VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

DRAFT HAZARDOUS WASTE MANAGEMENT POST-CLOSURE CARE PERMIT
RADFORD ARMY AMMUNITION PLANT, RADFORD, VIRGINIA
EPA ID NO. VA1210020730
MONTH XX, 2025

Commonwealth of Virginia
VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY
www.deq.virginia.gov

Stefanie K. Taillon
Secretary of Natural and Historic Resources

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Director

Hazardous Waste Management
Post-Closure Care Permit

Permittee: **Radford Army Ammunition Plant**
4050 Pepper's Ferry Road
Radford, Virginia 24141

BAE Systems Ordnance Systems Inc.
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. No.: **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, a Permit is issued to the United States Army Radford Army Ammunition Plant and BAE Systems Ordnance Systems Inc. (hereinafter referred to as the Permittees), for the post-closure care of two closed hazardous waste management units (HWMUs) of one hazardous waste disposal facility: HWMU-5, and HWMU-16. The facility is located in Montgomery and Pulaski Counties. HWMU-5 is located in Montgomery County and HWMU-16 is located in Pulaski County at latitude 37°11'12" to 49" North and longitude 80°33'15" to 31'26" West

The Permittee shall comply with all terms and conditions set forth in this Permit including all Permit Attachments. If the Permit and the Permit Attachments conflict, the wording of the Permit shall prevail. The Permittee 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 the *Resource Conservation and Recovery Act* (RCRA) Regulations under in 40 CFR Parts 124, 260, 261, 262, 264, 265, 268, and 270, as adopted by reference in the VHWMR. (For convenience, wherever the RCRA Regulations are adopted by reference and cited in this Permit and the Permit Attachments, the regulatory citations will be only those from 40 CFR).

The Commonwealth of Virginia has received authorization for its hazardous waste pro-gram under Section 3006(b) of the RCRA, 42 U.S.C. § 6926(b), to administer and enforce the RCRA regulations under the VHWMR in lieu of the federal hazardous waste management pro-gram. Applicable regulations are those under the VHWMR (9 VAC 20-60) which are in effect on the date of final administrative action on this Permit and as well as any self-implementing statutory provisions and related regulations which are automatically applicable to the Permittee's 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 Permittee and contained in the administrative record is complete and accurate. The Permittee's failure to fully disclose all relevant facts in the submittal of the permit application or during the permit issuance process, or the Permittee's misrepresentation of any relevant facts at any time, shall be grounds for the modification or termination of this Permit pursuant to the VHWMR, and in accordance with 40 CFR § 124.5, § 270.41, § 270.42 and § 270.43, and shall also be grounds for initiation of an enforcement action. The Permittee shall inform the Department of any deviations from permit conditions or changes in the information provided in the application. In particular, the Permittee shall inform the Department of any proposed changes that might affect the ability of the Permittee 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 _____ and shall remain in effect until _____ 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 9 VAC 20-60-270.B.15.

_____
Date Signed

_____
Ashby R. Scott
Hazardous Waste Program Manager
Office of Financial Responsibility and Waste Programs

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LIST OF ATTACHMENTS

The following Attachments are incorporated, in their entirety, by reference into this Permit. These incorporated attachments are enforceable conditions of this Permit. The Department has, as deemed necessary, modified specific language from the permit application. Additional modifications are prescribed in the Permit Conditions (Modules I through VII), and thereby supersede the language of the Attachments.

DEFINITIONS

All definitions contained in 40 CFR Sections 124.2, 260.10, 264.141, 264.1031, 264.1051, 264.1081, 270.2, and 9 VAC 20-60 are hereby incorporated, in their entirety, by reference into this Permit. Any of the definitions used below shall supersede any definition of the same term given in 40 CFR Sections 124.2, 260.10, 264.141, 264.1031, 264.1051, 264.1081, 270.2, and 9 VAC 20-60. Where terms are not defined in the regulations or the Permit, the meaning associated with such terms shall be defined by a standard dictionary reference or the generally accepted scientific or industrial meaning of the term.

Throughout the Permit, all references to 40 CFR Parts 124, 261-266, 268, 270, 273, 279, are as adopted by reference in the Virginia Hazardous Waste Management Regulations, 9 VAC 20-60.

a. The term “Area of Concern” shall mean an area at the facility or an off-site area, which is not at this time known to be a solid waste management unit, where hazardous waste and/or hazardous constituents are present or are suspected to be present as a result of a release from the facility.

b. The term "Permit" shall mean the Permit issued by the Virginia Department of Environmental Quality, pursuant to Chapter 14, Article 4, Title 10.1, Code of Virginia (1950), as amended, and 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).

c. The term "Director" shall mean the Director of the Virginia Department of Environmental Quality or his designated representative.

d. The term "Department" shall mean the Virginia Department of Environmental Quality (DEQ) (with the address as specified in Permit Condition I.K.).

e. The terms "facility" or "site" shall mean all contiguous land, and structures, other appurtenances, and improvements on the land, used for treating, storing, or disposing of hazardous waste. For the purpose of implementing corrective action under 40 CFR § 264.101, “facility” means all contiguous property under the control of the owner or operator seeking a permit under Subtitle C of RCRA.

f. The term "hazardous waste management unit” is a contiguous area of land on or in which hazardous waste is placed, or the largest area in which there is significant likelihood of mixing hazardous waste constituents in the same area. Examples of hazardous waste management units include a surface impoundment, a waste pile, a land treatment area, a landfill cell, an incinerator, a tank and its associated piping and underlying containment system and a container storage area. A container alone does not constitute a unit; the unit includes containers and the land or pad upon which they are placed.

g. The term "release" shall mean any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment, including abandonment or discarding of barrels, containers, and other closed receptacles containing any hazardous substance, pollutant, or contaminant (40 CFR § 302.2 and CERCLA § 101(22)).

h. The term “Hazardous Constituent” shall mean all constituents that are listed in 40 CFR 261, Appendix VIII and 40 CFR Part 264, Appendix IX (9 VAC 20-60-264.B.6.).

i. The term “Permittee” shall mean the owner/operator of the facility to which the Permit is issued.

j. The term “EPA” shall mean United States Environmental Protection Agency.

k. The term “Solid Waste Management Unit” shall mean any discernable unit at the facility from which hazardous constituents might migrate, irrespective of whether the units were intended for the management of solid and/or hazardous wastes. Such units include any area at a facility where solid wastes have been routinely and systematically released.

l. The term “unit” refers to containers, container storage areas, tanks, surface impoundments, waste piles, land treatment units, landfills, incinerators, underground injection wells, and other physical, chemical, and biological units or treatment units.

m. The term “Days” shall mean calendar days except as otherwise provided herein.

n. The term “Plume Monitoring Wells” shall mean those groundwater monitoring wells designated by Permit Conditions V.D.1.a.ii, V.D.2.a.ii, VI.C.1.b and located as shown in Permit Attachments II.A and V.A.

o. The term “Exceedance” shall mean any measured concentration greater than established standard. May be verified by resampling.

p. The term “Independent Samples” shall mean samples collected after a new volume of purged water has completely passed through the filter pack. Sampling interval is calculated based upon aquifer characteristics.

q. The term “Point of Compliance” shall mean the vertical plane at the hydraulically downgradient limit of the waste management unit.

r. The term “Point of Compliance Wells” shall mean those groundwater monitoring wells at the hydraulically downgradient limit of the Regulated Unit as designated by Permit Conditions V.D.1.a.i, V.D.2.a.i, and VI.C.1.a and located as shown Permit Attachments II.A and V.A.

s. The term “Regulated Unit” shall mean any hazardous waste management unit for treatment, storage, or disposal regulated under the Virginia Hazardous Waste Management Regulations.

MODULE I - STANDARD CONDITIONS

This Permit has been developed for Radford Army Ammunition Plant (Radford AAP) Hazardous Waste Management Units (HWMUs) 5 and 16 to ensure compliance with all appropriate reporting and monitoring requirements as defined by 9 VAC 20-60-10 et seq. for the closed HWMU- 5 located in Montgomery County and HWMU- 16 located in Pulaski County at latitude 37°11'12" to 49" North and longitude 80°33'15" to 31'26" West. Hazardous waste management at the Facility addressed by this Permit is currently limited to the following activity: maintenance and monitoring of one closed hazardous waste surface impoundment (HWMU- 5) and one closed hazardous waste landfill (HWMU-16) containing hazardous wastes and various laboratory chemicals as specified in this Permit.

The Permit Conditions in this module apply to both units, HWMU- 5 and HWMU-16.

I.A. EFFECT OF PERMIT

This Permit, issued by the Director pursuant to 40 CFR § 270.1(c)(4), authorizes only the management of hazardous waste expressly described in this Permit and in accordance with the conditions of this Permit and with the applicable provisions of the VHWMR under 9 VAC 20-60. Any management of hazardous waste by the Permittee which is not authorized by this Permit or 9 VAC 20-60, and for which a permit is required under Chapter 14, Article 4, Title 10.1, Code of Virginia (1950), as amended, is prohibited (40 CFR §§ 270.30(g) and 270.4(b) and (c)). Compliance with this Permit generally constitutes compliance, for the purposes of enforcement, with Chapter 14, Article 4, Title 10.1-1426, Code of Virginia (1950), as amended. This Permit does not convey any property rights of any sort, or any exclusive privilege. Possession of a permit does not authorize any injury to persons or property or invasion of other private rights, or any infringement of Commonwealth of Virginia or local laws or regulations. Compliance with the terms of this Permit may not constitute a defense to any action brought under Chapter 14, Article 8, Code of Virginia (1950), as amended, or any other Commonwealth law governing protection of public health or the environment.

I.B. PERMIT ACTIONS

I.B.1 This Permit may be modified, revoked and reissued, or terminated for cause as specified in 40 CFR §§ 124.5, 270.30(f), 270.41, 270.42, and 270.43. The filing of a request by the Permittee for a permit modification, revocation and reissuance, or termination, or the notification of planned changes or anticipated noncompliance does not stay the applicability or enforceability of any Permit Condition (40 CFR § 270.30(f)).

I.B.2 Permit modifications at the request of the Permittee shall be done as specified by 40 CFR § 270.42.

I.B.3 This Permit may be renewed as specified in 9 VAC 20-60-270.B.6. and 40 CFR § 270.10(h), and Permit Condition I.D.2. Review of any application for a permit renewal shall consider improvements in the state of control and measurement technology, as well as changes in applicable regulations.

I.C. SEVERABILITY

I.C.1 The provisions of this Permit are severable, and if any provision of this Permit or the application of any provision of this Permit to any circumstance is held invalid, the application of such provision to other circumstances and the remainder of this Permit shall not be affected thereby. Invalidation of any Commonwealth or federal statutory or regulatory provision which forms the basis for any condition of this Permit does not affect the validity of any other Commonwealth or Federal statutory or regulatory basis for said condition (40 CFR § 124.16(a)(2)).

I.C.2 In the event that a condition of this Permit is stayed for any reason, the Permittee shall continue to comply with the conditions of the existing permit which correspond to the stayed condition unless the Director determines such compliance would be technologically incompatible with compliance with other conditions of this Permit which have not been stayed (40 CFR §124.16(c)(2)).

I.D. DUTY AND REQUIREMENTS

I.D.1. Duty to Comply

The Permittee shall comply with all conditions of this Permit, except that the Permittee need not comply with the conditions of this Permit to the extent and for the duration such noncompliance is authorized by an emergency permit under 40 CFR § 270.61. Any other noncompliance with the Permit constitutes a violation of Title 10.1, Code of Virginia (1950), as amended, and regulations promulgated thereunder and is grounds for enforcement action; for Permit termination, revocation and reissuance, or modification; or denial of a Permit renewal application (40 CFR 270.30(a)).

I.D.2. Duty to Reapply

If the Permittee wishes to or is required to continue an activity regulated by this Permit after the expiration date of this Permit, the Permittee shall apply for and obtain a new Permit as specified below.

a. The Permittee shall submit a new and complete application for a new Permit at least 180 days before the Permit expires, unless a later date has been approved by the Director. (40 CFR §270.30(b)).

b. Pursuant to 40 CFR § 270.10(h), the Director shall not grant permission for an application to be submitted later than the existing Permit's expiration date.

I.D.3. Need to Halt or Reduce Activity Not a Defense

It shall not be a defense in an enforcement action to argue that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this Permit (40 CFR 270.30(c)).

I.D.4. Duty to Mitigate

In the event of noncompliance with the Permit, the Permittee shall take all reasonable steps to minimize releases to the environment and shall carry out such measures as are reasonable to prevent significant adverse impacts on human health and the environment (40 CFR § 270.30(d)).

I.D.5. Proper Operation and Maintenance

The Permittee shall at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) which are installed or used by the Permittee to achieve compliance with the conditions of this Permit. Proper operation and maintenance includes effective performance, adequate funding, adequate operator staffing and training, and adequate laboratory and process controls; including appropriate quality assurance procedures. This provision requires the operation of back-up or auxiliary facilities or similar systems only when necessary to maintain compliance with the conditions of the Permit (40 CFR § 270.30(e)).

I.D.6. Duty to Provide Information

The Permittee shall furnish the Director within a reasonable time, any relevant information the Director may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this Permit, or to determine compliance with this Permit. The Permittee shall also furnish the Director, upon request, copies of records required to be kept by this Permit (40 CFR § 270.30(h)).

I.D.7. Inspection and Entry

The Permittee shall allow the Director or an authorized representative, upon the presentation of credentials and other documents as may be required by law to:

a. Enter at reasonable times upon the Permittee's premise where a regulated facility or activity is located or conducted, or where records must be kept under the conditions of this Permit;

b. Have access to and copy, at reasonable times, any records that must be kept under conditions of this Permit;

c. Inspect at reasonable times any facilities, equipment (including monitoring and control equipment), practices, or operations regulated or required under this Permit; and

d. Sample or monitor, at reasonable times, for the purpose of assuring Permit compliance or as otherwise authorized by 9 VAC 20-60, any substances or parameters at any location (40 CFR § 270.30(i)).

I.D.8. Reporting Planned Changes

The Permittee shall give advance written notice to the Director as soon as possible of any planned physical alterations or additions to the permitted facility. This notice shall include a description of all incidents of noncompliance reasonably expected to result from the proposed changes (40 CFR § 270.30(l)(1)).

I.D.9. Anticipated Noncompliance

The Permittee shall give advance notice to the Director of any planned changes in the permitted facility or activity which may result in noncompliance with the Permit requirements (40 CFR § 270.30(l)(2)).

I.D.10. Twenty-four Hour Reporting

The Permittee shall report to the Director any non-compliance which may endanger human health or the environment. Information shall be provided orally within 24-hours of the Permittee becoming aware of the circumstances. Information specified in a., b., and c. below shall be reported orally within 24 hours:

a. Information concerning the release of any hazardous waste that may cause an endangerment to public drinking water supplies.

b. Any information of a release or discharge of hazardous waste, or of a fire or explosion at the facility, which could threaten the environment or human health outside the facility.

c. The description of the occurrence and its cause shall include:

i. Name, address, and telephone number of the owner or operator;

ii. Facility name, address, and telephone number;

iii. Date, time, and type of incident;

iv. Name and quantity of material(s) involved;

v. The extent of injuries, if any;

vi. An assessment of actual or potential hazard to the environment and human health outside the facility, where this is applicable; and

vii. Estimated quantity and disposition of recovered material that resulted from the incident (40 CFR §270.30 (l)(6)).

d. A written submission shall also be provided to the Director within five (5) days of the time the Permittee become aware of the circumstances. The written submission shall contain at a minimum the following:

i. A description of the noncompliance and its cause;

ii. The periods of noncompliance, including exact dates and times, and if the noncompliance has not been corrected, the anticipated time it is expected to continue; and

iii. The steps taken or planned to reduce, eliminate, and prevent reoccurrence of the noncompliance.

The Director may waive the five (5) day notice requirement in favor of a written report within fifteen (15) days (40 CFR § 270.30(l)(6)(iii)).

I.D.11. Other Noncompliance

The Permittee shall report all other instances of noncompliance not otherwise required to be reported pursuant to Permit Conditions I.D.10, I.D.12, and I.E.1, at the time monitoring reports are submitted. The reports shall contain at a minimum the information listed in Permit Condition I.D.10 (40 CFR § 270.30(l)(10)).

I.D.12. Other Information

Whenever the Permittee becomes aware that it failed to submit any relevant

facts in the Permit application, or submitted incorrect information in a permit application or in any report to the Director, the Permittee shall promptly submit such facts or information to the Director (40 CFR § 270.30(l)(11).

I.E. MONITORING AND RECORDS

I.E.1. Monitoring Reports

Monitoring shall be performed and results shall be reported at the intervals specified in the Permit.

I.E.2. Samples and measurements taken for the purpose of monitoring shall be representative of the monitored activity (40 CFR § 270.30(j)(1)). The method used to obtain a representative sample of the waste to be analyzed must be the appropriate method specified in 40 CFR 261, Appendix I, or an equivalent method approved by the EPA. Laboratory methods must be those specified in *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, SW-846* (3rd ed.; November, 1986, as updated), *Standard Methods of Wastewater Analysis* (16th ed.; 1985, as updated), or an equivalent method approved by the EPA. Additionally, the laboratory must be accredited for the analytical method, matrix and target analyte (where applicable) by the Virginia Environmental Laboratory Accreditation Program (VELAP).

I.E.3. The Permittee shall retain records of all monitoring information, including all calibration and maintenance records, and all original strip chart recordings for continuous monitoring instrumentation, copies of all reports and records required by this Permit, all certifications required by 40 CFR § 264.73(b)(9), and records of all data used to complete the application for this Permit, for a period of at least 3 years (or longer if specified elsewhere in this Permit) from the date of the sample collection, measurement, report, certification, or application. These retention periods may be extended by the request of the Director at any time and are automatically extended during the course of any unresolved enforcement actions regarding this facility. The Permittee shall maintain records from all ground-water monitoring wells and associated ground-water surface elevations, for the active life of the facility, and for disposal facilities for the post-closure care period as well.

Records of monitoring information shall include at a minimum:

a. The date, exact place, and time of sampling or measurements;

b. The individual(s) who performed the sampling or measurements;

c. The date(s) analyses were performed;

d. The individual(s) who performed the analyses;

e. The analytical techniques or test methods used; and

f. The results of such analyses (40 CFR § 270.30(j)).

I.F. COMPLIANCE NOT CONSTITUTING DEFENSE

Compliance with the terms of this Permit does not constitute a defense to any action brought under Chapter 14, Article 8 of Title 10.1, Code of Virginia (1950) as amended or any other Commonwealth law governing protection of the public or the environment.

I.G. TRANSFER OF PERMITS

This Permit is not transferable to any person except after notice to the Director. (40 CFR § 270.30(l)(3)) The Director may require modification or revocation and reissuance of the Permit pursuant to 40 CFR §§124.5, 270.40, 270.41, 270.42, and 270.43, to identify the new Permittee and incorporate such other requirements as may be necessary. If the name of the Permittee changes, the Director may require modification of the Permit through a Class 1 modification pursuant to 40 CFR § 270.42(a). Before transferring ownership or operation of the facility during its operating life, the Permittee shall notify the new owner or operator in writing of the requirements of 9 VAC 20-60-264 and 40 CFR Parts 264 and 270 and at the same time shall send a copy of such notice to the Director (40 CFR § 264.12(c)).

I.H. PERMIT DURATION AND POST-CLOSURE CARE PERIOD

Pursuant to 9 VAC 20-60-270.B.15 this Permit will remain in force until the effective date of a new permit if the Permittee has submitted a timely, complete application pursuant to Permit Condition I.D.2.a. and through no fault of the Permittee, the Director has not issued a new permit with an effective date on or before the expiration date of this Permit. All conditions of the continued Permit shall remain fully effective and enforceable (40 CFR § 270.51(d)).

The post-closure period for each hazardous waste management unit shall begin after completion of closure of the unit and continue for 30 years after that date (264.117(a)), or for a reduced period if the Director approves clean closure of the unit and the reduced period is sufficient to protect human health and the environment (264.117(a)(2)(i)), or for an extended period if the Director finds that the extended period is necessary to protect human health and the environment (e.g., leachate or ground-water monitoring results indicate a potential for migration of hazardous wastes at levels which may be harmful to human health and the environment) (264.117(a)(2)(ii)). The date of final closure

certification for each unit is different; therefore, the final date of post-closure care is different for each unit.

I.H.1. HWMU-5

The hazardous waste surface impoundment was closed on October 26, 1989 and the post-closure care period was to extend to October 26, 2019. The facility is required to manage this unit under a Post-closure Permit until October 26, 2019, until the Director approves clean closure of the unit, or for an extended period if the Director finds that an extended period is necessary to protect human health and the environment.

I.H.2. HWMU-16

UNIT 16 was operated from 1980 to 1988. The hazardous waste landfill was certified closed on August 10, 1993 and the post-closure care period was extend to August 10, 2023. The facility is required to manage this unit under a Post-closure Permit until August 10, 2023, until the Director approves clean closure of the unit, or for an extended period if the Director finds that an extended period is necessary to protect human health and the environment.

I.I. EXTENSION OR REDUCTION OF POST-CLOSURE PERIOD

I.I.1. The Permittee may request a reduction in the 30-year post-closure period if the following condition exists (40 CFR § 264.117(a)(2)(i)): A shortened period is sufficient to protect human health and the environment based upon: leachate or groundwater monitoring results, characteristics of the hazardous wastes, application of advanced technology, or alternate disposal, treatment, or reuse techniques indicate that the facility is secure.

I.I.2. The Director may extend the post-closure period applicable to the hazardous waste management unit or facility if the extended period is necessary to protect human health and the environment (e.g., leachate or groundwater monitoring results indicate a potential for migration of constituents at levels which may be harmful to human health and the environment). (40 CFR § 264.117(a)(2)(ii)).

I.J. COMPLIANCE PERIOD

I.J.1. The Compliance Period is the period of time that the facility is required to remain in compliance with the Groundwater Protection Standards (GPS) in the uppermost aquifer beneath the unit at the point of compliance (40 CFR § 264.92 and § 264.96). The compliance period is the number of years equal to the active life of the Regulated Units including any waste management activity prior to permitting, and the closure period. The compliance period begins when the owner or operator initiates a compliance monitoring program, which was the effective date of the

original Permit issued.

I.J.2. HWMU-5

The closed surface impoundment (unlined from 1970 to 1981; lined from 1981 to 1989) operated as the collection impoundment downstream from an acid tank farm from 1970 until final closure of the unsaturated soils in 1989. The compliance period during which the GPS (Permit Attachment V.F) applies is nineteen (19) years. The original permit for HWMU-5 was issued on September 28, 2001. The original compliance period, therefore, continued until October 28, 2020. Exceedances above the GPS values continued to occur at the point of compliance beyond the original compliance period. Therefore, the compliance period has been extended to October 28, 2030, or until the Director approves clean closure of the unit.

I.J.3. HWMU-16

The closed hazardous waste landfill consisted of a trench without a liner or leachate collection system. HWMU-16 was operated from 1980 to 1988 and the unit was certified closed on August 10, 1993. The original compliance period during which the GPS (Permit Attachment V.F) applied was thirteen (13) years from the effective date of the original permit and continued until October 30, 2015. Due to the continued presence of hazardous waste buried within the unit, the potential for impact to human health and the environment remains. Therefore, the compliance period has been extended to October 30, 2035, or until the Director approves clean closure of the unit.

I.J.4. If at the end of the specified compliance period for either HWMU, the facility is engaged in a corrective action program, the compliance period shall be extended until the Permittee can demonstrate that the GPS has not been exceeded at the point of compliance for a period of three (3) consecutive years (40 CFR § 264.96(c)).

I.K. REPORTS NOTIFICATIONS AND SUBMISSIONS TO THE DEPARTMENT

I.K.1. Duty to Submit Documents

All reports, notifications or other submissions which are required by this Permit to be sent or given to the Director of the Virginia Department of Environmental Quality (DEQ) shall be sent electronically, by certified mail, overnight express, or be hand-delivered to:

Department of Environmental Quality
Hazardous Waste Program Manager

Office of Financial Responsibility and Waste Programs
P.O. Box 1105
Richmond, Virginia 23218

Street address:
1111 East Main Street, Suite 1400
Richmond, VA 23219

and one (1) copy of all such correspondence, reports, and submissions shall also be sent to:

Land Protection Manager, Blue Ridge Regional Office
Department of Environmental Quality
901 Russell Drive
Salem, VA 24153

Associate Director, Office of Remediation
Environmental Protection Agency, Region III
1650 Arch Street
Philadelphia, PA 19103-2029
(3LC20)

I.K.2. Signatory Requirements

All applications, work-plans, reports, and other information submitted shall be signed and certified as specified by 40 CFR §270.11.

I.L. DOCUMENTS TO BE MAINTAINED AT THE FACILITY

I.L.1. The Permittee shall maintain at the facility, until post-closure care is completed and certified by the Permittee and by an independent, Virginia-registered professional engineer, the following documents (as amended, revised, and/or modified):

a. The Permit, including all attachments, revisions and modifications;

b. All Part A and B Permit Applications supporting the Permit;

c. The facility operating record required by 40 CFR § 264.73;

d. Inspection schedules and logs required by 40 CFR § 264.15(b)(2) § 264.15(d), and this Permit;

e. Personnel training documents and records required by 40 CFR § 264.16 and this Permit;

f. Closure Plans, as required by 40 CFR § 264.112(a), as applicable;

g. Post-Closure Plans, as required by 40 CFR § 264.118(a), as applicable;

h. Groundwater sampling and analysis plan required by 40 CFR § 264.92 and this Permit;

i. Groundwater monitoring results required by 40 CFR § 264.73(b)(6) and this Permit;

j. All other documents required by Permit Conditions I.D.8 through I.D.12 and I.E.

I.M. TRADE SECRET PROTECTION

In accordance with §10.1-1458 of the Code of Virginia (1950, as amended), the permittee may claim any information this permit requires, or is otherwise submitted to the Director as trade secret. In doing so, the permittee shall: 1) assert any such claim at the time of submittal, 2) identify the data or materials for which protection is being sought, and 3) state the reasons why protection is necessary. Further information regarding trade secret protection, the basis for submittal of such a request, the Department's decision process and handling of trade secret protected information is available on the Virginia Regulatory Town Hall website (http://townhall.virginia.gov/L/ViewGDoc.cfm?gdid=5322). If no claim is made at the time of submittal, the Director may make the information available to the public without further notice. The permittee has the burden of substantiating that the claimed information is trade secret, and the Department may request further information regarding such claim, and may reasonably determine which such information to treat as trade secret. The Department may disclose trade secret information to the appropriate officials of the Environmental Protection Agency pursuant to the requirements of the federal Solid Waste Disposal Act, 42 U.S.C. § 3251, *et seq*., or as otherwise required by law.

I.N. APPROVAL/DISAPPROVAL OF SUBMISSIONS

I.N.1. The Department will review the plans, reports, schedules and other documents (hereinafter collectively referred to as "submissions") that are submitted which require the Director's approval. The Department will notify the Permittee in writing of the Department's approval, conditional approval, or disapproval of each submission.

I.N.2. Each submission required by this Permit, upon approval by the Director, is incorporated into this Permit. Any noncompliance with a Department-approved submission shall be deemed as noncompliance with this Permit. A conditionally approved submission, including any terms of such conditional approval set forth in the Department's decision, shall constitute the Department-approved submission and shall be incorporated into this Permit.

I.N.3. In the event of the Department's conditional approval of a submission, the Director shall specify in writing any deficiencies in the submission and the terms upon which approval of the submission is conditioned. If the Permittee disputes any term upon which approval of the submission was conditioned, the Permittee may initiate Dispute Resolution pursuant to Permit Condition I.O.

I.N.4. In the event of the Department's disapproval of a submission, the Director or the Department shall specify the deficiencies in writing. Such disapproval shall not be subject to the Dispute Resolution provision set forth in Permit Condition I.O. The Permittee shall modify the submission to correct/address the specified deficiencies within a reasonable time period established by the Director or the Department taking into account the tasks to be performed, and submit the revised submission to the Department for approval.

I.N.5. If the revised submission is disapproved, the Director or the Department will notify the Permittee of the deficiencies in writing and specify a schedule for the Permittee to correct the deficiencies and resubmit the submission to the Department. The Permittee shall correct the deficiencies as directed by the Department, and forward the revised submission within the time period specified by the Department. In the event the Permittee disagrees with the Department's disapproval of the revised submission, the Permittee shall notify the Department in writing and the disagreement shall be resolved in accordance with the Dispute Resolution provision in Permit Condition I.O. of this Permit.

I.O. DISPUTE RESOLUTION

I.O.1. Except as otherwise provided in this Permit, in the event the Permittee disagrees, in whole or in part, with Department disapproval of any submission required by this Permit, the Permittee shall notify the Department in writing of its objections, and the basis thereof, within fourteen (14) days of receipt of the Department's disapproval. Such notice shall set forth the specific matters in dispute, the position(s) the Permittee asserts which should be adopted as consistent with the requirements of the Permit, the basis for the Permittee's position, and supporting documentation considered necessary for the Department's determination.

I.O.2. The Department and the Permittee shall have an additional fourteen (14) days from the Department's receipt of the notification to meet or confer to resolve any disagreement or dispute. In the event agreement is reached, the Permittee

shall submit the revised submission and implement the same in accordance with such agreement.

I.O.3. In the event the Permittee and the Department are not able to reach an agreement on the dispute items within the additional 14-day period, the Department will notify the Permittee in writing of its decision on the dispute and the Permittee shall comply with the terms and conditions of the Department's decision in the dispute. The Permittee does not waive its right to assert any and all available defenses in a proceeding to enforce this Permit.

I.O.4. In the event the Permittee disagrees with the Department 's disapproval of a submission or revised submission and the Department’s written decision regarding dispute items, the Permittee may file an appeal with the Director within 30 days of the disapproval (as provided for in Rule 2A:2 of the Supreme Court of Virginia).

MODULE II - GENERAL FACILITY CONDITIONS

The Permit Sections in this module apply to both units, HWMU-5 and HWMU-16.

II.A. DESIGN AND OPERATION OF FACILITY

The Permittees shall maintain and operate the facility, the location of which is shown by the location map, topographic map, and facility map (Permit Attachment II.A), to minimize the possibility of fire, explosion, or any unplanned sudden or non-sudden release of hazardous waste constituents to the air, soil, or surface water which could threaten human health or the environment.

II.B. FACILITY DESCRIPTION AND SITE IDENTIFICATION

The facility, Radford Army Ammunition Plant, is located in the mountains of southwestern Virginia within Pulaski and Montgomery Counties. The site location map is presented in Figure II.A-1 of Permit Attachment II.A. The installation consists of two noncontiguous areas - the Radford Unit (or Main Section) and the New River Ammunition Storage Area Unit. The Main Section is located approximately 4 miles northeast of the city of Radford, approximately 10 miles west of Blacksburg, and 47 miles southwest of Roanoke, Virginia. The New River Unit is located approximately 6 miles west of the Main Section, near the town of Dublin, Virginia. The New River divides the Radford Army Ammunition Plant into two areas (see Figures II.A-2 and II.A-3). The southern area, which comprises approximately two-thirds of Radford Army Ammunition Plant, is called the "Main Plant Area." The remaining northern one-third section is called the "Horseshoe Area," and is located within a meander of the New River.

Forty three (43) Solid Waste Management Units (SWMUs) and six (6) HWMUs are located in both the Main Plant Area and the Horseshoe Area (Figure II.A-4). This permit includes two (2) Hazardous Wastes Management Units: HWMU-5 and HWMU-16 (Figure II.A-5).

The Radford Army Ammunition Plant is a government-owned, contractor-operated (GOCO) military industrial installation supplying solvent and solventless propellant grains and trinitrotoluene (TNT) explosives. From its inception as a GOCO installation in 1940 until 1995, the Radford Army Ammunition Plant was operated by Hercules Incorporated. On March 15, 1995 Alliant Techsystems, Incorporated acquired Hercules Incorporated and took over operation of the Radford Army Ammunition Plant. BAE Systems, Ordnance Systems Inc. became the operating contractor on July 1, 2012.

Construction of the Radford Army Ammunition Plant began in 1940. Initially, the Radford Army Ammunition Plant consisted of two distinct areas - a smokeless-

powder plant (Radford Ordnance Works [ROW]) and a bag-manufacturing and loading plant for artillery, cannon, and mortar projectiles (New River Ordnance Works [NROW]). These two production facilities were operated separately from 1940 to 1945. Late in 1945, ROW was designated as the Radford Arsenal, and NROW was designated as a subpost. By January 1950, NROW was made an integral part of the Radford Arsenal and no longer considered a subpost. The arsenal was renamed Radford Ordnance Plant in 1961 and was finally redesignated as the Radford Army Ammunition Plant in August 1963.

Expansion of both ROW and NROW continued throughout World War II. Late in 1945, the Radford Unit was placed on standby status. The following year, the nitric acid area of the plant was reactivated to produce ammonium nitrate fertilizer, an activity that continued until 1949 under contract with Hercules Powder Company (later Hercules Incorporated). In September 1945, the NROW was declared surplus; but in April 1946, the magazine areas were changed from surplus to standby status. Between December 1946 and January 1948, large parcels of the NROW plant manufacturing area were sold. These parcels were excess land holdings that had never been used for production purposes. Between 1952 and 1958, the Goodyear Aircraft Corporation was contracted to manufacture component parts used in missile production at the Radford Army Ammunition Plant. In 1958, Hercules took over the Goodyear operations at the Plant. In mid-1968, the continuous TNT plant was put into production and remained in operation until destroyed by an explosion in May 1974. The TNT plant was restarted in 1983 and operated until 1986. In December 1988, a facility cleanup was conducted and the TNT plant was prepared for long-term standby status. Between 1990 and 1992, two nitroglycerin lines were modernized and went back into production as needed.

The general responsibilities assigned to the Radford Army Ammunition Plant include:

a. Manufacturing of explosives and propellants;

b. Handling and storage of strategic and critical materials as directed for other government agencies;

c. Operation and maintenance, as directed, of active facilities in support of current operations. Maintenance and/or lay-away in accordance with Ammunition Procurement and Supply Agency instructions, of standby facilities, including any machinery and packaged lines received from industry, in such conditions as will permit rehabilitation and resumption of production within the time limitations prescribed;

d. Receipt, surveillance, maintenance, renovation, demilitarization, salvage, storage, and issue of assigned Field Service Stock and industrial stock as

required or directed;

e. Procurement, receipt, storage, and issue of necessary supplies, equipment, components, and essential materials;

f. Mobilization planning, including review and revision of plant as required;

g. Custodial maintenance and administrative functions of subinstallations; and

h. Support services for tenants.

These responsibilities are met through the efforts of the operating contractor, BAE Systems Ordnance Systems Inc. The Administrative Contracting Officer (ACO) and his or her staff provide technical assistance and administer the contracts with the civilian operating contractors. Radford Army Ammunition Plant also provides logistics support for tenant activities.

Production at Radford Army Ammunition Plant is accomplished at the primary and secondary manufacturing areas. The primary manufacturing processes include the production of single-base and multi-base solvent propellants, cast propellant, solventless propellant (rolled powder), and TNT. From 1941 to present the principle products at Radford AAP have been single or multi base solvent and solventless propellants.

II.B.1. HWMU-5

HWMU-5 is a closed lined neutralization pond/ surface impoundment (Figure II.A-6). It is located on a river terrace which gently slopes to the north towards the New River. This pond was operated as an unlined pond from 1970 to 1981, prior to being retrofitted with a Hypalon™ liner in 1981. Leakage from the unit may have occurred prior to the installation of the liner. Numerous karst features, predominantly sinkholes, are near this unit. Intermittent drainages are located to the west and northeast of the Unit, and the New River is located approximately 3,000 feet northeast of the Unit.

II.B.2. HWMU-16

HWMU-16 is located within the Horseshoe Area of the New River and is a hazardous waste trench located within a solid waste landfill (Figure II.A-7). Several sources, the Soil Conservation Services and consultant reports, indicated that the unit is located within a karst dominated area. The unit is underlain by clay, silty sands, gravels, and limestone. The clay and silt deposits can be up to 38 feet thick. The overburden materials are terrace deposits. The bedrock is the Elbrook Formation which is encountered at a depth of 50 to 60 feet on the west end and at 70 feet on the east end. The formation is highly fractured and

fragmented with breccia, vugs, and solution channels. A spring and perennial stream are located approximately 730 feet northeast of the Unit, and the New River is located approximately 1,500 feet south of the Unit.

II.B.3. The Permittee has provided GIS coordinate surveys for HWMU-5 and HWMU-16 to support EPA with long-term geospatial recordkeeping goals for hazardous waste management units. As part of the facility operational security measures, these surveys shall be kept in the site operating record and shall be made available for viewing at the request of DEQ. All surveys of the units shall meet the following requirements:

a. Define the boundary of each unit as a polygon

b. Establish the longitude and latitude of each polygon vertex as follows:

i. Decimal degrees format

ii. At least seven decimal places

iii. Negative sign for west longitude

iv. World Geodetic System (WGS) 1984 datum

II.C. GENERAL WASTE ANALYSIS

The general chemical and physical analysis of the wastes handed in the facility for each unit are addressed as in the following.

II.C.1. HWMU-5

During its operation, the lined neutralization pond received stormwater runoff, spilled liquids, and washdown waters from an acid tank farm. The effluent from HWMU-5 was discharged to an equalization basin (HWMU-4). The primary function of HWMU-5 was to hold acidic waste waters prior to discharge to an equalization basin. The wastes deposited in HWMU-5 were characteristically hazardous as corrosive (D002). The waste waters in HWMU-5 were both nitric (NO_3) and sulfuric (SO_4) in composition.

Process waste water containing low concentrations of nitrocellulose (NC) was conveyed from the acid screen house to HWMU-5 until the process was discontinued in 1983. Microscopic examination of sludge samples from other acid waste lagoons that received similar waste streams indicated NC in concentrations less than one percent. According to test criteria used by the Radford AAP laboratory, sludges containing less than 26 percent NC are non-reactive when NC is the only reactive component present. Analyses for other explosive materials

including nitroglycerin and dinitroglycerin showed very low concentrations of these constituents in the lagoon sludges. These results indicated that it was unlikely that the solids in HWMU-5 were reactive due to NC or other explosive materials which may have been present.

The pH of the surface impoundment was 1.5 and the dominant components of the hazardous wastes sent to the unit were the noted mixed acids. Several heavy metals were detected in low (i.e., non-hazardous) concentrations. The results of the analyses conducted on the lagoon water are presented in Permit Attachment II.D. This description is based upon information provided by the Facility.

II.C.2. HWMU-16

HWMU-16 is a closed hazardous waste landfill, which is closed in accordance with the regulations promulgated under the authority of the Resource Conservation and Recovery Act (RCRA) of 1976. Hazardous wastes and other waste known to have been disposed of within HWMU-16 included 3898 tons of ash from the burning of waste explosives and explosives-contaminated material (EPA Hazardous Waste Code D003, D004, D007 and D008; arsenic, cadmium, chromium and lead), 545 tons of wastewater treatment sludges (EPA Hazardous Waste Code K044 and K045, with the characteristic of ignitability, corrosivity or reactivity), 6 tons of asbestos, and various laboratory chemicals. Additionally, the following wastes were disposed of in HWMU-16 in unknown quantities: ash from waste propellant incinerator (EPA Hazardous Waste Code D003), residue from waste propellant burning (EPA Hazardous Waste Code D003), residue from explosive contaminated waste burning (EPA Hazardous Waste Code D003), Sulfur Acid Regeneration (SAR) area fume burner ash (EPA Hazardous Waste Code D006 and D007), sludges from Bioplant Building 470 (EPA Hazardous Waste Code K044), and NG 2 Pretreatment Building 9410 (EPA Hazardous Waste Code K044).

From the beginning of disposal activities at HWMU-16, reactive wastes were incinerated or open burned prior to disposal in the unit. However, several heavy metals were detected during extraction procedure toxicity analyses conducted on ash residues disposed in the Unit. Furthermore, several of the laboratory chemicals disposed of within the Unit are listed. A complete listing of the wastes contained in the Unit and the results of the analyses conducted on the ash residues are presented in Attachment II.D.

The groundwater has been monitored since 1981 as part of the requirements of RCRA interim status. The Unit was certified as closed in 1993 with all waste materials remaining in place and a final cover system has been provided. No waste has been managed in HWMU-16 since it was closed.

The primary contaminants of concern at HWMU-16 are lead, the explosive-

related compounds, several purgeable organic compounds, and a few of the base-neutral extractable organic compounds.

A description of all hazardous wastes and waste constituents, which were ever known to have been discharged to and which were suspected to have been placed in the hazardous waste landfill, are provided in the List of Wastes (Attachment II.D) and the Compliance (Semiannual) Groundwater Monitoring List (Attachment V.D). These lists are based upon information provided by the facility. All Appendix IX to 40 CFR 264 Annual Groundwater Sampling constituents (Attachment V.C), that have been detected in groundwater and are reasonably expected to have originated from the unit, have been included on the list.

II.D. SECURITY

The Permittees shall comply with the security provisions of 40 CFR § 264.14. The security measures shall follow the requirements described in Permit Attachments II.E and III.A.

II.E. GENERAL INSPECTION REQUIREMENTS

The Permittees shall follow the inspection plan set out in Permit Attachment II.F. The Permittees shall remedy any deterioration or malfunction discovered by an inspection (40 CFR § 264.15). Inspection records shall be kept as required by 40 CFR § 264.15(d).

II.F. PERSONNEL TRAINING

The Permittees shall conduct required personnel training (40 CFR § 264.16). This training program shall follow Permit Attachment II.G. The Permittees shall maintain training documents and records (40 CFR § 264.16(e)).

II.G. RECORDKEEPING AND REPORTING

II.G.1 Operating Record

Pursuant to 40 CFR § 264.73, the Permittees shall maintain a written operating record at the Facility. The record can be a compilation of various documents and shall include, but not be limited to, the information listed below.

a. The following records shall be maintained until post-closure is complete and certified:

i. Records of spills and releases required by existing environmental laws, including, but not limited to Section 103 of the Comprehensive Environmental Response, Compensation and Liability Act;

ii. Written reports and records of verbal notification to the Director to address releases, fires, and explosions;

iii. All reports of noncompliance pursuant to Permit Condition I.D.9 and I.D.11.;

iv. All submittals prepared pursuant to Permit Condition I.D.10.;

v. Records of all monitoring information pursuant to Permit Section I.E.; and

vi. Training records of current Facility personnel.

b. The following records shall be maintained for a minimum of 3 years. This time period may be extended by the Department in the event of enforcement action or notification by the Department that an investigation is ongoing.

i. Generator Biennial Reports submitted in compliance with 40 CFR § 262.41;

ii. Facility Biennial Reports submitted in compliance with 40 CFR § 264.75;

iii. Training records of former Facility personnel; and

iv. Records of all inspections, pursuant to 40 CFR § 264.15, which shall include at a minimum:

- The date and time of the inspection;
- The name of the person performing the inspection;
- A notation of the observations made; and
- The date and nature of any repairs or remedial actions.

c. Current copies of the following documents as amended, revised, and modified shall be maintained at the Facility until post-closure and corrective action are complete and certified:

i. Training Plan; and

ii. All closure, post-closure, interim measures, and final corrective action cost

estimates; financial assurance documents prepared pursuant to this Permit; and the company names and addresses of Facility insurers.

II.G.2 Required Reports

The Permittees shall comply with all applicable reporting requirements as described in Permit Module I.

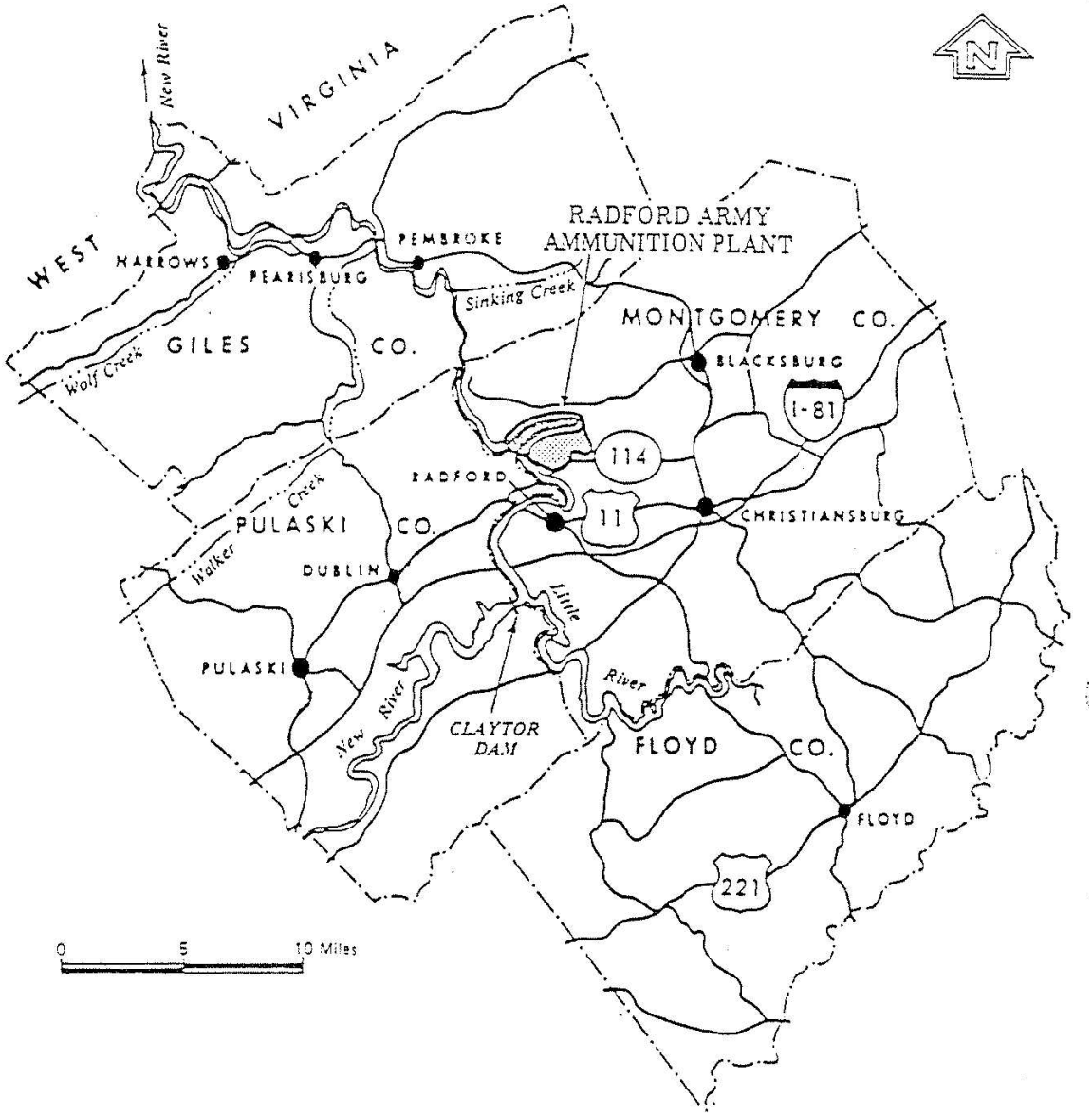
II.H. COST ESTIMATE AND FINANCIAL ASSURANCE FOR FACILITY POST-CLOSURE

Pursuant to Subpart H to 40 CFR 264 – Financial Requirement. The federal government is exempt from the financial requirements. As the Radford AAP is a federal government installation, and all the HWMUs at the Radford AAP are exempted from the requirements of 40 CFR 264.142 through 145.

