

END

Appendix H
ERA Exposure Calculations

Remedial Investigation Report
80th Division Reserve Site
Fort Story, Virginia

MOVING TO PROTECT OUR WORLD

USATC ENVIRONMENTAL

RED-TAILED HAWK EXPOSURE CA[illegible]LATIONS - 80th DRS, FT. STORY, VIRGINIA

Chemical	Concentration in Soil (mg/kg)	Estimated Exposure from Soil (mg/kg BW-day)	Estimated Exposure from Prey (mg/kg BW-day)	Total Estimated Exposure (mg/kg BW-day)	Red-tailed Hawk NOAEL (mg/kg BW-day)	Hazard Quotents (unitless)
1,1,2-trichloro-1,2,2-trifluoethane	2.00E-03	2.00E-06	2.00E-04	2.02E-04	NA	NA
1,3-Dichlorobenzene	5.00E-04	5.00E-07	5.00E-05	5.05E-05	NA	NA
2-Butanone (MEK)	5.00E-03	5.00E-06	5.00E-04	5.05E-04	NA	NA
2-Hexanone	2.30E-01	2.30E-04	2.30E-02	2.32E-02	NA	NA
Acetone	5.70E-02	5.70E-05	5.70E-03	5.76E-03	NA	NA
Carbon disulfide	6.00E-03	6.00E-06	6.00E-04	6.06E-04	NA	NA
Dichlorodifluoromethane	6.00E-04	6.00E-07	6.00E-05	6.06E-05	NA	NA
Methyl acetate	6.90E-02	6.90E-05	6.90E-03	6.97E-03	NA	NA
Tetrachloroethylene	1.20E-01	1.20E-04	1.20E-02	1.21E-02	NA	NA
Trichlorofluoromethane	3.00E-03	3.00E-06	3.00E-04	3.03E-04	NA	NA
1,1'-Biphenyl	4.70E-01	4.70E-04	4.70E-02	4.75E-02	NA	NA
2,4-Dinitrotoluene	1.30E-01	1.30E-04	1.30E-02	1.31E-02	NA	NA
2,6-Dinitrotoluene	5.10E-02	5.10E-05	5.10E-03	5.15E-03	NA	NA
2-Methylnaphthalene	2.40E+00	2.40E-03	2.40E-01	2.42E-01	NA	NA
3,3'-Dichlorobenzidine	2.90E-01	2.90E-04	2.90E-02	2.93E-02	NA	NA
Acenaphthene	9.60E-01	9.60E-04	9.60E-02	9.70E-02	NA	NA
Acenaphthylene	2.20E+00	2.20E-03	2.20E-01	2.22E-01	NA	NA
Benzo(a)anthracene	5.60E+00	5.60E-03	5.60E-01	5.66E-01	NA	NA
Benzo(a)pyrene	5.50E+00	5.50E-03	5.50E-01	5.56E-01	NA	NA
Benzo(b)fluoranthene	6.80E+00	6.80E-03	6.80E-01	6.87E-01	NA	NA
Benzo(g,h,i)perylene	3.70E+00	3.70E-03	3.70E-01	3.74E-01	NA	NA
Benzo(k)fluoranthene	4.10E+00	4.10E-03	4.10E-01	4.14E-01	NA	NA
bis(2-Ethylhexyl)phthalate	3.40E-01	3.40E-04	3.40E-02	3.43E-02	1.10E+00	3.12E-02
Carbazole	4.90E-01	4.90E-04	4.90E-02	4.95E-02	NA	NA
Chrysene	6.00E+00	6.00E-03	6.00E-01	6.06E-01	NA	NA
Dibenzo(a,h)anthracene	1.50E+00	1.50E-03	1.50E-01	1.52E-01	NA	NA
Dibenzofuran	7.90E-01	7.90E-04	7.90E-02	7.98E-02	NA	NA
Di-n-octylphthalate	2.80E-01	2.80E-04	2.80E-02	2.83E-02	NA	NA
Fluoranthene	9.80E+00	9.80E-03	9.80E-01	9.90E-01	NA	NA
Fluorene	1.60E+00	1.60E-03	1.60E-01	1.62E-01	NA	NA
Indeno(1,2,3-cd)pyrene	3.60E+00	3.60E-03	3.60E-01	3.64E-01	NA	NA
Naphthalene	1.50E-01	1.50E-04	1.50E-02	1.52E-02	NA	NA
Phenanthrene	1.20E+01	1.20E-02	1.20E+00	1.21E+00	NA	NA
Pyrene	1.60E+01	1.60E-02	1.60E+00	1.62E+00	NA	NA
Aluminum	**8.53E+03**	**8.53E+00**	**8.53E+02**	**8.62E+02**	**1.10E+02**	**7.85E+00**
Calcium	3.06E+03	3.06E+00	3.06E+02	3.09E+02	NA	NA
Chromium	**1.00E+01**	**1.00E-02**	**1.00E+00**	**1.01E+00**	**1.00E+00**	**1.01E+00**
Lead	3.39E+01	3.39E-02	3.39E+00	3.42E+00	3.85E+00	8.89E-01
Potassium	4.94E+02	4.94E-01	4.94E+01	4.99E+01	NA	NA
Sodium	1.33E+02	1.33E-01	1.33E+01	1.34E+01	NA	NA
alpha-BHC	1.70E-03	1.70E-06	1.70E-04	1.72E-04	3.60E-01	4.77E-04
beta-BHC	1.00E-01	1.00E-04	1.00E-02	1.01E-02	3.60E-01	2.81E-02
delta-BHC	1.30E-03	1.30E-06	1.30E-04	1.31E-04	3.60E-01	3.65E-04
Endosulfan I	9.00E-04	9.00E-07	9.00E-05	9.09E-05	1.00E+01	9.09E-06
Endosulfan II	1.80E-02	1.80E-05	1.80E-03	1.82E-03	1.00E+01	1.82E-04
Endosulfan sulfate	1.10E-01	1.10E-04	1.10E-02	1.11E-02	1.00E+01	1.11E-03
Endrin aldehyde	9.70E-04	9.70E-07	9.70E-05	9.80E-05	3.00E-01	3.27E-04
Endrin ketone	1.10E-01	1.10E-04	1.10E-02	1.11E-02	NA	NA
Heptachlor	1.00E-03	1.00E-06	1.00E-04	1.01E-04	4.16E+01	2.43E-06

EEs=CsxFRsxNIRs EEp=CpxFRpxNIRp EEtotal = EEs + EEw + EEp Table 7-11 HQ = EE total/NOAEL

Cs = Conc. in sediment
FRs = 1
NIRs = 0.001

Cp = Cs
FRp = 1
NIRp = NIRf x 100%
NIRp = 0.1 g/g-day

AMERICAN ROBIN EXPOSURE CALCULATIONS - 80th DRS, FT. STORY, VIRGINIA

Chemical	Concentration in Soil (mg/kg)	Concentration in Invertebrates (mg/kg)	EUF	Concentration in Plants (mg/kg)	PUF	Estimated Exposure from Soil (mg/kg BW-day)	Estimated Exposure from Invertebrates (mg/kg BW-day)	Estimated Exposure from Plants (mg/kg BW-day)	Total Estimated Exposure (mg/kg BW-day)	American Robin NOAEL (mg/kg BW-day)	Hazard Quotents (unitless)
1,1,2-trichloro-1,2,2-trifluoethane	2.00E-03	2.00E-03	1.00E+00	1.14E-03	5.70E-01	3.20E-05	9.80E-04	8.81E-04	1.89E-03	NA	NA
1,3-Dichlorobenzene	5.00E-04	5.00E-04	1.00E+00	1.75E-04	3.50E-01	8.00E-06	2.45E-04	1.35E-04	3.88E-04	NA	NA
2-Butanone (MEK)	5.00E-03	5.00E-03	1.00E+00	1.32E-01	2.64E+01	8.00E-05	2.45E-03	1.02E-01	1.05E-01	NA	NA
2-Hexanone	2.30E-01	2.30E-01	1.00E+00	1.42E+00	6.16E+00	3.68E-03	1.13E-01	1.09E+00	1.21E+00	NA	NA
Acetone	5.70E-02	5.70E-02	1.00E+00	3.06E+00	5.36E+01	9.12E-04	2.79E-02	2.36E+00	2.39E+00	NA	NA
Carbon disulfide	6.00E-03	6.00E-03	1.00E+00	1.75E-02	2.92E+00	7.20E-05	2.94E-03	1.35E-02	1.65E-02	NA	NA
Dichlorodifluoromethane	6.00E-04	6.00E-04	1.00E+00	1.30E-03	2.17E+00	9.60E-06	2.94E-04	1.01E-03	1.31E-03	NA	NA
Methyl acetate	6.90E-02	6.90E-02	1.00E+00	2.11E+00	3.06E+01	1.10E-03	3.38E-02	1.63E+00	1.67E+00	NA	NA
Tetrachloroethylene	1.20E-01	1.20E-01	1.00E+00	4.92E-02	4.10E-01	1.92E-03	5.88E-02	3.80E-02	9.87E-02	NA	NA
Trichlorofluoromethane	3.00E-03	3.00E-03	1.00E+00	3.99E-03	1.33E+00	4.80E-05	1.47E-03	3.08E-03	4.60E-03	NA	NA
1,1'-Biphenyl	4.70E-01	4.70E-01	1.00E+00	8.93E-02	1.90E-01	7.52E-03	2.30E-01	6.90E-02	3.07E-01	NA	NA
2,4-Dinitrotoluene	1.30E-01	1.30E-01	1.00E+00	3.59E-01	2.76E+00	2.08E-03	6.37E-02	2.77E-01	3.43E-01	NA	NA
2,6-Dinitrotoluene	5.10E-02	5.10E-02	1.00E+00	1.20E-01	2.35E+00	8.16E-04	2.50E-02	9.26E-02	1.18E-01	NA	NA
2-Methylnaphthalene	2.40E+00	2.40E+00	1.00E+00	4.56E-01	1.90E-01	3.84E-02	1.18E+00	3.52E-01	1.57E+00	NA	NA
3,3'-Dichlorobenzidine	2.90E-01	2.90E-01	1.00E+00	1.04E-01	3.60E-01	4.64E-03	1.42E-01	8.06E-02	2.27E-01	NA	NA
Acenaphthene	9.60E-01	9.60E-01	1.00E+00	2.02E-01	2.10E-01	1.54E-02	4.70E-01	1.56E-01	6.41E-01	NA	NA
Acenaphthylene	2.20E+00	2.20E+00	1.00E+00	4.40E-01	2.00E-01	3.52E-02	1.08E+00	3.40E-01	1.45E+00	NA	NA
Benzo(a)anthracene	5.60E+00	2.13E+00	3.80E-01	1.06E-01	1.90E-02	8.96E-02	1.04E+00	8.22E-02	1.21E+00	NA	NA
Benzo(a)pyrene	5.50E+00	4.73E+00	8.60E-01	6.60E-02	1.20E-02	8.80E-02	2.32E+00	5.10E-02	2.46E+00	NA	NA
Benzo(b)fluoranthene	6.80E+00	6.53E+00	9.60E-01	8.16E-02	1.20E-02	1.09E-01	3.20E+00	6.30E-02	3.37E+00	NA	NA
Benzo(g,h,i)perylene	3.70E+00	1.48E+00	4.00E-01	7.40E-03	2.00E-03	5.92E-02	7.25E-01	5.72E-03	7.90E-01	NA	NA
Benzo(k)fluoranthene	4.10E+00	3.94E+00	9.60E-01	4.92E-02	1.20E-02	6.56E-02	1.93E+00	3.80E-02	2.03E+00	NA	NA
bis(2-Ethylhexyl)phthalate	3.40E-01	3.40E-01	1.00E+00	5.10E-04	1.50E-03	5.44E-03	1.67E-01	3.94E-04	1.72E-01	1.1	1.57E-01
Carbazole	4.90E-01	4.90E-01	1.00E+00	2.35E-01	4.80E-01	7.84E-03	2.40E-01	1.82E-01	4.30E-01	NA	NA
Chrysene	6.00E+00	2.22E+00	3.70E-01	7.20E-02	1.20E-02	9.60E-02	1.09E+00	5.56E-02	1.24E+00	NA	NA
Dibenzo(a,h)anthracene	1.50E+00	5.70E-01	3.80E-01	1.14E-02	7.60E-03	2.40E-02	2.79E-01	8.81E-03	3.12E-01	NA	NA
Dibenzofuran	7.90E-01	7.90E-01	1.00E+00	1.26E-01	1.60E-01	1.26E-02	3.87E-01	9.76E-02	4.97E-01	NA	NA
Di-n-octylphthalate	2.80E-01	2.80E-01	1.00E+00	2.24E-04	8.00E-04	4.48E-03	1.37E-01	1.73E-04	1.42E-01	NA	NA
Fluoranthene	9.80E+00	3.14E+00	3.20E-01	4.12E-01	4.20E-02	1.57E-01	1.54E+00	3.18E-01	2.01E+00	NA	NA
Fluorene	1.60E+00	5.12E-01	3.20E-01	2.24E-01	1.40E-01	2.56E-02	2.51E-01	1.73E-01	4.50E-01	NA	NA
Indeno(1,2,3-cd)pyrene	3.60E+00	2.70E+00	7.50E-01	4.32E-02	1.20E-02	5.76E-02	1.32E+00	3.34E-02	1.41E+00	NA	NA
Naphthalene	1.50E-01	1.50E-01	1.00E+00	6.60E-02	4.40E-01	2.40E-03	7.35E-02	5.10E-02	1.27E-01	NA	NA
Phenanthrene	1.20E+01	3.48E+00	2.90E-01	1.07E+00	8.90E-02	1.92E-01	1.71E+00	8.25E-01	2.72E+00	NA	NA
Pyrene	1.60E+01	1.18E+01	7.40E-01	6.88E-01	4.30E-02	2.56E-01	5.80E+00	5.31E-01	6.59E+00	NA	NA
Aluminum	**8.53E+03**	**8.53E+03**	**1.00E+00**	**8.53E+03**	**1.00E+00**	**1.36E+02**	**4.18E+03**	**6.59E+03**	**1.09E+04**	**109.7**	**9.94E+01**
Calcium	3.06E+03	3.06E+03	1.00E+00	3.06E+03	1.00E+00	4.90E+01	1.50E+03	2.36E+03	3.91E+03	NA	NA
Chromium	**1.00E+01**	**3.06E+00**	**3.06E-01**	**7.50E-02**	**7.50E-03**	**1.60E-01**	**1.50E+00**	**5.79E-02**	**1.72E+00**	**1**	**1.72E+00**
Lead	**3.39E+01**	**9.02E+00**	**2.66E-01**	**1.53E+00**	**4.50E-02**	**5.42E-01**	**4.42E+00**	**1.18E+00**	**6.14E+00**	**3.85**	**1.59E+00**
Potassium	4.94E+02	4.94E+02	1.00E+00	4.94E+02	1.00E+00	7.90E+00	2.42E+02	3.82E+02	6.32E+02	NA	NA
Sodium	1.33E+02	1.33E+02	1.00E+00	1.33E+02	1.00E+00	2.13E+00	6.52E+01	1.03E+02	1.70E+02	NA	NA
alpha-BHC	1.70E-03	1.70E-03	1.00E+00	2.55E-04	1.50E-01	2.72E-05	8.33E-04	1.97E-04	1.06E-03	0.36	2.94E-03
beta-BHC	1.00E-01	4.20E-01	4.20E+00	1.60E-02	1.60E-01	1.60E-03	2.06E-01	1.24E-02	2.20E-01	0.36	6.10E-01
delta-BHC	1.30E-03	1.30E-03	1.00E+00	1.95E-04	1.50E-01	2.08E-05	6.37E-04	1.51E-04	8.08E-04	0.36	2.25E-03
Endosulfan I	9.00E-04	9.00E-04	1.00E+00	3.06E-04	3.40E-01	1.44E-05	4.41E-04	2.36E-04	6.92E-04	10	6.92E-05
Endosulfan II	1.80E-02	1.80E-02	1.00E+00	6.12E-03	3.40E-01	2.88E-04	8.82E-03	4.73E-03	1.38E-02	10	1.38E-03
Endosulfan sulfate	1.10E-01	1.10E-01	1.00E+00	3.74E-02	3.40E-01	1.76E-03	5.39E-02	2.89E-02	8.46E-02	10	8.46E-03
Endrin aldehyde	9.70E-04	8.73E-03	9.00E+00	1.94E-05	2.00E-02	1.55E-05	4.28E-03	1.50E-05	4.31E-03	0.3	1.44E-02
Endrin ketone	1.10E-01	1.10E-01	1.00E+00	1.10E-01	1.00E+00	1.76E-03	5.39E-02	8.50E-02	1.41E-01	NA	NA
Heptachlor	1.00E-03	3.50E-03	3.50E+00	1.10E-04	1.10E-01	1.60E-05	1.72E-03	8.50E-05	1.82E-03	41.6	4.37E-05

