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### COMMONWEALTH of VIRGINIA

#### DEPARTMENT OF ENVIRONMENTAL QUALITY

Street address: 629 East Main Street, Richmond, Virginia 23219

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David K. Paylor Director

(804) 698-4000 1-800-592-5482

November 5, 2009

Ms. Paige Holt Environmental Manager Alliant Ammunition and Powder Company, LLC Radford Army Ammunition Plant Route 114, P.O. Box 1 Radford, Virginia 24143-0100

Re:

L. Preston Bryant, Jr. Secretary of Natural Resources

Final Class 3 Hazardous Waste Permit Modification – Approval Final Hazardous Waste Management Post-Closure Care Permit Radford Army Ammunition Plant, Radford, VA EPA ID No. VA1210020730

Dear Ms. Holt:

The Virginia Department of Environmental Quality, Office of Waste Permitting and Compliance (the Department) has completed its review of the Class 3 Hazardous Waste Permit Modification (Class 3 HW Permit Mod) request submitted with correspondence dated December 17, 2008 for the Radford Army Ammunition Plant (RAAP) located in Radford, Virginia.

No comments were received during the public comment period that began on September 8, 2009 and ended on October 23, 2009. In addition, the Department did not receive any comments during the public hearing that was held on October 8, 2009.

Based upon the information submitted, the Department concurs that the requested changes constitute a Class 3 permit modification pursuant to 40 CFR 270.42. The requested modification is hereby approved, and the Department has modified its copies of the *Final Hazardous Waste Management Post-Closure Care Permit* with the replacement pages provided in Enclosure (1). Please ensure that RAAP's copies of the permits are also updated accordingly.

As provided by Rule 2A:2 of the Supreme Court of Virginia, you have 30 days from the date of service of this decision to initiate an appeal by filing a notice of appeal with:

Final Class FFIM Permit Mod – Approval RAAP, Radford, Virginia Ms. Paige Holt—1 November 5, 2009 Page 2 of 2

David K. Paylor
Director, Virginia Department of Environmental Quality
P.O. Box 1105
Richmond, Virginia 23218

In the event that this decision is served to you by mail, three days are added to this period. Please refer to Part 2A of the rules of the Supreme Court of Virginia, which describes the required contents of the Notice of Appeal, including specification of the Circuit Court to which the appeal is taken, and additional requirements governing appeals from decisions of administrative agencies.

The Department appreciates the courtesy and professionalism shown during the modification process. If you have questions concerning any of the above, please contact Matthew M. Stepien at (804) 698-4026 or by e-mail at <a href="matthew.stepien@deq.virginia.gov">matthew.stepien@deq.virginia.gov</a>.

Sincerely,

Leslie A. Romanchik

Hestie a. Homanchie

Hazardous Waste Program Manager
Office of Waste Permitting and Compliance

#### Attachments:

Enclosure 1 — Final Class 3 HW Permit Mod to the Final Hazardous Waste Management Post-Closure Care Permit — Replacement Pages

cc: Robert N. Davie, III
Radford Army Ammunition Plant
SMARF-OP, P. O. Box 2
Radford, Virginia 24141-0099

Lillie Ellerbe – EPA, Region III (3LC50)
Aziz Farahmand – DEQ, BRRO-Roanoke
Matthew M. Stepien – DEQ, CO (w/o attachments)
Jutta Schneider – DEQ, CO (w/o attachments)
Fuxing Zhou – DEQ, CO (w/o attachments)
Julia King-Collins – DEQ, CO (w/o attachments)
Cynthia Houchens – DEQ, CO (w/o attachments)
Central Hazardous Waste File

#### **ENCLOSURE 1**

# FINAL CLASS 3 HW PERMIT MODIFICATION TO THE FINAL HAZARDOUS WASTE MANAGEMENT POST-CLOSURE CARE PERMIT REPLACEMENT PAGES

## RADFORD ARMY AMMUNITION PLANT RADFORD, VIRGINIA

**NOVEMBER 5, 2009** 

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#### HAZARDOUS WASTE MANAGEMENT POST-CLOSURE CARE PERMIT

PERMITTEES:

L. Preston Bryant, Jr.

Secretary of Natural Resources

**Radford Army Ammunition Plant** 

Alliant Ammunition and Powder Company, L.L.C.

Route 114, P.O. Box 1

Radford Army Ammunition Plant

Radford, VA 24141-0100

US Army Radford Army Ammunition Plant

Route 114, P.O. Box 2

Radford Army Ammunition Plant

Radford, VA 24141

EPA I.D.#:

VA1210020730

Pursuant to Chapter 14, Section 10.1-1426, Code of Virginia (1950), as amended and regulations promulgated thereunder by the Department of Environmental Quality (hereinafter referred to as the Department), a Post-closure Permit is issued to the United States Army and Alliant Techsystems Inc. (hereinafter referred to as the Permit and the Permittees), for the post-closure care of four closed hazardous waste management units (HWMU) of one hazardous waste disposal facility: Unit 5, Unit 7, Unit 10, and Unit 16. The facility is located in Montgomery and Pulaski Counties at Route 114, PO. Box 1, Radford, Virginia, 24141-0100.

HWMU-5 is a former lined surface impoundment (Neutralization Pond) located at latitude 37°11'12" North and longitude 80°32'15" West. HWMU-7 is a former closed surface impoundment (Unlined Holding and Neutralization Basin) located at 37°11'12" N longitude and 80°33'15" W latitude. HWMU-10 is a Closed Equalization Basin for the Biological Treatment System located at latitude 37°11'31" North and longitude 80°31'51" West. HWMU-16 is a closed hazardous waste landfill located at latitude 37°11'49" North and longitude 80°31'26" West.

These four HWMUs, 5, 7, 10, and 16, at the above facility are currently limited to the following activities: maintenance and monitoring of three closed hazardous waste surface impoundments (5, 7 and 10) and one hazardous waste landfill (16).

The Permittees shall comply with all terms and conditions set forth in this Permit including all attachments. If the Permit and the attachments conflict, the wording of the Permit shall prevail. The Permittees shall also comply with all applicable regulations contained in the Virginia Hazardous Waste Management Regulations (VHWMR) as codified in Title 9 of the Virginia Administrative Code, Agency 20, Chapter 60 (9 VAC 20-60) and in 40 CFR 124, 260, 261, 262, 264, 265, 268, and 270 as adopted by reference in these regulations (for convenience, wherever regulations adopted by reference are cited in this Permit and the attachments, citations will be only those from 40 CFR). The Commonwealth of Virginia has received authorization for these programs under Section 3006(b) of the Resource Conservation and Recovery Act (RCRA), 42 U.S.C. § 6926(b), to administer and enforce in lieu of the federal hazardous waste management program under RCRA. Applicable regulations are those which are in effect on the date of final administrative action on this Permit (9 VAC 20-60; Virginia Hazardous Waste Management Regulations, Amendment 15A, effective March 13, 2002) as well as any self implementing statutory provisions and related regulations which are automatically applicable to the Permittees' hazardous waste management activities, notwithstanding the conditions of this Permit.

This Permit is based on the administrative record and the assumption that the information submitted by the Permittees and contained in the administrative record is complete and accurate. The Permittees' failure in the application or during the Permit issuance process to fully disclose all relevant facts, or the Permittees' misrepresentation of any relevant facts at any time, shall be grounds for the termination or modification of this Permit pursuant to 40 CFR 124.5, 270.41, and 270.43 and shall also be grounds for initiation of an enforcement action. The Permittees' shall inform the Department of any deviations from permit conditions or changes from information provided in the application. In particular, the Permittees' shall inform the Department of any proposed changes that might affect the ability of the Permittees to comply with applicable regulations and/or permit conditions, or which alter any of the conditions of the Permit in any way.

This Permit is effective as of <u>November 4, 2002</u> and shall remain in effect until <u>November 4, 2012</u> unless revoked and reissued in accordance with 40 CFR 124.5 and 270.41, terminated in accordance with 40 CFR 270.43, or continued in accordance with VHWMR 9 VAC 20-60-270.B.5.

November 5 2009

Date Modified

Leslie A. Romanchik

Alster a Romanchile

Hazardous Waste Program Manager

Office of Waste Permitting and Compliance

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November 5 2009

Date Modified

Leslie A. Romanchik Hazardous Waste Program Manager Office of Waste Permitting and Compliance

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#### **PERMIT ATTACHMENT 2**

#### Unit 5 Information

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Unit Topographic Map and Well Location Map

Appendix A.2-

Geologic Cross Sections

Appendix A.3-

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Appendix B-

PLUME AND CONSTITUENT CONCENTRATION MAPS

Appendix C-

DESCRIPTION OF WASTES

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CONTINGENCY PLAN

(Refer to Permit Attachment 1 Appendix B)

Appendix E-

COMPLIANCE GROUNDWATER MONITORING CONSTITUENT LIST

Appendix F-

INITIAL GROUNDWATER BACKGROUND DATA

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**GROUNDWATER PROTECTION STANDARDS** 

Appendix H-

BORING LOGS AND WELL CONSTRUCTION DIAGRAMS: Unit 5

Appendix I-

CORRECTIVE ACTION PLAN FOR HAZARDOUS WASTE MANAGEMENT

UNIT 5

Appendix I.A

Supporting Information from Investigational Activities (Partially

Included)

Appendix I.B

Analytical Laboratory Data and Data Validation Reports (Not Included)

Appendix I.C

**Development of Remedial Timeframe Predictions** 

Appendix J-

CA TARGETED CONTAMINANTS - GPS AND SEMI-ANNUAL MONITORING

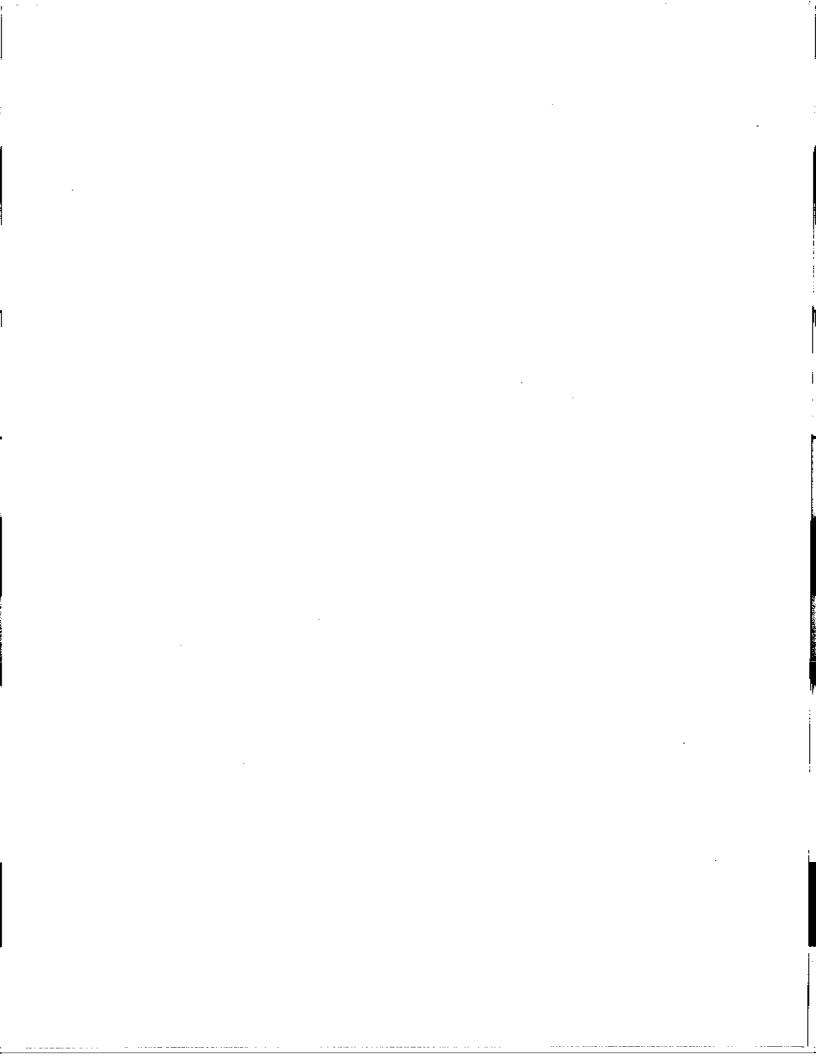
LIST FOR UNIT 5

Appendix K-

(REDUCED) ANNUAL MONITORING CONSTITUENTS IN APPENDIX IX TO

40 CFR 264

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#### **MODULE VI**

## GROUNDWATER CORRECTIVE ACTION AND MONITORING PROGRAM FOR UNIT 5

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#### MODULE VI GROUNDWATER CORRECTIVE ACTION AND MONITORING PROGRAM FOR UNIT 5

#### VI.A. HIGHLIGHTS

The concentration of TCE in groundwater has exceeded the GPS in the POC Wells 5W5B, 5WC21, 5WC22 and 5WC23 since the issuance of the original permit for Unit 5 on September 28, 2001. During 2008, TCE concentrations were less than historic levels in wells 5WC21, 5WC22 and 5WC23. Appendix A of the Corrective Action Plan (CAP), Attachment 2, Appendix I provides the historical TCE concentrations in groundwater.

In response to exceedences of the Groundwater Protection Standards (GPSs) at point of compliance (POC) wells for Unit 5, surface impoundment (former lined neutralization pond), Radford Army Ammunition Plant (The Permittee) is implementing a Groundwater Corrective Action (CA) Monitoring Program at the regulated Unit 5. The CA will be implemented as follows:

The Permittee will implement a groundwater CA and monitoring program focused on evaluating the natural attenuation of trichloroethene (TCE) and its daughter products [1,1-Dichloroethene (1,1-DCE), cis-1,2-Dichloroethene (cDCE), trans-1,2-Dichloroethene (cDCE), and Vinyl Chloride (VC)] in the subsurface at Unit 5. Based on the characteristics of the plume that has been currently delineated, and the low concentrations of the constituents of concern (COC) currently present in the plume with decreasing TCE trends exhibited by the existing data, a monitored natural attenuation (MNA) CA program will be implemented. The MNA CA program will be conducted as specified in Permit Module VI (Groundwater CA and Monitoring Program) and implemented according to the schedule provided in Permit Section VI.N.

A groundwater monitoring program designed to evaluate the effectiveness of the CA program including compliance with the CA Specific GPSs is detailed in **Permit Attachment 2**, Appendix J. Reporting and recordkeeping requirements are presented in **Permit Section VI.J.** The schedule contained in this module (Module VI) shall be followed to implement the remedy for Unit 5.

#### VI.B. GROUNDWATER CA PROGRAM -- NATURAL ATTENUATION REMEDY

The goal of this CA measure, through performance monitoring, is to measure and track the reduction of chlorinated Volatile Organic Compounds (VOCs) to levels below the GPSs as defined in Attachment 2, Appendix J for the respective COCs, within a reasonable period of time. Compliance will be achieved, at the POC Wells and throughout the plume in the aquifer downgradient of Unit 5 (40 CFR 264.100(b) and 264.100(e)). During natural attenuation, multiple processes such as dispersion, diffusion, dilution, sorption, volatilization, biological degradation and chemical decomposition of

COCs result in an effective reduction of contaminant concentration, toxicity, mobility, or volume to levels that are protective of human health and the ecosystem. The daughter products of TCE will be monitored and evaluated to determine the progress (effectiveness and timeliness) of the degradation process (see Permit Attachment 2, Appendix I).

#### VI.B.1. <u>Design Conformance</u>

The Permittee shall install one (1) monitoring well (5W12A) to replace the Plume Monitoring Wells S5W5, S5W7, 5W9A, 5W10A and 5W11A. This monitoring network will be specific to the monitoring of the Natural Attenuation Remedy. The location of the new well is specified in Permit Attachment 2, Appendix I, Figure 2. Subsequent changes to the Remedy Design are to be addressed in accordance with Permit Condition VI.B.5.

#### VI.B.2. Remedial Objectives

The MNA CA Program shall be initiated, operated and maintained in accordance with the CAP (see Permit Attachment 2, Appendix I) and the monitoring requirements set forth in Permit Condition VI.C..

The principal remedial objective is to reduce or eliminate the chlorinated VOCs of concern to levels below the GPSs as defined in **Permit Attachment 2**, **Appendix J**, within a reasonable period of time, defined as in Permit Condition VI.B.7.a. To accomplish this principal objective, data from the monitoring and compliance wells will be collected and evaluated following **Permit Condition VI.B.6.** 

#### VI.B.3. Operation Specifications to Be Initiated

As a passive remedy, Natural Attenuation requires no active operation except for groundwater monitoring. The following design system shall be implemented and maintained:

- a. The Permittee shall implement the CA monitoring program specified under Permit Section VI.C for Natural Attenuation of VOCs in groundwater at Unit-5 generally as described in the CAP (Permit Attachment 2, Appendix I) but subject to modifications in analytes and reporting as permitted by Permit Condition VI.B.5.
- b. Additional monitoring wells, if needed, will be installed in accordance with Permit Condition VI.D.3.b.

#### VI.B.4. Measurement and Maintenance of Natural Attenuation Remedy

Natural Attenuation is the reduction of COC concentrations in the environment through destructive biological processes (including, but not limited to; aerobic and anaerobic biodegradation, plant and animal uptake), non-destructive physical mechanisms (advection, dispersion, diffusion, dilution, volatilization, sorption/desorption), and chemical reactions (ion exchange, complexation, decomposition, and abiotic transformation). Biodegradation of chlorinated solvents (e.g., TCE) most commonly

occurs via reductive dechlorination, a process that requires both electron acceptors (chlorinated aliphatic hydrocarbons) and an adequate supply of electron donors (natural organic carbon, fuel hydrocarbons, landfill leachate) in order to proceed to complete destruction. It is, therefore, a passive remedial approach reliant upon natural transport and degradation processes.

Beyond the monitoring wells, covered under Permit Condition VI.C.1., there is no capital equipment requiring regular maintenance or upkeep other than as described below. The operation system for the continued maintenance of the Natural Attenuation Remedy shall, as similarly stated in Permit Condition VI.B.3., above, comply with the approved CAP (Permit Attachment 2, Appendix I). The following design system shall be maintained on a regular basis, as specified:

- a. Groundwater monitoring well(s). In compliance with 40 CFR 264.97(a)(3), a performance well is designated as an effective well when the Department recognizes that the well is necessary for the practical and effective detection of hazardous waste constituents that have migrated beyond Unit 5.
- b. In accordance with Permit Condition VI.C.2, the Permittee shall conduct groundwater samplings semi-annually, or annually depending on the well designation and locations. The monitoring results will be reported in an annual report defined under Permit Condition VI.J.4.
- c. If the GPS continue to be exceeded for any contaminant listed in Appendix J to Attachment 2 at any of the POC Wells or the Plume Monitoring Well, the Permittee shall be required to continue to monitor the well(s) according to Permit Condition VI.C., and all decisions and outcomes shall be reported in accordance with Permit Condition VI.J.4.
- d. Water Quality Sampling Events-The Permittee shall conduct groundwater sampling and analysis following installation of Plume Monitoring Well 5W12A required by issuance of the Permit in accordance with the sampling and analysis procedures in Permit Section VI.F. In addition to the water level in the well, the following field parameters shall be measured from each well during each sampling event: pH, temperature, oxidation-reduction potential (ORP), specific conductivity and dissolved oxygen. The samples must be collected from the upgradient well, the POC wells and the plume monitoring well, and must be analyzed for all CA specific VOCs [TCE, 1,1-Dichloroethene (1,1-DCE), cis-1,2-Dichloroethene (cDCE), trans-1,2-Dichloroethene (IDCE), and Vinyl Chloride (VC)] (Appendix J to Attachment 2), on a semiannual basis. In addition, groundwater samples collected during the first year of monitoring will also be analyzed for MNA indicators (ethane, ethene, methane, sulfate/sulfide, nitrate/nitrite, and total organic carbon) for the purpose of establishing a baseline concentration of these analytes. The facility's analytical laboratory shall analyze these samples in accordance with the sampling and analytical methods listed in Permit Attachment 2, Appendix J. Alternate analytical methods may be approved by the Department in accordance with the procedure established in Permit Condition VI.C.2.

- e. If at any point during the CA Program any monitoring well, established in or incorporated into the Natural Attenuation Remedy, can no longer yield groundwater samples representative of the area's groundwater quality based upon low water levels the Permittee must apply for a Permit modification to deepen or replace the affected monitoring well(s).
- f. Sampling points and monitoring wells in the Natural Attenuation Remedy (both temporary and permanent in status) are subject to the inspection requirements for groundwater monitoring wells as set forth in Permit Attachment 1, Appendix F (Inspection Requirements).
- g. Piezometers or monitoring wells designated solely for the purpose of measuring water levels (and not for water quality sampling), that are part of the Natural Attenuation Remedy, may be installed (with or without prior Department approval) or abandoned (with abandonment subject to prior Department approval). Such piezometers or water-level monitoring wells normally will not require a formal modification of the Permit under 40 CFR 270.41 or 270.42—unless an accompanying change in the text or maps of the Permit is required. Also, piezometers and water-level monitoring wells remain subject to the inspection requirements for groundwater monitoring wells as set forth in Permit Attachment 1, Appendix F.

#### VI.B.5. Changes in MNA Program

If changes are required, during implementation of the Natural Attenuation Program, to either correct deficiencies or enhance resolution/performance, the Permittee shall submit a written request to the Department to change the approved design.

- a. The Department shall be notified by letter of any proposed changes to the Program, at least thirty (30) days prior to the proposed date of the change. The Department shall approve the proposed changes prior to implementation. The following information shall be included in the notification:
  - Description of the change to be made;
  - ii. Justification/reason for the change;
  - iii. Revaluation plan for Program performance after the change in design;
  - iv. Revised maps, drawings, and schematics, if appropriate.
- b. Design or Program changes which are required for the continued operation of the Remedy or are required for protection of human health and the environment shall be implemented as soon as practicable following approval. In the event of an emergency, the facility must act while assuming the risk of immediate action, subject to the subsequent administrative approval of the design or Program changes. Therefore, the Permittee is encouraged to contact the Department as soon as the consequences are known. The Department shall be notified in writing of the actions taken, within 14 calendar days of the emergency event. This notification will contain

a schedule for the submission of the corresponding request for the design or systems change. The Department will decide on a case by case basis whether such a design or systems change requires a permit modification (see Permit Section VI.M).

#### VI.B.6. <u>Evaluation of MNA Program</u>

The effectiveness of the Natural Attenuation Program shall be evaluated on an annual basis (40 CFR 264.100(g)). This evaluation shall be submitted to the Department as part of the Annual Monitoring Report (see Permit Condition VI.J.4). The evaluation shall contain information to demonstrate that natural attenuation is still functioning as designed. Continued decrease in concentrations will be considered progress toward the remedial objectives. The following shall be contained in the evaluation, if available:

- a. Present sampling and analysis results collected for the Natural Attenuation Program in field and lab analysis (see Permit Conditions VI.B.3 and VI.B.4);
- Evaluation of the changes in concentration trends over the previous twelve months, natural attenuation rate, and resulting remedial progress;
- c. Review of constituent concentrations and evaluation of natural attenuation processes/progress possibly occurring. For example, potential for biodegradation occurrence, detection of daughter products, and general water quality conditions.
- d. Updated compliance timeframe predictions based on revised point attenuation rates determined from concentration vs. time graphs using the principles and methods presented in Section 7.4 of **Permit Attachment 2**, **Appendix I**.
- Modifications to the Remedy proposed to correct deficiencies/malfunctions or, enhance performance and;
- f. Provide other recommendations regarding the CA program, as appropriate.

#### VI.B.7 Contingency Measures and Termination of Natural Attenuation

a. If the dissolved phase constituent concentrations in groundwater outside the containment area do not naturally attenuate within a reasonable time frame contingency, measures shall be considered and implemented as presented in Permit Attachment 2, Appendix I (CAP). For the purpose of this evaluation, a reasonable timeframe is defined as the MNA-based projected remedial timeframe determined in the CAP (i.e., 12 years from the date of the evaluation in 2007, or 2019). The projected remedial timeframe was calculated based on pore-volume flushing calculations. Updated compliance timeframe predictions will be based on annually revised point attenuation rates derived from concentration v. time graphs. If the estimated remedial timeframe determined on an annual basis exceeds the projected remedial timeframe of 12 years [2019] for three consecutive years, then contingency measures as defined in Permit Attachment 2, Appendix I (CAP) will be implemented.

The Department shall terminate this Natural Attenuation Program subject to the Director's approval of a Permit Modification for an alternative remediation system

designed to achieve the same or equivalent objectives for remediation of chlorinated VOCs in compliance with 40 CFR 264.100, if the natural attenuation is ineffective. For the purpose of this evaluation, MNA would be considered to be ineffective if for three consecutive years, the estimated remedial timeframe determined from annually revised point attenuation rates is greater than 19 years [2026], which is the time for one additional pore flush, or an additional 7 years.

#### VI.B.8 Alternative Groundwater Remediation Methods

If the Department or the Permittee determines that MNA is ineffective as a CA program, the Permittee shall evaluate and pursue other means of groundwater remediation. The Permittee shall submit to the Department an application for a Class II permit modification to modify the CAP within 180 days of the determination that MNA is no longer effective and that a modification to the CA process is required. The alternative groundwater remediation method would be enhanced in situ anaerobic bioremediation or a similar insitu technology which can effectively meet the remediation objectives.

#### VI.B.9. Termination of CA/Remedy Program

The CA/Remedy (40 CFR 264.100) for Unit-5 must continue until TCE and its daughter products' concentrations in groundwater have decreased below the GPSs specified in **Appendix J to Attachment 2** (40 CFR 264.100(f)) in the downgradient POC Wells and through the plume(s). The termination of CA must be approved by the Director. The following steps are to be taken by the Permittee in establishing that the GPSs are no longer exceeded and before the Permittee can return to the Groundwater Compliance Monitoring Program (**Permit Module V**) under 40 CFR 264.99:

a. Interpretation and Evaluation of Data Supporting Completion of 40 CFR 264.100

Termination of the use of MNA as a remedy (change from 40 CFR 264.100 to 40 CFR 264.99) shall be based on the interpretation and evaluation of the data (concentrations, parameters and indicators). In addition, 40 CFR 264.100(e) specifically requires compliance with the GPSs throughout the groundwater plume. The data from all POC Monitoring Wells associated with the release of COC from Unit 5 must be at or below the GPSs to demonstrate that the 40 CFR 264.100 objectives have been met. The procedure for completing the data evaluation is as follows:

i. This groundwater CA and monitoring program was triggered by the exceedence of the GPS for TCE. The GPS for a contaminant was developed from the background value, MCL, ACL, or RBC. The GPSs for TCE and its daughter products are listed in the Appendix J to Attachment 2. The exceedence of the GPS for TCE was indicated by the simple comparison of the concentrations for TCE in downgradient wells to the GPS. If GPSs have not been exceeded as determined by simple comparisons of the concentrations for TCE and its daughter products in downgradient wells to the GPSs, the Permittee can petition the Department to terminate this groundwater CA and monitoring program. The

concentrations for TCE and its daughter products in downgradient wells will be obtained through **Permit Section VI.C** (groundwater monitoring).

- ii. Pursuant Permit Condition I.K.1 the compliance period during which the GPSs applies for Unit 5 will continue until October 28, 2020. If the compliance period has not ended at the time of the Director's approval to terminate the CA program, groundwater monitoring shall then be conducted in accordance with Permit Module V Compliance Monitoring Program. The Permittee shall continue CA measures during the compliance period to the extent necessary to ensure that the GPS is not exceeded, pursuant to 40 CFR 264.100(f).
- iii. Any future detections at concentrations greater than the CA specific GPSs that may result from rebound effects will result in a return to the requirements of Permit Module VI (and 40 CFR 264.100). Thus, to avoid a premature outcome, and the resulting requirement for an immediate return to 40 CFR 264.100 groundwater monitoring and corrective measures, the Permittee must demonstrate the long-term effectiveness of the remedy prior to initiating the steps in Permit Condition VI.B.9.

#### VI.B.10. Extension of Compliance Period and CA/Remedy Program

If CA is required beyond the compliance period, as calculated in **Permit Condition I.K.1**, it shall continue until the GPS for any constituent in any well has not been exceeded for three consecutive years, pursuant to 40 CFR 264.100(f).

#### VI.C. GROUNDWATER CA MONITORING PROGRAM

A groundwater monitoring program must be implemented to demonstrate the effectiveness of the CA program (§264.100(d)). This program is based upon a Modification of the preexisting Groundwater Compliance Monitoring Program (Permit Module V), modified as necessary to meet the performance standards for a CA Program (40 CFR 264.100).

#### VI.C.1. Groundwater Monitoring System

- a. The groundwater beneath the closed Unit 5 shall be monitored with one (1) upgradient groundwater monitoring well and five (5) downgradient POC Wells located as specified on Figure 2 of Permit Attachment 2, Appendix I. Monitoring well 5W8B is the upgradient well and monitoring wells 5W7B, 5W5B, 5WC21, 5WC22, 5WC23 are the POC Wells for the unit.
- b. In addition to the wells specified in Permit Condition VI.C.1.a, one Plume Monitoring Well, 5W12A will be installed and monitored to ensure that contaminants, TCE and its daughter products are not moving downgradient away from Unit 5 and the downgradient POC wells.

#### VI.C.2. Sampling and Analysis Schedule

All the wells from Permit Condition VI.C.1 will be sampled in accordance with the methods and procedures specified in the Compliance Monitoring Sampling and Analysis Plan (Permit Attachment 1, Appendix H, Sampling and Analysis Plan, "SAP") and the following schedule:

- All the wells specified in Permit Condition VI.C.1. will be sampled at least semiannually for the analysis of the current CA-targeted constituents listed in Appendix J to Attachment 2. In addition, groundwater samples collected during the first year of monitoring will also be analyzed for MNA indicators (ethane, ethene, methane, sulfate/sulfide, nitrate/nitrite, and total organic carbon) for the purpose of establishing a baseline concentration of these analytes. Analyses shall be obtained using the EPA SW-846 Methods specified in Permit Attachment 2, Appendix J. Alternate/updated SW-846 methods for the contaminants listed in Appendix J may be approved by the Department, provided the request is in writing and submitted 30 days prior to the sampling event and the proposed alternate/updated methods for the contaminants listed in Appendix J must achieve the same Practical Quantification Limit (PQL) (or lower) as the specified method. Also, with pre-approval, alternate/updated methods for the indicators listed in Appendix J to Attachment 2 may be used, provided the analyte is quantified using the alternate/updated method. Proposed alternate/updated methods for the indicators listed in Appendix J to Attachment 2 may obtain a higher PQL than the method specified.
- b. The POC Wells specified in Permit Condition VI.C.1.a shall be sampled on at least an annual basis for the analyses of all CA Annual Monitoring Constituents (Appendix K) using the EPA SW-846 Methods specified in Permit Appendix K to Attachment 2. The CA Annual Monitoring Constituents (Appendix K) are based on the Compliance Monitoring List (Appendix E/G), plus those constituents historically detected.
- c. Static groundwater elevations and total depths as well as the hydrogeologic and physical parameters pH, temperature, specific conductivity, DO, and ORP will be measured at all wells specified in Permit Condition VI.C.1 during each sampling event.