ATTACHMENT II.A - FACILITY MAPS

Figure II.A-1 – Facility Location Map
Figure II.A-2 – Geological/ Terrace Map
Figure II.A-3 – Fracture Trace Map
Figure II.A-4 – Radford Army Ammunition Plant Installation Restoration Program Sites
Figure II.A-5 – Topographic Map
Figure II.A-6 – HWMU-5 Topographic Map
Figure II.A-7 – HWMU-16 Topographic Map

Figure II.A-1 – Facility Location Map



Location of the Radford Army Ammunition Plant
Hazardous Waste Management Facility

Figure II.A-2 – Geological/ Terrace Map

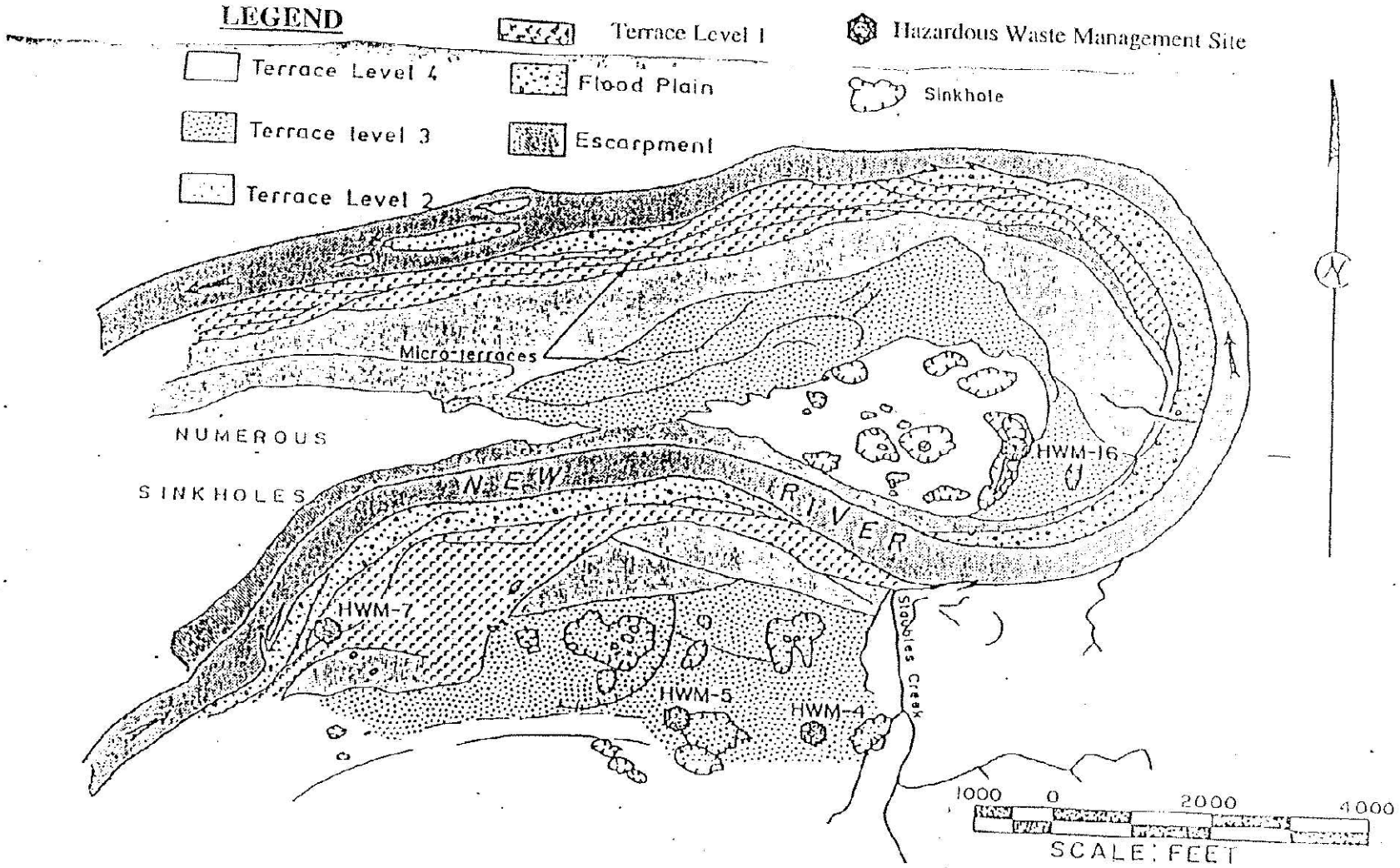


Figure 3. Terrace map.

Figure II.A-3 – Fracture Trace Map

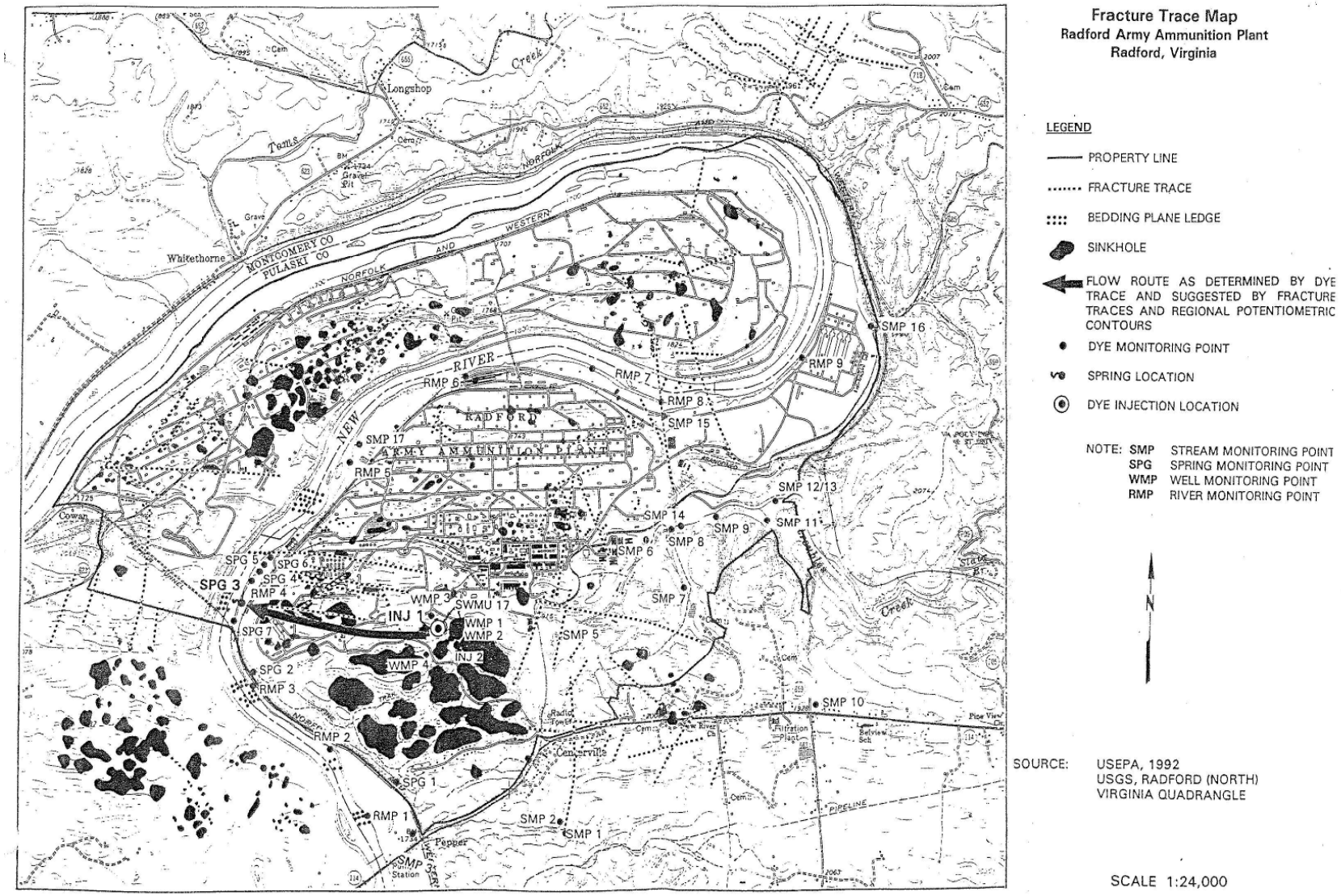


Figure II.A-4 – Radford Army Ammunition Plant Installation Restoration Program Sites

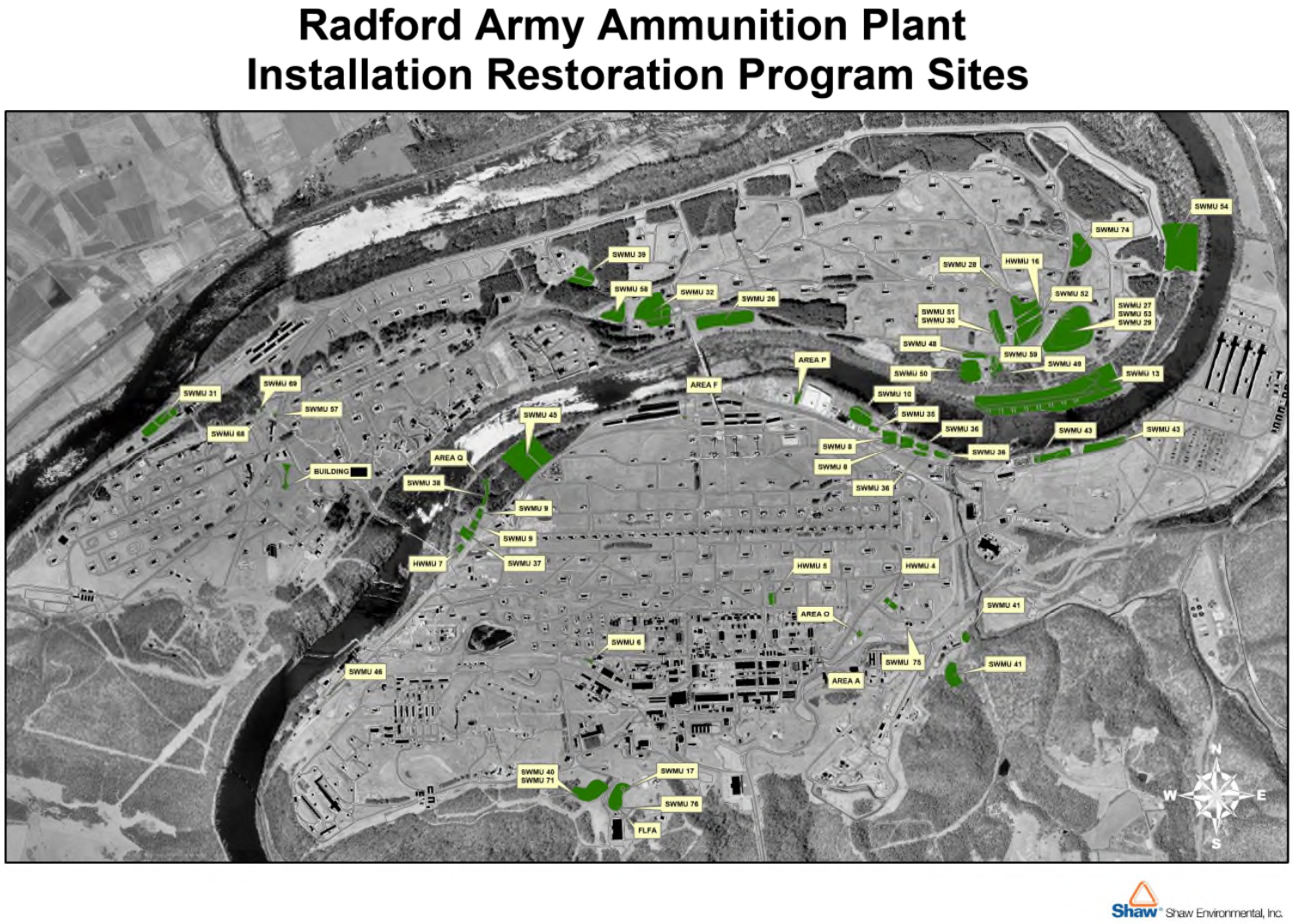


Figure II.A-5 – Topographic Map

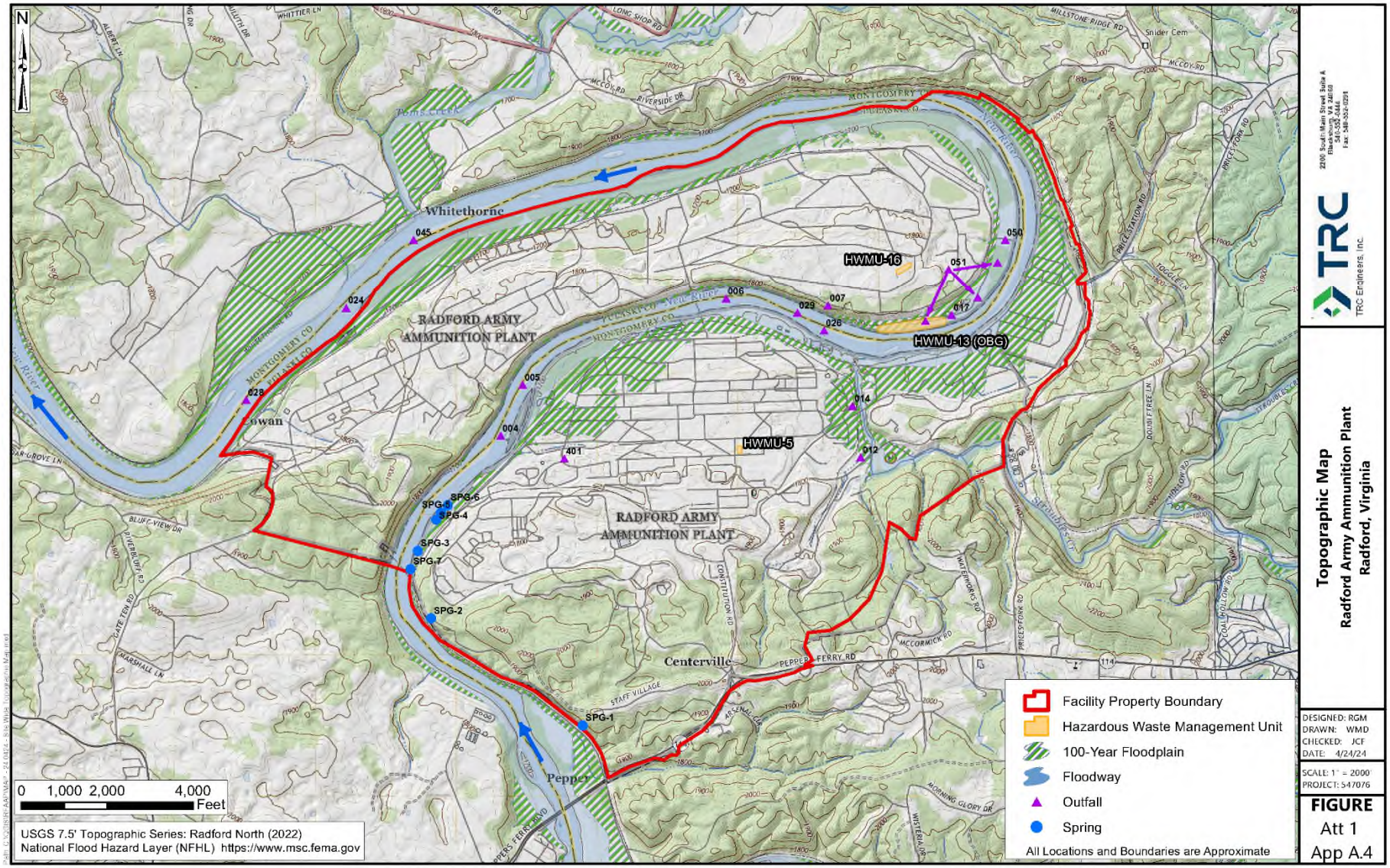


Figure II.A-6 – HWMU-5 Topographic Map

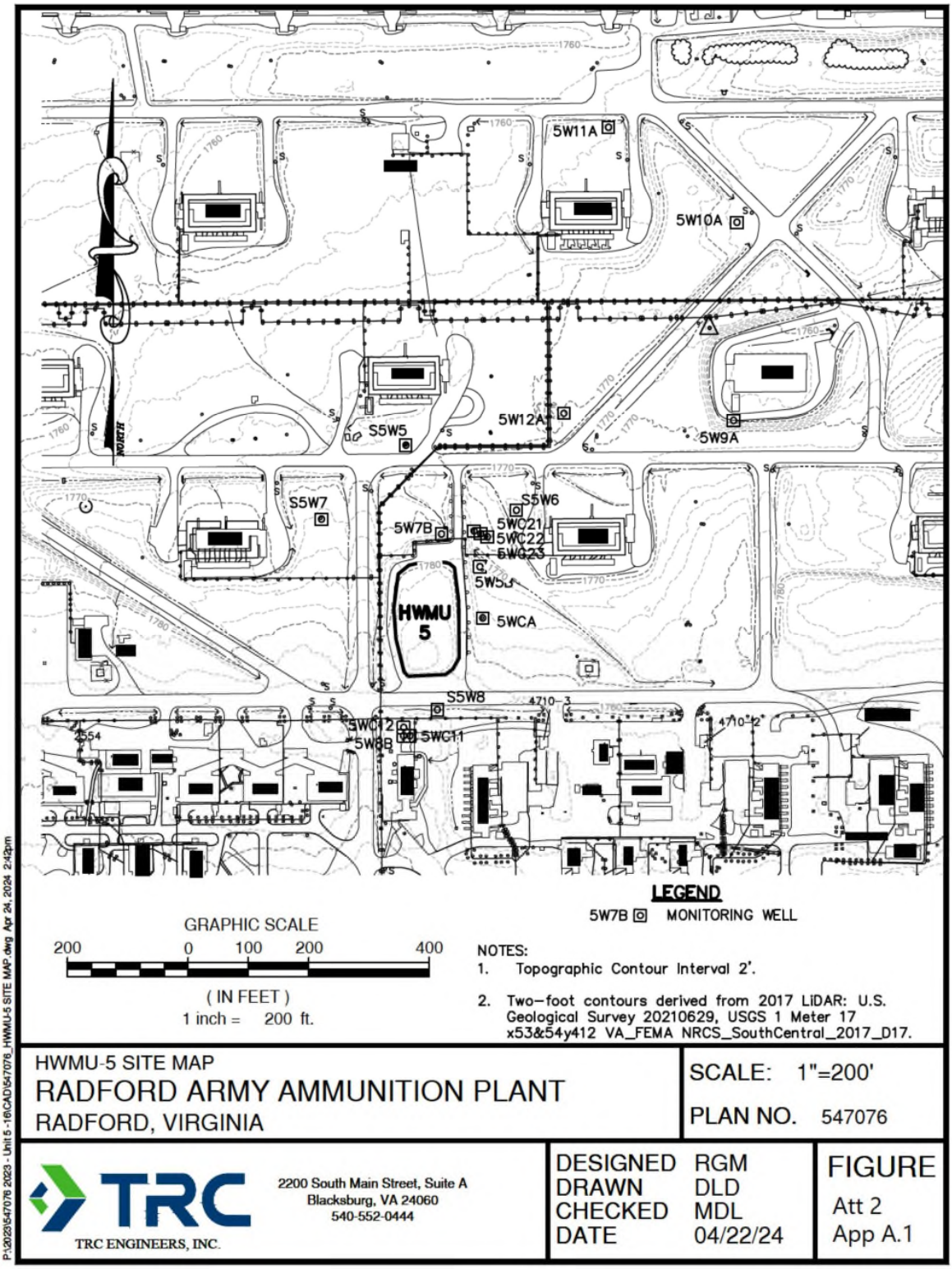
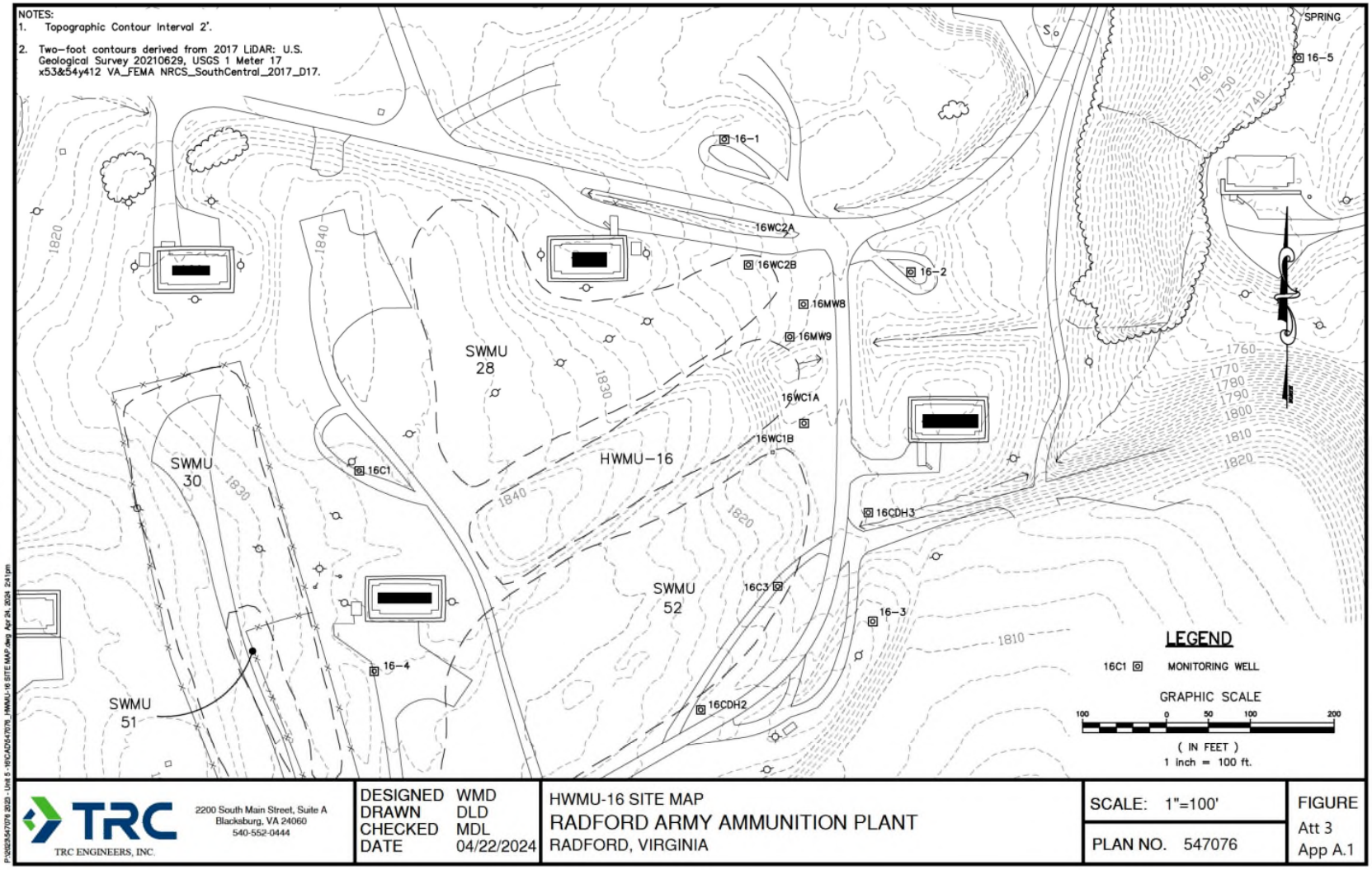


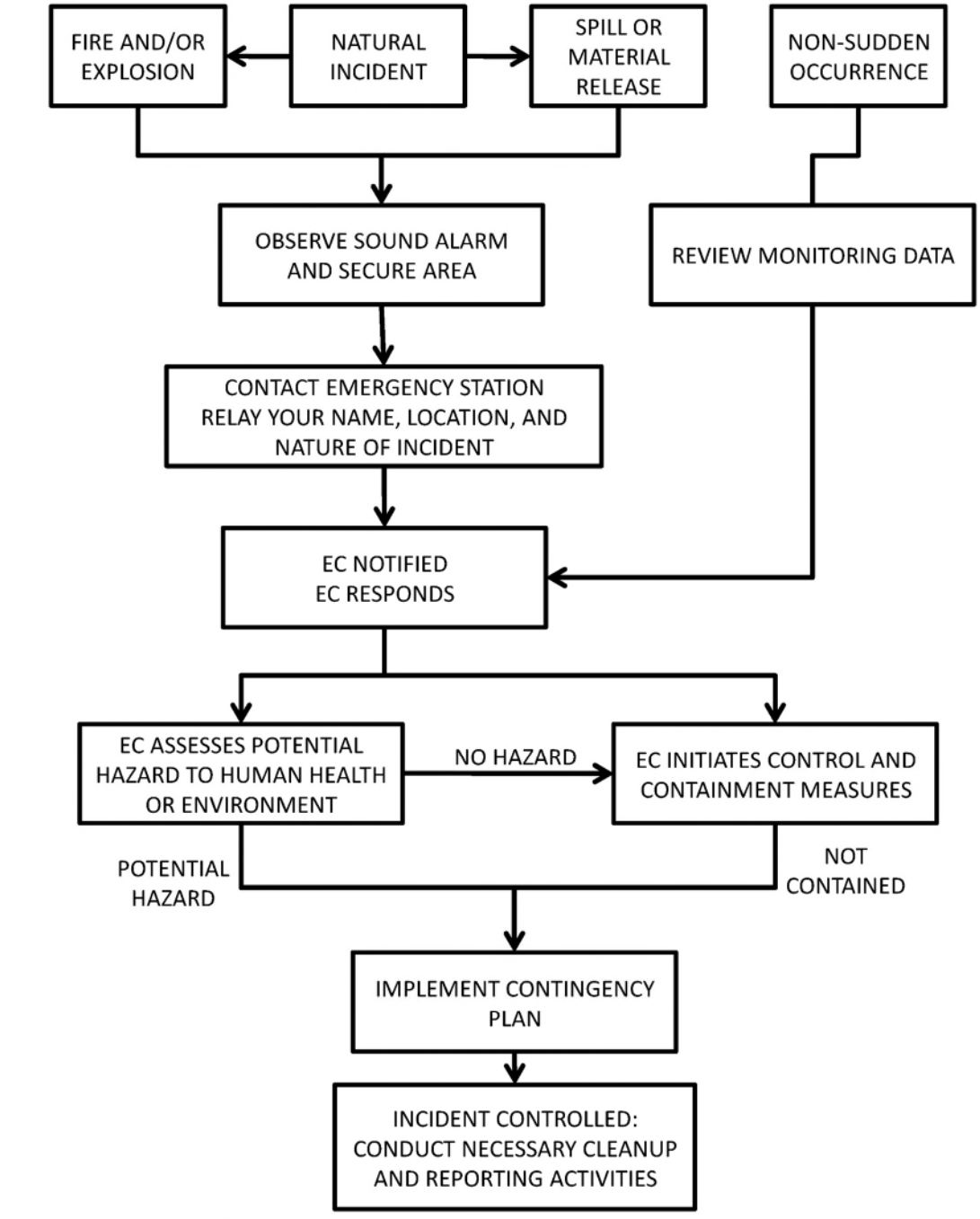
Figure II.A-7 – HWMU-16 Topographic Map



ATTACHMENT II.B - CONTINGENCY PLAN

II.B-A. CONTINGENCY PLAN TABLES AND FIGURES

Figure II.B-1 – Contingency Plan Implementation Logic Diagram



EC: Emergency Coordinator

Figure II.B-2 – Emergency Equipment Locations

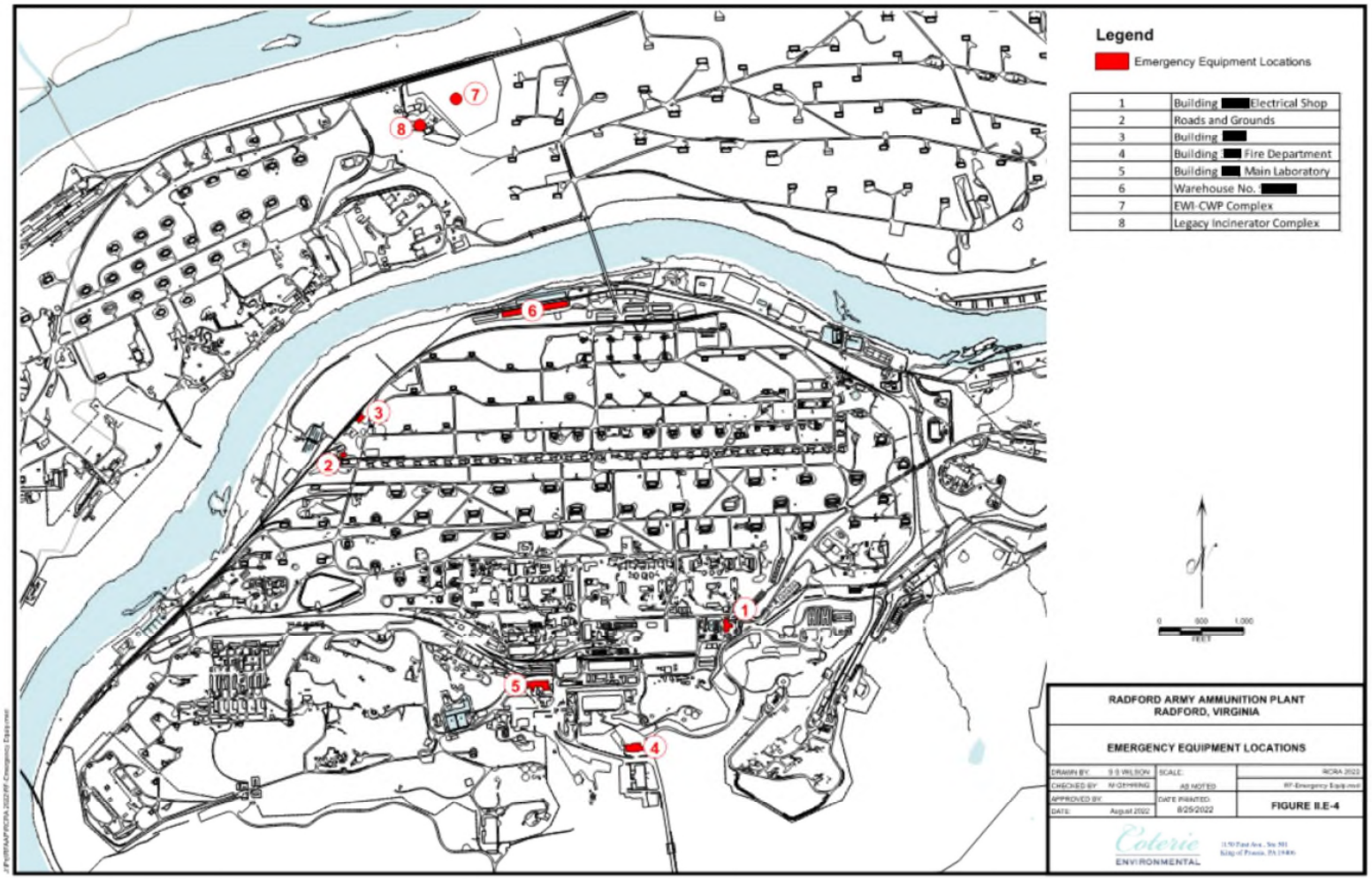


Table II.B-1 – Emergency Procedures

RFAAP Disaster Control And Emergency Action Plan (DCP-EAP) provides plans for:

1) Hazardous material emergency response
2) Pollution incident reporting
3) Chemical, nuclear or radiological accident/incident control
4) Emergency situation reporting
5) Bomb threats
6) Crisis emergency/relocation plan
7) Flood watch

Spill Prevention, Control, and Countermeasures Plan (SPCC) and Management Manual (MM) 3-1.1 Environmental, Quality, and Safety Incident Reporting for spills other than hazardous waste described in the Part B permit.

SPCC provides area specific plans including:

1) Description of physical layout and processes performed
2) Inventory of tanks, drums, and containment structures
3) Identification of potential spill scenarios and volumes
4) Flow path(s) for spills
5) Any area specific response measures, which may be required
6) Listing of any treatment facilities servicing the area

MM 3-1.1 Environmental, Quality, and Safety Incident Reporting is concerned with the recognition, reporting, containment and notification procedures in the event of leaks and spills.

Fire Prevention and Protection Program describes:

1) Employee and Fire Department personnel responsibilities for fire prevention and protection
2) Inspection and use of equipment and supplies
3) Fire Department training program
4) Building evacuation procedures
5) Annual Fire Prevention and Protection Program
6) Prefire plan and other fire plans

Plant Protection Plan (PPP) outlines plan protection/security procedures including the security of explosives, intrusion detection systems, protective communications and key and lock control.

Plant Operating Procedures:

GOP 4-27-008C:	Electrical Distribution System Switching, Shutdowns, & Safe Clearances
PPS 2.00:	Personal Protective Equipment
PPS 1.70:	Flood Watch
PPS 2.60:	Respiratory Protection Equipment
GOP 4-A-049:	Operation of Two-Way Radio Mobile Units and Fixed Base Central
GOP 4-A-111:	General Safety Rules for Preparing Waste Explosives

Table II.B-2 – Notification Action Summary

Emergency Contacts
Contacts to be made in accordance with Management Manual 3-1.1

The shift fire captain will act as the Incident Commander (IC) in the event of an incident. Area specific reporting procedures should be followed; however, all emergency events should be reported to the RFAAP Dispatch Emergency number. All appropriate contact information is listed in the table below.

Entity	Telephone Number
Emergency Dispatch	540-639-7163
On-Call Environmental	540-230-8970
Hospital	540-639-7123
Non-Emergency Dispatch	540-639-7323
Security HQ	540-639-8289

Communications during emergency events are discussed in more detail in the RFAAP DCP-EAP. Facility staff will contact selected local and regional entities and authorities that may be involved in responding to an emergency situation according to the anticipated needs at the plant. Personnel from these organizations may be asked to support RFAAP personnel in response to fires, explosions, or chemical releases if RFAAP personnel cannot adequately address the situation internally. Personnel from these agencies will act under the direction of the IC; and will be directed and escorted by plant personnel.

Table II.B-3 – Evaluation Criteria For Implementation Of Contingency Plan

In accordance with the Contingency Plan Implementation Logic Diagram (Figure II.B-1), the following are examples of when the contingency plan would need to be implemented:

For a fire and/or explosion:

- If the fire causes a release of toxic fumes that go off plant or impacts personnel
- If the fire could spread (is not contained), thereby possibly igniting materials in other locations on-site or off site, or could cause heat induced leaks or explosions
- If the use of fire suppressant could result in contaminated runoff that cannot be contained.
- If an explosion has or could:
    - Result in damage from flying fragments or shock waves
    - Ignite other hazardous waste at the facility
    - Release toxic materials that could cause harm to human health or the environment or cannot be contained.
- Or if a fire or explosion endangers human health or the environment for any other reason.

For spills or material releases:

- If a spill could release toxic or explosive liquids, thus causing a fire or explosion hazard
- If a spill could result in off-site or on-site soil contamination and/or ground or surface water contamination
- If a spill constitutes a release of a “reportable quantity” of a hazardous substance under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).
- Or if a spill endangers human health or the environment for any other reason.

Table II.B-4 – Spill Response Measures

The spill response program will be coordinated by the Emergency Coordinator or designated representative. Guidelines are provided concerning safety, containment, evaluation, notification, treatment and monitoring as related to each spill incident.

1. Safety
   a. Evaluate the hazard of the spilled chemical to personnel which may be involved in containment, clean up, treatment and monitoring operations.
   b. Assure proper clothing and protective equipment is available and used by personnel involved in the spill response.

2. Containment
   a. Establish the expected flow path of the spilled material.
   b. Locate the nearest proposed damming site.
   c. Erect a dam – notify Roads and Grounds regarding construction of dam.

3. Evaluation of Spill Extent
   a. Obtain pH readings at site if chemical spilled was an acid or base.
   b. Confirm stoppage of leak at source.

4. Initial Notification
   a. Delegated to the Emergency Coordinator
   b. Notify appropriate agencies (see Notification Action Summary)

5. Treatment
   a. Straw or other absorbers will be supplied to entrap hazardous wastes which are spilled. Sites/locations within the plant containing straw and other entrapment materials are controlled by Roads and Grounds.

6. Monitor Program

   Upon receiving notification of an accidental loss to the industrial sewer or surface streams, personnel will obtain grab samples at specified locations and time intervals as determined by the Emergency Coordinator.

a. In-Plant Sites

   i. Suggested sampling sites will be determined based on the location of the spill

   ii. Samples will be collected at internal locations designated.

b. New River Site

   i. Sampling at the New River site will be performed on a staggered basis since the river flow approximates one mile per hour.

7. Final Treatment

   a. Determine disposition of impounded material depending on type and quantity of spill. Ensure EPA and DEQ concur with disposition.

   b. Provide monitoring for duration of disposition.

8. Explosion fragments and materials as well as contaminated soils will be decontaminated in either the decontamination oven or the decontamination incinerator on-site at Radford AAP provided they are not TCLP toxic or reactive. The decontaminated materials will then be disposed of in a permitted landfill or as decontaminated scrap.

Table II.B-5 – Emergency Equipment Locations At RFAAP

All Equipment listed below is maintained, repaired, or replaced as necessary. Locations are shown on Figure II.B-2. The fire trucks, maintained by the onsite Fire Department, undergo required annual pump testing through an offsite contractor.

Location Description	Equipment Available
Bldg. 1034, Electric Shop	Rubber gloves and respirators
Roads & Grounds	Respirators, goggles, air fed respirators, safety belts, shoe cleats, air compressors (250 and 700 cfm ratings), portable pumps (50, 100, and 700 gpm capacities), cranes, bulldozers, movers, graders, tow tractors, portable electric generators, backhoes, front end loaders, portable tankers, absorbent pads, booms, cloths
Bldg. 1908, Material Storage	Absorbent materials and booms
Bldg. 350, Fire Department	Ladder truck, engine, utility truck, brush truck, ATV's, command vehicle, HAZMAT truck with response gear, boat, and ambulance
Bldg. 201, Main Lab	Nitroglycerin remover
Bldg. 9387-2, River Warehouse	Soda Ash

II.B-B. LETTERS OF AGREEMENT/ MUTUAL AID AGREEMENTS

DEPARTMENT OF THE ARMY
RADFORD ARMY AMMUNITION PLANT
P.O. BOX 2
RADFORD, VIRGINIA 24143–0002

Letter of Agreement between
Radford Army Ammunition Plant (RFAAP) and
LewisGale Hospital Pulaski (Hospital)
for Medical Assistance

This letter of agreement, entered in to the 19th day of July, 2021 between the Radford Army Ammunition Plant (RFAAP) acting according to the authority of Section 1856a, Title 42 of United States Code (USC) and **LewisGale Hospital Pulaski**, ("Hospital") details the responsibilities and expectations of each party relative to a condition of natural or manmade disaster.

It is agreed that, in the event of an accident or other occurrence which may create an unknown number of casualties at RFAAP, RFAAP agrees to provide to the Hospital Emergency Room through the designated office or individual, information relative to the nature of the accident or occurrence, type of hazardous material involved, known or estimated number of casualties, and type(s) of or extent of injuries. Such communications shall be transmitted via radio, in person or telephone as conditions dictate. Both Parties agree to implement the National Incident Management System (NIMS) during all emergency responses on and off installations.

Upon notification, the Hospital will determine the extent of mobilization necessary to accommodate the number of casualties anticipated. If, upon evaluation by Hospital's Emergency Room physician on duty, the Charge Nurse in the ER and the Administrative Nursing Supervisor, current staffing is inadequate to provide adequate care to the incoming casualties, the Hospital's Emergency Action Plan will be implemented. The Hospital agrees to provide triage for all casualties, management of casualties are defined in the Hospital Emergency Action Manual.

The provision of triage, admission and management of casualties is extended on behalf of the Hospital to all civilian, military employees and agents of RFAAP so affected by the accident or other occurrence without regard to the nature of the occurrence. In a mass casualty event, On-Scene first responders wll initiate the triage process to determine level of care needed and bed availability of local providers.

Strict adherence to the principles of security and patient confidentiality is assured by both parties. RFAAP agrees to comply with the Health Insurance Portability and Accountability Act of 1996, as codified at 42 USC § l320d ("HIPPA ") and any current and future regulations promulgated there under including without limitation the federal privacy regulations contained in 45 CFR parts I and 164 (the "Federal Privacy Regulations "), the Federal Security Standards contained in 45 CFR part 142 (the "Federal Security

Regulations"), and the federal standards for electronic transactions contained in 45 CFR Parts 160 and 162, all collectively referred to herein as "HIPPA Requirements". RFAAP agrees not to use or further disclose any Protected Health Information (as defined in 45 CFR Section 164.501) or Individually Identifiable Health Information (as defined in 42 USC Section 1320d), other than as permitted by HIPPA Requirements and the terms of this Agreement. RFAAP will make its internal practices, books, and records relating to the use and disclosure of Protected Health Information available to the Secretary of Health and Human Services to the extent required for determining compliance with the Federal Privacy Regulations.

The rendering of assistance under the terms of this Agreement will not be mandatory; however, the Hospital receiving a request for assistance will endeavor to immediately inform RFAAP if the requested triage, admission and management of casualties assistance cannot be provided and, if assistance can be provided, the quantity of such resources as may be used in management of care in response to such request.

This Agreement will become effective on the date of the last signature to the Agreement Either Party may unilaterally terminate this Agreement during the Term by sending notification of its intent to terminate to the other Party at least one hundred and eighty (180) days in advance of the proposed date of termination. Such notification will be in the form of a written submission to the other Party.

LewisGale Hospital Pulaski

BY: _____

Sean Pressman
CEO of LewisGale Hospital Pulaski

RADFORD ARMY AMMUNITION PLANT

BY: _____

Russell A. Jones
LTC, CM
Commanding

Approved per City Council Action on 6/29/21 Yes-5, No-0

MUTUAL AID AGREEMENT
BETWEEN
CITY OF RADFORD, VIRGINIA
AND
RADFORD ARMY AMMUNITION PLANT

THIS AGREEMENT made effective this 15th day of June, 2021, by and between the Radford Army Ammunition Plant ("RFAAP") and the City of Radford, Virginia (the "City").

WITNESSETH:

WHEREAS, it has been determined by the City and RFAAP that an inter-jurisdictional arrangement in planning for, preventing, or responding to a disaster within the two jurisdictions will increase the ability of the parties to preserve the health, safety and welfare of the citizens of the City and RFAAP; and,

WHEREAS, Virginia Code Sections 44-146.20, 27-1, 27-2.1, and 15.2-1728, and the authority of Section 1856a, Title 42, United States Code, authorizes political subdivisions to establish and carry into effect a plan to provide mutual aid; and,

WHEREAS, the City Council of the City of Radford, Virginia and the Installation Commander of the Radford Army Ammunition Plant have adopted Resolutions agreeing to this inter-jurisdictional mutual aid arrangement between the City and RFAAP.

NOW, THEREFORE, in consideration of the mutual covenants and conditions herein contained, the parties hereto agree as follows:

1. That the parties hereto will endeavor to provide emergency services support to each other's jurisdiction within the capabilities available at the time the request for such support is made. "Emergency Services" in this Agreement are defined as, but not limited to, emergency management services, public works, fire-fighting services, emergency medical services, law enforcement services, rescue services, and communications.

2. That nothing contained in this Agreement should in any manner be construed to compel each of the parties hereto to respond to a request for emergency services support when the apparatus or equipment of the jurisdiction to whom the request is made is, in the opinion of that jurisdiction, needed or is being used within the boundaries of that jurisdiction, nor shall any such request compel the requested jurisdiction to continue to offer emergency services support in another jurisdiction when its apparatus or equipment is, in the opinion of the requested jurisdiction, needed for any reason within the boundaries of its jurisdiction.

3. That no party to this Agreement shall to the extent permitted by law be liable to any other party hereto for any loss, damage, personal injury, or death to emergency services support personnel or equipment resulting from the performance of any services under this Agreement, except those claims authorized under 15 U.S.C. § 2210, whether such loss, damage, injury or death shall occur within or without the jurisdictional boundaries of the respective parties hereto. Neither party shall be deemed to have waived sovereign immunity or any other immunities or protections from liability provided by federal, state, or local law. Notwithstanding any other provision contained in this Agreement, the City shall be entitled to reimbursement for the direct costs, expenses, and losses in furnishing fire protection services to RFAAP, as provided by 42 U.S.C § 1856a and 15 U.S.C. § 2210.

4. The services performed, and expenditures made, under this Agreement shall be deemed for public and governmental purposes and all immunities from liability enjoyed by the political subdivision within its boundaries shall extend to its participation in rendering emergency assistance outside its boundaries. It is understood that for the purpose of this Agreement, the responding party is rendering aid once it has entered the jurisdictional boundaries of the party receiving assistance. The protections afforded by this provision, and those provided by federal, state, and local law, extend to the parties, and their officers, employees, agents, and departments, including, without limitation, the Radford City Fire Department and the Radford City Police Department, who are signatories to this Agreement.

5. That there shall be no liability to the extent permitted by law, to any of the parties hereto for reimbursement for injuries or damage to apparatus, equipment or personnel associated with a response, or for injuries or damage to such apparatus, equipment or personnel incurred when going to or returning from another jurisdiction. The deputies or other agents or employees of either party, when acting hereunder without their territorial jurisdiction shall enjoy all exemptions from laws, ordinances and regulations and shall have from their normal jurisdiction all of the pension, relief, disability, workers compensation and other benefits enjoyed by them while performing their respective duties within their normal jurisdiction.

6. That each party requesting assistance under the terms of this Agreement agrees to pay the actual cost of any expended consumable supplies borrowed from another jurisdiction, which is used in providing emergency services within its jurisdiction.

7. That any party hereto desiring to request assistance pursuant to the terms and conditions of this Agreement shall make such request to the ranking operational duty officer or to the chief executive officer of each party hereto.

8. The personnel of any party rendering assistance to a jurisdiction requesting assistance under this agreement shall render such assistance under the direction of the appropriate official designated by the requesting jurisdiction; provided, however, that the ultimate control of the personnel of any party rendering assistance shall be by the officers or supervisors of such personnel.

9. The parties agree to utilize each other's FCC licensed radio frequencies for communications during mutual aid operations in support of each agency and in the event of loss of communications due to equipment failure.

10. The effective date of this Agreement is June 15, 2021. The initial term of this Agreement is two (2) years, and this Agreement shall automatically renew for successive terms of two (2) years each unless either party notifies the other in writing of its intent to terminate the Agreement at least sixty (60) days prior to the expiration of any term. This Agreement may be amended or modified by the mutual written agreement of all the parties hereto. Notwithstanding any other provision contained herein, any party to this Agreement may terminate this Agreement at any time for any reason by giving thirty (30) days written notice to that effect to the other parties hereto.

IN WITNESS WHEREOF, the parties hereto have executed this Agreement as of the date first above written.

CITY OF RADFORD, VIRGINIA:

BY _____
David Ridpath, City Manager

RADFORD ARMY AMMUNITION PLANT:

JONES.RUSSELL.ALAN.1240096699 Digitally signed by JONES.RUSSELL.ALAN.1240096699 Date: 2021.07.19 10:39:51 -04'00'

BY _____
Russel A. Jones, LTC CM
Commanding

RADFORD CITY FIRE DEPARTMENT:

BY _____
Rodney Haywood, Fire Chief

RADFORD CITY POLICE DEPARTMENT:

BY _____
Jeff Dodson, Police Chief

Approved as to Form:

_____
Michael Bedsaul,
Radford City Attorney

MUTUAL AID AGREEMENT
BETWEEN
COUNTY OF PULASKI
AND
RADFORD ARMY AMMUNITION PLANT

THIS AGREEMENT made this 15th day of June, 2021 by and between the County of Pulaski Virginia, and the Radford Army Ammunition Plant.

WITNESSTH:

WHERAS, it has been determined by the County of Pulaski, and the Radford Army Ammunition Plant that an inter-jurisdictional arrangement in planning for, preventing, or responding to, a disaster within the two jurisdictions will increase the ability of the parties to preserve the health, safety and welfare of the citizens of Pulaski County, and the Radford Army Ammunition Plant.

WHERAS, Section 22-146.20 of the Code of Virginia, 1950, as amended, and the authority of section 1856a, title 42, United States Code authorizes local governments to establish and carry into effect a plan to provide mutual aid.

WHERAS, The Board of Supervisors of the County of Pulaski, and the Installation Commander for the Radford Army Ammunition Plant have adopted Resolutions agreeing to this inter-jurisdictional mutual aid arrangement between the County of Pulaski and the Radford Army Ammunition Plant.

NOW, THEREFORE, In consideration of the mutual covenants and conditions herein contained, the parties hereto agree as follows:

1. That the parties hereto will endeavor to provide emergency services support to each other's jurisdiction within the capabilities available at the time the request for such support is made. "Emergency Services" in this agreement are defined as, but not limited to, emergency management services, public works, fire-fighting services, law enforcement services, rescue services and communications.

2. That nothing contained in this agreement should in any manner be construed to compel each of the parties hereto to respond to a request for emergency services support when the apparatus or equipment of the jurisdiction to whom the request is made is, in the opinion of that jurisdiction, needed or is being used within the boundaries of that jurisdiction, nor shall any such request compel the requested jurisdiction to continue to offer emergency services support in another jurisdiction when its apparatus or equipment is, in the opinion of the requested jurisdiction, needed for any reason within the boundaries of its jurisdiction.