Ci = Cs x EUF

Cpl = Cs x PUF

EEs=CsxFRsxNIRs

Cs = Conc. in sediment
FRs = 0.75
NIRs = 0.016

EEi=CixFRixNIRi

Ci = Conc. in inverts.
FRi = 1.0
NIRi = NIRf x 0.32
NIRi = 0.49

EEpl=CplxFRplxNIRpl

Cpl = Conc. in plants
FRpl = 0.75
NIRpl = NIRf x 0.68
NIRpl = 1.03

EEtotal = EEs + EEw + EEi + EEpl

Table 7-11

HQ = EE total/NOAEL

EASTERN COTTONTAIL EXPOSURE C. .JLATIONS - 80th DRS, FT. STORY, VIRGINIA

Chemical	Concentration in Soil (mg/kg)	Concentration in Plants (mg/kg)	PUF	Estimated Exposure from Soil (mg/kg BW-day)	Estimated Exposure from Plants (mg/kg BW-day)	Total Estimated Exposure (mg/kg BW-day)	Rabbit NOAEL (mg/kg BW-day)	Hazard Quotents (unitless)
1,1,2-trichloro-1,2,2-trifluoethane	2.00E-03	1.14E-03	5.70E-01	2.00E-06	2.28E-05	2.48E-05	NA	NA
1,3-Dichlorobenzene	5.00E-04	1.75E-04	3.50E-01	5.00E-07	3.50E-06	4.00E-06	NA	NA
2-Butanone (MEK)	5.00E-03	1.32E-01	2.64E+01	5.00E-06	2.64E-03	2.65E-03	8.48E+02	3.12E-06
2-Hexanone	2.30E-01	1.42E+00	6.16E+00	2.30E-04	2.83E-02	2.86E-02	NA	NA
Acetone	5.70E-02	3.06E+00	5.36E+01	5.70E-05	6.11E-02	6.12E-02	4.80E+00	1.27E-02
Carbon disulfide	6.00E-03	1.75E-02	2.92E+00	6.00E-06	3.50E-04	3.56E-04	2.56E+01	1.39E-05
Dichlorodifluoromethane	6.00E-04	1.30E-03	2.17E+00	6.00E-07	2.60E-05	2.66E-05	NA	NA
Methyl acetate	6.90E-02	2.11E+00	3.06E+01	6.90E-05	4.22E-02	4.23E-02	NA	NA
Tetrachloroethylene	1.20E-01	4.92E-02	4.10E-01	1.20E-04	9.84E-04	1.10E-03	3.99E-01	2.77E-03
Trichlorofluoromethane	3.00E-03	3.99E-03	1.33E+00	3.00E-06	7.98E-05	8.28E-05	2.16E+02	3.84E-07
1,1'-Biphenyl	4.70E-01	8.93E-02	1.90E-01	4.70E-04	1.79E-03	2.26E-03	NA	NA
2,4-Dinitrotoluene	1.30E-01	3.59E-01	2.76E+00	1.30E-04	7.18E-03	7.31E-03	NA	NA
2,6-Dinitrotoluene	5.10E-02	1.20E-01	2.35E+00	5.10E-05	2.40E-03	2.45E-03	NA	NA
2-Methylnaphthalene	2.40E+00	4.56E-01	1.90E-01	2.40E-03	9.12E-03	1.15E-02	NA	NA
3,3'-Dichlorobenzidine	2.90E-01	1.04E-01	3.60E-01	2.90E-04	2.09E-03	2.38E-03	NA	NA
Acenaphthene	9.60E-01	2.02E-01	2.10E-01	9.60E-04	4.03E-03	4.99E-03	NA	NA
Acenaphthylene	2.20E+00	4.40E-01	2.00E-01	2.20E-03	8.80E-03	1.10E-02	NA	NA
Benzo(a)anthracene	5.60E+00	1.06E-01	1.90E-02	5.60E-03	2.13E-03	7.73E-03	2.85E-01	2.71E-02
Benzo(a)pyrene	5.50E+00	6.60E-02	1.20E-02	5.50E-03	1.32E-03	6.82E-03	2.85E-01	2.39E-02
Benzo(b)fluoranthene	6.80E+00	8.16E-02	1.20E-02	6.80E-03	1.63E-03	8.43E-03	2.85E-01	2.96E-02
Benzo(g,h,i)perylene	3.70E+00	7.40E-03	2.00E-03	3.70E-03	1.48E-04	3.85E-03	2.85E-01	1.35E-02
Benzo(k)fluoranthene	4.10E+00	4.92E-02	1.20E-02	4.10E-03	9.84E-04	5.08E-03	2.85E-01	1.79E-02
bis(2-Ethylhexyl)phthalate	3.40E-01	5.10E-04	1.50E-03	3.40E-04	1.02E-05	3.50E-04	5.21E+00	6.72E-05
Carbazole	4.90E-01	2.35E-01	4.80E-01	4.90E-04	4.70E-03	5.19E-03	NA	NA
Chrysene	6.00E+00	7.20E-02	1.20E-02	6.00E-03	1.44E-03	7.44E-03	2.85E-01	2.61E-02
Dibenzo(a,h)anthracene	1.50E+00	1.14E-02	7.60E-03	1.50E-03	2.28E-04	1.73E-03	NA	NA
Dibenzofuran	7.90E-01	1.26E-01	1.60E-01	7.90E-04	2.53E-03	3.32E-03	NA	NA
Di-n-octylphthalate	2.80E-01	2.24E-04	8.00E-04	2.80E-04	4.48E-06	2.84E-04	NA	NA
Fluoranthene	9.80E+00	4.12E-01	4.20E-02	9.80E-03	8.23E-03	1.80E-02	2.85E-01	6.33E-02
Fluorene	1.60E+00	2.24E-01	1.40E-01	1.60E-03	4.48E-03	6.08E-03	NA	NA
Indeno(1,2,3-cd)pyrene	3.60E+00	4.32E-02	1.20E-02	3.60E-03	8.64E-04	4.46E-03	2.85E-01	1.57E-02
Naphthalene	1.50E-01	6.60E-02	4.40E-01	1.50E-04	1.32E-03	1.47E-03	NA	NA
Phenanthrene	1.20E+01	1.07E+00	8.90E-02	1.20E-02	2.14E-02	3.34E-02	2.85E-01	1.17E-01
Pyrene	1.60E+01	6.88E-01	4.30E-02	1.60E-02	1.38E-02	2.98E-02	2.85E-01	1.04E-01
Aluminum	**8.53E+03**	**8.53E+03**	**1.00E+00**	**8.53E+00**	**1.71E+02**	**1.79E+02**	**5.50E-01**	**3.26E+02**
Calcium	3.06E+03	3.06E+03	1.00E+00	3.06E+00	6.12E+01	6.43E+01	NA	NA
Chromium	1.00E+01	7.50E-02	7.50E-03	1.00E-02	1.50E-03	1.15E-02	1.31E+03	8.77E-06
Lead	3.39E+01	1.53E+00	4.50E-02	3.39E-02	3.05E-02	6.44E-02	3.83E+00	1.68E-02
Potassium	4.94E+02	4.94E+02	1.00E+00	4.94E-01	9.88E+00	1.04E+01	NA	NA
Sodium	1.33E+02	1.33E+02	1.00E+00	1.33E-01	2.66E+00	2.79E+00	NA	NA
alpha-BHC	1.70E-03	2.55E-04	1.50E-01	1.70E-06	5.10E-06	6.80E-06	7.66E-01	8.87E-06
beta-BHC	1.00E-01	1.60E-02	1.60E-01	1.00E-04	3.20E-04	4.20E-04	1.92E-01	2.19E-03
delta-BHC	1.30E-03	1.95E-04	1.50E-01	1.30E-06	3.90E-06	5.20E-06	7.66E-01	6.79E-06
Endosulfan I	9.00E-04	3.06E-04	3.40E-01	9.00E-07	6.12E-06	7.02E-06	7.18E-02	9.77E-05
Endosulfan II	1.80E-02	6.12E-03	3.40E-01	1.80E-05	1.22E-04	1.40E-04	7.18E-02	1.95E-03
Endosulfan sulfate	1.10E-01	3.74E-02	3.40E-01	1.10E-04	7.48E-04	8.58E-04	7.18E-02	1.19E-02
Endrin aldehyde	9.70E-04	1.94E-05	2.00E-02	9.70E-07	3.88E-07	1.36E-06	2.62E-02	5.18E-05
Endrin ketone	1.10E-01	1.10E-01	1.00E+00	1.10E-04	2.20E-03	2.31E-03	NA	NA
Heptachlor	1.00E-03	1.10E-04	1.10E-01	1.00E-06	2.20E-06	3.20E-06	7.16E-02	4.47E-05

Cpl = Cs x PUF

EEs=CsxFRsxNIRs EEplCplxFRplxNIRpl EEtotal = EEs + EE_w + EEpl Table 7-11 HQ = EE total/NOAEL

Cs = Conc. in sediment Cpl = Conc. in plants
FRs = 1 FRpl = 1
NIRs = 0.001 NIRpl = NIRf x 1
NIRpl = 0.02