#### VI.D WELL LOCATION, INSTALLATION AND CONSTRUCTION

- VI.D.1. The Permittee shall maintain the monitoring wells located at the facility as specified below:
  - a. All monitoring wells listed in **Permit Condition VI.C.1** shall be maintained in accordance with the maps and boring logs in **Permit Attachment 2**, **Appendix I**.
  - b. The wells shall be inspected at least semi-annually to ensure proper operation. Any required repairs shall be made by the Permittee as soon as reasonably possible.
- VI.D.2. All groundwater monitoring wells required by this Permit in the CA Program shall be maintained in conformity with the following:

- a. The groundwater monitoring system must yield samples in upgradient well(s) that represent the quality of the background groundwater unaffected by leakage from any regulated unit, and in downgradient wells must yield samples that represent the quality of groundwater passing the POC.
- b. The number and location of monitoring wells must be sufficient to identify and define all potential release pathways from the unit to the uppermost aquifer, based on site specific hydrogeologic characterization.
- VI.D.3. The Department must approve the addition or removal of all Permanent monitoring wells that are part of the sampling network, prior to inclusion into the network or abandonment.
  - a. All wells removed from the monitoring program shall be plugged and abandoned in accordance with Permit Attachment 1, Appendix K. Well decommissioning methods and abandonment certification shall be submitted to the Department within thirty (30) days from the date the wells are removed from the monitoring program.
  - b. All monitoring wells added to the existing groundwater monitoring system described in Permit Section VI.C. must be constructed in accordance with the requirements of EPA's RCRA Groundwater Monitoring Technical Enforcement Guidance Document (TEGD) and subsequent guidance, and must be approved by the Department.

#### VI.E. GROUNDWATER PROTECTION STANDARD

VI.E.1. The Permittee shall monitor the groundwater to ensure that the regulated unit is in compliance with the GPSs under 40 CFR 264.92, or that the groundwater is being remediated to attain the GPS.

The GPSs are established based upon background values statistically calculated from background groundwater monitoring at the Unit 5 (Permit Attachment 2, Appendix F), USEPA Safe Drinking Water Act Maximum Contaminant Levels (MCL), Alternate Concentration Limits (ACL) established by the Department, or USEPA Region III Risk Based Concentrations (RBCs). The GPSs of the constituents annually to be analyzed are provided in Appendix K, Attachment 2

The GPSs for TCE and its daughter products, together with their detection limits, background values, and applicable MCL/ACL/RBCs, are listed in **Permit Attachment 2**, **Appendix J**.

- VI.E.2. Background concentrations established at the time of permit issuance are listed in Appendix F to Permit Attachment 2. For any newly detected hazardous constituents, background values shall be established in accordance with 40 CFR 264.97(g) and as specified in Appendix J to Permit Attachment 1 Background groundwater quality for a constituent or monitoring parameter shall be based on at least four (4) data points collected at background monitoring well(s) during a period not exceeding one (1) year.
- VI.E.3 The Permittee shall use the most up-to-date USEPA MCL, the Department ACL, or EPA Region III RBC as the GPS. If USEPA implements any changes to MCLs or RBCs, the

GPS defined by that MCL or RBC will be updated to reflect the most current value established by USEPA.

Any concentration limit based on a background value or ACL may be updated if new data become available. The Department will review the ACL changes annually and decide if the changes were significant enough to warrant the Department pursuing a permit amendment. The Department will notify the Permittee of any such change and will provide an amended Appendix K to Permit Attachment 2 to the Permittee. Within ninety (90) days of receiving the amended Appendix K to Permit Attachment 2 to the Permittee, the Permittee shall provide notice of the modification(s) to all persons on the facility mailing list.

VI.E.4. Pursuant **Permit Condition I.K.1** the compliance period during which the GPSs apply for Unit 5 will continue until October 28, 2020. If the Permittee is conducting CA at the end of the compliance period specified, then the compliance period shall be extended automatically until the Permittee demonstrates that the COC concentrations are less than the GPS in all downgradient wells for three (3) consecutive years as defined under 40 CFR 64.100 (f)

#### VI.F. SAMPLING AND ANALYSIS PROCEDURES

Pursuant to 40 CFR 264.97(e), the groundwater monitoring program must include sampling and analytical methods that are appropriate for groundwater sampling and that accurately measure hazardous constituents in groundwater samples. The groundwater monitoring program must include consistent sampling and analysis procedures that are designed to ensure monitoring results that provide a reliable indication of groundwater quality below the waste management area. To make changes to the groundwater sampling and analysis procedures specified in this section, the Permittee will submit for Director approval an application for a Class 1 permit modification in accordance with 40 CFR 270.42, Appendix I. The Permittee shall use the following techniques and procedures when obtaining and analyzing samples from the groundwater monitoring wells described in **Permit Condition VI.C.1.** 

- VI.F.1. Samples shall be collected using the techniques and procedures described in **Permit**Attachment 1, Appendix H (SAP) and at the frequency specified in **Permit Condition**VI.C.2.
- VI.F.2. Samples shall be preserved, packed, and shipped or hand-delivered off-site for analysis in accordance with the procedures specified in **Permit Attachment 1**, **Appendix H.4**.
- VI.F.3. Samples shall be tracked and controlled using the chain-of-custody procedures specified in Permit Attachment 1, Appendix H.3.

#### VI.G. ELEVATION OF THE GROUNDWATER SURFACE

The Permittee shall determine the groundwater potentiometric surface elevation (and depth to bottom of wells not equipped with dedicated pumps) at each monitoring well

specified in Permit Sections VI.C to 0.01 foot each time groundwater is sampled in accordance with procedures contained in Permit Attachment 1, Appendix H.

- (1) Static groundwater elevations (and total depths for wells that do not contain dedicated pumps) will be measured at all wells specified in Permit Section VI.C. during each sampling event.
- (2) If, during the course of purging and sampling the data from field parameters and visual observation indicate that silt has accumulated in any well, the pump (if dedicated) shall be pulled and the total well depth and sediment thickness shall be calculated. Corrective measures shall be taken prior to the next sampling event, if necessary.

#### VI.H. MONITORING PROGRAM AND DATA EVALUATION

The Permittee shall determine groundwater quality as follows:

- VI.H.1. The Permittee will determine the groundwater flow rate and direction in the uppermost aquifer at least semiannually in accordance with **Permit Condition VI.C.2**. Constituent migration rate will be calculated, if necessary to demonstrate the effectiveness of the CA and the CA monitoring program. Potentiometric maps showing groundwater elevation contours and flow direction during each sampling event shall be prepared at least annually.
- VI.H.2 The Permittee shall present the analytical data obtained from the contract analytical laboratory as follows:
  - a. The Permittee shall determine semiannually the concentrations/values of hazardous constituents listed in Appendix J to Attachment 2 and annually the concentrations/values of hazardous constituents listed in Appendix K to Permit Attachment 2 in accordance with Permit Sections VI.C and VI.F. The Permittee shall independently complete the validation of the data within two (2) weeks of the data being available from the laboratory performing the analyses.
    - Estimated values between the MDL and QL will be validated and qualified with the "J" flag to indicate the result that a constituent is present and detected at or above the MDL, but below the QL. The "U" flag will be used to indicate that the constituent is not detected at or above the MDL.
  - b. The Permittee will present the groundwater quality at each monitoring well in a form appropriate for the determination of statistically significant increases, in accordance with 40 CFR 264.97(h).
  - c. The Permittee's report will include at least the following information: the constituents analyzed and concentrations with qualifiers, the background values, the GPSs, the SW-846 test methods, method detection limits (MDL), quantitation limits (QL), the internal laboratory quality assurance/quality control (QA/QC), matrix spike duplicates, percent recovery, duplicate analyses, dilution factors, any lab specific detection limit and/or quantitation limit, the results of any screening analyses, and

any other information needed to evaluate accuracy, precision, representativeness, comparability, and completeness of the groundwater quality data.

- VI.H.3. At least semiannually, the Permittee shall determine if constituents contained in Appendix J to Attachment 2 are present at concentrations greater than the GPS (Permit Attachment 2, Appendix J) in any POC well in accordance with 40 CFR 264.99(h) and Permit Section VI.I to evaluate the effectiveness of natural attenuation in this groundwater CA program. The Permittee shall use suitable methods to evaluate effectiveness and progress of the groundwater CA and monitoring program, for example, long-term time concentration plots of constituents of concern exceeding GPS for each well and graphic representation of groundwater impact plumes for constituents exceeding GPS, when appropriate.
- VI.H.4. At least semiannually, the Permittee shall review the data and monitoring results to evaluate the concentration trends, the fate and transport for the constituents/indicators listed in Appendix J to Attachment 2 and to evaluate the process and progress of natural attenuation.

#### VI.I. COMPARISON TO GROUNDWATER PROTECTION STANDARDS

At least annually, the Permittee shall analyze samples from the POC Wells specified in Permit Condition VI.C.1. for all constituents contained in Appendix K to Permit Attachment 2 (Annual Monitoring List for CAP) to determine whether additional hazardous constituents, which are not the targets for the current CA (e.g. TCE and its daughter products), are present in the uppermost aquifer at levels exceeding the established GPSs specified in Appendix K to Permit Attachment 2. The following procedures shall be used:

#### VI.I.1 <u>Methods of Comparison</u>

- a. If a single independent sample was collected at the monitoring well, the Permittee shall conduct an empirical comparison in accordance with Permit Attachment 1, Appendix J (Statistical Procedure).
- b. If multiple independent samples were collected from each monitoring well, a statistical comparison to the GPS which is approved by the Department shall be conducted. Guidelines for method selection are contained in **Permit Attachment 1**, **Appendix J**.
- VI.I.2. The Permittee shall submit written notification to the Department within 7 days of the Permittee's identification of the exceedence, for constituents that have not previously exceeded the GPS (40 CFR 264.99(h)). The notification shall include the concentration of each constituent exceeding the GPS and shall identify the monitoring well(s) where the GPS was exceeded.

The Permittee may resample within 60 days from receipt of the laboratory data and repeat the analysis for the constituent exceeding the GPS. If the second analysis confirms the presence of constituents at levels exceeding an established GPS or if the Permittee does not resample, the Permittee shall then report the constituents to the Director in writing

within seven (7) days and the Permittee must propose CA for that contaminant as required by Permit Section VI.L.

- VI.I.3. In accordance with 40 CFR 264.99(i), the Permittee may make a demonstration that the GPS was exceeded due to sources other than the regulated unit, was due to an error in sampling, analysis or statistical evaluation, or was due to natural variability in the groundwater. The demonstration shall be conducted as follows:
  - a. Within 7 days of the identification of the exceedence (see Permit Condition VI.I.2. above) the Permittee shall notify the Department that the Permittee will attempt an alternate source demonstration, and in 90 days from the identification of the exceedence, the Permittee shall submit a report demonstrating this alternate contamination source to the Department for its approval.
  - b. Any resampling, if a part of the demonstration, must be conducted within sixty (60) days of receipt of original laboratory data.
  - c. Throughout the alternate source demonstration the Permittee must continue to monitor in accordance with the CA Monitoring Program established under 40 CFR 264.100 and to fulfill all its Permit obligations
  - d. Concurrent with the submission of an alternate source demonstration, the Permittee is obligated to provide the Department with a plan for the facility's proposed CA (see procedure at 40 CFR 264(h) and Permit Section VI.L.) chosen from all the technologically feasible CA alternatives investigated by the facility and documented in the plan.
- VI.I.4. The Permittee shall specify all GPS exceedences in the Annual Monitoring Report defined under **Permit Condition VI.J.4**, whether it is the first exceedence of that constituent or a repeated exceedence.

#### VI.J. REPORTING AND RECORD KEEPING

The Permittee shall enter all monitoring, testing, and analytical data obtained pursuant to Permit Section VI.J. in the operating record. The data packages must include all computations, calculated means, variances, t-statistic values, and t-test results or the calculations and results of statistical tests that the Department has determined to be equivalent as appropriate. Information concerning the maintenance of the monitoring network wells shall also be entered into the Operating Record. Reports containing the information shall be submitted in accordance with Permit Condition I.E.3.

VI.J.1 Groundwater Elevation/Potentiometric Contour Maps

As a component of the annual report containing all information gathered under the CA Monitoring Program, the Permittee will submit groundwater elevations and potentiometric contour maps depicting groundwater flow paths and supporting groundwater elevation data for each sampling event to determine that the existing monitoring network continues to be adequate.

#### VI.J.2. <u>Maintenance and Operation of the Remedial System</u>

- a. If the evaluation determines that the existing monitoring well network no longer satisfies the requirements of 40 CFR 264.97(a), the Permittee will submit an application for a permit modification to make appropriate changes to bring the monitoring system into compliance. Actions taken for maintenance and repair of the monitoring system shall be recorded in the Facility Operating Record and included in the Annual Monitoring Report.
- b. The Department shall be notified in writing when the monitoring portion of the natural attenuation remedy is taken off-line or is being repaired, equipment replaced, or upgraded and the anticipated or actual duration is greater than 30 days. Periods less than 30 days shall be noted in the Operating Record and included in the Annual Monitoring Report. Note that such notification is required only for action or inaction other than the regular routine operation of the remedy set forth in this Permit Module or in the CAP in Permit Attachment 2, Appendix I.

#### VI.J.3. Annual Appendix IX of 40 CFR 264 Data (Appendix K)

The Permittee shall report the data from the specified wells (Permit Conditions VI.C.1.a and VI.C.1.b) for all constituents contained in (Reduced) Annual Appendix IX of 40 CFR 264 as specified in Appendix K to Attachment 2 in the appropriate Annual Monitoring Report.

#### VI.J.4. Contents of an Annual Report

The annual report, submitted on March 1, of each year shall for monitoring performed in the previous calendar year meet all the requirements of an Annual Groundwater Monitoring Report and shall include an evaluation of the CA program as required by **Permit Section VI.B.6.** The following items shall be included, at a minimum:

- The operator/owner certification signed and dated by an authorized representative of the Facility;
- Copies of current potentiometric surface maps and static groundwater level elevations for each event during the period.
- Evaluation of groundwater flow directions and gradients and the calculated or measured rate of migration of hazardous constituents in the groundwater for the period.
- d. Data package with the certification from the contract analytical laboratory.
- e. Analytical Result/Data Summary containing the following columns: well name, sampling/analytical dates, constituents analyzed, analytical methods, MDL, PQL, resulting data (concentrations) with qualifiers, and GPSs.

- f. Long-term time concentration plots of constituents of concern exceeding GPS for each well. When appropriate, graphic representation of groundwater impact plumes for constituents exceeding GPS;
- g. An evaluation of the effectiveness of the remedial measures per 40 CFR 264.100(g) and meeting the requirements of Permit Condition VI.B.6.. The evaluation shall contain adequate information to demonstrate that the remedial measures are addressing the groundwater contamination at and downgradient of Unit 5 and progress is being made toward the remediation objectives. The evaluation shall also contain updated compliance timeframe predictions using the principles and methods presented in the Section 7.4 of Permit Attachment 2, Appendix I.
- Copies of all notifications and reports required by this Permit, and 9 VAC 20-60 et seq., for the period, and
- i. Copies of all statistical evaluations of the groundwater data for the period.

#### VI.K. <u>ASSURANCE OF COMPLIANCE</u>

The Permittee shall demonstrate through the implementation of the groundwater monitoring and CA measuresin this Permit, that compliance with the GPS of 40 CFR 264.92 will be achieved.

### VI.L. SPECIAL REQUIREMENT IF ADDITIONAL CA AT THE REGULATED UNIT IS REQUIRED

In accordance with the requirements of this permit and the Virginia Hazardous Waste Management Regulations (VHWMR), if the Department or the Permittee has determined that additional CA at or downgradient of the POC of the Waste Management Area is required in pursuant to Permit Condition VI.I.2., Permit Section VI.L applies. The Permittee is responsible for compliance with Permit Section VI.L. immediately upon notification by the Department that additional CA is required at or downgradient of the POC (40 CFR 264.99(h)(1)).

- VI.L.1. The Permittee must notify the Department in writing within seven (7) days from the date that the analytical data is available from the laboratory that the GPS has been exceeded for any constituent listed in **Permit Attachment 2**, **Appendix K** at any well in which the GPS has not been exceeded previously and the Department has not been previously notified, in accordance with **Permit Section VI.J.**
- VI.L.2. Within 180 days from the date when the new GPS exceedence was first identified by the Permittee, the Permittee must submit a Plan to the Department for the proposed CA to address the exceedence (40 CFR 264.99(h)(2)). The Permittee is to choose this proposed CA(s) from all the technologically feasible CA alternatives evaluated, and documented in the Plan. The Plan shall address and conform to requirements set forth at 40 CFR 264.99(h)(2) and shall constitute the Permittee's application for a permit modification to initiate the additional CA.

VI.L.3. To demonstrate an alternative contamination source for the GPS exceedence, other than the regulated unit, the Permittee should follow the procedures set forth at 40 CFR 264.99(i) and in Permit Condition VI.I.3., above.

#### VLM. REQUESTS FOR PERMIT MODIFICATION

- VI.M.1. If the Permittee or the Department determines in writing that the Groundwater Corrective Action ongoing at the facility is not adequate, the Permittee shall submit to the Department an application for a permit modification proposing a CA Program meeting the requirements of 40 CFR 264.100 within 180 days of receipt of the Department's determination that CA is required to be modified. Specifically, permit modification during implementation of corrective measures at the POC for the regulated Unit 5 shall be required if the Permittee or the Department has made any of the following determination:
  - Significant changes must be made to the remedial measures contained in this Permit
    to protect human health and the environment (Permit Condition VI.B.5);
  - b. The corrective measure contained in this permit, e.g., MNA, is no longer effective in remediating groundwater at the POC and the GPSs are still being exceeded. A modification incorporating a different alternate remedial measure is required (Permit Condition VI.B.8) to meet the requirements of 40 CFR 264.100; or
  - c. A GPS has been exceeded for a constituent for which the current corrective measure contained in the Permit will not achieve the remediation goals (see Permit Condition VI.I.2 above).
- VI.M.2. If the Permittee or the Department determines the CA Monitoring Program no longer satisfies the requirements of 40 CFR 264.99 and 264.100, then within 90 days, the Permittee must submit an application for a permit modification to make any major changes.

#### VI.N. <u>CA SCHEDULE</u>

Upon addition of **Permit Module VI** and associated attachments to this permit, the following actions will be taken:

- VI.N.1. Within 120 days from the effective date of the permit modification, monitoring well 5W12A specified under Permit Conditions VI.B.1 and VI.C.1.b will be installed. In accordance with Permit Conditions VI.D.3 and VI.J.2., details of the wells installation shall be provided in the subsequent Annual Monitoring Report.
- VI.N.2 Upon completion of the installation of well 5W12A, the first CA Monitoring event, defined under Permit Section VI.C., will be conducted in place of the compliance monitoring event scheduled for second quarter 2010. Thereafter, the CA Monitoring Program will replace the Compliance Monitoring Program until such time as Permit Condition VI.B.9 and/or Permit Condition VI.B.10, has been met. Additionally,

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meeting the requirements of Permit Condition I.J.1 (Post-Closure Period Reduction) will allow the cessation of the MNA remedy.



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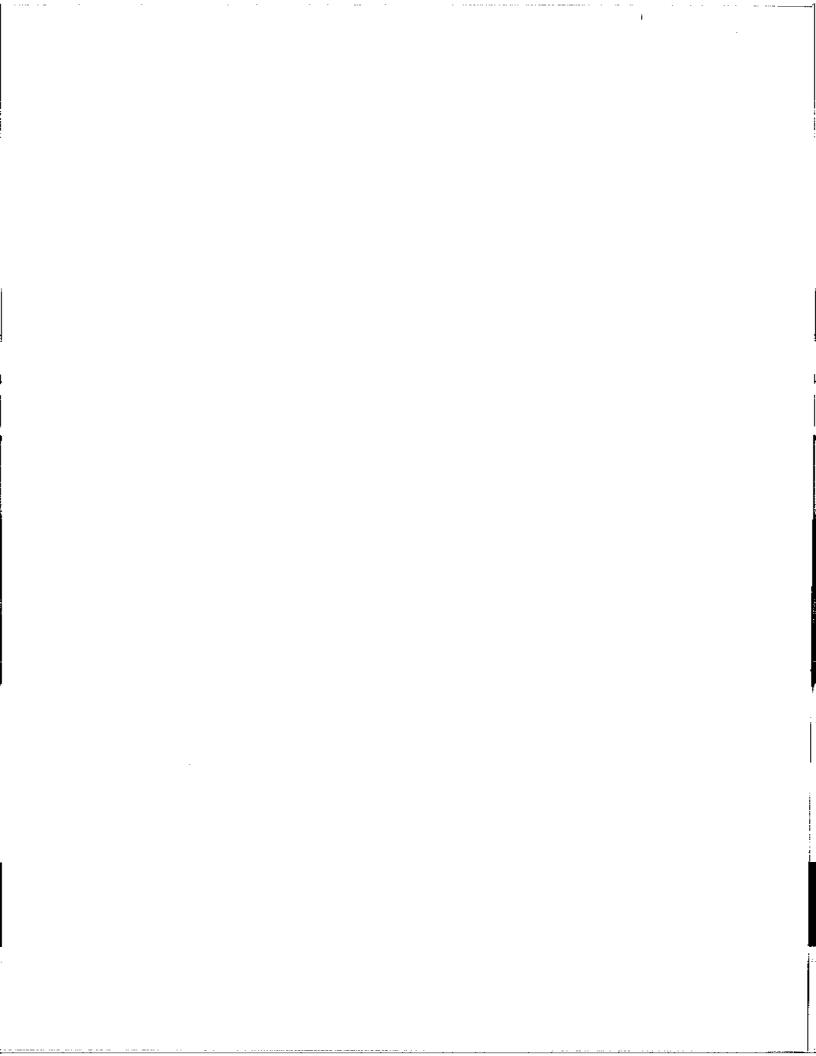
# MODULE VII SITE-WIDE CORRECTIVE ACTION

# VII.A. <u>CORRECTIVE ACTION FOR CONTINUING RELEASES</u>; <u>PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT</u>

The requirements of 40 CFR 264.101 are addressed by the Corrective Action Permit issued to the Permittees by EPA Region III which became effective on October 31, 2000 and shall remain in effect until October 31, 2010. The terms and conditions of the Corrective Action Permit issued by EPA are adequate to fulfill the Department's requirements for facility-wide corrective action as specified in 40 CFR 264.101 as made applicable by 9 VAC 20-60-264.

# VII.B REPORTS, NOTIFICATIONS, AND SUBMISSIONS TO THE DEPARTMENT

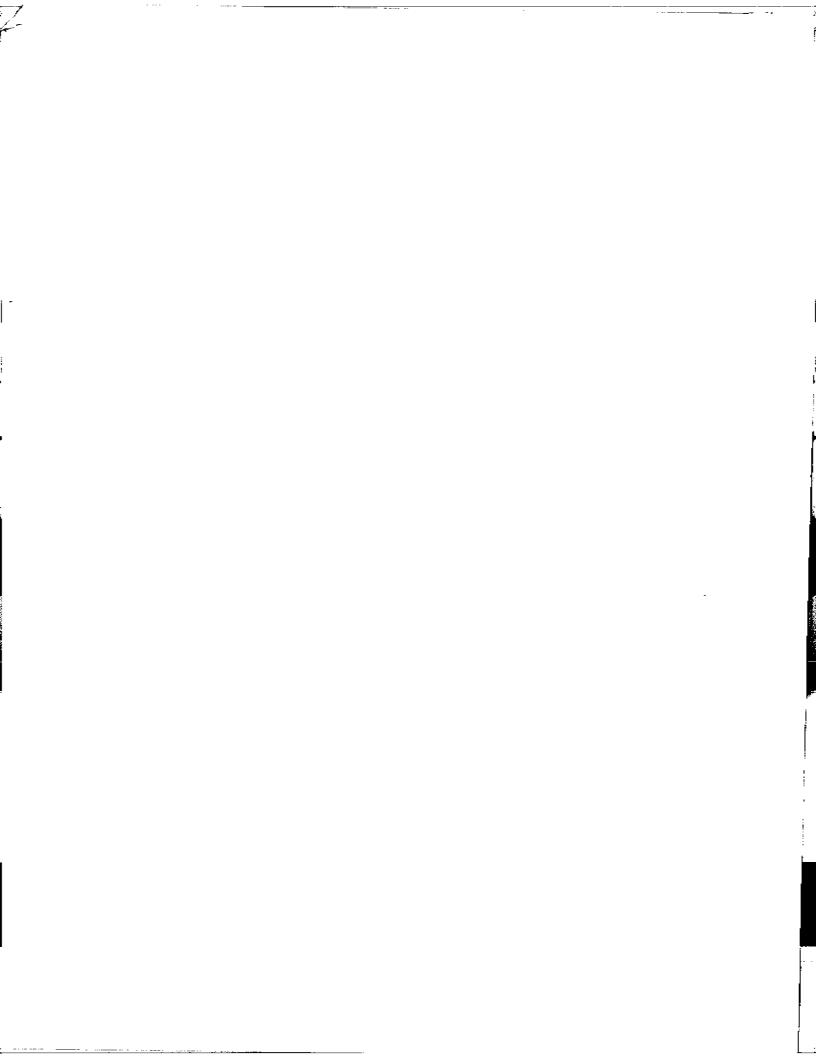
Copies of all notifications, cover letters for reports, and submissions made in compliance with the EPA permit shall be provided to the Director of Waste Permits in accordance with the EPA permit Part I.B.8.

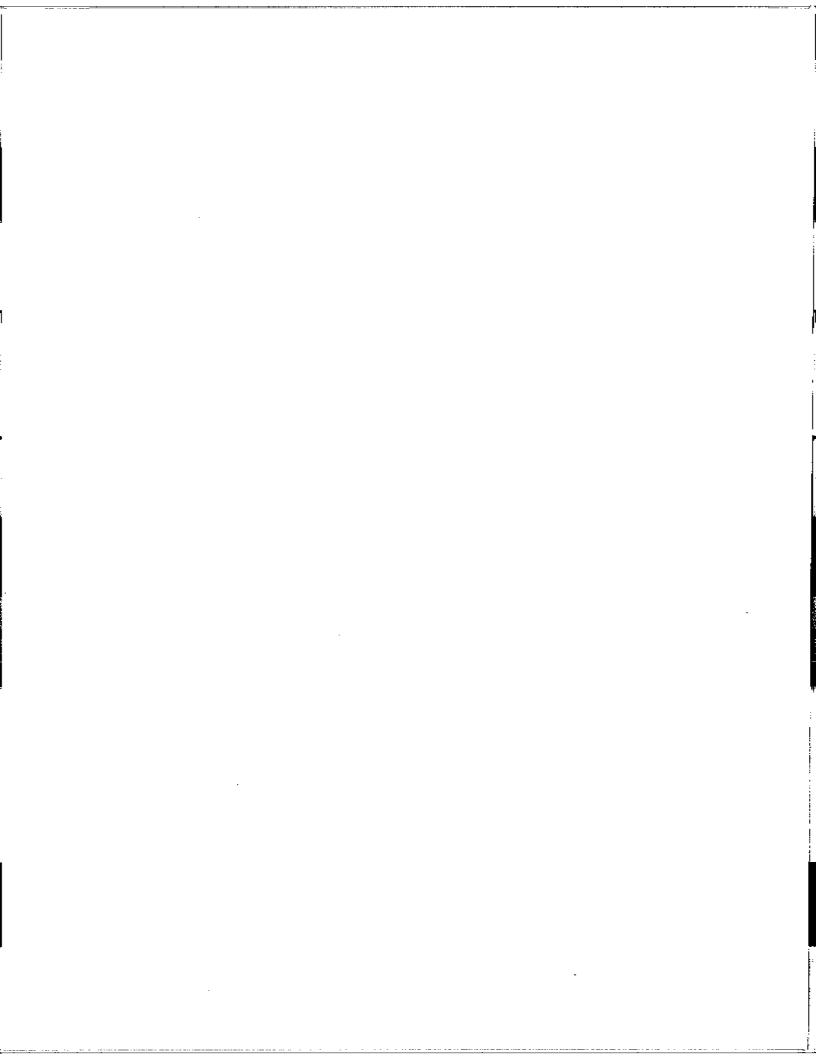


EPA ID No.:VA1210020730 06/26/2002

# MODULE VIII. SCHEDULE OF COMPLIANCE

(RESERVED)





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Appendix I-

# CORRECTIVE ACTION PLAN FOR HAZARDOUS WASTE MANAGEMENT UNIT 5

# Final

# Corrective Action Plan for Hazardous Waste Management Unit 5 (RAAP-042)

Radford Army Ammunition Plant

Radford, Virginia

April 2009

Corrective Action Plan for Hazardous Waste Management Unit 5 (RAAP-042) Radford Army Ammunition Plant

Prepared for:

Radford Army Ammunition Plant

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Our Ref.: GP08RAAP

Date: April 2009

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# Acronyms and Abbreviations

Bgs below Ground Surface
CAP Corrective Action Plan
CSM Conceptual Site Model

fit feet

FID flame-ionization detector

GPS Groundwater Protection Standard(s)

IDM investigation derived material

μg/L micrograms per Liter
mg/L milligrams per Liter
mg/Kg milligrams per Kilogram
MMA Main Manufacturing Area
MNA monitored natural attenuation
O&M Operation and Maintenance
PID photo-ionization detector

QA/QC Quality assurance/quality control
QAPA Quality Assurance Plan Addendum

RAB restoration advisory board

RCRA Resource Conservation and Recovery Act

RFAAP Radford Army Ammunition Plant

RSLs Regional Screening Levels

SBA South Bank Area
TCE trichloroethene

USEPA United States Environmental Protection Agency
VADEQ Virginia Department of Environmental Quality

VOCs volatile organic compounds

Radford Army Ammunition Plant, Virginia

#### 1. Introduction

This Corrective Action Plan (CAP) for RAAP-042, Hazardous Waste Management Unit 5 (Unit 5), has been completed in support of the Hazardous Waste Management Post Closure Care Permit for the Radford Army Ammunition Plant (RFAAP), located in Radford, Virginia. This CAP addresses concentrations of trichloroethene (TCE) detected in shallow overburden groundwater adjacent to Unit 5.

#### 1.1 Setting

RFAAP is located along the New River, at the Montgomery-Dublin County line near Radford, Virginia. The location is shown on Figure 1. The Main Manufacturing Area (MMA) is composed of two sections; 1) The Horseshoe Area, contained within a loop of the New River and 2) the South Bank Area (SBA). Unit 5 is located in the SBA. The Unit, Compliance Monitoring Wells and Piezometers are shown on Figure 2.

### 1.2 Objective

This CAP presents data to support monitored natural attenuation (MNA) as a protective and technically appropriate remedial approach to address a small dilute TCE plume that has been delineated in Unit 5 groundwater. The CAP also summarizes a two-phase subsurface investigation conducted in the vicinity of Unit 5 in 2008. The history of Unit 5 is discussed within the Resource Conservation and Recovery Act (RCRA) Hazardous Waste Management Post Closure Care Permit (the Permit), to which this document is included as Attachment 2, Appendix I. The data and analysis provided in this document provide supporting detail for information already presented in the Permit.

## 2. Background

#### 2.1 History

Unit 5 is a former lined acid neutralization surface impoundment located in an open area of the SBA immediately downhill from an area of manufacturing facilities. The Unit was operated as an unlined impoundment from 1970 to 1981, when it was retrofitted with a Hypalon™ liner. The unit was taken out of operation in 1986 and was closed in 1989. Closure included stabilization of the waste material and capping with an impervious PVC liner.

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TCE has been historically detected at concentrations greater than the Groundwater Protection Standard (GPS) at four network monitoring wells located within 150 ft downgradient of Unit 5: 5WC21, 5WC22, 5WC23 and 5W5B. Detections of TCE have occurred consistently in the wells since 1996; however, the concentration in only one well (5W5B) was greater than the GPS in the most recent round of sampling (8.9 micrograms per Liter [µg/L] in December 2007).

### 2.2 Previous Investigations

Two previous subsurface investigations were conducted at Unit 5 in October 2002 (Alliant Ammunition and Powder Co., 2003) and February 2004 (Draper Aden, 2007). These investigations included soil and groundwater sampling beneath and in the vicinity of Unit 5. Results were generally consistent with the findings of the current investigation. Results of the previous investigations are provided, as appropriate, in this document.