3. That no party to this agreement shall to the extent permitted by law be liable to any other party hereto for any loss, damage, personal injury, or death to emergency services support personnel or equipment resulting from the performance of any services under this agreement except those claims authorized under 15 U.S.C. 2210, whether such loss, damage, injury or death shall occur within or without the jurisdictional boundaries of the respective parties hereto. Neither party shall be deemed to have waived sovereign immunity.

4. The services performed and expenditures made under this agreement shall be deemed for public and governmental purposes and all immunities from liability enjoyed by the local government within its boundaries shall extend to its participation in rendering emergency assistance outside its boundaries. It is understood that for the purpose of this agreement, the responding party is rendering aid once it has entered the jurisdictional boundaries of the party receiving assistance.

5. That there shall be no liability to the extent permitted by law, to any of the parties hereto for reimbursement for injuries or damage to apparatus, equipment or personnel associated with a response, or for injuries or damage to such apparatus, equipment or personnel incurred when going to or returning from another jurisdiction. The deputies or other agents or employees of either party, when acting hereunder without their territorial jurisdiction shall enjoy all exemptions from laws, ordinances and regulations and shall have from their normal jurisdiction all of the pension, relief, disability, workers compensation and other benefits enjoyed by them while performing their respective duties within their normal jurisdiction.

6. That each party requesting assistance under the terms of this agreement agrees to pay the actual cost of any expended consumable supplies borrowed from another jurisdiction, which is used in providing emergency services within its jurisdiction.

7. That any party hereto desiring to request assistance pursuant to the terms and conditions of this agreement shall make such request to the ranking operational duty officer or to the chief executive officer of each party hereto.

8. The personnel of any party rendering assistance to a jurisdiction requesting assistance under this agreement shall render such assistance under the direction of the appropriate official designated by the requesting jurisdiction; provided, however, that the ultimate control of the personnel of any party rendering assistance shall be by the officers of supervisors of such personnel.

9. The parties agree to utilize each other's FCC licensed radio frequencies for communications during mutual aid operations in support of each agency and in the event of loss of communications due to equipment failure.

10. The effective date of this agreement is June 15, 2021. Its term is ten (10) years and shall automatically renew for a period of ten (10) years until either party notifies the other in writing of its intent to allow the agreement to expire. This agreement may amended or modified by the mutual consent of all the parties hereto and any party to this agreement may withdrawal from this agreement at any time by giving thirty (30) days written notice to that effect to the other parties hereto.

IN WITNESS WHEREOF, the parties hereto have executed this agreement as of the date first above written.

COUNTY of PULASKI

BY _____

JONATHAN D. SWEET
County Administrator

RADFORD ARMY AMMUNITION PLANT

BY _____

RUSSELL A. JONES
LTC, CM Commanding

DEPARTMENT OF THE ARMY
RADFORD ARMY AMMUNITION PLANT
P.O. BOX 2
RADFORD, VIRGINIA 24143-0002

MUTUAL AID AGREEMENT

This mutual aid agreement, entered into the 8th day of June, 2021 between the Secretary of the Army acting according to the authority of Section 1856a, Title 42 of United States Code (USC), Radford Army Ammunition Plant ("RFAAP"), a Government Owned Contractor Operated (GOCO) facility agrees to be bound by this Mutual Aid Agreement by their representatives and Montgomery County, Virginia to secure for each the benefits of mutual aid in the prevention of loss of life and damage to property from natural and man-made hazards, through firefighting, and emergency medical services. It is agreed that:

a. On request to a representative of RFAAP, by a representative of the participating agency; firefighters, firefighting equipment and personnel of RFAAP Fire Department and EMS will be dispatched if available, to any point within the area for which the agency normally provides fire protection as designated by the representative of participating agency.

b. On request to a representative of the participating agency by a representative of RFAAP; firefighters, firefighting equipment, emergency medical services personnel of that agency will be dispatched if available to any point within the jurisdiction of RFAAP.

c. The rendering of assistance under the terms of this agreement shall not be mandatory but the party receiving the request for assistance should immediately inform the requesting department if, for any reason, assistance cannot be rendered.

d. Any dispatch of equipment and personnel pursuant to this agreement is subject the following conditions:

    1. Any request for aid under this agreement will specify the location to which the equipment and personnel are to be dispatched; however, the amount and type of equipment and number of personnel to be furnished will be determined by the responding organization.

    2. The responding organization will report to the officer in charge of the requesting organization at the location to which the equipment is dispatched and will be subject to the orders of the officer in charge.

    3. A responding organization will be released by the requesting organization when the services of the responding organization are no longer required, or when the responding organization is needed within the area for which it normally provides fire protection.

e. Each party hereby waivers all claims against every other party for compensation for any loss, damage, injury, or death occurring as a consequence of the performance of this agreement except those claims under 15 U.S.C. 2210.

f. Fire leadership along with personnel of the fire department of both parties to this agreement are invited and encouraged on a reciprocal basis, to frequently visit each other's activity for guided familiarization tours consistent with local security requirements and, as feasible, to jointly conduct pre-fire planning inspections and drills.

g. The technical heads of the fire departments of the parties to this agreement are authorized and directed to meet and draft any detailed plans and procedures of operations necessary to effectively implement this agreement. Such plans and procedures of operations shall become effective by the signatory parties.

h. All equipment used in carrying out this agreement will be owned by the participating agency and all personnel supporting this request will be an employee or volunteer member of the participating agency.

i. This agreement shall become effective upon the date hereof and remain in full force until canceled by mutual agreement of the parties hereto, or by written notice by one party to the other party, giving thirty days notice of said cancellation.

County of Montgomery, Virginia

BY: Craig Meadows

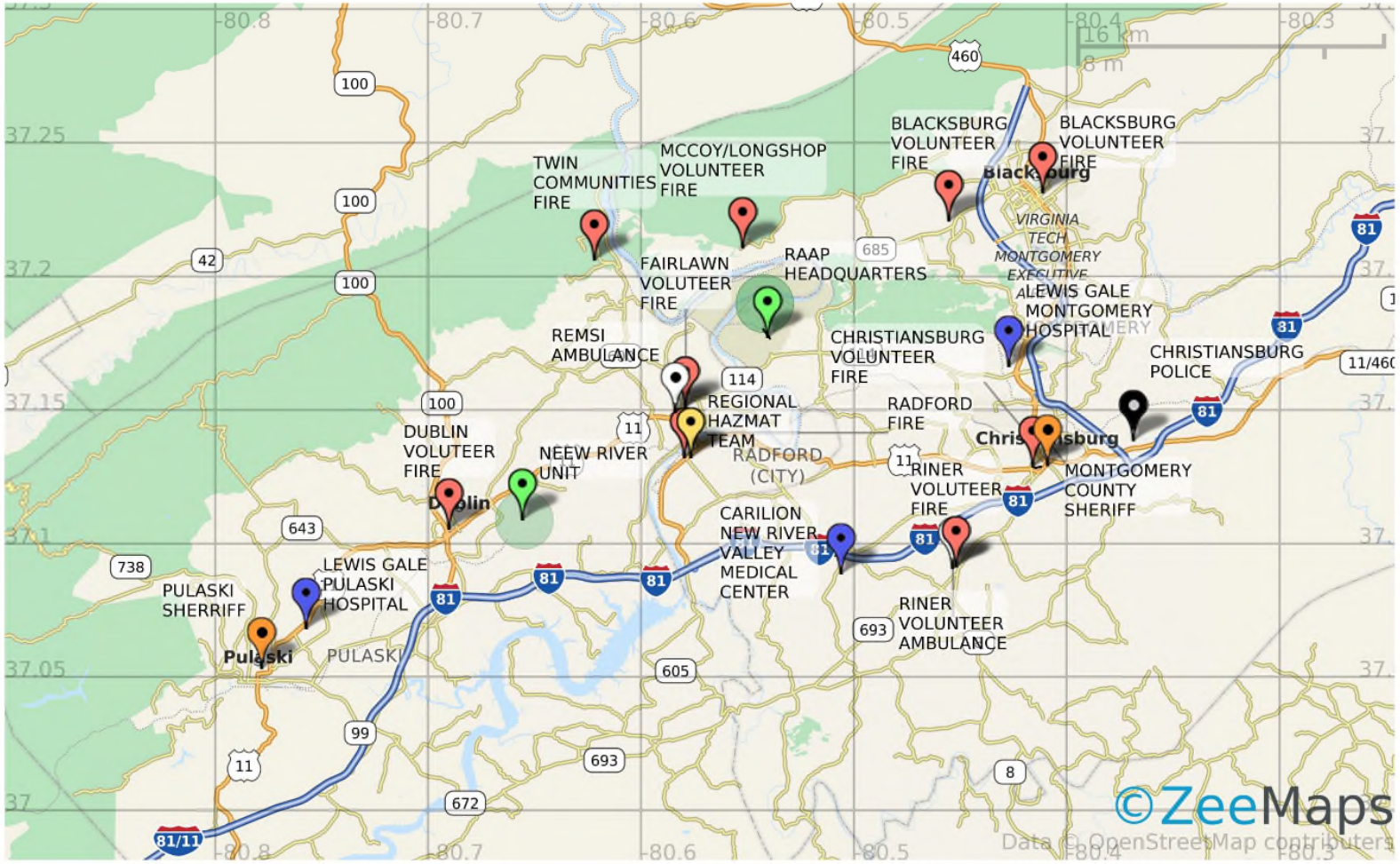
Craig Meadows
County Administrator

Radford Army Ammunition Plant

BY: _____

RUSSEL A. JONES
LTC, CM
Commanding

RFAAP


TWIN COMMUNITIES FIRE
MCCOY/LONGSHOP VOLUNTEER FIRE
BLACKSBURG VOLUNTEER FIRE
BLACKSBURG VOLUNTEER FIRE
FAIRLAWN VOLUTEER FIRE
RAAP HEADQUARTERS
VIRGINIA TECH MONTGOMERY EXECUTIVE
LEWIS GALE MONTGOMERY HOSPITAL
REMSI AMBULANCE
CHRISTIANSBURG VOLUNTEER FIRE
CHRISTIANSBURG POLICE
REGIONAL HAZMAT TEAM
RADFORD FIRE
DUBLIN VOLUTEER FIRE
NEEW RIVER UNIT
RADFORD (CITY)
RINER VOLUTEER FIRE
MONTGOMERY COUNTY SHERIFF
CARILION NEW RIVER VALLEY MEDICAL CENTER
LEWIS GALE PULASKI HOSPITAL
PULASKI SHERRIFF
Pulaski
PULASKI
RINER VOLUNTEER AMBULANCE
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ATTACHMENT II.C - FACILITY CONTACT REPRESENTATIVES

The post-closure care contact representative for the Radford Army Ammunition Plant is noted below:

On-site Operator Contact:

Mr. Nelson Hernandez
Environmental Manager
BAE Systems Ordnance Systems Inc. Radford Army Ammunition Plant
Route 114, P.O. Box 1
Radford, VA 24141-0100

Owner Contact:

Mr. Robert Davie, II
Chief Operations
United States Army
Route 114, PO Box 2
Radford Army Ammunition Plant
Radford, VA 24141

United States Army (Owner)
BAE Systems Ordnance Systems Inc. (Operator)

Radford Army Ammunition Plant
Route 114
Radford, Virginia, 24141-0100

ATTACHMENT II.D - DESCRIPTION OF WASTES

II.D-A. HWMU-5 WASTES

Revised RCRA Post-Closure Permit Application, HWMU-5, Radford AAP
First Revision: August, 1999

TABLE B-2

RESULTS OF ANALYSIS OF INFLUENT WASTE SAMPLE

TAKEN DURING LOW FLOW FROM HWMU-5

PARAMETER	RESULT
pH	1.5
Arsenic	ND
Barium	ND
Cadmium	0.029 mg/l
Chromium	0.20 mg/l
Lead	ND
Mercury	0.020 mg/l
Selenium	ND
Silver	ND

ND = Not Detected

Source: USAEHA (December 1981)

II.D-B. HWMU-16 WASTES

TABLE 4

SUMMARY DESCRIPTION OF WASTES DISPOSED IN HWM 16

Waste[a]	Rate of Generation[a] (tons/yr)	Physical[a] Form	Hazard Description	EPA Hazard[a] Number
Ash from waste propellant incineration	unknown	solid	reactive, non-EP toxic[a]	D003
Residue from waste propellant burning	unknown	solid	reactive, EP toxic[a]	D003 D008
Residue from explosive contaminated waste burning	200	solid	reactive[a]	D003
SAR area fume burner ash	0.1	solid	EP toxic[a]	D006, D007
Sludge from neut. of SAR process water	unknown	sludge	nonhazardous[a]	--
Sludge from neut. of nitro-cellulose mfg acid process water	unknown	sludge	nonhazardous[b]	--
Sludges from Bioplant, Building 470, and NG 2 Pretreatment Building 9410	50	sludge	non-hazardous[c,d,e]	--

a USAEHA (December 1981)
b Ewing (15 January 1982)
c Everett (19 March 1982)
d Everett (10 November 1982)
e Jenrette (18 November 1983)

TABLE B-2

EP TOXICITY RESULTS FOR WASTES DISPOSED IN HWMU-16

PARAMETER	Incinerator Ash from Waste Propellant Incinerator	Contaminated Burning Ground Ash	Propellant Burning Ground Ash
Arsenic	ND	ND	ND
Barium	ND	0.64 mg/l	0.76 mg/l
Cadmium	0.092 mg/l	0.032 mg/l	0.012 mg/l
Chromium	0.148 mg/l	0.026 mg/l	0.031 mg/l
Lead	3.4 mg/l	ND	51 mg/l
Mercury	ND	0.029 mg/l	ND
Selenium	ND	ND	ND
Silver	0.037 mg/l	ND	ND

ND = Not Detected

Source: USAEHA (December 1981)

P. O. No.	Date	Quantity	Material
80-83	9-19-80	58 lbs.	Lead Salicylate
80-100	11-3-80	550 lbs.	Sulfur
80-108	11-18-80	500 lbs.	Sulfur
81-3	1-7-81	250 lbs.	Nitrodiphenylamine
81-7	2-2-81	76 lbs.	Carbolac
81-7	2-2-81	25 lbs.	Alum. Powder
81-8	2-2-81	100 lbs.	Potassium Nitrate
81-14	2-11-81	400 lbs.	Cryolite
81-34	4-2-81	650 lbs.	Diphenylamine
81-43	4-27-81	15 lbs.	Chromium Nitrate Crystals
81-57	5-27-81	500 lbs.	Sulfur
81-74	7-8-81	450 lbs.	Cryolite, Synthetic
83-07	1-10-83	100 lbs.	Magnesium Oxide
83-10	1-19-83	200 lbs.	Charcoal
83-15	2-3-83	1.1 lbs.	Ferrous Ammonium Sulfate
83-25	2-14-83	1 lb.	Phenolphthalein Powder
		3 Bottles	Ferrous Ammonium Sulfate
83-48	4-15-83	150 lbs.	Ethyl Cellulose Flake
83-72	6-6-83	1.1 lbs.	Ferrous Ammonium Sulfate
83-76	6-13-83	3.0 lbs.	Barium Perchlorate
		0.5 lb.	Lead Dioxide
		0.5 lb.	Lead Nitrate
83-89	7-5-83	21 lbs.	Carbon Black
83-119	9-27-83	220 lbs.	Potassium Sulfate
82-67	8-10-82	3 Bottles	Tetra Bromethane
		17 Bottles	Stabilizer Sol. Ph 4
		11 Bottles	Sodium Methoxide
		9 Bottles	Chlorobenzene ←
82-77	8-26-82	120 Bottles	Yellow Ink
82-86	10-1-82	1095 Each	Combat Meals
82-107	12-8-82	2 Bottles	Alkalinity #1, Reagent #1
"	"	2 Bottles	Alkalinity, #2, Reagent #2
"	"	2 Bottles	Buffer Salt pH 7.2 Mixture
"	"	2 Rolls	Cotton, Aseptic, Absorbent
"	"	54 Gals.	Diubutyl Phthalate ←
"	"	2 Bottles	1, 3-Diphenylguanidine
"	"	2 Each	Mannitol - MP 166-167
"	"	2 Bottles	Mercuric Chloride
"	"	1 Bottle	Morpholine
"	"	2 Bottles	No. 2 Absorbing Reagent
"	"	2 Bottles	Nitrilotriethanol MP 20-22 DEG
"	"	2 Bottles	Sodium Sulfate Anhydrous
"	"	1 Lot	Perchloric Acid 70-72 PC
"	"	3 Pks.	Perfluoroelastomer
"	"	2 Bottles	Phosphorus Pentoxide Powder
"	"	1 lb.	Potassium Sulfate Powder
"	"	3 lbs.	Sodium Acetate, Crystals

B-1-2

P. O. No.	Date	Quantity	Material
82-107	12-8-82	3 Bottles	Sodium Citrate, Crystal
"	"	1 lb.	Sodium Cobaltinitrate Powder ←
"	"	1 Bottle	Sodium Methoxide
"	"	2 Bottles	Sodium Oxalate Standard
"	"	6 lbs.	Stearic Acid
"	"	1 Lot	Sucrose Rea Cry
"	"	4 Gals.	Tetrahydrofuran ←
"	"	1 Lot	Thymol Blue B Indicator Solution
"	"	9 Bottles	Triphenyl Phosphate
"	"	1 lb.	Uranyl Acetate
"	"	1 Bottle	Zinc Metal Dust
"	"	4 Pks.	Total Count Millipore Filters

0713b

B-1-3

Additional Materials Placed in Site 16 Hazardous Waste Trench Since 1980

a. 2168 tons of residues from burning explosives and explosives - contaminated wastes

b. 545 tons of wastewater treatment sludges

c. 165 tons of flashed spent activated carbon

B-1-4

ATTACHMENT II.E - SECURITY PROVISIONS AND MAINTENANCE

II.E-A. INTRODUCTION

Protection of plant personnel, property, resources and operations at the Radford Army Ammunition Plant (RFAAP), a Government-owned, contractor-operated (GOCO) manufacturing facility, is provided under contract by BAE Systems Ordnance Systems Inc. (BAE) in accordance with Department of the Defense (DOD), Department of the Army (DA), United States Army Joint Munitions Command (USAJMC) and other regulatory guidance and standards. A subcontractor security guard force, Centerra, is used to perform and enforce prescribed physical security measures.

II.E-B. SECURITY PROCEDURES AND EQUIPMENT

Security areas on the installation have been designated as Limited and Posted Areas. These areas and corresponding control measures are documented in Chapter 2 of the Plant Protection Plan (PPP). RFAAP is considered a "closed post" in that access is controlled at all times by perimeter barriers with limited, manned entry control points. The PPP also contains Security Guard orders, Security Guard standing operating procedures (SOPs) and numerous plans for execution in specific situations such as bomb threat, installation closure, work stoppage and civil disturbance. SOPs cover a range of subjects such as property movement, personnel and visitor identification and control, vehicle and personnel searches, perimeter inspections, key and lock control, and use of force. Security Guard Orders cover specific duties and requirements at assigned Security Guard posts, gates and stations. Physical security measures at RFAAP include Security Guard patrols, manned security posts, perimeter fencing, badge identification system, lock and key accountability and rotation, vehicle registration, pre-employment background investigations, security lighting, warning signs and physical barriers. At storage sites, tank inlets and disbursing valves are secured with security padlocks.

II.E-C. SECURITY GUARD FORCE

The Security Guard Force provides 24 x 7 security coverage and is divided into three (3) shifts. Each shift consists of manned posts, roving patrols and management personnel. The roving patrols perform random checks each shift of manufacturing areas, locked explosive storage buildings and road-visible perimeter fencing.

II.E-D. BARRIERS AND ENTRY CONTROL

Entry to the Radford Army Ammunition Plant is restricted. Personnel must be in possession of a valid personnel identification badge or visitor badge. If the person

has valid official business at the plant or is accompanying a person who does have such business, posted area visitor badges are issued and the time and date of entry is recorded. Entry onto any of the HWMUs by anyone other than environmental or sampling personnel requires an Area Entry Permit.

II.E-E. WARNING SIGNS

At all plant entrances and in areas designated as posted, the following "Condition of Entry" signs have been erected:

CONDITION OF ENTRY

TO

RADFORD ARMY AMMUNITION PLANT

All persons, their possessions and vehicles are liable to search upon entering, during their stay, or upon their leaving this installation. Entry of persons and/or vehicles constitutes consent to search by proper authorities at any time.

The following articles are prohibited on this installation:

- Alcohol
- Firearms, Ammunition and Weapons
- Explosives and Explosives Devices
- Cameras (Unless Authorized in Writing)
- Camera Cell Phones (Unless Registered)
- Intoxicants and Drugs
- Gambling Devices
- Chemical Emission Devices
- Stolen Property and Obscene Literature

By Order of the Commanding Officer

Signs reading "U.S. Government Property-No Trespassing" are located approximately every 500 feet on the installation boundary, except where designated Limited Area fences are not located on or reasonably adjacent to the property boundary.

Every 500 feet on Limited Area fencing and at other highly visible locations, such as corners and gates, the following sign is located on the fence facing outward:

U.S. ARMY

RESTRICTED AREA

WARNING

This area has been declared a restricted Area by authority of the Commanding Officer, in accordance with provisions of the Directive issued by the Secretary of Defense on 20 August 1954, pursuant to the provisions of Section 21, Internal Security Act of 1950. Unauthorized entry is prohibited. All persons and vehicles entering heron are liable to search. Photographing, making notes, drawings, maps, or graphic representations of this area or test activities are prohibited unless specifically authorized by the Commanding Officer. Any such material found in the possession of unauthorized persons will be confiscated.

In addition, information signs warning against smoking and the introduction of matches and other flame-producing devices are displayed at all normally used gates.

ATTACHMENT II.F - INSPECTION AND MAINTENANCE PLAN

II.F-A. HIGHLIGHTS

In accordance with 40 CFR 264.15, the Permittees shall follow a written inspection schedule for each Unit, shall maintain a signed and dated Inspection Log, and shall implement remedial action when necessary to remediate any observed malfunctions, deterioration, operational errors, and discharges from the erosion controls, final cover system, and peripheral drainage swales; the security controls; the ground water monitoring system; and, the condition of benchmarks.

The Inspection Log shall be maintained at the facility and shall be made available to the Department for inspection upon request. The Inspection Log shall provide inspection observations, deficiencies noted, and corrective action taken. All inspections shall be performed by persons properly trained for this task, as specified in Permit Attachment II.G (Personnel and Training), at the frequencies specified in Table II.F-1.

II.F-B. GENERAL INSPECTION REQUIREMENTS

Inspections function as a preventative measure to help ensure safe operations and to identify potential problems before they can become serious problems. All Units will be inspected as specified in this Inspection Schedule.

All inspection results will be recorded by the individual who performs the inspection, at that time of the inspection, on an inspection form. The individual performing the inspection will sign and date each completed inspection form. Separate inspection forms are used for each unit and are documented on *DUP 6057F, Inspection of Closed Hazardous Waste Management Unit* (see Appendix II.F.1).

Only personnel who have completed appropriate training and are approved for the task shall conduct inspections pursuant to this Inspection Schedule.

II.F-C. INSPECTION SCHEDULE

The Permittees shall inspect the final soil cover, vegetative cover, peripheral drainage swales, PVC liner, stormwater drainage areas, fence, warning signs, access road, monitoring wells, and benchmarks at least semi-annually, in accordance with the schedule specified in Table II.F-1. The Inspection Items and their associated Types of Problems listed in Table II.F-1 are important due to their role in preventing, detecting, or responding to environmental or human health hazards.

For each Inspection Item subject to inspection, a list of problems normally encountered is identified in Table II.F-1. Inspections will explicitly examine each item for the presence of the potential problems for each inspection item as specified in Table II.F-1. Inspections of each item will be conducted at the frequency specified.

Table II.F-1 – Inspection Schedule

INSPECTION ITEM	TYPES OF PROBLEMS	FREQUENCY OF INSPECTION
Final Soil Cover	Erosion, Settlement, Subsidence, or Displacement, and Ponding	Semi-annually
Vegetative Cover	Dead vegetation, or inadequate growth, presence of trees, shrubs, or deep rooted vegetation, need to fertilize, irrigate, or cut grass	Semi-annually
Peripheral Drainage Swales	Erosion, Subsidence, Pooling	Semi-annually
PVC Liner	Exposure	Semi-annually
Stormwater Drainage Areas	Erosion, Subsidence, Vegetation growth, Accumulated Sediment	Semi-annually
Monitoring Wells (Outer protective casing, well caps and locks, concrete pad, and inner cap and riser)	Damage to Locks and Caps and cracks or settlement	Semi-annually
Security	Damage to Fencing, Warning Signs, and Access road	Semi-annually
Benchmarks	Damage to monument	Semi-annually

II.F-D. SECURITY CONTROLS

II.F-D.1. Fencing

Access to Units shall be restricted by the Permittees' Security System, as specified in Permit Attachment II.E. The Permittees shall inspect the installation fencing at least semi-annually and any damage shall be noted in the Semi-annual Inspection Log (see Appendix II.F.1) and repaired or replaced as necessary.

II.F-D.2. Warning Signs

"U.S. Government Property-No Trespassing" signs and as specified in Permit Attachment II.E, shall be posted on the fences at the installation boundary near Units. The Permittees shall inspect the condition of the warning signs at least semi-annually during security inspections.

II.F-E. GROUND WATER MONITORING SYSTEM INSPECTION AND MAINTENANCE PLAN

II.F-E.1. Inspection

During the post-closure care period all monitoring wells and piezometers shall be inspected at least semi-annually during ground water sampling events for general condition and integrity. All inspection observations shall be recorded on an inspection log sheet similar to that given in Appendix II.F.1. Copies of the inspection log sheets shall be maintained on file for a minimum of three years. The inspection shall consist of the following:

a. Inspection of outer protective casing

   i. The outer protective casing shall be visually inspected to determine casing integrity.

b. Well caps and locks

   i. Well caps and locks shall be visually inspected to insure that both are in place and functioning properly.

c. Concrete pad

   i. The concrete pad shall be visually inspected for the presence of cracks and settlement.

d. Inspection of inner cap and riser pipe

   i. The inner cap and riser pipe shall be visually inspected to insure that they are intact and functioning properly.

II.F-E.2. Preventive/Corrective Maintenance

Based on the visual inspections, monitoring wells shall be maintained by conducting the following as required:

a. Replacement of well caps.

b. Lubrication of locks.

c. Replacement of locks.

d. Painting of outer protective casing in high visibility color.

e. Replacement of concrete pad.

f. Replacement of well.

II.F-E.3. Inspection Record Keeping

The operators involved with ground water monitoring will record each inspection on a Semi-annual Inspection Log. These forms will be maintained as part of the facility operating record for at least three years from the date of inspection. These records will include the date and time of inspection, the name of the inspector (including full signature), a notation of the observations made, and the date and nature of any repairs or remedial actions.

II.F-F. BENCHMARKS

The Permittees shall inspect all surveyed benchmarks (see Appendix II.F.2) at least annually. The benchmarks shall be maintained, repaired, or replaced as necessary. The benchmarks shall be clearly identified and protected.

Permanent survey benchmarks are constructed of concrete. These units are not typically degradable and should not require replacement during the post-closure care period.

II.F-G. MAINTENANCE PLAN - REMEDIAL ACTION FOR EROSION CONTROLS, FINAL COVER SYSTEM, AND PERIPHERAL DRAINAGE SWALES

If the Permittee discovers any problems or deficiencies with the erosion controls, final cover system, and peripheral drainage swales during an inspection, then that problem or deficiency will be recorded on the Semi-annual Inspection Log (see Appendix II.F.1). Any necessary remediation actions will also be noted on the form and the problem or deficiency will be brought to the attention of the appropriate supervisor. After repairs or remedial actions have been completed, the date and nature of the repairs or remedial actions will be recorded on the same inspection form on which the problem or deficiency was originally noted.

If the Inspector discovers any problems or deficiencies that could lead to a release of hazardous waste or which could threaten personnel safety, operations will cease until the problem or deficiency is rectified. In no case will operations resume until all spill and emergency response equipment is operable and adequately stocked.

II.F-G.1. Erosion Controls

The Permittees shall inspect the peripheral drainage swales and riprap at each Unit at least semi-annually or after every major rainfall (approximately 2 inches per 8-hour period) or catastrophic events (e.g., fire or explosion elsewhere at the installation). The erosion controls (riprap and drainage swales) shall be maintained/repaired in accordance with the approved Closure/Post-Closure Plan (see Permit Attachment III.A).

II.F-G.2. Final Cover System

a. All Units were capped with a composite liner consisting of (from ground surface to base of cap):

i. vegetative cover;

ii. riprap perimeter;

iii. filter fabric between the riprap and the cover soil;

iv. two feet of topsoil;

v. one foot of drainage layer (10^{-3} cm/sec permeability);

vi. a 30 mil PVC membrane liner; and

vii. two feet of clay (10^{-7} cm/sec permeability).

The final cover system is designed to ensure the integrity and to minimize surface water run-on and run-off with a minimum of maintenance. No heavy equipment or vehicles shall be permitted on the final cover area unless involved in maintenance or repair activities.

b. Settlement, Subsidence, and Displacement

The Permittees will maintain the final cover at the approximate slope and gradients specified in the Post-Closure Plan. Slope and gradient shall be checked when there is an apparent change detected during inspections due to settling, subsidence, or displacement

c. Erosion Damage/Water Pooling

The Permittees shall inspect the final cover at least semi-annually or after every major rainfall (approximately 2 inches per 8-hour period) or catastrophic event (e.g., fire or explosion elsewhere at the installation) for erosion, pooling of water, and visible damage. Erosion or pooling of water shall be corrected.

d. Vegetative Cover

The Permittees shall inspect the vegetative cover at least semi-annually or after every major rainfall (approximately 2 inches per 8-hour period) or catastrophic event (e.g., fire or explosion elsewhere at the installation). Maintenance shall be performed as needed. Damaged or dead vegetation shall be removed and replaced with equivalent vegetation. No trees, shrubs, or other deep-rooted plants shall be allowed to grow on any Unit. Areas damaged by erosion shall be repaired and re-vegetated.

The vegetative layer shall be maintained by fertilizing, irrigating, and cutting, if necessary. Fertilizing shall be performed as often as necessary to maintain the layer. Irrigating and cutting are seasonally dependent and shall be performed as often as necessary.

II.F-G.3. Peripheral Drainage Swales

The Permittees shall inspect the peripheral drainage swales at least semi-annually or after every major rainfall (approximately 2 inches per 8-hour period) or catastrophic event (e.g., fire or explosion elsewhere at the installation).

All peripheral drainage swales shall be maintained and kept free of debris or other blockage. Drainage controls shall be inspected semi-annually and after major storms (approximately 2 inches of rain over an 8-hour period) and cleaned, as necessary. Repairs shall include regrading and re-vegetation, if necessary.

Appendix II.F.1. – EXAMPLE SEMI-ANNUAL INSPECTION LOG

DUP 6057F (Rev. Lev. 0, 11/1/2000)

INSPECTION OF CLOSED HAZARDOUS WASTE MANAGEMENT FACILITIES

Name of Hazardous Waste Management Facility: _____
HWMU Facility No. _____
EPA Permit No. _____
Date of Inspection _____ /_____ /_____ Time of Inspection _____: _____ AM/ PM
Reason for Inspection: Semiannual/ Major rainfall event (2" in 8 hr period)/ catastrophic event

ITEM	INSPECT FOR	DEFICIENCIES NOTED	REMEDIAL ACTION REQUIRED
Final Soil Cover	Erosion Settlement, Subsidence, or Displacement Pooling		
Vegetative Cover	Dead vegetation, or inadequate growth Presence of trees, shrubs, or deep rooted vegetation Need to fertilize, irrigate, or cut grass		
PVC Liner	Liner exposed		
Peripheral Drainage Swales	Erosion Subsidence Pooling		
Stormwater Drainage Areas	Erosion Subsidence Vegetation growth Accumulated sediment		
Security	Access road in place Warning signs legible and in place Fences not breached and no visible damage		
Monitoring Wells Outer protective casing Well caps and locks Concrete pad Inner cap and riser	 Casing in good condition In place and functioning Cracks or settlement Intact and functioning		
Benchmarks (3)	Monuments present and visible Damage to monument		

Date and nature of repairs or remedial action: _____
_____

Printed Name of Inspector: _____ Signature of Inspector: _____

Company: _____

Date remedial action completed: _____ Remedial action approved by: _____

Appendix II.F.2. – RADFORD ARMY AMMUNITION PLANT BENCHMARK LOCATIONS MAPS

RADFORD ARMY AMMUNITION PLANT
HERCULES INCORPORATED
RADFORD, VIRGINIA

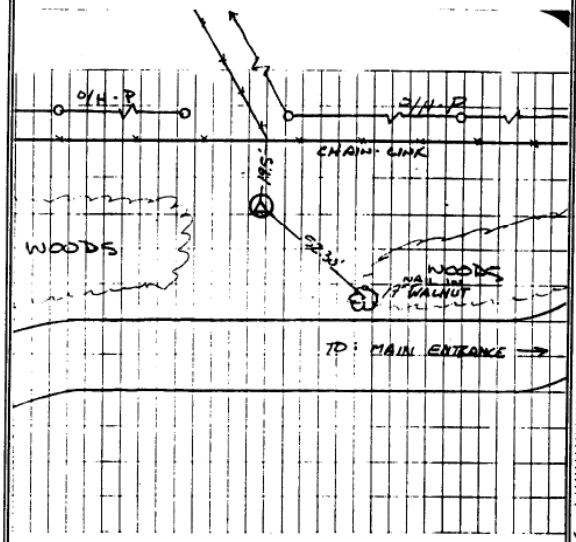
1991 GEODETIC GROUND CONTROL NETWORK MONUMENT SURVEY

REFERENCE AND RECOVERY DATA SHEET

VIRGINIA COORDINATE SYSTEM OF 1983 - SOUTH ZONE			
STATION	UNITS	NORTHING (Y)	EASTING (X)
Flip	METERS	1095506.5627	3317792.2313
	U.S. SURVEY FT.	3594174.448	10885123.346
LATITUDE		LONGITUDE	
37-10-33.984691		80-33-07.249064	

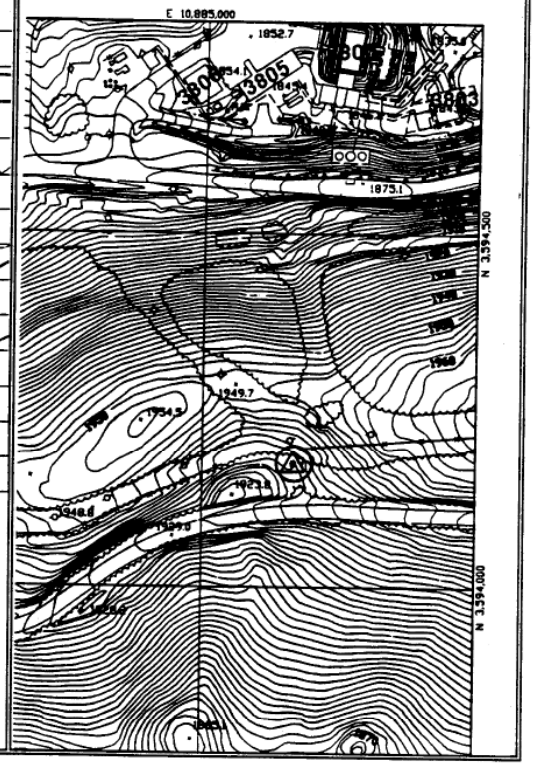
VERTICAL DATA	
ELEVATIONS REFER TO UNITED STATES GEODETIC SURVEY VERTICAL DATUM (1988)	
ELEVATION OF STATION IN FEET = 1934.813	
STATION Flip	FIELD BOOK 6452.03R V.C. 1 of 2 pg. 66
COUNTY/STATE Montgomery County, VA	USGS QUADRANGLE Radford North

LOCATION SKETCH (NOT TO SCALE)



A 3" disk set in concrete flush with ground surrounded by 3 metal fence posts forming a triangular configuration.

LOCATION MAP (SCALE 1"=200)



Draper Aden Associates
CONSULTING ENGINEERS
BLACKSBURG - RICHMOND, VIRGINIA
NASHVILLE, TENNESSEE

RADFORD ARMY AMMUNITION PLANT
HERCULES INCORPORATED
RADFORD, VIRGINIA

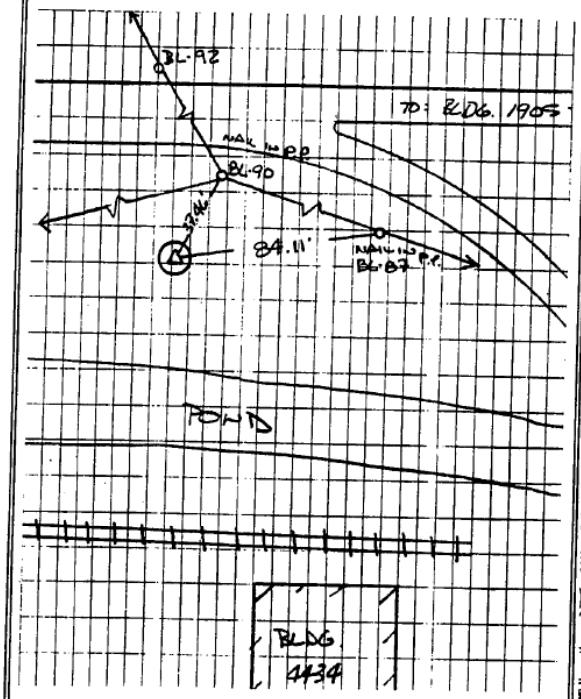
1991 GEODETIC GROUND CONTROL NETWORK MONUMENT SURVEY

REFERENCE AND RECOVERY DATA SHEET

VIRGINIA COORDINATE SYSTEM OF 1983 - SOUTH ZONE			
STATION	UNITS	NORTHING (Y)	EASTING (X)
Klutz	METERS	1096461.7814	3317529.5764
	U.S. SURVEY FT.	3597308.361	10884261.619
LATITUDE		LONGITUDE	
37-11-04.778915		80-33-18.737496	

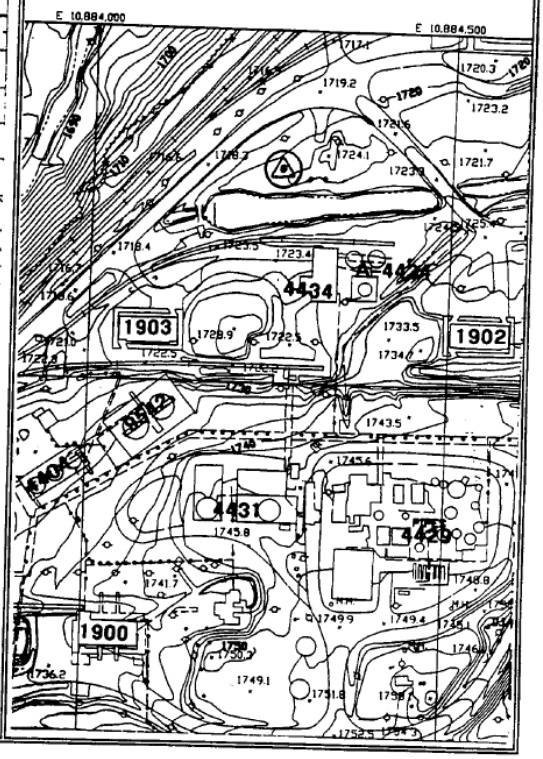
VERTICAL DATA	
ELEVATIONS REFER TO UNITED STATES GEODETIC SURVEY VERTICAL DATUM (1988)	
ELEVATION OF STATION IN FEET = 1720.849	
STATION Klutz	FIELD BOOK 6452.03R V.C. 1 of 2 pg. 75
COUNTY/STATE Montgomery County, VA	USGS QUADRANGLE Radford North

LOCATION SKETCH (NOT TO SCALE)



A 3" disk set in concrete flush with ground surrounded by 3 metal fence posts forming a triangular configuration.

LOCATION MAP (SCALE 1"=200)



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NASHVILLE, TENNESSEE

RADFORD ARMY AMMUNITION PLANT
HERCULES INCORPORATED
RADFORD, VIRGINIA

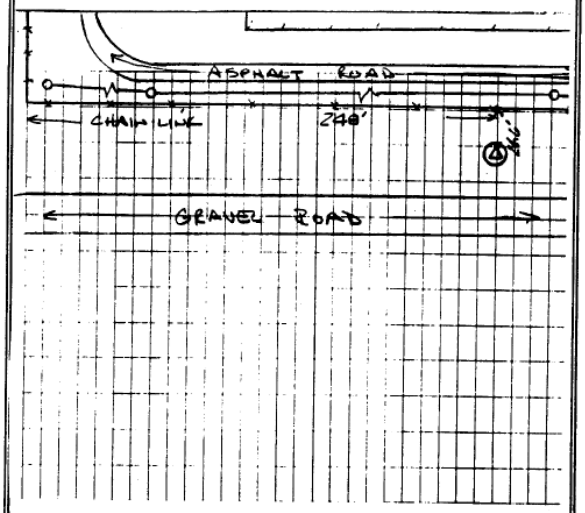
1991 GEODETIC GROUND CONTROL NETWORK MONUMENT SURVEY

REFERENCE AND RECOVERY DATA SHEET

VIRGINIA COORDINATE SYSTEM OF 1983 - SOUTH ZONE			
STATION	UNITS	NORTHING (Y)	EASTING (X)
Elroy	METERS	1095391.1480	3317058.9906
	U.S. SURVEY FT.	3593795.791	10882717.705
LATITUDE		LONGITUDE	
37-10-29.723548		80-33-36.865315	

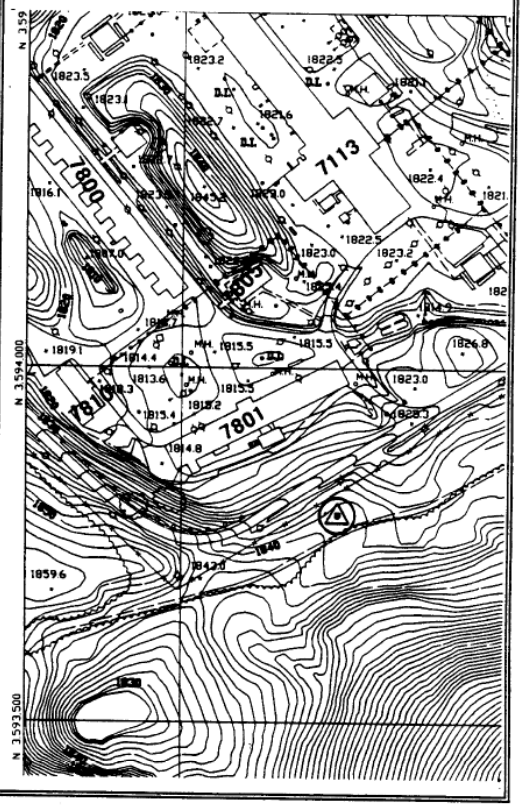
VERTICAL DATA	
ELEVATIONS REFER TO UNITED STATES GEODETIC SURVEY VERTICAL DATUM (1988)	
ELEVATION OF STATION IN FEET = 1838.856	
STATION Elroy	FIELD BOOK 6452.03R V.C. 1 of 2 pg. 69
COUNTY/STATE Montgomery County, VA	USGS QUADRANGLE Radford North

LOCATION SKETCH (NOT TO SCALE)



A 3" disk set in concrete flush with ground, surrounded by three metal fence posts forming a triangular configuration.

LOCATION MAP (SCALE 1"=200)



Draper Aden Associates
CONSULTING ENGINEERS
BLACKSBURG - RICHMOND, VIRGINIA
NASHVILLE, TENNESSEE

ATTACHMENT II.G - PERSONNEL AND TRAINING

II.G-A. Appropriate training shall be completed by all persons at RAAP and/or their consultants who are or may be involved in a task associated with a hazardous waste post-closure care activity. The Permittee shall insure that those individuals responsible for groundwater monitoring, inspections, and repair are appropriately trained. New employees who have as part of their job responsibility tasks which are associated or may be associated with a post-closure care activity shall not work unsupervised until the training requirements in accordance with this permit are completed. Such new employees shall complete required training within six months of their employment date.

II.G-B. All training of personnel shall be documented at the time of each completed session and such documentation shall be maintained in the facility files in the operating log for at least three years from the date on which the training was completed. Such documentation shall include the name of each trainee and trainer, date of instruction, and a summary or outline of the training session.

II.G-C. All training under this permit shall be reviewed at least annually and updated as necessary. All personnel who are subject to the training requirements under this permit shall be required to review their training at least annually.

II.G-D. In general, all personnel who are actively associated or may be associated with the proper inspection and maintenance of the monitoring wells and the proper operation of the monitoring wells are required to read the Permittees' Post-closure Plan and/or Sampling and Analysis Procedures as appropriate. The personnel shall be trained to properly perform their assigned duties including, but not limited to, conducting inspections required by Permit Attachment II.F, obtaining samples from groundwater monitoring wells and maintaining documentation in accordance with the requirement of this permit.

II.G-E. The personnel noted above shall be required under this permit to fully understand the techniques of proper maintenance and operation and maintain appropriate documentation required under this permit. Supervisory staff shall be trained to review and to provide appropriate guidance and/or liaison with the Permittees' management. The Permittee shall provide sufficient opportunity for personnel to acquire a full understanding of maintenance and operation techniques by providing sufficient instruction and/or sponsoring sufficient instruction by professionals who are qualified to provide such instruction.

II.G-F. All personnel who are or may be exposed to the hazards associated with the post-closure care activity shall receive the appropriate training and shall utilize the appropriate personnel training as specified by the Occupational Safety and Health Act (OSHA) requirements in 29 CFR 1910.120.

II.G-G. The personnel involved in the actual post-closure care activity, specifically the groundwater monitoring wells, within the scope of this permit will be trained in the proper procedures for spent monitoring well sample effluent (i.e., purge water, decontamination fluids) and the Sampling and Analysis Plan and Groundwater Monitoring Program required by Permit Modules IV, V, and VI. These procedures will ensure continued safe operation and maintenance and compliance with applicable environmental regulations.

II.G-H. The facility contact will be responsible for the overall training program, scheduling and documentation of such training and shall serve as the post-closure care Training Director. He/she shall ensure that all sub-contractors are trained in accordance with OSHA 1910.120(3)(2).

II.G-I. All personnel required under this permit to receive training shall at minimum be instructed in the following areas:

a. Area specific management practices regarding post-closure care activities.

b. Security and safety.

c. General and area specific inspections and record keeping.

d. Regulatory updates which affect operations and activities.

e. Job function and procedural descriptions of each employee's respective role in post-closure care.

II.G-J. Appendices II.G.1 – II.G.3 of this Attachment provide a summary of the position descriptions and specific training requirements for personnel who have or may be given tasks associated with post-closure care activity.

Appendix II.G.1 – OUTLINE OF TRAINING PROGRAM

1. Personnel Training

The purpose of the introductory and continuing hazardous waste training program is to educate the employees who are responsible for handling hazardous wastes and any post closure care permit related tasks. The program makes known to the employee the hazards of those wastes and the proper procedures to follow in the event of an emergency. The employee training has been and will be completed through formal classes and through on-the-job training given by Permittee.

2. Outline of the Training Program

The permittees have an established section of personnel responsible for the employee training program. The training program at the facility consists of a general orientation, instruction for area-specific procedures, on-the-job training, and a general and continuing training program.

3. Job Title/Job Description

Job titles, job descriptions, and the names of those individuals involved with hazardous wastes at the permitted treatment and storage area are summarized in the table in Appendix II.G.3. Those job titles and the name of the individual filling it are maintained and kept on file at the facility.

4. Training Content, Frequency, and Techniques

Introductory training for all facility employees consists of general orientation which is provided by the facility training department. Training in operating procedures is given on-the-job by the area foreman. The operating procedures cover subjects such as cleaning equipment and materials, operating equipment and materials, safety rules and precautions, and a step-by-step description of the designated task.

Facility personnel have or will successfully complete the required training program within six (6) months after the effective date of their employment or assignment to the permitted treatment and storage area, or to a new position at the permitted treatment and storage area, whichever is later. Employees will not work in unsupervised positions until they have completed the training requirements described in this section. Facility personnel will also participate in an annual review of the introductory training program.

All personnel who are or may be exposed to the hazards associated with the post-closure care activity shall receive the appropriate training and shall utilize the appropriate personnel training as specified by the Occupational Safety and Health

Act (OSHA) requirements in 29 CFR 1910.120.

5. Training Director

The overall responsibility for facility training is the Permittee.