0285-917

SHORT-TAILED SHREW EXPOSURE CALCULATIONS - 80th DRS, FT. STORY, VIRGINIA

Chemical	Concentration in Soil (mg/kg)	Concentration in Invertebrates (mg/kg)	EUF	Estimated Exposure from Soil (mg/kg BW-day)	Estimated Exposure from Invertebrates (mg/kg BW-day)	Total Estimated Exposure (mg/kg BW-day)	Short-tailed Shrew NOAEL (mg/kg BW-day)	Hazard Quotents (unitless)
1,1,2-trichloro-1,2,2-trifluoethane	2.00E-03	2.00E-03	1.00E+00	3.20E-05	9.80E-04	1.01E-03	NA	NA
1,3-Dichlorobenzene	5.00E-04	5.00E-04	1.00E+00	8.00E-06	2.45E-04	2.53E-04	NA	NA
2-Butanone (MEK)	5.00E-03	5.00E-03	1.00E+00	8.00E-05	2.45E-03	2.53E-03	3.38E+03	7.48E-07
2-Hexanone	2.30E-01	2.30E-01	1.00E+00	3.68E-03	1.13E-01	1.16E-01	NA	NA
Acetone	5.70E-02	5.70E-02	1.00E+00	9.12E-04	2.79E-02	2.88E-02	1.91E+01	1.51E-03
Carbon disulfide	6.00E-03	6.00E-03	1.00E+00	9.60E-05	2.94E-03	3.04E-03	1.02E+02	2.97E-05
Dichlorodifluoromethane	6.00E-04	6.00E-04	1.00E+00	9.60E-06	2.94E-04	3.04E-04	NA	NA
Methyl acetate	6.90E-02	6.90E-02	1.00E+00	1.10E-03	3.38E-02	3.49E-02	NA	NA
Tetrachloroethylene	1.20E-01	1.20E-01	1.00E+00	1.92E-03	5.88E-02	6.07E-02	1.59E+00	3.82E-02
Trichlorofluoromethane	3.00E-03	3.00E-03	1.00E+00	4.80E-05	1.47E-03	1.52E-03	8.60E+02	1.77E-06
1,1'-Biphenyl	4.70E-01	4.70E-01	1.00E+00	7.52E-03	2.30E-01	2.38E-01	NA	NA
2,4-Dinitrotoluene	1.30E-01	1.30E-01	1.00E+00	2.08E-03	6.37E-02	6.58E-02	NA	NA
2,6-Dinitrotoluene	5.10E-02	5.10E-02	1.00E+00	8.16E-04	2.50E-02	2.58E-02	NA	NA
2-Methylnaphthalene	2.40E+00	2.40E+00	1.00E+00	3.84E-02	1.18E+00	1.21E+00	NA	NA
3,3'-Dichlorobenzidine	2.90E-01	2.90E-01	1.00E+00	4.64E-03	1.42E-01	1.47E-01	NA	NA
Acenaphthene	9.60E-01	9.60E-01	1.00E+00	1.54E-02	4.70E-01	4.86E-01	NA	NA
Acenaphthylene	2.20E+00	2.20E+00	1.00E+00	3.52E-02	1.08E+00	1.11E+00	NA	NA
Benzo(a)anthracene	5.60E+00	2.13E+00	3.80E-01	8.96E-02	1.04E+00	1.13E+00	1.14E+00	9.97E-01
Benzo(a)pyrene	**5.50E+00**	**4.73E+00**	**8.60E-01**	**8.80E-02**	**2.32E+00**	**2.41E+00**	**1.14E+00**	**2.12E+00**
Benzo(b)fluoranthene	**6.80E+00**	**6.53E+00**	**9.60E-01**	**1.09E-01**	**3.20E+00**	**3.31E+00**	**1.14E+00**	**2.91E+00**
Benzo(g,h,i)perylene	3.70E+00	1.48E+00	4.00E-01	5.92E-02	7.25E-01	7.84E-01	1.14E+00	6.90E-01
Benzo(k)fluoranthene	**4.10E+00**	**3.94E+00**	**9.60E-01**	**6.56E-02**	**1.93E+00**	**1.99E+00**	**1.14E+00**	**1.76E+00**
bis(2-Ethylhexyl)phthalate	3.40E-01	3.40E-01	1.00E+00	5.44E-03	1.67E-01	1.72E-01	2.08E+01	8.27E-03
Carbazole	4.90E-01	4.90E-01	1.00E+00	7.84E-03	2.40E-01	2.48E-01	NA	NA
Chrysene	**6.00E+00**	**2.22E+00**	**3.70E-01**	**9.60E-02**	**1.09E+00**	**1.18E+00**	**1.14E+00**	**1.04E+00**
Dibenzo(a,h)anthracene	1.50E+00	5.70E-01	3.80E-01	2.40E-02	2.79E-01	3.03E-01	NA	NA
Dibenzofuran	7.90E-01	7.90E-01	1.00E+00	1.26E-02	3.87E-01	4.00E-01	NA	NA
Di-n-octylphthalate	2.80E-01	2.80E-01	1.00E+00	4.48E-03	1.37E-01	1.42E-01	NA	NA
Fluoranthene	**9.80E+00**	**3.14E+00**	**3.20E-01**	**1.57E-01**	**1.54E+00**	**1.69E+00**	**1.14E+00**	**1.49E+00**
Fluorene	1.60E+00	5.12E-01	3.20E-01	2.56E-02	2.51E-01	2.76E-01	NA	NA
Indeno(1,2,3-cd)pyrene	**3.60E+00**	**2.70E+00**	**7.50E-01**	**5.76E-02**	**1.32E+00**	**1.38E+00**	**1.14E+00**	**1.22E+00**
Naphthalene	1.50E-01	1.50E-01	1.00E+00	2.40E-03	7.35E-02	7.59E-02	NA	NA
Phenanthrene	**1.20E+01**	**3.48E+00**	**2.90E-01**	**1.92E-01**	**1.71E+00**	**1.90E+00**	**1.14E+00**	**1.67E+00**
Pyrene	**1.60E+01**	**1.18E+01**	**7.40E-01**	**2.56E-01**	**5.80E+00**	**6.06E+00**	**1.14E+00**	**5.33E+00**
Aluminum	8.53E+03	8.53E+03	1.00E+00	1.36E+02	4.18E+03	4.32E+03	2.19E+00	1.97E+03
Calcium	3.06E+03	3.06E+03	1.00E+00	4.90E+01	1.50E+03	1.55E+03	NA	NA
Chromium	1.00E+01	3.06E+00	3.06E-01	1.60E-01	1.50E+00	1.66E+00	5.23E+03	3.17E-04
Lead	3.39E+01	9.02E+00	2.66E-01	5.42E-01	4.42E+00	4.96E+00	1.53E+01	3.25E-01
Potassium	4.94E+02	4.94E+02	1.00E+00	7.90E+00	2.42E+02	2.50E+02	NA	NA
Sodium	1.33E+02	1.33E+02	1.00E+00	2.13E+00	6.52E+01	6.73E+01	NA	NA
alpha-BHC	1.70E-03	1.70E-03	1.00E+00	2.72E-05	8.33E-04	8.60E-04	3.06E+00	2.81E-04
beta-BHC	1.00E-01	4.20E-01	4.20E+00	1.60E-03	2.06E-01	2.07E-01	7.64E-01	2.71E-01
delta-BHC	1.30E-03	1.30E-03	1.00E+00	2.08E-05	6.37E-04	6.58E-04	3.06E+00	2.15E-04
Endosulfan I	9.00E-04	9.00E-04	1.00E+00	1.44E-05	4.41E-04	4.55E-04	2.87E-01	1.59E-03
Endosulfan II	1.80E-02	1.80E-02	1.00E+00	2.88E-04	8.82E-03	9.11E-03	2.87E-01	3.18E-02
Endosulfan sulfate	1.10E-01	1.10E-01	1.00E+00	1.76E-03	5.39E-02	5.57E-02	2.87E-01	1.94E-01
Endrin aldehyde	9.70E-04	8.73E-03	9.00E+00	1.55E-05	4.28E-03	4.29E-03	1.05E-01	4.11E-02
Endrin ketone	1.10E-01	1.10E-01	1.00E+00	1.76E-03	5.39E-02	5.57E-02	NA	NA
Heptachlor	1.00E-03	3.50E-03	3.50E+00	1.60E-05	1.72E-03	1.73E-03	2.86E-01	6.06E-03

Ci = Cs x EUF

EEs=CsxFRsxNIRs

Cs = Conc. in sediment
FRs = 1
NIRs = 0.016

EEi=CixFRixNIRi

Ci = Conc. in inverts.
FRi = 1
NIRi = NIRf x 1
NIRi = 0.49

EEtotal = EEs + EEw + EEi

Table 7-11

HQ = EE total/NOAEL

GRAY FOX EXPOSURE CALCU[illegible]NS - 80th DRS, FT. STORY, VIRGINIA

Chemical	Concentration in Soil (mg/kg)	Concentration in Plants (mg/kg)	PUF	Estimated Exposure from Soil (mg/kg BW-day)	Estimated Exposure from Prey (mg/kg BW-day)	Estimated Exposure from Plants (mg/kg BW-day)	Total Estimated Exposure (mg/kg BW-day)	Gray Fox NOAEL (mg/kg BW-day)	Hazard Quotents (unitless)
1,1,2-trichloro-1,2,2-trifluoethane	2.00E-03	1.14E-03	5.70E-01	4.00E-06	1.20E-04	1.14E-05	1.35E-04	NA	NA
1,3-Dichlorobenzene	5.00E-04	1.75E-04	3.50E-01	1.00E-06	3.00E-05	1.75E-06	3.28E-05	NA	NA
2-Butanone (MEK)	5.00E-03	1.32E-01	2.64E+01	1.00E-05	3.00E-04	1.32E-03	1.63E-03	8.13E+02	2.01E-06
2-Hexanone	2.30E-01	1.42E+00	6.16E+00	4.60E-04	1.38E-02	1.42E-02	2.84E-02	NA	NA
Acetone	5.70E-02	3.06E+00	5.36E+01	1.14E-04	3.42E-03	3.06E-02	3.41E-02	2.58E+00	1.32E-02
Carbon disulfide	6.00E-03	1.75E-02	2.92E+00	1.20E-05	3.60E-04	1.75E-04	5.47E-04	2.45E+01	2.23E-05
Dichlorodifluoromethane	6.00E-04	1.30E-03	2.17E+00	1.20E-06	3.60E-05	1.30E-05	5.02E-05	NA	NA
Methyl acetate	6.90E-02	2.11E+00	3.06E+01	1.38E-04	4.14E-03	2.11E-02	2.54E-02	NA	NA
Tetrachloroethylene	1.20E-01	4.92E-02	4.10E-01	2.40E-04	7.20E-03	4.92E-04	7.93E-03	3.82E-01	2.08E-02
Trichlorofluoromethane	3.00E-03	3.99E-03	1.33E+00	6.00E-06	1.80E-04	3.99E-05	2.26E-04	2.07E+02	1.09E-06
1,1'-Biphenyl	4.70E-01	8.93E-02	1.90E-01	9.40E-04	2.82E-02	8.93E-04	3.00E-02	NA	NA
2,4-Dinitrotoluene	1.30E-01	3.59E-01	2.76E+00	2.60E-04	7.80E-03	3.59E-03	1.16E-02	NA	NA
2,6-Dinitrotoluene	5.10E-02	1.20E-01	2.35E+00	1.02E-04	3.06E-03	1.20E-03	4.36E-03	NA	NA
2-Methylnaphthalene	2.40E+00	4.56E-01	1.90E-01	4.80E-03	1.44E-01	4.56E-03	1.53E-01	NA	NA
3,3'-Dichlorobenzidine	2.90E-01	1.04E-01	3.60E-01	5.80E-04	1.74E-02	1.04E-03	1.90E-02	NA	NA
Acenaphthene	9.60E-01	2.02E-01	2.10E-01	1.92E-03	5.76E-02	2.02E-03	6.15E-02	NA	NA
Acenaphthylene	2.20E+00	4.40E-01	2.00E-01	4.40E-03	1.32E-01	4.40E-03	1.41E-01	NA	NA
Benzo(a)anthracene	**5.60E+00**	**1.06E-01**	**1.90E-02**	**1.12E-02**	**3.36E-01**	**1.06E-03**	**3.48E-01**	**2.73E-01**	**1.28E+00**
Benzo(a)pyrene	**5.50E+00**	**6.60E-02**	**1.20E-02**	**1.10E-02**	**3.30E-01**	**6.60E-04**	**3.42E-01**	**2.73E-01**	**1.25E+00**
Benzo(b)fluoranthene	**6.80E+00**	**8.16E-02**	**1.20E-02**	**1.36E-02**	**4.08E-01**	**8.16E-04**	**4.22E-01**	**2.73E-01**	**1.55E+00**
Benzo(g,h,i)perylene	3.70E+00	7.40E-03	2.00E-03	7.40E-03	2.22E-01	7.40E-05	2.29E-01	2.73E-01	8.41E-01
Benzo(k)fluoranthene	4.10E+00	4.92E-02	1.20E-02	8.20E-03	2.46E-01	4.92E-04	2.55E-01	2.73E-01	9.33E-01
bis(2-Ethylhexyl)phthalate	3.40E-01	5.10E-04	1.50E-03	6.80E-04	2.04E-02	5.10E-06	2.11E-02	5.00E+00	4.22E-03
Carbazole	4.90E-01	2.35E-01	4.80E-01	9.80E-04	2.94E-02	2.35E-03	3.27E-02	NA	NA
Chrysene	**6.00E+00**	**7.20E-02**	**1.20E-02**	**1.20E-02**	**3.60E-01**	**7.20E-04**	**3.73E-01**	**2.73E-01**	**1.37E+00**
Dibenzo(a,h)anthracene	1.50E+00	1.14E-02	7.60E-03	3.00E-03	9.00E-02	1.14E-04	9.31E-02	NA	NA
Dibenzofuran	7.90E-01	1.26E-01	1.60E-01	1.58E-03	4.74E-02	1.26E-03	5.02E-02	NA	NA
Di-n-octylphthalate	2.80E-01	2.24E-04	8.00E-04	5.60E-04	1.68E-02	2.24E-06	1.74E-02	NA	NA
Fluoranthene	**9.80E+00**	**4.12E-01**	**4.20E-02**	**1.96E-02**	**5.88E-01**	**4.12E-03**	**6.12E-01**	**2.73E-01**	**2.24E+00**
Fluorene	1.60E+00	2.24E-01	1.40E-01	3.20E-03	9.60E-02	2.24E-03	1.01E-01	NA	NA
Indeno(1,2,3-cd)pyrene	3.60E+00	4.32E-02	1.20E-02	7.20E-03	2.16E-01	4.32E-04	2.24E-01	2.73E-01	8.19E-01
Naphthalene	1.50E-01	6.60E-02	4.40E-01	3.00E-04	9.00E-03	6.60E-04	9.96E-03	NA	NA
Phenanthrene	**1.20E+01**	**1.07E+00**	**8.90E-02**	**2.40E-02**	**7.20E-01**	**1.07E-02**	**7.55E-01**	**2.73E-01**	**2.76E+00**
Pyrene	**1.60E+01**	**6.88E-01**	**4.30E-02**	**3.20E-02**	**9.60E-01**	**6.88E-03**	**9.99E-01**	**2.73E-01**	**3.66E+00**
Aluminum	**8.53E+03**	**8.53E+03**	**1.00E+00**	**1.71E+01**	**5.12E+02**	**8.53E+01**	**6.14E+02**	**5.27E-01**	**1.17E+03**
Calcium	3.06E+03	3.06E+03	1.00E+00	6.12E+00	1.84E+02	3.06E+01	2.20E+02	NA	NA
Chromium	1.00E+01	7.50E-02	7.50E-03	2.00E-02	6.00E-01	7.50E-04	6.21E-01	1.26E+03	4.94E-04
Lead	3.39E+01	1.53E+00	4.50E-02	6.78E-02	2.03E+00	1.53E-02	2.12E+00	3.67E+00	5.76E-01
Potassium	4.94E+02	4.94E+02	1.00E+00	9.88E-01	2.96E+01	4.94E+00	3.56E+01	NA	NA
Sodium	1.33E+02	1.33E+02	1.00E+00	2.66E-01	7.98E+00	1.33E+00	9.58E+00	NA	NA
alpha-BHC	1.70E-03	2.55E-04	1.50E-01	3.40E-06	1.02E-04	2.55E-06	1.08E-04	7.35E-01	1.47E-04
beta-BHC	1.00E-01	1.60E-02	1.60E-01	2.00E-04	6.00E-03	1.60E-04	6.36E-03	1.84E-01	3.46E-02
delta-BHC	1.30E-03	1.95E-04	1.50E-01	2.60E-06	7.80E-05	1.95E-06	8.26E-05	7.35E-01	1.12E-04
Endosulfan I	9.00E-04	3.06E-04	3.40E-01	1.80E-06	5.40E-05	3.06E-06	5.89E-05	6.89E-02	8.55E-04
Endosulfan II	1.80E-02	6.12E-03	3.40E-01	3.60E-05	1.08E-03	6.12E-05	1.18E-03	6.89E-02	1.71E-02
Endosulfan sulfate	1.10E-01	3.74E-02	3.40E-01	2.20E-04	6.60E-03	3.74E-04	7.19E-03	6.89E-02	1.04E-01
Endrin aldehyde	9.70E-04	1.94E-05	2.00E-02	1.94E-06	5.82E-05	1.94E-07	6.03E-05	2.51E-02	2.40E-03
Endrin ketone	1.10E-01	1.10E-01	1.00E+00	2.20E-04	6.60E-03	1.10E-03	7.92E-03	NA	NA
Heptachlor	1.00E-03	1.10E-04	1.10E-01	2.00E-06	6.00E-05	1.10E-06	6.31E-05	6.87E-02	9.19E-04