#### 2.3 Conceptual Site Model

The Conceptual Site Model (CSM) developed for Unit 5 and presented herein is based on stratrographic data gathered during the two previous investigations and the recent investigation conducted to characterize the contents of Unit 5 and to evaluate possible sources of the TCE in groundwater. The TCE data were used in conjunction with other installation wide data to compile the CSM as it is presented in the permit. The vicinity of Unit 5 is underlain by unconsolidated materials that range in depth from 40 to 50 feet below ground surface (bgs). The geologic setting is illustrated conceptually in Figure 3. These materials consist of alluvial terrace deposits and overlying residuum. The alluvial terrace deposits consist predominantly of day and silt, with sporadic basal deposits of river jack (rounded cobbles embedded in a fine-grained matrix). The residuum consists of the insoluble weathering products of the underlying dolomite, predominantly interbedded fine sand, silt and clay. Beneath the unconsolidated materials lies competent dolomite of the Elbrook Formation.

A profile of Unit 5 is shown on Cross Section A-A' (Figure 4). The Hypalon™ underliner at the bottom of the former impoundment is estimated to be at or near the predevelopment grade. The total thickness of the Unit, including the PVC liner and day cap is approximately 10 feet.

Groundwater flow in the unconsolidated materials is from southwest to northeast, ultimately discharging to the New River approximately 3,000 feet downgradient. The

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overburden groundwater system forms a discrete aquifer, and is inferred not to be significantly influenced by the bedrock aquifer. Concentrations decline with depth and as such there is no evidence suggesting that TCE has migrated into bedrock.

Quarterly monitoring data from 1996 to 2007 (Appendix A, Table A-1) consistently show that groundwater upgradient of Unit 5 does not contain detectable concentrations of TCE or its daughter products. However, TCE, but not its daughter products, has been detected in shallow groundwater downgradient of Unit 5 at concentrations up to 26 µg/L, the historical maximum concentration (observed in 2003 at well 5WC21).

In the more than 12 years of quarterly groundwater monitoring, repeated TCE concentrations greater than the 5  $\mu$ g/L GPS are limited to four wells: 5W5B, approximately 80 ft downgradient of Unit 5, and 5WC21, 5WC22 and 5WC23, a well cluster located approximately 140 feet downgradient of Unit 5. Concentration trends show that an irregular pulse of TCE moved past well 5W5B between 1998 and 2001. The pulse appeared at well 5WC21 approximately 4 years later (from 2001 to 2005).

An average solute transport velocity of approximately 15 feet per year was estimated by evaluating the elapsed time between breakthrough peaks observed at wells 5W5B and 5WC21. The timing of the origin of the pulse coincides with closure of the Unit in 1989 (based on an origin in the southeast interior of the Unit). The pulse arrivals reflect a travel time of approximately 10 years to 5W5B and 15 years to the 5WC21.

TCE concentrations documented in groundwater during the 2007 fieldwork reported herein at the four monitoring wells immediately downgradient of Unit 5 are between 2.5  $\mu$ g/L to 8.9  $\mu$ g/L (Figure 6). Based on these data, the current area of TCE levels greater than the 5  $\mu$ g/L GPS is approximately 160 feet long and 40 feet wide.

#### 3. Scope of Recent Investigations

ARCADIS completed a thorough subsurface investigation in two phases: the first, completed May 5 through 10, 2008 and the second June 18 through July 1, 2008. As described in Work Plan Addendum 25 (dated May 2008), the investigation was modeled on the United States Environmental Protection Agency's (USEPA's) interactive triad approach (USEPA, 2004), and therefore utilized adaptive field techniques each building upon the others to comprehensively define site conditions for the investigated area. In keeping with the Triad approach, the scope of work for Phase 2 was finalized following completion of Phase 1, with regulatory concurrence provided by the appropriate VADEQ and USEPA personnel (Decision Point 1 Meeting

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June 17, 2008). The scope of both phases of investigations are described in the following sections.

#### 3.1 Phase 1 - Direct Push Soil and Groundwater Sampling

Direct push soil borings were completed at seven locations east of Unit 5. Four locations, 5DitchGP01 through 5DitchGP04, were completed as a transect along the axis of a northwest trending ditch running from the vicinity of Building 1549 towards Unit 5, with borings spaced approximately 80 feet apart. An additional three borings were completed east of Unit 5: borings 5GP-12A, 5GP-25, and 5GP-26. Boring locations are shown on Figure 5. At each location, the following activities were performed.

- Continuous soil samples were collected and logged by a geologist. Sample/boring logs are provided in Appendix A.
- Groundwater samples were collected from just beneath the water table, and analyzed for volatile organic compounds (VOCs).
- Soil samples were collected at each boring and held pending groundwater analytical results. Five of seven soil samples were analyzed for VOCs to confirm VOC results in groundwater samples.

Table 1 summarizes the depth and sample intervals of the borings completed near Unit 5 during Phase I.

# 3.2 Phase 2 - Vertical Aquifer Profiling

The second phase of field investigations consisted of additional direct-push soil and groundwater sampling. Where possible, borings were advanced to the top of rock (15 to 45 ft bgs), and multiple groundwater samples were collected across the saturated overburden to vertically profile groundwater quality. This second phase included three borings advanced directly adjacent to Unit 5 (5GP27, 5GP28 and 5GP34) and five borings completed on a transect in the road immediately south of Unit 5 (borings 5GP29 through 5GP33). Boring locations are shown on Figure 6.

The following activities were performed at each location.

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- Continuous soil samples were collected and logged by a geologist. Sample/boring logs are provided in Appendix A.
- Groundwater samples were collected from just beneath the water table and, where feasible, approximately every 10 feet vertically to refusal. At three of the eight locations, only one vertical interval was sampled due to shallow refusal. Samples were analyzed for VOCs.

At a subset of boring locations (5), the shallowest groundwater sample intervals were collected by setting temporary 1-inch PVC monitoring wells. At these locations, groundwater levels were allowed to equilibrate so that an approximate water-table depth could be determined.

Table 2 summarizes the depth and sample intervals of the borings completed near Unit 5 during Phase 2.

#### 4. Field Methods

Field tasks were completed in accordance with the RFAAP Master Work Pian (URS, 2003), and Work Plan Addendum 25 (ARCADIS, 2008). The tasks are described in more detail below.

#### 4.1 Utility Clearance

Prior to each boring program, a utility mark out was completed by Mid Atlantic Utility Locators using industry standard equipment and a facility utility map. An ARCADIS representative escorted the subcontractor to the proposed work areas and provided oversight during their activities.

#### 4.2 Direct Push Borings

In both phases of work, direct-push drilling was completed by Columbia Technologies. During Phase 1, continuous soil samples were collected using a Macrocore™ sampler, hammered by a track-rig Geoprobe™. The second phase of work completed soil sampling using a combination of Geoprobe sample tools, including Macrocores, dual-tube samplers, and stop-pin discrete interval samplers. By all methods, undisturbed soil samples for lithologic characterization and laboratory analyses were obtained in dedicated, disposable Lexan™ liners. Soil samples were field screened for the presence of VOCs using a photo-ionization detector (PID). In the second phase of

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work, the screening with the PID was supplemented with a flame-ionization detector (FID), because of its higher sensitivity to chlorinated VOCs.

All borings were abandoned using bentonite chips. Investigation derived material (IDM) wastes including soil cuttings, decontamination water, sample liners, and other disposable sampling equipment were contained in drums that were stored in a 90 day (maximum) storage area pending transport to an approved offsite treatment and disposal facility.

#### 4.3 Grab Groundwater Sampling and Vertical Aquifer Profiling

Grab groundwater samples were obtained from the direct push borings by two methods:

- Hydropunch™ sampling devices. By this method, a sealed sampler is advanced
  by the Geoprobe rig across the target interval through undisturbed soil. By pulling
  back the tools, the sampling device opens exposing a 3 or 4 foot stainless steel
  well screen. After allowing time for groundwater to enter the well and equilibrate,
  sampling may be conducted using a peristaltic or inertial pump.
- Temporary well points. For sampling locations at the top of the water table (e.g., where vertical isolation of the sample interval is not required), samples could be collected by removing the Geoprobe tools and installing a temporary, dedicated 1-inch diameter PVC well, with a 5-foot screened section. Temporary well points were used particularly at locations where aquifer yield was low, and significant time was required for water to enter the well and equilibrate. Samples were collected via a peristaltic or inertial pump.

Selection of groundwater sample intervals was made by the field geologist, biased to intercept zones of higher permeability. For vertical aquifer profile borings, interval selection was also biased to collect representative samples of all discrete hydrostratigraphic intervals encountered.

Temporary well points and hydropunch samplers were purged prior to sampling. Where feasible, the groundwater quality parameters pH, temperature, conductivity and turbidity were evaluated using a field meter prior to sampling. All purge water generated via sampling was contained in drums that were stored in a 90 day (maximum) storage area pending transport to an approved offsite treatment and disposal facility.

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#### 4.4 QA/QC

Quality assurance/quality control (QA/QC) samples were collected at the frequency prescribed by the Quality Assurance Plan Addendum (QAPA). All samples were analyzed by Empirical Laboratory, Knoxville, TN. QA/QC samples included field duplicates, field blanks, and trip blanks. Data was validated and found to be usable in all cases. The laboratory analytical reports and associated data validation reports are provided as Appendix B.

#### 5. Results

A total of 6 soil and 18 groundwater samples were collected during the two phases of field investigation in 2008 for analysis of VOCs. Summaries of detected constituents in soil and groundwater are provided in Tables 2 and 3, respectively. Figure 5 depicts TCE concentrations detected in soil and includes the results of previous investigations (Alliant, 2003). Figure 6 depicts TCE concentrations detected in groundwater and also integrates results from previous investigations (Oraper-Aden, 2007, and 2008).

#### 5.1 Soll

Neither TCE nor any other analytes were detected in soil in excess of their industrial Regional Screening Level (RSL) (USEPA, 2008). However, TCE was detected in saturated soil samples from two borings located on the northeast perimeter of Unit 5 (5GP-12A and 5GP-28). Both samples were collected beneath the water table at a depth of 23 to 24 ft and 27 to 28 ft, respectively. TCE concentrations in the 23 to 24 foot sample were 0.0019 milligrams per Kilogram (mg/kg) and were 0.0057 mg/kg in the 27 to 28 ft sample relative to a residential soil RSL of 2.8 mg/kg. The soil analytical results for the samples collected show decreasing TCE concentrations with depth. Previous investigations (Draper-Aden, 2007) also reported TCE detections in saturated soil along the eastern edge of Unit 5 at a depth of 14 feet bgs and a concentration range of 0.011 to 0.120 mg/kg. The presence of TCE in saturated soils is consistent with the presence of TCE in groundwater in the same vicinity.

#### 5.2 Groundwater

Groundwater monitoring has been ongoing since 1996 at Unit 5 and these data have been previously reported to the USEPA and VADEQ. Long term data trends are provided as Figures A-1 through A-4 of Appendix A. The results of the work reported

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herein are generally consistent with the long-term groundwater monitoring, and have also been used to determine the extent of the TCE plume in the vicinity of Unit 5.

TCE was detected in groundwater samples at 6 of the 18 boring locations all of which were located east and northeast of the Unit 5. Concentrations of TCE were greater than the GPS (5  $\mu$ g/L) at just one location, 5GP-28. TCE concentrations in groundwater samples collected from two intervals at 5GP-28 (27 to 30 ft, and 36.5 to 39.5 ft) were both greater than the GPS, at 11 and 5.7  $\mu$ g/L, respectively. TCE concentrations in the remaining five direct push borings ranged from non-detect to 11 $\mu$ g/L and defined the vertical and horizontal extent of the TCE in groundwater northeast of the Unit.

TCE was also detected in one of the permanent monitoring wells (5W5B) above the GPS at a concentration of 8.9  $\mu$ g/L in December 2007. Concentrations in the remaining wells ranged between 2.3  $\mu$ g/L to 3.4  $\mu$ g/L. There was no evidence of TCE in any of the vertical aquifer profile samples collected upgradient of Unit 5 (Figure 6). No reductive dechlorination daughter products of TCE (cis-1,2 dichloroethene and vinyl chloride) were detected.

#### 6. Nature and Extent of Plume

Recent and historical analytical results indicate that TCE is present within saturated soils just beneath Unit 5 at one location, and at two locations under the access road located to the northeast of Unit 5 (Figure 5). The highest concentration of TCE detected in soil was 120  $\mu$ g/kg, collected beneath Unit 5 at a depth of 14 ft bgs at boring 5GP-21.

The current horizontal extent of the TCE plume in groundwater above the GPS of 5  $\mu$ g/L is approximately 160 feet long and 40 feet wide (Figure 6). The maximum detection of TCE in 2008 was 11  $\mu$ g/L. TCE has not been detected in the Plume Monitoring Wells located 500 ft to 700 ft downgradient of the Unit since 1999, and prior 1999 only very low level and sporadic detects were noted in these wells. Though historically TCE concentrations at wells 5WC21, 5WC22, and 5WC23 were slightly greater than the GPS, however the 2007 data suggests that the downgradient extent of the plume has dissipated.

Vertically oriented samples have been collected in the vicinity of Unit 5 and TCE concentrations have been documented to decrease with depth in the surficial aquifer, which extends to an approximate depth of 50 feet below ground surface. The TCE

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plume is limited in vertical extent to shallow groundwater in the interbedded zone. Concentrations of TCE in groundwater were observed to decrease with depth at each Vertical Aquifer Profile sample location where TCE was detected (Table 3 & Appendix A). This decreasing trend trends is also apparent at the 5WC2 well cluster, where the shallowest well, 5WC21, has historically had higher concentrations than the adjacent deeper wells. These data illustrate the limited vertical extent of the plume.

Figure A-5 (Appendix A) depicts the relationship between aqueous TCE concentrations and downgradient (northeast) distance from Unit 5 for both the most recent groundwater data set and the previous eight quarters. These data clearly indicate a stable relationship and decreasing concentration trend with distance from Unit 5. TCE concentrations are less than the GPS approximately 160 feet from the location of the initial detection (GP-021) below Unit 5. The relationship between distance and concentration, as shown by the trend line on Figure A-5, suggests that the concentrations in the range of the TCE GPS could be expected at a distance of 175 to 225 feet from Unit 5. Because of the distance between the current extent of the TCE plume and the location of the existing downgradient Plume Monitoring Wells (S5W5, S5W7, 5W9A, 5W10A and 5W11A), a more proximal downgradient Plume Monitoring Well would enhance the level of confidence in the continued definition of the plume extent . As discussed in Module VI of the Class 3 Permit Modification, and in Section 7, below, a replacement Plume Monitoring Well is proposed approximately 200 ft downgradient (northeast) of Point of Compliance Well 5WC21 (Figure 2). This well will enhance the level of confidence in the limits of the plume extent and is recommended within Module VI of the Class 3 Permit Modification.

#### 7. Recommended Corrective Action

At Unit 5, a well defined stable or decreasing plume has been identified. The current maximum TCE concentration in groundwater is 11 µg/L, and extends downgradient less than 200 feet from the Unit. As stated in Section 2.3, the average solute transport velocity has been estimated at less than 15 feet per year. The TCE source has been remediated (through capping) and no receptors are being affected. As such, MNA is recommended as the remedy for Unit 5 groundwater. Natural attenuation is defined as "naturally occurring processes in the environment that act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater" (USEPA, 2000). These natural processes include dispersion and diffusion, which may be the primary mechanisms at this site. The site conditions at Unit 5 are conducive to and align closely with the governing principles of selecting MNA as a remedial strategy.

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#### 7.1 Basis for MNA recommendation

The principal data objectives for selecting MNA are reviewed below.

#### 1. Affected media/phases of constituents are known

TCE at Unit 5 is present in the dissolved-phase in groundwater and likely sorbed to soils. The presence of separate phase product is not supported directly or implicitly by the data and the plume area is well defined.

## Concentration levels are not significantly greater than the GPS

The current maximum TCE concentration observed in groundwater near Unit 5 is 11  $\mu$ g/L relative to a GPS of 5  $\mu$ g/L. The maximum TCE concentration currently observed in the permanent groundwater monitoring network is 8.9  $\mu$ g/L, at well 5W5B. Currently, concentrations at no other permanent monitoring locations are greater than the GPS. Groundwater concentrations at two of the four affected wells (5WC22 and 5WC23) have been less than the GPS for least eight quarters and concentrations at all four affected wells have exhibited decreasing trends over the past 10 quarterly events. The historical maximum concentration is 26  $\mu$ g/L.

#### 3. Delineation of plume extent

As indicated in Section 6 of this report, the extent of the TCE plume is fully delineated. The plume (Figure 6) is approximately 40 feet wide and extends from the east side of Unit 5 approximately 160 feet toward the northeast. TCE has not been detected above the laboratory detection limit in any downgradient Plume Monitoring Well since 1999. The vertical extent of the plume is delineated. The presence of TCE in groundwater at concentrations greater than the GPS is limited to the interbedded soil zone, at depths ranging from approximately 15 to 50 feet bgs. TCE concentrations in groundwater at depths greater than 40 feet bgs are less than the GPS. In addition, concentrations of TCE in groundwater decrease with depth.

#### 4. Groundwater data show natural attenuation is occurring

Concentrations of TCE at all locations are below their historical maximums, and show clear downward trends (Figures A1-A4). The TCE concentration at well 5W5B is currently 8.9 µg/L, down from a maximum concentration of 20.5 µg/L in

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1999. Farther downgradient, TCE concentrations at the wells of the 5WC21, 5WC22, and 5WC23 cluster are each now between 2.5 and 3.5  $\mu$ g/L, down from their historical maximum of 26  $\mu$ g/L (at 5WC21) in 2003.

The Mann-Kendall and Senn-slope statistical tests were performed on the historical data sets for each of the affected wells. These analyses indicate statistically significant decreasing trends over the last 10 quarters at each of the four Point of Compliance Wells exhibiting detections (Appendix A, Figures A-1 through A-4). The confidence levels in these trends are greater than 95% for all four data sets. This is of particular significance because while the individual wells have each historically demonstrated decreasing trends from time to time, in no other period have all affected wells demonstrated a contemporaneous decreasing trend.

Additionally a spatial analysis was conducted for the most recent data set to verify the plume stability and attenuation of dissolved phase concentrations with distance from Unit 5. Figure A-5 (Appendix A) provides this summary plot clearly demonstrating the decreasing TCE concentrations with distance from Unit 5. Additionally, for reference, the prior eight quarters of data are shown for wells 5W5B and 5WC21. These data indicate that a stable relationship exists between these wells and that concentrations have been declining with both time and distance.

Because detectable concentrations of TCE daughter products are not present (Draper Aden, 2008), reductive dechlorination is not held to be the dominant attenuation process. Observed decreasing groundwater trends are inferred to reflect diminishing source concentrations, dispersion and diffusion.

#### Temporal variability is understood

Groundwater flow direction does not change significantly throughout the period of record. A consistent northeastward flow direction from Unit 5 is consistent the narrow dimension of the plume. A review of historical data indicates that seasonal variations in precipitation and recharge may cause minor TCE concentration fluctuations.

#### No potential receptors

The TCE is contained within the area of the Unit and is not affecting either surface water receptors or drinking water sources.

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#### 7. Source remediation

The Unit has been closed under RCRA in 1989 and is lined, stabilized, and has an impermeable cover system.

#### 7.2 CAP Implementation

implementation of MNA for TCE in groundwater at Unit 5 would include several components detailed in Permit Module VI. The components are as follows:

- VADEQ approval of this CAP and the Permit Amendment.
- Installation of a Plume Monitoring Well (5W12A) to replace the existing downgradient Plume Monitoring Wells S5W5, S5W7, 5W9A, 5W10A and 5W11A as shown on Figure 2. This new well will be located approximately 200 feet downgradient of Point of Compliance Well 5WC21 and screened at approximately the same interval targeted by well 5WC21 and hydropunch location GP025 (20 to 30 bgs, contingent upon field conditions). The proposed location of the new Plume Monitoring Well will monitor the plume extent and stability more effectively than the current, more distal Compliance Monitoring Program Plume Monitoring Wells. The existing Plume Monitoring Wells, S5W5, S5W7, 5W9A, 5W10A and 5W11A, have not exhibited detections since 1999 and are located either side gradient or are too distant (500-700 feet downgradient) to effectively monitor the present extent of the plume. Because of the nature and extent of the plume are clearly defined, a single, more proximal Plume Monitoring Well will provide better surety of plume control than a disperse and distal monitoring network. The existing wells will be retained as piezometers to monitor the slope and direction of the hydraulic gradient downgradient of the Unit.
- A schedule for groundwater monitoring to verify MNA effectiveness and plume stability. The site is presently monitored under the RCRA Post Closure Care Permit. Appendix J summarizes the proposed Corrective Action Monitoring Program, incorporating proposed Plume Monitoring Well 5W12A (Figure 2). The present monitoring program is defined in Module V of the permit. The permit will be amended with Module VI (Groundwater Corrective Action) to include MNA as the remedy. A schedule for the shift from the present compliance monitoring program to the MNA remedy monitoring is provided in Permit Condition VI.N of the amended permit. Approval of the permit will effectively be the required impetus for installation of the new well and the subsequent shift to the Corrective Action

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Monitoring Program. This CAP document will be attached to the permit as Attachment 2, Appendix I. A proposed time table for system installation, including the potential addition of one additional monitoring well is provided in the Permit.

- A description and schedule for the Corrective Action operation and maintenance.
   The only capital equipment associated with the MNA Remedy monitoring network is the wells for which the Operation and Maintenance (O&M) is addressed under Module VI of the permit.
- A contingency for the provision of an alternate water supply. This is addressed in the Permit, but is not applicable. The plume extent is entirely contained within the RFAAP, approximately ½ mile from the nearest surface water discharge, with no current or potential groundwater use downgradient.
- A schedule for the submission of status reports. Reporting of the results of the MNA Remedy data will continue the present Annual reporting frequency presently used for the Compliance Monitoring Program. Details are contained in Module VI of the Permit.
- A recommended public notice procedure. The public is routinely updated as to the status of the various investigations and remediations being conducted at the site through the restoration advisory board (RAB). This procedure will continue through the MNA remedy. In addition the required public notifications and comment periods for a corrective action will be provided.

# 7.3 Development of MNA Remedial Timeframe

Based on the MNA remedy selected for Unit 5, the predicted timeframe to achieve GPSs is 12 years (i.e., October 2019). Hereafter this date is referred to as the MNA projected remedial timeframe. During this period, semi-annual groundwater monitoring and annual data reporting will be performed, as required, to ensure compliance with the MNA remedy.

For clarity, it is noted that the predicted 2019 MNA remedial timeframe coincides with the end date of the Post-Closure Care Period (October 26, 2019) as specified in the Post-Closure Care Permit. This permit, issued on September 28, 2001, requires compliance monitoring until October 28, 2020. The current MNA remedial timeframe predicts that concentrations will be less than the GPSs within the compliance period.

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The 2019 MNA remedial timeframe was calculated based on pore-volume flushing calculations. These calculations are summarized below. Additional supporting information is provided in Appendix C. First, a composite retardation coefficient was calculated based on the sorption coefficient, soil bulk density and aquifer porosity. Second, the number of pore-volume flushes was calculated to attenuate TCE concentrations to the GPS by multiplying the composite retardation coefficient by the natural log of TCE concentrations (current detection/divided by TCE GPS). Third, the solute travel time across the plume was calculated by dividing the average solute transport velocity by the distance between sample location of the current maximum detection and first downgradient location with concentrations less than the GPS. Finally, the remedial timeframe was calculated by multiplying the number of porevolume flushes by the solute travel time. These calculations predicted a range of MNA remedial timeframes with a maximum at 11.5 years. The final remedial timeframe, derived from the upper limit of this range, is considered to be conservative. These calculations assume the average TCE transport velocity at Unit 5 is approximately 15 ft per year. One environmental condition not directly factored into these calculations is the potential for seasonal variations in precipitation and recharge to cause concentration fluctuations.

## 7.4 Annual Evaluation Methodology (Calculation of MNA Timeframe)

The technical approach and methodology used for the data evaluation will be based on USEPA guidance for MNA studies (Newell et al., 2002). This approach involves the calculation of point attenuation rates and comparison of updated predicted timeframes to the 2019 MNA remedial timeframe. The point attenuation rate represents the cumulative effects of all natural attenuation processes at a specific well location and thus is likely to be more representative of actual conditions than the conservative porevolume flushing calculations. The following steps describe the methodology for this evaluation:

- Construction of graphs of natural log concentrations versus time for monitoring wells (5W5B, 5WC21, 5WC22, 5WC23, and 5W12A) exhibiting current detections of TCE and degradation products at concentrations greater than GPS values.
   Non-detect values will be plotted at half the detection limit.
- Calculation of the point attenuation rate constant for each constituent based on a linear regression whereas the slope of the regression represents the attenuation rate constant. The dataset used to calculate the rate constant will encompass at least eight monitoring events.

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Updated MNA compliance predictions using the following equation.

$$t = \frac{-Ln\left[\frac{C_{goal}}{C_{start}}\right]}{k_{goint}}$$

#### Whereas:

t = predicted GPS remedial timeframe

C<sub>poal</sub> = GPS concentration

C<sub>start</sub> = current constituent concentration

K<sub>point</sub> = point attenuation rate

 Provide an updated MNA remedial timeframe prediction with the additional data in each annual report using the methods described above. An example calculation is provided in Appendix C.

#### 7.5 Contingency Measures

Recent field investigations and data analysis indicate that the residual TCE source area is defined, the TCE plume is stable or shrinking, and only one monitoring well (5W5B) and hydro-punch sample location exhibit TCE detections at concentrations greater than the GPS. While existing monitoring data indicate that TCE will attenuate within a reasonable timeframe, it should be noted that short-term concentration increases due to seasonal or other factors (such as variations with sampling technique or laboratory analysis) are possible. If the predicted MNA timeframe based on future monitoring data exceeds 12 years (2019) for three successive monitoring years, then contingency activities will be implemented. Three successive monitoring years was selected as a trigger for contingency measures to account for scatter associated with long-term monitoring data related to seasonal or other factors. If concentrations decrease to less than the GPS, contingency measures will be discontinued. Contingency activities may include the following:

 Increased sampling frequency to quarterly and/or additional monitoring parameters/analysis to evaluate seasonal effects or other factors that may be affecting the data trends.

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- Evaluation of concentration changes along the plume transect and/or changes in plume geometry and contaminant mass estimates based on isocontour maps.
- Provide an updated MNA remedial timeframe prediction upon completion of 7 quarterly events using the methods described in Section 7.4.
- Additional data collection and technical evaluation performed for these contingency activities will be documented in the Annual Monitoring reports, as appropriate.
- Design and implementation of an alternate remedial approach using enhanced insitu anaerobic degradation or similar in-situ technology, if the predicted MNA timeframe exceeds 19 years (2026) for three consecutive years, which is the time predicted for one additional pore flush, or an additional 7 years.

#### 8. Conclusions

MNA is recommended as a remedial approach for TCE in groundwater at Unit 5. The basis for selecting MNA is:

- The recently observed concentrations of TCE in monitoring wells are not significantly above GPS and have shown a declining trend in the past 10 quarters.
- The TCE groundwater plume is contained within the facility site.
- No surface water bodies have been, or will be, affected by the plume.
- There is no current or planned future use of the groundwater at the facility.
- The plume of TCE in groundwater is small, stable, declining, and clearly defined.
- The potential source of TCE (Unit 5) has been stabilized and capped.
- Historical data collected in the past 10 quarterly monitoring events show that the
  plume is currently stable and concentrations of TCE in groundwater attenuate
  below the GPS as groundwater moves away from the Unit. There is no known
  existing source of TCE. Unit 5 has been lined and capped.

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 Statistical analyses show decreasing trends for TCE concentrations at all affected monitoring wells over the previous 10 quarterly sampling events.

#### 9. References

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Tables

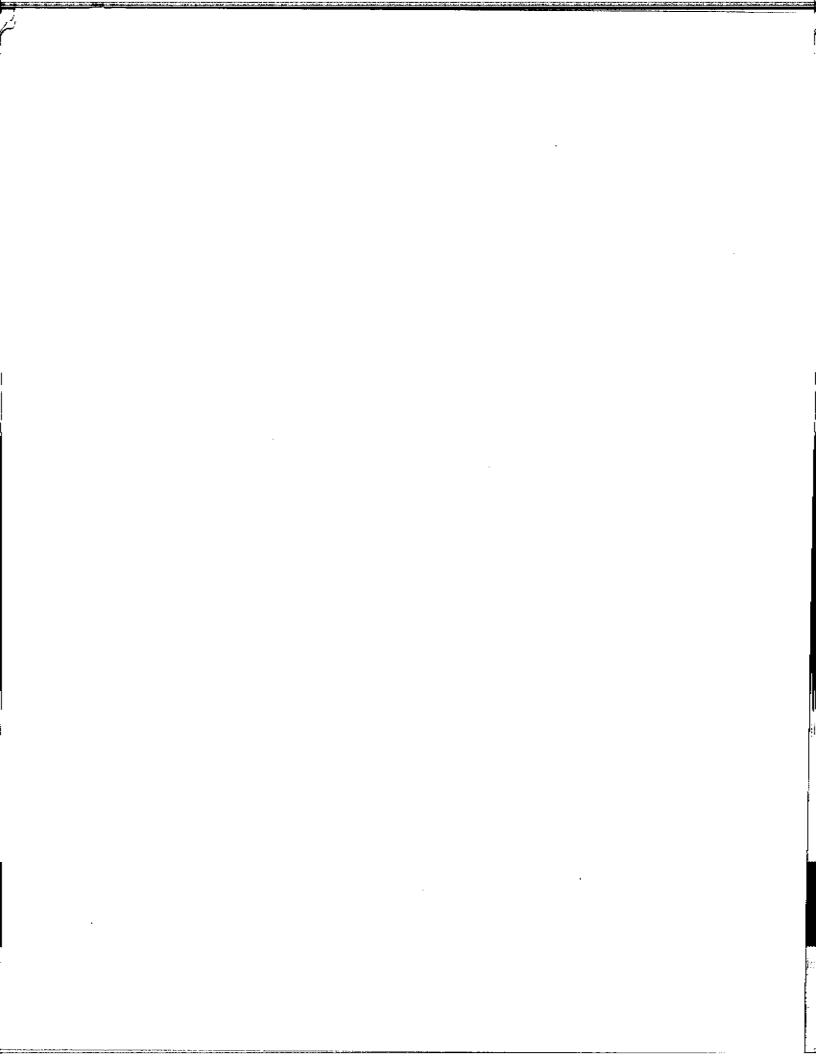


Table 1. Summary of Phase 1 Investigation Locations, Radford Army Ammunition Plant HWMU 5 (RAAP-042) Corrective Action Plan, U.S. Army Environmental Command, Radford, Virginia

5DITCHGP01	21	17.21		Markin dileta tempiana darehamatanania
5D/TCHGP02	20	16 20		Mithin clini, of the same and
SDITCHGP03	22	18 - 22	11 - 12	Within cites, 2 Hour south and
SDITCHGP04	44	14 . 18	11-12	Within ditch, location furtheat north
5GP12A	32	28 · 32	23 - 24	Next to HWMU 5, between HWMU and TCE impected monitoring wells
SCP25	28	24 - 28	19 - 20	Near building 1602.
5GP26	28	24 - 28	19 - 20	Northwest of building 1602 near drainage feature.
Phase Z Borings				
5GP27	04	35 – 28		Immediately east of HWMU-5
5GP28	43	27 – 30 *	27-28	Immedialely east of HWML-5
5GP29	38	17 - 22 (\$C) 26 - 29		Westernmost in transect south of HWMU-5
5GP30	23.5	18.5 - 23.5 (SC)		2" location from west in transect
SGP31	39.5	14.5 - 19.5 (SC) 35 - 38		Central point on transoct
5GP3Z	18.5	13.5 - 18.5 (SC)		2" location from east in transact
5GP33	24	19 – 24 (SC)		Easternmost in transact south of HWMU-5
5GP34	30	27-30		Northeast of HWMU-5.

Boning 5GP12A was renamed from its field and sample designation 5GP21.

SC = sample collected from (emporary 5 tt PVC well; all other samples collected using a hydropunch<sup>TM</sup> sampler.

A confirmatory soil semple 5GP28(27-28) was analyzed for VOCs.