Permittee conducts or oversees all hazardous waste management training and maintenance of personnel training records. The responsibilities for this position include compiling the hazardous waste annual report, notifying health, safety, security, operations, and fire departments of changes in facility status, and reviewing operating procedures. Appropriate changes in facility operating procedures are implemented as a result of training.

Operating personnel receive on-the-job training based on these operating procedures. In this way, the training of the operating personnel in facility procedures is accomplished. The training department manager maintains the records of all training at RFAAP.

6. Relevance of Training to Job Description

All employees receive general plant orientation and training in area specific procedures. Employees then receive on-the-job training which specifically pertains to their area of involvement. If the monitoring is outsourced, the contractor employees will be trained to comply with the requirements of the permit.

Training records are maintained for all facility employees. Training records of all employees involved with hazardous waste management will be reviewed annually in order to ensure that employee training is current and that appropriate and relevant training is coordinated with employee job functions.

Contractor employees training records will be maintained by the contractor and supplied to BAE on an annual basis for recordkeeping.

7. Training for Emergency Response

The training program at RFAAP includes on-the-job training to cover effective response to emergencies.

Due to the reactive wastes at the facility, it is imperative that adequate fire prevention and protection is provided by the facility's fire department. The Fire Prevention and Protection Training Program includes drills, exercises, and hands-on training sessions. Each fireman receives minimum of four hours training each week. A training schedule is prepared and a training record is maintained on each fireman and retained in the fire station. New firemen receive formal and on-the-

job training and respond with the fire company to all fires. The basic training period usually covers at least 18 months depending on prior qualification and experience of the new fireman. Training of other employees is conducted during drills and safety meetings. Fire department personnel are available to other people on request to conduct classes, demonstrations and drills.

8. Implementation of the Training Program

There exists at RFAAP, an extensive system and computer program to ensure that required on-the-job training has been conducted with each employee. Based on the job title/description, each employee is assigned two sets of training programs and procedures. The first set is a general plant training set that each new employee gets and the second set of training is an area and job specific set. These training sets have a deadline that they have to be completed by and if they are reaching the deadline or miss it, the employee and/or employee's supervisor will receive notification to that effect. On-the-job training and area specific procedure training is usually performed by the foreman/supervisor to the employees and when complete they will verify the training by signing a sign-off sheet.

Training records and the computer training program is maintained by the training department. The system notifies supervision when training is required.

Current training records of employees involved with hazardous waste management will be kept until closure of the hazardous waste facilities. Training records on former employees will be kept for at least three years from the date the employee last worked at the facility.

Appendix II.G.2 – JOB DESCRIPTION SUMMARY

A. Facility Coordinator:

Oversees the monitoring wells, unit cap, security fence safety, and inspection and maintenance programs. Has record keeping responsibilities, retains Hazardous Waste Management Facility Permit, inspection checklists and/or logs, and assures that all inspection and maintenance schedules are in accordance with Permit Attachment II.F.

B. Monitoring Well Samplers:

Follows sampling protocol as described in Permit Attachment V.B. Collects samples and decontaminates equipment. Stabilizes samples and provides transport to appropriate laboratory facility for analysis. Transports and disposes of purge or decontamination water at the on-site water treatment facility. Checks wells for structural integrity and security. Redevelops monitoring wells when necessary. Maintains accurate and detailed records/logs of observations and remediation if required in accordance with Permit Attachment V.B.

C. Hazardous Waste Management Unit Inspectors:

Follows inspection requirements as outlined in Attachment II.F. Inspects the HWMU's following the inspection schedule, record keeping requirements, and training. Maintains accurate and detailed inspection forms noting any issues and corrective/preventive actions taken.

Appendix II.G.3 – PERSONNEL TRAINING SUMMARY

TITLE	RESPONSIBILITY AND TRAINING REQUIREMENTS
RCRA Coordinator	Responsible for overall administration of hazardous waste management program as directed by the Army under the terms of the operating contract for the installations. Trained in all aspects of hazardous waste management. Involved in pollution abatement and hazardous waste management. Responsible for Waste Analysis Plan.
Training Coordinator	Conduct general and continuing training program.
Plant Protection Manager	Overall monitoring of radio transmissions and HWMU security. Trained in all aspects of hazardous waste emergency response.
Fire Department Coordinator	Assist in preparation and presentation of training program, maintain pre-fire plan for SWMU's, responds to fire alarms. Trained in hazardous waste emergency procedures.
Medical Director	Responds to all health emergencies. Responsible for all aspects of hazardous waste emergency health responses.
Sub-contract Groundwater Samplers	Responsible to have trained personnel to properly collect groundwater samples. Trained to collect groundwater samples.
Inspector	Responsible for performing the required inspections and trained to inspect the closed units according to the permit.
Firemen	Respond to hazardous waste emergencies. Trained in all aspects of hazardous waste emergency response. Training conducted with regular fire training and not hazardous waste program.
Environmental Manager	Functions as alternate to RCRA Coordinator. Responsible for overall plant environmental management. Trained in all aspects of manufacturing and hazardous waste disposal operations.
VP Operations	Functions as alternate to RCRA Coordinator. Responsible for overall plant management. Trained in all aspects of manufacturing operations.

NOTE: Names of responsible personnel associated with Permit compliance will be maintained in the facility record at Radford AAP in accordance with 40 CFR § 264.16(d).

MODULE III - POST-CLOSURE CARE

The Permit Sections in this Module apply to both units: HWMU-5 and HWMU-16.

Mr. Nelson Hernandez, Environmental Program Manager, of BAE Systems Ordnance Systems Inc., Route 114, Radford, Virginia, 24143-0100 (540-639-7701), and Mr. Matt Alberts of the Department of the Army ACOP staff, Route 114 Radford, Virginia 24143-0002 are the designated persons to contact in reference to this post-closure permit during the post closure care period.

III.A. UNIT IDENTIFICATION AND CLOSURE CONSTRUCTION

III.A.1 HWMU-5

HWMU-5 is a single hazardous waste management unit (HWMU) for the purposes of groundwater monitoring. The waste is remained in place at closure. Therefore, the Permittees are required to conduct post-closure care for the HWMU in accordance with the terms and conditions of this permit. The basic closure construction includes a cap and a liner.

The closed HWMU-5 has been capped with a composite liner consisting of (from ground surface to base of cap):

a. Vegetative cover;
b. Two feet of topsoil;
c. One foot of drainage layer (no less than 10^{-3} cm/sec permeability);
d. A 30 mil PVC membrane liner; and
e. Two feet of clay (10^{-7} cm/sec permeability or less).

Additional features associated with the cover system include a perimeter of riprap slope protection, filter fabric between the riprap and cover soil, and drainage swales to divert surface flows away from the Unit. Construction was performed per the approved Closure Plan dated May 27, 1988. Details of the cap construction and effectiveness are presented in the post-closure plan for the Unit (Permit Attachment III.A).

HWMU-5 was put into operation as an unlined surface impoundment in 1970 and was retrofitted with a 60 mil Hypalon liner in 1981. The liner was covered with approximately 12 inches of sand and the sides were covered with approximately 6 inches of sand and 6 inches of granite riprap. The Unit's dimensions were approximately 150 feet by 100 feet at the top of the berm. The berm rose 10 feet above the base of the impoundment. The impoundment was taken out of operation in 1986. HWMU-5 was closed in 1989. The basin was drained of all waters and the soil was treated in place with lime kiln dust to achieve a target pH between 6.3 and 10.5. As part of demolition and cleanup activities, per the

Closure Plan for HWMU-5, the riprap was removed and used for the perimeter of the cover system for the Unit. The cover sand on the bottom and side slopes were removed and later used as backfill material in HWMU-5. The Hypalon liner was cut into pieces and disposed of in HWMU-5 as part of backfilling. HWMU-5 has never had leachate collection system in place.

III.A.2 UNIT 16

The hazardous waste landfill post-closure details and specifications are included in Permit Attachment III.A. Construction was performed per the approved Closure Plan dated May 27, 1988. HWMU-16 consisted of a trench measuring approximately 60 feet width, 400 length and 10 to 14 depth feet. The trench was constructed without a liner or leachate collection system. The hazardous waste landfill unit trench was first used in 1980. Waste disposal within the Unit began in 1980. The trench had an estimated capacity of 6,000 cubic yards, and was filled to approximately 80% of its capacity.

The closure construction included leachate drain system installation and cover system installation, including associated drainage swales to divert surface flows away from the Unit. The final cover system consists of one foot of topsoil with grass cover; one foot of cover soil; one foot of drainage sand layer (no less than 10^{-3} cm/sec permeability), a 30-mil PVC membrane liner; and a two-foot thick clay liner (10^{-7} cm/sec permeability or less). To the knowledge of current facility personnel, leachate has not been produced, collected, or sampled at HWMU-16.

III.B. POST-CLOSURE PROCEDURES AND USE OF PROPERTY

III.B.1. Post-Closure Care

The Permittees shall conduct post-closure care for the hazardous waste management units listed in Permit Sections III.A.1 (HWMU-5) and III.A.2 (HWMU-16), for a period of thirty (30) years after final closure certification was accepted by Department. The specific date for each unit is listed Permit Section I.J. The 30-year post-closure care period may be shortened upon petition and demonstration by the facility, if the Director determines that the facility is secure. Conversely, the post-closure care period may be extended if the Director finds this necessary to protect human health and the environment in accordance with 40 CFR § 264.117(a)(2).

III.B.2. Groundwater System Maintenance

The Permittees shall maintain and monitor the groundwater system and comply with all other applicable requirements of 40 CFR § 264.90 during the post-closure care period in accordance with 40 CFR § 264.117(a).

III.B.3. Post-Closure Use

The Permittees shall not allow any post-closure use in Permit Sections III.A.1 (HWMU-5) and III.A.2 (HWMU-16) that would disturb the integrity or the function of the facility's monitoring systems and cover during the post-closure care period in accordance with 40 CFR § 264.117(c).

III.B.4. Post-Closure Plan

The Permittees shall implement the Post-Closure Plan in accordance with the Permit Modules and Permit Attachment III.A. Where post-closure care activities have been updated since development of the Post-Closure Plan, language in the Permit Modules shall supersede any language in Permit Attachment III.A. All post-closure care activities must be conducted in accordance with the provisions of the Permit Modules, the Post-Closure Plan, and 40 CFR § 264.117(d) and 40 CFR § 264.118(b).

III.C. INSPECTIONS

The Permittees shall inspect the components, structures, and equipment at the site in accordance with the Inspection Requirements of Permit Attachment II.F and 40 CFR § 264.117(a)(1)(ii).

III.D. SECURITY

The Permittees shall maintain security at the facility during the post-closure care period, in accordance with Permit Attachment II.E, and 40 CFR § 264.117(b).

III.E. NOTICES AND CERTIFICATION

III.E.1. Notices

If the Permittees or any subsequent owner or operator of the land upon which any of or all two units were located, wish to remove hazardous wastes and hazardous waste residues, or contaminated soils, or contaminated groundwater, then they shall request modification to this Post-closure Permit in accordance with the applicable requirements in 40 CFR § 264.119(c) and 40 CFR § 270.42. The Permittees or any subsequent owner or operator of the land shall demonstrate that the removal of hazardous wastes will satisfy the criteria of 40 CFR § 264.117(c).

III.E.2. Certification

No later than sixty (60) days after completion of the established post-closure care period, the Permittees shall submit, by registered mail to the Director for approval, a certification that the post-closure care for the hazardous waste

disposal unit was performed in accordance with the specifications in the approved Post-closure Plan. The certification must be signed by the Permittees and an independent, registered, Virginia-certified professional engineer. Documentation supporting the independent, registered professional engineer's license and certification must be furnished upon request.

III.F. FINANCIAL ASSURANCE

Financial assurance is not required for the federal facility.

III.G. POST-CLOSURE PERMIT MODIFICATIONS

The Permittees must request a permit modification to authorize a change in the approved Post-closure Plan. This request must be in accordance with applicable requirements of 40 CFR § 264.119(c) and 40 CFR § 270.42 and must include a copy of the proposed amended Post-closure Plan for approval by the Director. The Permittees shall request a permit modification whenever changes in operating plans or facility design affect the approved Post-closure Plan, or other events occur that effect the approved Post-closure Plan.

ATTACHMENT III.A - CLOSURE NOTICES AND POST-CLOSURE PLANS

III.A-A. POST-CLOSURE NOTICES

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EN = action
R-

COMMONWEALTH of VIRGINIA

DEPARTMENT OF WASTE MANAGEMENT
11th Floor, Monroe Building
101 N. 14th Street
Richmond, VA 23219
(804) 225-2667

MAY 27 1988

CERTIFIED-RETURN
RECEIPT REQUESTED

G. J. Savitske
Lieutant Colonel, Ordinance Corps
COMMANDING OFFICER
Radford Army Ammunition Plant
Radford, Virginia 24140

RE: Closure Plans
(HWM #5, #7, #16)
EPA ID# VA121002730

Dear Colonel Savitske,

Enclosed, please find a copy of the Approved Closure plans developed for Hazardous Waste Management Units #5, #7, and #16. The approved plans are essentially the same as those plans submitted to our office dated November 1986 with the agreed to changes detailed in your letter dated May 11, 1988. Please note that the completion date of closure must be 180 days from the date of this letter.

Should you have any questions, please contact Kevin Greene at (804) 225-2466.

Sincerely,

Karol A. Akers

Karol A. Akers
Technical Services Chief
Division of Technical Services

Enclosure

OLVER INCORPORATED
Consulting Engineers · Environmental Laboratories
1116 South Main Street Blacksburg, Virginia 24060 (703) 552-5548

January 4, 1990

Mr. Kevin L. Greene, Geologist
Division of Technical Services
Department of Waste Management
101 North 14th Street, 11th Floor
Richmond, VA 23219

Re: Radford Army Ammunition Plant, Closure Certification; HWM 5, 7, and 16, EPA ID No. VA1210020730, Job No. 11074

Dear Kevin:

This letter is to provide certification to the Department of Waste Management that the three above-referenced sites were closed in accordance with the approved closure plan dated May 27, 1988. Olver Incorporated had a professional engineer, Kevin Murray, on site from September 19, 1988, through October 14, 1988, which was every day that the contractor worked, and throughout the entire length of time that the contractor was on the referenced project sites. Additional inspections were accomplished on each of the hazardous waste management units on the dates indicated in the table previously sent to you. All inspection trips met the requirements of the closure plan. I have reviewed all of Mr. Murray's notes and memoranda concerning the above-referenced project and, as he no longer works for Olver Incorporated, I am certifying that the work was completed in conformance with the approved closure plan.

If you should have any questions concerning this matter, please do not hesitate to contact me.

Sincerely,

Robert M. Roberts, P.E.
Vice President

RMR/ma

cc: Mr. Patrick J. Golden, Radford Army Ammunition Plant

FILE COPY

COMMONWEALTH of VIRGINIA

James S. Gilmore, III
Governor

John Paul Woodley, Jr.
Secretary of Natural Resources

DEPARTMENT OF ENVIRONMENTAL QUALITY
Street address: 629 East Main Street, Richmond, Virginia 23219
Mailing address: P.O. Box 10009, Richmond, Virginia 23240
Fax (804) 698-4500 TDD (804) 698-4021
http://www.deq.state.va.us

Dennis H. Treacy
Director

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

Certified Mail
Return Receipt Requested

November 4, 1998

C.A. Jake
Environmental Manager
Alliant Techsystems Inc.
Radford Army Ammunition Plant
P.O. Box 1
Radford, VA 24141-0100

RE: Radford Army Ammunition Plant [RAAP]
HWMU 5, 7, and 16 Closure Verification
EPA ID# VA12100207306

Dear Ms. Jake:

On November 3, 1989, the professional engineer's closure certifications for RAAP's hazardous waste management units 5, 7, and 16 were submitted. Additionally, it should be noted that the information required per 9 VAC 20-60-580.G and 580.K was submitted to the local zoning authorities via a letter dated September 15, 1998. However, review of DEQ's records indicate that no closure verification was performed. As these units are currently in the post-closure permitting process, the closure verification needs to be completed per the requirements of 9 VAC 20-60-1010.

Based on the information submitted and the closure verification inspection performed on April 22, 1998, closure of HWMUs 5, 7, and 16 as landfills in accordance with the *Virginia Hazardous Waste Management Regulations* [VHWMR] and the approved closure plan dated May 27, 1988, is deemed acceptable and approved. The units closed as hazardous waste landfills in accordance with the VHWMR and, are therefore, subject to the post-closure requirements of these regulations. These units are now subject to post-closure care in accordance with the VHWMR Parts IX, X, and XI. The Part B permit application for post-closure maintenance of these units was received on November 7, 1985. Currently, post-closure permitting of HWMU 7 is actively being pursued.

If there are any additional questions, please contact Debra Miller, Environmental Engineer Senior, of my staff at (804) 698-4206.

Sincerely,

Leslie A. Romanchik

for Dennis H. Treacy
Director

cc: Debra Miller, DEQ
Glenn Von Gonten, DEQ
Claire Ballard, DEQ
Melissa Porterfield, DEQ
Aziz Farahmand, DEQ-RRO

FILE COPY

COMMONWEALTH of VIRGINIA

James S. Gilmore, III
Governor

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Secretary of Natural Resources

DEPARTMENT OF ENVIRONMENTAL QUALITY
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Dennis H. Treacy
Director

(304) 698-4000
1-800-592-5482

December 8, 1998

C.A. Jake
Alliant Techsystems Inc.
Radford Army Ammunition Plant
P.O. Box 1
Radford, VA 24141-0100

RE: **Radford Army Ammunition Plant (RAAP)**
EPA ID# VA12100207306
Equalization Basin Closure
Closure Verification

Dear Ms. Jake:

On August 7, 1998, RAAP submitted the required closure certifications and report for its Equalization Basin. Additionally, on March 27, 1998, RAAP's Equalization Basin, SWMU #10, was visited by Mike Scott of the Virginia Department of Environmental Quality's (DEQ) West Central Regional Office. This information has been reviewed.

Based on this closure inspection and the closure certifications and report, clean closure by background comparison was achieved for all constituents, except Fluoranthene. Clean closure to a residential risk-based determination was achieved for Fluoranthene. Therefore, the DEQ concurs that clean closure for soils only has been achieved for RAAP's Equalization Basin. Please note, however, that the U.S. Environmental Protection Agency retains the authority to address possible corrective action of continuing releases pursuant to the Hazardous and Solid Waste Amendments of 1984. The groundwater underneath the Sludge Drying Bed is still undergoing closure and may be subject to the post-closure permit process established under Title 9 of the Virginia

Administrative Code, Chapter 20-60 (9 VAC 20-60 et seq.), if clean closure cannot be achieved.

If you have any questions regarding this letter, please contact Debra A. Miller, Environmental Engineer Senior, of my staff at (804) 698-4206.

Sincerely,

Leslie A. Romanchik

for Dennis H. Treacy

c: Claire Ballard - DEQ
Melissa Porterfield- DEQ
Glenn VonGonten-DEQ
Aziz Farahmand-DEQ/WCRO
Central Hazardous Waste File

III.A-B. POST-CLOSURE PLAN

POST CLOSURE CARE AND GROUNDWATER MONITORING

HAZARDOUS WASTE SURFACE IMPOUNDMENTS

In accordance with the Virginia Hazardous Waste Regulations, this section presents the post-closure plan for HWM 5 and 7 based on the closure of both sites as hazardous units. Unless otherwise determined by the State Executive Director post-closure care is to extend over a 30-year period (10.6.H). The major components of post-closure care as proposed in this plan are groundwater monitoring, inspection and maintenance. Possible contingency activities are also described in this section. This plan will extend until such time as a post closure care permit is issued.

Post Closure Contact

Regginald Tyler
RADFORD ARMY AMMUNITION PLANT
(703) 639-8641

Groundwater Monitoring

Results of the Groundwater Quality Assessment Program conducted at the sites indicate that groundwater contamination has occurred. In response to these monitoring results a Compliance Monitoring program will be instituted under 10.5.B and will continue during the post-closure period.

This Compliance Monitoring Program will be implemented using a minimum of four wells (one upgradient and three downgradient), constructed in accordance with 10.5.H. The wells to be used will be selected after final review of the Groundwater Quality Assessment Program.

Samples will be collected in accordance with 10.5.H.4 and (5) on a quarterly basis. Background groundwater quality will be determined for each constituent as specified in 10.5.H.7. The water quality parameters that will be analyzed as part of this program include:

- Specific conductance
- Total organic carbon (TOC)
- Total organic halogen (TOX)
- pH
- Any additional parameters as agreed

For quality control purposes, samples will be split into four portions for analysis. Groundwater elevations will be measured for each sampling event and the direction and rate of groundwater flow will be determined on an annual basis. Additionally, all monitoring wells will be analyzed for Virginia Regulations Appendix 3.6 hazardous constituents on an annual basis.

It is anticipated that because of the nature of the wastes in the surface impoundments and the closure activities to be conducted as described in Section 6.0, the Radford AAP may elect after several years of groundwater monitoring to discuss with the State the requirement for monitoring over a 30-year period. It is probable that the groundwater quality at these sites will improve to ambient levels after several years. If monitoring confirms this then groundwater monitoring could be terminated or reduced in scope.

Inspection

In accordance with 10.6.I.2.(a) regular post-closure inspections of the sites will be made to ensure the integrity of the cover system and all associated structures. Inspections will be conducted by qualified personnel on a monthly basis, with additional inspections following inclement weather or catastrophic events (e.g., fire or explosion elsewhere at the Radford AAP). To ensure that all items of

interest are addressed during the inspection, an inspection log will be used during each inspection. This inspection log will list the potential problems/conditions that the inspector should note while conducting the inspection. The inspector will be asked to identify the existence or absence of each problem and, if present, to address its degree of severity (e.g., low, moderate or high). Table 7.1, discussed in the following paragraphs, provides a listing of all items to be inspected.

Because failure of the soil cover or the underlying PVC liner could result in increased infiltration and leachate generation, it is necessary to inspect the cover for surface erosion, subsidence, or ponding; plant root penetration, or exposure of the liner. The grass cover should be inspected for general health and the presence of undesirable competitive species, particularly deep-rooted plants or shrubs. Vegetation should be kept trimmed to prevent encroachment on access controls, roads and signs. Stormwater drainage controls (i.e., slopes and swales) should be inspected for erosion, subsidence, and in the case of swales, accumulated sediment that might block the flow of stormwater. Locks and caps on groundwater monitoring wells should be inspected for damage.

The need for additional security is expected to be minimal due to the overall secure nature of the Radford plant. Therefore, the installation of warning signs will be the only additional security measure taken during the post-closure care period, as only authorized personnel are allowed to enter the restricted portion of the Radford AAP.

Maintenance

The nature and degree of post-closure maintenance of the site will be primarily determined by observations made during the routine inspections. However, since the Radford AAP will remain in operation, plant personnel will have the opportunity to observe the need for maintenance on a more frequent basis. A description of the expected maintenance activities that will be performed in accordance with 10.6.I is discussed below.

The cover, drainage slopes, and vegetation will be maintained as needed. Damage due to erosion and subsidence will be corrected by adding soil and regrading the site. It is expected that no significant subsidence will occur following closure, and thus only erosion would be the major long term concern. Maintenance of vegetation necessary to control erosion will include removing deep-rooted plants and adding fertilizer to enhance growth as necessary. Overgrowth into drainage swales and access roads will be controlled. Swales will be cleared of any accumulated material. These precipitation run-off pathways will be tested annually for the constituents of which were disposed in the units to determine if precipitation run-off is becoming contaminated.

Security will be maintained by immediately repairing or replacing any damaged signs or access roads. Damaged monitoring wells will be repaired if possible. If it is determined that the integrity of the well has been destroyed, then the well will be replaced. Surveyed benchmarks used to indicate the location of the site will be protected and maintained as necessary. The general perimter of the surface impoundment will be easily recognizable due to the presence of riprap for slope protection.

Contingency Activities

In the event of major damage, contingency measures will be promptly taken erosion will be repaired by the most appropriate of the following measures: replacement of cover or fill soil; restoration of original grade design or replacement with new grade design; and/or installation of riprap. Any other cover deterioration due to deep-rooted plants, cracking, cold weather, or slope instability will be promptly corrected by filling, regrading and reseeding, as appropriate. Damage to vegetation will be controlled by the addition of nutrients, manual watering (in the event of drought), and/or pest control as appropriate.

HAZARDOUS WASTE LANDFILL TRENCH

Since post-closure care is also required for HWM 16, groundwater monitoring and inspection programs similar to those outlined will be implemented. An additional inspection item for HWM 16 would be the leachate collection sump. If any leachate is found to have accumulated in the sump, it will be removed and managed as a listed hazardous waste and more frequent inspections will be conducted. If it is deemed necessary, a routine leachate removal program will be implemented. As in the case of the surface impoundments, surface water monitoring will be performed annually along drainage ditches to determine if surface water run-off has become contaminated to ensure that there will be no release to surface water from the site. Post-closure care will continue for 30 years, unless otherwise determined by the Executive Director. This plan will remain in effect until such time as a Post Closure Permit is issued.

FUTURE USE RESTRICTIONS

In accordance with 10.6.H.3., there will be no use of the disposal areas (HWM #5, HWM #7, and HWM #16) which would allow any disturbance of the integrity of the final cover, liner(s) or any other components of any containment system, or of the function of the associated monitoring systems. Land use activities that will be prohibited at each facility include:

- On-site construction
- Excavation (except as necessary for major maintenance activities)
- Well construction on or near the site
- Agricultural use
- Silvicultural use
- Water infiltration (run-on, ponding, irrigation)
- Recreational use
- Disposal operations
- Vehicular traffic (except as necessary for major maintenance activities)
- Housing on or near the site.

NOTICE TO LOCAL LAND AUTHORITY

As required by 10.6.J, the Radford AAP will submit to the local land authority survey plans prepared and certified by a professional land surveyor which show the disposal areas (HWM #5,

#7, and #16) with respect to permanently surveyed benchmarks. These plans shall contain a note stating that there will be no disturbance of the disposal areas by Radford AAP.

NOTICE IN DEED TO PROPERTY

As required by 10.6.J, a notation (HWM #5, #7, and #16) will be made on the deed to the facility property that will notify, in perpetuity, any potential purchaser of the property that: (1) the land has been used to manage hazardous waste; (2) its use is restricted to that of open space; and (3) the survey plan and record of the type, location, and quantity of hazardous wastes disposed on site has been filed with the Executive Director and local land authority.

INSPECTION CHECKLIST FOR CLOSED ON-SITE FACILITIES

Inspector Name:

Date:

Unit #:

Correction Action:

Item	Problem	Problem Exists? (Yes or No)	Degree of Problem? (e.g., Low)
Soil Cover	erosion		
	subsidence		
	ponding		
PVC Liner	exposed		
Grass Cover	inadequate growth/health		
	deep-rooted vegetation		
	presence of undesirable species		
	inadequate trimming		
Stormwater Drainage slopes	erosion		
	subsidence		
drainage swale	erosion		
	subsidence		
	vegetation growth		
	accumulated sediment		
Monitoring Wells locks	damage		
caps	damage		
Security warning signs	missing		
	defaced		
	obscured		
access road	disrepair		
LEACHATE COLLECTION SYSTEM (HAM #16)	BASIN FULL		
	OPERATING EFFECTIVLY		

MODULE IV - GROUNDWATER DETECTION MONITORING

IV.A. HIGHLIGHTS

Neither of the two units (HWMU- 5 or 16) are currently in detection monitoring. The original Post-closure Care Permit for HWMU-5 was issued on September 28, 2001, and the final and consolidated Post-Closure Care Permit for Hazardous Waste Management Units 5, 7, 10, and 16 was issued on October 4, 2002 and was effective on November 4, 2002. Prior to issuance of the final Post-closure Care Permit, Groundwater Quality Assessment Plans (GWQAPs) were established and implemented for HWMUs 5 and 16. At the time of Permit issuance, RFAAP implemented Compliance Monitoring Programs for HWMUs 5 and 16 rather than Detection Monitoring Programs. Therefore, the Units transitioned directly from Interim Status GWQAPs to Compliance Monitoring Programs and were never in Detection Monitoring Programs. HWMU-5 transitioned from a Compliance Monitoring Program to a Corrective Action Monitoring Program in November 2009.

[HWMU- 5 is currently under Corrective Action Monitoring (in accordance with Permit Module VI); HWMU-16 is currently under Groundwater Compliance Monitoring (Module V). HWMU-7 was determined to be clean-closed for soil and groundwater on June 26, 2013 and HWMU-10 was determined to be clean-closed soil and groundwater on April 2, 2014. These Units were removed from the Permit upon previous reissuance on August 16, 2014. Any references to HWMU-7 and HWMU-10 in the current Permit are historical reference only.]

IV.A.1. HWMU-5

At the time of the GWQAP report (August 1999), eleven inorganic constituents, three volatile organic constituents, and two explosive/propellant constituents had been historically detected in the groundwater monitoring network at HWMU-5, at statistically significant concentrations above calculated background concentrations.

From the first quarter of 1996 to the first quarter of 1999, the concentrations of antimony, beryllium, 2-6 dinitrotoluene, lead, thallium, trichloroethene and bis(2-ethylhexyl)phthalate are historical maximums that were recorded prior to the establishment of groundwater protection standards in the permit, for the monitored constituents proposed by the facility in point of compliance wells at HWMU-5.

IV.A.2. HWMU-16

Groundwater samples from the HWMU-16 area have been collected and analyzed since 1981 in compliance with the Virginia Hazardous Waste Management

Regulations. Groundwater quality assessment data indicated that the groundwater in the HWMU-16 area is contaminated by low levels of DNT and halomethane compounds. The nearby former TNT neutralization sludge disposal trench was identified as source of the DNT contamination. Well 16-4 is the most contaminated well and is very close to the former TNT trench. Radford AAP has submitted Annual Groundwater Monitoring Reports for the Unit during the period that Unit 16 has been under interim status.

Historically, from 1992 through 1998 at least the following constituents were detected in downgradient wells: Cyanide, Xylene (Total), TOC, TOX, Antimony, Arsenic, Barium, Beryllium, Cadmium, Chromium, Cobalt, Copper, Lead, Mercury, Nickel, Selenium, Silver, Thallium, Vanadium, Zinc, Bromoform, Carbon Tetrachloride, Chloromethane (methyl chloride), di-n-Butylphthalate (2-Benzenedicarboxylic acid dibutyl ester), 1,4-Dichlorobenzene, Dichlorodifluoromethane, 1,1-Dichloroethane, 1,2-Dichloroethane, 2,4-Dinitrotoluene (2,4-DNT), and 2,6-Dinitrotoluene (2,6-DNT), Ethylbenzene, Methyl ethyl ketone (MEK, 2-Butanone), 1,1,2,2-Tetrachloroethane, Trichloroethene, Toluene, trans-1,2-Dichloroethylene, 1,1,1-Trichloroethane, 1,1,2-Trichloroethane, Trichlorodifluoromethane,Tetryl (trinitrophenylmethylnitramine), and Vinyl chloride. Potential hazardous constituents include a series of Polychlorodibenzofuran compounds (TCDF – Tetrachlorodibenzofuran, PECDF – Pentachlorodibenzofuran, HPCDF – Hexachlorodibenzofuran, HPCDF – Heptachlorodibenzofuran, and OCDE - Octachlorodibenzofuran).

MODULE V - GROUNDWATER COMPLIANCE MONITORING

The Permit Sections in this Module apply to both units: HWMU-5 and HWMU-16.

HWMU-5 is currently under Corrective Action Monitoring (in accordance with Permit Module VI) and will not be conducting Compliance Monitoring currently under Module V; however, if the facility is able to demonstrate that Corrective Action goals have been met, HWMU-5 may revert to Compliance Monitoring and the requirements in Module V will apply.

V.A. HIGHLIGHTS

Radford AAP is implementing a compliance monitoring program because a groundwater quality assessment monitoring program was established prior to the Permit issuance.

In October 1995, a GWQAP was submitted for HWMUs 4, 5, 7, 10, and 16. A GWQAP Addendum was submitted for these HWMUs in November 1995. DEQ met with Alliant on May 21, 1996 to negotiate a Post-closure permitting schedule for the HWMUs. It was agreed that a revised GWQAP report would be prepared for each individual HWMU rather than to consolidate the HWMUs. But, at 2001 after a negotiation between DEQ and the facility an agreement has been achieved to issue one consolidated Permit, which is this permit.

V.A.1. HWMU-5

Historically, the Permittees determined that hazardous waste constituents were found in groundwater at levels statistically higher than background; therefore, groundwater monitoring shall be conducted under a Compliance Monitoring program during the compliance period.

V.A.2. HWMU-16

From historic data, the Permittees determined that a plume of contamination had been released at the point of compliance for HWMU-16. At least forty three (43) hazardous constituents have been detected in the downgradient groundwater monitoring wells at HWMU-16. Data collected in previous investigations clearly indicated that groundwater was being impacted. Therefore, the groundwater is being monitored in the Compliance Monitoring Program.

V.B. HISTORICAL OVERVIEW

V.B.1. HWMU-5

In 1984, a GWQAP for HWMU's 4,5,7 and 16 was submitted. The Permittees' Phase I - Ground Water Assessment Report for SWMU's 4,5,7 was submitted in 1985. The Phase I report included hydraulic conductivity, ground water flow and rates, and chemical analyses. Also in 1985, the Permittees submitted a GWQAP report on additional ground water monitoring wells with an associated earth resistivity study for HWMU's 4,5,7, and 16. The HWMU-5 was closed 1989. The Permittees submitted interim GWQAP reports and modifications to the GWQAP in 1987, 1988, 1992, 1993, and 1995 for HWMU's 4,5,7, and 16 jointly. In August, 1999, the facility submitted a last Groundwater Quality Assessment Report (GWQAR) in the Post-closure Care Permit Application Part B for HWMU-5. In this GWQAR historical Isoconcentration Maps were produced to depict constituent plumes in the groundwater beneath the HWMU-5 using the historical maximum concentrations for the constituents monitored at the HWMU-5 for the time periods of 1992 through 1995 and 1996 through First quarter 1999.

V.B.2. HWMU-16

A final GWQAR for the unit was submitted with the Post-closure Care Permit Application Part B together. In order to evaluate the shape and position of constituent plumes over time, historical Isoconcentration Maps were developed to illustrate the lateral extent of the combined inorganic metals, the combined volatile organic constituents, and the combined explosive/propellant constituents using the historical maximum concentrations for the constituents monitored at the site for the time periods of 1992 through 1995 and 1996 through 1998.

V.C. SITE HYDROGEOLOGY

V.C.1. Geologic Setting

This part applies the whole facility.

The geological and stratigraphic map is provided in Permit Attachment II.A.

The facility is situated in one of a series of narrow valleys typical of the Valley and Ridge physiographic province of the Appalachian Highland region of North America. Oriented in a northeast-southwest direction, the valley is approximately 25 miles long. The valley has width of approximately eight miles at the southwest end and narrows to approximately two miles at the northeast end. Radford AAP lies along the New River in the relatively narrow northeast corner of the valley. The maximum elevation at Radford AAP is 2225 feet above mean sea level (amsl) in the southeast corner and the minimum elevation is approximately 1675 feet amsl along the New River at the northern property boundary.

The valley and Ridge physiographic province consists of folded and thrust-faulted

Paleozoic sedimentary rocks ranging in age from Cambrian to Mississippian. Post-deformation weathering of these thrust-faulted and overturned Paleozoic rocks has resulted in the formation of resistant sandstone and dolomite ridges separated by valley underlain by more easily eroded shale and limestone. Well-developed karst features such as sinkholes and caves are common in the Valley and Ridge.

The general geology at Radford AAP consists of limestone/dolomite bedrock covered by weathered residual deposits and/or alluvial deposits. The alluvial deposits consists of typical fluvial deposits of interbedded clay, silt, and sand/gravel deposits with cobble lenses. The thickness of the alluvial deposits ranges from a few feet to approximately 50 feet, with an average thickness of 20 feet. The residual deposits consists of clay, silt, and clasts resulting from the physical and chemical weathering of the parent bedrock. The residual deposits typically underlie the alluvium, except in locations where the residuum has been eroded to bedrock and replaced by alluvium. The thickness of the residual deposits ranges from a few feet to approximately 40 feet. Underlying the alluvium and residuum throughout most of Radford AAP is a series of dolomite, limestone, and shale strata known as the Cambrian-aged Elbrook Formation. The Elbrook formation is the major outcropping formation as well as the predominant karstic formation below the facility. Sinkholes, solution channels, pinnacled surfaces, and springs are common to the Elbrook Formation.

V.C.2. Karst Trace Analysis

This part applies the whole facility.

A fracture trace map is provided in Permit Attachment II.A.

a. Fracture Trace Analysis

A total of 66 fracture traces were identified within and around Radford AAP in a photogeologic study conducted by the USEPA's Environmental Photographic interpretation center (EPIC) in 1992. Fracture traces are linear features identified in aerial photographs that represent the surface expression of primary joint sets, major fractures, and/or zones of fracturing in the subsurface. These features may be expressed as soil-tonal variations and vegetational and topographical alignments, and are significant in consideration of groundwater flow at Radford AAP. The fractures and joint sets can act as discrete conduits for groundwater flow, increasing flow rates, and in some cases, redirecting flow away from the expected flow direction. In Karst terrains, such features are environmentally significant because solutionization and resulting conduits develop along bedding plans as well as fractures and joints.

The primary traces identified at Radford AAP in the 1992 USEPA EPIC study are illustrated on the Fracture Trace Map (Appendix A.3 of Permit Attachment II.A). The bedding plane structures, seen as ledges in the New River channel, are also illustrated on the Fracture Trace Map.

b. Sink Hole Delineation

The locations of sinkholes at Radford AAP were also mapped during the 1992 USEPA EPIC study (Fracture Trace Map in Appendix A.3 of Permit Attachment II.A). In the vicinity of Radford AAP, the strike of bedding in the Elbrook Formation is roughly west/northeast, with dips to the south/southeast. As shown on the Fracture Trace Map, the orientation of bedding can be seen in the nearly east-west alignment of sinkholes at Radford AAP and surrounding areas. Most of the sinkholes in the area are oval shaped and elongated with respect to the strike of bedding planes. In some instances, the sinkholes appear to align with respect to the fracture traces. The sinkholes most likely represent bedrock units with a greater carbonate content and lower shale content within the underlying Elbrook formation (USEPA, 1992).

c. Dry Trace Results

In September 1993 through December 1993, engineering-Science, Inc. of Fairfax, VA conducted a dye-trace test to identify hydrologic connections between areas of groundwater recharge (upland sinkholes) in the south-central portion of Main Plant and their respective discharge areas around the facility. The south-central portion of the Main Plant area is characterized by numerous sinkholes and a deep water table. The karst development within the underlying folded limestone and dolomite of the Elbrook Formation likely has a significant influence on groundwater flow through the bedrock in this area.

V.C.3. Occurrence of Groundwater

The general hydrogeological setting at Radford AAP is characterized by porous alluvial sediments overlying weathered and unweathered dolomite and limestone. In areas where the porous allluvial sediments are the uppermost water-bearing zone, groundwater flow is generally from topographically high areas to topographically low areas. In some areas of Radford AAP, the uppermost water-bearing zone is within the limestone and dolomite bedrock. The karst features within the bedrock aquifer can provide conduits for rapid transport of groundwater to the New River, which is the discharge area for regional groundwater flow.

Seasonal variations in precipitation can affect the direction of groundwater flow within the bedrock aquifer at Radford AAP. During wet seasons (high flow conditions), groundwater flow may occur in higher elevation conduits that are not

normally saturated during dry seasons (low flow conditions). As a result, flow may short-circuit the predominant flow paths and be redirected, discharging in unexpected areas.

In addition to seasonal variations, groundwater levels within the bedrock aquifer may fluctuate dramatically during heavy precipitation events. Groundwater levels in the karst bedrock aquifer generally respond to heavy precipitation within approximately 14 hours, and may rise several feet in a short time (Engineering-Science, 1994). This condition exists throughout Radford AAP, especially in areas where surface water infiltrates through these conduits, stormwater infiltrating in the uplands of the facility may discharge to the New River in a matter of a few days following a storm event. The turbulent flow created by these conditions aerates the infiltrating water. The increased O2 content can significantly affect the chemistry of the groundwater, increasing the concentration of many commonly occurring inorganic analytes. It is this direct connection between surface water and groundwater and the rapid movement of groundwater through the aquifer that is vital to interpreting the migration of both naturally occurring and released constituents in the groundwater at Radford AAP.

V.C.4. HWMU-5

a. Geology/Structure

Geological Cross Sections are presented in Permit Attachment V.A. Bedrock below the unit is generally encountered at a depth ranging from 28 to over 56 feet below ground level, with alluvial sediments and weathered bedrock residuum overlying the bedrock. It is characterized by “floaters”, depressions and pinnacles resulting from differential physical and chemical weathering influenced primarily by the structural, depositional, and mineralogical nature of the uppermost lithologic unit (i.e., predominantly brecciated, shaley, or crystalline carbonate). The shaley units of the Elbrook Formation tend to be more resistant, resulting in pinnacles or bedrock highs. In general, the bedrock below the southern portion of the unit slopes downward to the north-northeast, while the bedrock to the north of the unit slopes downward to the south-southwest. This appears to indicate the development of a sinkhole in the vicinity of monitoring well cluster 5WC21, 5WC22, and 5WC23. The area around HWMU-5 is characterized by the development of sinkholes without any apparent alignment or preferred orientation. The fracture lineations identified during the fracture trace analysis, however, appear to be oriented radially, trending northeast-southwest to northwest-southeast in the area of HWMU-5. It is probable that there are well developed karst conduits which convey aerated surface water during precipitation events from the upland sinkholes through these solution-enhanced fractures and joints towards the New River at relatively rapid velocities.

b. Groundwater Movement

Groundwater elevation (potentiometric surface) and flow direction maps are provided in Permit Attachment V.A. GW is encountered at depths ranging from 9 feet to 18 feet bgl with the water table generally located at or just above alluvium/weathered residuum interface. GW level fluctuation in this zone do not appear to exceed 2 to 5 feet annually over most of the site; however, GW levels fluctuated by as much as 8 feet in the farthest downgradient locations (wells 5W10A and 5W11A) in 1994. These farthest downgradient wells are the only monitoring wells that appear to be screened across the bedrock/weathered residuum interface. Groundwater movement beneath the unit is generally to the north-northeast towards the New river. The groundwater contours and the topography in this unit suggest that the unit is located on a river terrace that contains several sinkholes and drains north toward the New River.

V.C.5. UNIT 16

a. Geology/Structure

Geological Cross Sections are presented in Attachment V.A. Bedrock below the unit is generally encountered at a depth ranging from 30 to 70 feet below ground level (bgl), although the soil/bedrock interface is gradational. It is characterized by “floaters”, depressions and pinnacles resulting from differential physical and chemical weathering influenced primarily by the depositional and mineralogical nature of the uppermost lithologic unit (i.e. predominantly shaley, or crystalline carbonate). The shaley units of the Elbrook Formation tend to be more resistant, resulting in pinnacles or bedrock highs. In general, the bedrock below the unit slopes to the east and south towards the New River. The area around HWMU-16 is characterized by the development of sinkholes without any apparent alignment or preferred orientation. The fracture lineations identified during the fracture trace analysis, however, appear to be oriented radially, trending east-west to north-south from the crest of the horseshoe towards the New River. It is probable that there are well developed karst conduits which convey aerated surface water during precipitation events from the upland sinkholes through these solution-enhanced fractures and joints towards the New River at relatively rapid velocities.

b. Groundwater Movement

Groundwater elevation (potentiometric surface) and flow direction maps are provided in Permit Attachment V.A. GW is encountered at roughly 40 feet bgl with the water table generally located at or just above the soil bedrock interface. Groundwater fluctuations in this zone do not appear to exceed 2 to 4

feet annually, although individual wells tapping karst conduits could show dramatic fluctuations following storm events. Groundwater movement beneath the unit is generally to the east-northeast towards a spring located roughly 500 feet northeast of HWMU-16. The groundwater contours and the topography in this unit suggest that the unit is located on top of a structural swale which directs water towards the spring.

V.D. COMPLIANCE MONITORING SYSTEM AND SAMPLING SCHEDULE

V.D.1. HWMU-5

a. Groundwater Monitoring System

The Compliance Monitoring Program requires monitoring at the background well(s), Point of Compliance Wells and at all wells designated as Plume Monitoring Wells semiannually in single samples. Static groundwater elevations (as made applicable by Permit Condition V.H.) will be measured at all wells specified in V.D.1.a.i, ii, and iii below during each sampling event. The groundwater monitoring system follows:

i. The groundwater beneath the closed WMA shall be monitored with one upgradient groundwater monitoring well and five (5) downgradient point of compliance wells located as specified on the map presented in Figures II.A-6 and V.A-1 through V.A-6. Monitoring well 5W8B is the background well for the WMA and monitoring wells 5W5B, 5W7B, 5WC21, 5WC22, and 5WC23 are the point of compliance wells.

ii. In addition to the wells specified in Permit Condition V.D.1.a.i above, well 5W12A will serve as plume monitoring wells downgradient of the unit to determine whether continued migration of contaminants has occurred.

iii. Well(s) S5W5, S5W7, 5W9A, 5W10A, 5W11A, 5WCA, S5W6, S5W8, 5WC11, and 5WC12 will be used as piezometers to measure static groundwater elevations during each sampling event.

b. Sampling Schedule

The upgradient well, the point of compliance wells, and plume monitoring wells will be sampled in accordance with the Compliance Monitoring Sampling and Analysis Plan (Permit Attachment V.B) and the following schedule:

i. The upgradient well and downgradient point of compliance wells specified

in Permit Conditions V.D.1.a.i will be sampled at least semi-annually for the constituents listed in Permit Attachment V.D. The Permittees must collect, at least, a single independent sample at each monitoring well for all required constituents and analyses must be conducted using the EPA SW-846 Methods specified in Permit Attachment V.D.

ii. The Plume Monitoring Wells specified in Permit Condition V.D.1.a.ii shall be sampled at least semi-annually for all constituents listed in Permit Attachment V.D. The Permittees must collect, at least, a single independent sample at each monitoring well for all required constituents and analyses must be conducted using the EPA SW-846 Methods specified in Permit Attachment V.D.

iii. Downgradient Point of Compliance Wells listed in Permit Condition V.D.1.a.i. will be sampled annually for all constituents in Appendix IX to 40 CFR Part 264 as listed in Permit Attachment V.C and analyses shall be obtained using the EPA SW-846 Methods specified in Permit Attachment V.C.

c. Additional Monitoring Wells

If additional constituents on the Compliance Monitoring list are detected at statistically significant levels above background in the Plume Monitoring Wells specified in Permit Condition V.D.1.a.ii and if there is evidence that changes in the nature or extent of groundwater contamination have occurred as required by 40 CFR Part 264.99(j), the Permittees shall install groundwater monitoring wells to further define the vertical and horizontal extent of contamination in accordance with 40 CFR Section 264.90.

i. The Permittees shall notify the Director within seven (7) days of determining that a constituent was detected at statistically significant levels above background in any downgradient plume monitoring well.

ii. If the Permittees choose to attempt a verification sampling event as defined by Permit Conditions V.J.5.a and V.J.8, this intent and a brief description of proposed resampling activities shall be included in the notification required by Permit Condition V.D.1.c.i.

iii. If the results of the resampling indicate that the statistical increase was valid or no resampling is conducted, the Permittees shall submit to the Director a plan to sample existing wells and/or install additional monitoring wells to define the vertical and horizontal extent of the constituent in the groundwater downgradient of the unit. This plan shall be submitted within thirty (30) days of the notification required by Permit Condition V.D.1.c.i.

iv. Appropriate modifications to the Compliance Monitoring Program shall be proposed following the installation of any additional wells, as required to meet the performance standards of the monitoring program.

v. The Permittees may choose to demonstrate that the statistical increase was a result of a source or sources other than the unit. Notification that this demonstration will be attempted should be forwarded to the Director along with the notification that a statistically significant increase has been detected. Additional plume delineation will not be required if the Permittees demonstrate to the satisfaction of the Director that a source or sources other than the unit is the source of increased groundwater contamination.