Cpl = Cs x PUF

EEs=CsxFRsxNIRs

Cs = Conc. in sediment
FRs = 1
NIRs = 0.002

EEp=CpxFRpxNIRp

Cp = Cs
FRp = 1
NIRp = NIRf x 0.85
NIRp = 0.06

EEplCplxFRplxNIRpl

Cpl = Conc. in plants
FRpl = 1
NIRpl = NIRf x 0.15
NIRpl = 0.01

EEtotal = EEs + EEw + EEp + EEpl

Table 7-11

HQ = EE total/NOAEL

Appendix I
ERA Toxicity Profiles

Remedial Investigation Report
80th Division Reserve Site
Fort Story, Virginia

MOVING TO PROTECT OUR WORLD

USATC ENVIRONMENTAL

Toxicological Profiles
For Chemicals of Potential Concern
80th Division Reserve Site, Fort Story, VA

Acenaphthene

Acenaphthene is a tricyclic aromatic hydrocarbon, crystalline solid at ambient temperature. Acenaphthene does not dissolve in water but is soluble in many organic solvents. Acenaphthene occurs in coal tar produced during the high temperature carbonization or coking of coal. It is used as a dye intermediate in the manufacture of some plastics and as an insecticide and fungicide. Acenaphthene is an environmental pollutant and has been detected in cigarette smoke, automobile exhausts, and urban air; in effluents from petrochemical, pesticide, and wood preservative industries; and in soils, groundwater, and surface waters at hazardous waste sites. This compound is one of a number of polycyclic aromatic hydrocarbons (PAHs) on EPA's priority pollutant list.

The toxic effects to humans of PAH exposure is well studied, however, the human studies of acenaphthene are limited. Acenaphthene is irritating to the skin and mucous membranes of humans and animals. Oral exposure of rats to acenaphthene for 32 days produced peripheral blood changes, mild liver and kidney damage, and pulmonary effects. Subchronic oral exposure to acenaphthene for 90 days produced increased liver weights, hepatocellular hypertrophy, and increased cholesterol levels in mice. Reproductive effects included decreased ovary weights and decreased ovarian and uterine activity as well as smaller and fewer corpora lutea. Adverse effects on the blood, lungs, and glandular tissues were reported in rats exposed daily for 5 months.

The EPA has not assigned a weight-of-evidence classification for carcinogenicity to acenaphthene.

Acenaphthylene

Inadequate data has been gathered on acenaphthylene to describe the primary effects of dermal or inhalation exposure. No tumors were observed in a lifetime study, when 0.25% acenaphthylene (purity not specified) was applied to the skin (dose, frequency and duration not stated) of mice (sex and strain not specified) (Cook, 1932). Survival was 65% at 6 months, and 35% at 1 year. It is not stated whether a control group was used. In the series of experiments, however, the dermal application of other polycyclic aromatic hydrocarbons did result in the formation of mouse skin tumors. Acenaphthylene has not yet been classified according to its carcinogenity.

Mild nephropathy was chosen as the critical effect, and was seen in male rats only in the Dietz et al. (1991) and NTP (1991) study. The choice of critical effect is supported by the report of tubular degeneration of the kidneys in male and female rats and hyaline droplet accumulation in males at 500 and 2,500 mg/kg-day in the American Biogenics Corp. (1986) study. An oral gavage study on isopropanol (Bevan et al., 1995), which is metabolized primarily to acetone, also supports nephropathy as the critical effect. In this two-generation reproductive toxicity study, kidney effects (including an increased number of hyaline droplets in epithelial cells of the proximal tubules and an increase in severity of epithelial degeneration) were noted at 500 and 1000 mg/kg-day P1 male rats and also at 100 mg/kg-day in P2 male rats. Changes in hematological parameters (erythrocyte and leukocyte counts and hemoglobin levels) in male rats, but not mice, were noted in the Dietz et al. (1991) study. Red blood cell parameters only were significantly affected at 2,500 mg/kg-day in male rats in the American Biogenic Corp. (1986) study.

Minimal or mild nephropathy was present in all groups. One out of ten animals in the control group was rated with a mild degree of nephropathy. No animals in groups dosed at intermediate levels of 10,000 ppm or lower were rated with mild nephropathy. In contrast, nine out of ten animals dosed at both 20,000 and 50,000 ppm were rated with mild nephropathy. This type of response is not amenable to benchmark dose modeling, since a graded dose-response curve is lacking (a response of 1/10 animals for controls compared with a response of 9/10 animals at the lowest response level) and the lowest response is much higher than what might be considered a low, e.g., 10%, benchmark response. For this reason, the NOAEL/LOAEL approach was used.

Overall, the most pronounced effect of acetone reported in human inhalation studies is irritation of the eyes and respiratory tract. Additionally, human data indicate that exposure to acetone may produce neurobehavioral effects. Studies that report responses over time note that the most pronounced effects occur during initial exposure and dissipate over time. Similarly, animal data also indicate that neurological effects from less than lifetime inhalation exposure are mild and transient. Although the available data base may be sufficient to support concerns for short-term exposure (based largely on irritation) extrapolation to chronic exposure is not recommended.

Available human and animal studies on acetone exposure provide insufficient information for the generation of an RfC. The available PBPK models are not amenable for route-to-route extrapolation from the oral route to the inhalation route of exposure since the oral exposure models have not been validated.

Acetone has been given the classification D, not a human carcinogen by the USEPA.

Benzo[a]pyrene

Benzo[a]pyrene is one of many chemicals known as polycyclic aromatic hydrocarbons (PAH). It exists as yellowish plates and needles. Benzo[a]pyrene is practically insoluble in water but is soluble in benzene, toluene, xylene and sparingly soluble in alcohol and methanol. No current commercial production or use of benzo[a]pyrene is known. It occurs ubiquitously in products of incomplete combustion and in fossil fuels. It has been identified in surface water, tap water, rain water, groundwater, waste water, and sewage sludge. Benzo[a]pyrene is primarily released to the air and removed from the atmosphere by photochemical oxidation and dry deposition to land or water. Biodegradation is the most important transformation process in soil or sediment.

No data are available on the systemic (non-carcinogenic) effects of benzo[a]pyrene in humans. Benzo[a]pyrene is readily absorbed following inhalation, oral, and dermal routes of administration. Following inhalation exposure, benzo[a]pyrene is rapidly distributed to several tissues in rats. The metabolism of benzo[a]pyrene is complex and includes the formation of a proposed ultimate carcinogen, benzo[a]pyrene 7,8 diol-9,10-epoxide. Dietary administration of doses as low as 10 mg/kg during gestation caused reduced fertility and reproductive capacity in mice offspring, and treatment by gavage with 120 mg/kg/day during gestation caused stillbirths, resorptions, and malformations.

Numerous epidemiological studies have shown a clear association between exposure to various mixtures of PAHs containing benzo[a]pyrene (e.g., coke oven emissions, roofing tar emissions, and cigarette smoke) and increased risk of lung cancer and other tumors. However, each of the mixtures also contained other potentially carcinogenic PAHs; therefore, it is not possible to evaluate the contribution of benzo[a]pyrene to the carcinogenicity of these mixtures. Based on United States Environmental Protection Agency (EPA) guidelines, benzo[a]pyrene was assigned to weight-of-evidence group B2, probable human carcinogen.

Benz[a]anthracene

Benz[a]anthracene is a polycyclic aromatic hydrocarbon (PAH) containing four aromatic rings two of which share carbons with only one other ring. It is soluble in alcohol, ether and benzene but practically insoluble in water. There is no commercial application for benz[a]anthracene, however, it is a ubiquitous contaminant formed during the incomplete combustion of organic material. Benz[a]anthracene is found in various kinds of smoke and flue gases, tobacco smoke, automobile exhaust, roasted coffee and in charcoal broiled, barbecued or smoked meats. It is also found in creosote, coal tar, petroleum asphalt, and a variety of foods, including vegetable oils and baker's yeast. It is an atmospheric contaminant near power plants and busy highways, and tends to bind to particulate matter in the atmosphere. In general, there is a region in the structure of PAH's that is known to react with DNA, which may account for both their toxicity and carcinogenicity.

The toxic effects of benz[a]anthracene and similar PAHs are primarily directed toward tissues that contain proliferating cells. Animal studies indicate that exposure to PAH's with distinct chemical structure can damage the hematopoietic system leading to progressive anemia as well as agranulocytosis. The lymphoid system can also be affected resulting in lymphopenia. Toxic effects have been observed in the rapidly dividing cells of the intestinal epithelium, spermatogonia and resting spermatocytes in the testis and primary oocytes of the ovary. Most of these effects have occurred following both oral and parenteral exposure. Epithelial proliferation and cell hyperplasia in the respiratory tract have been reported following subchronic inhalation exposure.

The primary concern with benz[a]anthracene exposure is its potential carcinogenicity. There is no unequivocal, direct evidence of the carcinogenicity of the compound to humans, however, benz[a]anthracene and other known carcinogenic PAHs are components of coal tar, soot, coke oven emissions and tobacco smoke. There is adequate evidence of its carcinogenic properties in animals. Oral exposures of mice to benz[a]anthracene have resulted in hepatomas, pulmonary adenomas and forestomach papillomas. The EPA weight-of-evidence classification is: B2, probable human carcinogen, for both oral and inhalation exposure based on adequate animal evidence and no human evidence.

Benzo[b]fluoranthene

Benzo[b]fluoranthene is a polycyclic aromatic hydrocarbon (PAH) with one five-membered carbon ring and four six-membered carbon rings. It is a crystalline solid with. Benzo[b]fluoranthene is virtually insoluble in water and is slightly soluble in benzene and acetone. There is no commercial production or known use of this compound. Benzo[b]fluoranthene is found in fossil fuels and occurs ubiquitously in products of incomplete combustion. It has been detected in mainstream cigarette smoke; urban air; gasoline engine exhaust; emissions from burning coal and from oil-fired heating; broiled and smoked food; oils and margarine; and in soils, groundwater, and surface waters at hazardous waste sites.

No absorption data were available for benzo[b]fluoranthene; however, by analogy to structurally-related PAHs, primarily benzo[a]pyrene, it would be expected to be absorbed from the gastrointestinal tract, lungs, and skin. No data were found concerning the acute, subchronic, chronic, developmental, or reproductive toxicity of benzo[b]fluoranthene in humans.

No long-term oral or inhalation bioassays were available to assess the carcinogenicity of benzo[b]fluoranthene in humans. Benzo[b]fluoranthene was tested for carcinogenicity in animals in dermal application, lung implantation, subcutaneous (s.c.) injection, and intraperitoneal (i.p.) injection studies. Dermal applications of 0.01-0.5% solutions of benzo[b]fluoranthene for life produced a high incidence of skin papillomas and carcinomas in mice. Sarcomas and carcinomas of the lungs and thorax were seen in rats receiving single lung implants of 0.1-1 mg benzo[b]fluoranthene. Newborn mice receiving 0.5 umol benzo[b]fluoranthene via i.p. injection developed liver and lung tumors and mice administered three s.c. injections of 0.6 mg benzo[b]fluoranthene developed injection site sarcomas.

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

Benzo[k]fluoranthene

Benzo[k]fluoranthene is a polycyclic aromatic hydrocarbon (PAH) with one five-membered and four six-membered carbon rings. It is a crystalline solid. Benzo[k]fluoranthene is insoluble in water but is soluble in acetic acid, benzene, and ethanol. No commercial production or commercial use of benzo[k]fluoranthene is known at this time, however, small amounts of this compound are used for research. Benzo[k]fluoranthene is found in fossil fuels and occurs ubiquitously in products of incomplete combustion. It has been detected in mainstream cigarette smoke, gasoline engine exhaust, emissions from burning coal and from oil-fired heating, lubricating oils, used motor oils, crude oils, and in soils, surface waters, and groundwater at hazardous waste sites.

No absorption or excretion data were available for benzo[k]fluoranthene; however, by analogy to structurally-related PAHs, primarily benzo[a]pyrene, it would be expected to be absorbed from the gastrointestinal tract, lungs, and skin. No data were found concerning the acute, subchronic, chronic, developmental, or reproductive toxicity of benzo[k]fluoranthene in humans.