11/14/2008 Table 1

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Table 2. Summary of Detacted Volatile Organic Compounds in Soil, Redford Army Ammunition Plant HWMU 5 (RAAP-042) Corrective Action Plan, U.S. Army Environmental Command, Radford, Virginia

Location ID:					SDTCHSB003	6DITCHSB004	5GP-012	5GP028
Sample Depth(Feet):	Adjusted	Adjusted Soil Screening Values			1-12	11 - 12	25.52	27.
Date Collected:	Regional Screening Level	Industrial Regional Screening Level	Soll-to-Groundwater SSL (DAF 20)		05/06/08	DS/DG/CB	0.5709/08	D6/73/08
Volatile Organics								
1.2.4-Tnchlorobenzene	180 (52**)	220 (set)	2.2	шоўса	40.0054	<0.0053	<0.0072	0.00037.1
Acetone	6,100 (nc)	110,000 (set)	88	DA/SE	0.026	0.0085	410.0	66000
Dichlorodifluoromethane	19 (nc)	78 (nc)	12.2	mg/kg	0.00095 J	<0.0053	<0.0072	4500.05
Methylene Chloride	11 (ca)	54 (ca)	0.026	mg/kg	<0.017 B	<0.012 B	<0.0098 B	0.00
Toluene	930 (sat)	930 {eat}	15.2	mg/kg	40.0054	<0.0053	<0.0072	0,0013
Trichlomethene	2.8 (cm)	14 (ca)	0.038	ma/kg	40.0054	<0.0053	L 6100.6	0.0057

B - analyte was also detected in the associated method blank .

J - indicates an estimated value

U - The compound was aniayzed for but not detected. The associated value is the compound quantitation limit.

(ca\*) - cancer (ca\*\*) - where no screening level < 10X cs screening level (nc) - noncenter (sst) - concentration may exceed Css; (see User's Guide) \$\$L - soll screening level

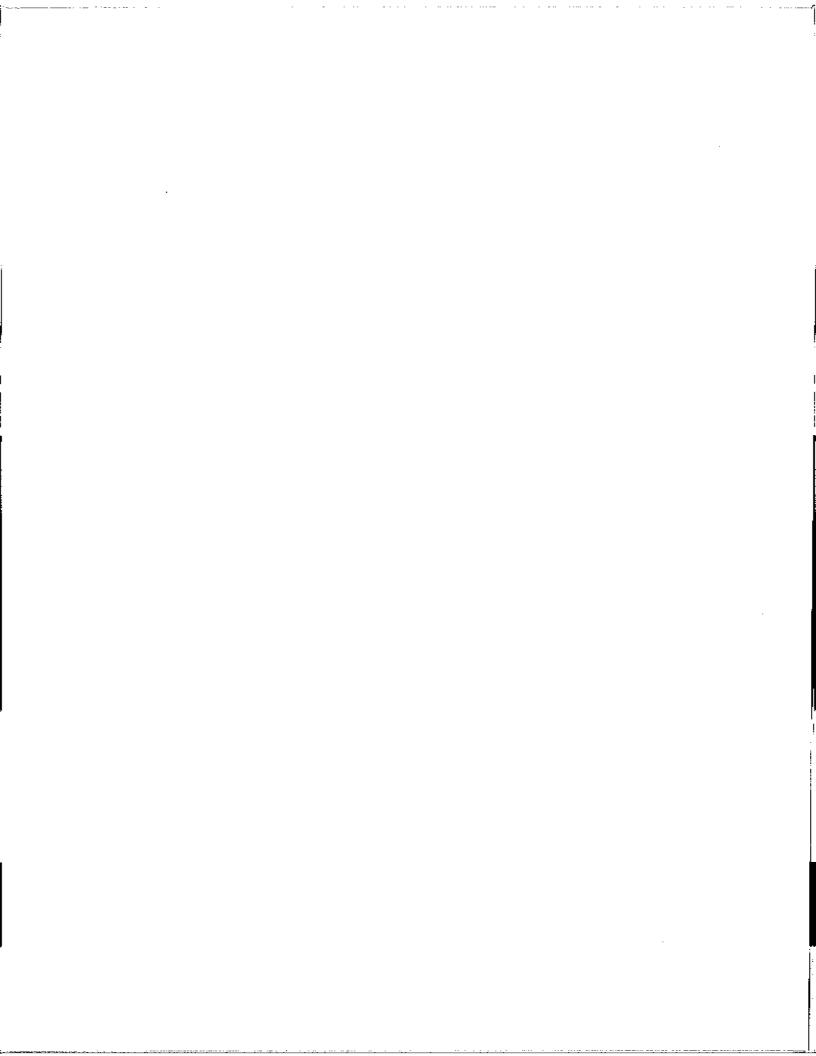


Table 3. Summary of Detected Volatile Organic Compounds in Groundwater, Radford Army Ammunition Plant (WHA) 5 (RAAP-042)
Corrective Action Plan, U.S. Army Environmental Command, Radford, Virginia

							A CONTRACTOR OF THE PERSON OF	eriotis.	4/1000/7	SCHOOL	5CP028
	Sample Depth(ft): Date Collected:	10	- Torita	50/TCHP001 17 - 21 05/06/08	16 - 20 05/06/08	50/1/C-N-9-003 18 - 22 05/06/08	14 - 18 04/04/08	25 - 25 06/25/08	35 - 37 06/24/08	36.6 - 39.5	27 - 30 06/24/08
	The Communication										
Volatile Organica								٩	100	240	50.5
		  -	Į.	9.7	ç	<10 (410)	410	2	?		
2-Butanone					-	F 8 (B 4 II	05	15	0.6	14	17
Acetone			-	212	,				4	4	140
		- I	, C1	C 1	0.2	61.0 [41.0]	0,5	ני ניודיט [	0114	01.	
Benzene		֓֟֝֟֟֝֟֟֝֟֟					1 580	760	0.68.3	0.67.3	196'0
Chlomform		:	5	0.54 J	18	1.10	2000				3
			3	0.7	410	10.15	ā.	0.58.1	61.0	41.0	
Cichlorodiffuorometrano	ana.		•				Ţ	0.78	0.30	0 V	0,41
Methylana Chloride	i	wi	Ž	0.1.5	41.0	10,121,01	2	2			٤
		1000	, ma	51.0	0.5	0.15[0.15	0.6	0,15	9.5	-	N.V
Lounge		3		,		0 10 10 10	-	٩	٠. م	5.7	Ξ
			2								

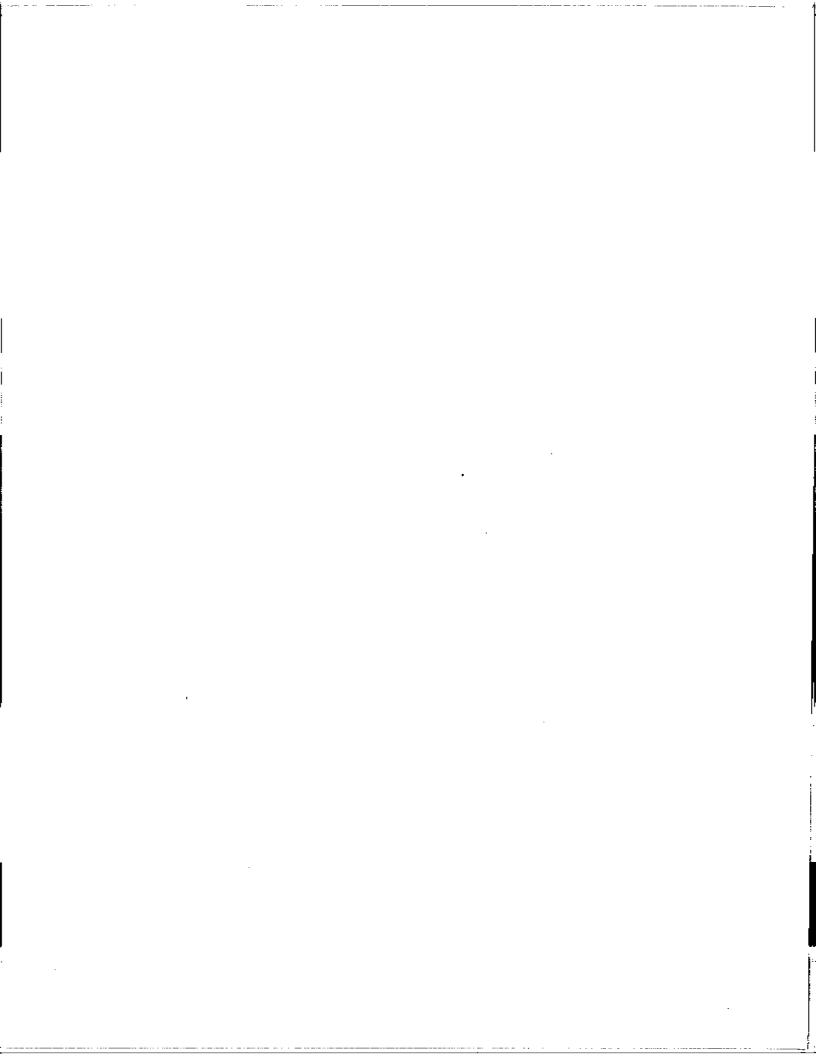
The service was also delected in associated method blank

[] - associated find duplicate results

J - indicates an eatimated value

U - The compound were analyzed for but not detected. The associated value is the compound

Shaded Value - Indicates an cooperation is greater than MCL.





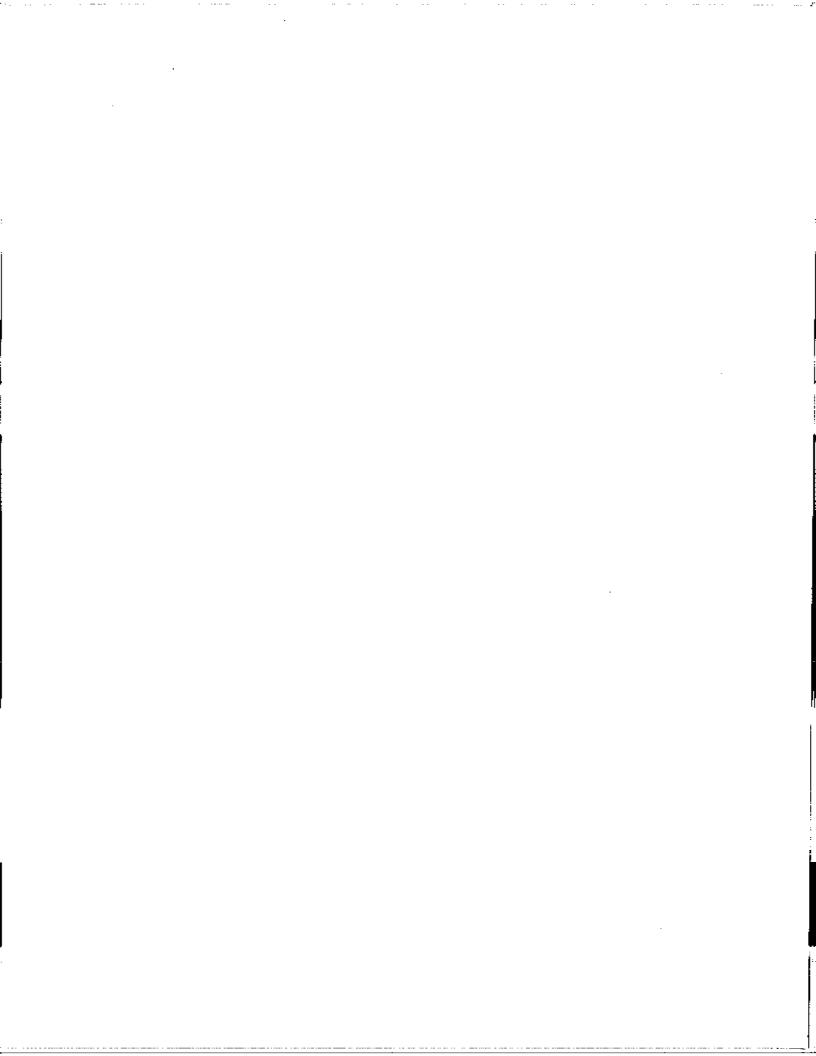
									TANAL S	- CANADA	AF OULD	COP-LIPO25	SCD-H-4D/S	SGP-MP026
Sample Dept	Locarbon ID: mple Depth(ft):			15 - 22 06/28/08	5GP022 35 - 35 06/28/08	50P030 14 - 23.5 06/29/06	15 - 19.5 06/22/05	35 - 38 04/29/98	15 - 18.5 06/30/08	17 - 24	27 - 30 06/30/08	28 - 32 05/10/06	24 - 28 05/10/08	24 - 28 05/10/08
3 880	TO THE CASE OF													
/otable Organics										۶	5	410	, P	Q.
			1000	C.V	ç	Ç	10 10	5	015	•	2		,	ŀ
-Butanone	†	1	†				10,576.7	٤	3.0	4.1	4	£52B	42.0B	42.0 B
control	_	:	5	2.5	2		20.0				3	1	Ţ	440
			1		5	Ų	0.570.65	Ç	Ç.	0,0	0.12	2.17	21.7	
3enzana		1	i						1	72	-	0.15	40.48 B	ç
T. I. standards		:	Ą	-	=	5.2	2	18	2,4	,				
A CONTRACTOR	ļ		-		5	4	510 (-10)	0.15	Ç	ű	41.0	41.0	41.0	
ichlorodfilluoromethane		:		2	?						3		-	410
7 7 7			551	5	0.5	Ç	0.1510.15	o.	41.0	21.5	2			
Appropriate Chicago	1						10,77,0	4	- T	0.5	0.5	0.5	Q T	ç
Column		80	nov.	0.15	41.0	21.5	21.2	,				1 66 0	֚֚֚֚֓֞֝֝֝֝֝֟ <u>֚</u>	1
	ļ	ď	<b>/</b> 011	2.5	0.5	0.5	0.610.6	0,5	<1.0	41.0	1470	777	Ç.	
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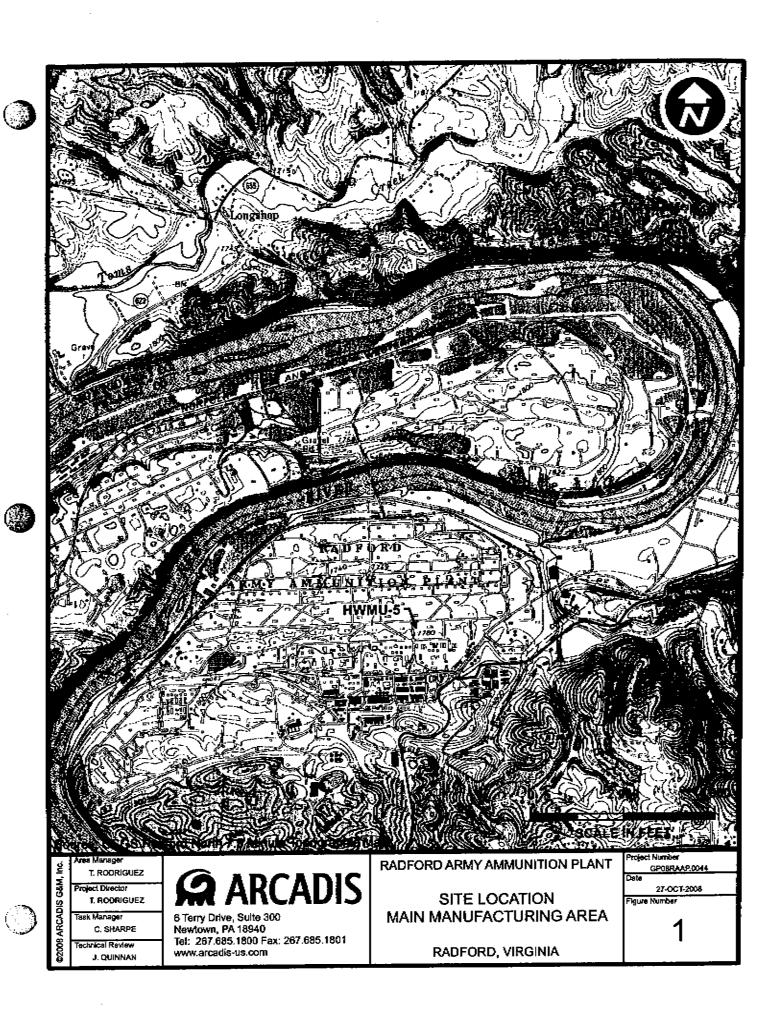
Notes:
B - emaryte was also detected in associated method blank
[1 - associated field duplicate results
1 - indicates an estimated value
U - The compound was analyzed for but not detected. The associated value is the compound

Shaded Value - indicates an concentration is greater than MCL.

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Figures





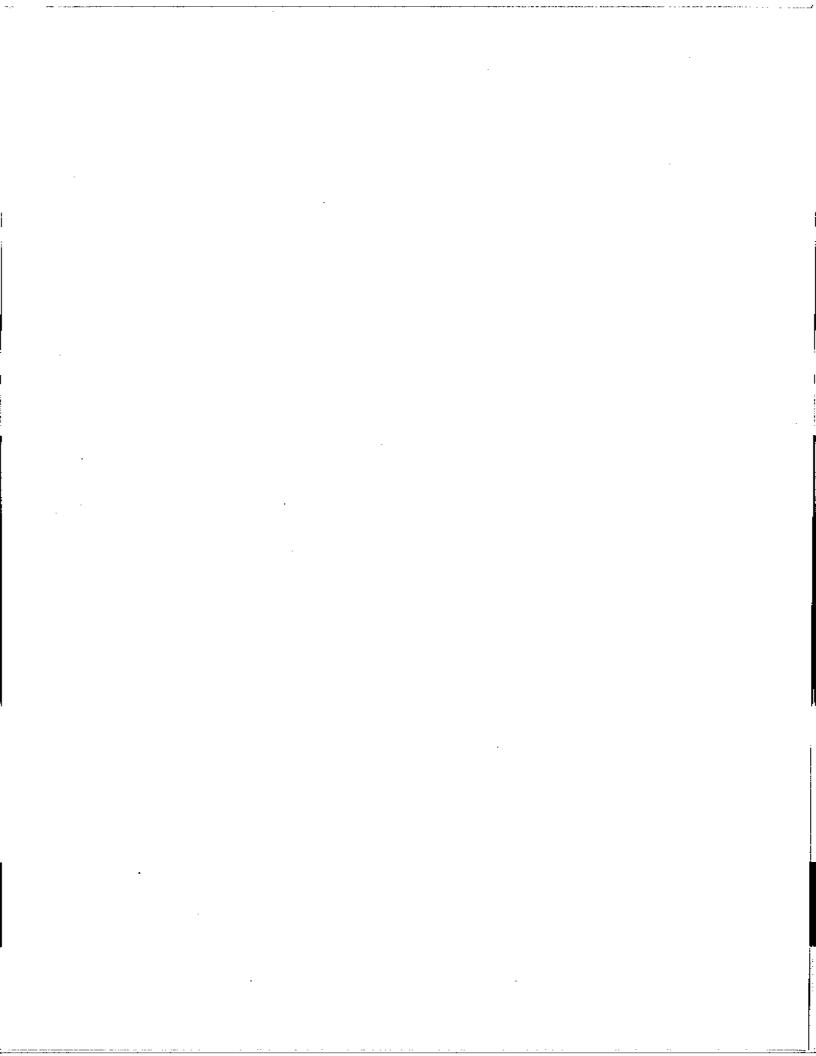
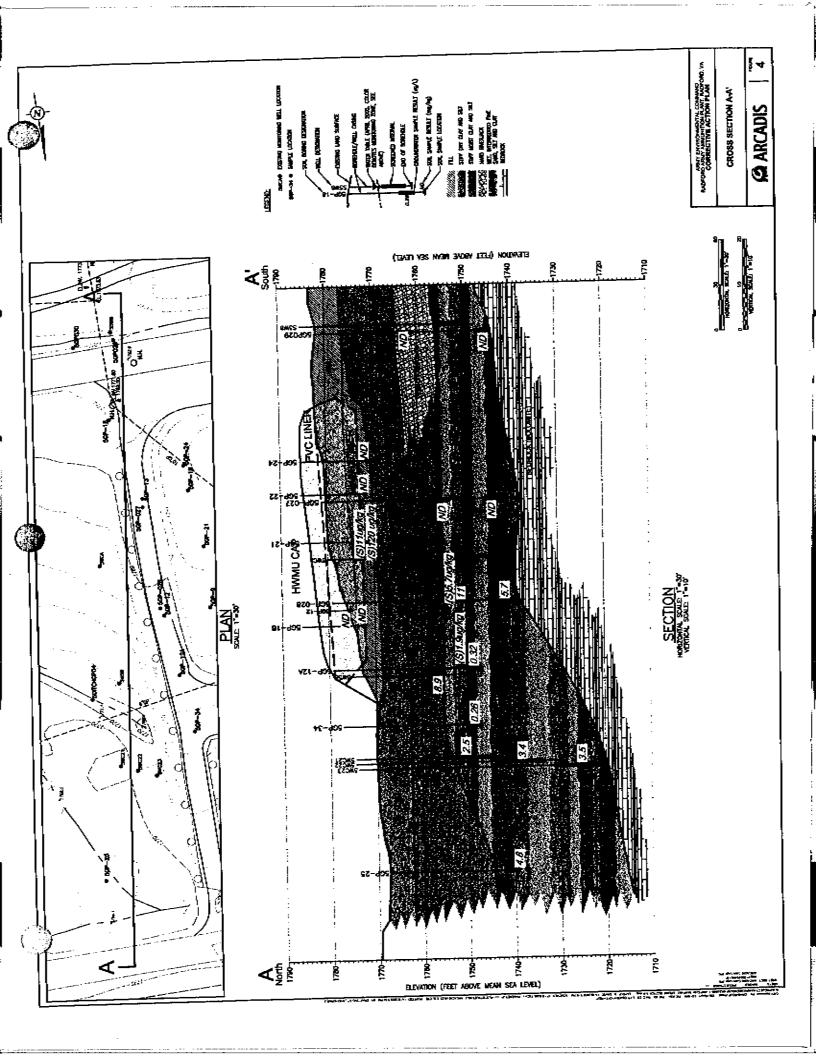




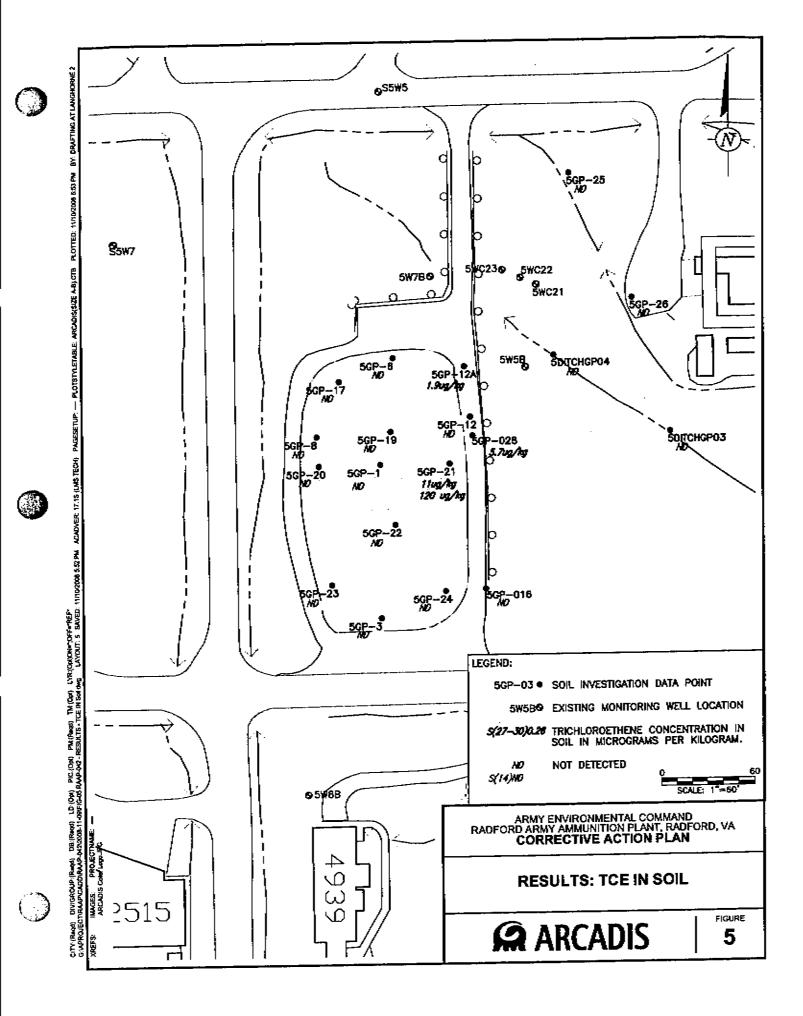


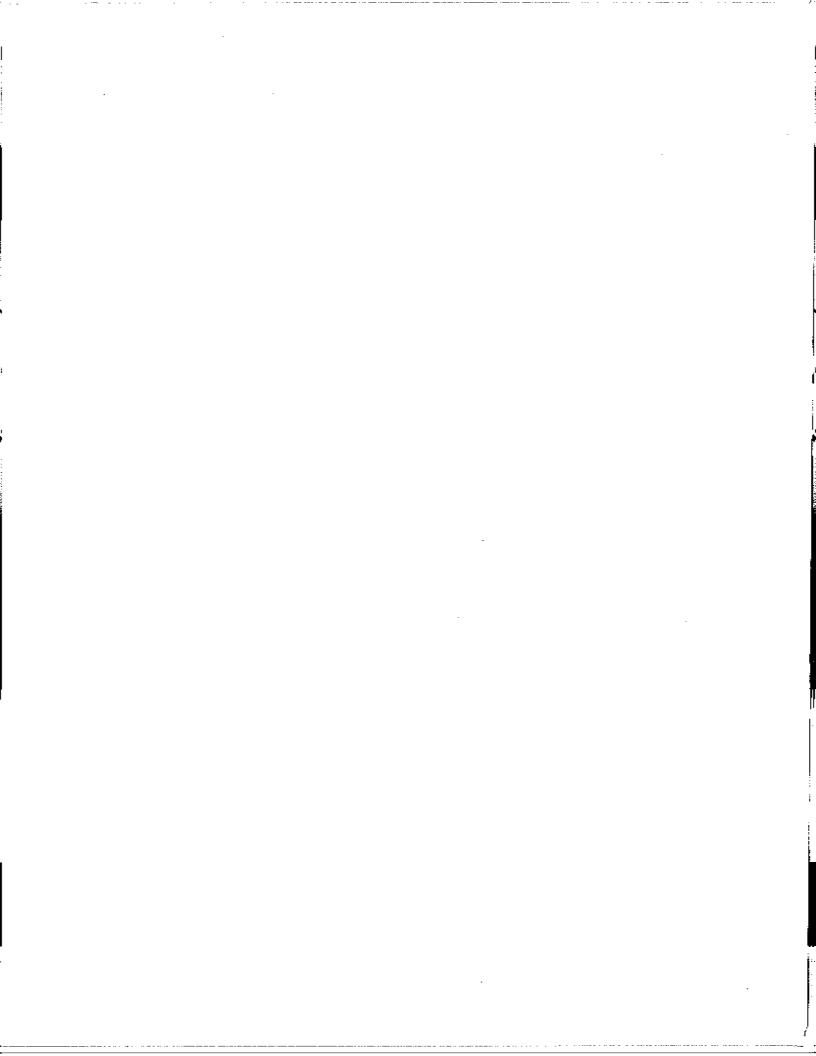
FIGURE ARMY ENVIRONMENTAL COMMAND
RADFORD ARMY AMMUNITION PLANT, RADFORD, VA
CORRECTIVE ACTION PLAN CONCEPTUAL MODEL **G** ARCADIS CITY (Reve) DIVIGROUP (Res) DB (Res) LD (ON) PIG (ON) PIG (ON) PIG (ON) PIG (ON) PIG (ON) PIG (ON) TATA (O

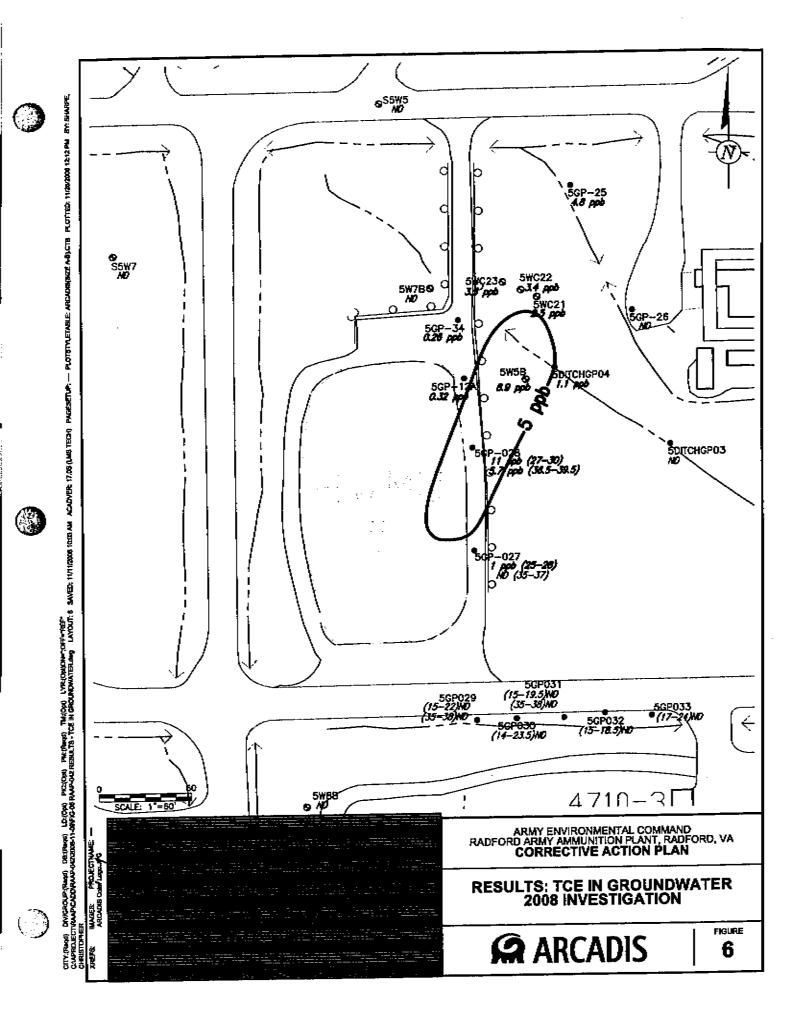
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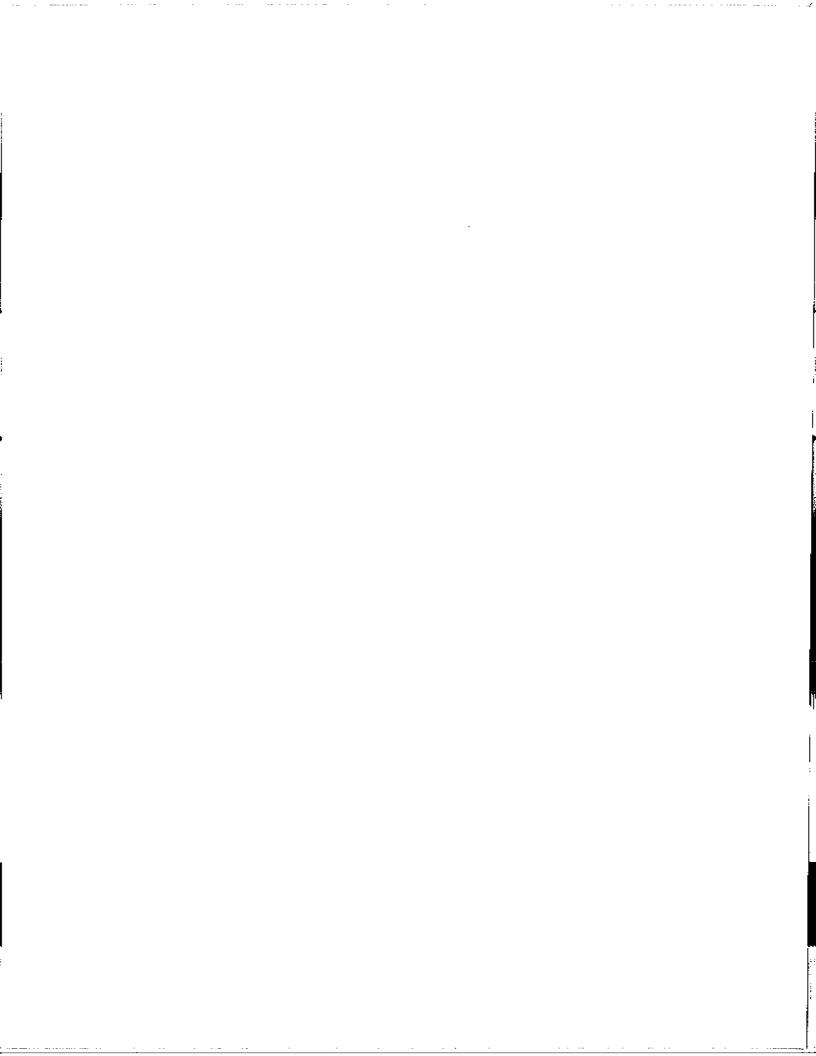