V.D.2. HWMU-16

a. Groundwater Monitoring System

The Compliance Monitoring Program requires monitoring at the background well (s), Point of Compliance Wells and at all wells designated as Plume Monitoring Wells semiannually in single samples. Static groundwater elevations (as made applicable by Permit Condition V.H) will be measured at all wells specified in V.D.2.a.i, ii, and iii below during each sampling event. The groundwater compliance monitoring system follows:

i. The groundwater beneath the HWMU shall be monitored with one (1) upgradient groundwater monitoring well and four (4) downgradient point of compliance wells located as specified on the map presented in Figures II.A-7 and V.A-7 through V.A-10. Monitoring well 16C1 is the background (upgradient groundwater monitoring) well for the HWMU-16 and the downgradient groundwater monitoring wells 16MW8, 16MW9, 16WC1A, and 16WC1B are the point of compliance wells.

ii. In addition to the wells specified above, four (4) wells, 16-2, 16-3, 16-5 and 16WC2B, will serve as plume monitoring wells downgradient of the unit. The Spring (16SPRING) will serve as an additional sampling point. These five monitoring points shall be used to determine whether continued migration of contaminants is occurring.

iii. Four wells, 16-1, 16WC2A, 16C3, and 16CDH3, will be used as piezometers to measure static groundwater elevations during each sampling event.

b. Sampling Schedule

The upgradient well, the point of compliance wells, and plume monitoring wells will be sampled in accordance with the Compliance Monitoring Sampling and Analysis Plan (Permit Attachment V.B) and the following schedule:

i. The upgradient well and downgradient point of compliance wells specified in Permit Conditions V.D.2.a.i will be sampled at least semi-annually for the constituents listed in Permit Attachment V.D. The Permittees must collect, at least, a single independent sample at each monitoring well for all required constituents and analyses must be conducted using the EPA SW-846 Methods specified in Permit Attachment V.D.

ii. The Plume Monitoring Wells specified in Permit Condition V.D.2.a.ii. shall be sampled at least semi-annually for all constituents listed in Permit Attachment V.D. The Permittees must collect, at least, a single independent sample at each monitoring well for all required constituents and analyses must be conducted using the EPA SW-846 Methods specified in Permit Attachment V.D.

iii. Downgradient Point of Compliance Wells listed in Permit Condition V.D.2.a.i. will be sampled annually for all constituents in Appendix IX to 40 CFR Part 264 as listed in Permit Attachment V.C and analyses shall be obtained using the EPA SW-846 Methods specified in Permit Attachment V.C.

c. Additional Monitoring Wells

If additional constituents on the Compliance Monitoring list are detected at statistically significant levels above background in the Plume Monitoring Wells specified in Permit Condition V.D.2.a.ii. and if there is evidence that changes in the nature or extent of groundwater contamination have occurred as required by 40 CFR Part 264.99(j), the Permittees shall install groundwater monitoring wells to further define the vertical and horizontal extent of contamination in accordance with 40 CFR Section 264.90.

i. The Permittees shall notify the Director within seven (7) days of determining that a constituent was detected at statistically significant levels above background in any downgradient plume monitoring well.

ii. If the Permittees choose to attempt a verification sampling event as defined by Permit Conditions V.J.5.a and V.J.8, this intent and a brief description of proposed resampling activities shall be included in the notification required by Permit Condition V.D.2.c.i.

iii. If the results of the resampling indicate that the statistical increase was

valid or no resampling is conducted, the Permittees shall submit to the Director a plan to sample existing wells and/or install additional monitoring wells to define the vertical and horizontal extent of the constituent in the groundwater downgradient of the unit. This plan shall be submitted within thirty (30) days of the notification required by Permit Condition V.D.2.c.i.

iv. Appropriate modifications to the Compliance Monitoring Program shall be proposed following the installation of any additional wells, as required to meet the performance standards of the monitoring program.

v. The Permittees may choose to demonstrate that the statistical increase was a result of a source or sources other than the unit. Notification that this demonstration will be attempted should be forwarded to the Director along with the notification that a statistically significant increase has been detected. Additional plume delineation will not be required if the Permittees demonstrate to the satisfaction of the Director that a source or sources other than the unit is the source of increased groundwater contamination.

V.E. WELL CONSTRUCTION AND MAINTENANCE

V.E.1. Well Construction

a. The locations of the monitoring wells for HWMU-5 listed in Permit Condition V.D.1.a are specified on the map presented in Permit Attachment II.A, Figure II.A-6.

b. The locations of the monitoring wells for HWMU-16 listed in Permit Condition V.D.2.a are specified on the map presented in Permit Attachment II.A, Figure II.A-7.

c. Boring logs, design and construction details for monitoring wells listed in Permit Condition V.D.1.a and V.D.2.a are included as Permit Attachment V.G.

V.E.2. Maintenance

All monitoring wells in the Compliance Monitoring Program, as listed in Permit Conditions V.D.1. and V.D.2, shall be maintained and inspected at least semiannually to ensure proper operation. Any required repairs shall be made by the Permittees as soon as possible and before the next sampling event. If any of these wells are damaged beyond reasonable efforts for repair, the Permittees may petition the Director for approval to abandon the affected. Appropriate permit modification applications shall be submitted.

V.E.3. Standard

All monitoring wells required by this Permit shall be maintained in conformance with the following:

a. The monitoring system must yield samples in upgradient well(s) that represent the quality of the background groundwater unaffected by leakage from the Regulated Units, and in downgradient wells yield samples that represent the quality of groundwater passing the compliance point.

b. The number and location of wells must be sufficient to identify and define all logical release pathways from the unit(s) to the uppermost aquifer based on site specific hydrogeologic characterization.

V.E.4. Installation and Abandonment

The Director must approve the addition or removal of all monitoring wells prior to installation or abandonment through a permit amendment.

a. All wells deleted from the monitoring program shall be plugged and abandoned in accordance with Permit Attachment V.H. Well plugging methods and abandonment certification shall be submitted to the Director within thirty (30) days from the date the wells are removed from the monitoring program.

b. All wells added to the existing monitoring system described in Permit Condition V.E.1. must be constructed in accordance with the requirements of EPA's *RCRA Groundwater Monitoring Technical Enforcement Guidance Document (TEGD)*(September 1986, as updated), and/or as approved by the Department .

V.F. GROUNDWATER PROTECTION STANDARD

V.F.1. Groundwater Protection Standard

The Permittees shall monitor the groundwater to determine whether regulated units are in compliance with the groundwater protection standard under 40 CFR Part 246.92. The groundwater protection standard is based upon upgradient concentrations from the facility's background groundwater monitoring (Attachment V.E), EPA Safe Drinking Water Act Maximum Contaminant Levels (SDWA MCLs), USEPA Regional Screening Levels for Chemical Contaminants at Superfund Sites (RSLs; Summary Table TR=1E-06, HQ=1), or an Alternate Concentration Limit (ACL) approved by the Director (DEQ ACLs, Health-based Risk Assessment Levels generated by the REAMS model, VURAM, or an

equivalent method). The hazardous constituents, and their concentration limits listed in Attachment V.F comprise the groundwater protection standard.

V.F.2. Background Concentration for Additional Constituents

The Permittees shall monitor all wells as described in Permit Condition V.D.1. and V.D.2. for all parameters and constituents specified in Attachment V.D and Attachment V.C as appropriate. For any additional hazardous constituents detected during the annual analysis of all monitoring wells at the point of compliance, as specified above in Permit Section V.D.1, and V.D.2. for all constituents contained in Appendix IX to 40 CFR 264 (see Permit Attachment V.C) for which no accurate background values have been established at the time the Permit was issued, the Permittees shall establish accurate background values in accordance with 40 CFR 264.97(g), and as specified below:

a. Background groundwater quality for a monitoring parameter or constituent shall be based on data from quarterly sampling of a properly installed well(s) upgradient from the waste management area for one (1) year.

b. The Permittees shall take a sequence of at least four (4) samples from each upgradient well, to determine background groundwater quality for each parameter and/or constituent each time the system is sampled.

c. An alternate sampling procedure may be used if proposed by the Permittees and approved by the Director in accordance with 40 CFR 264.97(g)(2).

V.F.3. The Permittee shall use the most up-to-date USEPA MCL or DEQ ACL / EPA RSL (if no USEPA MCL has been promulgated) as the GPS for any GPS based on those regulatory values. If USEPA/ DEQ implements any changes to MCLs, RSLs, or ACLs, the GPS defined by that MCL/RSL/ACL will be updated to reflect the most current value established by USEPA/DEQ, and the most current updated value will be used for data evaluation. The currently published values at the time of the sampling event will be used as the GPS to evaluate all data for that sampling event, as well as for any verification sampling associated with that sampling event. Additionally, the Permittee shall submit a Class 1 Modification request biennially (every two years) to update all MCL, ACL, and RSL values listed in the Permit to the most current published values at the time of the modification request submission. If no changes have been made to the MCL, ACL, or RSL values for the constituents listed in the Permit for the preceding two years, then the Permittee can provide a letter to DEQ stating that no permit modification is necessary in lieu of a Class 1 modification request for that two year time period.

Any GPS based on a background value or site-specific ACL may be updated if

new data become available. When available, the Permittee shall provide the Department with any new site-specific data for review. If the changes are significant enough to warrant a Permit modification, the Permittee shall submit a Class 1 Permit modification request to amend the associated GPS value(s).

V.F.4. Effective Duration

The Compliance Period, during which The Groundwater Protection Standard applies, is equal to the period of time from the beginning of the waste management area's active life until the end of the closure period and begins when the Permittees initiate a Compliance Monitoring Program meeting the requirements of 40 CFR 264.99. The Compliance Period for each unit in this Permit is specified in Permit Condition I.J.

V.G. SAMPLING AND ANALYSIS PROCEDURES

The Permittees shall use the following techniques and procedures when obtaining and analyzing samples from the groundwater monitoring wells described in Permit Conditions V.D.1., and V.D.2.:

V.G.1. Samples shall be collected using the techniques described in Permit Attachment V.B.

V.G.2. Samples shall be preserved, packed, and shipped off-site for using the techniques described in Permit Attachment V.B.

V.G.3. Samples shall be analyzed in accordance with the procedures specified in Permit Attachments V.C and V.D. Additionally, the laboratory must be accredited for the analytical method, matrix, and target analyte (where applicable) by the Virginia Environmental Laboratory Accreditation Program (VELAP).

V.G.4. Samples shall be tracked and controlled following the chain-of-custody techniques in Permit Attachment V.B.

V.G.5. The Permittees must determine the concentration of constituents and parameters listed in Permit Attachment V.D in the groundwater at the compliance point at least semiannually during the compliance periods specified in Permit Condition V.F.4.

V.G.6. The Permittees must analyze samples from all monitoring wells listed in Permit Condition V.D.1.a.(i) and V.D.2.a.(i) at the compliance point, for all constituents contained in Appendix IX to 40 CFR Part 264 (Permit Attachment V.C) at least annually during the compliance period.

V.H. ELEVATION OF THE GROUNDWATER SURFACE

V.H.1. Groundwater Surface Elevation

The Permittees shall determine the groundwater surface elevation (and depth to bottom of wells not equipped with dedicated pumps) at each monitoring well specified in Permit Conditions V.D.1.a., and V.D.2.a., for HWMU-5 and HWMU-16, respectively, each time groundwater is sampled in accordance with procedures contained in Permit Attachment V.B.

a. Static groundwater elevations (and total depths--for wells that do not contain dedicated pumps) will be measured at all wells specified in Permit Condition V.E.1. during each sampling event.

b. The first semiannual monitoring event as described in Permit Module V shall be completed no later than 90 days from the date of Permit issuance.

c. If, during the course of purging and sampling, the data from turbidity measurements and field parameters 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.

V.H.2. Additional/Replacement Wells

The Permittees shall report the surveyed elevation of any additional or replacement monitoring well(s) when installed with as-built drawings. The total depth of wells and the elevation of the following shall be recorded: top of the casing, ground surface and/or apron elevation, and the protective casing.

V.I. STATISTICAL PROCEDURES

V.I.1. Statistical Evaluation

When evaluating the monitoring results in accordance with Permit Section V.J., the Permittees shall determine whether there is statistically significant evidence of increased contamination for any hazardous constituent or parameters specified in the Groundwater Protection Standard (Permit Attachment V.F) using the statistical procedures specified in Permit Attachment V.I in accordance with 40 CFR 264.97(h), 264.97(i), 264.99(d), and 264.99(h) or using an alternative method approved by the Director.

V.I.2. Simple Empirical Comparison

The Permittees may elect to perform a simple empirical comparison of Point of

Compliance data to the Groundwater Protection Standard (Permit Attachment V.F) or Compliance Well data to the established background concentration in Permit Attachment V.E, instead of the statistical procedures specified in Permit Attachment V.I.

V.I.3. Statistical Procedures

The Permittees shall conduct all statistical procedures as specified in Permit Attachment V.I.

V.I.4. Schedule for Statistical Evaluation

The Permittees shall perform the statistical evaluation required by Permit Conditions V.I.1, 2, and 3 above within 30 days from when the results of the analyses are available from the laboratory performing the analyses, but not later than the following schedule in accordance with 40 CFR 264.99(d)(2).

Samples Collected During The Months of:	***Statistical Results Due by:***
January- June	*August 15*
July – December	*March 1*

The results of the evaluation shall be reported to the Director.

V.J. MONITORING PROGRAM AND DATA EVALUATION

The Permittees shall conduct groundwater quality evaluation as follows:

V.J.1. Sampling and Analysis

The Permittees shall collect, preserve, and analyze groundwater samples taken from all monitoring wells specified in this Permit, at least semiannually, pursuant to Permit Section V.G and Permit Attachment V.B..

V.J.2. Analytical Constituents

The Permittees shall determine the concentration of compliance monitoring constituents and/or parameters, as listed in the Compliance Monitoring Constituent List (Permit Attachment V.D), in the groundwater at each monitoring well specified in Permit Section V.D.1.a.(i) and (ii) and V.D.2.a.(i) and (ii) at least semiannually in accordance with 40 CFR 264.99(a).

The Permittees shall determine the concentration of hazardous constituents and/or parameters, as specified in the Groundwater Protection Standard (Permit Section V.F.1 and Permit Attachment V.F), in the groundwater at each monitoring well specified in Permit Section V.D.1.a.(i) and V.D.2.a.(i) at least semiannually in accordance with 40 CFR 264.99(a).

V.J.3. Analysis Data Presentation

The Permittees shall 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).

The Permittees' report shall include at least the following information: the constituents analyzed; the SW-846 test methods; method detection limits; level of quantitation; estimated quantitation limits; the internal laboratory quality assurance/quality control (QA/QC); matrix spike duplicates; percent recovery; duplicate analyses; dilution factors; any lab specific limit of detection and/or limit of quantitation; and, the results of any screening analyses.

V.J.4. Groundwater Flow Direction and Rate

The Permittees shall determine the groundwater flow rate and direction in the uppermost aquifer at least annually to determine compliance with 40 CFR 264.99(e). The Permittees shall also measure the groundwater surface elevations each time groundwater is sampled in accordance with the requirements of 40 CFR 264.97(f).

V.J.5. Appendix IX to 40 CFR Part 264

The Permittees shall analyze samples from all wells listed in Permit Condition V.D.1.a.i and V.D.2.a.i at the compliance point, for all constituents contained in Appendix IX to 40 CFR Part 264 (Permit Attachment V.C) at least annually to determine whether additional Appendix IX to 40 CFR Part 264 constituents, which are not listed in Permit Attachment V.D, are present in the uppermost aquifer.

a. If the Permittees find additional constituents present (i.e. not listed in Permit Attachment V.D), the Permittees shall notify the Director within seven (7) days of the data being available from the laboratory. The Permittees may resample within (60) days from the date of the data validation and repeat the analysis for the detected Appendix IX to 40 CFR Part 264 constituent. If confirmation sampling is intended, the Permittees shall include the proposed sampling date with the notification.

b. If the second analysis confirms the presence of the additional constituents, the

Permittees shall report the concentration of these constituents to the Director in writing within seven (7) days of the second analysis data being available from the laboratory and add them to the Compliance Monitoring list (Permit Attachment V.D). If the constituent is hazardous (listed in Appendix VIII to 40 CFR Part 261), the Permittees shall add it to the Groundwater Protection Standard list (Permit Attachment V.F).

c. If the Permittees choose not to resample, then the Permittees shall report the concentrations of these additional constituents to the Director within seven (7) days of the initial analysis data being available from the laboratory and add them to the Compliance Monitoring list (Permit Attachment V.D). If the constituent is hazardous (listed in Appendix VIII to 40 CFR Part 261), the Permittees shall add it to the Groundwater Protection Standard list (Permit Attachment V.F).

d. If the constituent has been previously detected in the monitoring well, then the Permittees may choose not to resample. The Permittees shall report the concentration within seven (7) days of the data being available from the laboratory and add them to the Compliance Monitoring list (Permit Attachment V.D). If the constituent is hazardous (listed in Appendix VIII to 40 CFR Part 261), the Permittees shall add it to the Groundwater Protection Standard list (Permit Attachment V.F).

e. The Permittees may attempt to demonstrate that the newly detected additional Appendix IX constituent was from a source or sources other than the Regulated Unit. The Director shall be notified of the intent to make the demonstration either with the original notification that a new constituent was detected or with the results of the resampling.

   i. This demonstration shall prove to the satisfaction of the Director that an alternate source caused the detection.

   ii. The demonstration shall commence within a reasonable time following the notification in Permit Condition V.J.5.b. or c. above, and the results shall be submitted for review no later than 90 days from the original notification.

   iii. The Permittees must continue to monitor in accordance with the Compliance Monitoring Program established under 40 CFR Section 264.99.

V.J.6. Background Values for Newly Detected Constituents

If the second analysis (Permit Condition V.J.5.b) confirms the presence of constituents not included in the Compliance Monitoring program, the Permittees

choose not to resample (Permit Condition V.J.5.c.), or the Permittees are unable to prove to the satisfaction of the Director that a source other than the Regulated Unit is responsible, the Permittees shall establish the background values for each additional Appendix IX to 40 CFR Part 264 constituent listed in Permit Attachment V.C found in the groundwater in accordance with the following procedures:

a. Background groundwater quality for a newly listed monitoring parameter or constituent shall be based on data (single samples) from at least quarterly sampling of an upgradient monitoring well for each unit, as specified by Permit Condition V.D.1.a.(i) or V.D.2.a.(i)., for one (1) year.

b. Background groundwater quality for each newly listed parameter and/or constituent for each compliance point and plume monitoring wells, as listed in Permit Conditions V.D.1.a.(i)/ V.D.2.a.(i) and V.D.1. a.(ii)/ V.D.2.a.(ii), respectively, shall be based on data (single samples) from at least quarterly sampling for one (1) year.

c. An alternate sampling procedure may be used if proposed by the Permittees and approved by the Director in accordance with 40 CFR 264.97(g)(2).

V.J.7. GPS for Newly Detected Constituents

For each additional Appendix VIII to 40 CFR Part 261 hazardous constituent confirmed in accordance with Permit Condition V.J.5.b or directly added to the monitoring list (Permit Attachment V.D) without resampling in accordance with Permit Condition V.J.5.c, the Director shall establish a Groundwater Protection Standard and amend Permit Attachment V.F. The groundwater protection standard will be based upon the background value determined through Permit Condition V.J.6, EPA Safe Drinking Water Act Maximum Contaminant Levels (SDWA MCLs), USEPA Regional Screening Levels for Chemical Contaminants at Superfund Sites (RSLs; Summary Table TR=1E-06, HQ=1), or an Alternate Concentration Limit (ACL) approved by the Director (DEQ ACLs, Health-based Risk Assessment Levels generated by the REAMs model, VURAM, or an equivalent method).

V.J.8. Comparison to Background Concentrations

During the compliance period, for each hazardous constituent identified in Permit Condition V.J.5, the Permittees shall determine whether there is statistically significant evidence of increased contamination each time when the concentration of hazardous constituents is monitored in groundwater at the compliance point; pursuant to Permit Section V.I.1 and using the statistical procedures in Permit Attachment V.I or an alternate method approved by the Director prior to use. To make that determination, the Permittees shall compare the groundwater quality at

each monitoring well specified in Permit Section V.D. to the background concentrations for that constituent, in accordance with the procedures specified in Permit Section V.I.1. These determinations shall be made at least semiannually and the results reported to the Director.

a. If the appropriate statistical test (specified in Permit Attachment V.I and/or approved by the Director) indicates that the difference between the established background (or upgradient concentration) and the downgradient well concentration is significant, the Permittees shall notify the Director in writing within seven (7) days of determining that a constituent was detected at statistically significant levels in any downgradient well. The notice should indicate whether the Permittees resample to confirm the exceedance.

b. The Permittees may repeat the same procedure with an independent sample from the monitoring well within 30 days of determination that the difference was statistically significant. If the Permittees choose to attempt a resampling demonstration as defined by Permit Condition V.J.5.a., this intent and a brief description of proposed confirmation sampling activities shall be include in the notification required above.

V.J.9. Comparison to Groundwater Protection Standards

For each hazardous constituent identified in Permit Condition V.J.5 and listed in Permit Attachment V.F., the Permittees shall determine whether there is statistically significant evidence of increased contamination each time when the concentration of hazardous constituents is monitored in groundwater at the compliance point. In determining whether such an increase of contamination has occurred, at least semiannually the Permittees shall compare the groundwater concentration at each monitoring well specified in Permit Section V.D.1.a (i) and V.D.2.a.(i) to the Groundwater Protection Standard for that constituent, in accordance with the procedures specified in Permit Attachment V.I if appropriate.

a. Methods of Comparison

i. If a single independent sample was collected at the monitoring well, the Permittees shall conduct a simple empirical comparison of the measured value to the GPS (Permit Attachment V.F).

ii. If multiple independent samples were collected from each monitoring well, a statistical comparison to the GPS, as approved by the Director, shall be conducted. Guidelines for method selection are contained in Permit Attachment V.I.

b. Notification

For constituents that have not statistically exceeded the Groundwater Protection Standard during previous sampling events, the Permittees shall submit written notification to the Director within 7 days of determining that the GPS has been exceeded for the additional constituent. The notification shall include the following:

i. concentration of constituent exceeding the GPS;

ii. identification of the monitoring well where the GPS was exceeded; and

iii. a map showing the extent of the groundwater contaminant plume with concentrations mapped.

c. Other Source Demonstration

The Permittees may make a demonstration that the groundwater protection standard as indicated in Permit Attachment V.F was exceeded due to sources other than the unit; errors in sampling, analysis, and evaluation; or natural variation in the groundwater. The demonstration shall be conducted as follows:

i. The Permittees shall include in the notification to the Director in Permit Condition V.J.9.b., that the demonstration will be attempted.

ii. Resampling must be conducted as described in V.J.5.a.

iii. Four (4) independent samples shall be collected from the well for each constituent the Permittees included in the demonstration. A statistical evaluation of the data shall be conducted using a statistical method approved by the Director.

iv. The Permittees must submit a report to the Director within 90 days of the notification that demonstrates a source other than the unit caused the groundwater protection standard to be exceeded or that the apparent non-compliance was a result of an error in sampling, analysis, or evaluation. The Permittees must also submit to the Director within 90 days of the notification in Permit Condition V.J.9.b an application for a permit modification to make any appropriate changes in the Compliance Monitoring Program.

v. If the Director approves the results of the demonstration, the constituent shall remain on the Annual 40 CFR 264 Appendix IX Constituent list (Permit Attachment V.C) and Compliance Monitoring List (Permit Attachment V.D) and samples shall continue to be collected and analyzed as specified.

d. Specification

The Permittees shall specify all Groundwater Protection Standard exceedances from the reported sampling event in the Semiannual Monitoring Report.

V.K. REPORTING AND RECORDKEEPING

V.K.1. Record

The Permittees shall enter all monitoring, testing, and analytical data obtained pursuant to Permit Section V.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 Director has determined to be equivalent as appropriate and shall be submitted to the Director at least annually, no later than March 1 of the calendar year, pursuant to 40 CFR 264.91(b). Reports containing the information shall be submitted in accordance with Permit Condition I.N.2.

V.K.2. Groundwater Elevation

The Permittees shall submit the groundwater surface elevations and potentiometric contour maps with flow paths for both HWMUs, as specified in Permit Section V.J.4.,to determine whether the requirements for locating the monitoring wells continue to be satisfied, at least annually, no later than March 1 of the calendar year, pursuant to 40 CFR 264.73(b)(6). All potentiometric contour maps shall be properly annotated with monitoring wells and groundwater surface elevations clearly marked. If the evaluation shows that the performance standards specified in Permit Section V.E.3. are no longer satisfied, the Permittees shall, within ninety (90) days, submit a permit modification request to the Director to modify the number, location, or depth of the monitoring wells to bring the groundwater monitoring system into compliance with this requirement, pursuant to 40 CFR 264.99(j) and 40 CFR 270.42(c).

V.K.3. Background Values

The established background values and the computations necessary to determine background values shall be submitted to the Department whenever requested by the Director or at least annually with the annual groundwater monitoring report, no later than March 1 of the calendar year pursuant to 40 CFR 264.73(b).

V.L. ASSURANCE OF COMPLIANCE

The Permittees shall demonstrate to the Director that groundwater monitoring

necessary to ensure compliance with the groundwater protection standard under 40 CFR Part 264.92 is being conducted during the term of the Permit by submitting all required reports, documentation, and notifications.

V.M. SPECIAL REQUIREMENT IF THE GROUNDWATER PROTECTION STANDARD IS EXCEEDED

In accordance with the requirements of this Permit and the VHMWR, if the Director or the Permittees have determined that corrective action at the point of compliance of the Waste Management Area is required, the Permit Conditions in Permit Section V.M. shall be applicable. The Permittees are responsible for compliance with Permit Section V.M. immediately upon notification by the Director that corrective action is required at the point of compliance.

V.M.1. Notice

The Permittees must notify the Director in writing within seven (7) days from the date that the analytical data is available from the laboratory that the groundwater protection standard Permit Attachment V.F) has been exceeded at any well for any constituent contained in Permit Attachment V.D not included in previous notifications in accordance with Permit Condition V.J.9. The notification must indicate specifically which concentration limits have been exceeded and be made following each semiannual sampling event if appropriate, pursuant to 40 CFR 264.99(h)(1).

V.M.2. Establishment for Corrective Action

The Permittees shall submit to the Director a permit modification to establish a corrective action program meeting the requirements of 40 CFR Part 270.14(c)(8) and 40 CFR Part 264.100 within 180 days, or within 90 days if the Permittees have previously submitted an engineering feasibility study, pursuant to 40 CFR 264.99(h)(2). The application shall at a minimum include the following information:

a. A detailed description of corrective actions that shall achieve compliance with the Groundwater Protection Standard specified in Permit Section V.F. and

b. A plan for a groundwater monitoring program that shall demonstrate the effectiveness of the corrective action. Such a groundwater monitoring program may be based on a compliance monitoring program developed to meet the requirements of 41 CFR 264.99.

V.M.3. Other Source Demonstration

In accordance with 40 CFR Part 264.99(i)., The Permittees may make a

demonstration that the groundwater protection standard as indicated in Permit Attachment V.F was exceeded due to sources other than a regulated unit or errors in sampling, analysis, evaluation, or natural variation in the groundwater.

a. The Permittees must notify the Director in writing, within seven (7) days from the date that the analytical data is available from the laboratory, that a demonstration will be made.

b. The Permittees must submit a report to the Director within 90 days from the original notification that demonstrates that a source other than a regulated unit caused the groundwater protection standard to be exceeded or that the apparent non-compliance was a result of an error in sampling, analysis, or evaluation, pursuant to 40 CFR 264.99(i)(2).

c. The Permittees must submit to the Director within 90 days from rejection of the demonstration an application for a permit modification to make any appropriate changes in the Compliance Monitoring Program at the facility, pursuant to 40 CFR 264.99(i)(3); and

d. The Permittees must continue to monitor in accordance with the Compliance Monitoring Program established under 40 CFR Part 264.99(i)(4).

V.N. REQUESTS FOR PERMIT MODIFICATION

This section, V.N, applies to both units in this permit.

If the Permittees or the Director determines that groundwater corrective action is required to protect human health and the environment or if the Director determines that the corrective action ongoing at the facility is not adequate, the Permittees shall submit to the Director an application for a permit modification to establish or modify a Corrective Action Program meeting the requirements of 40 CFR Section 264.100 within 180 days of receipt of the Director's determination that corrective action is required.

If the Permittees or the Director determines the Corrective Action Program no longer satisfies the requirements of 40 CFR Part 264.100, then, within 90 days, the Permittees must submit an application for a permit modification to make any appropriate changes to the program.

V.O. EVALUATION OF GROUNDWATER CONTAMINANT PLUME LOCATION

The results of the statistical comparisons of monitoring data from the plume monitoring wells specified in Permit Condition V.I. shall be used to determine if the groundwater contaminant plume has migrated vertically or horizontally

following the completion of the groundwater quality assessment program.

If constituents on the compliance Monitoring List Permit Attachment V.D are detected at statistically significant levels above background in the plume monitoring well(s) specified in Permit Condition V.D.1. and V.D.2. for HWMU-5 and HWMU-16, respectively, the Permittees shall take appropriate measures to further define the extent of groundwater contamination.

V.O.1. Other Source Demonstration

The Permittees may make a demonstration that the background concentration was exceeded due to sources other than a regulated unit, errors in sampling, analysis, evaluation, or natural variation in the groundwater.

a. The Permittees must notify the Director in writing, within seven (7) days from the date that the analytical data is available from the laboratory, that a demonstration will be made.

b. The Permittees must submit a report to the Director within 90 days from the original notification that demonstrates that a source other than a regulated unit caused the background to be exceeded or that the apparent non-compliance was a result of an error in sampling, analysis, or evaluation.

c. The Permittees must submit to the Director within 90 days from rejection of the demonstration a request for a modification to this Permit to make any appropriate changes in the Compliance Monitoring Program at the Facility (Permit Condition V.N.)

V.O.2. Additional Wells

If the demonstration in Permit Condition V.O.1. above is not attempted or is not accepted by the Director, the Permittees shall submit to the Director a plan to sample existing wells and/or install additional monitoring wells to define the vertical and horizontal extent of the constituent in the groundwater downgradient of the unit. This plan shall be submitted within thirty (30) days of the notification required by Permit Condition V.O.1.a.

V.O.3. New Well Sampling

Unless specific approval is granted in advance by the Director, all monitoring wells installed in accordance with Permit Condition V.O.2., above, shall be sampled in accordance with Permit Condition V.D.1.b and 2.b for HWMU-5 and HWMU-16, respectively, at least semiannually following installation and pending any appropriate modification to the Compliance Monitoring Program pursuant to Permit Condition V.O.4. below.

V.O.4. Modification for New Well

Appropriate modifications to the Compliance Monitoring Program shall be proposed following the installation of any additional wells and/or as required to meet the performance standards of the monitoring program.

V.O.5. Statistical Evaluation

The results of the statistical evaluation shall be included in the semiannual monitoring report (Permit Condition V.K.1.).

ATTACHMENT V.A - HYDROLOGICAL AND GEOLOGICAL INFORMATION

Figure V.A-1 – HWMU-5 Geological Cross Section Location Map
Figure V.A-2 – HWMU-5 Geological Cross Section A – A'
Figure V.A-3 – HWMU-5 Geological Cross Section B – B'
Figure V.A-4 – HWMU-5 Geological Cross Section C – C'
Figure V.A-5 – HWMU-5 Potentiometric Surface (Groundwater Elevation) Map
Figure V.A-6 – HWMU-5 Potentiometric Surface (Groundwater Elevation) Map
Figure V.A-7 – HWMU-16 Geological Cross Section Location Map
Figure V.A-8 – HWMU-16 Geological Cross Section A – A'
Figure V.A-9 – HWMU-16 Potentiometric Surface (Groundwater Elevation) Map
Figure V.A-10 – HWMU-16 Potentiometric Surface (Groundwater Elevation) Map

Figure V.A-1 – HWMU-5 Geological Cross Section Location Map

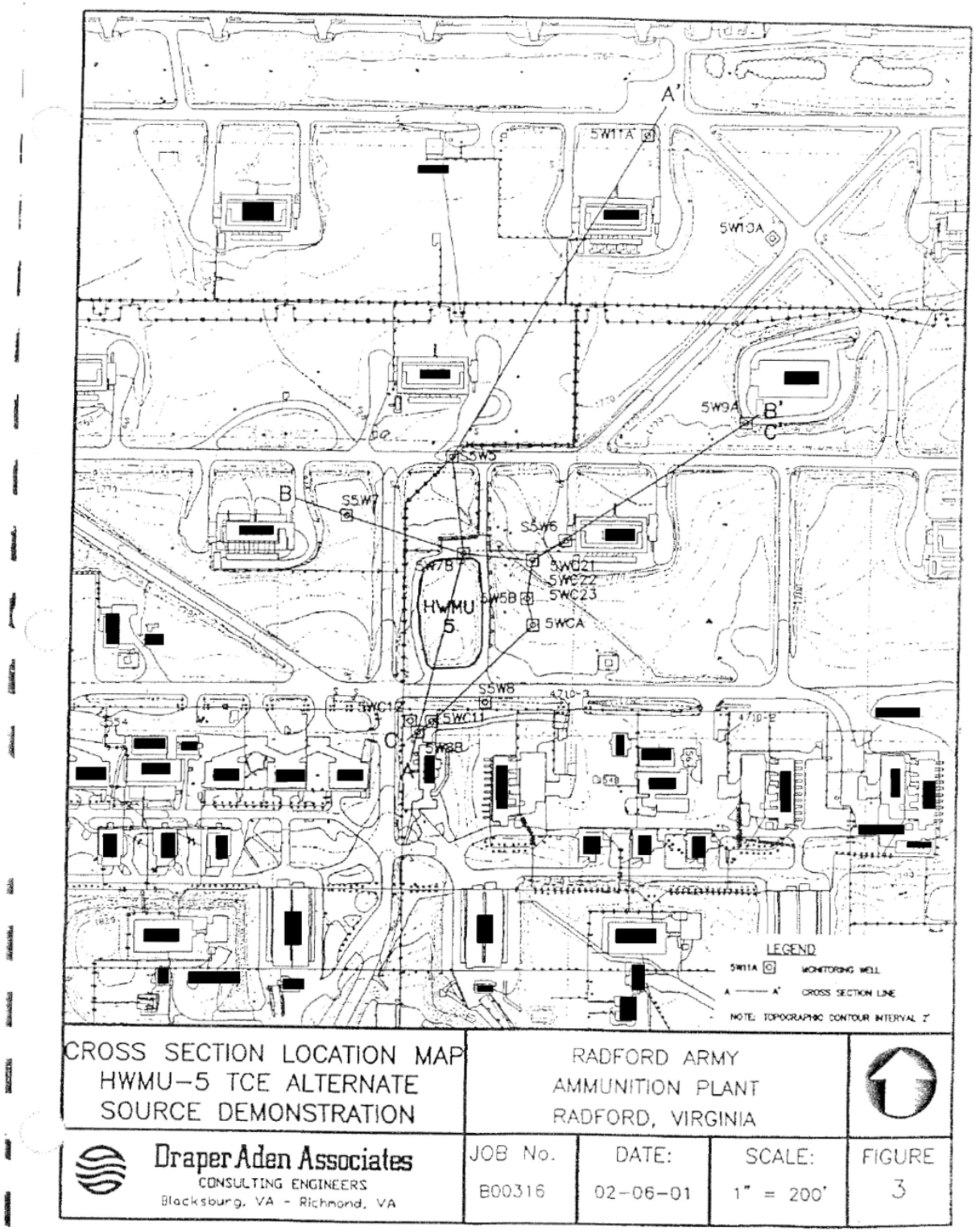


Figure V.A-2 – HWMU-5 Geological Cross Section A – A'

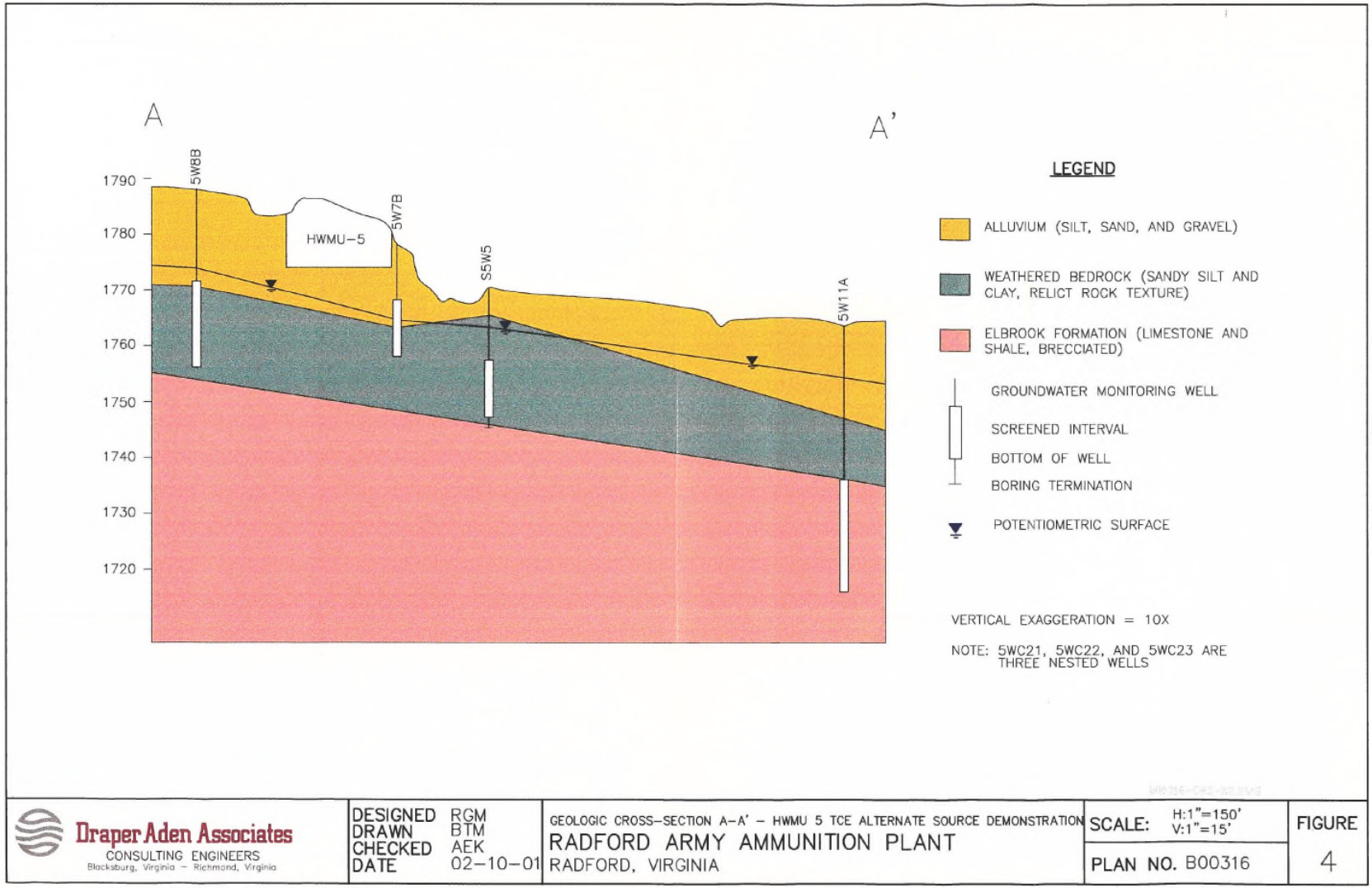


Figure V.A-3 – HWMU-5 Geological Cross Section B – B'

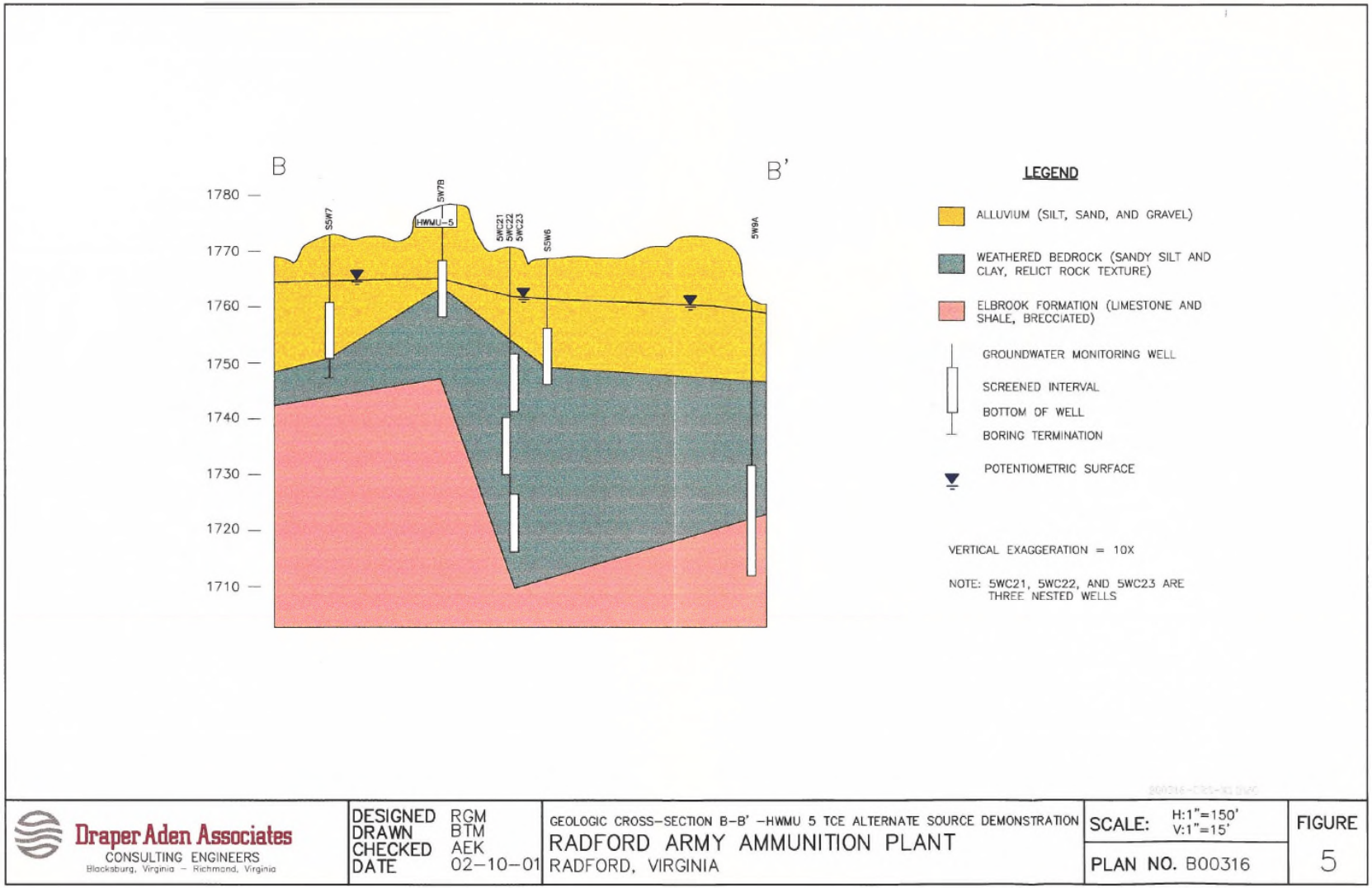


Figure V.A-4 – HWMU-5 Geological Cross Section C – C'