No long-term oral or inhalation bioassays were available to assess the carcinogenicity of benzo[k]fluoranthene in humans. Benzo[k]fluoranthene was tested for carcinogenicity in animals in dermal application, subcutaneous (s.c.) injection, lung implantation, and intraperitoneal (i.p.) injection studies. Dermal applications of 0.5% solutions of benzo[k]fluoranthene for life produced only a few skin papillomas in mice, but in initiation-promotion assays, benzo[k]fluoranthene was active as an initiator of skin carcinogenesis. Injection site sarcomas developed in mice given three s.c. injections of 0.6 mg benzo[k]fluoranthene and dose-related increases of epidermoid carcinomas of the lungs were reported in rats receiving single lung implants of 0.16-4.15 mg benzo[k]fluoranthene. In a short-term assay, hepatic and lung tumors occurred in newborn mice receiving 2.1 umol benzo[k]fluoranthene via i.p. injection.

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

Benzo[g,h,i]perylene

Benzo[g,h,i]perylene is a polycyclic aromatic hydrocarbon (PAH) with six carbon rings. It is a crystalline solid. Benzo[g,h,i]perylene is practically insoluble in water but is soluble in 1,4-dioxane, dichloromethane, benzene, and acetone. There is no known commercial production or use of benzo[g,h,i]perylene. It occurs naturally in crude oils and is present ubiquitously in products of incomplete combustion and in coal tar. It has been identified in cigarette smoke, charcoal-broiled steaks, and edible oils and in soils, groundwater, and surface waters at hazardous waste sites.
No absorption data were available for benzo[g,h,i]perylene; however, by analogy to other PAHs, primarily benzo[a]pyrene, it would be expected to be absorbed from the gastrointestinal tract, lungs, and skin. No human or animal data were available to evaluate the toxicity of benzo[g,h,i]perylene.

No oral or inhalation bioassays were available to assess the carcinogenicity of benzo[g,h,i]perylene in humans. Negative results were reported in dermal application studies and in initiation-promotion assays for skin tumorigenesis in mice. Although a few pulmonary tumors were observed in Osborne-Mendel rats when benzo[g,h,i]perylene was administered as single lung implants of >=83 mg, the tumors may have been caused by impurities in the test compound. In subcutaneous injection studies, benzo[g,h,i]perylene did not produce injection site tumors in mice.

Based on no human data and inadequate data with experimental animals, the United States Environmental Protection Agency (EPA) has classified benzo[g,h,i]perylene in weight-of-evidence Group D, not classifiable as to human carcinogenicity.

BHC

Hexachlorocyclohexane (HCH), also known as benzene hexachloride (BHC), is a synthetic chemical that exists in eight chemical forms called isomers. The different isomers are named according to the position of the hydrogen atoms in the structure of the chemical. One of these forms, gamma-HCH (or g-HCH, commonly called lindane) is produced and used as an insecticide on fruit, vegetables, and forest crops. It is also used in the United States and in many other countries as a topical treatment for head and body lice and scabies, a contagious skin disease caused by mites. It is a white solid whose vapor may evaporate into the air. The vapor is colorless and has a slight musty odor when it is present at 12 or more parts HCH per million parts air (ppm). g-HCH has not been produced in the United States since 1976. However, imported g-HCH is available in the United States for insecticide use as a dust, powder, liquid, or concentrate. It is also available as a lotion, cream, or shampoo to control scabies and head lice. The scope of this profile includes information on technical-grade HCH, as well as the alpha (a), beta (b), gamma (g), and delta (d) isomers.

In humans, the effects of breathing toxic amounts of g-HCH and/or a-, b-, and d-HCH can result in blood disorders, dizziness, headaches, and possible changes in the levels of sex hormones in the blood. These effects have occurred in workers exposed to HCH vapors during pesticide manufacturing. People who have swallowed large amounts have had seizures; some have died. A few people, who have used very large amounts of g-HCH or used it frequently on their skin, have developed blood disorders or seizures. However, no cause-and-effect relationship between exposure to g-HCH and blood disorders in humans has been established. Animals that have been fed g- and a-HCH have had convulsions, and animals fed b-HCH have become comatose. All isomers can produce liver and kidney effects. Reduced ability to fight infection was reported in animals fed g-HCH, and injury to the ovaries and testes was reported in animals given g-HCH or b-HCH. The body changes HCH isomers into other chemical products, some of which may be responsible for the harmful effects. Long-term oral administration of a-HCH, b-HCH, g-HCH, or technical-grade HCH to laboratory rodents has been reported to result in liver cancer. The Department of Health and Human Services (DHHS) has determined that HCH may reasonably be anticipated to cause cancer in humans.

The three BCH isomers identified as COPCs (alpha -BHC, beta-BHC, and gamma-BHC) are classified as C possible human carcinogens.

Bis(2-ethylhexyl)phthalate

Bis(2-ethylhexyl)phthalate or di(2-ethylhexyl)phthalate (DEHP) is a clear oily liquid and is practically insoluble in water. Bis(2-ethylhexyl)phthalate is primarily used in the plastics industry as a plasticizer with such varied applications as wire insulation, food packaging and biomedical applications such as tubing and blood containers. Other uses include vacuum pump oil and as a dielectric fluid in capacitors. The combined annual production of dioctyl phthalates in the United States exceeds 300 million pounds. The wide-spread uses of bis(2-ethylhexyl)phthalate have made the compound, along with other phthalic acid esters, ubiquitous in the environment. It has been detected in ground water, surface water, drinking water, air, soil, plants, fish and animals.

There is no evidence that DEHP causes serious health effects in humans. Most of what we know about the health effects of DEHP comes from high exposures to rats and mice. Brief exposure to very high levels of DEHP in food or water damaged sperm, but the effect reversed when DEHP was removed from the diet. Longer exposures to high doses affected the ability of both males and females to reproduce and caused birth defects. High levels of DEHP damaged the livers of rats and mice. Long exposures of rats to DEHP caused kidney damage similar to the damage seen in the kidneys of long-term dialysis patients. Whether or not DEHP contributes to human kidney damage, is unclear at present. Health effects from skin contact with products containing DEHP do not cause harmful effects because it cannot be taken up easily through the skin.

There is no direct evidence in any study on humans exposed to bis(2-ethylhexyl)phthalate that it causes cancer. Bis(2-ethylhexyl)phthalate is known to induce the proliferation of peroxisomes, which has been associated with carcinogenesis. Dose-dependent, statistically-significant increases in the incidences of hepatocellular carcinomas and combined carcinomas and adenomas were seen in mice and rats exposed to bis(2-ethylhexyl)phthalate in their diet. An increased incidence of neoplastic nodules and hepatocellular carcinomas was also reported in exposed rats.

Based on U.S. EPA guidelines, bis(2-ethylhexyl)phthalate was assigned to weight-of-evidence Group B2, probable human carcinogen, on the basis of an increased incidence of liver tumors in rats and mice.

Chrysene

Chrysene is a polycyclic aromatic hydrocarbon (PAH). Pure chrysene is a colorless crystalline solid that is virtually insoluble in water; only slightly soluble in alcohol, ether, carbon bisulfide or glacial acetic acid; and moderately soluble in benzene. Chrysene is not used or produced commercially; it is used primarily in research applications. Chrysene is a ubiquitous environmental contaminant that occurs as a product of the incomplete combustion of organic compounds. Environmental manmade sources of chrysene include gasoline, diesel, and aircraft turbine exhausts; coal combustion and gasification; emissions from coke ovens, wood burning stoves, and waste incineration; and various industrial applications such as iron, aluminum, and steel production. Chrysene is also a constituent of coal, oil, and their distillates, such as coal tar, and creosote. Non-manmade sources of chrysene include forest and grass fires, as well as volcanoes; however, these latter sources do not contribute significantly to the total environmental concentration of chrysene.

Little information on the absorption, distribution, metabolism and excretion of chrysene in humans is available. Animal studies have shown that approximately 75% of the administered chrysene may be absorbed by oral, dermal, or inhalation routes. Humans are exposed to chrysene by oral, inhalation, and dermal routes. Meats, particularly those with high fat contents, contribute significant quantities of chrysene to the diet from cooking the fat. Foods smoked or cooked over open coals contain even greater concentrations. Significant exposure to chrysene also occurs through the inhalation of mainstream and sidestream cigarette smoke. Occupational exposure to chrysene occurs during tar production or from coking plants, coal gasification, smoke houses and smoked meat production, road and roof-tarring, incinerators, and aluminum production. Human or animal systemic, developmental, and reproductive health effects following exposure to chrysene were not identified.

Oral and inhalation carcinogenic bioassays were not identified for humans. In mouse skin painting studies, chrysene was an initiator of papillomas and carcinomas. In addition, intraperitoneal injections of chrysene have induced liver adenomas and carcinomas in male CD-1 and BLU/Ha Swiss mice. EPA has classified chrysene in weight-of-evidence Group B2, probable human carcinogen, based on the induction of liver tumors and skin papillomas and carcinomas following treatment and the mutagenicity and chromosomal abnormalities induced in in-vitro tests.

Dibenz[a,h]anthracene

Dibenz[a,h]anthracene is a polycyclic aromatic hydrocarbon (PAH) with five aromatic carbon rings. Dibenz[a,h]anthracene exists as crystalline plates or leaflets and is insoluble in water; slightly soluble in alcohol and ether; and soluble in petroleum ether, benzene, toluene, xylene, oils, and other organic solvents. No commercial production or use of dibenz[a,h]anthracene is known. It occurs as a component of coal tars, shale oils, and soots and has been detected in gasoline engine exhaust, coke oven emissions, cigarette smoke, charcoal broiled meats, vegetation near heavily traveled roads, and surface water and soils near hazardous waste sites.

Dibenz[a,h]anthracene is poorly absorbed from the digestive tract. No human studies were available to evaluate the toxicity of dibenz[a,h]anthracene. In animals, depressed immune responses were observed in mice following single or multiple subcutaneous injections of dibenz[a,h]anthracene. Weekly subcutaneous injections of 0.05% dibenz[a,h]anthracene for 40 weeks produced lymphoid tissue changes, decreased spleen weights, and liver and kidney lesions in mice. Weekly intramuscular injections of 20 mg/kg promoted the development of arteriosclerotic plaques in chickens.

No epidemiologic studies or case reports addressing the carcinogenicity of dibenz[a,h]anthracene in humans were available. In animals, dibenz[a,h]anthracene has produced tumors by different routes of administration (oral and dermal), having both local and systemic carcinogenic effects. After administration, dibenz[a,h]anthracene produced pulmonary adenomatosis, alveologenic carcinomas of the lung, hemangio-endotheliomas of the pancreas and mesentery/abdominal lymph nodes, mammary carcinomas (females), forestomach papillomas, and skin papillomas. Based on no human data and sufficient evidence for carcinogenicity in animals, EPA has assigned dibenz[a,h]anthracene a weight-of-evidence classification of B2, probable human carcinogen.

Dibenzofuran

The USEPA is currently investigating dibenzofuran due to its longevity in the environment. Currently there is no data avavailible on dibenzofuran's acute, chronic or carcingenity.

Fluoranthene

Fluoranthene is a polycyclic aromatic hydrocarbon (PAH). It exists as pale yellow needles or plates. Fluoranthene is almost insoluble in water, but is soluble in alcohol, ether, benzene, and acetic acid. Fluoranthene can be produced by the pyrolysis of organic raw materials such as coal and petroleum at high temperatures; it is also known to occur naturally as a product of plant biosynthesis. Fluoranthene is a constituent of coal tar and petroleum-derived asphalt. Currently, there is no known production or use of this compound.

Fluoranthene can be absorbed through dermal exposure and, based on similar PAHs, would be expected to be absorbed from the digestive tract and lungs. Although a large body of literature exists on the toxicity and carcinogenicity of PAHs, toxicity data for fluoranthene are very limited. No human data were available that addressed the toxicity of fluoranthene. Toxicity studies in animals have shown that fluoranthene exposure can cause eye irritation, nephropathy, increased liver weights, and increased liver enzyme levels.

No oral or inhalation bioassays were available to assess the carcinogenicity of fluoranthene to humans; bioassays by other exposure routes generally gave negative results. Studies involving topical application to the skin of mice and subcutaneous injection in mice provided no evidence of carcinogenicity. Fluoranthene was also inactive in mouse skin initiation and promotion assays. Based on no human data and inadequate data from animal bioassays, U.S. EPA has placed fluoranthene in weight-of-evidence group D, not classifiable as to human carcinogenicity.

Fluorene

CD-1 mice (25/sex/group) were exposed to 0, 125, 250, or 500 mg/kg/day fluorene suspended in corn oil by gavage for 13 weeks. Parameters used to assess toxicity included food intake, body weight, clinical observations, hematology and serum chemistry and gross and histopathological examinations. Increased salivation, hypoactivity, and urine-wet abdomens in males were observed in all treated animals. The percentage of mice exhibiting hypoactivity was dose-related. In mice exposed at 500 mg/kg/day, labored respiration, ptosis (drooping eyelids), and unkempt appearance were also observed. A significant decrease in red blood cell count and packed cell volume were observed in females treated with 250 mg/kg/day fluorene and in males and females treated with 500 mg/kg/day. Decreased hemoglobin concentration and increased total serum bilirubin levels were also observed in the 500 mg/kg/day group. Decreases in erythrocyte count, packed cell volume, and hemoglobin concentration were all observed at 125 mg/kg; however, these effects, although apparently dose-dependent, were not statistically significant. A significant decreasing trend in BUN and a significant increasing trend in total serum bilirubin were observed in both high-dose males and females. A dose-related increase in relative liver weight was observed in treated mice; a significant increase in absolute liver weight was also observed in the mice treated with 250 and 500 mg/kg/day fluorene. A significant increase in absolute and relative spleen and kidney weight was observed in males and females exposed to 500 mg/kg/day and males at 250 mg/kg/day. Increases in the absolute and relative liver and spleen weights in the high-dose males and females were accompanied by histopathological increases in the amounts of hemosiderin in the spleen and in the Kupffer cells of the liver. No other histopathological lesions were observed. The LOAEL is 250 mg/kg/day based on hematological effects; the NOAEL is 125 mg/kg/day.