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## Appendix A

Appendix A - Supporting Information From Investigational Activities (Historic and Present)

- 1. Historical Potentiometric Surface Maps [Not included in Permit Attachment]
- 2. Historical Investigation Data [Not included in Permit Attachment]
- 3. Historical TCE Concentrations in Groundwater
- 4. Boring Logs (2008)
- 5. Fate and Transport Plots
- 6. Historical Investigation Boring Logs [Not included in Permit Attachment]



Historical TCE Concentrations in Groundwater

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Date	5W8B	5W5B	SWC21	5WC22	5WC23	5W7B	S5WS	S5W7	59/9A	5W10A	5W11A
1st Qt 1996		2.3		2.2	(2.9	-			0.6 J	-	
2nd Qir 1996	-	5.7	0.4 J	3.8	4.5		-	-	0.7 J	-	
3rd Qtr 1996		4.3	0.4 J	5	5.8		~	-	0.8 J		
4th Q1r 1996		2.4	0.9J	6.2	5.3	~	~	-	0.6 J		~
1st Qtr 1997		2.5	1.8	7.4	6.6	0.2 J	~	0.1 J	0.3 J	~	
2nd Ofr 1997	0.3 J	7.8	2.7	7.4	6.B	0.13	0.4 J	~	0.0 J	0.1 J	~
3rd Otr 1997		6	2.4	8.4	8.7	~	0.2 J	-	0.5 J	~	~
4th Qt 1897	0.8 J	B.4	1.2	8.9	2.8	0.3 J	0.3 J	-	0.3 J	-	-
1st Otr 1998	-	3.2	0.5	4.5	5.6	~	~	~	0.2 J		~
2nd Qtr 1998		12.8	1.3	4.7	4.7	~	0,2 J	-	0.2 J		
3rd Qtr 1998		12.8	2	4.7	5.1	-		~	0.5 J	~	~
4di Qtr 1998	~	7.5	4.6	5.4	5.6	-	~	-	-		~
1st Qtr 1999	-	9.5	6.7	7.5	7.5			-	. 7	7.4	~
2nd Qlr 1999	~	15.9	5.6	6.7	6	-			0.2 J	-	~ _
3rd Qtr 1899		20.5	7.B	9.9	7.8	~			0.5 J	~	~ _
4th Qtr 1999	~	19.5	4.06	8.68	6.98	-	~		~		
1st Qtr 2000	~	15.B	3.1	6.3	6.3	~	~		~	~ _!	~
2nd Qfr 2000		13.2	3.9	5.7	5.5	~			-	~ !	-
3rd Q1r 2000		16.3	5.42	DRY	DRY	~	~	-	-	~	
4th Qtr 2000	~	14.9	6,55	5.33	5.41	~	~		-	~	~
1st Q1r 2001	~	18.B	7,32	5.81	4.98	~	~		-	-	
2nd Qtr 2001	~	1.67	12.1	9.33	9.11	-	~	-	~	~	-
3rd Qtr 2001	~	6.06	20.4	13.2	11.B	~	~	-	~	~	_ ~
4th Qtr 2001	~	9.91	19.2	7.78	7.83		~		~	~	
1st Qir 2002	9.13	~	19.1	6.83	6.33	-	~	~		~	
2nd Otr 2002		9.84	16.6	7.03	6.25		-	[ <u> </u>	-	~_	~
3rd Qtr 2002		6.36	8.46	1.94	2.13	-	.~_	-	~	~	
4th Qtr 2002	~	5.84	11.3	2.54	2.69	-		-	_		-
2nd Qtr 2003		4.2	25	7.4	7.6	~	-				_ ~
3rd Qtr 2003		1.9	22	8	7.9	-	~	-			_~
4th Qtr 2003	~	6	23	7.1	7.1	~			~		
1st Qtr 2004	~	7.4	23	7.4	6.8					~	
2nd Qtr 2004		B	22	6.2	6.8	-					
3rd Qtr 2004	~	7	17	4.8	4.9			<u> </u>	~		
4st Qtr 2004	~	9.4	20	6.2	6.6	-				<u></u>	
1st Qtr 2005	~	7.9	24	5.9	5.9						
2nd Qtr 2005	~	13	16	5.5	5.8				_~_		<u> </u>
3rd Otr 2005	~	12	10	4.2	5.1	-			-		
4th Qtr 2005	~	12	6.8	4.4	4.3		_~			<del>-</del>	<u> </u>
1st Q1r 2006	i	8.5	3.9	3.7	4.5						
2rsd Qtr 2006	_~	17	4	4	4	~	~	<u> </u>		~	
3rd Qtr 2006		11	3.7	3.3	3.7	~	_ ~			-	
4th Qtr 2006	<u> </u>	9.4	3.5	4.7	3.5		_~				
1st Q1r 2007		. 9	5.6	3.3	3.6		ļ		ļ.——		<del></del>
2nd Qtr 2007	-	10	5.5	3.5	3.5		ļ				<del></del>
4th Qtr 2007	-	8.9	2.5	3.4	3.5		<u> </u>		<u> </u>	İ	<u> </u>

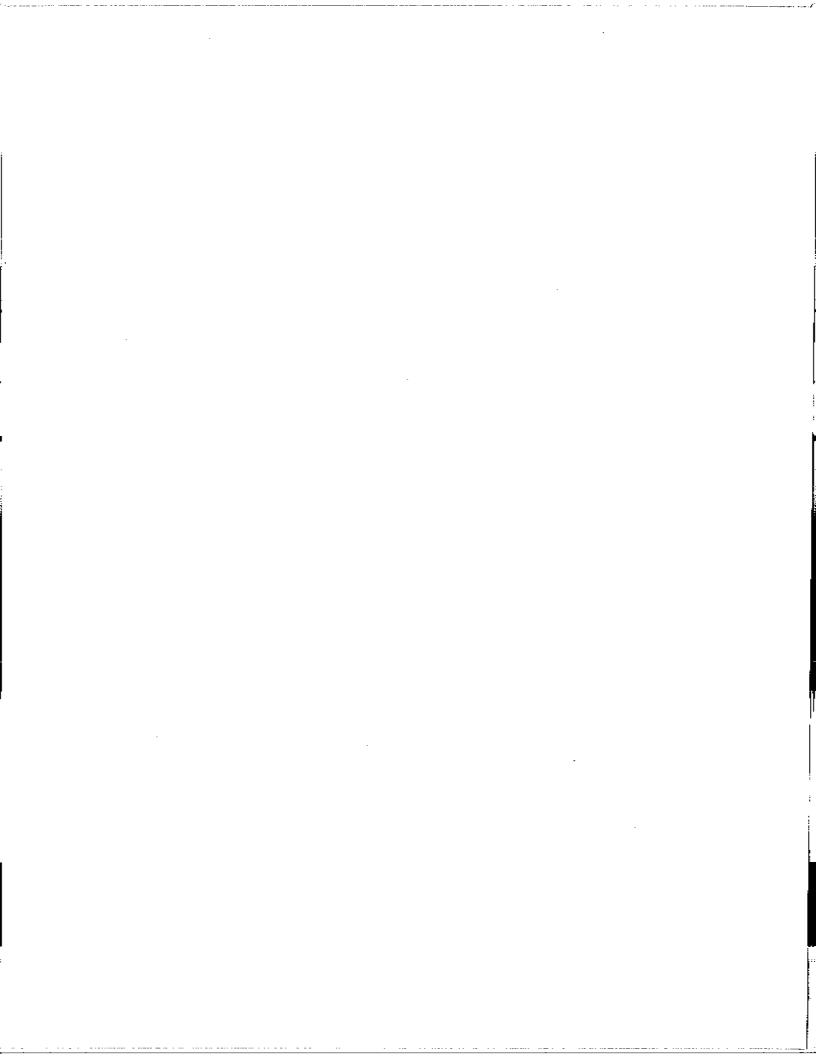
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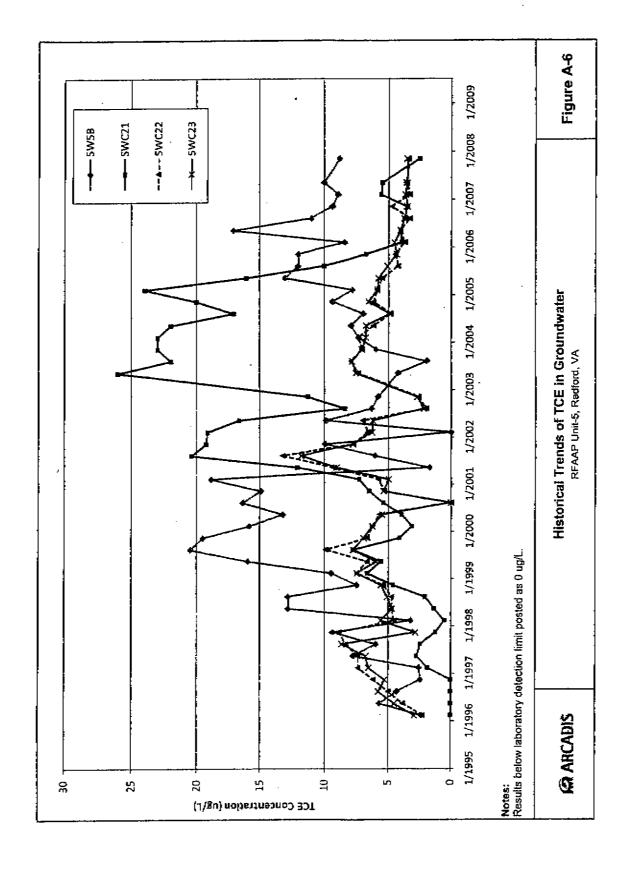


<sup>~ -</sup> TCE not detected above laboratory detection Smit.

J - Trichlogethens was detected at a concentration greater than the detection fmit but less trian line quantitation first. These results are estimates only DRY - Monitoring walls 5WC22 and 5WC23 were dry during 3rd Quarter 2000. No samples were collected.

NA - Not analyzed. The monitoring walls at HWMU-5 were not analyzed for trichloroemene during the 1st Quarter





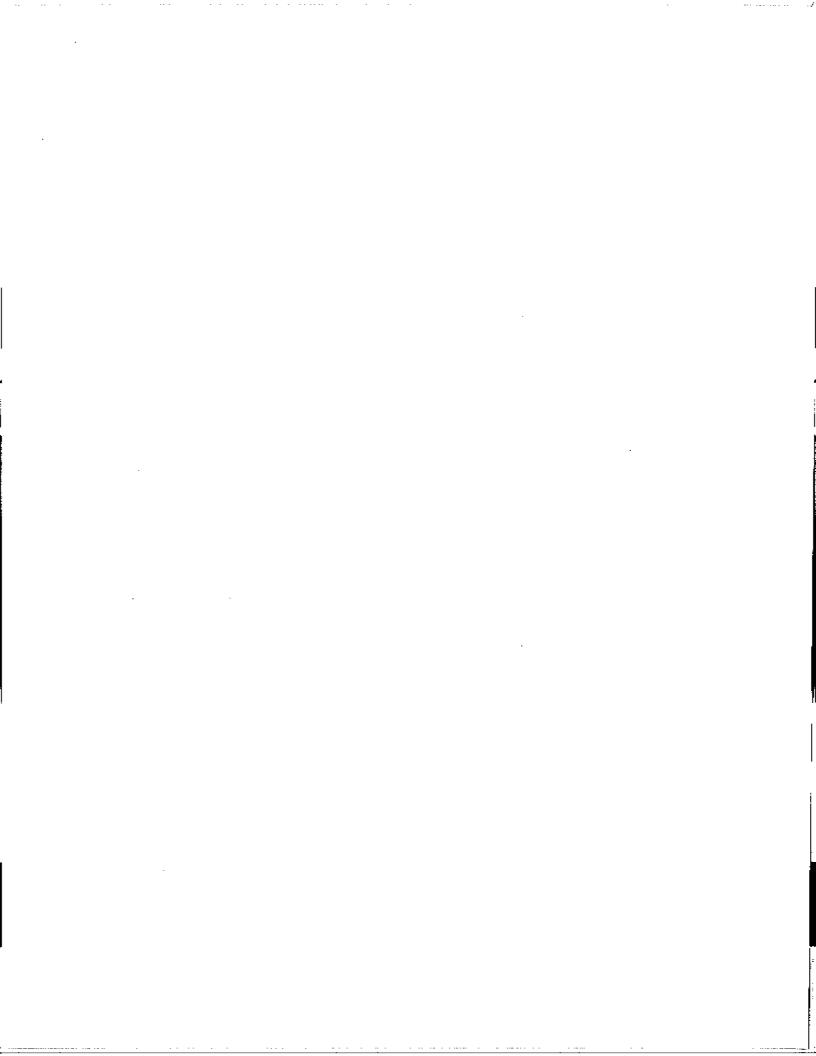


**Boring Logs** 

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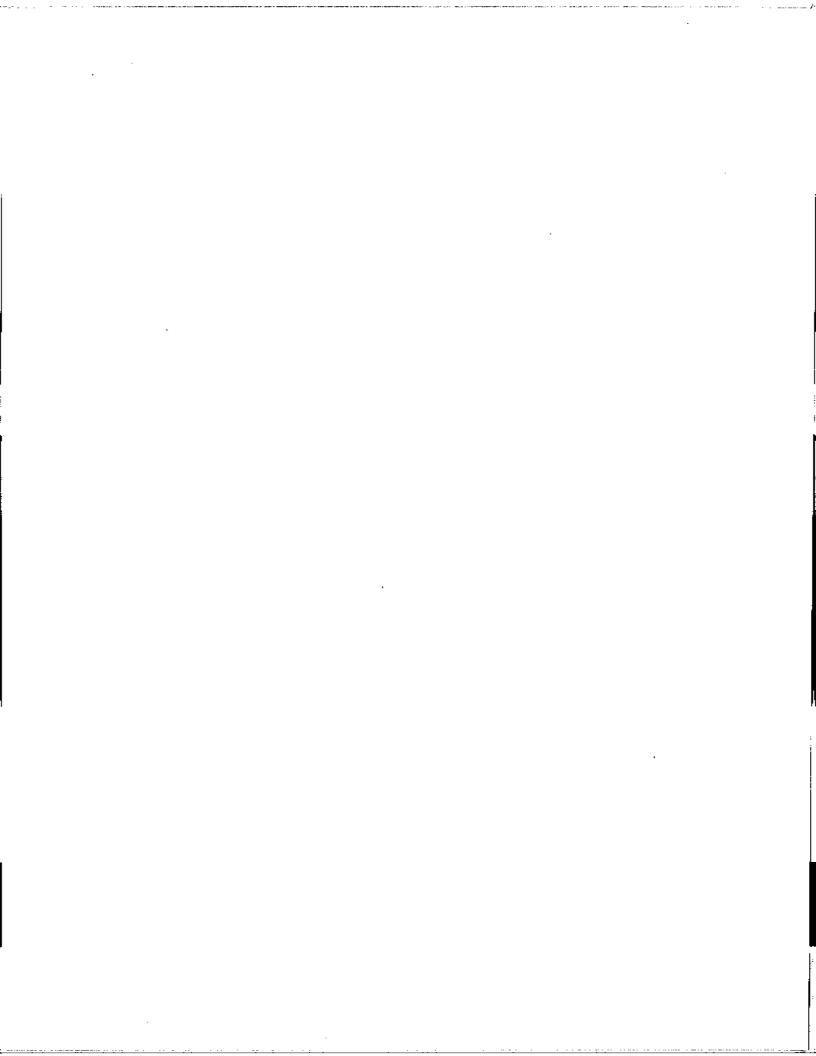


Boring/Well	5D17	TCH-1	Project/No.	Radford Army Ammunition P!	ant / GPD8RA	AP,0047.DF00	0	Page _	1 of _	1
Site Location	Radford, 1	VA			orilling Started	5/6/2008	Drilling Completed		5/6/200	<u> </u>
Total Depth	Drilled	12	Feet	Hole Diameter 1.5 in	ches	Collection	times of samples		14:10	
Length and I of Coring De		4 feet / 1.5	inches				Soll Sample	Intervali	<u>11 - 12</u> f	eet.
Land-Surfac	e Elev,	N/A	feel	Surveyed DE	slimated	Datum	N/A			
Orilling Fluid	Used	N/A				Orllling M	lethod	geoprobe		
Orllling Contractor	Columbia	Technologi	es			Driller Rol	pert Stewart	Helper _	-	<del></del>
Prepared By	Sandra G	rabowski				Hammer Weight		Drop	i	15.
Sample/Core (feet below is: From		Care Recovery (inches)	PID Reading (ppb)	Swmple/Core Description						
0	4'	36	0	0 - 4", top soil (Pt)						
			0,0	4 - 36" orange brown	CLAY, stiff, o	iry (CL)			_	
4	8'	48	0,0,0,0	0 - 48" orange brown						
8	12'	48	0,0	0 - 30" orange brown			(CL)			
ļ <del></del>	·-	10	19, 7	30 - 48" orangish brov				slightly m	noist (CL	.)
	<u> </u>		73, 7	*water ~12 ft bgs		·				
<del></del>										
			<del> </del>	Hydropunch screen int	erval set at 1	7 - 21 ft bgs	Due to hard s	soil and s	lowly flo	wing
				groundwater rods were						
			<del>-</del>	3			· · · · · ·			
<del></del>	<del></del> -	<u> </u>		END BORING	· · · · · · · · · · · · · · · · · · ·		. <u>.</u>			
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Boring/Well	6DI	TCH-2	Project/No.	Radford Army Ammunition	on Piant / GP	08RAAP.0047.D	F000	Page 1 of 1
Site Location	Redford,	VA			Orilling Started	5/6/2008	Drilling Completed	5/6/2008
Total Depth	Drilled	18	Feet	Hote Diameter 1.5	inches	Collec	tion times of samples	12:25
Length and ( of Coring De		4 feet / 1.5	5 inches	···		·····	Soil Sample	Interval 13 - 14 feet
Land-Surfac	e Efev.	N/A	_feel	Surveyed	Estimated	Datu	m <u>N/A</u>	
Orilling Fluid	Used	N/A				Drillo	ng Method	geoprobe
Orlilling Contractor	Columbia	Technolog	les			Dille.	Robert Stewart	Helper
Prepared By	Sandra G	rabowski				Hami Weig		Hammer Drop ins.
Sample/Core (feet below ha		Recovery	PID Reading					
From	To	(inches)	(ppb)	Sample/Core Description	· ···			
0	4'	48	0,0,0,41	0 - 4" top soil (Pt)				
<u></u>		<u> </u>	<del> </del>	4 - 48" reddish bro			<del></del>	
4	8'	48	0,0,0,0	0 - 36" reddish bro	own CLAY, r	nedium stiff, d	ry (CL)	<del></del>
ļ		<u> </u>		36 - 46" reddish b	rown CLAY	with some san	d and gravel, dry	(CL)
		<u> </u>		46 - 48" quartz co	bbles	· · · · · · · · · · · · · · · · · · ·		
8	12'	36	0,0,24	0 - 24" reddish bri	own CLAY w	ith some sand	and gravel, medi	um stiff, dry (CL)
<u> </u>				24 - 36" reddish b	rown CLAY,	medium stiff,	dry (CL)	
†2	16'	48	0,0,0,0	0 - 12" reddish bre	own CLAY, r	nedium stiff, d	ry (CL)	
				12 - 18" reddish b	rown CLAY,	medium stiff,	moist (CL)	<del></del>
<u> </u>				18 - 48" orange bi	rown, sandy	CLAY, loose,	wet (CL)	
			<u> </u>	*water ~14 ft bg:	5			··
				<u> </u>				
				Hydropunch scree	n interval se	at 16 - 20 ft 1	ogs. Good flow o	f waler.
				END BORING				
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Boring/Well	5DITCH-3		Project/No.	Radford Army Ammunifion Plant / GP08RAAP.0047.DF090 Page 1 of 1						
Sile			•		Orilling Started	5/6/2008	Drilling Completed	5/6/2008		
Location Total Depth	Radford, 1	12	Feet	Hole Diameter 1.5	inches	Collecti	on times of samples	13;50		
Length and		<del></del>	=		_		Soit Sumple	Interval 11 - 12 fe	eel	
of Coring De		4 feet / 1.5		Surveyed	Eslimated	———— Datum	_	11.01421		
Land-Surfac		N/A	_feet		L		Method	geoprobe		
Drilling Fluid Used Orllling		N/A	<del></del>			<del></del>		Hataaa		
Contractor	Columbia	Technolog	ies	<del> </del>		Driller	Robert Stewart	_ Helper Hammer		
Prepared By	Sandra G	rabowski			<del></del>	Weigh			MS.	
Sample/Core (feet below to	Depth nd surface) To	Core Recovery (mohes)	PID Reading (ppb)	Sample/Core Descriptio	п					
From	4'	48	0,0,0,41	0 - 2" top soil (Pt)					$\Box$	
-	<del> </del>	<del>                                     </del>	0,070,	2 - 48" orange bro		iff, dry (CL)			$\dashv$	
4	8'	48	0,0,0,0	0 - 48" orange bro			L)			
8	12'	48	0,0,0,0	0 - 48" orange bro					_	
12	16'	48	0,0,0.0	0 - 24" orange bro				(CL)		
	1			24 -48" orange br	own CLAY w	ith little sand, s	stiff, wet (CL)	<u> </u>	_	
<u> </u>		<del>                                     </del>	1							
	ļ		<u> </u>	12 feet to 20 feet :	soft pushed v	ith no hamme	ring, rods came l	back wet		
				deployed hydropu	nch, water di	d not flow in.	Re-deployed at 1	8 - 22 ft bgs;		
				let sit for 1 hour a	nd returned to	collected san	nple	<del></del>		
							<del></del> -			
		<u> </u>	<u> </u>	END BORING						
	<u> </u>	<u> </u>	ļ. <del></del>	<u> </u>						
	ļ	<u> </u>	<del></del>					·,·-		
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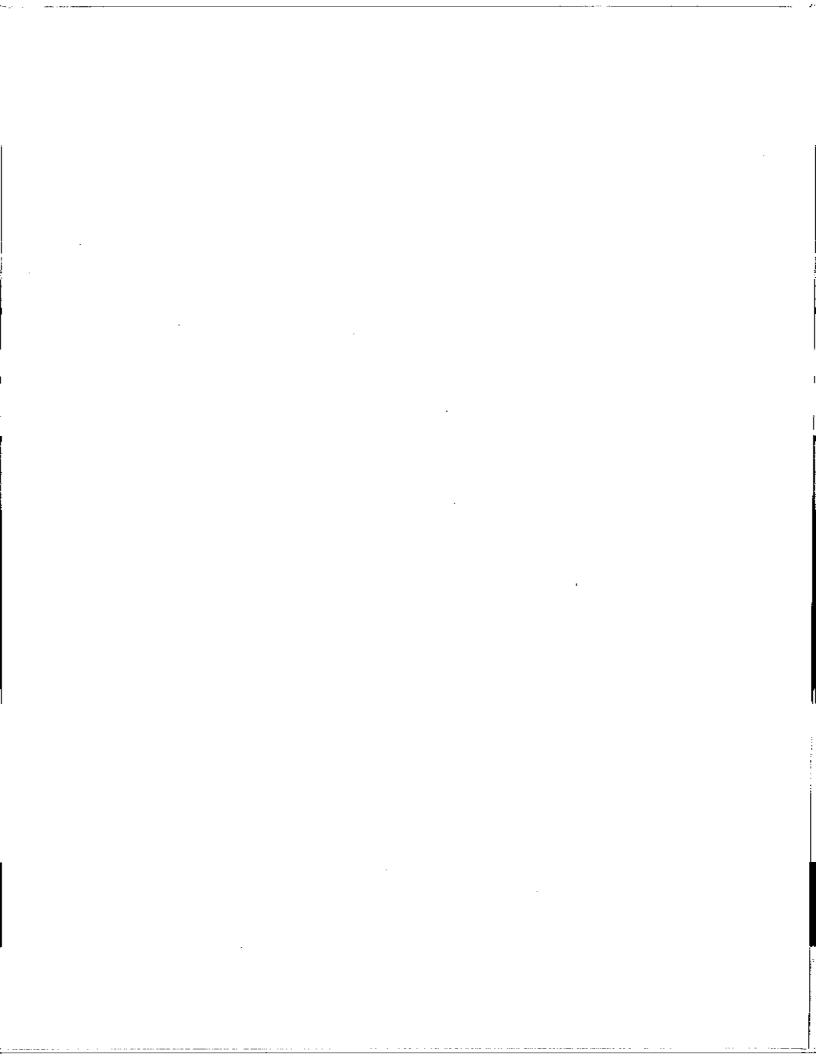


Boring/Well	5D1	TCH4	Project/No.	Radford Army Am	munition Plant / GP08	RAAP.0047.DF0	00	Page _ i of	1
Site Location	Radford,	VA			Drilling Started	5/6/2008	Drilläng Completed	5/6/2008	}
Total Depth	Drilled	44	Feet	Hole Diameter	1,5 inches	Collectio	n times of samples	17:10	
Length and of Coring De		4 feet / 1.	5 inches			<del></del>	Soil Sample	Interval 11 - 12	leel
Land-Surfac	e Eley.	N/A	feel	Surveyed	Estimated	Datum	N/A		-
Orilling Fluid	Used	N/A				Drilling I	Method	geoprobe	
Orilling Contractor	Columbia	Technolog	jies			Driller R	obert Stewart	Helper	
Prepared By	Sandra G	Grabowski				Hamme Weight	·	Hammer Drop	ins.
Sample/Care (lest below la From		Core Recovery (inches)	PID Reading (ppb)	Sample/Core De	sarlplian				
0	4'	48	0,0,0,0	0 - 4" top so	-			<del></del>	
<u> </u>	<del> </del>	40_	0,0,0,0	<del> </del>	n silty CLAY, mediu	ım soft, div (CL	1		
			<u> </u>	<del> </del>	nge brown CLAY, st		<del>7</del>		
	8'	48	0,0,0,0	<u> </u>	ge brown CLAY, stif				
4	-	+0	0,0,0,0		owish orange CLAY		and fine gravel	slightly moist (	CL)
	12'	48	0,0,0,0	1	wish orange CLAY,				
12	16'	48	0,0,0,0	·	ge brown sandy CL			·	<del>,</del>
1,2	1.0		0,0,0,0	· · · · · · · · · · · · · · · · · · ·	nge brown clayey S			nse, wet (SP)	
<u></u>	<del>                                     </del>			<del> </del>	andant from 12 - 16				
	<del> </del>	<del>                                     </del>	<del> </del>	<del></del>	nch screen interval		gs; sample colle	ected	
16	20'	48	0,0,0,0		je brown cłayey SAI				
				12 - 28" SAA	A increasing sand				
	<u> </u>			28 - 30" SA/	A decreasing sand				<u></u>
				30 - 36" wet	expanding clay (CF	1)			
				36 - 48" ora	nge brown clayey S	AND, wet			
20	24'	48	0,0,0.0	0 - 30" claye	y SAND and slough	wet			
				30 -48" oran	ige sandy CLAY, sti	ff			
24	28'	48	0,0,0,0	0 - 36" wet o	dayey SAND, loose,	with cohesive	clayey zone		
				36 - 48" wet	stiff clayey SAND				
28	32'	48	0,0,00	0 -24" well or	ange clayey SAND	with increasing	gravel (~4mm)		
				24 - 48" clay	ey SAND, tan with	grey and some	dark brown zor	185	
				* due to time	constraints blind pu	ish to refusal a	t 44 fl bgs		
j				END BORIN	G				

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Boring/Well	BG	P-021	Project/No.	Radford Army Ammun	ition Plant / GP08	RAAP,0047,DF00	0	.Page _1_0	יי יי <u>י</u>
Site Location	Radford,	VA			Drilling Started	5/9/2008	Drizing Campleled	5/9/2008	8
Total Depth	Drilled	28	Feet	Hole Diameter13	inches	Collection	times of samples	16:30	
Length and of Coring D		4 feet / 1.	5 inches			<del></del>	Soil Sample	interval 23 - 24	4_feel
Land-Surfac	e Elev.	N/A	feet	Surveyed	Estimated	Daţum	N/A		
Orilling Fluid	Used	N/A		<del> </del>		Drilling M	elhod	geoprobe	
Drilling Contractor	Columbia	Technolog	ies			Orter Rol	bert Slewart	Helper	<u></u>
Prepared By	Sendra G	Srabowski			· .	Hammer Weight		Harrimer Drop	_ins.
\$ample/Core (feet below la	Dapih nd surface)	Core Recovery	PID Reading						
From	To	(Inches)	(ppb)	Sample/Core Descript					
0	4'	24	0.0	0 - 6" asphalt ar					
	ļ			6 - 24" brown to	orange brown (	CLAY with some	gravel, stiff, di	ry (CL)	
4	8'	36	0,0,0	0 - 24" orange b	rown CLAY, ver	y stiff, dry (CL)			
	<u> </u>	<u> </u>	<u> </u>	24 - 36" orange	brown CLAY, m	redium loose, dr	y (CL)	- <del></del>	
8	12'	48	0,0,0,0	0 -12" orange br	own CLAY, stiff	dry (CL)			
i				12 - 48" orange	brown CLAY, ve	ery stuff, dry (CL	.)		
12	16'	48	0,0,0,0	0 - 48" orange b	rown CLAY, ver	y stiff, dry (CL)			
16	20'	48	0,0,0,0	0 - 48" orange b	rown CLAY, ver	y stiff, dry (CL)			
20	24'	48	0,0,0,0	0 -24" orange bi	rown CLAY, ver	y stiff, dry (CL)			
		1	-	24 - 48" orange	brown CLAY, st	tiff, moist (CL)			
24	28'	48	0,0,0,0	0 - 48" orange b	rown CLAY, me	edium loose, wet	(CL)		
			<u> </u>						
<del></del>				Hydropunch scre	en interval set a	et 28 - 32 ft bgs	Good flow of	water.	
	<del> </del>								
		<u> </u>	1	END BORING	<del></del>	<del>-</del>			
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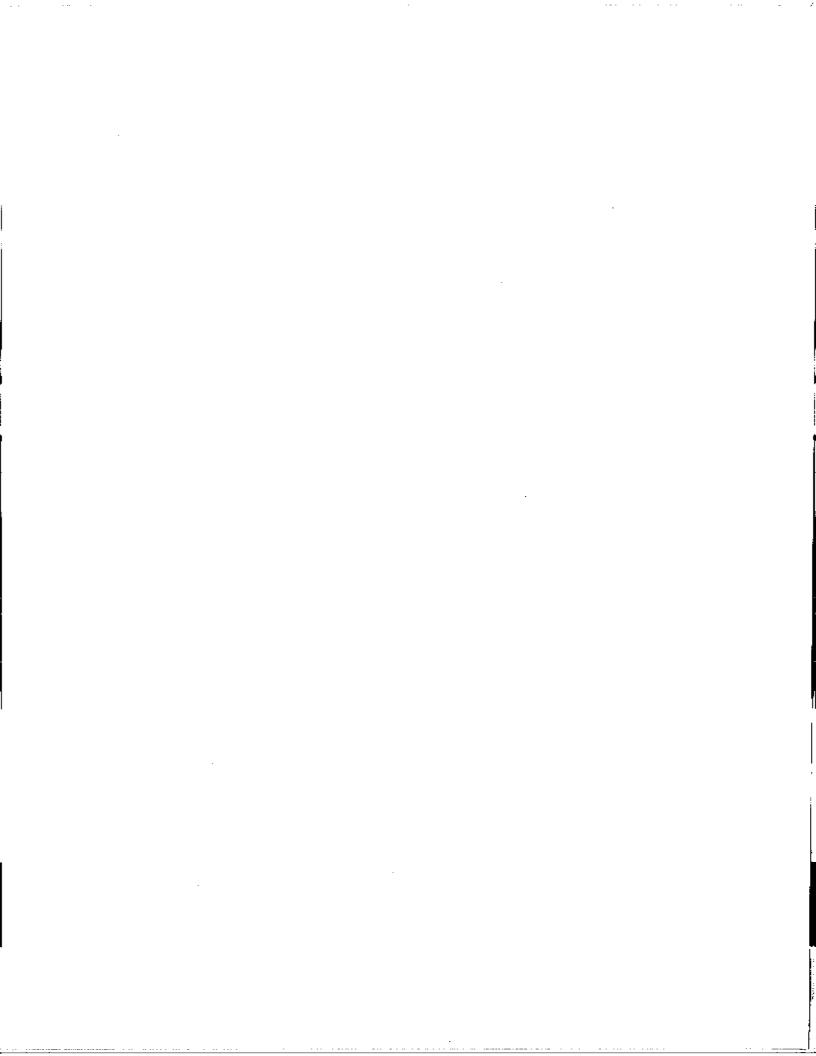