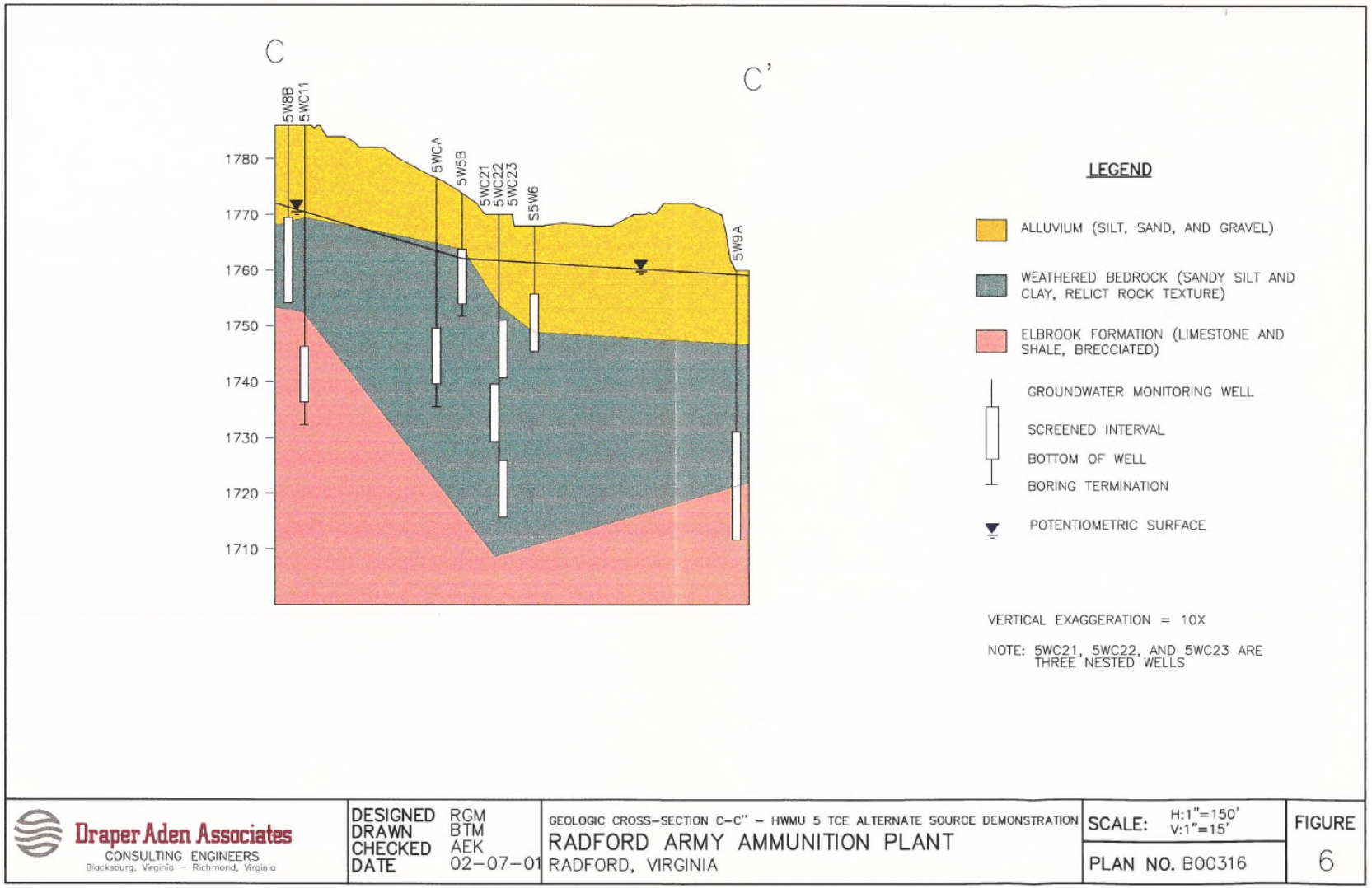


Figure V.A-5 – HWMU-5 Potentiometric Surface (Groundwater Elevation) Map

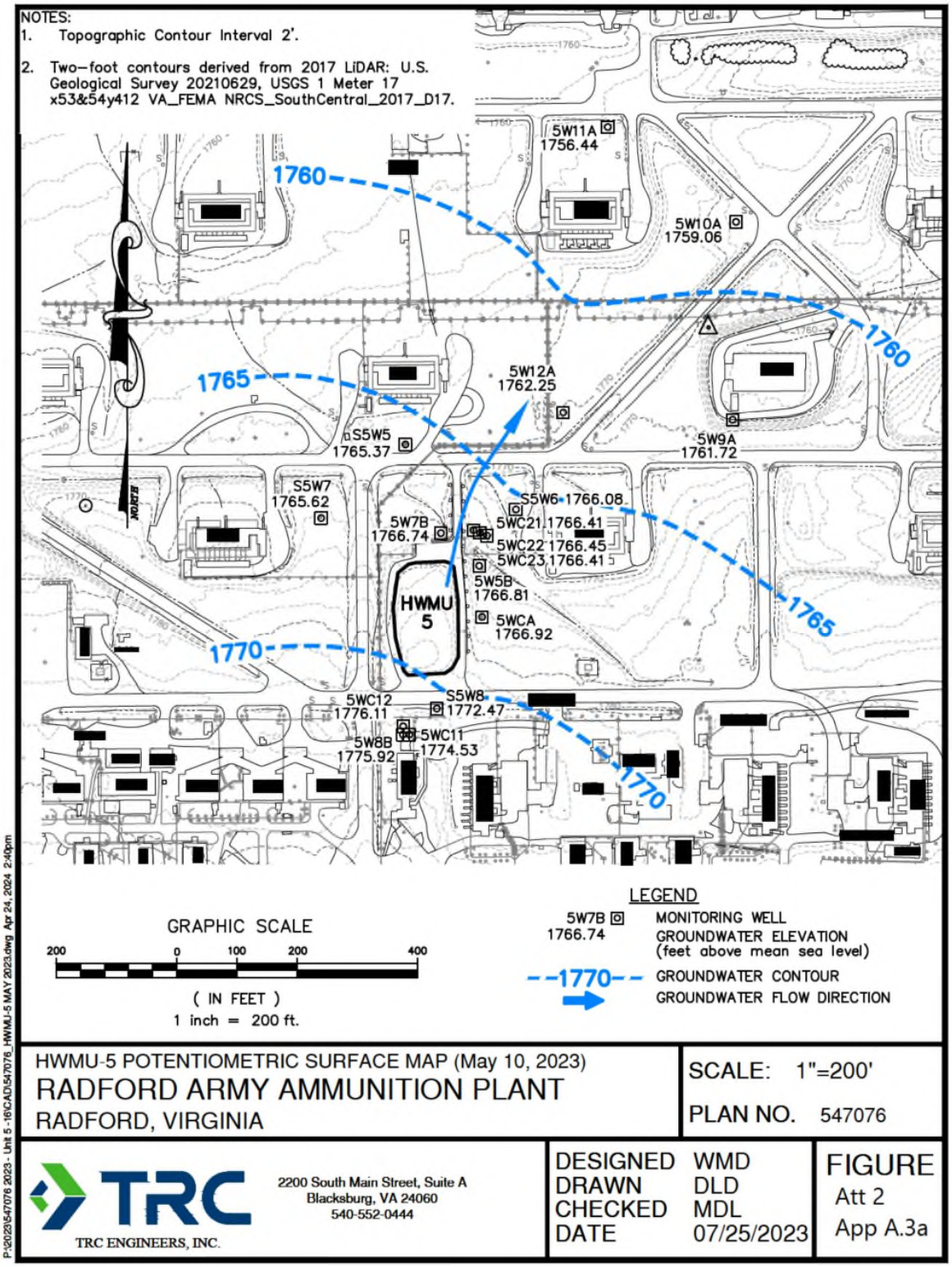


Figure V.A-6 – HWMU-5 Potentiometric Surface (Groundwater Elevation) Map

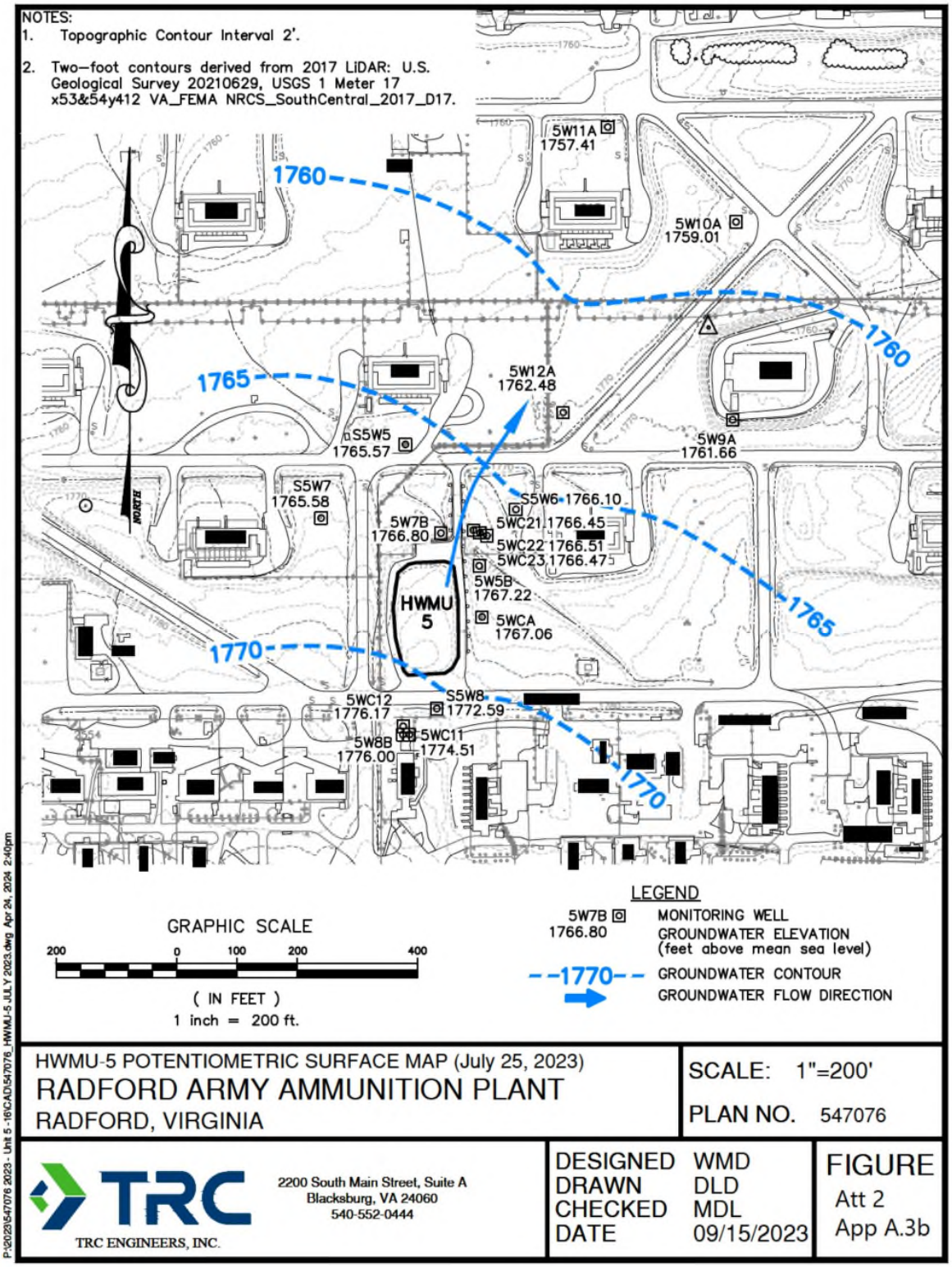


Figure V.A-7 – HWMU-16 Geological Cross Section Location Map

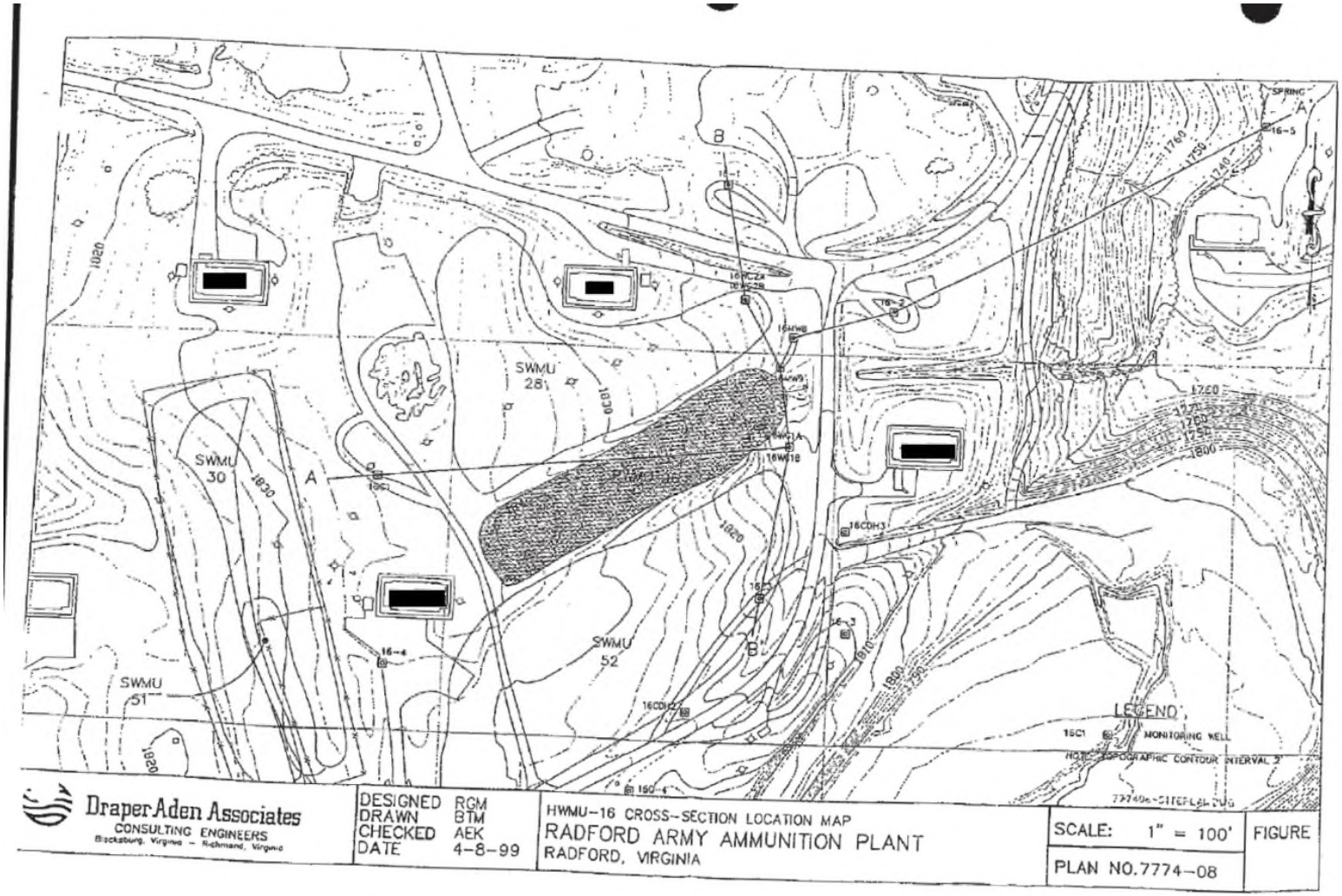


Figure V.A-8 – HWMU-16 Geological Cross Section A – A'

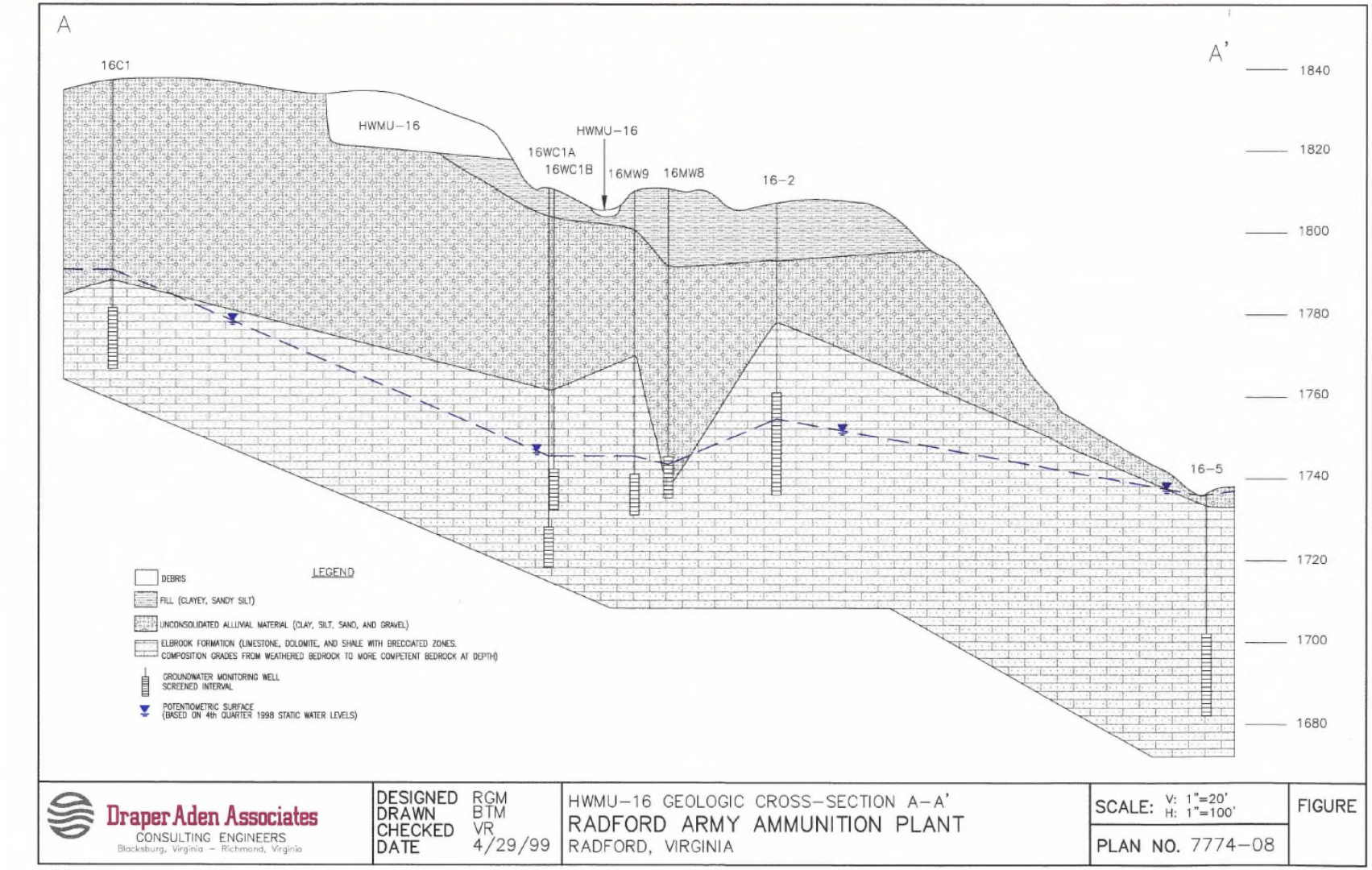


Figure V.A-9 – HWMU-16 Potentiometric Surface (Groundwater Elevation) Map

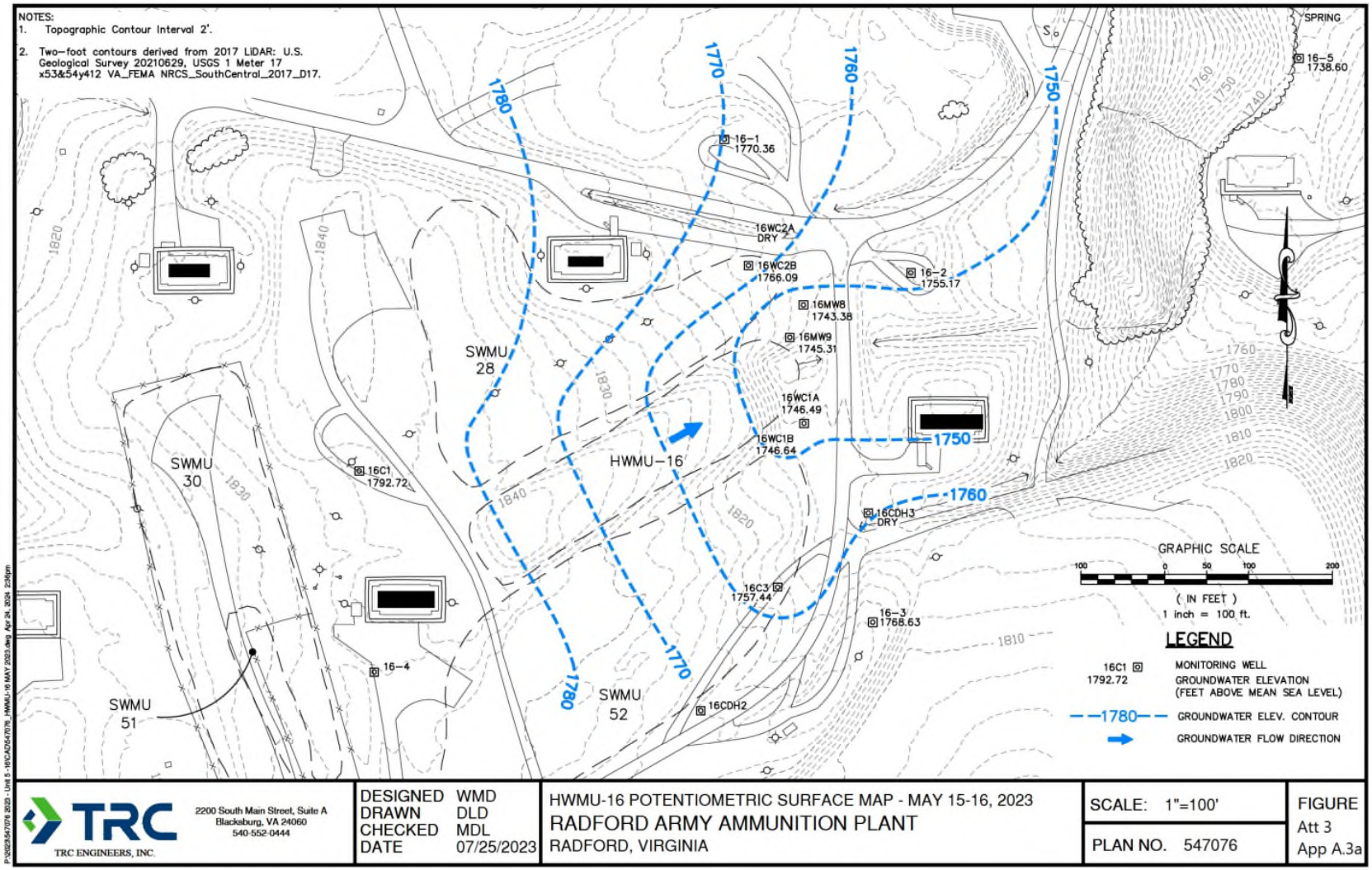
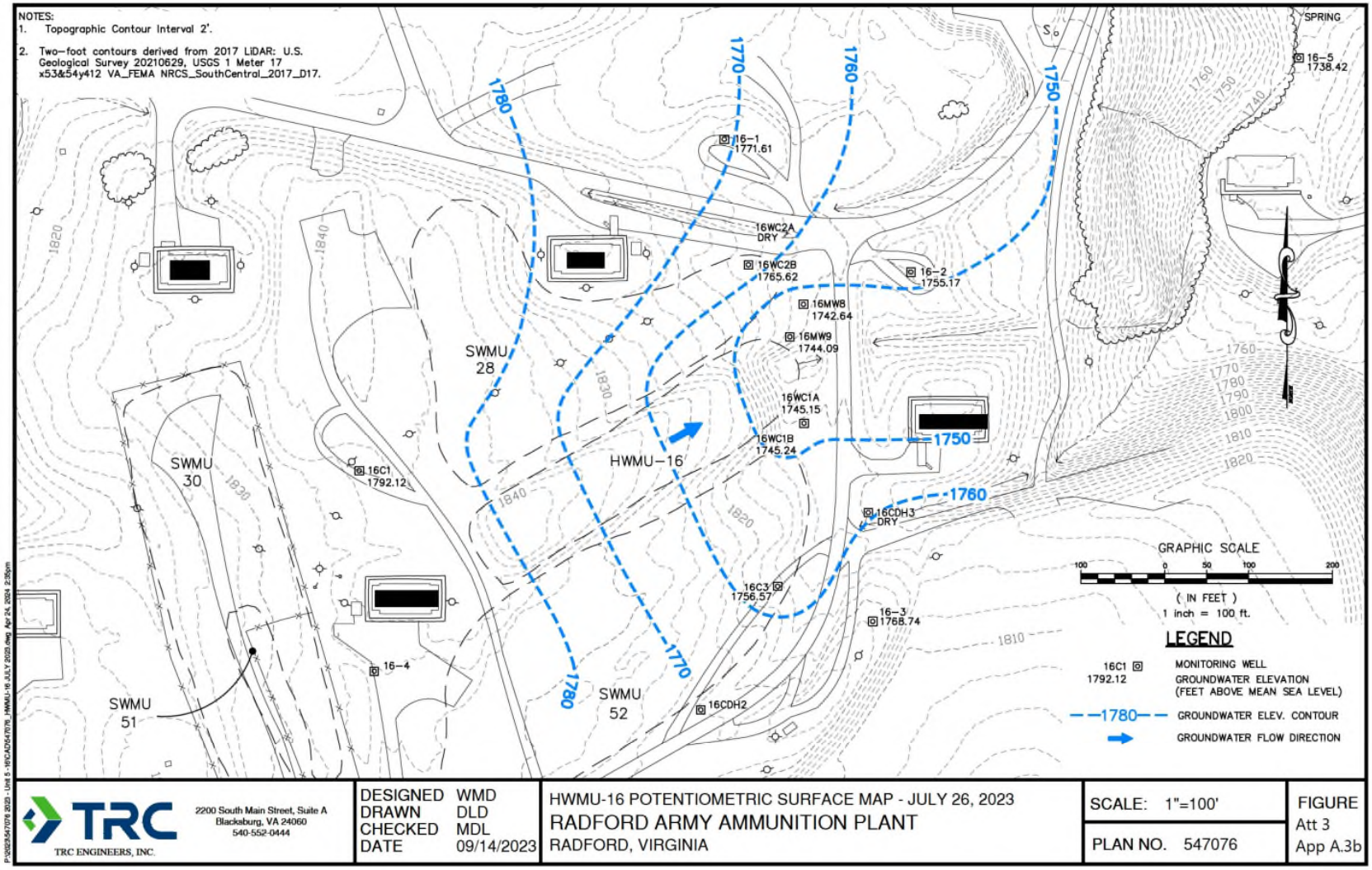


Figure V.A-10 – HWMU-16 Potentiometric Surface (Groundwater Elevation) Map



ATTACHMENT V.B - GROUNDWATER COMPLIANCE MONITORING PROGRAM

V.B-A. BAE SYSTEMS ORDNANCE SYSTEMS INC. RADFORD ARMY AMMUNITION PLANT LOW-FLOW GROUNDWATER SAMPLING AND ANALYSIS PLAN

BAE SYSTEMS ORDNANCE SYSTEMS INC.
RADFORD ARMY AMMUNITION PLANT
RADFORD, VIRGINIA

Low-Flow Groundwater Sampling and Analysis Plan

Updated September 2002
Revised November 2016
Revised April 6, 2021
Revised January 23, 2025

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LIST OF APPENDICES

1.0 INTRODUCTION

This Sampling and Analysis Plan (SAP) is for utilization in the groundwater monitoring program for the hazardous waste management units (Units) located at the Radford Army Ammunition Plant (Radford AAP). This document meets the groundwater sampling and analysis plan requirements of 40 CFR 264 Subpart F. This SAP is based on the USEPA SW-846 and the RCRA Groundwater Monitoring Technical Enforcement Guidance Document (TEGD), "Low Stress (low flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells" (latest version), and "Ground Water Issue, Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures" (latest version).

2.0 PURGING AND SAMPLE COLLECTION PROCEDURES

Purging and sample collection procedures govern all the activities in the field prior to sample preservation. This section contains several initial activities that are significant in maintaining the integrity of the sample and data. These include maintaining a field log book, measurement of static water level, detection of immiscible layers, well evacuation, sample withdrawal, and analysis of field parameters.

2.1 Field Log Sheet/Book

A Field Log Sheet (Appendix A) is utilized to record the field information at each well location. The Field Log Sheet in conjunction with a Field Log Book is used to record field activities for each well. The Field Log Sheet includes the following information:

- well identification
- static water level measurement and equipment used
- presence of immiscible layers noted
- reference point for static water level measurements
- purge volume and pumping rate
- well yield comments
- well purging (evacuation) procedure, time, and equipment
- well sampling date, time, and equipment
- sample identifications (by constituents)
- preservatives used
- constituents to be analyzed
- field measurements; pH , Temperature, specific conductivity, dissolved oxygen, ORP, and turbidity
- headspace in containers review
- time and meters used in field analysis
- sample preparation date, time, and filtering method
- sampler's and sample preparer's names

2.2 Measurement of Static Water Levels

Prior to all sampling activities, plastic sheeting will be placed around each well to protect the sampling equipment from coming in contact with contamination around the well head and to

facilitate the collection of spilled purge water as recommended by the TEGD.

A static water level measurement should be performed in each well at the Unit prior to each sampling event. The total depths of all of the wells at Radford AAP have been established. This information is used to assist in determining if the horizontal and vertical flow gradients have changed since initial site characterizations and/or prior sampling events.

The field crew utilizes well logs to assist in the water level measurements. The measurements are taken with an electronic water level probe. The probe is decontaminated with alconox soap followed by isopropanol/ methanol and distilled/ deionized water rinses. The probe is then lowered into the well, the water level is measured to the nearest 0.01 foot. The permanent reference point is the top of the casing. To determine the desired value of depth to water from ground surface, the length of casing is measured and subtracted from the depth to water from the top of casing. Any changes in length of casing measurement (i.e., modification of well pad or apron) should be noted and corrected. The same value for length of casing above ground should be used each time the water level is measured in the well. Any damage to well or well casing should be noted at this time.

2.3 Detection of Immiscible Layers

The detection of immiscible layers (i.e., LNAPLS and DNAPLS) is an important process in waste management. These two types of liquids can provide valuable information concerning types of existing contamination within the monitored aquifer. This detection requires specialized equipment such as a flame ionization detector (FID) or a photoionization detector (PID) organic vapor analyzer, interface probe, and a modified bailer as well as sample collection prior to well purging.

In the event immiscible layers are suspected the air in the well head should be sampled with a FID. A manometer will be used to detect the static liquid level. The interface probe will then be lowered into the well to determine the presence of any immiscible layer(s). The probe will register the depths of light and/or dense liquid as well as the water level.

The collection of varying layers requires a modified Teflon® bailer. For the light phase immiscible, the bailer should be slowly lowered until contact is made with the air and light phase liquid interface. The bailer should then be lowered to a depth that is less than the immiscible/water interface depth as determined by the preliminary interface probe measurements. This collection method works best with immiscible layers of two (2) feet or greater thickness. If the layer is less than two (2) feet thick but the depth to the surface of the light phase layer is less than 25 feet use a peristaltic pump. In the event that a peristaltic pump can not be used, a modified bailer will be used. The bailer should have the bottom check valve sealed with plastic sheeting and the top check valve removed to allow the sample to enter the top. A bottom check valve bailer without the top check valve can be used if the modification is performed on the bottom check valve. To compensate for buoyancy of the bailer, a section of one-inch stainless steel pipe can be placed on the retrieval line. The bailer should be lowered carefully to the depths indicated from the preliminary measurements. The target sampling depth is to lower the bailer to one-half thickness of the immiscible layer and collect the sample.

The dense phase immiscibles are to be collected with a double check valve bailer. The bailer should be lowered and raised in a slow controlled method. The decontamination procedures specified below shall be performed after collection of the sample.

2.4 Low-Flow Well Purging and Sampling Procedures

2.4.1 Well Purging

Low-flow refers to the velocity with which water enters the pump intake and that is imparted to the formation pore water. Water level drawdown provides the best indication of the stress imparted by a given flow-rate for a given hydrological situation. The objective is to pump in a manner that minimizes stress (drawdown) to the system to the extent practical taking into account established Unit sampling objectives. Flow rates on the order of 0.1 – 0.5 l/min are used; however, this is dependent on Unit specific hydrogeology. Water quality indicator parameters are used to determine purging needs. Once parameters such as pH, specific conductance, dissolved oxygen, oxidation-reduction potential, and temperature have stabilized purging is considered complete. In-line flow cells will be used to continuously measure the above parameters.

The stagnant water within the casing is not representative of the in-situ groundwater quality. The well needs to have this stagnant water removed so that formation water can be sampled. To remove the stagnant formation water the pump will be started at the lowest speed setting and slowly increased until discharge occurs. The water level will then be checked. The pump speed will be adjusted until there is little or no water level drawdown (less than 0.3 feet). If the minimal drawdown that can be achieved exceed 0.3 feet but remains stable, continue purging until indicator field parameters stabilize.

Water level and pumping rates will be monitored and recorded every five minutes (or as appropriate) during purging. Any pumping rate adjustments (both time and flow rate) will be recorded in the field logbook. Pumping rates will, as needed, be reduced to the minimum capabilities of the pump (for example, 0.1 – 0.4 l/min) to ensure stabilization of indicator parameters. Adjustments will be made in the first fifteen minutes of pumping in order to help minimize purging time. During pump start-up, drawdown may exceed the 0.3 feet target and then "recover" the stabilized drawdown value will be recorded, not the initial drawdown. The water level will not be allowed to fall to the intake level (if the static water level is above the well screen, the water level will not lowered to the screen). The final purge volume will be greater than the stabilized drawdown volume plus the extracted tubing volume. This volume will be calculated by the following equation:

$$V_{total} = V_{tubing} + V_{drawdown}$$

$$V_{tubing} = (h_{tubing})(\pi\, r_{tubing}^2)$$

$$V_{drawdown} = (h_{water} * \pi\, r_{well}^2) - (h_{purged} * \pi\, r_{well}^2)$$

Wells with low recharge rates may require the use of special pumps capable of attaining very

low pumping rates. If the recharge rate of the well is lower than extraction rate capabilities of currently manufactured pumps and the well is essentially dewatered during purging, then the well will be sampled as soon as the water level has recovered sufficiently to collect the appropriate volume needed for all anticipated samples (the intake will not be moved during this recovery period). Samples may then be collected even though the indicator field parameters have not stabilized.

Water level, extraction rate, and drawdown information will be recorded in a field logbook. The extraction rate (final pump dial setting) will be duplicated in future sampling efforts.

2.4.2 Measurement of Indicator Field Parameters

During well purging, indicator field parameters (temperature, specific conductance, pH, Eh, DO) will be monitored every five minutes (or less frequently, if appropriate). Purging will be considered complete and sampling may begin when all above indicator field parameters have stabilized. Stabilization is considered to be achieved when three consecutive readings, taken at five-minute intervals, are within the following limits:

Constituent	**Variability**
DO	10%
Specific conductance	3%
Temperature	3%
pH	± 0.1 unit
ORP/Eh	± 10 millivolts

All measurements will be obtained using a flow through-cell. A transparent flow-through-cell will be used, because they allow field personnel to watch for particulate build-up within the cell. This build-up may affect indicator field parameter values measured within the cell. If the cell needs to be cleaned during purging operations, the cell will be disconnected while the pump remains running. The cell will be cleaned and reconnected and monitoring activities will continue.

The flow-through-cell will be designed in a way that prevents air bubble entrapment in the cell. When the pump is turned off or cycling on/off, water in the cell must not drain out. Monitoring probes will remain submerged in water at all times. If two flow-through-cells are used in series, the one containing the dissolved oxygen probe will come first (this parameter is most susceptible to error if air leaks into the system).

2.4.3 Sample Withdrawal

Water samples for laboratory analyses must be collected before water has passed through the flow-through-cell (the cell will be disconnected prior to obtaining samples).

VOC sample aliquots will be collected first and directly into pre-preserved sample containers. Allowing the pump discharge to flow gently down the inside of the container with minimal turbulence will fill all sample containers.

During purging and sampling, the tubing will remain filled with water so as to minimize possible changes in water chemistry upon contact with the atmosphere. Quarter inch or three-eighths inch (inside diameter) tubing will be used to help insure that the sample tubing remains water filled. If the pump tubing is not completely filled to the sampling point, one of the following procedures will be used to collect samples: (1) a clamp, connector (Teflon® or stainless steel) or valve to constrict sampling end of tubing will be added; (2) a small diameter Teflon® tubing will be inserted into water filled portion of pump tubing allowing the end to protrude beyond the end of the pump tubing, samples will be collected from the small diameter tubing; (3) non-VOC samples will be collected first, then the flow rate will be increased slightly until water completely fills the tubing, at that time collection of remaining samples and the new drawdown, flow rate and new indicator field parameter values are then recorded.

2.5 Alternative Well Purging and Sampling Procedures

2.5.1 Alternative Well Purging and Sampling Equipment

In the event of malfunctions with any of the dedicated low-flow pumps, well purging will be conducted using either decontaminated non-dedicated Teflon® or stainless steel bailers, or new disposable polyethylene bailers. In order to reduce the possibility of cross-contamination during sample collection upon completion of well purging, sampling personnel will use either freshly decontaminated non-dedicated Teflon® or stainless steel bailers, or use new, disposable polyethylene bailers for collecting samples from each well.

Any non-dedicated sampling equipment will be decontaminated prior to use at each well. In addition, equipment blanks will be collected from non-dedicated sampling equipment.

2.5.2 Purge Volume Calculations

The Field Log Sheet (Appendix A) will be used to document the calculation of the minimum purge volume of water from the well prior to sample collection. The form also will be used to record the field pH, specific conductivity and temperature measurements for each well sampled.

Prior to collecting groundwater samples from each well, a volume of water equal to three (3) times the combined volume of the wetted well casing and the sand filter pack shall be purged from the well. The goal is to ensure that all of the stagnant water within the well is replaced with fresh formation water upon completion of the process.

The purge volumes will be calculated using the following methods:

- For each well, measure the depth to water (DTW) and total depth of the well (TD) with respect to the top of the well casing prior to disturbing the water column.

- Subtract the depth to water from the total well depth (TD-DTW) in order to obtain the height of the water column in the well casing in feet (h_w).

- For wells with water levels above the top of the sand filter pack, the equation for calculating the purge volume shall be:

  $3 * [(\Pi r_b^2 h_s - \Pi r_c^2 h_s) * 0.3 + (\Pi r_c^2 h_w)]$

- For wells with water levels below the top of the sand filter pack, the equation for calculating the purge volume shall be:

  $3 * [(\Pi r_b^2 h_w - \Pi r_c^2 h_w) * 0.3 + (\Pi r_c^2 h_w)]$

  Where: r_b = radius of well borehole;
  r_c = radius of well casing;
  h_s = height of sand filter pack;
  h_w = height of the water column.

In the event that a well has a low yield, it shall be purged to dryness if dryness occurs prior to purging the required three well casing volumes. A minimum of one well volume will be purged in this instance.

2.5.3 Measurement of Indicator Field Parameters

During well purging, indicator field parameters temperature, specific conductance, and pH will be measured. Purging shall continue until temperature, specific conductance, and pH readings have stabilized. "Stability" is defined as variation less than 10% of the preceding reading for two consecutive readings. Water temperature, specific conductance, and pH shall be measured a minimum of two times per well volume or once per 2.5 gallons of purge water (whichever is less). Each measurement of temperature, specific conductance, and pH shall be recorded along with the cumulative purge volume and the time-of-day.

2.5.4 Sample Withdrawal

For each monitoring well, the samples will be collected using either freshly decontaminated non-dedicated Teflon® or stainless steel bailers, or new, disposable polyethylene bailers upon completion of well purging. Individual sample aliquots will be collected in order of decreasing constituent volatility. VOC samples will be collected first and directly into pre-preserved sample containers.

Low yield wells must be sampled within 24 hours of purging. If yield is insufficient to obtain the required sample volume, the samples should be noted as “not obtainable due to insufficient well yield” on the Field Log Sheet for that well and in the Field Log Book.

2.5.5 Equipment Decontamination

Any non-dedicated sampling equipment will be decontaminated prior to use at the site, and after use at each well. Decontamination will be performed in a manner such that the decontamination solutions may be captured. The non-dedicated sampling equipment will be decontaminated as follows:

- Wash equipment with phosphate-free detergent.
- Rinse equipment with distilled/ deionized water.
- Rinse equipment with isopropanol or methanol.
- Rinse equipment with distilled/ deionized water.

Following decontamination, the equipment will be allowed to air dry or dried using clean disposable wipes.

2.6 Sample Preservation and Handling

Samples will be preserved with the proper preservatives in accordance with USEPA SW-846 (Test Methods for Evaluating Solid Waste, latest edition). Prior to sample collection, sample bottles will be prepared by the analyzing laboratory. Preservatives (as required by analytical methods) will be added to samples immediately after they are collected if the sample containers are not pre-preserved by the laboratory. More detailed preservation information is provided in Table 1.

The groundwater-monitoring program requires certain special handling considerations. Initially, the samples should not be transferred to another container due to loss of analyte and volatilization. The VOC containers should be slowly filled to eliminate any headspace within the container. Any headspace remaining in these containers should be noted in the logbook.

All sample containers shall be packed in a cooler with ice as soon as they are collected. Upon the completion of activities at the Unit, the coolers will be packed with additional ice for transport to the contract laboratory. The samples will be relinquished directly from the samplers to representatives from the contract analytical laboratory for transport to the laboratory, or the samples will be shipped to the laboratory by common carrier.

In the event that final receipt by the laboratory of any shipping container or sample bottle indicates evidence of compromised sample integrity, the laboratory QA/QC officer or his/her representative shall notify the operator within 24 hours of receipt. Subsequent to notification, sample integrity will be evaluated and appropriate actions will be taken to assure representative samples. Sample integrity determinations and needs for additional actions will be conducted according to QA/QC guidance from USEPA SW-846 (Test Methods for Evaluating Solid Waste, latest edition). Resampling will be conducted if determined necessary.

TABLE 1

SAMPLING AND PRESERVATION PROCEDURES

PARAMETER	ANALYTICAL METHOD	CONTAINER[a]/ VOLUME REQUIRED	PRESERVATIVE	MAXIMUM HOLDING TIME
INORGANICS ANALYSES				
Metals (total) except Mercury	6010/6020	P - 1L or 500 ml	HNO, to pH<2	6 months
Mercury (total)	7470	P - 300 ml	HNO, to pH<2	28 days
Cyanide	9010/9012	P, G - 500 ml	Cool to ≤6°'C, NaOH to pH>12, 0.6 g ascorbic acid.	14 days
ORGANICS ANALYSES				
Acrolein and acrylonitrile	8260	3 - 40 ml VOA[b] G, Teflon-lined septum	Cool to 0 - 6°C HCl to pH less than 2 (Note 1)	14 days
Purgeable Volatile Compounds	8260	3 – 40 ml VOA[b] G, Teflon-lined septum	Cool to 0 - 6°C HCl to pH less than 2	14 days
Semivolatile Organics	8270	G, Teflon-lined cap – 1 L Amber (or other size, as appropriate, to allow use of entire sample for analysis)	Cool to 0 - 6°C	Samples extracted within 7 days and extracts analyzed within 40 days following extraction.

NOTES:
1 - The USEPA document SW 846 notes that for acrylonitrile and acrolein the recommended preservation is pH 4-5 S.U.; however, this is used for guidance purposes and therefore allows for deviations. SW-846 Chapter 4 – Section 4.1 – Sampling Considerations states "preservation and holding time information does not represent USEPA requirements, but rather is intended solely as guidance." SW-846 Method 8260 does not exclude analysis of acrylonitrile (and acrolein) preserved at pH <2 S.U.

[a] Container Types:
P: Plastic (polyethylene)
G: Glass

[b] Do not allow any headspace in the container.

2.7 Chain-of-Custody Documentation

The groundwater-monitoring program incorporates a chain-of-custody program to track the route and handlers of the groundwater samples. The monitoring of sample possession from field sampling to laboratory analysis is important in the event that unexpected lab results occur and the security of transportation is evaluated. This documentation contains several records and logs that assist in the quality control of the program.

Sample labels are used to prevent misidentification of samples. The labels are filled and affixed to the sample containers prior to field sampling. The labels contain the following information:

- Sample identification number
- Name of sampler (initials)
- Date and time of sample collection
- Sampling location
- Constituents to be analyzed

Sample seals should be used when a common carrier transports the sample shipment to the laboratory. These seals are placed on the outside of the shipping container to ensure that the samples have not been disturbed during transportation. The sample identification and date will be included on the sample seal.

The chain-of-custody record is filled out for each Unit and accompanies the samples to the contract laboratory. The completed form is returned to Radford AAP with the analysis for each Unit. This record is shown in Appendix A. The sample possession is established from time of collection to the time of analysis. This record contains the following information:

- sample identification and location
- signature of sampler
- date and time of sampling
- sample type
- well identification
- number of containers
- required analysis
- signatures of person(s) involved in possession
- times and dates of possession
- method of transportation
- statement for packing on ice
- internal temperature upon arrival at laboratory

A sample analysis request sheet can further clarify the samples for each requested constituent. This additional check sheet will be utilized when necessary (i.e., beginning of a new contract with a new laboratory). This sheet sent along with the samples will contain the following information:

- name of person receiving samples

- laboratory sample number
- date of sample receipt
- analysis to be performed
- internal temperature during shipping

2.8 Sample Transport

The samples will be relinquished directly from the samplers to representatives from the contract analytical laboratory for transport to the laboratory. In the event that a laboratory courier is unavailable, the samples will be shipped to the laboratory by a certified carrier.

2.9 Analytical Procedures

The analytical methods set forth in USEPA SW-846 (Test Methods for Evaluating Solid Waste, latest edition) will be used to analyze all constituents. Suggested analytical methods and associated practical quantitation limits (PQLs) for each Unit are listed in Appendix B.

The laboratory shall perform the necessary preparation on all samples, including blanks and duplicates.

All records of analysis will be distributed to the appropriate agency as well as maintained on site.

Additionally, the laboratory must be accredited for the analytical method, matrix, and target analyte (where applicable) by the Virginia Environmental Laboratory Accreditation Program (VELAP).

2.10 Quality Assurance/Quality Control

The SAP addresses the Quality Assurance/Quality Control (QA/QC) program to ensure the reliability and validity of field and analytical laboratory data gathered as part of the overall groundwater monitoring program.

2.10.1 Field QA/QC Program

The field QA/QC program is designed to ensure the reliability and validity of the field data gathered as part of the overall groundwater monitoring program. The field QA/QC program consists of regular calibration of field analytical instruments, and routine collection and analysis of trip blanks, and blind field duplicates. In the event that non-dedicated sampling equipment is used, equipment blanks will be collected and analyzed as well.

Field analytical instruments shall be calibrated in the field at each Unit prior to sampling the first well using standard solutions prepared by the manufacturer of the instrument or other laboratory. Calibration of these instruments shall be checked against standard solutions between each well and after sampling the final well at the Unit, or as recommended by the instrument manufacturer. All calibration data shall be recorded, indicating time-of-day and value.

For each sampling event, one trip blank per Unit shall be filled with laboratory-grade reagent water in the laboratory that has been selected to conduct the groundwater analyses. The trip blank shall be analyzed only for the same Unit-specific volatile organic compounds for which the samples will be analyzed. The trip blank shall accompany the sampling kit, in the transport cooler, at all times.

One blind field duplicate sample will also be taken for every 20 samples per Unit, whether that sampling event occurs on one day or longer. The blind field duplicate will be analyzed for the Unit-specific constituents. The monitoring well from which the blind field duplicate is collected should be noted on the Field Log Sheet for that well and in the Field Log Book.

Equipment blanks will be used to monitor the decontamination of non-dedicated equipment used in the sampling process. The blank consists of filling sample bottles with Type II reagent grade water through the sampling device, transfer to sample bottles, and return to the laboratory for analysis. Again, this blank is handled like a groundwater sample. One equipment blank every 20 samples will be used whether that sampling event occurs over one day or longer. The equipment blank will be analyzed for the Unit-specific constituents.

The occurrence of constituents in blank samples may serve to invalidate the analytical results of the affected constituents. Additional blanks or duplicate samples may be prepared and analyzed to address specific, unanticipated conditions.

2.10.2 Laboratory QA/QC Program

The contract laboratory is to provide a QA/QC plan for laboratory analysis according to USEPA SW-846 (Test Methods for Evaluating Solid Waste, latest edition). This plan utilizes standards, laboratory blanks, duplicates, batch spikes, and matrix spikes for calibration and identification of potential matrix interferences. This data is on file at the laboratory and is routinely reviewed by Radford AAP personnel. This data is a measure of performance as well as an indicator of potential sources of cross contamination. This control data is for performance review and not for correction of groundwater analysis data.

The contract laboratory will keep a logbook to document the processing steps that are applied to the sample. All sample preparation techniques and instrumental methods must be identified in this logbook. The results of the analysis of all quality control samples should be identified specific to each batch of groundwater samples analyzed. The logbook should also include the time, date, and name of person who performed each processing step.

Dilution during analyses has a major impact on the overall quality and usability of the ground water monitoring data. Large dilution factors may mask hazardous constituents that are present at low concentrations, which may result in constituent concentrations not being identified completely throughout the plume. Therefore, when multiple analyses using sequential dilutions are required, the results from these multiple analyses will be reported.

BIBLIOGRAPHY

USEPA Groundwater Vol. 1 - Groundwater and Contamination; EPA 625/6-90/016A , Office of Research and Development, Washington, D. C., September 1990

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Guidance on Remedial Actions for Contaminated Groundwater at Superfund Sites; EPA/54001G-88/003, OERR, December 1988

RCRA Groundwater Monitoring Technical Enforcement Guidance, EPA/ EC-G-2002-130, OSWER-9950.1, 1986

Test Methods for Evaluating Solid Waste (SW-846)

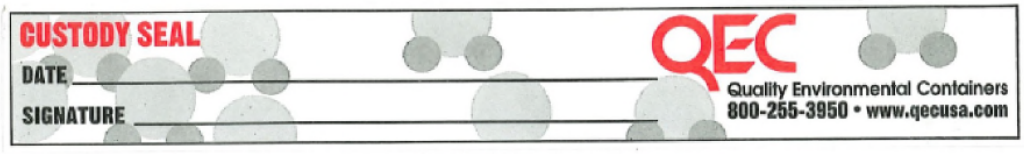
Low Stress (low flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells, Region I, SOP #: GW 0001, July 30, 1996. Revised January 19, 2010, Revised September 19, 2017 or latest version when revised.

Ground Water Issue, Low-Flow (Minimal Drawdown) Ground-water Sampling Procedures, EPA/540/S-95/504, April 1996 or latest version when revised.

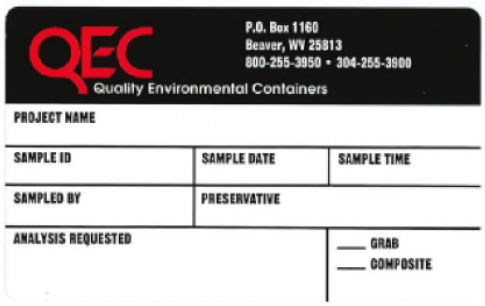
APPENDIX A

Field Log Sheet

Example Custody Seal



Example Sample Label



Example Chain-of-Custody Form

CHAIN OF CUSTODY RECORD

Laboratory: Eurofins Lancaster Laboratories Environmental, LLC - 2425 New Holland Pike, Lancaster, PA, 17605 - Barb Weyandt, Sr. Project Manager, 717-556-7264,Barbara.Weyandt@et.eurofinsus.com

Consultant: Draper Aden Associates, LLC, a TRC Company
Attn: Janet C. Frazier
Address: 2206 South Main Street Suite A
Blacksburg, Virginia 24060
Phone: (540) 552-0444
Fax: (540) 552-0291

Box 1: Matrix
SW Surface Water; GW Groundwater; L Leachate; S Soil; T Trip Blank; E Equipment Blank; P Product; O Other:

Box 2: Preservative
A HCl; B HNO_3; C H_2SO_4; D $Na_2S_2O_3$; E NaOH; F ZnAc; G Other (Specify); H None

Box 3: V VOA; CG Clear Glass

Box 4: Sample Type
G Grab; C Composite

Box 4 - Sample Type
Box 3 - Filtered/Unfiltered
Required/# of Sample
Box 2 - Preservative
Box 1 - Sample Container Type

GENERAL NOTES:
1. Full Deliverable
2. Report DL/QL and estimated results.
3. VELAP Accreditation required.
4. See attached target analyte lists.