Morris et al. (1960) fed 18 female Buffalo strain rats 12.3 mg fluorene/kg/day for 6 months or 13.1 mg fluorene/kg/day for 18 months. The diet in the 6- month study was composed of purified materials, low in protein and fat, and prepared in 3% propylene glycol. The diet in the longer study was composed of a mixture of natural foodstuffs in 3% corn oil. In the 6-month study, of 11 animals examined, the incidences of non-neoplastic reactions were reported by organ as follows: forestomach (acanthosis, hyperkeratosis), 5 animals; kidney (squamous metaplasia of pelvis), 7 animals; uterus (squamous metaplasia), 1 animal; small intestine (epithelial ulcer, acute), 1 animal; and liver (cirrhosis), 3 animals.

In the longer study using 18 rats, none of the effects seen in the 6-month study were observed. The only effect reported in this experiment was hyperplasia of the pituitary (predominantly chromophobe cells) in two animals.

It appears that the effects observed in the 6-month study were related to either dietary composition or propylene glycol, since none of these effects were observed after 18 months at a similar dosage using a different diet and vehicle. Consequently, this study is not considered acceptable as a basis for chronic RfD derivation.

Classification -- D; not classifiable as to human carcinogenicity

Indeno[1,2,3-cd]pyrene

Indeno[1,2,3-cd]pyrene is a polycyclic aromatic hydrocarbon (PAH) with one five-membered carbon ring and five six-membered carbon rings. It is a crystalline solid that is insoluble in water but is soluble in organic solvents. There is no commercial production or known use of indeno[1,2,3-cd]pyrene. The compound is found in fossil fuels and occurs ubiquitously in products of incomplete combustion. It has been detected in mainstream cigarette smoke; gasoline engine exhaust; emissions from burning coal; lubricating oils; used motor oils; and soils, surface waters, and groundwater at hazardous waste sites.

No absorption data were available for indeno[1,2,3-cd]pyrene; however, by analogy to structurally-related PAHs, it would be expected to be absorbed from the digestive tract, lungs, and skin. No data were found concerning the acute, subchronic, chronic, developmental, or reproductive toxicity of indeno[1,2,3-cd]pyrene.

No long-term oral or inhalation human bioassays were available to assess the carcinogenicity of indeno[1,2,3-cd]pyrene. The compound was tested for carcinogenicity in dermal application, lung implant, subcutaneous injection, and intraperitoneal injection studies in animals. Dermal application produced skin papillomas and carcinomas in mice. Lung implants produced epidermoid carcinomas in rats. Injection site sarcomas developed in mice given injections of indeno[1,2,3-cd]pyrene. Based on no human data and sufficient evidence for carcinogenicity in animals, the United Stated Environmental Protection Agency (EPA) has assigned a weight-of-evidence classification of B2, probable human carcinogen to indeno[1,2,3-cd]pyrene.

Naphthalene

Naphthalene is a white solid that is found naturally in fossil fuels and that exhibits a typical mothball odor. Naphthalene is a polycyclic aromatic hydrocarbon composed of two fused benzene rings. Burning tobacco or wood produces naphthalene. It occurs in crude oil, from which it may be recovered directly as white flakes; it can also be isolated from cracked petroleum, coke-oven emissions, or from high-temperature carbonization of bituminous coal. The major products made from naphthalene are moth repellents. It is also used for making dyes, resins, leather, tanning agents, and the insecticide carbaryl.

Naphthalene can be absorbed by the oral, inhalation, and dermal routes of exposure and can cross the placenta in amounts sufficient to cause fetal toxicity. Exposure to large amounts of naphthalene may damage or destroy some red blood cells, causing a low level until the body replaces the destroyed cells. People, particularly children, have developed this problem after eating naphthalene-containing mothballs or deodorant blocks. Some of the symptoms of this problem are fatigue, lack of appetite, restlessness, and pale skin. Exposure to large amounts of naphthalene may also cause neurotoxic effects (confusion, lethargy, listlessness, vertigo), gastrointestinal distress, hepatic effects (jaundice, hepatomegaly, elevated serum enzyme levels), renal effects, and ocular effects (cataracts, optical atrophy). The estimated lethal dose of naphthalene is 5-15 g for adults and 2-3 g for children. Animals sometimes develop cloudiness in their eyes after swallowing naphthalene. It is not clear if this also develops in people. When mice were repeatedly exposed to naphthalene vapors for 2 years, their noses and lungs became inflamed and irritated.

Available cancer bioassays were insufficient to assess the carcinogenicity of naphthalene. Using the EPA's 1996 Proposed Guidelines for Carcinogen Risk Assessment, the human carcinogenic potential of naphthalene via the oral or inhalation routes "cannot be determined" at this time based on human and animal data. However, there is suggestive evidence (observations of benign respiratory tumors and one carcinoma in female mice only exposed to naphthalene by inhalation) that naphthalene may cause cancer. Additional support includes increase in respiratory tumors associated with exposure to 1-methylnaphthalene.

Phenanthrene

Phenanthrene, also known as phenanthrin, is a polycyclic aromatic hydrocarbon (PAH) with three aromatic carbon rings. It exists as a colorless crystalline solid that occurs in fossil fuels and is present in products of incomplete combustion. Some of the known sources of phenanthrene in the atmosphere are vehicular emissions, coal and oil burning, wood combustion, coke plants, aluminum plants, iron and steel works, foundries, municipal incinerators, synfuel plants, and oil shale plants. According to U.S. EPA, there is no current commercial production of phenanthrene in the United States. Phenanthrene can be used in the manufacture of dyestuffs, explosives, drugs, in the synthesis of other chemicals, and in biochemical research. A derivative of phenanthrene has been used as a starting material for synthesizing bile acids, cholesterol, and other steroids.

Phenanthrene is absorbed following oral and dermal exposure. Data from structurally related PAHs suggest that phenanthrene would be absorbed from the lungs. Although a large body of literature exists on the toxicity and carcinogenicity of other PAHs, toxicity data for phenanthrene are very limited. No human data were available that addressed the toxicity of phenanthrene. Phenanthrene produced slight liver toxicity in rats.

No inhalation bioassays were available to assess the carcinogenicity of phenanthrene in humans. Many animal studies failed to increase tumor incidence. However, phenanthrene was found to be an active tumor initiator in one mouse study. Based on no human data and inadequate data from animal bioassays, U.S. EPA has placed phenanthrene in weight-of-evidence group D, not classifiable as to human carcinogenicity.

Pyrene

Pyrene, also known as benzo(def)phenanthrene, is a polycyclic aromatic hydrocarbon (PAH) with four aromatic carbon rings. Pure pyrene is a colorless crystalline solid at ambient temperature; the presence of tetracene, a common contaminant, gives it a yellow color. Pyrene can be derived from coal tar, but there is no commercial production or known commercial use of this compound. Pyrene from coal tar has been used as the starting material for the synthesis of benzo[a]pyrene.

Human exposure to pyrene occurs primarily through inhalation of tobacco smoke and polluted air and by ingestion of water polluted by combustion effluents. Pyrene is common in the environment as a product of incomplete combustion and has been identified in water, food, and in the air. Although a large body of literature exists on the toxicity and carcinogenicity of other PAHs, toxicity data for pyrene are limited. No human data were available that addressed the toxicity of pyrene. Subchronic oral exposure to pyrene produced nephropathy, decreased kidney weights, increased liver weights, and slight hematological changes in mice and produced fatty livers in rats. A single intraperitoneal injection of pyrene produced swelling and congestion of the liver and increased serum aspartate amino transferase (AST) and bilirubin levels in rats. No data were available concerning the toxic effects of inhalation exposure to pyrene.

No oral or inhalation bioassays were available to assess the carcinogenicity of pyrene in humans. Many studies involving different routes of pyrene exposure were done on animals. None of these studies saw an increase in tumor rates, but there is evidence that pyrene enhances the tumor causing ability of benzo[a]pyrene. Based on no human data and inadequate data from animal bioassays, U.S. EPA has placed pyrene in weight-of-evidence group D, not classifiable as to human carcinogenicity.

Appendix J
Fort Story PA/SI Report

Remedial Investigation Report
80th Division Reserve Site
Fort Story, Virginia

MOVING TO PROTECT OUR WORLD

USATC ENVIRONMENTAL

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U.S. Army Corps of Engineers
Missouri River Division
Omaha District

Final Site Investigation Report for the

Fort Story Preliminary Assessment/Site Investigation and Fort Story NIKE Preliminary Assessment/Site Investigation

Fort Story, Virginia
January 1992

JMM James M. Montgomery

and the appropriate site number. For example, the generic designation for a soil sample collected from a monitoring well is as follows: S(site number)MW(associated number)(sample depth), e.g., S12MW104(0).

2.1.2 Identification of Trigger Levels

The analytical results from the Fort Story PA/SI sites and NIKE PA/SI field investigations were utilized to evaluate site specific contamination and the need for further investigations at the sites. To provide a basis for evaluating the data, media-specific trigger levels were developed for each of the analytes detected. The trigger levels are based on statistically-significant site background data and regulatory standards promulgated by the EPA or the Commonwealth of Virginia for the chemicals of concern.

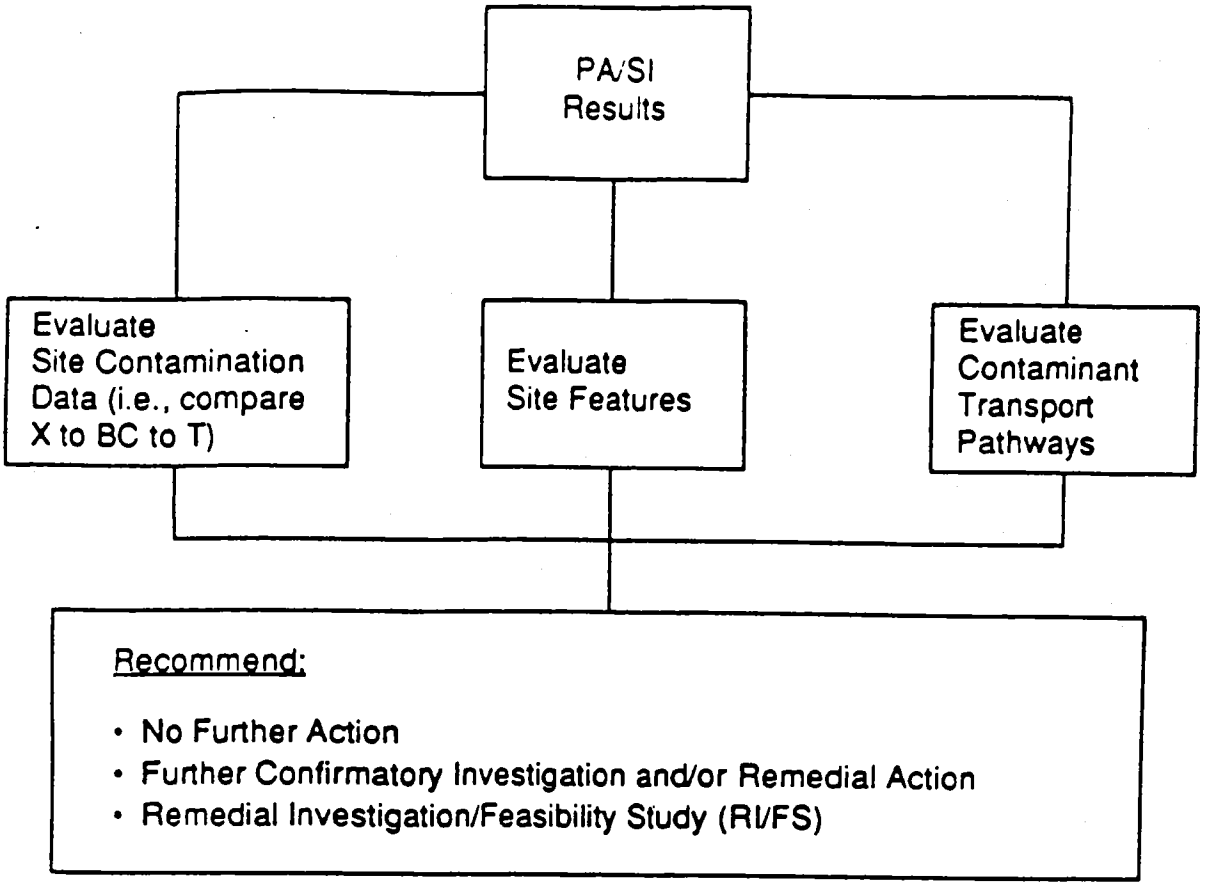
The selection of the type of further investigation that is appropriate for a given PA/SI or NIKE PA/SI site is based on comparison of analytical results to trigger levels for compounds of concern, evaluation of contaminant transport pathways for compounds of concern and consideration of pertinent site features. The assessment of site contamination data involved comparison of contaminant concentrations measured in site media to appropriate background concentrations and/or trigger levels. This interpretation is not strictly quantitative, however. For example, if one contaminant is detected at a level above the trigger level in the groundwater from an isolated monitoring well, this factor would not necessarily constitute recommending further investigative activity. However, if the presence of this contaminant in the groundwater was indicative of the presence of a plume or a source at the site, further study would be recommended. Other data, such as site features and contaminant transport pathways, are relevant for consideration in this context and in those instances where multiple site contaminants are present in site media at levels above background but below trigger levels. Figure 2-1 is a matrix showing the decision and recommendation process for PA/SI sites. The possible additional site activities presented in order of increasing levels of effort required are:

- **No Further Action:** This option may be recommended for a PA/SI site when analyte concentrations in site environmental media are below the background concentrations. In this instance, trace levels of environmental contamination imply that any potential contaminant transport at or near the site would be insignificant.

- **Further Confirmatory Investigation and/or Removal Action:** This option may be recommended for a PA/SI site when concentrations of a limited number of compounds of concern in site environmental media are above the trigger levels. Additional confirmatory investigation might focus on particular media, compounds of concern or site locations in an attempt to verify existing data. Removal action denotes mitigation of possibly contaminated material or media present at a PA/SI site to reduce or eliminate potential contaminant transport.

- **Remedial Investigation/Feasibility Study (RI/FS):** This option may be recommended for a PA/SI site when concentrations of many compounds of concern in site environmental media are above the corresponding trigger levels or when data possibly indicate the presence of a contaminated groundwater plume. An RI/FS involves focused additional investigation at a site to confirm source areas and delineate the nature and extent of environmental contamination. An RI/FS provides additional data necessary for estimating exposure concentrations and dosages and predicting health or environmental risks associated with exposure.