Boring/Wei	- 6G	P-025	Project/No.	Radford Army Ammunitio	n Plant / GP0	6RAAP.0047,DF000	Page1_ of1_					
Site Location	Radford,	VA			Drilling Started	Drilling 5/9/2008 Completed	5/9/2008					
Total Depth	Drilled	24	_Feel	Hole Diameter 1.5	_ inches	Collection times of samples	15:30					
Length and of Coring De		4 feet / 1.5	5 inches	<del></del>		. Soil Sample	Interval 19 - 20 feel					
Land-Surfac	e Elev.	N/A	_ feet	Surveyed	Estimated	Datum N/A						
Drilling Fluid	Used	N/A		<u></u>		Drilling Method	geoprobe					
Drilling Contractor	Columbia	Technolog	ies			Driller Robert Stewart	Helper					
Prepared By	Sandra G	rabowski				Hammer Weight	Hammer Dropins					
Samp'e/Cote	nd surface)	Recovery	PID Reading									
From	To	(Inches)	(ppb)	Sample/Core Description								
0	41	48	0,0,0,0	0 - 6" top soil (Pt)		(U)	. ,,,					
ļ		<del> </del>	<del> </del>			ittle gravel, stiff, dry (CL)						
	-	<del> </del>	<del> </del>		8 - 48" orange brown CLAY, very stiff, dry (CL)							
4	8'	48	0,0,0,0	<u> </u>	- 48" orange brown CLAY, very stiff, dry (CL) - 12" orange brown CLAY, stiff, dry (CL)							
8	12'	48	0,0,0,0	<u> </u>	*****							
<u> </u>	ļ —		<del> </del>	12 - 48" orange bri	own CLAY, y	very stiff, dry (CL)						
12	16'	48	0,0,0,0	0 - 48" orange bro	wn CLAY, ve	ry stiff, dry (CL)						
16	20'	48	0,0,0,0	0 -12" orange brov	n CLAY, stit	ff, dry (CL)						
	<u></u>			12 - 48" orange bri	own CLAY, s	tiff, moist (CL)						
20	24'	48	0,0,0,0	0 - 48" orange bro	wn CLAY, m	edium soft, wet (CL)						
<u> </u>	<del> </del>			<u> </u>		<u> </u>						
			ļ <u></u> -	Hydropunch screen	interval set	at 24 - 28 ft bgs. Good flow of	water.					
				<u> </u>								
				END BORING								
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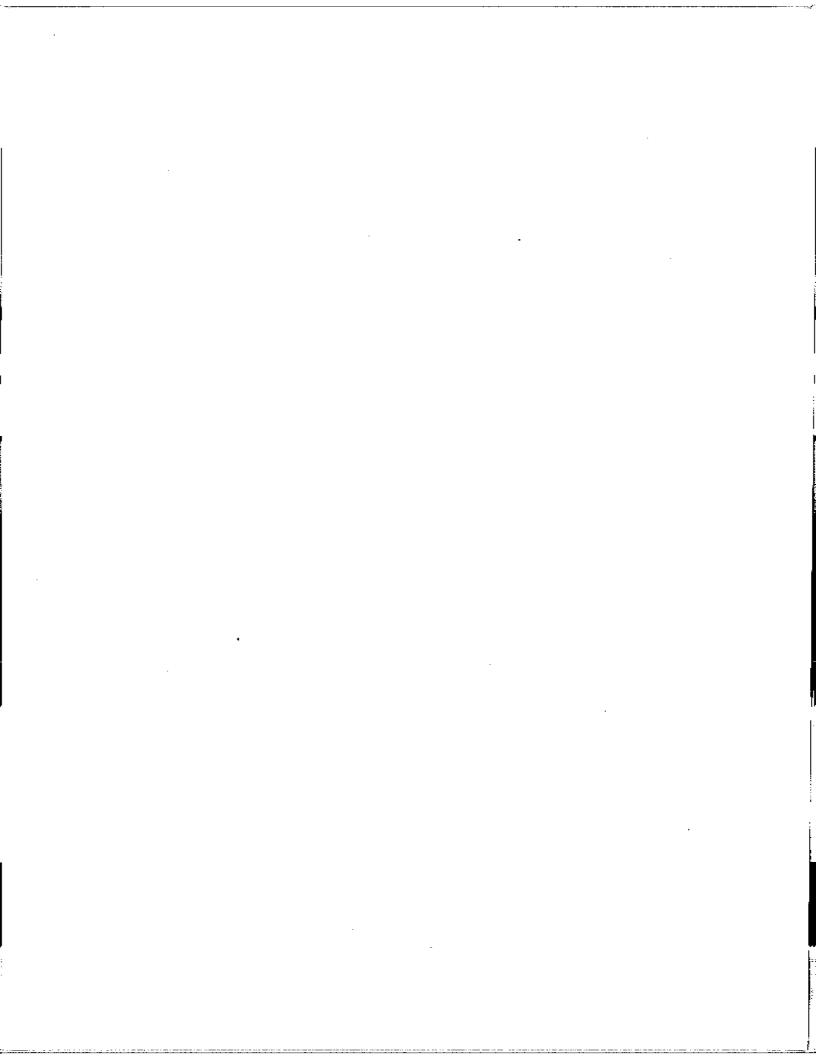


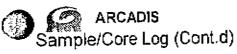
Boring/Well	6G	P-026	Project/No.	Radford Army Am	munilio	an Pfant / GPC	ISRAAP.(X	,0047.DF000		Page	
Sile Location	Radford,	VA				Drilling Started	5/9/	2008	Drilling Completed	5i	9/2008
Total Depth	Drilled	24	Feel	Hole Diameter	1.5	inches	ı	Collection	imes of samples		14:50
Length and of Coring D		4 feet / 1.	5 inches				<u>-</u>		Soil Sample	interval_	19 - 20 feet
Land-Surfac	e Elev.	N/A	feel	Surveyed	[	Estimated		Datum	N/A		
Orllling Fluid	l Used	N/A		<u> </u>				Drilling M	ethod	geoprobe	
Orlifing Contractor	Columbia	Technolog	ies				Driller	Rot	ert Slewart	Helper	· <u>-</u>
Prepared By	Sandra G	irabowski						Hammer Welgh		Hammer Drop	គាs
Sample/Core (leet below la		Core Recovery	PID Reading						-		
From	To .	(inches)	(ppb) 1	Sample/Core De	scripbor	<u> </u>					<del></del>
0	4'	36	0,0,0	0 - 6" top so	ii (Pt)						
<u></u>		<u> </u>	<u> </u>	6 - 18" light l	brown	CLAY, very	stiff, dry (	CL)			<del></del>
		_		18 - 48" ora	nge bi	own CLAY,	very stiff,	dry (CL)			<del>.</del>
4	8'	48	0,0,0,0	0 - 48" oran	ge bro	wn CLAY, ve	ery stiff, o	lry (CL)			_,
8	12'	48	0,0,0,0	0 - 48" oran	ge bro	wn CLAY, w	ery stiff, c	Iry (CL)			
12	16'	48	0,0,0,0	0 - 48" oran	ge bro	WIN CLAY, V	ery stiff, c	Iry (CL)			
16	20	48	0,0,0,0	0 - 24" oran	ge bro	wn CLAY, v	ery sliff, c	Iry (CL)	<del></del> -		
	<u> </u>		1	24 - 42" ora	nge to	orange brow	vm CLAY,	stiff, dry	to slightly mo	ist (CL)	
	1	†		42 - 48" ora							
20	24'	36	0,0,0,0	0 - 12" orat	nge br	own CLAY, s	tiff, wet (	CL)			
				12 - 36" ora	nge b	rown CLAY,	medium I	oose, we	t (CL)		
<del></del>			1	Hydropunch	scree	—— n inlerval set	at 24 - 2	B ft bgs.	Good flow of	water.	
		†	1.								
ļ	<u> </u>			END BORIN	iG					1	
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Boring/Well	5GP-27		Project/No.	GP08RAAP.0047.DF000					Page	<u> </u>	<u> 2</u>
Site Location	Radford, <sup>1</sup>	VA.			Drilling Started	6/24/2	006 14:45	Drilling Completed		6/24/200	18
Total Depth	Drilled	40	Feet	Hole Diameter 3	inches		Type of S Coring Os				
Length and			-	•	_			Sampling Inte	n mal		íee!
of Coring De	vice	5 feet / 1.		п г	Eslimated		– Datum	NA NA	1401		'``
Land-Surfac		NA	_ feet _	Surveyed	TERNUISTEO		Orllling M.		geopfo	ne	
Dritting Fluid	Used						_ Ciliuli 19 14:	etilon.	gcopio	<u> </u>	
Drilling Contractor	Columbia	Technolog	ies			Drittler	Josh K		Helper Hamm		
Prepared By	Sandra G	rabowski/ N	dichael Cobb			•	Hammer Weigh!	NA NA	Drap	NA.	ins.
Sample/Core (feet below la		Core Recovery	PID/FID Reading								
From	То	(Feel)	(cpm)	Sample/Core Description							
0	5	4.4	0.0 /, 0.0	0 - 4 SILT and CLAY,	some fine	to coarse	sand an	<u> </u>			
				gravel, dry to moist,	hard, red	brown (F	ILL).				
	<u> </u>		0.0 / 0.0	4 - 4.4 SILT, trace fin	e lo medit	ım sand,	dry to mo	ist, brown.	····		
			<u></u>					<u>.</u>			
5	10	2.5	0.010.0	0 - 1.6 CLAY and SIL	T, moist, r	nedium s	tlff, red-b	rown.			
			0.010.0	1.6 - 2.1 SILT, little ci	ay, trace l	ine to co	arse sand	soft to medi	um sliff,		
				trace mica flakes, n	ed-brown v	vith black	mottling.				
<del> </del>	<u> </u>		0.0 / 0.0	2.1 - 2.5 SILT, mediu	ım stiff, tra	ce organ	ics, olive (	gray with blac	k mattli	ng.	
	<u> </u>										
	ļ										
10	15	4	0.0 / 0.0	0 - 2 Same as above	, grades to	light bro	wn				
		<u> </u>	0.0 / 0.0	2 - 4" CLAY, highly pi	lastic, little	silt, trace	e medium	to coarse sai	nd,		
<u> </u>		<u> </u>		soft to medium stif						<del></del>	
	-			<u> </u>							
45	20	3.9	0.0 / 0.0	0 - 3.9 CLAY, highly	plastic, litt	le silt, tra	ce mediur	n to coarse S	AND,		
15	20	0.0	0.01 0.0	maist, medium stil						 k),	
	<del> </del>		<del> </del>	no apparent beddi							
	<del> </del> -	<del> </del>	<del> </del>	по врратели оваси	119 01 00111	·81					
	<del> -</del>	┼	+	<del>.  </del>							-
		12.6	0.070.0	I0 - 3 CLAY, medium	to highly o	lastic so	me silt. tr	ace medium I	to coars	e sand	
20	25	3.6	0.070.0	"floating" in matrix			-				
<b> </b>	<del> </del>	┼	00100	3 - 3.6 SILT with tittle					um to c	oarse sa	and
		<del> </del>	0.010.0		-			- 1220 IIIO			
	<del> </del>	<del> </del>	<del> </del>	moist, red brown w	nin mack c	olored sa	1105.				
<b>9</b>	1			<u> </u>							



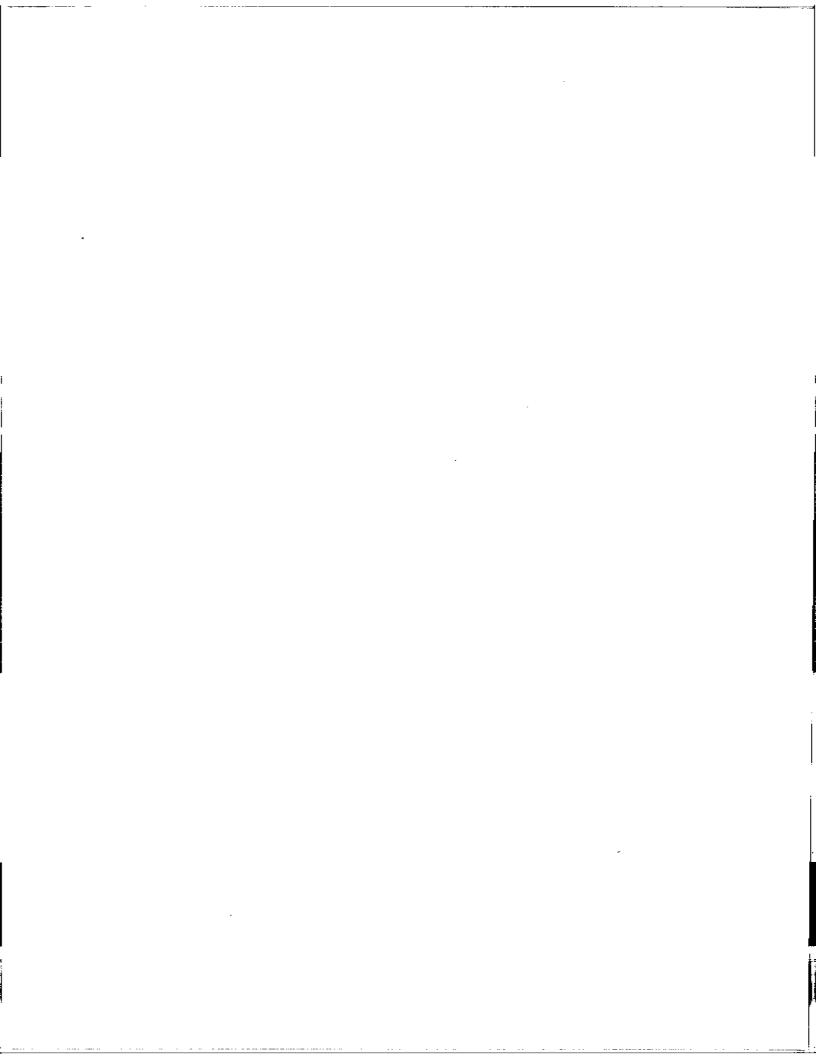


Baring/W	łejl	5GP-27		Page <u>2</u> of <u>2</u>
Prepared	l by	SGMC		
Sample/C (feet below From	ore Depth w lend surface) To	Core Recovery (inches)	PID Reading (ppm)	Sample/Core Description
25	30	2	0.0 / 0.0	0 - 2 SILT and CLAY, highly plastic, trace medium to coarse sand,
				trace black angular gravel, yellowish brown, little gray and reddish brown mottling (increasing with depth), trace mica flakes.
				Note: Sample is medium stiff, however, rods push without hammering.
30	35	\	-	NO RECOVERY
			-	*SOFT. Rods push across interval without hammering*
35	40	1.8	0.0 / 0.0	0 - 1.2 CLAY, little silt, trace medium to coarse sand ("floating"),
		<del>- </del>	<del> </del>	medium stiff, medium brown with little black mottling.
		<del> </del>	0.0 / 0.0	1.2 - 1.8 (39-40 bgs) WEATHERED ROCK, occurs as SILT, some fine to coarse.
		<del></del>	<del></del> -	sand and fine gravel (angular), dense, matrix supported, light blue/gray.  Note: rods push to 39 feet, hammer hard last foot.
		<del> </del>	<del> </del>	Note: rods push to 39 lest, training hard ask 1995.
				END BORING
		<u> </u>		Hydropunch samples collected 25-28 and 35-37 ft
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Boring/Well	5GP-28		_Project/No.	GP08RAAP.0047.DF000					Page	01	-2
Site Location	Radford,	VA			Ori <sup>m</sup> ing Started	6/23/2008		Drilling Completed	6/24/2008		
							Type of Sa	mple/			
Total Depth	Drilled	43	_ Feel	Hole Diameter3	_ inches		Coring Dev	nce			
Length and of Coring D		5 feet / 1.1	75 inches				_	Sampling Into	erval		teel
Land-Surfac	e Elev.	NA	feet	Surveyed	Estimate	d	Datum	NA_			
Drilling Flux	l Used	<u>NA</u>					Drilling Me	thod	geoprobe		
Orlling Contractor	Columbia	. Technolog	ies			Driller	Josh K.		Helper	NA	
Prepared By	-		Michael Cobb			_	Hammer Weight	NA NA	Hammer Drop	HA	ins.
Sample/Core (feet below to		Core Recovery (Feet)	PIO(FID Reading (ppm)	Sample/Core Description							
0	5	4		0 - 0.9 GRAVEL (FIL	.L)						
	<u> </u>	<del> </del>		0.9 - 4 SILT, some c	lay and gr	avel (1-5 mr	n), hard, dr	y, brown (F	ILL).		
<del></del>	1	<u> </u>									
5	10	3		0 - 3 Same as above	probable)	e filli).					
			<u> </u>			<del></del>					
10	15	5		0 - 2.5 Same as abo	ve (probal	ole fill). Rour	nded gravel	and cinder	s at 12 ft bg:	ò.	
				2.5 - 5 SILT, low to r	nedium pl	asticity, no c	dilatancy, li	tle clay, tra	ce sand,		
			<u></u>	gray silt, moist, stir	ff, red-bro	wn with little	pale gray r	nottling.			
	<u> </u>			<u> </u>							
15	20	5		D - 3 Same as above							
	<u> </u>	<u> </u>		3 - 5 CLAY, little slit,	moist, sti	ff, red-brown	with little	pale gray m	ottling.		
			ļ							<del></del>	
20	25	5	<u></u>	0 - 1 Same as above							
	<u> </u>		<u> </u>	1 - 3 CLAY, high plas	sticity, little	silt, moist t	o wet, red	brown,			
	<u> </u>	ļ	ļ	streaks of black, r	nica flakes	i					
	<u> </u>		<u> </u>								
25	30	<u> </u>	ļ <u>-</u>	0 - 5 fine SAND, litt	le silt, wei	sorted, wet,	ted prowu	mica flakes	5.		
	<u> </u>		<del></del>	27 - 27	5' with lit	le medium s	sand				
	ļ	ļ	<u> </u>						<del>-</del>		
30	35	2		0 - 1 fine SAND, little				, trace			
	1	1	<u> </u>	angular gravel, col						<del></del>	<del></del>
1	1		1	1 - 2 CLAY, highly pl	astic, trac	e angular gra	ave!, mediu	ım stiff, red	brown		



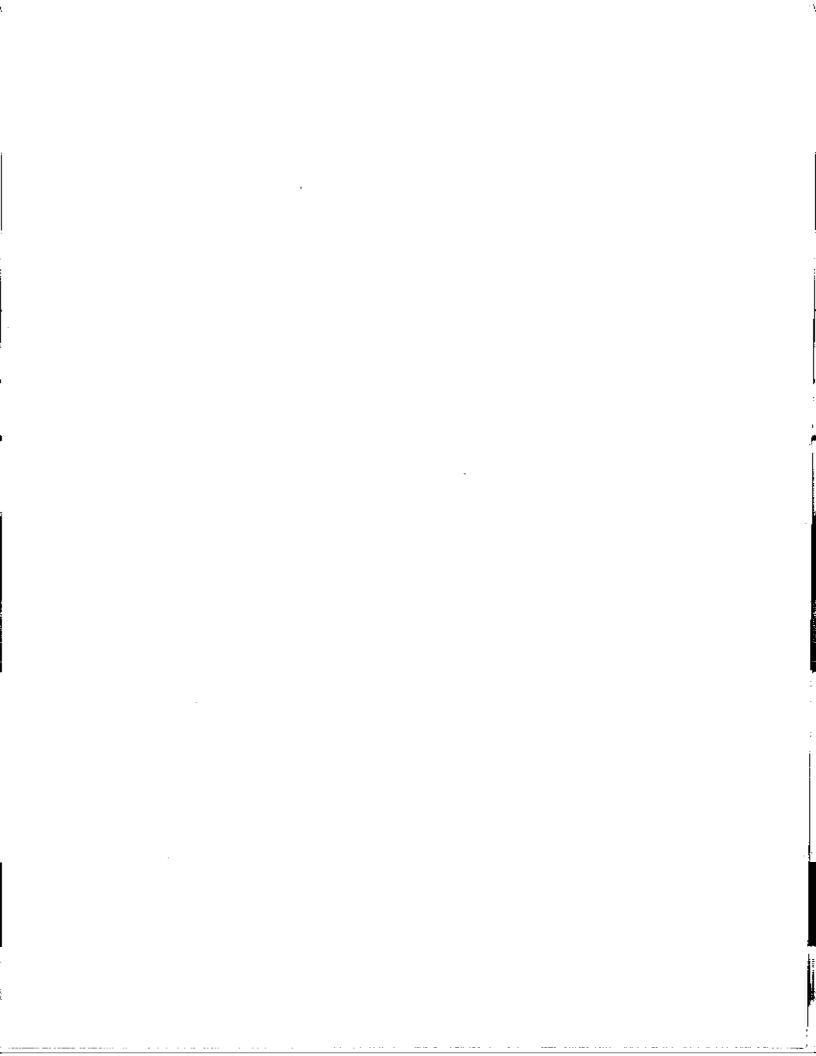


   Boring/Well	5GP-29		Project/No.	GP08RAAP.0047.DF000	·				Page	1_af	2
Site Location	Radford, '	VA	-		Drilling Started	6,28/2	008 8:00	Drilling Completed		6/28/2008 9:	:15
					! <b>b</b>		Type of S				
Total Depth			_ Feet _	Hole Diameter 3	inches		Coring De	AIC &			
Length and of Coring Di		5 feet / 1.3	75 inches		<del></del>		-	Sampling Inter	rval	NA fee	et.
Land-Surfac	e Elev.	NA	feet	Surveyed	Eslimated		Datum				
Drilling Fluk	Used	NA					_Drilling Mi	ethod	geoprot	e	
Orllling Contractor	Columbia	Technolog	ies			Driller	Josh K.		_ Helper	NA	
Prepared By	Sandra G	rabowski/ k	Archael Cobb				Hammer Welght	NA	Hamme Drop	r <u>NA</u> ins	<b>i</b> .
Sample/Core	Depth			<del></del>							
(feet below ta	nd surface)	Core Recovery	PIOFID Reading								
From	To	(Feet)	(p.pm)	Sample/Core Description					<del></del>	<del>.</del> <del>.</del>	· <del></del> ·
0	5	2.5	0.0 / 0.0	0 - 2 Top soil and roa	**-		<del></del>				
	<del></del>	<u> </u>	0.070.0	2 - 2.5 CLAY, little sl	lt, some gr	avel, med	lium soft,	moist, mediu	m prowi	i (FILL).	
<u></u>			ļ	<u> </u>	-					<del></del>	
<u></u>		<u> </u>	ļ <u>.</u>	<u></u>						<del></del>	
5	10	2.6	0.010.0	0 - 1 Fine to medium	GRAVEL,	some me	dium to co	erse SAND,	maist, d	ark gray.	
		<u> </u>	<u> </u>							<del></del>	
			0.0/0.0	1 - 1.8 fine to mediu	m SAND, w	ell sorted	l, clean, m	ioist, dense, l	ight gra	(FILL).	
		T									
			0.010.0	1.8 - 2.6 CLAY, high	ly plastic, n	naist, ver	y stiff, red	dish brown			
· · ·								·			
<del></del>								_,			
10	15	5	0.0 / 0.0	0 - 5 SILT, little clay	moderate	to highly	plastic, tra	ace fine to me	edium co	arse sand,	
				maist, medium sof	t, reddish b	rown, no	distinct st	ructure or be	dding.		
ļ	<del>                                     </del>	<u> </u>	1		•						
	<del>                                     </del>	<del> </del>	<u> </u>								
15	20	5	0.0 / 0.0	0 - 0.5 Same as abo	ıve						<u> </u>
		<u> </u>	1								
	<del> </del>		1						· -		
	<del>                                     </del>	<del> </del>	0.0 / 0.0	0.5 - 1 fine SAND, lit	tle silt mois	st to wet	soft, redd	ish brown, mi	icaceous	i.	
}	<del>                                     </del>	<del>                                     </del>	0.070.0	1 - 2.5 SILT, little cla							
<del> </del>	-	<del>                                     </del>	00700	medium soft, redo					<u> </u>		
<del></del>	<del> </del>	<del>                                     </del>	0.0100	25-5 fine to coarse		l fine to c	narse GP	AVF  subro	unded to	rounded	
<u> </u>	<del> </del>	┼	00/00	apparent cobble fr							
<b>}</b>	<del> </del>	┼─	<del> </del>	<del></del>			_		131 10 17	e cousaire	·
<b>}</b>	<del> </del>	<del> </del>	<del> </del>	dense reddish bro	wn, mix roc	k types i	KIVEK JA	ory.			

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Bering/Well	5GP-30		Project/No.	GPOBRAAP.0047.DF000	I				_ Page	1_of2
Site Lecation	Radford,	VA			Drilling Started	6/29/	2008 8:15	Drilling Completed	6/	29/2008 9:05
Total Depth	Drilled	23.5	Feet	Hole Diameter 3	inches		Type of S Coring De			
Length and I		5 feet / 1.	75 inches					Sampling Inte	erval	NA_feet
Land-Surfac	e Elev.	NA	leet	Surveyed [	Estimated		Datum			
Orilling Fluid	Used	NA				<u></u> .	_ Orilling M.	elhod	geopro	be
Drilling Contractor	Columbia	Technolog	ies			Driller	Josh K.		_ Helper	NA
Prepared By	Sandra G	rabovski i	Aichael Cobb			_	Hammer Weight	NA .	Hammi Drop	NA' ins.
Sample/Core (feet below la)		Care Recovery	PID/FID Reading							
From	To	(Feel)	(pg:m)	Sample/Core Description						<del></del>
0	5	2.6	0.0/0.0	0 - 1.9 Top soll and				<del></del>		
	 			1.9 - 2.4 CLAY, with I	ittle sitt, tra	ce fine n	nicaceous	sand, little fir	ne grave	<u>l,                                      </u>
		ļ	ļ	stiff, dry to moist,	reddish bro	wn (FILL	.).	··		
		<u> </u>	0.010.0	2.4 - 2.6 broken COB	BLE/grave	, gray m	oisl (FILL)	·		
<del> </del>		<u> </u>		<u> </u>					-	<del></del>
5	10	3.5	0.0 / 0.0	0 - 0.4 fine to medium	n GRAVEL	little coa	rse sand,	trace silt and	clay	
, 		<u> </u>	<u> </u>	matrix, moist.				<del> </del>		
<del>-</del>		ļ	0.0 / 0.0	0.4 - 1.9 medium SA	ND, mediu	m dense	, moist, we	ell sorted, ligh	nt gray (I	FILL).
<del></del>		<del> </del>	0.0 / 0.0	1.9 - 2.5 CLAY, little	silt, trace fi	ne micac	eous sand	. hard, moist		
			0,010.0	reddish brown with						
	-	! 	<u> </u>	<u> </u>						
10	15	3.9	0.0./ 0.0	0 - 0.9 Same as abo						
	i 	ļ	0.010.0	0.9 - 3.9 SILT/CLAY						
				trace medium to c	oarse sand	sub-rou	inded, moi	st, dense, re	d-orange	· <u> </u>
<del></del>		· · ·	<u> </u>	different rock type	s (RIVER J	ACK).				
15	20	4	0.07 0.0	0 - 1 Same as above	(wel at 15.	 5 ft)		·		
10	20	-	0.070.0	1 - 2.6 CLAY, little fi			fium to co	arse sand.		
			1 0.570.8	soft, wet, orange/b						<del></del>
		<del>                                     </del>	0.0 / 0.0	2.6 - 4 CLAY/SILT, r			e medium	to coarse sa	nd,	<del></del>
	<del></del>	-	0.270.0	moist to wet, medi						
	<del></del>	<u> </u>								
<b>3</b> 0	23 5	3.5	0.010.0	0-33 CLAY/SILT, t	race mediu	m to coa	rse sand,	fine gravel (fl	oating),	
)			1	soft, wet, yellowish	brown to l	ght brow	n.			





Sampi	C) COI 6	s Lug				-	-					
Boring/Well	5GP-31		Project/No.	GP08RAAP.0047.DF0	000				Page	_1	of	2
Site Location	Radford,	VA			Orilling Started	6/28/2	2008 10:10	Drilling Completed		6/28/3	2008 10:	55
Total Depth	Drilled	38.5	Feet	Hole Diameter3	inches		Type of S Coring De					
Length and of Coring De		5 feet / 1.1	75 inches				_	Sampling Inter	rval		fe	eet
Land-Surface	e Elev.	NA	fest	Surveyed	Estimaled		Dalum	NA				
Orlling Fluid	Used		NA				_ Daliting Me	elihod	geopi	obe		
Drilling Contractor	Columbia	Technolog	les			Driller	Josh K.		_Hefpe	ı <u>NA</u>		
Prepared By	Sandra G	rabowski/ N	dichael Cobb			_	Hammer Weight	NA	Hamn Drop		NA_in	ns.
Sample/Core (feet below la From		Core Recovery (Feet)	PID/FID Reading (ppm)	Sample/Core Descrip	Alon		•					
О	5	2.7	0,0 / 0.0	0 - 2.2 Top soil, g	ravel, some fi	ne to coa	rse sand,	little silt, dry (	FILL)			
<del></del>			0.0 / 0.0	2.2 - 2.7 CLAY, Iltt								
	-	,	<u> </u>	reddish brown (F								
			<del>                                     </del>			•				-	-	_
5	10	3.3	0.0 / 0.0	0 - 0.6 fine to med	ium GRAVEL	little silt	, little fine	sand, mediun	ı dens	ė, mo	oist (FII	LL}.
			0.0 / 0.0	0.6 - 1.8 fine to me	dium SAND,	well sort	ed, moist,	medium loos	e, Itghi	i gray	(FILL)	<u>).                                    </u>
			0.0 / 0.0	1.8 - 2.1 SILT/CLA	Y/GRAVEL, r	noist, me	edlum soft,	reddish brow	n (FIL	L).		
			0.0.7 0.0	2.1 - 3.3 CLAY, hi	ghly plastic, li	ttle silt, r	medium sti	ff, moist, redo	lish br	own v	vith	
				little mottling, no	apparent bed	lding.	·					
10	15	5	0.0 / 0.0	0 - 1.6 Same as a	bove, but very	stiff, tra	ce floating	micaceous s	and.			
			0,070.0	1.6 - 3 stiff SILT, li	ittle clay, mod	erately p	lastic, trac	e floating san	d, mic	a,		
		<u> </u>		moist, reddish ៦	rown, no appa	rent bed	lding, grad	es downward.		<del></del>		
	· · · · · ·		0.0 / 0.0	3 - 5 fine SAND, se	ome siit, mica	ceaus, m	noist, reddi	sh brown, no	арраг	ent b	edding	J
	<u>"</u>											
15	20	4.5	0.0 / 0.0	0 - 3.5 Same as at	pove, no dilata	incy, trac	e floating	medium sand	, unifo	rm co	olor,	
				moist to wet.								
		-	0.0 / 0.0	3,5 - 4.5 fine to m	edium SAND,	some g	avel, sub-	rounded, little	silt,			
			<u> </u>	mix rock types, a								
				trace floating gra					•			
		<del> </del>	<del>                                     </del>									
l				<del> </del>								

Refusal at 19.5 ft bgs with dual-tube geoprobe sampler PVC temporary well set screened 14.5-19.5 ft bgs.