Sample ID	Date: 2024	Time	Box 1: Matrix	Number of Bottles									

Check Special Instructions:

Received by lab in Good Condition: ____ Yes ____ No Custody Seal Intact: ____ Yes ____ No Temperature upon arrival: ____ Received on Ice ____ Yes ____ No
Describe problems, if any:

Sampler Name (Print):	Date:	#1 Relinquished by (Signature):	Date:	#2 Relinquished by (Signature):	Date:	Sample Storage Time Requested:
Sampler Signature:	Time:	Company Name:	Time:	Company Name:	Time:	
Sampler Name (Print):	Date:	#1 Received by (Signature):	Date:	#2 Received by (Signature):	Date:	30 DYS 10 DYS 5 DYS 72 HRS 48 HRS
Sampler Signature:	Time:	Company Name:	Time:	Company Name:	Time:	

GROUNDWATER SAMPLING RECORD | **WELL NUMBER:** _____ | **Page:**____ **of** ____

Project Name: _____ Project Number: _____

Date: _____
Developed by: _____
Measuring Point of Well: _____
Screened Interval (ft. TOC) _____
Filter Pack Interval (ft. TOC) _____

Starting Water Level (ft TOC): _____
Casing Stickup (ft): _____
Total Depth (ft TOC): _____
Casing Diameter (inches): _____

Casing Volume _____ (ft Water) x _____ (Lpfv)(gpf) = _____ (L)(gal)
Casing volumes: 2" = 0.16 gpf 4" = 0.65 gpf 6" = 1.47 gpf
2" = 0.62 Lpf 4" = 2.46 Lpf 6" = 5.56 Lpf

Sample Intake Depth (ft TOC): _____

PURGING MEASUREMENTS

Time	Cumul. Vol. (gal or L)	Purge Rate (gpm or Lpm)	Water Level (ft)	Temp. (C or F)	Specific Conductance (µS/cm)	Dissolved Oxygen (mg/L)	pH	Eh ORP (mv)	Turbidity (NTU)	Comments

Total Gallons Purged: _____ Total Casing Volumes Removed: _____

Ending Water Level (ft TOC): _____ Ending Total Depth (ft TOC): _____

SAMPLE INVENTORY

Time	Volume	Bottle Type		Quantity	Filtration	Preservation	Appearance		Remarks
							Color	Turbidity & Sediment	

METHODS

Sampling Equipment and IDs: _____

Purging Equipment: _____ Decon Equipment: _____

Disposal of Discharged Water: _____

Observations/Comments: _____

Field Meter Verification/Calibration Form

PROJECT INFORMATION

Job Name: ______________________

Job No.: ______________________ Task No.: ______________________

Project Manager: ______________________ Field Team Leader: ______________________

Acceptable Verification Ranges

Parameter	Range
pH	± 0.1 SU
DO	98% - 102% (± 2%)
Specific Conductance	± 5 %
ORP	± 10 mV
Turbidity	± 10 %

Date	Time	Calibration Technician Initials	Equipment assigned to:	Meter Type	Serial #	Cal Standard 1	Meter Reading	Cal Standard 2	Meter Reading	Calibration or Verification	Comments
				YSI 556		pH 7		pH 4		Calibration Verification	
				YSI 556		ORP 240mV		S.Cond 1.413mS/cm		Calibration Verification	
				YSI 556		DO 100%				Calibration Verification	
				Turbidimeter		NTU		NTU		Calibration Verification	
				Turbidimeter		NTU		NTU		Calibration Verification	
				YSI 556		pH 7		pH 4		Calibration Verification	
				YSI 556		ORP 240mV		S.Cond 1.413mS/cm		Calibration Verification	
				YSI 556		DO 100%				Calibration Verification	
				Turbidimeter		NTU		NTU		Calibration Verification	
				Turbidimeter		NTU		NTU		Calibration Verification	
				YSI 556		pH 7		pH 4		Calibration Verification	
				YSI 556		ORP 240mV		S.Cond 1.413mS/cm		Calibration Verification	
				YSI 556		DO 100%				Calibration Verification	
				Turbidimeter		NTU		NTU		Calibration Verification	
				Turbidimeter		NTU		NTU		Calibration Verification	
				YSI 556		pH 7		pH 4		Calibration Verification	
				YSI 556		ORP 240mV		S.Cond 1.413mS/cm		Calibration Verification	
				YSI 556		DO 100%				Calibration Verification	
				Turbidimeter		NTU		NTU		Calibration Verification	
				Turbidimeter		NTU		NTU		Calibration Verification	
				YSI 556		pH 7		pH 4		Calibration Verification	
				YSI 556		ORP 240mV		S.Cond 1.413mS/cm		Calibration Verification	
				YSI 556		DO 100%				Calibration Verification	
				Turbidimeter		NTU		NTU		Calibration Verification	
				Turbidimeter		NTU		NTU		Calibration Verification	
				YSI 556		pH 7		pH 4		Calibration Verification	
				YSI 556		ORP 240mV		S.Cond 1.413mS/cm		Calibration Verification	
				YSI 556		DO 100%				Calibration Verification	
				Turbidimeter		NTU		NTU		Calibration Verification	
				Turbidimeter		NTU		NTU		Calibration Verification	

APPENDIX B

Unit-Specific Groundwater Monitoring Constituent Lists

Hazardous Waste Management Unit 5
Groundwater Compliance Monitoring (Semiannual) Constituent List
Radford Army Ammunition Plant, Radford, Virginia

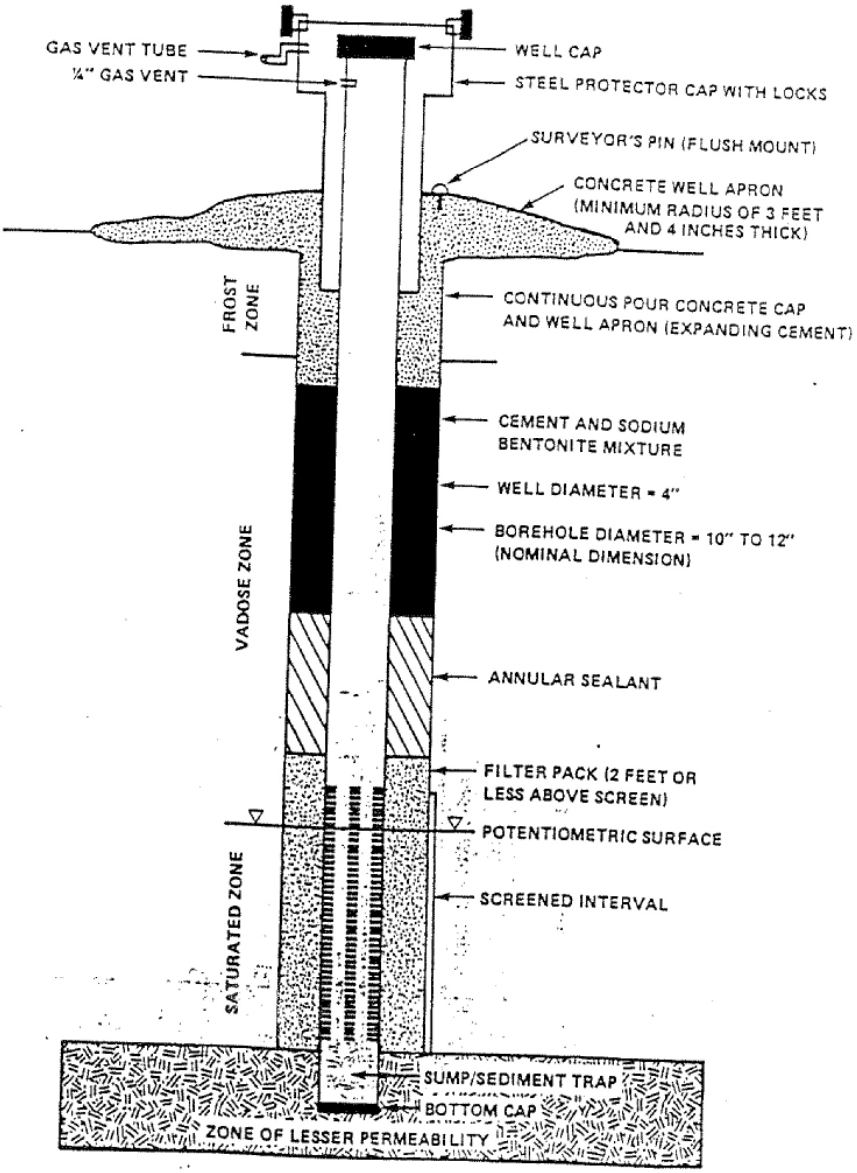
Analyte	METHOD	PQL (ug/l)
Antimony, total	6010/6020	2
Arsenic, total	6010/6020	10
Barium, total	6010/6020	10
Beryllium, total	6010/6020	1
Cadmium, total	6010/6020	1
Chromium, total	6010/6020	5
Cobalt, total	6010/6020	5
Copper, total	6010/6020	5
Lead, total	6010/6020	3
Mercury, total	7470	2
Nickel, total	6010/6020	10
Selenium, total	6010/6020	10
Silver, total	6010/6020	2
Thallium, total	6010/6020	1
Vanadium, total	6010/6020	10
Zinc, total	6010/6020	30
Acetone	8260	10
Bis (2-ethylhexyl) phthalate (DEHP)	8270	10
2-Butanone (Methyl ethyl ketone; MEK)	8260	10
Chloroform	8260	1
Dichlorodifluoromethane	8260	1
1,2-Dichloroethane	8260	1
Diethyl ether	8260	12.5
Diethyl phthalate	8270	10
2,4-Dinitrotoluene	8270	10
2,6-Dinitrotoluene	8270	10
Methylene chloride (Dichloromethane)	8260	5
o-Nitroaniline; 2-	8270	10
p-Nitroaniline; 4-	8270	10
Nitrobenzene	8270	10
Toluene	8260	1
Trichloroethene	8260	1
Xylenes (total)	8260	3

Groundwater Compliance Monitoring (Semiannual) Constituent List
Hazardous Waste Management Unit 16
Radford Army Ammunition Plant, Radford, Virginia

Analyte	METHOD	PQL (ug/l)
Arsenic, total	6010/6020	10
Barium, total	6010/6020	10
Beryllium, total	6010/6020	1
Cadmium, total	6010/6020	1
Chromium, total	6010/6020	5
Cobalt, total	6010/6020	5
Copper, total	6010/6020	5
Lead, total	6010/6020	3
Mercury, total	7470	2
Nickel, total	6010/6020	10
Silver, total	6010/6020	2
Vanadium, total	6010/6020	10
Zinc, total	6010/6020	30
Benzene	8260	1
2-Butanone	8260	10
Carbon tetrachloride	8260	1
Chloroethane	8260	1
Dichlorodifluoromethane	8260	1
1,1-Dichloroethane	8260	1
1,1-Dichloroethene	8260	1
Diethyl ether	8260	12.5
Dimethyl ether;	8260	12.5
Ethylbenzene	8260	1
Methylene chloride	8260	5
Tetrachloroethene; PCE	8260	1
Chloromethane	8260	1
Toluene	8260	1
1,1,1-Trichloroethane	8260	1
Trichloroethene	8260	1
1,1,2-Trichloro-1,2,2-Trifluoroethane	8260	1
Trichlorofluoromethane	8260	1
Tetrahydrofuran	8260	25
Vinyl chloride	8260	1
Xylenes, total	8260	3
Diethyl phthalate	8270	10
2,4-Dinitrotoluene	8270	10
2,6-Dinitrotoluene	8270	10

Notes: ug/l = micrograms per liter,
PQL = Practical Quantitation Limit

V.B-B. GROUNDWATER MONITORING WELL CONSTRUCTION DIAGRAM



GENERAL MONITORING WELL – CROSS SECTION

V.B-C. INVESTIGATION DERIVED WASTE POLICY

20-80-004-1995
References Revised 09-2003

MEMORANDUM

TO: Waste Operations Staff
Regional Waste Compliance Managers

FROM: Hassan Vakili, Director
Waste Operations

DATE: July 5, 1995

COPY: Bob Burnley

SUBJECT: Department Policy on Investigation Derived Waste (IDW)

Attached is a copy of the "Policy for the Handling of Investigation Derived Waste (IDW)" that has recently been finalized. Please ensure that all appropriate staff receive copies of this policy which will hopefully serve to address the questions that have been raised regarding the proper management of these types of wastes.

If you should have any questions regarding this matter or require further clarification, please contact Ulysses Brown at (804) 527-5148.

Department of Environmental Quality
Waste Operations
Policy for the Handling of
Investigation Derived Waste (IDW)

The Department of Environmental Quality (DEQ), Waste Operations has received a request for guidance from the regulated community concerning the Commonwealth of Virginia's requirements regarding the management and disposal of investigation derived waste (IDW). Because Virginia administers an authorized state RCRA program, the Virginia Solid Waste Management Regulations (VSWMR) and the Virginia Hazardous Waste Management Regulations (VHWMR) will serve as the governing requirements in lieu of Federal RCRA regulations contained in the Code of Federal Regulations (40 CFR 260 - 270) except for the Land Disposal Restrictions of 40 CFR 268. For reference, please see the Virginia Waste Management Act, Code of Virginia §10.1-1400 et seq.; the Virginia Hazardous Waste Management Regulations (VHWMR) (9 VAC 20-60-10 et seq.); the Virginia Solid Waste Management Regulations (VSWMR) (9 VAC 20-80-10 et seq.); Federal: the Resource Conservation and Recovery Act (RCRA), 42 USC 6901; and the U. S. Department of Transportation Rules for the Transportation of Hazardous Materials, 49 CFR Part 107, 171.1 - 172.558.

With regard to IDW, it is the site manager's responsibility to determine whether the wastes generated during an investigation meet the definition of a solid or hazardous waste. The site manager will be either the on-scene coordinator (i.e., either the federal official predesignated by the Environmental Protection Agency (EPA) or the U.S. Coast Guard to coordinate and direct federal responses under subpart D or the official designated by the lead agency to coordinate and direct removal actions under subpart E of the National Contingency Plan (NCP)), or the remedial project manager (i.e., the official designated by the lead agency to coordinate, monitor, or direct remedial or other response actions under subpart E of the NCP).

If there is a possibility that either the ground water or the soil at the location where a monitoring well is installed is contaminated, the site manager must determine whether or not the well cuttings, purge water, and/or other IDW are contaminated (i.e., whether they are solid or hazardous wastes). In these cases, the site manager may use knowledge of the contaminated media to declare that the IDW is solid or hazardous waste. If analysis shows that no contamination is present in the soil or the ground water at the location where the monitoring well is installed, neither the well cuttings, nor the purge water would be regulated as a solid waste. An example of a situation where the site manager might use knowledge to determine proper disposition (i.e., testing would not be required) would involve materials generated at locations where wells are installed for the purpose of ascertaining naturally occurring levels of inorganic

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constituents and there is no basis to expect contamination, i.e., there is no past history of hazardous waste management activities or releases in these areas. If this is the case, the soils, cuttings, purge water, etc. would not be regulated as solid wastes. Test results or knowledge of the waste should be used to screen the well cuttings, purge water and other IDW to demonstrate that concentrations of contaminants are below or equal to background levels.

Purge water, well cuttings from monitoring wells, and other IDW, if tested, must be done so in accordance with EPA SW-846, Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods, 3rd edition, 1986, as updated. If contaminant levels are found to be above background levels, the IDW would be considered a solid waste. Should test results further indicate that the IDW contains a listed hazardous waste, or if the IDW exhibits a characteristic of hazardous waste, the IDW is a hazardous waste and must be managed and disposed in accordance with the VHWMR. Alternatively, contaminated IDW that contains a listed hazardous waste must be managed as a hazardous waste until it no longer "contains" the hazardous waste, i.e., until the constituent levels are below site specific risk based levels. This is consistent with EPA's Contained In Policy. The DEQ should be contacted directly to determine the site specific risk based levels that would apply to IDW that contains listed hazardous waste.

If the IDW is not a hazardous waste, but contains levels of contaminants above background levels, the IDW must be managed in accordance with the VSWMR. Solid waste generated from cleanup or investigation activities is considered a special waste under Part VIII of the VSWMR. Prior to acceptance of a special waste for disposal at a solid waste management facility, the operator must obtain prior authorization from the Department. Purge water, on the other hand, must be disposed at a publicly owned treatment works (POTW) or other wastewater treatment system operating in accordance with its Virginia Pollutant Discharge Elimination System (VPDES) permit, provided that all other pertinent criteria are satisfied.

The on-site treatment, storage, or disposal of IDW must be authorized by a permit from the DEQ. A generator of hazardous IDW may accumulate such wastes in tanks or containers in accordance with 40 CFR 262.34. Treatment of hazardous waste in tanks or containers within the 90 day accumulation period may only occur upon prior written approval from the appropriate DEQ Regional Office.

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This policy may be revised or rescinded at any time as Federal and/or State regulations change.

Signed:

[signed]

_____
Hassan Vakili, Director
Waste Operations

6-28-95
References Revised 09-2003

_____
Date

04-1996

ADDENDUM

Department of Environmental Quality
Waste Operations
Policy for the Handling of
Investigation Derived Waste (IDW)

This Addendum is being provided to clarify the distinction between the disposal requirements for Investigation Derived Waste (IDW) that is generated from an undefined area, and the requirements for soil and sediment IDW when soil and sediment is generated from an area of known contamination subject to further response measures with oversight from DEQ and/or EPA.

"DEQ Policy for the Handling of Investigation Derived Waste" dated July 5, 1995, specifies that IDW contaminated above background levels is considered a solid waste and must be managed in accordance with the Virginia Solid Waste Management Regulations. If the IDW contains a listed hazardous waste or exhibits the characteristic of a hazardous waste, it must be managed as a hazardous waste in accordance with the Virginia Hazardous Waste Management Regulations. Under this policy, returning the IDW to the location from which it is generated is prohibited.

However, this policy was not intended to address the requirements associated with soil and sediment IDW generated from an area of known contamination when this area is subject to future response activities with oversight from the DEQ or EPA. In such a case, the management and disposal of the IDW should be in accordance with pertinent EPA guidance governing the applicability of RCRA land disposal restrictions. ("Management of IDW During SI's", EPA/540/G-91/009).

Under the EPA guidance, replacement of soil and sediment IDW into the area of contamination from which it is generated is permissible provided that the waste is not treated prior to placement. Therefore, the above-referenced DEQ IDW policy now recognizes that if soil and sediment IDW is generated from an area of known contamination, and this area is subject to further response measures with oversight from DEQ and/or EPA, the IDW may be placed back into the area from which it is taken provided there is no treatment of this waste prior to placement.

Signed *[SIGNED]* Date 7/24/96
Hassan Vakili, Director
Division of Waste Operations

ATTACHMENT V.C - ANNUAL GROUNDWATER SAMPLING CONSTITUENT LIST (APPENDIX IX, 40 CFR PART 264)

Analyte	CAS Number	Method	PQL(ug/l)	MDL (ug/l)
1,1,1,2-Tetrachloroethane	630-20-6	8260	1	0.3
1,1,1 -Trichloroethane	71-55-6	8260	1	0.3
1,1,2,2-Tetrachloroethane	79-34-5	8260	1	0.3
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	8260	1	0.4
1,1,2-Trichloroethane	79-00-5	8260	1	0.3
1,1 -Dichloroethane	75-34-3	8260	1	0.4
1,1 -Dichloroethene	75-35-4	8260	1	0.3
1,2,3-Trichloropropane	96-18-4	8260	1	0.3
1,2,4,5-Tetrachlorobenzene	95-94-3	8270	10	2
1,2,4-Trichlorobenzene	120-82-1	8260	1	0.6
1,2,4-Trichlorobenzene	120-82-1	8270	10	0.43
1,2-dibromo-3-chloropropane	96-12-8	8260	1	0.4
1,2-dibromoethane	106-93-4	8260	1	0.3
1,2-Dichlorobenzene	95-50-1	8260	1	0.4
1,2-Dichlorobenzene	95-50-1	8270	10	0.48
1,2-Dichloroethane	107-06-2	8260	1	0.3
1,2-Dichloropropane	78-87-5	8260	1	0.4
1,3-Dichlorobenzene	541-73-1	8260	1	0.4
1,3-Dichlorobenzene	541-73-1	8270	10	0.52
1,3-Dichloropropane	142-28-9	8260	1	0.4
1,3-Dinitrobenzene	99-65-0	8270	10	2.3
1,4-Dichlorobenzene	106-46-7	8260	1	0.4
1,4-Dichlorobenzene	106-46-7	8270	10	0.37
1,4-Dioxane	123-91-1	8260	200	45.48
1,4-Napthoquinone	130-15-4	8270	10	3.0
1 -Naphthylamine	134-32-7	8270	10	3.0
2,3,4,6-Tetrachlorophenol	58-90-2	8270	10	1.8
2,4,5-Trichlorophenol	95-95-4	8270	10	2.0
2,4,6-Trichlorophenol	88-06-2	8270	10	1.8
2,4-Dichlorophenol	120-83-2	8270	10	1.59
2,4-Dimethylphenol	105-67-9	8270	10	3.0

Analyte	CAS Number	Method	PQL (ug/l)	MDL (ug/l)
2,4-Dinitrophenol	51-28-5	8270	10	6.2
2,4-Dinitrotoluene	121-14-2	8270	10	2.1
2,6-Dichlorophenol	87-65-0	8270	10	2.0
2,6-Dinitrotoluene	606-20-2	8270	10	2.1
2-Acetylaminofluorene	53-96-3	8270	10	3.0
2-Butanone (MEK)	78-93-3	8260	10	1.7
2-Chloronaphthalene	91-58-7	8270	10	0.5
2-Chlorophenol	95-57-8	8270	10	1.0
2-Hexanone	591-78-6	8260	10	2.0
2-Methylnaphthalene	91-57-6	8270	10	0.29
2-Naphthylamine	91-59-8	8270	10	7.0
2-Nitroaniline	88-74-4	8270	10	1.0
2-Nitrophenol	88-75-5	8270	10	1.27
2-Picoline	109-06-8	8270	10	2.0
2-Propanol	67-63-0	8260	100	50
3,3 '-Dichlorobenzidine	91-94-1	8270	10	3.0
3,3 '-Dimethylbenzidine	119-93-7	8270	10	3.3
3-Methylcholanthrene	56-49-5	8270	10	2.0
3-Nitroaniline	99-09-2	8270	10	2.0
4,6-Dinitro-2-methylphenol	534-52-1	8270	10	3.0
4-Aminobiphenyl	92-67-1	8270	10	3.0
4-Bromophenyl phenyl ether	101-55-3	8270	10	0.56
4-Chloro-3-methylphenol	59-50-7	8270	10	1.0
4-Chloroaniline	106-47-8	8270	10	3.3
4-Chlorophenyl phenyl ether	7005-72-3	8270	10	0.6
4-Methyl-2-pentanone	108-10-1	8260	10	2.0
4-Nitroaniline	100-01-6	8270	10	1.5
4-Nitrophenol	100-02-7	8270	10	3
4-Nitroquinoline-1 -oxide	56-57-5	8270	50	5
5-Nitro-o-toluidine	99-55-8	8270	10	2.0
7,12-Dimethylbenz(a)anthracene	57-97-6	8270	10	2.0
a,a-Dimethylphenethylamine	122-09-8	8270	50	5
Acenaphthene	83-32-9	8270	10	0.35

Analyte	CAS Number	Method	PQL(ug/l)	MDL(ug/l)
Acenaphthylene	208-96-8	8270	10	0.48
Acetone	67-64-1	8260	10	2.0
Acetonitrile	75-05-8	8260	100	31.67
Acetophenone	98-86-2	8270	10	1.0
Acrolein	107-02-8	8260	20	2.1
Acrylonitrile	107-13-1	8260	10	1.7
Allyl chloride/ (3-Chloropropene)	107-05-1	8260	10	1.0
Aniline	62-53-3	8270	10	1.1
Anthracene	120-12-7	8270	10	0.52
Antimony	7440-36-0	6020/6010	2	0.6
Aramite	140-57-8	8270	10	3.7
Arsenic	7440-38-2	6020/6010	10	2
Barium	7440-39-3	6020/6010	10	1.3
Benzene	71-43-2	8260	1	0.4
Benzo(a)anthracene	56-55-3	8270	10	0.45
Benzo(a)pyrene	50-32-8	8270	10	1.5
Benzo(b)fluoranthene	205-99-2	8270	10	1.2
Benzo(g,h,i)perylene	191-24-2	8270	10	0.42
Benzo(k)fluoranthene	207-08-9	8270	10	1.6
Benzyl alcohol	100-51-6	8270	10	3.0
Beryllium	7440-41-7	6020/6010	1	0.3
Bis(2-chlorethoxy)methane	111-91-1	8270	2	0.5
Bis(2-chloroethyl)ether	111-44-4	8270	2	0.5
Bis(2-chloroisopropyl)ether	108-60-1	8270	10	1.0
Bis(2-ethylhexyl)phthalate	117-81-7	8270	10	2.0
Bromodichloromethane	75-27-4	8260	1	0.3
Bromoform	75-25-2	8260	1	0.4
Bromomethane	74-83-9	8260	1	0.542
Butyl benzyl phthalate	85-68-7	8270	10	0.7
Cadmium	7440-43-9	6020/6010	1	0.2
Carbon disulfide	75-15-0	8260	10	0.4
Carbon tetrachloride	56-23-5	8260	1	0.3
Chlorobenzilate	510-15-6	8270	10	3.0

Analyte	CAS Number	Method	PQL(ug/l)	MDL(ug/l)
Chloroform	67-66-3	8260	1	0.4
Chloroprene/ (2-chloro-1,3-butadiene)	126-99-8	8260	10	0.46
Chromium	7440-47-3	6020/6010	5	1.0
Chrysene	218-01-9	8270	10	1.0
Cobalt	7440-48-4	6020/6010	5	1.0
Copper	7440-50-8	6020/6010	5	1.7
Cyanide	57-12-5	9010	20	5
Diallate	2303-16-4	8270	10	3.0
Dibenzo(a,h)anthracene	53-70-3	8270	10	0.38
Dibenzofuran	132-64-9	8270	10	1.0
Dibromochloromethane	124-48-1	8260	1	0.4
Dibromomethane/ (methylene bromide)	74-95-3	8260	1	0.4
Dichlorodifluoromethane	75-71-8	8260	1	0.4
Diethyl ether/ (ethyl ether)	60-29-7	8260	12.5	1.11
Diethyl phthalate	84-66-2	8270	10	2.0
Dimethoate	60-51-5	8270	10	3.0
Dimethyl ether	115-10-6	8260	12.5	1.11
Dimethyl phthalate	131-11-3	8270	10	0.5
Di-n-butyl phthalate	84-74-2	8270	10	1.8
Di-n-octyl phthalate	117-84-0	8270	10	0.8
Diphenylamine (as n-nitrosodiphenylamine)	86-30-6	8270	10	0.58
Disulfoton	298-04-4	8270	10	3.0
Ethyl methacrylate	97-63-2	8260	10	0.81
Ethyl methacrylate	97-63-2	8270	10	0.2
Ethyl methanesulfonate	62-50-0	8270	10	2.0
Ethylbenzene	100-41-4	8260	1	0.3
Famphur	52-85-7	8270	10	5.0
Fluoranthene	206-44-0	8270	10	0.42
Fluorene	86-73-7	8270	10	0.38

Analyte	CAS Number	Method	PQL (ug/l)	MDL (ug/l)
Heaxachloroethane	67-72-1	8260/8270	10	0.5
Hexachlorobenzene	118-74-1	8270	10	0.87
Hexachlorobutadiene	87-68-3	8260	1	0.4
Hexachlorocyclopentadiene	77-47-4	8270	10	3.0
Hexachlorophene	70-30-4	8270	500	185
Hexachloropropene	1888-71-7	8270	10	2
Indeno(l ,2,3-cd)pyrene	193-39-5	8270	10	0.15
Iodomethane/ (methyl iodide)	74-88-4	8260	10	0.7
Isobutyl alcohol	78-83-1	8260	200	14.6
Isodrin	465-73-6	8270	10	1.1
Isophorone	78-59-1	8270	10	0.5
Isosafrole	120-58-1	8270	10	2.0
Kepone	143-50-0	8270	50	25
Lead	7439-92-1	6020/6010	3	1.0
m,p-Cresol (3 & 4-Methylphenol)	106-44-5	8270	20	2.47
m,p-Xylene	179601-23-1	8260	2	0.4
Mercury	7439-97-6	7470	2	0.2
Methacrylonitrile	126-98-7	8260	100	9.75
Methapyrilene	91-80-5	8270	10	3
Methyl methacrylate	80-62-6	8260	10	3.58
Methyl methanesulfonate	66-27-3	8270	10	2.0
Methyl parathion	298-00-0	8270	10	3.2
Methylene chloride	75-09-2	8260	5	0.5
Naphthalene	91-20-3	8260	1	0.4
Nickel	7440-02-0	6020/6010	10	2.0
Nitrobenzene	98-95-3	8270	10	1.0
N-Nitrosodiethylamine	55-18-5	8270	10	3.0
N-Nitrosodimethylamine	62-75-9	8270	10	2.0
N-Nitroso-di-n-butylamine	924-16-3	8270	10	3.0
N-Nitrosodi-n-propylamine	621-64-7	8270	10	0.5
N-Nitrosodiphenylamine (as diphenylamine)	86-30-6	8270	10	0.58
n-Nitrosomethylethylamine	10595-95-6	8270	10	2.0

Analyte	CAS Number	Method	PQL(ug/l)	MDL (ug/l)
N-Nitrosomorpholine	59-89-2	8270	10	3.0
N-Nitrosopiperidine	100-75-4	8270	10	2.0
N-Nitrosopyrrolidine	930-55-2	8270	10	2.0
o,o,o-Triethylphosphorothioate	126-68-1	8270	10	2.6
o,o-Diethyl-o-2-pyrazinyl phosphorothioate/ (Thionazin)	297-97-2	8270	10	2.4
o-Cresol/ (2-methylphenol)	95-48-7	8270	10	0.96
o-Toluidine	95-53-4	8270	10	4.0
o-Xylene	95-47-6	8260	1	0.4
Parathion/ (Ethyl parathion)	56-38-2	8270	10	3.0
p-Dimethylaminoazobenzene	60-11-7	8270	10	3.0
Pentachlorobenzene	608-93-5	8270	10	2.0
Pentachloroethane	76-01-7	8260	10	1.7
Pentachloroethane	76-01-7	8270	10	2.7
Pentachloronitrobenzene	82-68-8	8270	10	2.0
Pentachlorophenol	87-86-5	8270	10	3
Phenacetin	62-44-2	8270	10	2.0
Phenanthrene	85-01-8	8270	10	0.52
Phenol	108-95-2	8270	10	1.0
Phorate	298-02-2	8270	10	2.5
p-Phenylenediamine/ (1,4-phenylenediamine)	106-50-3	8270	150	50
Pronamide	23950-58-5	8270	10	1.5
Propionitrile	107-12-0	8260	100	10.22
Pyrene	129-00-0	8270	10	0.41
Pyridine	110-86-1	8270	10	2.0
Safrole	94-59-7	8270	10	2.2
Selenium	7782-49-2	6020/6010	10	3.0
Silver	7440-22-4	6020/6010	2	0.3
Styrene	100-42-5	8260	1	0.3
Sulfotep	3689-24-5	8270	10	2.4
sym-Trinitrobenzene/ (1,3,5-trinitrobenzene)	99-35-4	8270	10	3.0
Tetrachloroethene	127-18-4	8260	1	0.3
Tetrahydrofuran	109-99-9	8260	25	2
Thallium	7440-28-0	6020/6010	1	0.2
Toluene	108-88-3	8260	1	0.3

Analyte	CAS Number	Method	PQL (ug/l)	MDL (ug/l)
trans-1,2-Dichloroethene	156-60-5	8260	1	0.4
trans-1,3-Dichloropropene	10061-02-6	8260	1	0.4
trans-1,4-Dichloro-2-butene	110-57-6	8260	10	1.5
Trichloroethene	79-01-6	8260	1	0.4
Trichlorofluoromethane	75-69-4	8260	1	0.4
Vanadium	7440-62-2	6020/6010	10	2.5
Vinyl acetate	108-05-4	8260	10	3.29
Vinyl chloride	75-01-4	8260	1	0.4
Xylenes, Total	1330-20-7	8260	3	0.4
Zinc	7440-66-6	6020/6010	30	7.3

Notes:
ug/l = micrograms per liter
PQL = Permit Required Practical Quantitation Limit
MDL = Permit Required Method Detection Limit
CAS = Chemical Abstracts Service Registry Number
Laboratory must be accredited for the analytical method, matrix, and target analyte (where applicable) by the Virginia Environmental Laboratory Accreditation Program (VELAP).

ATTACHMENT V.D - GROUNDWATER COMPLIANCE MONITORING (SEMIANNUAL) CONSTITUENT LISTS

V.D-A. HWMU-5 GROUNDWATER COMPLIANCE MONITORING (SEMIANNUAL) CONSTITUENT AND REQUIRED ANALYTICAL METHOD LIST

Analyte	Method	PQL (µg/l)
Antimony, total	6010/6020	2
Arsenic, total	6010/6020	10
Barium, total	6010/6020	10
Beryllium, total	6010/6020	1
Cadmium, total	6010/6020	1
Chromium	6010/6020	5
Cobalt, total	6010/6020	5
Copper, total	6010/6020	5
Lead, total	6010/6020	3
Mercury, total	7470	2
Nickel, total	6010/6020	10
Selenium, total	6010/6020	10
Silver, total	6010/6020	2
Thallium, total	6010/6020	1
Vanadium, total	6010/6020	10
Zinc, total	6010/6020	30
Acetone	8260	10
Chloroform	8260	1
Dichlorodifluoromethane	8260	1
1,2-Dichloroethane	8260	1
Diethyl ether	8260	12.5
Methylene chloride	8260	5
Methyl ethyl ketone (2-Butanone)	8260	10
Toluene	8260	1
Trichloroethene	8260	1
Xylenes (total)	8260	3
Bis (2-ethylhexyl) phthalate	8270	10
Diethyl phthalate	8270	10
2,4-Dinitrotoluene	8270	10
2,6-Dinitrotoluene	8270	10
o-Nitroaniline; 2-	8270	10
p-Nitroaniline; 4-	8270	10
Nitrobenzene	8270	10

Note:

µg/l = micrograms per liter
PQL = Practical Quantitation Limit

Note (1): All methods are as described in EPA's *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, EPA publication SW-846, Third Edition, Final Updates I (1993), II (1995), IIA (1994), IIB (1995), III (1997), IIIA (1999), IIIB (2005), IV (2008), and V (2015, as updated)* Web site: https://www.epa.gov/hw-sw846/sw-846-compendium

Note (2): The Permittees must collect, at least, a single independent sample at each monitoring well for all required constituents during each sampling event.

Note (3): Alternate SW-846 Methods may be approved by the Department if the request is in writing and submitted at least 30 days prior to the sample collection event. Proposed alternated methods shall achieve the same practical quantitation limit/estimated quantitation limit (or lower) as the specified method. Additionally, the laboratory must be accredited for the analytical method, matrix, and target analyte (where applicable) by the Virginia Environmental Laboratory Accreditation Program (VELAP).

V.D-B. HWMU-16 GROUNDWATER COMPLIANCE MONITORING (SEMIANNUAL) CONSTITUENT AND REQUIRED ANALYTICAL METHOD LIST

Analyte	Method	PQL (µg/l)
Arsenic, total	6010/6020	10
Barium, total	6010/6020	10
Beryllium, total	6010/6020	1
Cadmium, total	6010/6020	1
Chromium, total	6010/6020	5
Cobalt, total	6010/6020	5
Copper, total	6010/6020	5
Lead, total	6010/6020	3
Mercury, total	7470	2
Nickel, total	6010/6020	10
Silver, total	6010/6020	2
Vanadium, total	6010/6020	10
Zinc, total	6010/6020	30
Benzene	8260	1
2-Butanone	8260	10
Carbon tetrachloride	8260	1
Chloroethane	8260	1
Dichlorodifluoromethane	8260	1
1,1-Dichloroethane	8260	1
1,1-Dichloroethene	8260	1
Diethyl ether	8260	12.5
Dimethyl ether;	8260	12.5
Ethylbenzene	8260	1
Methylene chloride	8260	5
Tetrachloroethene; PCE	8260	1
Chloromethane	8260	1
Toluene	8260	1
1,1,1-Trichloroethane	8260	1
Trichloroethene	8260	1
1,1,2-Trichloro-1,2,2-Trifluoroethane	8260	1
Trichlorofluoromethane	8260	1

Tetrahydrofuran	8260	25
Vinyl chloride	8260	1
Xylenes, total	8260	3
Diethyl phthalate	8270	10
2,4-Dinitrotoluene	8270	10
2,6-Dinitrotoluene	8270	10

Notes:
µg/l = micrograms per liter
PQL = Practical Quantitation Limit

Note (1): All methods are as described in EPA's *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, EPA publication SW-846, Third Edition, Final Updates I (1993), II (1995), IIA (1994), IIB (1995), III (1997), IIIA (1999), IIIB (2005), IV (2008), and V (2015, as updated)* Web site: https://www.epa.gov/hw-sw846/sw-846-compendium

Note (2): The Permittees must collect, at least, a single independent sample at each monitoring well for all required constituents during each sampling event.

Note (3): Alternate SW-846 Methods may be approved by the Department if the request is in writing and submitted at least 30 days prior to the sample collection event. Proposed alternated methods shall achieve the same practical quantitation limit/estimated quantitation limit (or lower) as the specified method. Additionally, the laboratory must be accredited for the analytical method, matrix, and target analyte (where applicable) by the Virginia Environmental Laboratory Accreditation Program (VELAP).

ATTACHMENT V.E - GROUNDWATER INITIAL BACKGROUND DATA

V.E-A. The initial background values are the calculated background values for the constituents monitored at HWMU-5 and HWMU-16 during the GWQAPs from First Quarter 1996 through First Quarter 1999 and presented in the Groundwater Quality Assessment Report for each respective Unit, dated August 1999.

This attachment also includes the calculated background values for the 40 CFR Part 264 Appendix IX constituents detected at HWMU-5 and HWMU-16 following issuance of the Permit in 2002. The current Permit Background Values for both Units are presented in Attachments V.F, VI.B, and VI.C of this Permit.

ATTACHMENT 2: UNIT 5

APPENDIX F

GROUNDWATER INITIAL BACKGROUND DATA

Background concentrations were calculated for each constituent in the groundwater monitoring program using the analytical data from First Quarter 1996 through First Quarter 1999 for upgradient well 5W8B. The background concentration calculations were based on site wide 95% confidence, 95% coverage upper prediction intervals.

The calculated background concentrations for antimony, arsenic, selenium, chloromethane, 1,2-dichloroethane, trans-1,2-dichloroethene, methylene chloride, tetrachloroethene, toluene, 1,1,2-trichloroethane, trichlorofluoromethane, vinyl chloride, xylenes, bis (2-ethylhexyl) phthalate, di-n-butyl phthalate, diethyl phthalate, diphenylamine, and 2,6-dinitrotoluene are the same as their respective detection limits.

TABLE 2
HWMU-5
CALCULATED BACKGROUND VALUES

Constituent	Background Concentration (µg/l unless otherwise noted)
Antimony	3
Arsenic	1
Barium	172.87
Beryllium	0.7
Cadmium	1.45
Cobalt	7
Copper	18
Lead	10
Mercury	0.9
Nickel	106
Selenium	1
Silver	2.3
Thallium	2
Vanadium	17
Zinc	75
Acetone	89
Benzene	0.1
Chloroform	0.5
Chloromethane	0.3
1,2-Dichloroethane	0.1
Methylene chloride	0.7
Methylethylketone	21.3
Tetrachloroethene	0.1
Toluene	0.1
trans-1,2-Dichloroethene	0.1
1,1,2-Trichloroethane	0.5
Trichloroethene	0.8
Trichlorofluoromethane	0.5
Vinyl chloride	0.1
Xylenes (total)	0.1
Bis (2-ethylhexyl) phthalate	10
Di-n-butylphthalate	5
Diethyl phthalate	5
Diphenylamine	10
2,4-Dinitrotoluene	0.18
2,6-Dinitrotoluene	0.08
Total Organic Carbon	253,000
Total Organic Halides	13.4
Specific Conductivity	450 µS/cm
pH	2.79 to 7.47 pH units

Appendix IX Constituents Detected Since Permit Issuance
HWMUs 5, 7, 10, and 16
Radford Army Ammunition Plant

Unit	Quarter Initially Detected	Constituent	Background–Calculated or QL?	Background (ug/L)	GPS Required? (261 Appendix VIII)	Proposed GPS (ug/L)	Source
HMWU-5	Fourth Quarter 2003	Chromium	QL	5	yes	100	USEPA MCL
		Diethyl Ether	QL	12	no	NA	NA
		2-Nitroaniline	QL	20	no	NA	NA
		4-Nitroaniline	QL	20	yes	20	Background/QL
		Nitrobenzene	QL	10	yes	10	Background/QL
	Third Quarter 2006	Dichlorodifluoromethane	QL	1	yes	125.2	VDEQ ACL
HWMU-7	Third Quarter 2003	Copper	Calculated	49	no	NA	NA
	Second Quarter 2004	Zinc	Calculated	217	no	NA	NA
HWMU-10	First Quarter 2003	Cobalt	QL	5	no	NA	NA
	Second Quarter 2003	Vanadium	QL	10	no	NA	NA
	Second Quarter 2005	Acetone	QL	10	no	NA	NA
		2-Propanol	QL	50	no	NA	NA
HWMU-16	Second Quarter 2003	Chloroethane	Calculated	20.7	yes	20.7	Background/QL
		Diethyl Ether	Calculated	75.5	no	NA	NA
		Dimethyl Ether	Calculated	17.0	no	NA	NA
	Third Quarter 2003	Methylene Chloride	Calculated	13.95	no*	NA	NA
	Second Quarter 2004	1,1,2-Trichloro-1,2,2-trifluoroethane	Calculated	1.2	no*	NA	NA

HWMU-5: The additional Appendix IX constituents detected in the downgradient point of compliance wells were not detected above their respective Quantitation Limits (QLs) in the upgradient well. As a result, background concentrations for those constituents were set as equal to their respective QLs. In accordance with the Permit (Condition V.J.1.g.), GPS are proposed for those additional Appendix IX constituents that are listed in Appendix VIII of 40 CFR Part 261 (chromium, 4-nitroaniline, nitrobenzene, and dichlorodifluoromethane). No GPS are proposed for the additional Appendix IX constituents that are not listed in Appendix VIII of 40 CFR Part 261 (diethyl ether and 2-nitroaniline).

HWMU-7: Background concentrations for the additional Appendix IX constituents detected in the downgradient point of compliance wells (copper and zinc) were previously calculated and submitted to the VDEQ in the August 1998 *Groundwater Quality Assessment Report for HWMU-7* prepared by ERM, Inc. In accordance with the Permit (Condition V.J.2.g.), no GPS are proposed for the additional Appendix IX constituents (copper and zinc), as they are not listed in Appendix VIII of 40 CFR Part 261.

HWMU-10: The additional Appendix IX constituents detected in the downgradient point of compliance wells were not detected above their respective Quantitation Limits (QLs) in the upgradient well. As a result, background concentrations for those constituents were set as equal to their respective QLs. In accordance with the Permit (Condition V.J.3.g.), no GPS are proposed for the additional Appendix IX constituents (cobalt, vanadium, acetone, and 2-propanol), as they are not listed in Appendix VIII of 40 CFR Part 261.

HWMU-16: Background concentrations for additional Appendix IX constituents chloroethane, diethyl ether, dimethyl ether, and methylene chloride were calculated using data collected from upgradient well 16C1 during the period from Third Quarter 2003 through Third Quarter 2004. The background concentration for additional Appendix IX constituent 1,1,2-trichloro-1,2,2-trifluoroethane was calculated using data collected from upgradient well 16C1 during the period from Second Quarter 2004 through Third Quarter 2006.
In accordance with the Permit (Condition V.J.4.g.), GPS are proposed for additional Appendix IX constituents that are listed in Appendix VIII of 40 CFR Part 261 (chloroethane). No GPS are proposed for the additional Appendix IX constituents that are not listed in Appendix VIII of 40 CFR Part 261 (diethyl ether and dimethyl ether).
*Methylene chloride and 1,1,2-trichloro-1,2,2-trifluoroethane should not be added to the Groundwater Monitoring List for HWMU-16, as these constituents were only detected in the upgradient well for the Unit, and not in the downgradient point of compliance wells.

TABLE 2
HWMU-16
Calculated Background Values

Constituent	Background Concentration (µg/l unless otherwise noted)
Antimony	3
Arsenic	1
Barium	175.4
Beryllium	0.7
Cadmium	0.2
Chromium	6.2
Cobalt	5
Copper	13
Lead	10
Mercury	0.2
Nickel	16
Selenium	1
Silver	0.5
Thallium	6
Vanadium	151
Zinc	51
Bromoform	0.3
Carbon Tetrachloride	0.2
Chlorobenzene	0.1
Chloromethane	0.3
1,4-Dichlorobenzene	0.1
Dichlorodifluoromethane	46.5
1,1-Dichloroethane	9.5
1,2-Dichloroethane	0.1
trans-1,2-Dichloroethene	0.1
Ethylbenzene	0.1
Methyl Ethyl Ketone	1.1
1,1,2,2-Tetrachloroethane	0.3
Tetrachloroethene	0.7
Toluene	0.1
1,1,1-Trichloroethane	9.2
1,1,2-Trichloroethane	0.5
Trichloroethene	0.1
Trichlorofluoromethane	11.3
Vinyl Chloride	0.1
Xylenes (total)	0.2

TABLE 2
HWMU-16
Calculated Background Values

Constituent	Background Concentration (µg/l unless otherwise noted)
Di-n-butylphthalate	5
2,4-Dinitrotoluene	0.10
2,6-Dinitrotoluene	0.11
2378-TCDF	0.0485 ppt
12378-PECDF	0.0439 ppt
23478-PECDF	0.0417 ppt
123478-HXCDF	0.0390 ppt
123678-HXCDF	0.0377 ppt
234678-HXCDF	0.0428 ppt
123789-HXCDF	0.0415 ppt
1234678-HPCDF	0.0615 ppt
1234789-HPCDF	0.0709 ppt
OCDF	0.1307 ppt
Cyanide	10
Total Organic Carbon (x4)	7000
Total Organic Halides (x4)	42.2
Specific Conductivity	672 µS/cm
pH	5.7 to 7.9 pH units

Statistical Computations – RAAP HWMU-16 – 1,1,2-Trichloro-1,2,2-Trifluoroethane

In accordance with the facility permit and VHWMR, statistical background concentration is being established for 1,1,1-Trichloro-1,2,2-Trifluoroethane. Inter-well upper prediction limits (UPL) were calculated on the background data for this target parameter in accordance with the facility permit and VHWMR (40 CFR 264.97(h)). Background data for this target parameter consisted of all data for the background well 16C1 collected from 2nd quarter 2004 through 3rd quarter 2006.

Discussion of Tests for Normality

The power of a statistical tool to account for false positive and false negative results, while accurately detecting true statistical variations for a facility under scrutiny depends on numerous factors, one of which is the distribution of the data. A great number of statistical tools are based on the assumption that data are normally distributed. Hence the distribution of the sample population for parameters evaluated under this statistical analysis is first determined. Sample populations are tested for normal distribution using several normality tests. "Groundwater Information Tracking System with Statistical Analysis Capability" (GRITS/STAT) v5.0 was the software used to run these statistical tests. GRITS/STAT is an analytical software package provided by the USEPA. The distributions of the data sets were verified in the original mode as well as in log-transformed mode. The normality of the data set was evaluated using the Shapiro-Wilk test for normality.

Discussion of Prediction Interval Tests

Normality tests are performed prior to running parametric tests (tests that require that the data be normal). Results of the normality tests show that the background data for 1,1,2-Trichloro-1,2,2-Trifluoroethane is non-normally distributed. Non-parametric UPL (NUPL) was constructed on the background data for this parameter. The confidence levels of NUPLs are typically approximate and estimated to be around 91%.

Summary of UPL

Parameter	Background Data Distribution	Type of UPL	Multiple Comparisons/year	UPL (µg/l)
1,1,2-Trichloro-1,2,2-Trifluoroethane	Non-Normal	NUPL	N/A	1.2

P:\B03\200\B03204\B03204-04\REPORTS\UNIT 16 BACKGROUND FOR 1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE\RPT - 05 0202 - HWMU16ADDPARAMETERSUPL - SN.DOC

Statistical Computations – RAAP HWMU-16

In accordance with the facility permit and VHWMR, statistical background concentrations are being established for the four new target parameters chloroethane, diethyl ether, dimethyl ether and methylene chloride. These four target parameters were added to the facility monitoring program during the 3rd quarter 2003 monitoring event. Inter-well upper prediction limits (UPL) were calculated on the background data for the target parameters in accordance with the facility permit and VHWMR (40 CFR 264.97(h)). Background data for these target parameters consisted of all data for the background well 16C1 collected from 3rd quarter 2003 through 3rd quarter 2004.

Discussion of Tests for Normality

The power of a statistical tool to account for false positive and false negative results, while accurately detecting true statistical variations for a facility under scrutiny depends on numerous factors, one of which is the distribution of the data. A great number of statistical tools are based on the assumption that data are normally distributed. Hence the distribution of the sample population for parameters evaluated under this statistical analysis is first determined. Sample populations were tested for normal distribution using several normality tests. "Groundwater Information Tracking System with Statistical Analysis Capability" (GRITS/STAT) v5.0 was the software used to run these statistical tests. GRITS/STAT is an analytical software package provided by the USEPA. The distributions of the data sets were verified in the original mode as well as in log-transformed mode. The normality of the data sets was evaluated using the Shapiro-Wilk test for normality.