The trigger levels represent a mechanism to screen each of the sites for the purpose of determining whether there is sufficient cause to warrant further inquiry into site conditions. As such, they are generally not intended to be action levels in a regulatory sense.



X = Detected Concentration of Analyte
BC = Background Concentration of Analyte
T = Trigger Level Concentration of Analyte

JMM

Site Evaluation and Recommendation Decision Matrix

Figure 2-1

The following sections discuss how the trigger levels are developed.

2.1.2.1 Soil. To date, regulatory standards have not been promulgated by federal or state authorities for most of the soil contaminants detected at Fort Story. As such, TFH and PCBs represent the only analytes that have regulatory-based trigger levels. The trigger levels for metals in soil were derived from a statistical analysis of the background boring results. No trigger level has been set for VOCs, BNAs or cyanide. DDT, DDD, DDE and Chlordane, while not having any set regulatory levels for soil, represent particular analytes that were widely used throughout the Installation in the past and warrant special consideration, as discussed below.

Total Fuel Hydrocarbons (TFH). Contaminant-specific guidelines for hydrocarbons in soil are provided in *Underground Storage Tanks; Technical Standards and Corrective Action Requirements VR-680-13-02* (Commonwealth of Virginia, 1989). Based on these regulations, any contaminated soil exhibiting a total fuel hydrocarbon level in excess of 100 parts per million (ppm) or 100 milligrams per kilogram (mg/kg) must be disposed of in accordance with state and federal guidelines. Although this criterion is disposal related, this concentration level (100 mg/kg) was adopted for this evaluation as a regulatory-based trigger level for TFH in soil.

Polychlorinated Biphenyls (PCBs). The EPA regulates PCBs under the Toxic Substance Control Act (TSCA). No regulatory requirements exist for PCB cleanup with the exception of the requirement for timely cleanup. However, EPA has published a nationwide TSCA PCB spill clean-up policy stipulating clean-up levels for PCB discharges to the environment (40 CFR Part 761) (EPA, 1987).

Since the sites at Fort Story are not considered by the Commonwealth of Virginia Department of Waste Management to be restricted access areas, the relevant section of the policy serves as the basis for the trigger level for PCBs. The TSCA policy for defining "clean fill" is less than 1 ppm by weight. JMM has adopted this standard as the appropriate trigger level for PCBs in soil at Fort Story PA/SI and NIKE PA/SI sites.

DDT, DDD, DDE and Chlordane. Review of previous investigations at Fort Story suggests that these compounds were used widely throughout the Installation in the past. They have been detected at low levels at numerous locations (USAEHA, 1987; ESE, 1988). JMM also determined through contacts with Commonwealth of Virginia employees associated with Virginia Polytechnic Institute and State University and Consolidated Laboratory Services, Pesticide Lab, respectively, that the levels of DDT and its metabolites, DDD and DDE along with Chlordane present at the sampling sites at Fort Story were not unusual compared to other areas in Virginia, given the extensive use of DDT and Chlordane at the installation in the past. Both contacts considered JMM's detected values to be within a reasonable range for concentrations of DDT and its metabolites, as well as Chlordane, within the soils in the area of the project sites (Personal Communication, Young, Chase, 1991). Subsequently, no trigger level has been set for DDT and its metabolites, along with Chlordane, as all concentrations are considered to be within expected background ranges (Personal Communication, Young, Chase, 1991).

Cyanide. Cyanide was detected in the analysis of soil at one site at Fort Story. Because of the highly toxic nature of this compound, further investigation into the nature of this compound was conducted.

Cyanide compounds all share the common ^{-}CN group. The simplest form of cyanide is HCN. The ^{-}CN group can also form simple salts with such cations such as potassium and sodium. More complex organic forms include the cyanates ^{-}OCN, and the thiocyanates ^{-}SCN. Metal cyanide complexes, ferricyanides, and ferrocyanides are also common.

Hydrogen cyanide and the simple salt forms (free cyanide) are highly toxic. In contrast, the complexed cyanide compounds appear to exhibit low toxicity. Toxicity of ferrocyanide complexes is related to the degree to which dissociation occurs and free cyanide is available. There is no evidence of cyanide accumulation in mammals or aquatic organisms.

A related problem in assessing the toxicity of cyanide at these sites concerns the methods by which the chemicals are analyzed. There are a number of methods available. However, there is considerable uncertainty concerning the form or species of cyanide that is actually being measured. Because different forms of cyanide differ in toxicity, there is a need to define better the methods used. When a priority pollutant analysis is done, only total cyanide analysis is required. This is the case at Fort Story.

Iron cyanide complexes are generated in the manufactured gas and coal industry through the process by which the produced gas is cleaned. Cyanide is commonly present in areas where coal is stored, and used to be a common ingredient in rodenticides. Cyanide was found in the soil at Site 2, Landfill 2, at a concentration of 2 mg/kg in a surface soil sample. It is possible that the cyanide found in the soil sample was from either of these sources if they were dumped in the landfill.

Cyanide has also been found in uncontaminated soils in some areas throughout the United States - levels for cyanide reported as indicative of uncontaminated conditions are (Kelly, 1979):

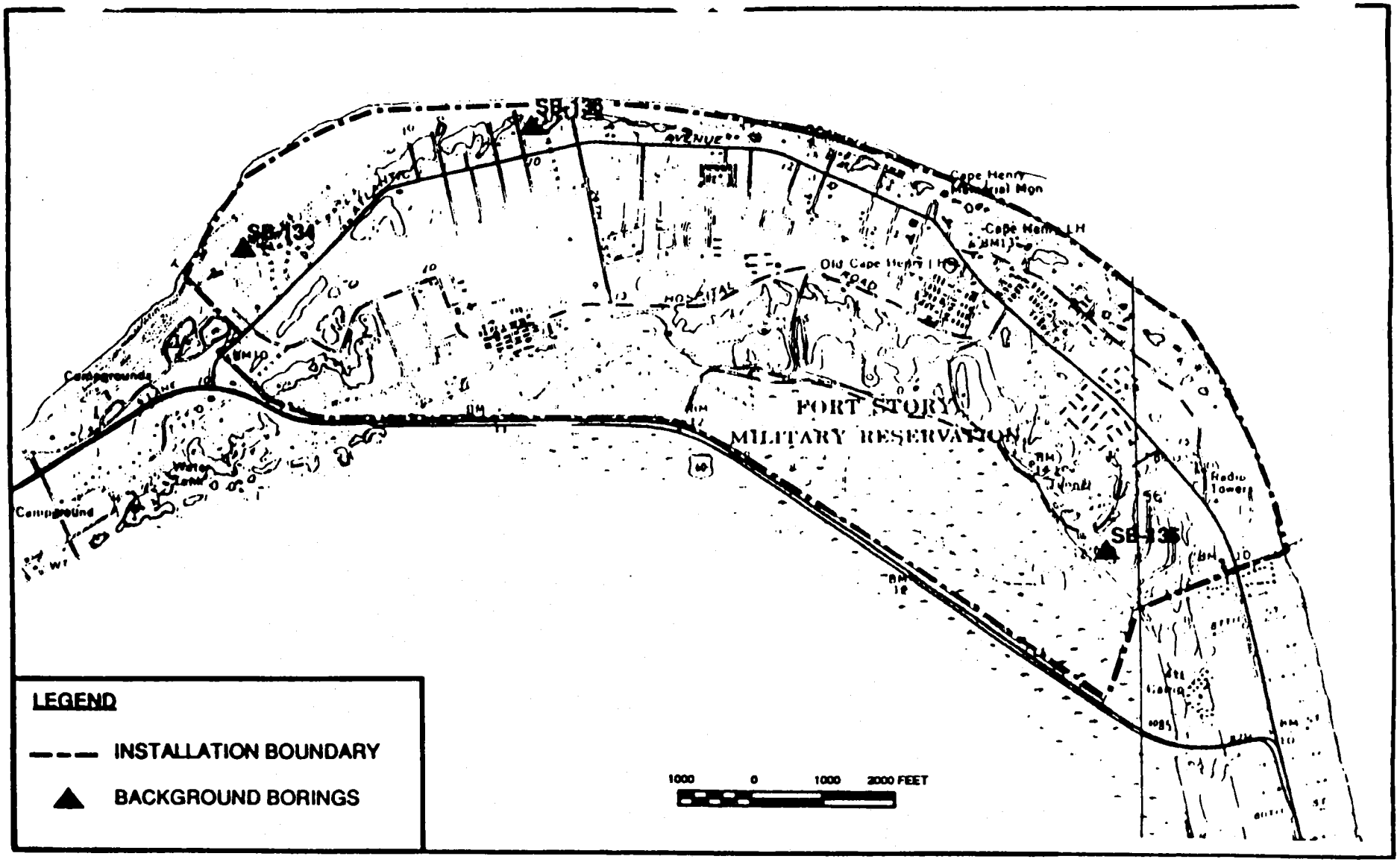
- Free cyanide, 0 - 1 mg/kg
- Total cyanide, 0 - 5 mg/kg
- Ferricyanide, 0 - 100 mg/kg
- Thiocyanide, 0 - 10 mg/kg

Several countries have developed guidelines for assessment and/or clean-up of contaminated soil. These guidelines consider background for total cyanide to be equal to or less than 1 mg/kg for total free cyanide and equal to or less than 5 mg/kg for total complex cyanide [(Moen, J.E.T., J.P. Cornet and C.W.A. Evers, 1985) (Quebec, Ministry of the Environment of, 1986) (Interdepartmental Committee on the Redevelopment of Contaminated Land (ICRCL), 1983a.) (Guidance on the Assessment and Redevelopment of Contaminated Land, ICRCL 59/83.) (CDEP/EPTS, Romney House, 43 Marsham Street, London, SWIP 3PY, UK, CDEP/EPTS, 1983b.); Notes on the Redevelopment of Gas Works Sites, ICRCL 18/79, 1983c.)].

The exact form of cyanide at Site 2 is unknown. It is possible that the cyanide is in a metal complex form and therefore less toxic than free cyanide. Despite the unknown form, the concentrations of cyanide found are within the range of total cyanide considered representative of uncontaminated soils. The concentrations identified on-site are sufficiently low to not be a human health concern. Regardless of the source, cyanide at the site does not require further evaluation.

Background Borings. Background borings were drilled and sampled during the project to determine the background levels of analytes at Fort Story. Figure 2-2 shows the location of background borings sampled for the Fort Story investigation. These include borings SB-134, SB-135 and SB-136. Soil boring SB-134 was located near the eastern perimeter of Fort Story and is representative of conditions in the sand flat area. Soil boring SB-135 was located adjacent to the western boundary of Fort Story and is representative of conditions in the central sand ridge area. Located in the north-central perimeter of Fort Story, SB-136 is representative of conditions in the coastal dune complex.

Two soil samples were collected from each background boring for analytical characterization. Seven analytical samples, including one field duplicate sample, were collected from the



JRM

Background Boring Locations
Ft. Story, VA

Figure 2-2

background borings. The analytical soil samples were collected from the ground surface and at the total depth of each boring. Table 2-6 summarizes the soil sampling depths for the samples collected from the three background borings. The laboratory analyses performed on each of the analytical soil samples collected included pesticides/PCBs, VOCs, BNAs, total metals, EP Toxicity metals and total solids. Results of these analyses are presented in the *FTSFARD*.

Statistical Evaluation of Background Soil Analytical Data. A statistical evaluation was performed on the analytical data for metals obtained from the Fort Story background boring analytical data. The purpose of the evaluation was to develop a single background concentration for each of the metal analytes found in native Fort Story area soils, i.e., areas where anthropogenic activities were not expected to have occurred. These single background concentration values were set equal to the upper one-sided 95 percent confidence limit of the mean concentration of each metal, using a standard statistical procedure described in a standard engineering statistics textbook (Devore, 1982).

This statistical method is based on the assumption that the metals concentrations are distributed according to the T-distribution, which is a distribution for a limited number of sample sizes, such as the background boring metals concentrations for Fort Story. The method involves estimating the upper limit of the range within which the true mean soil concentration of a metal at Fort Story lies, based upon the characteristics of data from background borings and a confidence criterion. In this case, that upper limit is called the upper one-sided (1-α) percent confidence limit ($\mu_{u,\alpha}$) where α represents the confidence criterion. For this analysis, α is set equal to 0.05 for a 95 percent confidence limit.

The value of the upper one-sided confidence limit of the mean is given by:

$$\mu_{u\alpha} = \bar{x} + t_{\alpha/2,\, df} \left(\frac{S}{\sqrt{n}} \right) \qquad (1)$$

where: $\bar{x}$ is the computed mean concentration in soil background samples; the quantity ($t_{\alpha/2}$,df) is the "t value" (obtained from standard statistics tables) for a given confidence criterion (α) and number of degrees of freedom (df), which is defined as the sample size (n) minus one; and S is the standard deviation of the set of concentration data.

At Fort Story, seven background soil samples were analyzed for metals. Therefore, for a 95 percent confidence limit (α = 0.05) and seven data points (n = 7, d.f. = 6), Equation (1) becomes:

$$\mu_{u,\,0.05} = \bar{x} + 2.447 \left(\frac{S}{\sqrt{7}} \right), \text{ or}$$

$$\mu_{u,\,0.05} = \bar{x} + 0.9249\,(S) \qquad (2)$$

Thus, the upper confidence limit values for metals at Fort Story were calculated using Equation (2) and the mean ($\bar{x}$) and standard deviation (S) of the set of concentrations obtained for each metal. In order to calculate the mean and standard deviation for each metal, a value had to be assigned to samples that had no detectable concentration (ND) to include their occurrence in the statistical evaluation. One method is to assign ND concentrations a value equal to the detection limit (DL) divided by two (DL/2). This method assumes that the data below the detection limit are uniformly distributed; i.e., every value between zero and the detection limit has an equal probability of occurrence. Hornung and Reed of the National Institute for Occupational Safety and Health (NIOSH) present another approach to estimating ND values in which they assume that the ND

TABLE 2-6

BACKGROUND BORINGS
SUMMARY OF SOIL SAMPLING DEPTHS

Boring Number	Total Depth[a] (ft.)	Samples Logged	Samples Analyzed	Depth of Soil Samples[b] (ft.)
SB-134	15	4	2	0,4,9,13
SB-135	42	9	2	0,5,10,15,20,25,30,35,40
SB-136	22	6	2	0,4,9,13,15,20

(a) Total depth relative to ground surface.
(b) An underlined number (e.g., 0) indicates depth at which an analytical sample was collected. Lithologic samples were collected at all depths shown.

values are distributed lognormally between the detection limit and zero. This assumption is probably more accurate than the assumption that the ND values are distributed normally because it weights the distribution of the ND values toward the detection limit. If all the data (above and below the detection limit) is distributed normally, such as in the T-distribution in this case, then the ND values would also be weighted toward the detection limit. By using a value equal to the detection limit divided by the square root of two ($DL/\sqrt{2}$), a more accurate representation of lognormal values below the detection limit can be achieved (Hornung and Reed, 1990). This technique ($DL/\sqrt{2}$) has been used in this *PA/SI*.