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8oring/Well	5PG-32		Project/No.	GP06RAAP0047.DF000	<del></del>				Page	_1_	of i	
Site Location	Radford,	VA			Drilling Started	6/30/	2008 6;20	Drilling Completed		6/30/20	208	
Total Depth	Drilled	18.5	_Feel	Hole Diameter3	inches		Type of S Coring De		AM			
Length and to of Coxing De		5 feet / 1.	75 inches			··	<b>-</b>	Sampling Inter	val	NA	feel	
Land-Surfac	e Elev.	NA	_feet	Surveyed	Estimated		Datum	NA				
Orlfling Fluid	Used	NA		<u> </u>			_ Drilling Mi	elihod	geoprob	jė		_
Orllling Contractor	Columbia	Technolog	ies			Driller	Josh K.		Helper	NA_		
Prepared By	Sandra G	irabwoskl/ ).	Aichael Cobb			_	Hammer Weight	NA NA	Hamme Drop	r NA	ins.	
Sample/Core (feet below/lar		Core Recovery (Feel)	PID/FID Reading (ppm)	Sample/Cure Description								
Đ	5	2.6	0.0 / 0.0	0 - 1.6 Top soil, organ	ics fine to	medium	GRAVEL	with little fine	to			_
<u> </u>		2.0	0.070.0	medium sand, slit, a			ORTICE	THE THE	<del></del> _			_
			0.0 / 0.0	1.8 - 2.6 SILT with litt	le clay, litt	le fine to	medium q	ravel, trace m	edium s	and,		_
				stiff, moist, orange l	····							_
			<del></del>		<u> </u>	<del>=/:</del>				-		
5	10	2.6	0.0 / 0.0	0 - 0.2 Same as abov	re							_
			<u> </u>	0.2 - 2.2 fine to mediu	ım SAND,	clean, w	ell sorted <sub>.</sub>	medium dens	е,			_
, <del></del>				dry to moist, light gr	ray (FILL).							_
			0.0 / 0.0	2.2 - 2.6 CLAY, highly	, plastic, tr	ace med	ium to coa	rse sand, moi	st,			
			<u> </u>	soft, medium brown	(possible	FILL).			<del></del>			_
			,,,									_
10	15	5	0.0 / 0.0	0 - 1.4 CLAY, little slit	l, trace floa	iting coar	se sand, r	noist,				
				medium stiff, yellow	ish brown.							
			0.070.0	1.4 - 5 CLAY, highly p	lastic, trace	e floating	fine to me	dium sand, vi	ery stiff,	·		_
	· 	 		maist, light brown, n	nottled red	dish/ ligh	i gray.	<del></del>				_
								·=				_
15	18.5	3.5	0.0 / 0.0	0 - 2.3 Same as abov	e, very stift	<u>[</u>						-
			0.0./ 0.0	2.3 - 3.5 Same as abo	ove grading	to fine s	and and c	lay, high				
			<u></u>	plasticity, moist, me	dium dens	e.						
				Refusal at 18.5 ft on	cobble (in	ferred).	<del></del>					4
				E	ND BORIN	IG	<del></del>					4
					·							
<b>&gt;</b>				PVC temporary well	set screer	ed 13 5-	18 5 ft bgs	<u> </u>				╽
<i>3</i>	1		1	1								1

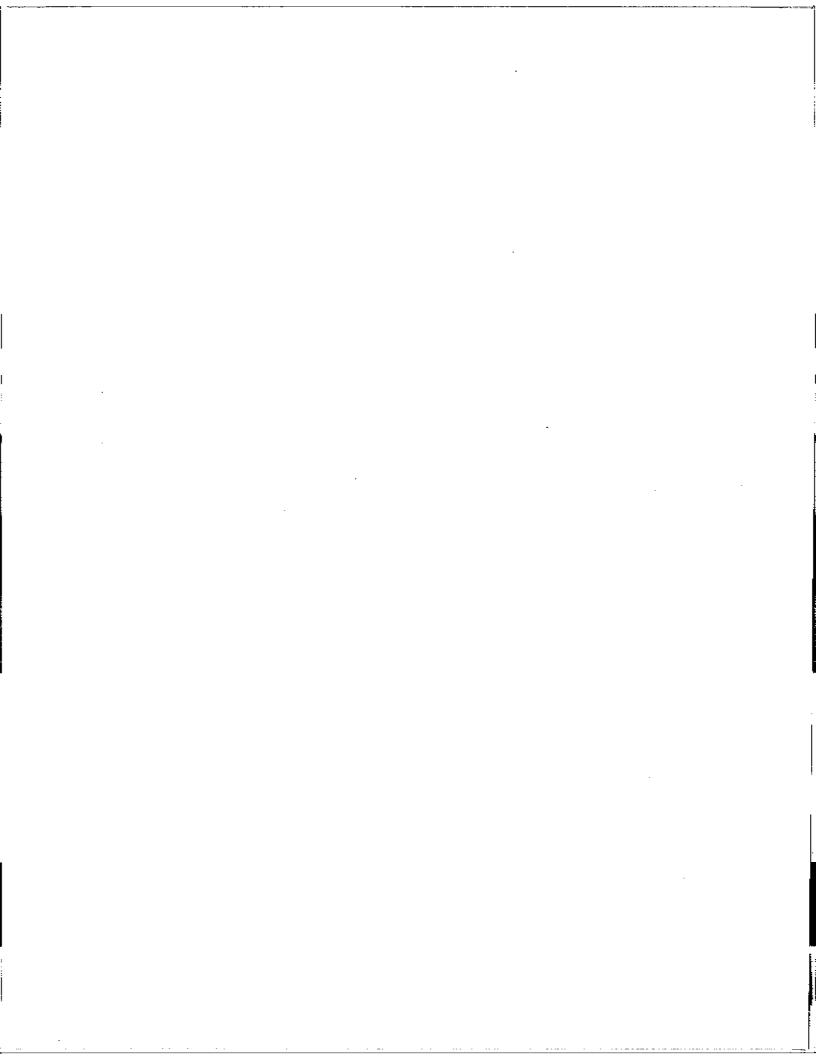
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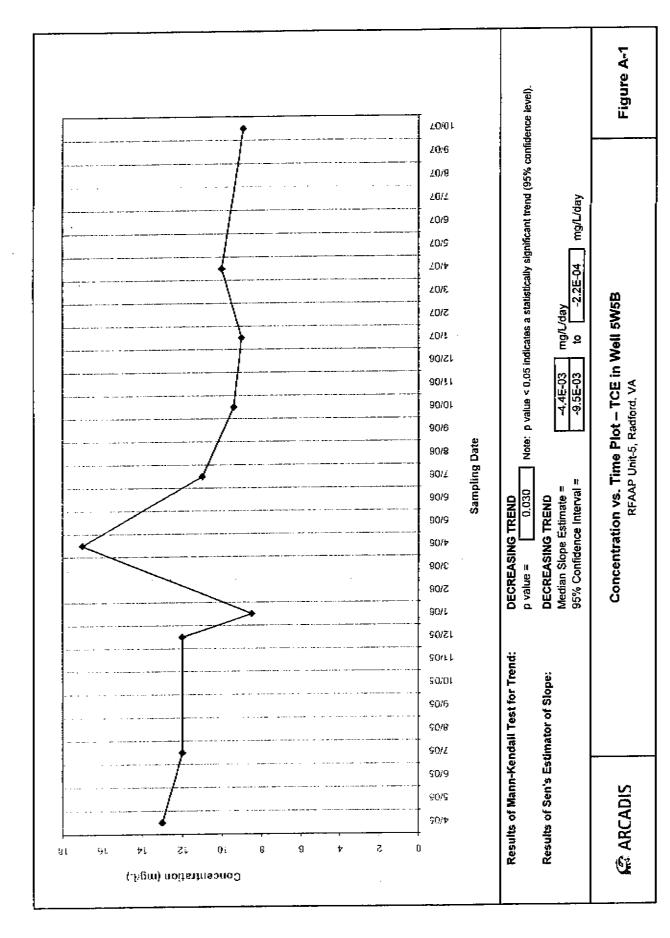


Boring/Well	5GP-33		Project/No.	GP08RAAP.0047.DF000					Page	<u> </u>	ıf <u>f</u>
Site Location	Radford,	PA			Drilling Started	6/28/2	008 16:50	Drilling Completed	6/	28/2008	17:40
Total Depth	Drilled	24	Feet	Hole Diameter 3	inches		Type of Sa Coring De				
Length and of Coring D		5 feet / 1.	75 inches				_	Sampling Inte	rval		feel
Land-Surfac	ce Efev.	NA	_ feet	Surveyed	Estimated		Dalum	NA			
Orilling Fluid	i Used	NA					_ Drilling Me	Mhod		geoproi	æ
Drilling Contractor	Columbia	Technolog	les			DriRer	Josh K.		Helper		NA
Prepared By	Sandra G	irabowski/ N	Aichael Cobb				Hammer Weight	NA	Hamme Drep	r NA	ins.
Sample/Core			<del></del>		-··				<u> </u>		_
(feet below to From		Core Recovery (Feel)	PID/FID Reading (ppm)	Sample/Core Description							
0	5	2.7	0.0.7 0.0	0 - 1.5 Top soil, gravel	. dry (FILL	٠ <u>.                                    </u>					
<u> </u>				1.5 - 2.2 SILT, some fi			and gravel	dry,		•	
				medium brown, ora	nge/black i	mottled (	FILL).				
			0.0.7 0.0	2.2 - 2.4 fine to mediu	m SAND, d	ry, medi	um soft, li	ght gray.			
			0.0 / 0.0	2.4 - 2.7 fine to mediu	n GRAVEL	., dry (F1	LL).				
5	10	-		NO RECOVERY		_					
10	15	5	0.0 / 0.2	0 - 3.2 CLAY, plastic,	trace mica	ceous fir	ne sand, vi	ery stiff, mois	t,		
		<u> </u>		light brown with red	mottling, n	о арраге	nt bedding	<b>)</b> .			
	<del> </del>		0.0 / 0.2	3.3 - 5 Same as above	e but reddis	sh brown	with dark	brown/light g	ray mot	tling.	
		 		a a a au Trai Av	<del></del>	h.					
15	20	5	0.0 / 0.0	0 - 0.8 SILT/CLAY, m							· O.
	-	<del> </del>	0.0 / 0.0	0.8 - 1.1 Same as about 1.1 - 5 Coarsening do							
<u> </u>	<del>                                     </del>		0.0./ 0.0	organic matter to m						uace_	
	<del> </del>	<u> </u>	<del> </del>	bedding, medium de		TIC OATSE	7, INTIC 311,	1110131 10 1101	, 121111	-	
20	24	4	0.0 / 0.0	0 - 0.2 Same as above		<del></del>	·				
		<u> </u>		0.2 - 3,2 fine to mediu		ittle silt, 1	trace floati	ng rounded f	ine gravi	 el,	
				wet, medium dense					¥		
		-	0.0 / 0.0	3.2 - 4 fine to coarse (			-		sub-		
				rounded, little fine to	medium s	and and	silt matrix	stiff, cohesin	re, mois	to wet	
١				Refusal at 24 ft bgs	END OF	BORING	S				
<i>)</i>	!			DMC temporary wall	est carpone		P has				

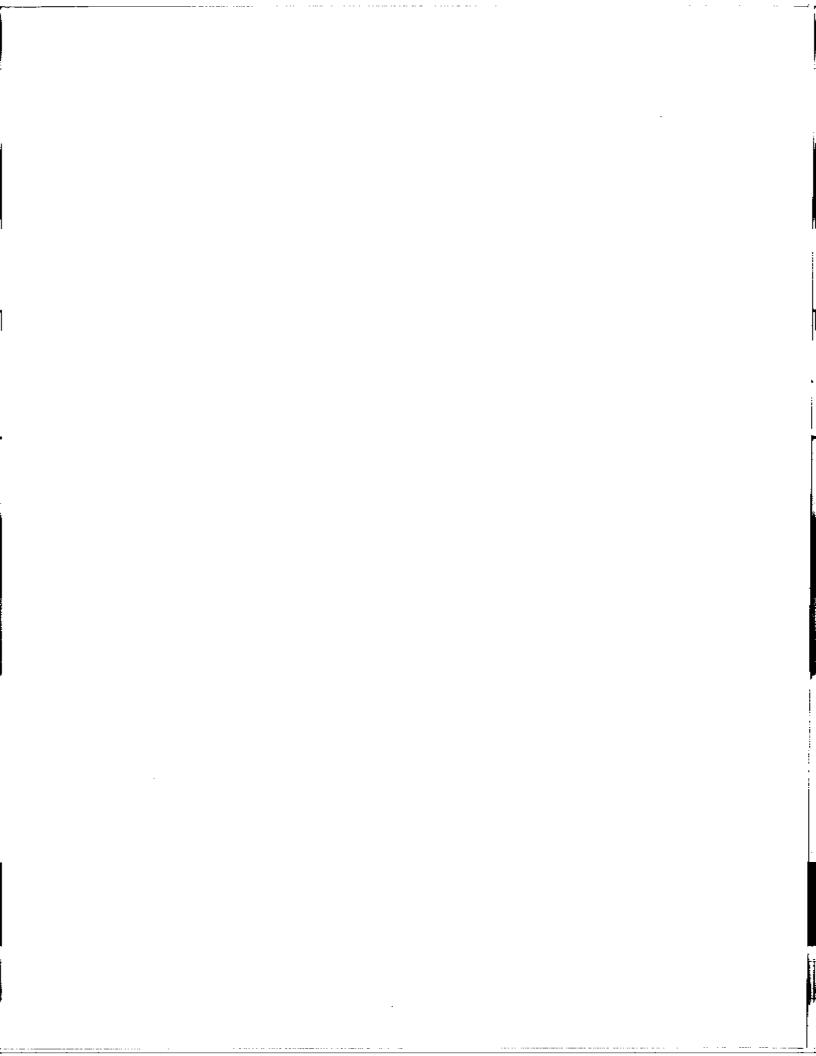
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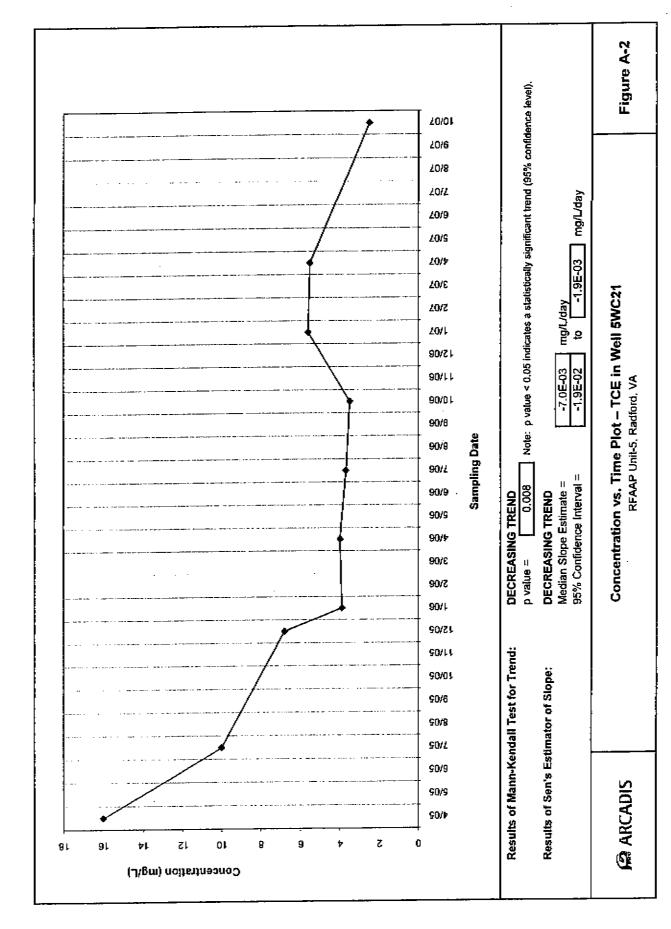




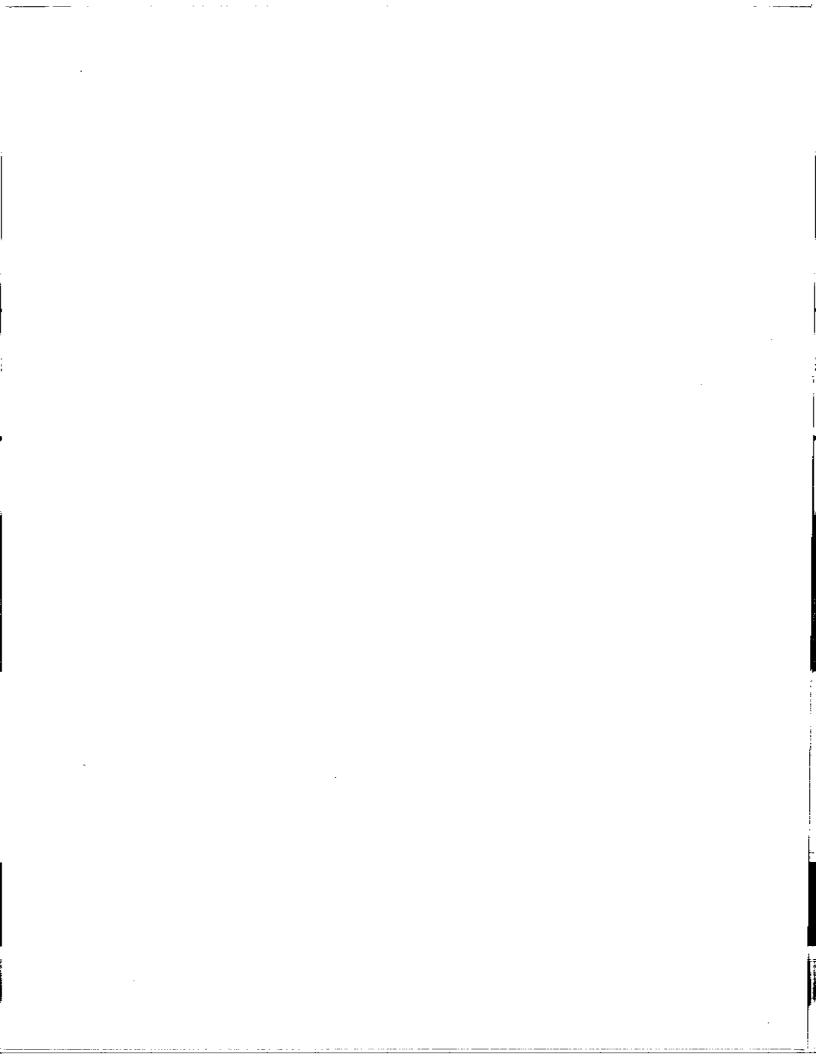


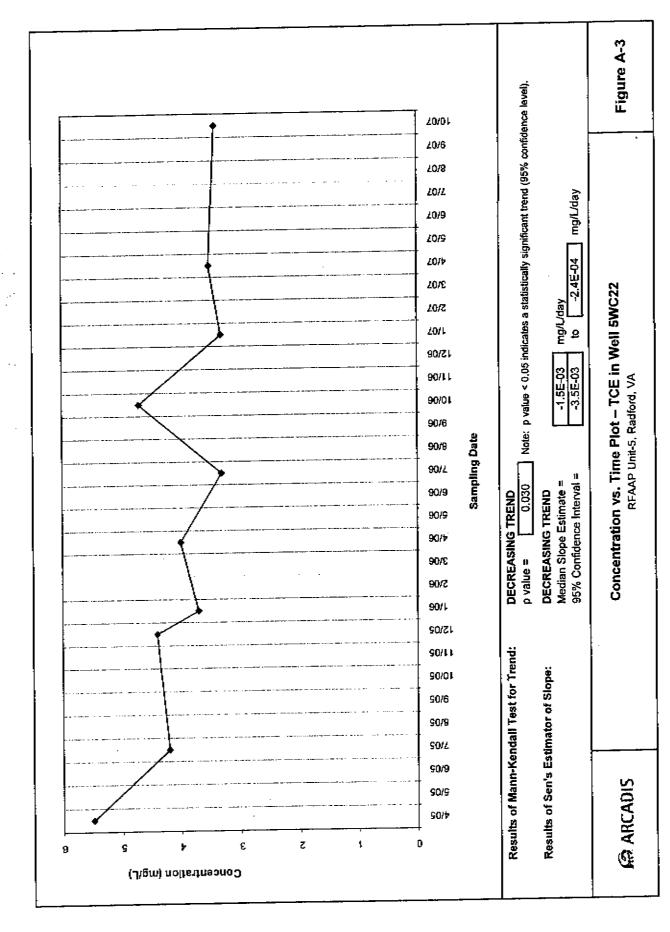
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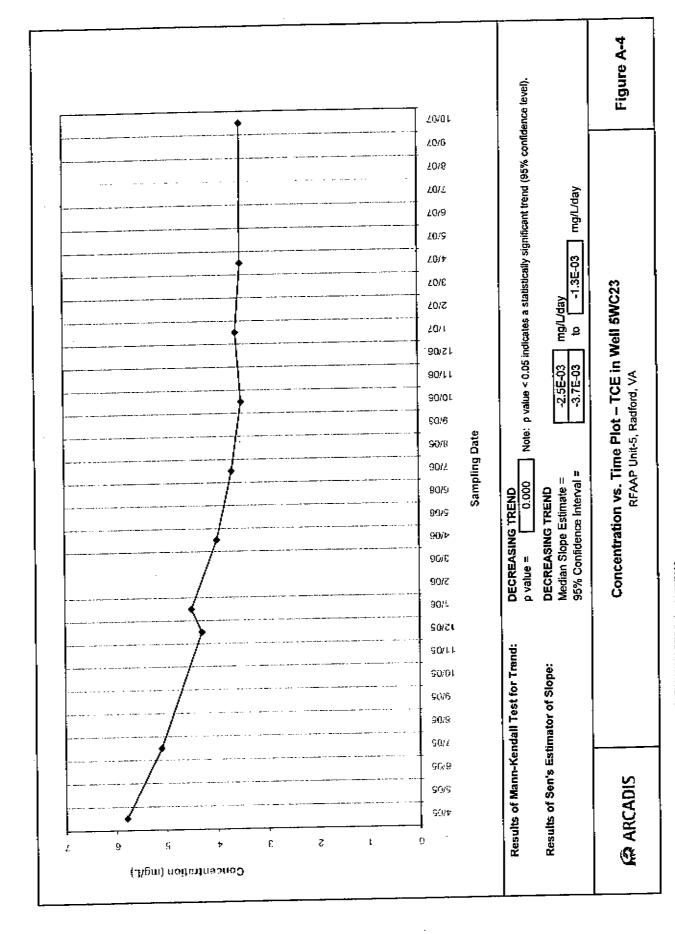
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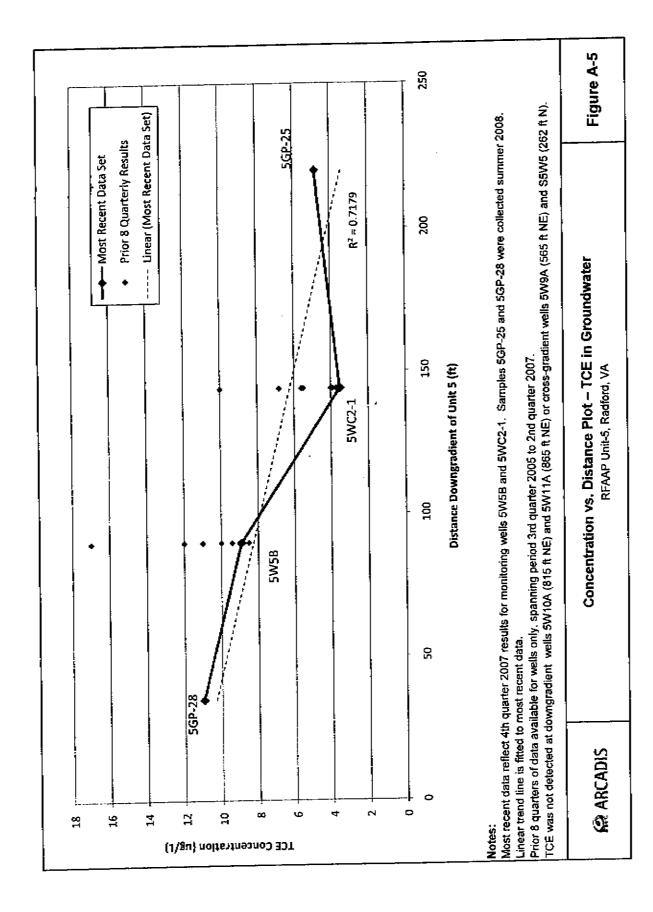
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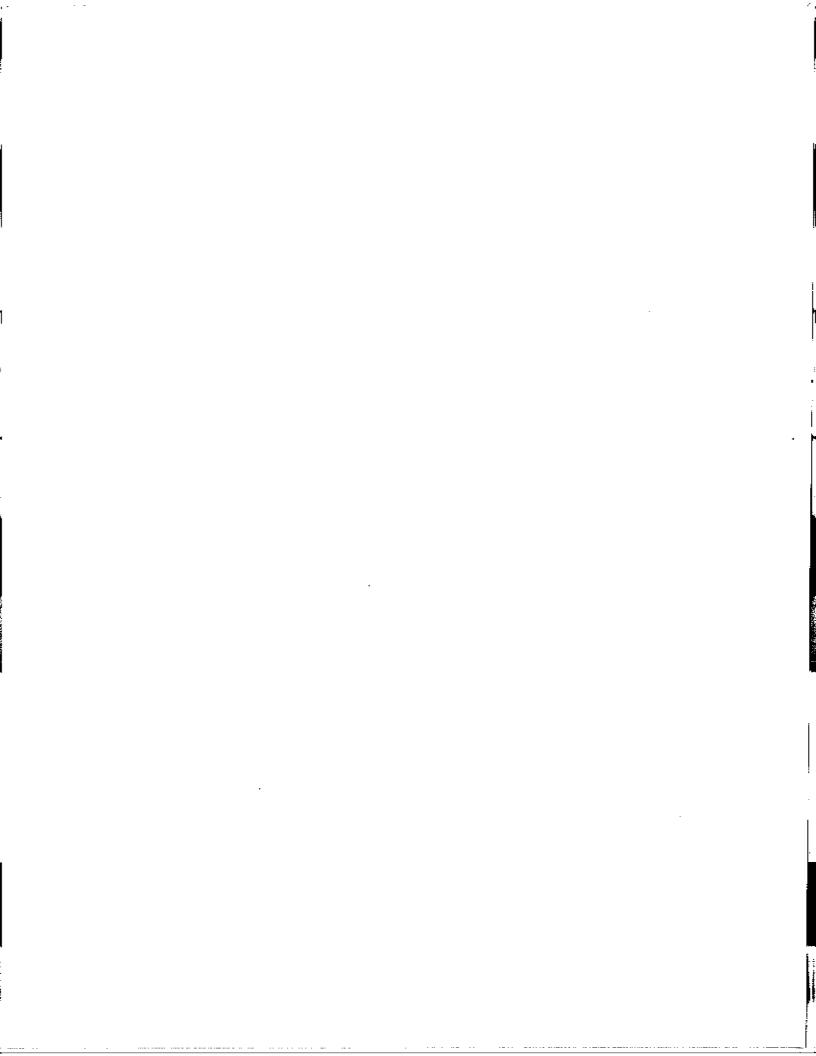


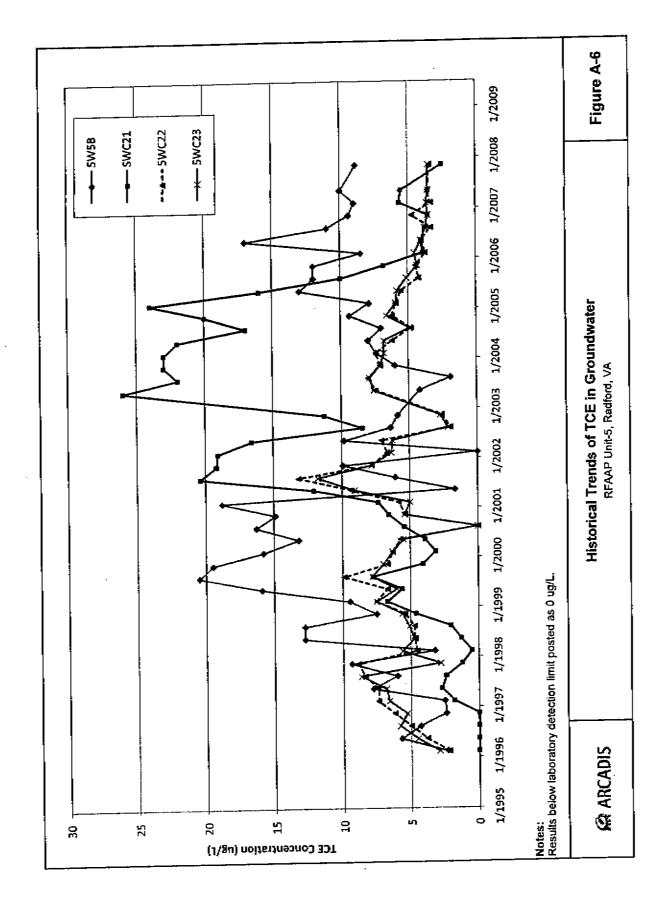


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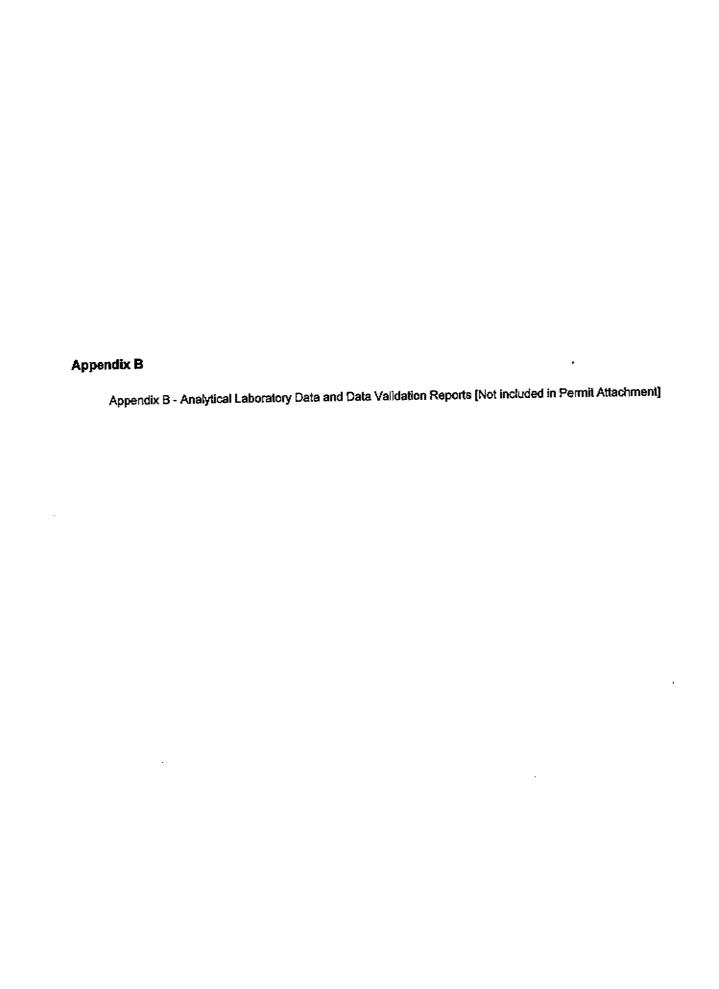
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Appendix C

Appendix C - Development of Remedial Timeframe Predictions

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### Appendix C

This appendix discusses the development of the Monitored Natural Attenuation (MNA) remedial timeframe predictions presented in the Corrective Action Plan (CAP) and the approach and methodology for future annual MNA timeframe evaluations.