Of the parameters analyzed for the Fort Story PA/SI, five metals (chromium, copper, zinc, arsenic and lead) and the pesticide DDT were detected in background soil boring samples. Table 2-7 shows the results of the statistical analysis for these metals. The remaining seven metals (barium, beryllium, cadmium, mercury, nickel, selenium and silver), as well as pesticides (other than DDT), PCBs, VOCs and BNAs were not detected in background borings from Fort Story.

Although DDT was found in two of the seven background soil samples, the use of the statistics developed herein is not recommended because the information provided by Commonwealth of Virginia employees has provided more focused guidance, as discussed at the beginning of this section. The ubiquitous nature of DDT, and its associated metabolites (DDD and DDE), is due to the extensive use of the pesticide in the past to control mosquito population (Personal Communication, Young, Chase, 1991) and is illustrated by the fact that it was found in the surface soil sample collected from a background boring as well as numerous other sampling locations throughout Fort Story.

As a result of this analysis, identification of any particular metal analyte at concentrations greater than the 95 percent confidence interval concentration should not automatically result in a recommendation for further investigation at the given Fort Story PA/SI site. A trigger level has been established for soils that realistically reflects a situation at any given site where anthropogenic activities have most likely resulted in contamination that requires further investigation. As a result of these considerations, the evaluation of the reported metals concentrations is based on the assumption that additional investigation is warranted when any metal analyte exceeds the 95 percent confidence interval for background concentration by an order of magnitude (10 times background) (EPA, 1988a). The EPA's Department of Site Assessment concurred with the use of 10 times background upon discussion with JMM and indicated that this was the best approach to take, given the lack of regulatory guidance (Personal Communication, Grubbs, 1991). This value, therefore, is utilized as the specified trigger level for the given analyte.

Analytes not Detected in Background Samples. The background soil samples were analyzed for pesticides/PCBs, VOCs, BNAs, total metals and EP Toxicity metals. Only DDT, arsenic, chromium, copper, lead and zinc were found in concentrations greater than the Method Reporting Level (MRL). Many analytes not found in the background samples were found in the site samples. Identification of any analyte greater than the MRL should not automatically result in recommendation for further action at any given site. Subsequently, evaluation of these will be based upon a site specific evaluation of all media sampled.

Because some trace metals were not detected in background soil borings, and in order to provide some supporting information to complement background boring analytical data, JMM attempted to determine the native concentrations of trace metals in the area of Fort Story.

Although it is clear that soils are derived from parent geologic materials as a result of physical, chemical and biological weathering processes, the range of natural or background metal

TABLE 2-7

BACKGROUND BORING DATA STATISTICS[a]
PRELIMINARY ASSESSMENT/SITE INVESTIGATION
FORT STORY, VIRGINIA

Analyte	Number of Samples Collected	Samples Above Detection Limit	Detection Limit	Assigned ND[b] Value	Mean	Standard Deviation	Upper 95% Confidence Limit Value
Arsenic	7	1	2.5	1.8	1.9	0.26	2.1
Chromium	7	7	1	0.71	2.2	0.69	2.8
Copper	7	3	1	0.71	1.0	0.46	1.4
Lead	7	6	1	0.71	3.6	3.8	7.1
Zinc	7	4	2	1.4	3.2	2.7	5.7
DDT	7	2	0.004	0.0028	0.0034	0.0011	0.0044

(a) All values given in (mg/kg).
(b) ND = Not detected.

concentrations is extremely large, with the composition of the parent material being the principal factor influencing the concentrations of metals in pristine soils. It was found that while there is some published information about typical ranges of concentrations for the United States as a whole (Shacklett and Boerngen, 1984, Kabata-Pendias and Pendias, 1984), no specific information was found that would help to determine native concentrations. JMM contacted representatives of the United States and Commonwealth of Virginia Departments of Agriculture (Personal Communication, Wenthouse, 1991) and the United States Geological Survey (Personal Communication, McNeil, 1991), along with professors from the Department of Crop and Environmental Sciences, Virginia Polytechnic Institute (Personal Communication, Daniels, Martins, 1991). No specific information was acquired from these contacts. JMM determined that while the background metal concentration levels were within the typical ranges for U.S. soils, a more specific determination could not be made for the Fort Story area.

Recommended Trigger Levels. Table 2-8 presents the MRL, background 95 percent confidence interval concentration levels, and the trigger level for each analyte detected in Fort Story soil samples. The trigger levels, as herein defined, provide conservative guidance for determination of whether further investigative activity is required at a given site.

The trigger levels determined for compounds of concern found at PA/SI and NIKE PA/SI sites are intended as a quantitative indicator whether further investigatory action may be appropriate for the site. The trigger levels are derived based on statistically-significant background concentrations of compounds of concern, or regulatory standards as may be appropriate. The trigger levels do not necessarily constitute applicable or relevant and appropriate requirements (ARARs). ARARs are developed while a project site is undergoing an RI/FS evaluation and the magnitude and extent of environmental contamination is being assessed. ARARs then serve as potential clean-up standards for contaminated site media.

2.1.2.2 Groundwater Trigger Levels. Regulatory maximum contaminant levels (MCLs), along with Commonwealth of Virginia groundwater protection levels (VGWPLs), have been established for most of the analytes present in the water samples analyzed for the PA/SI. MCLs are enforceable standards, promulgated under the Safe Drinking Water Act of 1986 (EPA, 1991 40 CFR Parts 141, 142 and 143) and regulated by the Commonwealth of Virginia State Department of Health, which has primary responsibility for enforcing compliance with all drinking water standards. MCLs are set at levels that are determined to be protective of human health and are as close as feasible to the Maximum Contaminant Level Goals (MCLGs). In addition, MCLs address the use of the best available water treatment technology, treatment cost and other considerations.

The VGWPLs are health-based standards derived from Federal Resource Conservation and Recovery Act (RCRA) groundwater protection standards (EPA, 1990) and Commonwealth of Virginia State Water Control Board Regulations VR 680-21-00 (Commonwealth of Virginia, 1990). The water quality standards are health-based in nature and were developed in the 1970s as standards to protect groundwater quality. They are not considered appropriate as clean-up standards (Personal Communication, Barron, August 1991) and consequently have not been integrated into this report. The VGWPLs are most appropriate as guidelines for groundwater protection associated with existing solid waste management units, such as surface impoundments, landfills or waste piles.

Generally, MCLs are considered relevant and appropriate for groundwater that is a current or potential source of drinking water. The presence of wetlands adjacent to a site, the possibility that a nonpotable aquifer could be used for supplying drinking water in the future, or significant interaction of groundwater with surface waters could prompt MCLs to be used as site clean-up goals. Therefore, based on the nature of the PA/SI and NIKE PA/SI project sites and consideration of these regulatory preferences, JMM considers the MCLs to be more relevant and

TABLE 2-8

SOIL TRIGGER LEVELS
PRELIMINARY ASSESSMENT/SITE INVESTIGATION
FORT STORY, VA

Parameter	Method Reporting Level[a] (mg/kg)	Background 95% Confidence Interval[b] (mg/kg)	Trigger Level[c] (mg/kg)
Pesticides/PCBs			
Chlordane	0.04	ND	-
p,p'DDD	0.02	ND	(d)
p,p'DDE	0.02	ND	(d)
p,p'DDT	0.02	0.0041	(d)
Arochlor 1254	0.02	ND	1[e]
Arochlor 1260	0.02	ND	1[e]
VOCs			
Carbon Disulfide	0.01	ND	-
Chloroform	0.01	ND	-
1,2-Dichlorobenzene	0.01	ND	-
1,3-Dichlorobenzene	0.01	ND	-
1,1-Dichloroethane	0.01	ND	-
1,2-Dichloroethane	0.01	ND	-
1,1-Dichloroethene	0.01	ND	-
cis-1,2-Dichloroethene	0.01	ND	-
Ethylbenzene	0.01	ND	-
Methylene Chloride	0.1	ND	-
Tetrachloroethene	0.01	ND	-
Toluene	0.01	ND	-
1,1,1-Trichloroethane	0.01	ND	-
Vinyl Chloride	0.025	ND	-
m,p-Xylenes	0.01	ND	-
o-Xylene	0.01	ND	-
Total Xylenes	0.01	ND	-
BNAs			
Benzoic Acid	10	ND	-
Di-n-butylphthalate	2	ND	-
Fluorene	1	ND	-
2-Methylnaphthalene	1	ND	-
Naphthalene	1	ND	-
Phenanthrene	1	ND	-
Phenol	1	ND	-
Pyrene	1	ND	-
TFH-L	0.20	ND	100[f]
TFH-H	10	ND	100[f]

TABLE 2-8 (Continued)

SOIL TRIGGER LEVELS
PRELIMINARY ASSESSMENT/SITE INVESTIGATION
FORT STORY, VA

Parameter	Method Reporting Level[a] (mg/kg)	Background 95% Confidence Interval[b] (mg/kg)	Trigger Level[c] (mg/kg)
Inorganics			
Arsenic	2.5	2.1	21
Barium	10	ND	-
Cadmium	0.5	ND	-
Chromium	1.0	2.8	28
Copper	1.0	1.4	14
Cyanide	0.1	ND	-
Lead	1.0	7.1	71
Mercury	0.02	ND	-
Nickel	4.0	ND	-
Zinc	7.0	5.7	57

(a) Method Reporting Level (MRL) represents the minimum concentration of an analyte that can be reported with a known confidence level.
(b) Upper bound of the 95 percent confidence interval on the population mean concentrations for background soil borings at Fort Story.
(c) For metal analytes detected in the background borings, the trigger levels are set at 10 times the 95 percent confidence interval.
(d) All DDT, DDE and DDD levels detected at Fort Story are within the expected background range (Personal Communication, Young, Chase, 1991).
(e) EPA, 1987, *Toxic Substances Control Act (TSCA) PCB Spill Cleanup Policy 40 CFR Section 761 Subpart G.*
(f) Commonwealth of Virginia, State Water Control Board, 1989 VR-680-13-02

ND = Not Detected in the background borings.

As discussed in detail in Section 2.2.1.3, the subsurface at Fort Story PA/SI project sites generally consists of unconsolidated, interbedded sands and clays with minor occurrences of gravel and shell fragments. The hydrogeologic framework within the Fort Story vicinity consists of a system of seven aquifer units separated by intervening semi-confining units.

The chief potable water supply in the region is the surface water reservoir system operated by the City of Norfolk. Potable water is reportedly obtained from groundwater sources only to a minor extent. Groundwater use at Fort Story is restricted to withdrawals from a single well located at Site 6, LARC Maintenance Area. Water obtained from this well is used for nonpotable applications only.

The water table below Fort Story PA/SI project sites is encountered at relatively shallow depths ranging from approximately 10 feet in low-lying areas to approximately 40 feet (bls) in high ridge areas. In coastal sand ridges to the north, however, groundwater levels decline to approximately 3 feet NGVD. Water table contours within the Fort Story area are generally characterized by the presence of a localized groundwater divide in the vicinity of the central sand ridge complex. Ambient groundwater flow directions are generally northward toward the coastline and southward toward the wooded wetland, respectively, from the central sand ridge area. Therefore, contaminants released to the subsurface could migrate through the unconsolidated overburden material into the groundwater. Subsequently, contaminants could discharge into the wetland areas or the Chesapeake Bay.

2.1.3.3 Surface Transport. The sandy surface soils characteristic of the Fort Story area promote efficient infiltration of precipitation received at the Installation. Overland surface runoff is collected in ponds or wetland areas or is routed through Fort Story's storm sewer system to one of three outfalls discharging to either the Atlantic Ocean or Chesapeake Bay. Contaminants adsorbed to affected soils at the PA/SI project sites could be carried by surface water runoff and discharged into ponds, wetland areas or the storm sewer system. Subsequently, contaminants could potentially be discharged into the ocean or bay.

2.2 RESULTS OF INVESTIGATIONS

Eight sites were investigated during the Fort Story PA/SI project. These include seven sites for the PA/SI project (under Delivery Order 0001) and one site for the NIKE PA/SI project (under Delivery Order 0004). No previous field investigation activities had been conducted at any of these sites.

Section 2.2.1 provides a discussion of the installation physical characteristics obtained during the literature search and associated fieldwork. Section 2.2.2 provides a site specific discussion for the seven PA/SI sites. For each medium investigated, the significance of site contamination is evaluated through a comparison of the analytical data to the identified trigger levels as defined in Section 2.1.2. Data of concern from each of the investigated media are summarized on the site figures presented in Sections 2.2.1 and 2.2.2.

2.2.1 Installation Physical Characteristics

Fort Story is located in Virginia Beach, Virginia. Virginia Beach is located in the Hampton Roads region of southeastern Virginia, which is included in the coastal tidewater portion of the Atlantic Coastal Plain physiographic province. Occupying an area of approximately 1,450 acres, Fort Story is situated on Cape Henry, which roughly divides the waters of the Chesapeake Bay to the north from those of the Atlantic Ocean to the east.

2.2.1.1 Topography. Land features encountered at Fort Story consist of linear sand ridges, sand flats and wetland areas. The topography is dominated by a series of prominent linear, well-