# Development of Remedial Timeframe Predictions

The MNA remedial timeframe for trichloroethene (TCE) to attenuate to less than the Groundwater Protection Standard (GPS) was predicted using a conservative pore-volume flushing calculation, which assumes that no degradation is occurring, and a series of pore flushes is the primary attenuation process to attenuate TCE. These calculations were performed based on the following steps. First, a composite retardation coefficient was calculated using the following equation (Payne et al. 2008):

$$R_{composite} = 1 + (\frac{K_d \times \rho_{BD}}{\theta_{conf}})$$
 Eq. 1

 $\rho_{BO}$  = bulk density of the soil. A value of 1.85 g/cm<sup>3</sup> was used assuming the total porosity of 30 percent.

 $\Theta_{\text{total}}$  = total porosity. The porosity for aquifer materials found at the site (clay with sand and fine gravel) ranges from 25 to 60 percent (Fetter, 2002). A value 30 percent was assumed for the purpose of estimating the remedial timeframe.

K<sub>d</sub> = TCE partition coefficient in soil determined as follows:

$$K_d = K_{\infty} \times f_{\infty}$$
 Eq. 2

Where:

 $K_{oc}$  = organic-carbon partition coefficient. The calculated value of 166 Liters per kilogram (L/kg) as reported in Table 39 of U.S. States Environmental Protection Agency (USEPA) (1996) was used; and

 $f_{\infty}$  = fraction organic carbon in the aquifer material. A value of 0.001 or 0.1 percent organic carbon which is the default value recommended by USEPA (1996) for subsurface aquifer materials was used.

Using Equation 1, the composite retardation coefficient was calculated as 2.02. The analytical model selected to evaluate the pore volume flushing is the mixed linear reservoir model (Zheng and Bennett, 2002). This model determines the number of pore volumes (N<sub>PV</sub>) required to reduce the starting dissolved concentration (C<sub>start</sub>) to a target concentration (C<sub>goal</sub>) using the following equation:

$$N_{PV} = -R_{composite} \ln \left( \frac{C_{goal}}{C_{start}} \right)$$
 Eq. 3

Where:

 $N_{pv}$  number of pore volume flushes

R<sub>composite</sub> = composite retardation coefficient (calculated as 2.02 for TCE)

 $C_{cost}$  = the MCL for TCL of 5 ug/L

 $C_{start}$  = current maximum TCE concentration (11 ug/L - 5GP-028)

Using Equation 3, the number of pore-volume flushes was 1.60.

Last, the predicted MNA remedial timeframe was calculated by multiplying the required number of pore volume flushes to adequately attenuate TCE contamination by the travel time across the plume (groundwater velocity divided by the distance between monitoring wells).

$$T = (N_{PV}*L)/V_S$$

Eq. 4

Where:

T\_predicted MNA timeframe

 $N_{py}$  number of pore volume flushes (1.6)

L = Length along the flow path between monitoring locations (108 ft)

 $V_S$  = Groundwater velocity across the plume (15 ft/year)

Using Equation 4, the predicted MNA timeframe for TCE to attenuate to the GPS based on pore-volume flushing is 11.5 years. An example of this pore-volume flushing calculation is provided as Appendix C-1. The final remedial timeframe of 12 years (2019) was derived from the upper limit of this range.

The time required for TCE to attenuate based on one additional pore flush was used to develop the timeframe for when contingency measures will be implemented, if required. Using Equation 4, the predicted MNA timeframe for TCE to attenuate to the GPS based on 2.6 pore flushes is 18.7 years.

### Methodology for Annual MNA Evaluation

The pore-volume flushing calculations, which were used to develop the predicted MNA remedial timeframe only account for dilution and dispersion as the primary attenuation mechanisms and thus are very conservative in nature. EPA guidance for MNA studies recommends that MNA predictions be based on attenuation rates derived from long-term monitoring data (Newell et al., 2002). These data represent the cumulative effects of all natural attenuation processes at a specific well location and thus are likely to be more representative of actual conditions than the conservative pore-volume flushing calculations. For the annual MNA Evaluation at Unit 5, the technical approach and methodology will be based on point attenuation rate calculations as described in Newell et al. (2002). This approach involves the calculation of point attenuation rates and comparison of updated predicted timeframes to the 2019 MNA remedial timeframe. The following steps describe the methodology for this evaluation:

- Construction of graphs of natural log concentrations versus time for monitoring wells (5W5B, 5WC21, 5WC22, 5WC23, and 5W12A) exhibiting current detections of TCE and degradation products at concentrations greater than GPS values. Non-detect values will be plotted at half the detection limit.
- Calculation of the point attenuation rate constant for each constituent based on a linear regression
  analysis whereas the slope of the regression represents the attenuation rate constant. The dataset
  used to calculate the rate constant will encompass at least eight monitoring events.
- Updated MNA compliance predictions using the following equation.

$$t = \frac{-\ln\left[\frac{C_{goal}}{C_{start}}\right]}{k_{relief}}$$
 Eq. 5

Where:

t = predicted GPS remedial timeframe

 $C_{goal} = GPS (ug/L)$ 

C<sub>start</sub> = current constituent concentration (ug/L)

K<sub>point</sub> = point attenuation rate

Comparison of updated MNA predictions to the 2019 MNA remedial timeframe.

An example calculation for TCE at well 5W5B is provided as Appendix C-2. Using Equation 5, the predicted remedial timeframe for the current TCE concentration (7.8 ug/L) at 5W5B to attenuate to the GPS (5 ug/L) is 2.4 years. Since this predicted timeframe (October 2010) is less than the 2019 MNA remedial goal, then the MNA remedy is considered effective. Similar calculations will be performed on an annual basis for any constituents in the monitoring program that exhibit concentrations above the GPS.

## References

Fetter, C. W., Jr. 2001. Applied Hydrogeology 4th Ed.

Newell, C., H. Rifai, J. Wilson, J. Connor, J. Azia, M. Suarez. (Newell et al., 2002). Calculation and Use of First-Order Rate Constants for Monitored Natural Attenuation Studies USEPA Position Paper.

Payne, F.C; J.A. Quinnan; S.T. Potter. 2008. Remediation Hydraulics. CRC Press. New York.

Suthersan, S.S and F.C. Payne. 2005. In-Situ Remediation Engineering. CRC Press. Washington D.C.

USEPA. 1996. Soil Screening Guidance: Technical Background Document. EPA/540/R-95-128. May.

USEPA. 2000. Region 5 Framework for Monitored Natural Attenuation Decisions for Groundwater, September.

Zheng, Chunmiao and Bennett, Gordon D., 2002. Applied Contaminant Transport Modeling. John Wiley and Sons Inc., New York.

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# Predicted MNA Remedial Timeframe per CAP

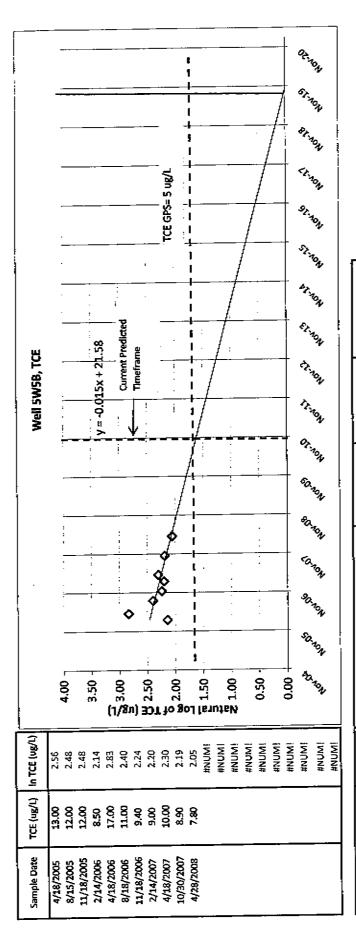
Total Porosity =	%   %08		Estimated
log(Koc) =	2.22	1	USEPA 1996
, C	0.00	1	USEPA 1996
Bulk Density =	1.85	g/cm³	1.85 g/cm³ assumed value based on 30% total porosity
1 Z	0.17		Calculated; K₀⁺f₀c
Retardation Coefficient =	2.02	ı	Calculated; 1+((Kd*Bulk Density)/total porosity)

- Alexander Control	Ę	*/\d	Fetimated
Groundwarer Velocity =		7	
Spacing Between 5GP-028 and 5CW21 =	108	Ħ	Calculated from Scale on Figure 1 (1"=80")
Travel Time Between Wells =	7.2	yr	Calculated
Retardation Coefficient for TCE =	2.02		Calculated
Current TCE Concentration in 5GP-028 =	11	ng/L	Given
Current TCE Concentration in 5CW21 =	2.5	2.5 ug/L	Given
End Concentration =	5	ug/L	TCE GW standard
Number of Pore Flushes =	1.60		Calculated
Predicted MNA Remedial Timeframe	11.5 yr	),	Calculated

PORE FLUSHES + 1			:
Number of Pore Flushes =	2.60		Calculated
Predicted MNA Remedial Timeframe	18.7	yr	Calculated

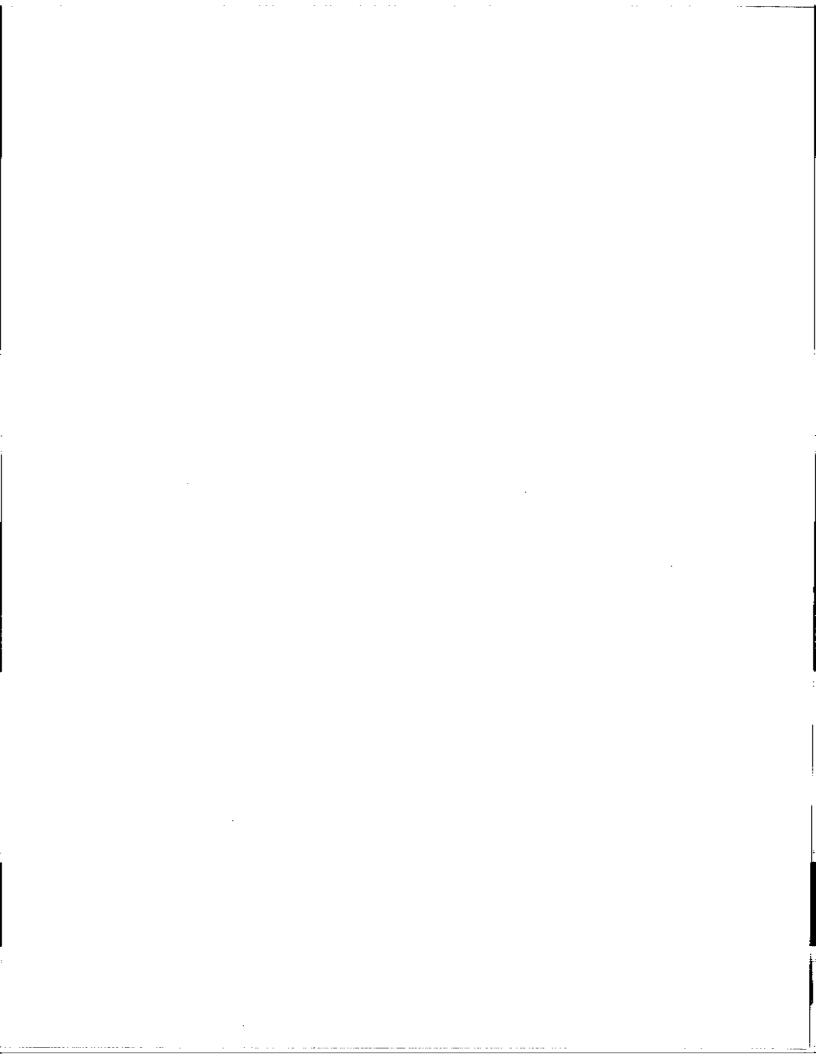


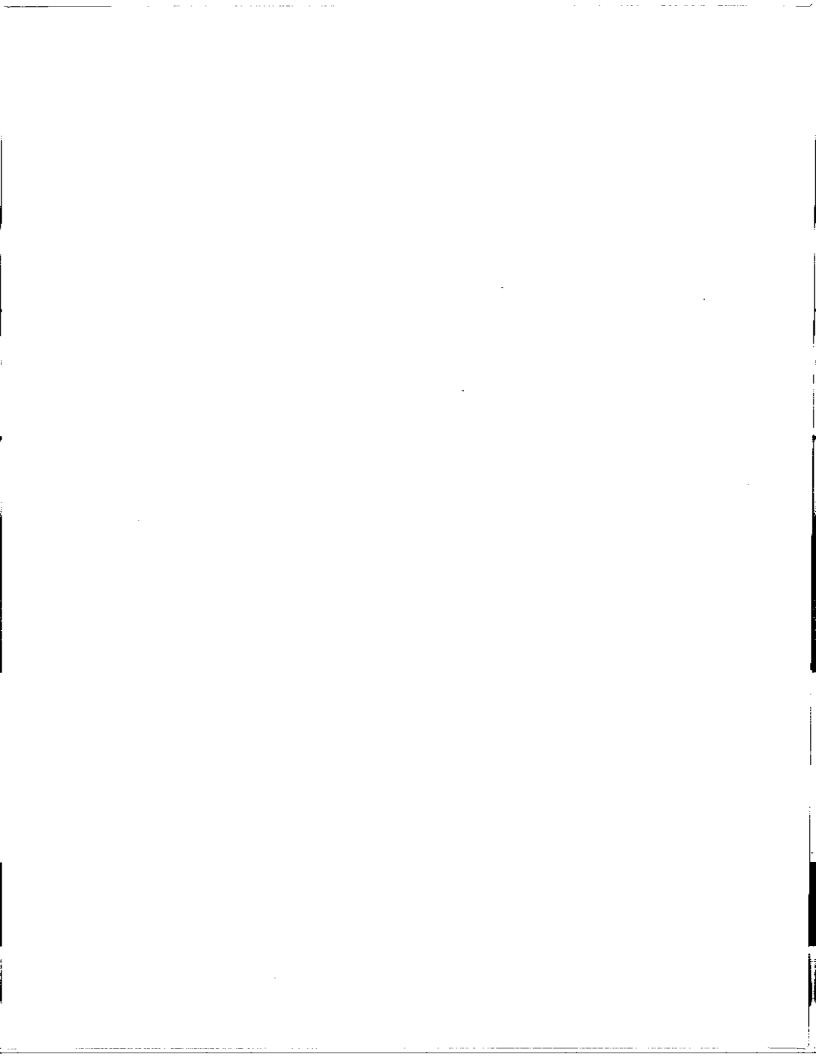
Appendix C-2
Point Attenuation Rate Calculation Example



			_
MNA Ineffective Date	(per CAP)		December-2026
MNA Goal (ner CAP)	السيد حضية الحد حداً		October-2019
Current MNA	Prodiction		October-2010
Ime Required	Time	(years)	2.44
stimated Rate and Time Required	Rate	(Jeek Jad)	0.183
Estima	Rate	(per day)	0.0005
TCE MCL		ug/L	5.000
spun	,	Last event	4/28/2008
Last 8 rounds	1	FIRST EVENT	2/14/2006

Effectiveness Evaluation for MNA Remedy	Status	Condition If 'yes', then the remedy is considered effective and no additional action is required. If 'no' for
1) is the current MNA remedial timeframe prediction less than the 2019 MNA Goal?	yes	three consecutive years, then contingency measures will be implemented as defined in the CAP.
2) is the current MNA remedial timeframe prediction less than the 2026 MNA ineffective date?	yes	If 'yes', the remedy will be considered effective. If 'no' for three consecutive monitoring years, then an alternate remedial approach will be implemethed as defined in the CAP.



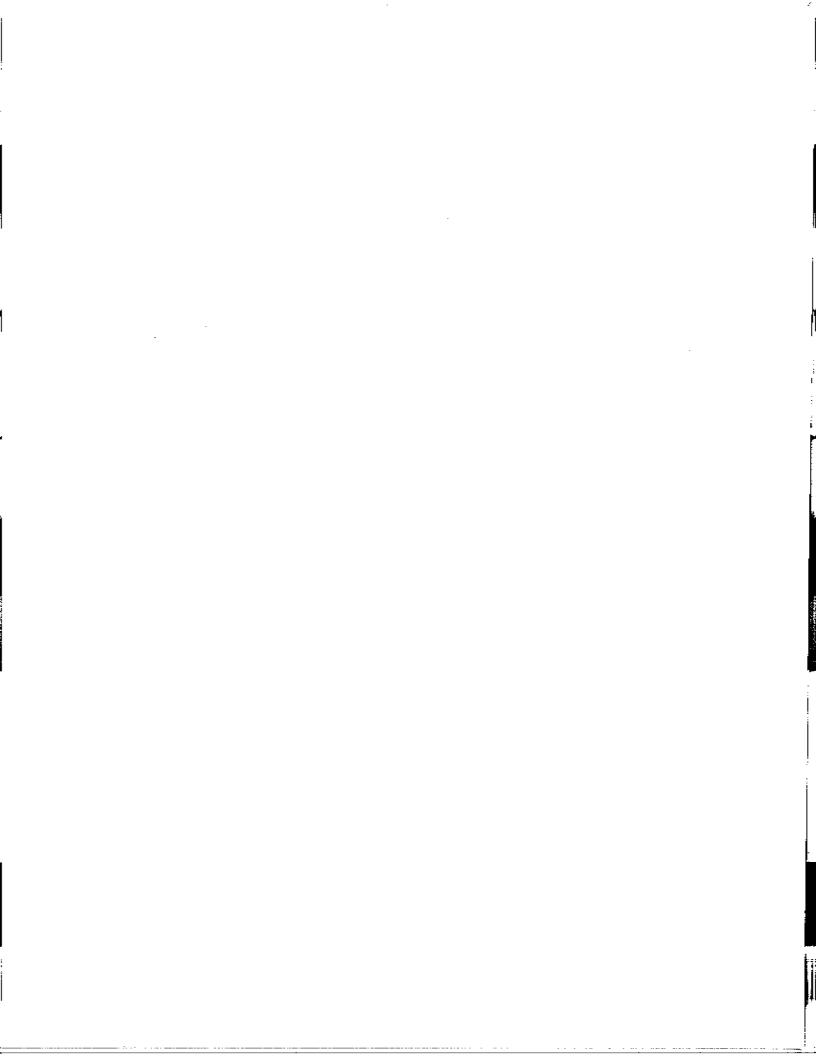


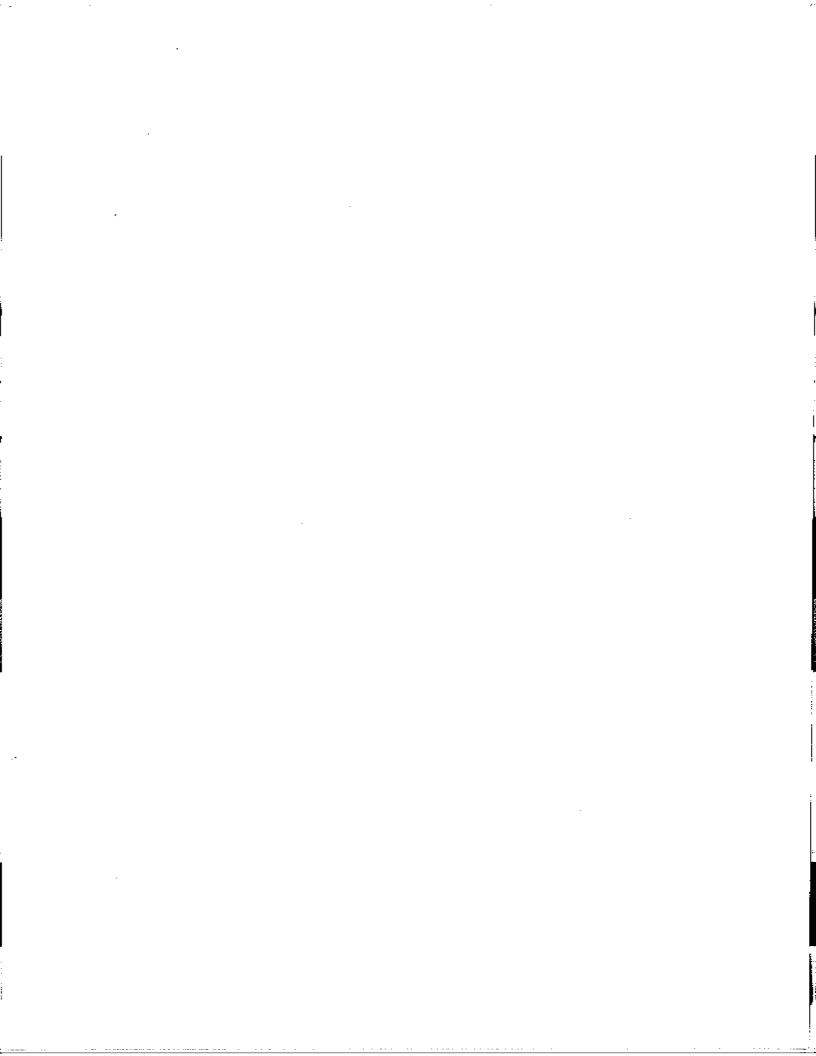
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Appendix J Groundwater Corrective Action Targeted Contaminants - GPSs and Semiannual Monitoring List for Unit 5

Tr 1 CA Contaminante (Concontration Ilnite 119())									
CONSTITUENTS	Cas RN#	SW-846	MDL	PQL	Back-	EPA	VA DEQ	Region III	GPS
		Method			ground	Z Z Z	ACE	RBC	
Trichloroethene (TCE)	79-01-6	8260B	0.177	1	0.8	5	1.3278	1.7	·ν
1 Dichlamathans (1 1-DOF: H.C=CCL)	75-35-4	8260B	0.44	_		7	125.2	340	7
cis-1 2-Dichloroethene (cDCE)	156-59-2	8260B	0.1	1		70	22.3571	370	0/_
trans-1,2-Dichloroethene (ADCE)	156-60-5	8260B	0.8	1		100	39.125	110	2
Vinvl chloride (Chloroethene, VC; H,C=CHCl)	75-01-4	\$260B	0.1	1		2	0.08347	0.016	2
See the note in Appendix K for Column Titles						İ		1	
MNA Indicators (First year of monitoring only)									   
	Analytic Method				į			Ī	
Methane Ethane & Ethene	RSK 175M	Anaerobic dechlorination	lechlorinat	ion					
Nitrate/nitrite	9026	Nitrate: Electron acceptor by denitrifying bacteria	ectron acce	ptor by d	enitrifying	bacteria			ļ
Suffare	9026	Sulfate/Sulfide: Electron acceptor/Sulfate reduction	fide: Elect	ron accep	itor/Sulfate		ı	ļ	
Sulfide	9034					İ			
Total Organic Carbon (TOC)	9060B								
4							1		
Field Farameters								Ē	
Hd		!			į				
Temperature									
Dissolved Oxygen (DO)	DO: aerobic environments; electron acceptor	ronments; elec-	tron accept	ĕ					
Oxidation-Reduction Potential (ORP)	Redox Potential: +500mV aerobic to -500mV anaerobic environments	+500mV aero	bic to -500	mV anae	robic envir	onments		į	
Specific Conductivity								ļ	
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Appendix K
GROUNDWATER CORRECTIVE ACTION ANNUAL MONTFORING LIST
Concentration Unit: µg/l

CONSTITUTENTS	Cas RN#	SW-846 Method	MOL	PQL	Back-	EPA	VA DEQ	Region III RBC	GPS
				į					
Antimony, total	7440-36-0	6020	0.4	1	3	6	6.26	15	6
Arsenic, total	7440-38-2	6020	2	10	1	10	0.04465	0.045	10
Barium, total	7440-39-3	6020	1	10	172.87	2000	3130	7300	2000
Beryllium, total	7440-41-7	6020	0.2	I	0.7	4	31.3	73	4
Cadmium, total	7440-43-9	6020	0.2	1	1.45	5	7.825	18	\$
Chromium, total	7440-47-3	6020	1	5	5	001	ľ	ŀ	100
Cobalt, total	7440-48-4	6020	1	\$	7		4.695	11	<i>L</i>
Copper, total	7440-50-8	6020	1	5	18	1300	626	1500	1300
Lead, total	7439-92-1	6020	0.2		10	15	NA	1	15
Mercury, total	7439-97-6	7470A	0.2	7	6.0	2	0.1916	0.57	
Nickel, total	7440-02-0	6020	2	2	106		313	730	313
Selenium, total	7782-49-2	6020	3	10	I	50	78.25	180	20
Silver, total	7440-22-4	6020	0.2	2	2.3		78.25	180	78.25
Thallium, total	7440-28-0	6020	0.2		2	7	1.0173	2.4	2
Vanadium, total	7440-62-2	6020	-	10	17		109.55	260	109.55
Zinc, total	7440-66-6	6020	Э	10	75		4695	11000	4695
Acetone	67-64-1	8260B	3	10	68		8750.2	22000	8750.2
Bis (2-ethylhexyl) phthalate (DEHP)	117-81-7	8270C	1.5	9	10	9	4.78	4.8	10
2-Butanone (Methyl ethyl ketone; MEK)	78-93-3	8260B	1	10	21.3		2667.6	7100	2667.6
Chloroform	67-66-3	8260B	0.1	1	0.5	#08	0.145	0.19	80
Dichlorodifluoromethane	75-71-8	8260B	0.28	1	1		142.27	390	142.27
1,2-Dichloroethane	107-06-2	8260B	0.147	_	0.1	5	0.115943	0.15	5
Diethyl ether	60-29-7	8260B	0.39	12	12		1	7300	7300

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Diethyl phthalate	84-66-2	8270C	0.5	10	0.2		12520	29000	12520
2,4-Dinitrotoluene	121-14-2	8270C	9.0	10	0.18		31.3	0.22	31.3
2,6-Dinitrotoluene	606-20-2	8270C	0.7	. 01	0.08		15.65	37	15.65
Methylene chloride (Dichloromethane)	75-09-2	8260B	0.182	1	0.7	5	8.9288	4.8	\$
o-Nitroaniline; 2-	88-74-4	8270C	0.7	10	10		ŇĀ	110	110
p-Nitroaniline; 4-	100-01-6	8270C	1.3	20	20		3.189	3.4	20
Nitrobenzene	98-95-3	8270C	0.8	10	10		1.252	0.12	10
Toluene	108-88-3	8260B	0.1	-	0.1	1000	937.13	2300	1000
Xvlenes (total)	1330-20-7	8260B	0.208	ť	0.1	1000	72.79	200	10000

CAS RN: Chemical Abstracts Service registry number.

SW-846: Test Methods for Evaluating Solid Waste-Physical/Chemical Methods, SW-846 (as updated).

MDL: Method Detection Limit;

PQL: Practical Quantitation Limit;

Background Values: calculated upgradient background concentrations (Appendix F, Permit Attachment 2).

MCL: Maximum Contaminant Level (MCL) - The highest level of a contaminant that is allowed in drinking water.

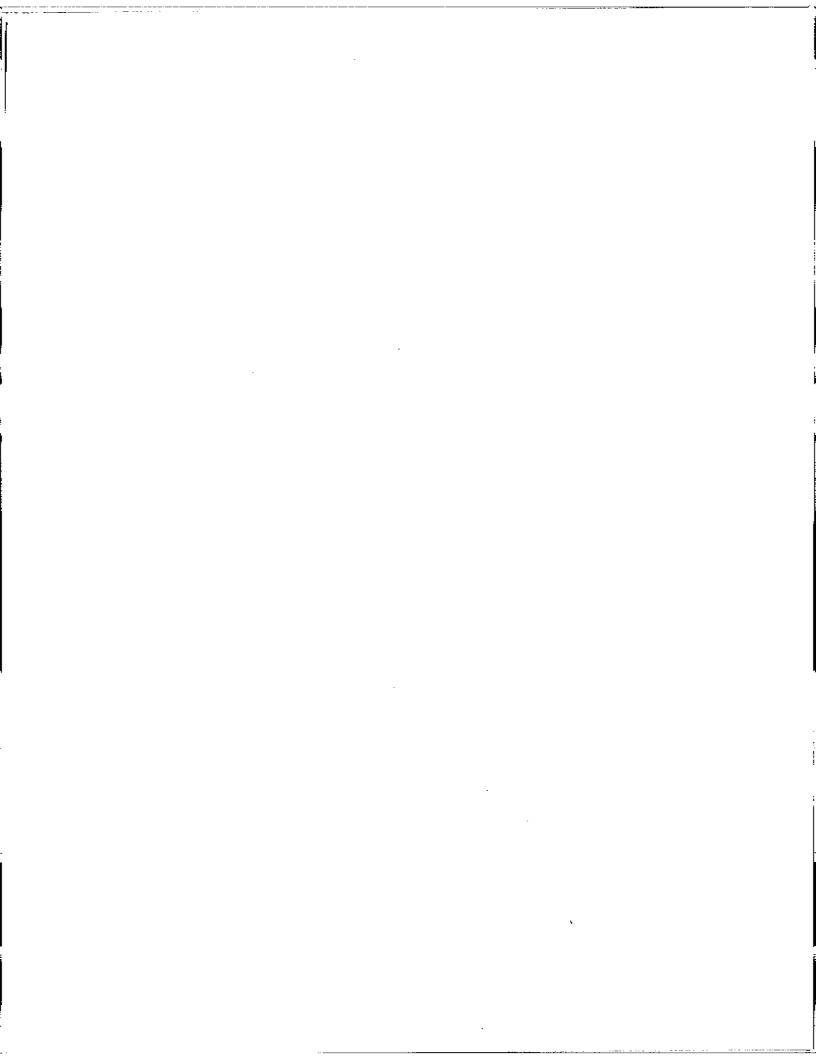
EPA, June, 2008. Subject to change when it is updated.

ACL: the Department's Alternate Concentration Limit, Jan 2009; subject to change when it is updated. RBC: EPA Region III Risk-Based Concentration, May 2009; subject to change when it is updated;

GPS: Groundwater Protection Standard

concentration will be established using low-level analytical methods, if appropriate, and the GPS will be updated based on from a PQL, the Permittee will perform verification of a detection (i.e. value greater than the Detection Limit) of such a For any monitoring event, if a GPS for a constituent in the table above is based on a background concentration derived commercial laboratories. Furthermore, the low-level analytical method will be used only if the PQL achievable by that constituent using low-level analytical methods, if such methods are standard methods that are routinely available from quantifiable detection (i.e. value greater than the PQL) above the applicable ACL or RBC, a revised background method is less than, or equal to, the ACL or RBC for the subject constituent. If the verification event confirms a the new background concentration if warranted.

#: the MCL for total trihalomethanes, including bromodichloromethane, bromoform, dibromochloromethane, and chloroform, is 80 µg/l.



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