Discussion of Prediction Interval Tests

Normality tests are performed prior to running parametric tests (tests that require that the data be normal). A 99% confidence parametric inter-well UPL was computed for each of the four target parameters that showed normally distributed background data. Results of the normality tests show that the background data for chloroethane, diethyl ether and methylene chloride are normally distributed, and the background data for dimethyl ether is non-normally distributed. Non-parametric UPL (NUPL) was constructed on the background data for dimethyl ether, and parametric UPLs (PUPL) were constructed on the background data for chloroethane, diethyl ether and methylene chloride. No adjustments to the error rates were made to the NUPLs for multiple comparisons. Adjustment for 10 comparisons per year (considering 10 compliance monitoring wells at the facility and 4 quarters of data for each year, and considering historic detects, 10 is considered a representative number for multiple comparisons per year) was made to the PUPLs. The confidence levels of NUPLs are well less than 95%. Any statistically significant increase (SSI) must be confirmed by verification sampling.

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Summary of UPLs

Parameter	Background Data Distribution	Type of UPL	Multiple Comparisons/year	UPL (µg/l)
Chloroethane	Normal	PUPL	10	20.7
Diethyl ether	Normal	NUPL	10	75.5
Dimethyl ether	Non-normal	PUPL	N/A	17.0
Methylene Chloride	Normal	PUPL	10	13.95

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RAAP-HWMU-16 - Statistical Analysis - Notes

1) Y2K Correction dates are as shown in table below.

Actual Event	Date Used in Stat Software
2000-Qtr1	12/13/1999
2000-Qtr2	12/14/1999
2000-Qtr3	12/15/1999
2000-Qtr4	12/16/1999
2001-Qtr1	12/17/1999
2003-Qtr3	12/18/1999
2003-Qtr4	12/19/1999
2004-Qtr1	12/20/1999
2004-Qtr2	12/21/1999
2004-Qtr3	12/22/1999

Interwell Tests:
2) Background data for target parameters chloroethane, diethyl ether, dimethyl ether and methylene chloride were evaluated using Shapiro-Wilk test. Background data showed normal distribution for chloroethane, diethyl ether and methylene chloride. Parametric interwell 99% confidence upper prediction limits were computed for parameters with normally distributed background data. Dimethyl ether background data was non-normally distributed. Therefore non-parametric Upper Prediction Limit (UPL) was computed for dimethyl ether.

3) No adjustments for multiple comparisons could be made for non-parametric UPLs. Adjustments were made to the parametric UPLs for 10 future comparisons per year to account for multiple compliance monitoring wells and quarterly event data.
Any Statistically significant increase (SSI) must be confirmed by verification sampling.

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Normality Tests

Report Printed: 02-02-2005 13:49

Facility:RAAPHWMU16 Haz. Waste Unit 16 - RAAP

Address:

City:Radford ST:VA Zip:24141
County:PULASKI

Contact:
Phone:( ) -

Permit Type:Detection

Constituent:ClEthane Chloroethane

CAS Number: 75-00-3
MCL: 0.000 ppb
ACL: 0.000 ppb
Detect Limit: 2.000 ppb

Start Date:Mar 31 1996
End Date:Dec 22 1999

Normality Test on Observations for wells listed below:

Well:16C1 Position:Upgradient Observations:5

Scale	Minimum	Maximum	Mean	Std Dev
Original:	1.000	6.400	4.340	2.078
Log:	0.000	1.856	1.303	0.749

Pooled Statistics
Observations: 5

Statistic	Original Scale	Log Scale
Mean:	4.340	1.303
Std Dev:	2.078	0.749
Skewness:	-0.810	-1.296*
Kurtosis:	-0.555	-0.011
Minimum:	1.000	0.000
Maximum:	6.400	1.856
CV:	0.479	0.575

Shapiro-Wilk Statistics

Scale	Test Statistic	5% Critical Value	1% Critical Value
Original:	0.9037	0.7620	0.6860

Log:	0.7615*	0.7620	0.6860

* Indicates statistically significant evidence of non-normality.
GRIT/STAT Version 5.0

Parametric Prediction Interval
Report Printed February 2,2005

Facility:Haz. Waste Unit 16 - RAAP
Parameter:Chloroethane(CAS Number:75-00-3)

ONE-TAILED UPPER PARAMETRIC PREDICTION INTERVAL

Observations (n):	5
Shapiro-Wilk (W):	0.9037
Critical W,α=0.01:	0.6860
Mean:	4.340 ppb
Std Dev:	2.078 ppb
DF:	4
Conf. Level (1-α):	~~0.9500~~ 0.99
Future Samples (k):	10
$t_{\left[1-\frac{\alpha}{k}\right]}$:	7.1732
Kappa:	7.8579
UL:	20.669 ppb
LL:	-∞

Report Produced by GRITS/STAT 5.01

Normality Tests

Report Printed: 02-02-2005 13:49

Facility:RAAPHWMU16 Haz. Waste Unit 16 - RAAP

Address:

City:Radford ST:VA Zip:24141
County:PULASKI

Contact:
Phone:( ) -

Permit Type:Detection

Constituent:DEthEth Diethyl ether

CAS Number: - -
MCL: 0.000 ppb
ACL: 0.000 ppb
Detect Limit: 24.000 ppb

Start Date:Mar 31 1996
End Date:Dec 22 1999

Normality Test on Observations for wells listed below:

Well:16C1 Position:Upgradient Observations:5

Scale	Minimum	Maximum	Mean	Std Dev
Original:	12.000	30.000	21.200	6.907
Log:	2.485	3.401	3.007	0.355

Pooled Statistics
Observations: 5

Statistic	Original Scale	Log Scale
Mean:	21.200	3.007
Std Dev:	6.907	0.355
Skewness:	-0.122	-0.491
Kurtosis:	-1.140	-1.024
Minimum:	12.000	2.485
Maximum:	30.000	3.401
CV:	0.326	0.118

Shapiro-Wilk Statistics

Scale	Test Statistic	5% Critical Value	1% Critical Value
Original:	0.9768	0.7620	0.6860

Log:	0.9507	0.7620	0.6860

* Indicates statistically significant evidence of non-normality.
GRIT/STAT Version 5.0

Parametric Prediction Interval
Report Printed February 2,2005

Facility:Haz. Waste Unit 16 - RAAP
Parameter:Diethyl ether(CAS Number:- -)

ONE-TAILED UPPER PARAMETRIC PREDICTION INTERVAL

Observations (n):	5
Shapiro-Wilk (W):	0.9768
Critical W,α=0.01:	0.6860
Mean:	21.200 ppb
Std Dev:	6.907 ppb
DF:	4
Conf. Level (1-α):	~~0.9500~~ 0.99
Future Samples (k):	10
$t_{\left[1-\frac{\alpha}{k}\right]}$:	7.1732
Kappa:	7.8579
UL:	75.470 ppb
LL:	-∞

Report Produced by GRITS/STAT 5.01

Normality Tests

Report Printed: 02-02-2005 13:53

Facility:RAAPHWMU16 Haz. Waste Unit 16 - RAAP

Address:

City:Radford ST:VA Zip:24141
County:PULASKI

Contact:
Phone:( ) -

Permit Type:Detection

Constituent:DMethEth Dimethyl ether

CAS Number: - -
MCL: 0.000 ppb
ACL: 0.000 ppb
Detect Limit: 24.000 ppb

Start Date:Mar 31 1996
End Date:Dec 22 1999

Normality Test on Observations for wells listed below:

Well:16C1 Position:Upgradient Observations:5

Scale	Minimum	Maximum	Mean	Std Dev
Original:	12.000	17.000	13.000	2.236
Log:	2.485	2.833	2.555	0.156

Pooled Statistics
Observations: 5

Statistic	Original Scale	Log Scale
Mean:	13.000	2.555
Std Dev:	2.236	0.156
Skewness:	1.500*	1.500*
Kurtosis:	0.250	0.250
Minimum:	12.000	2.485
Maximum:	17.000	2.833
CV:	0.172	0.061

Shapiro-Wilk Statistics

Scale	Test Statistic	5% Critical Value	1% Critical Value
Original:	0.5521*	0.7620	0.6860

Log:	0.5521*	0.7620	0.6860

* Indicates statistically significant evidence of non-normality.
GRIT/STAT Version 5.0

Nonparametric Prediction Interval
Report Printed February 2,2005

Facility:Haz. Waste Unit 16 - RAAP
Parameter:Dimethyl ether(CAS Number:- -)

ONE-TAILED UPPER PARAMETRIC PREDICTION INTERVAL

Observations (n):	5
Conf. Level (1-α):	33.330%

UL: 17.000 ppb
LL: 0.000

Report Produced by GRITS/STAT 5.01

Normality Tests

Report Printed: 02-02-2005 13:54

Facility:RAAPHWMU16 Haz. Waste Unit 16 - RAAP

Address:

City:Radford ST:VA Zip:24141
County:PULASKI

Contact:
Phone:( ) -

Permit Type:Detection

Constituent:MeCl Dichloromethane (Methylene chloride)

CAS Number: 75-09-2
MCL: 0.000 ppb
ACL: 0.000 ppb
Detect Limit: 2.000 ppb

Start Date:Mar 31 1996
End Date:Dec 22 1999

Normality Test on Observations for wells listed below:

Well:16C1 Position:Upgradient Observations:5

Scale	Minimum	Maximum	Mean	Std Dev
Original:	4.100	6.800	5.800	1.037
Log:	1.411	1.917	1.743	0.197

Pooled Statistics
Observations: 5

Statistic	Original Scale	Log Scale
Mean:	5.800	1.743
Std Dev:	1.037	0.197
Skewness:	-0.925	-1.088*
Kurtosis:	-0.436	-0.263
Minimum:	4.100	1.411
Maximum:	6.800	1.917
CV:	0.179	0.113

Shapiro-Wilk Statistics

Scale	Test Statistic	5% Critical Value	1% Critical Value
Original:	0.8964	0.7620	0.6860

Log:	0.8519	0.7620	0.6860

* Indicates statistically significant evidence of non-normality.
GRIT/STAT Version 5.0

Parametric Prediction Interval
Report Printed February 2,2005

Facility:Haz. Waste Unit 16 - RAAP
Parameter:Dichloromethane (Methylene chloride(CAS Number:75-09-2)

ONE-TAILED UPPER PARAMETRIC PREDICTION INTERVAL

Observations (n):	5
Shapiro-Wilk (W):	0.8964
Critical W,α=0.01:	0.6860
Mean:	5.800 ppb
Std Dev:	1.037 ppb
DF:	4
Conf. Level (1-α):	~~0.9500~~ 0.99
Future Samples (k):	10
$t_{\left[1-\frac{\alpha}{k}\right]}$:	7.1732
Kappa:	7.8579
UL:	13.947 ppb
LL:	-∞

Report Produced by GRITS/STAT 5.01

Target Analyte Monitoring Results - HWMU-16 Point of Compliance Wells
Radford Army Ammunition Plant, Radford, Virginia
Upgradient well = 16C1

All Results in ug/L.

Analyte/Quarter	*16C1*	*16MW8*	*16MW9*	*16WC1A*	*16WC1B*	*QL*	*GPS*	*Method*
Chloroethane					*CAS #*	*75-00-3*		
Third Quarter 2003	6.4	U	4.8	U	U	1	20.7	8260B
Fourth Quarter 2003	5.7	U	2.6	1.1	U	1	20.7	8260B
First Quarter 2004	U J	U J	U J	U J	U J	1	20.7	8260B
Second Quarter 2004	4.4	U	2.4	0.63 J	U	1	20.7	8260B
Third Quarter 2004	4.2	U	2	U	U	1	20.7	8260B
Fourth Quarter 2004	4.9	U	2.5	U	U	1	20.7	8260B
First Quarter 2005	7.6 J	U J	3.7 J	U J	U J	1	20.7	8260B
Second Quarter 2005	U J	U	U J	U	U	1	20.7	8260B
Third Quarter 2005	4.7 J	U J	U	U J	U J	1	20.7	8260B
Fourth Quarter 2005	4.6 J	U	2.6 J	U	U	1	20.7	8260B
First Quarter 2006	5.3	U	U	U	U	1	20.7	8260B
Second Quarter 2006	5 J	U	2 J	U	U	1	20.7	8260B
Third Quarter 2006	5	U	0.7 J	0.7 J	U	1	20.7	8260B
Fourth Quarter 2006	5.8	U	1	U	U	1	20.7	8260B
First Quarter 2007	6.1	U	1	U	U	1	20.7	8260B
Second Quarter 2007	5.2	U	1.4	U	U	1	20.7	8260B
Diethyl ether					*CAS #*	*60-29-7*		
Third Quarter 2003	12 J	U	12 J	U	U	12	-	8260B
Fourth Quarter 2003	30	U	14	U	U	12	-	8260B
First Quarter 2004	24	U	U	U	U	12	-	8260B
Second Quarter 2004	23 J	U J	13 J	U J	U J	12	-	8260B
Third Quarter 2004	17	U	U	U	U	12	-	8260B
Fourth Quarter 2004	24	U J	U	U	U J	12	-	8260B
First Quarter 2005	29	U	14	U	U	12	-	8260B
Second Quarter 2005	20	U J	9.2	U J	U J	12	-	8260B
Third Quarter 2005	30	U	15	U	U	12	-	8260B
Fourth Quarter 2005	25	U	18	U	U	12	-	8260B
First Quarter 2006	19	U	U	U	U	12	-	8260B
Second Quarter 2006	17	U	U	U	U	12.5	-	8260B
Third Quarter 2006	33	1.5 J	4.3 J	4.6 J	U	12.5	-	8260B
Fourth Quarter 2006	20	U	U	U	U	12.5	-	8260B
First Quarter 2007	21	U	U	U	U	12.5	-	8260B
Second Quarter 2007	17 J	1.5 J	5.7 J	2.1 J	U J	12.5	-	8260B
Dimethyl ether					*CAS #*	*115-10-6*		
Third Quarter 2003	6.6 J	U	9.9 J	U	U	12	-	8260B
Fourth Quarter 2003	U	U	U	U	U	12	-	8260B
First Quarter 2004	17 J	U J	13 J	U J	U J	12	-	8260B
Second Quarter 2004	U J	U J	6.6 J	U J	U J	12	-	8260B
Third Quarter 2004	U J	U J	U J	U J	U J	12	-	8260B
Fourth Quarter 2004	16 J	U J	12 J	U	U J	12	-	8260B
First Quarter 2005	26	U	25	U	U	12	-	8260B
Second Quarter 2005	15	U	14	U	U	12	-	8260B
Third Quarter 2005	13	U	U	U	U	12	-	8260B
Fourth Quarter 2005	U	U	U	U	U	12	-	8260B
First Quarter 2006	U	U	U	U	U	12	-	8260B
Second Quarter 2006	U	U	U	U	U	12.5	-	8260B
Third Quarter 2006	11 J	U J	3.2 J	2.8 J	U J	12.5	-	8260B
Fourth Quarter 2006	U	U	U	U	U	12.5	-	8260B
First Quarter 2007	U	U	U	U	U	12.5	-	8260B
Second Quarter 2007	11 J	U	7 J	2.6 J	1.2 J	12.5	-	8260B

See last page of this report for definitions.

Page 1 of 3

Draper Aden Associates
Engineering • Surveying • Environmental Services

Target Analyte Monitoring Results - HWMU-16 Point of Compliance Wells
Radford Army Ammunition Plant, Radford, Virginia
Upgradient well = 16C1

All Results in ug/L.

Analyte/Quarter	*16C1*	*16MW8*	*16MW9*	*16WC1A*	*16WC1B*	*QL*	*GPS*	*Method*
Methylene chloride					*CAS #* 75-09-2			
Third Quarter 2003	4.1	U	U	U	U	1	13.95	8260B
Fourth Quarter 2003	6.8	U	U	U	U	1	13.95	8260B
First Quarter 2004	6.4	U	U	U	U	1	13.95	8260B
Second Quarter 2004	5.7	U	U	U	U	1	13.95	8260B
Third Quarter 2004	6	U A	U A	U A	U A	1	13.95	8260B
Fourth Quarter 2004	6.4	U	U	U	U	1	13.95	8260B
First Quarter 2005	6.8 J	U	U	U	U	1	13.95	8260B
Second Quarter 2005	6.3	U	U	U	U	1	13.95	8260B
Third Quarter 2005	6.2	U	U	U	U	1	13.95	8260B
Fourth Quarter 2005	4.7	U	U	U	U	1	13.95	8260B
First Quarter 2006	4.9	U	U	U	U	1	13.95	8260B
Second Quarter 2006	7	U	U	U	U	1	13.95	8260B
Third Quarter 2006	U N	U N	U N	U N	U N	1	13.95	8260B
Fourth Quarter 2006	U A	U	U	U A	U	1	13.95	8260B
First Quarter 2007	6.3	U	U	U	U	1	13.95	8260B
Second Quarter 2007	3.4	U	U	U	U	1	13.95	8260B
1,1,2-Trichloro-1,2,2-Trifluoroethane					*CAS #* 76-13-1			
Third Quarter 2003	U	U	U	U	U	1	-	8260B
Second Quarter 2004	1.2	U J	U J	U J	U J	1	-	8260B
Third Quarter 2004	U	U	U	U	U	1	-	8260B
Fourth Quarter 2004	U	U	U	U	U	1	-	8260B
First Quarter 2005	1	U	U	U	U	1	-	8260B
Second Quarter 2005	U	U	U	U	U	1	-	8260B
Third Quarter 2005	U	U	U	U	U	1	-	8260B
Fourth Quarter 2005	U	U	U	U	U	1	-	8260B
First Quarter 2006	U	U	U	U	U	1	-	8260B
Second Quarter 2006	U	U	U	U	U	1	-	8260B
Third Quarter 2006	U	U	U	U	U	1	-	8260B
Fourth Quarter 2006	U	U	U	U	U	1	-	8260B
First Quarter 2007	U	U	U	U	U	1	-	8260B
Second Quarter 2007	U	U	U	U	U	1	-	8260B

See last page of this report for definitions.

Page 2 of 3

Draper Aden Associates
Engineering ♦ Surveying ♦ Environmental Services

Target Analyte Monitoring Results - HWMU-16 Point of Compliance Wells
Radford Army Ammunition Plant, Radford, Virginia
Upgradient well = 16C1

All Results in ug/L.

Analyte/Quarter	*16C1*	*16MW8*	*16MW9*	*16WC1A*	*16WC1B*	*QL*	*GPS*	*Method*

Definitions: **QL** Denotes permit required quantitation limit. **U** Denotes analyte not detected at or above QL. **UA** Denotes analyte not detected at or above adjusted sample QL. **J** Denotes associated result is estimated. When used with "U" (i.e., "UJ"), denotes analyte not detected at or above QL and QL is estimated. When used with "UA" (i.e., "UAJ"), denotes analyte not detected at or above adjusted QL and adjusted QL is estimated. **UN** Denotes analyte concentration is less than the quantiation limit and five times the blank concentration. Not reliably detected due to blank contamination. This qualifier used only for Appendix IX monitoring event when results are reported to at or above the project detection limit. **R** Denotes result rejected. **Q** Denotes data validation qualifier. **CAS#** Denotes Chemical Abstract Services registration number. **X** Denotes mass spectral confirmation not obtained-result suspect.

GPS Denotes Groundwater Protection Standards listed in Appendix G to Attachment 5 in the Final Hazardous Waste Post-Closure Care Permit for Hazardous Waste Units 5, 7, 10, and 16 (October 4, 2002).
NS denotes not sampled. **NA** denotes not analyzed. "–" denotes not detected (pre-2nd Quarter 2003) or not available / not sampled (beginning 2nd Quarter 2003).

Notes:
-**Appendix IX Groundwater Monitoring Events:**
Third Quarter 2003, Second Quarter 2004, Second Quarter 2005, Third Quarter 2006, Second Quarter 2007
For Appendix IX monitoring events, all results evaluated to detection limit. See laboratory data deliverable for detection limit.

-9/30/2003: Verification sampling event for 16C1 (heptachlor) and 16C1B (Endrin). Verification results: all results reported not detected to detection limit. Original results 0.067 µg/l and 0.39 µg/l, respectively. Confirmation results reported in this table.
-9/30/2003: Verification sampling event for 16C1 (chloroethane, ethyl ether, methyl ether, methylene chloride) and 16MW9 (chloroethane, ethyl ether, methyl ether). Verification results: all results confirmed original analysis. Original results reported in this table.
-June 21, 2004: Verification event for 8260B 16C1 (1,1-dichloroethene and 1,1,2-trichloro-1,2,2-trifluoroethane). Verification results: all not detected except 1,1,2-trichloro-1,2,2-trifluoroethane added to quarterly analyte list beginning 3Q 2004. Due to laboratory error, Appendix IX results for semivolatiles (Method 8270C) will be presented in 3Q 2004. Verification event results for 16WC1B and 16C1 (8081A) – all verification results were not confirmed.
-07/27-28/2005. Verification event for 16WC1B (Mercury Method 7470A.) Not detected in verification sample. Also, verification event for 16C1, 16WC1B-8081A. and 16C1, 16MW9, 16WC1A-ethanol. All verification results not detected. Verification results used.
-06/19/2007. Verification event for 16WC1B and 16MW9 thallium Not detected in verification sample. Verification results used.

See last page of this report for definitions.

ATK Armament Systems
Energetic Systems
Radford Army Ammunition Plant
Route 114, P.O. Box 1
Radford, VA 24143-0100

www.atk.com

August 1, 2011

Jutta Schneider
Program Manager
Office of Remediation Programs
Virginia Department of Environmental Quality
629 East Main Street
Richmond, Virginia 23219

Subject: Additional Appendix IX Groundwater Monitoring Results - Final Notification
Post-Closure Care Permit HWMUs 5, 7, 10, & 16
Radford Army Ammunition Plant, Radford, Virginia
EPA ID#: VA1210020730

Reference: ATK Letter No 11-815-90 Dated June 23, 2011

Dear Ms. Schneider:

During Second Quarter 2011, Alliant Techsystems Inc. completed semiannual groundwater monitoring for Hazardous Waste Management Units (HWMUs) 5, 7, 10, and 16 located at the Radford Army Ammunition Plant (Radford AAP) in Radford, Virginia. The Second Quarter 2011 groundwater monitoring event also served as annual monitoring under 40 CFR 264 Appendix IX for HWMUs 7, 10, and 16.

Verification samples were collected on June 27, 2011 at HWMUs 7 and 16 to confirm or refute the detection of additional Appendix IX constituents listed in the table below.

Well Location	Constituent(s)	Result
HWMU-7		
7W11B	Benzene	Not Verified
7MW6	Benzene; Diethyl ether	Not Verified
HWMU-16		
16WC1B	4,4'-DDD	Not Verified
16WC1A	Benzene	Not Verified
16MW9	Benzene	VERIFIED, Add to List

The verification sample results confirmed only the presence of the additional Appendix IX constituent, benzene, in point of compliance well 16MW9. Benzene was detected below the LOQ in well 16MW9; therefore, benzene will be added to the compliance monitoring list for HWMU-16. No other additional Appendix IX constituents were detected in the verification samples collected at HMWUs 7 and 16.

The permit requires collection of four quarters of monitoring data from a Unit's upgradient well(s) to establish background values for newly detected Appendix IX constituents. However, Alliant Techsystems Inc. has collected benzene data from HWMW-16 upgradient monitoring well 16C1 during the previous nine annual Appendix IX groundwater monitoring events (2003-2011). Benzene has never been detected at or above the LOQ in upgradient well 16C1; therefore, in lieu of quarterly background monitoring, we propose to use these data to set the background

11-815-106
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value for benzene at the LOQ of 1 µg/l and the groundwater protection standard (GPS) at the USEPA maximum contaminant level (MCL) of 5 µg/l.

Complete details regarding the Second Quarter 2011 monitoring event (field data, laboratory data, and data validation reports) will be forwarded to the VDEQ in the forthcoming *Semiannual Groundwater Monitoring Report for Hazardous Waste Management Units 5, 7, 10, and 16, Second Quarter 2011*, which is due to the VDEQ by August 15, 2011. However, Alliant Techsystems Inc. has submitted a request to the VDEQ for a 60-day extension to the August 15, 2011 reporting deadline; a response to the request is pending.

If you have any questions or concerns, please contact Mr. Jeremy Flint at 540/639-7668 (Jeremy.Flint@ATK.COM).

Sincerely,

Paige Holt, Environmental Manager
Alliant Techsystems Inc.

c: Aziz Farahmand, VDEQ-BRRO
Fuxing Zhou, VDEQ-Central

11-815-106
JFlint

Jutta Schneider
August 1, 2011
Page 3

Coordination: J. McKenna

M. A. Miano

bc: P. W. Holt
J. McKenna, ACO Staff
Jeremy Flint
Mike Lawless, Draper Aden Associates
Env. File

11-815-106
JFlint

Concerning the following:

CY 2011 Second Quarter Semiannual Monitoring Event
Additional Appendix IX Groundwater Monitoring Results - Final Notification
Radford Army Ammunition Plant, Radford, Virginia
EPA ID#: VA1210020730

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations.

SIGNATURE:

PRINTED NAME: for Wm Byron Penland
TITLE: Lieutenant Colonel, US Army
Commanding

SIGNATURE:

PRINTED NAME: Kent D. Holiday
TITLE: Vice President and General Manager
ATK Energetics Systems

11-815-106
JFlint

COMMONWEALTH of VIRGINIA

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Molly Joseph Ward
Secretary of Natural Resources

David K. Paylor
Director

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Office of Waste Permitting and Compliance

Land Protection and Remediation Division

September 12, 2014

VIA ELECTRONIC MAIL
Mr. Jay Stewart
Environmental Manager
BAE Systems, Ordnance Systems, Inc.
Radford Army Ammunition Plant
4050 Pepper's Ferry Road
Radford, Virginia 24141

Re: Radford Army Ammunition Plant, Radford, VA
EPA ID No.VA1210020730, Approval of Class 1 Permit Modifications
Hazardous Waste Management Units 5 and 16, Post Closure-Care Permit

Dear Mr. Stewart:

Enclosed are the final Class 1 Modifications to the Hazardous Waste Permit for Post Closure-Care of two hazardous waste management units (HWMUs) 5 and 16 at the Radford Army Ammunition Plant (RAAP), Radford, Virginia facility. The final Class 1 Modifications to the Permit have been approved.

The Virginia Department of Environmental Quality (DEQ) received the Class 1 Permit groundwater related modification request addressing the HWMU 16 that was communicated to the DEQ in an e-mail dated August 13, 2014, from the RAAP, Radford, Virginia facility. RAAP requested that 1,1-dichloroethene (1,1-DCE) be added to the Groundwater Compliance Monitoring Constituent List for HWMU-16.

1,1-DCE was detected in the most recent annual groundwater sampling event required under the Post-Closure Permit, and in a letter dated July 21, 2014, the VDEQ supported the RAAP's July 1, 2014, proposal that 1,1-DCE be added to the Groundwater Compliance Monitoring Constituent List and also the setting of the background value for 1,1-DCE at the Limit of Quantitation (LOQ) value of 1

ug/1 and the Groundwater Protection Standard (GPS) at the USEPA Maximum Contaminant Level (MCL) of 7 ug/l.

In the e-mail letter dated August 13, 2014, RAAP submitted the following requested changes to the facility's hazardous waste Post Closure-Care Permit as marked–up files comprising the Class 1 Permit modification:

- Permit Attachment 3, Appendix E (HWMU-16 Groundwater Compliance Monitoring Constituent List) from the Post-Closure Care Permit to add 1,1-DCE to the groundwater Compliance Monitoring Program for HWMU-16, and
- Permit Attachment 3, Appendix G (HWMU-16 Groundwater Protection Standards) from the Post-Closure Care Permit to add 1,1-DCE to the groundwater Compliance Monitoring Program for HWMU-16.

The requested changes represent a Class 1 permit modification under 40 CFR § 270.42, Appendix I.C.2 – *Changes in groundwater sampling or analysis procedures or monitoring schedule, with prior approval of the Director.*

Based on the above justification, this August 13, 2014, e-mailed letter requesting changes in the groundwater compliance monitoring program including the addition of 1,1-DCE and its associated background concentration and GPS; the RAAP has established sufficient documentation for approval of all requested changes. In accordance with the VHWMR, under 40 CFR § 270.42, Appendix I, Section C.2 and based upon the accuracy of the information contained in the Permittee's correspondence dated August 13, 2014, the requested Class 1 modifications to the permit are approved.

Enclosed are the final modified pages in electronic format to be inserted into the RAAP's copy of the hazardous waste permit.

All conditions and requirements of the facility Permit shall remain in effect for the duration of the Permit unless the existing Permit is modified, revoked and reissued, or terminated in accordance with 40 CFR § 124.5, and 40 CFR § 270.41 through 270.42, or continued in accordance with 9 VAC 20-60-270.B.5.

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 a legal appeal by filing a notice of appeal with:

David K. Paylor, Director
Department of Environmental Quality
629 East Main Street
P.O. Box 1105
Richmond, VA 23218

In the event that this decision is served to you by mail, the date of service will be calculated as three days after the postmark date. Please refer to Part 2A of the Rules of the Supreme Court of Virginia, which describes the required content of the Notice of Appeal, including specifications

of the Circuit Court to which the appeal is taken, and additional requirements concerning appeals from decisions of administrative agencies.

This above Class 1 permit modification under 40 CFR § 270.42(a)(1) requires the Permittee to send a notice of the modification to all persons on the facility mailing list (attached) within 90 days after the change is put into effect. In addition, RAAP must provide documentation to this Office regarding compliance with the public notice requirement. Please submit evidence of this mailing (return receipts, copy of the notification letter) when it is available.

If you should have any questions regarding these matters, please contact Russell McAvoy, Jr., PE, Environmental Engineer Senior, at (804) 698-4194 or by e-mail at russell.mcavoy@deq.virginia.gov.

Sincerely,

Leslie A. Romanchik

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

Enclosures: Facility Mailing List, Modified Permit Pages

cc: Andrea Barbieri – EPA, Region III (3LC50) e/enclosures
Jutta Schneider – DEQ, CO
Kurt Kochan – DEQ, CO
Aziz Farahmand – DEQ, BRRO
Elizabeth Lohman – DEQ, BRRO
Julia King–Collins – DEQ, CO
Central Hazardous Waste Files

COMMONWEALTH of VIRGINIA

DEPARTMENT OF ENVIRONMENTAL QUALITY

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Secretary of Natural Resources

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David K. Paylor
Director

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July 19, 2016

Mr. Jay Stewart
Environmental Manager
BAE Systems, Ordnance Systems Inc.
4050 Pepper's Ferry Road
Radford, Virginia 24141

VIA ELECTRONIC MAIL

Re: Annual Corrective Action Groundwater Monitoring Event Notification - HWMU-5
Semiannual Detection Notification – HWMU-16
Notification of Groundwater Verification Sampling Results for Post Closure Care Permit HWMUs 5 & 16
Radford Army Ammunitions Plant
Route 114, Radford, Virginia 24141
EPA ID#: VA1210020730

Dear Mr. Stewart:

This letter acknowledges the receipt and review of the Annual Corrective Action Groundwater Monitoring Event - HWMU-5, Semiannual Detection Notification – HWMU-16 dated June 14, 2016, and Notification of Groundwater Verification Sampling Results for Post Closure Care Permit HWMUs 5 & 16 dated June 5, 2015, submitted to the Virginia Department of Environmental Quality, Office of Remediation Programs (Department) by BAE Systems on behalf of the Radford Army Ammunitions Plant (RFAAP).

It appears that no new targeted constituents were detected during the groundwater monitoring activities conducted during the Second Quarter of 2016 for HWMUs 5. However, total cobalt was detected in Point of Compliance (POC) monitoring wells 16WC1B and 16WC9 at concentrations of 35 micrograms per liter (ug/L) and 5.5 ug/L, respectively. These concentrations are greater than the Groundwater Protection Standard (GPS) of 5 ug/L for total cobalt for this unit. RAAP had previously submitted an Alternate Source Demonstration (ASD) to the Department indicating that the detections of cobalt in this well were due to natural variation. As the report points out, the Department requested a minimum of one year of additional monitoring of this well prior to making a decision on this ASD request. Further, tetrahydrofuran and cyanide were detected in POC monitoring well 16WC8 and tetrahydrofuran, vinyl chloride, and cyanide were detected in POC monitoring well 16WC1A.

EPA ID#: VA1210020730
Radford Army Ammunitions Plant
Radford, Virginia
July 19, 2016

Tetrahydrofuran was detected in the verification sample from 16WC1A at an estimated concentration of 2.2 ug/l, which is greater than the detection limit of 2.0 ug/1; therefore, the original estimated tetrahydrofuran concentration of 4.6 ug/1was confirmed. A Class 1 Permit Modification to add tetrahyrofuran to the Groundwater Compliance Monitoring List for the Unit is required. The Department concurs with RFAAP that the background value for tetrahydrofuran is the permit specified QL of 25 ug/l and that the Groundwater Protection Standard (GPS) be the May 2016 USEPA Regional Screening Level (RSL) of 3,400 ug/l since there is no USEPA Maximum Contaminant Level (MCL) or VDEQ Alternate Concentration Limit (ACL) for tetrahydrofuran.

On June 16, 2016, verification samples were collected from HWMU-16 POC monitoring well 16MW9 to confirm or refute the initial sampling results of cobalt at concentrations greater than the unit specific GPS of 5 ug/L. Total cobalt was detected at concentrations greater than the GPS during the verification sampling. The Department understands that for confirmation, a split sample and split sample duplicate were collected and sent to different laboratories to verify the initial detection. The sample and sample duplicate result concentrations from Test America, the primary laboratory, were 4.7 ug/1 and 4.8 ug/l, respectively, which are less than the GPS of 5 ug/1. The split sample and split sample duplicate result concentrations from Eurofins were 5.6 ug/l and 6.0 ug/l, respectively, which are greater than the GPS of 5 ug/l. The Department respectfully disagrees with the Facility and considers this a confirmed detection.

RFAAP should continue to collect data as previously discussed for the Alternate Source Demonstration (ASD) for the cobalt detected above the applicable Groundwater Protection Standard in point of compliance well 16WC1B at HWMU-16 and now 16MW9.

As previously discussed, the Department acknowledges the presence of barium above the site-specific background concentration. The Department recognizes the variability of the lithology in the area of HWMU-16 that could potentially account for the natural variation of this trace element. No further investigation is required at this time; however, the Department may request further investigation if the barium levels in groundwater increase in the future.

EPA ID#: VA1210020730
Radford Army Ammunitions Plant
Radford, Virginia
July 19, 2016

If you have any additional technical questions, you may contact me at 703-583-3825 or by email at Kurt.Kochan@deq.virginia.gov.

Sincerely,

Kurt W. Kochan
Corrective Action Project Manager
Office of Remediation Programs

cc: RFAAP Correspondence File
Brett Fisher, VDEQ-CO
Russ McAvoy, VDEQ-CO
Cassie McGoldrick, EPA Region 3
Jim McKenna, ACO Staff
Matt Albers, BAE
Aziz Farahmand, VDEQ-BRRO
Mike Lawless, DAA

COMMONWEALTH of VIRGINIA

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Matthew J. Strickler
Secretary of Natural Resources

David K. Paylor
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May 3, 2021

Mr. Jim McKenna
Radford Army Ammunition Plant
Route 114, P.O. Box 1
Radford, Virginia 24143-0100

VIA ELECTRONIC MAIL

Re: 2020 Annual Groundwater Monitoring Report for
Hazardous Waste Management Units 5 & 16
Radford Army Ammunitions Plant
Route 114, Radford, Virginia 24141
EPA ID#: VA1210020730

Dear Mr. McKenna:

This letter acknowledges the receipt and review of the 2020 Annual Groundwater Monitoring Report for Hazardous Waste Management Units (HWMU) 5 & 16 dated February 2021, submitted to the Virginia Department of Environmental Quality (Department or DEQ), Office of Remediation Programs (ORP) by BAE Systems on behalf of the Radford Army Ammunitions Plant (RFAAP).

There were reportedly no new-targeted constituents detected during the groundwater monitoring activities conducted during the second or fourth quarters of 2020 for HWMU-5. However, total cobalt, a potentially newly detected constituent, continues to be detected at concentrations greater than the groundwater protection standard (GPS) and alternate concentration limit (ACL) in several monitoring wells at HWMU-16. The Department requested a revised Alternate Source Demonstration (ASD) for cobalt in December 2020. The revised ASD should be submitted as soon as practicable.

Further, the presence of vinyl chloride was verified in 16WC1A at HWMU-16. The Department concurs with the recommendations to utilize a background value of 1 ug/L based on permit specified QL as the constituent has not previously been detected at the unit and a GPS of 2 ug/L based on the USEPA MCL for vinyl chloride.

As previously noted, the Department acknowledges the presence of barium above the site-specific background concentration. The Department recognizes that the variability of the lithology in the area of HWMU-16 could potentially explain the variation of this element. No further investigation is required at this time; however, the Department may request further investigation if the barium levels in groundwater increase in the future.

The Department accepts the report as complete. However, the Department does want to acknowledge that several constituents were reported above the permit specified detection limits. The Department does not require any action at this time as this issue is being addressed by a Class 1 permit modification that is currently under review by DEQ.

If you have any questions regarding this correspondence, you may contact me at 703-583-3825 or by email at Kurt.Kochan@deq.virginia.gov.

Sincerely,

Kurt W. Kochan
Project Manager

cc: RFAAP Correspondence File
Tara Mason, Ashby Scott, DEQ-CO
Nikki Herschler, DEQ-BRRO
Melissa Lincoln, Jody Hawks, BAE
Mike Lawless, DAA

Commonwealth of Virginia

VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

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Travis A. Voyles
Secretary of Natural and Historic Resources

Michael S. Rolband, PE, PWD, PWS Emeritus
Director
(804) 698-4020

May 8, 2024

Mr. Matt Alberts
Radford Army Ammunition Plant
Route 114, P.O. Box 1
Radford, Virginia 24143-0100

VIA ELECTRONIC MAIL

Re: Annual Groundwater Monitoring Report for
Hazardous Waste Management Units 5 & 16
Radford Army Ammunitions Plant
Route 114, Radford, Virginia 24141
EPA ID#: VA1210020730

Dear Mr. Alberts:

This letter acknowledges the receipt and review of the 2023 Annual Groundwater Monitoring Report (Report) for Hazardous Waste Management Units (HWMU) 5 & 16 dated December 2023, submitted to the Virginia Department of Environmental Quality (Department or DEQ), Office of Remediation Programs (ORP) by BAE Systems on behalf of the Radford Army Ammunitions Plant (RFAAP).

The Department has no comment and accepts the Report as complete. Further, the Department concurs with the proposal to establish a background concentration and groundwater protection standard (GPS) for the newly detected compound silver. RFAAP may utilize historical data from monitoring well 16C1 to establish a background concentration and use the DEQ alternate concentration limit for the GPS as proposed.

If you have any questions regarding this correspondence, you may contact me at 703-232-4200 or by email at Kurt.Kochan@deq.virginia.gov.

Sincerely,

Kurt W. Kochan
Office of Remediation Programs

cc: RFAAP Correspondence File
Tara Mason, Ashby Scott, DEQ-CO
Laura Dickerson, RFAAP
Melissa Lincoln, BAE
Mike Lawless, TRC

ATTACHMENT V.F - GROUNDWATER PROTECTION STANDARDS (GPS)

V.F-A. GROUNDWATER PROTECTION STANDARDS: HWMU-5

Constituents	SW-846 Method	PQL (µg/l)	Back-ground (µg/l)	USEPA MCL (µg/l)	DEQ ACL (µg/l)	EPA RSL (µg/l)	GPS (µg/l)	GPS Basis
Antimony, total	6010, 6020	2	3	6			6	MCL
Arsenic, total	6010, 6020	10	1	10			10	MCL
Barium, total	6010, 6020	10	172.87	2,000			2,000	MCL
Beryllium, total	6010, 6020	1	0.7	4			4	MCL
Cadmium, total	6010, 6020	1	1.45	5			5	MCL
Chromium, total	6010, 6020	5	5	100			100	MCL
Cobalt, total	6010, 6020	5	7		6	6	7	BKG
Copper, total	6010, 6020	5	18	1,300*			1,300*	MCL*
Lead, total	6010, 6020	3	10	10*			10*	MCL*
Mercury, total	7470	2	0.9	2			2	MCL
Nickel, total	6010, 6020	10	106		390	390	390	ACL
Selenium, total	6010, 6020	10	1	50			50	MCL
Silver, total	6010, 6020	2	2.3		94	94	94	ACL
Thallium, total	6010, 6020	1	2	2			2	MCL
Vanadium, total	6010, 6020	10	17		86	86	86	ACL
Zinc, total	6010, 6020	30	75		6,000	6,000	6,000	ACL
Acetone	8260	10	89		18,000	18,000	18,000	ACL
Chloroform	8260	1	0.5	80#			80#	MCL#
Dichlorodifluoromethane	8260	1	1		200	200	200	ACL
1,2-Dichloroethane	8260	1	0.1	5			5	MCL
Diethyl ether	8260	12.5	12			3,900	3,900	RSL
Methylene chloride	8260	5	0.7	5			5	MCL
Methyl ethyl ketone; MEK; 2-butanone	8260	10	21.3		5,600	5,600	5,600	ACL

Toluene	8260	1	0.1	1,000			1,000	MCL
Trichloroethene	8260	1	0.8	5			5	MCL
Xylenes (total)	8260	3	0.1	10,000			10,000	MCL
Bis (2-ethylhexyl) phthalate	8270	10	10	6	5.6	5.6	10	BKG
Diethyl phthalate	8270	10	5		15,000	15,000	15,000	ACL
2,4-Dinitrotoluene	8270	10	0.18		0.24	0.24	10	PQL
2,6-Dinitrotoluene	8270	10	0.08		0.049	0.049	10	PQL
o-Nitroaniline; 2-	8270	10	20		190	190	190	ACL
p-Nitroaniline; 4-	8270	10	20		3.8	3.8	10	PQL
Nitrobenzene	8270	10	10		0.14	0.14	10	PQL

NOTES:

Units: µg/l Unless Otherwise Noted

SW-846: Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, EPA publication SW-846, Third Edition, Final Updates I (1993), II (1995), IIA (1994), IIB (1995), III (1997), IIIA (1999), IIIB (2005), IV (2008), and V (2015), as updated

EPA MCL: Maximum Contaminant Level of USEPA National Primary Drinking Water Regulations (web: http://water.epa.gov/drink/contaminants/index.cfm#Primary; as of December 12, 2024). Subject to change without notice as directed by DEQ.

* - Action Level.

Background (BKG): Calculated using analytical data from First Quarter 1996 through First Quarter 1999 for upgradient well 5W8B and/or as approved by DEQ (see Attachment V.E).

DEQ ACL: VA DEQ Alternate Concentration Limit (Default 10^{-6}) , effective January 2, 2025. Subject to change without notice as directed by DEQ.

RSL: Regional Screening Level - United States Environmental Protection Agency Region Regional Screening Level (RSL) (Tap Water; HQ=1; Default 10-6); as of November 2024 (https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables). Subject to change without notice as directed by DEQ.

#: The MCL for total Trihalomethanes, including Bromodichloromethane, Bromoform, Dibromochloromethane, and Chloroform, is 80 µg/L.

Note (1): For all GPS values based on the EPA MCL, DEQ ACL, or EPA RSL, the currently published values at the time of the sampling event will be used to evaluate all data for that sampling event, as well as for any verification sampling associated with that sampling event.

Note (2): Laboratory must be accredited for the analytical method, matrix, and target analyte (where applicable) by the Virginia Environmental Laboratory Accreditation Program (VELAP).

Note (3): For any monitoring event, if a GPS for a constituent in the table above is based on a PQL, the Permittee will perform verification of a detection (i.e. value greater than the Detection Limit) of such a constituent using low-level analytical methods, if such methods are standard methods that are routinely available from commercial laboratories. Furthermore, the low-level analytical method will be used only if the PQL achievable by that method is less than, or equal to, the MCL/ACL/RSL for the subject constituent. If the verification event confirms a quantifiable detection (i.e. value greater than the PQL) above the applicable MCL/ACL/RSL, a revised background concentration will be established using low-level analytical methods, if appropriate, and the GPS will be updated based on the new background concentration if warranted.

Note (4): The GPS for p-Nitroaniline is based on the current Permit-specified PQL of 10 ug/l (February 2025) instead of the calculated background concentration of 20 ug/l. P-Nitroaniline was initially detected at HWMU-5 during annual monitoring for the constituents listed in Attachment V.C during Fourth Quarter 2003 and subsequently added to the Compliance monitoring list for the Unit. During establishment of background for p-Nitroaniline at HWMU-5, the constituent was not detected in the upgradient well at concentrations greater than the then-current PQL of 20 ug/l; therefore, the background concentration for p-Nitroaniline was calculated as equal to the then-current PQL of 20 ug/l.

V.F-B. GROUNDWATER PROTECTION STANDARDS: HWMU-16

Constituents	SW-846 Method	PQL (µg/l)	Back-ground (µg/l)	EPA MCL (µg/l)	DEQ ACL (µg/l)	EPA RSL (µg/l)	GPS (µg/l)	GPS Basis
Arsenic, total	6010/6020	10	1	10			10	MCL
Barium, total	6010/6020	10	175.4	2,000			2,000	MCL
Beryllium, total	6010/6020	1	0.7	4			4	MCL
Cadmium, total	6010/6020	1	0.2	5			5	MCL
Chromium, total	6010/6020	5	6.2	100			100	MCL
Cobalt, total	6010/6020	5	5		6	6	6	ACL
Copper, total	6010/6020	5	13	1,300*			1,300*	MCL
Lead, total	6010/6020	3	10	10*			10*	MCL*
Mercury, total	7470	2	0.2	2			2	MCL
Nickel, total	6010/6020	10	16		390	390	390	ACL
Silver	6010/6020	2	2		94	94	94	ACL
Vanadium, total	6010/6020	10	151		86	86	151	BKG
Zinc, total	6010/6020	30	51		6,000	6,000	6,000	ACL
Benzene	8260	1	1	5			5	MCL
2-Butanone; Methyl ethyl ketone (MEK)	8260	10	1.1		5,600	5,600	5,600	ACL
Carbon tetrachloride	8260	1	0.2	5			5	MCL
Chloroethane	8260	1	20.7		8,300	8,300	8,300	ACL
Dichlorodifluoromethane	8260	1	46.5		200	200	200	ACL
1,1-Dichloroethane;	8260	1	9.5		2.8	2.8	9.5	BKG
1,1-Dichloroethene	8260	1	1	7	8.2	8.2	7	MCL
Diethyl ether	8260	12.5	75.5			3,900	3,900	RSL
Dimethyl ether;	8260	12.5	17				17	BKG
Ethylbenzene; Phenylethane	8260	1	0.1	700			700	MCL
Methylene chloride	8260	5	13.95	5			13.95	BKG
Tetrachloroethene (PCE)	8260	1	0.7	5			5	MCL

Chloromethane	8260	1	0.3		190	190	190	ACL
Toluene	8260	1	0.1	1,000			1,000	MCL
1,1,1-Trichloroethane; Methylchloroform;	8260	1	9.2	200			200	MCL
Trichloroethene	8260	1	0.1	5			5	MCL
Trichlorofluoromethane	8260	1	11.3		5,200	5,200	5,200	ACL
Trifluorotrichloroethane (1,1,2-Trichloro-1,2,2-Trifluoroethane)	8260	1	1.2			10,000	10,000	RSL
Tetrahydrofuran	8260	25	25			3,400	3,400	RSL
Vinyl chloride	8260	1	1	2			2	MCL
Xylenes (total)	8260	3	0.2	10,000			10,000	MCL
Diethyl phthalate	8270	10	5		15,000	15,000	15,000	ACL
2,4-Dinitrotoluene	8270	10	10		0.24	0.24	10	PQL
2,6-Dinitrotoluene	8270	10	10		0.049	0.049	10	PQL

NOTES:

Units: µg/l Unless Otherwise Noted

SW-846: Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, EPA publication SW-846, Third Edition, Final Updates I (1993), II (1995), IIA (1994), IIB (1995), III (1997), IIIA (1999), IIIB (2005), IV (2008), and V (2015), as updated

EPA MCL: Maximum Contaminant Level of USEPA National Primary Drinking Water Regulations (web: http://water.epa.gov/drink/contaminants/index.cfm#Primary; as of December 12, 2024). Subject to change without notice as directed by DEQ.

* - Action Level.

Background (BKG): Calculated using analytical data from 1996 through 1998 for upgradient well 16C1 and/or as approved by DEQ (see Attachment V.E).

DEQ ACL: VA DEQ Alternate Concentration Limit (Default 10^{-6}) , effective January 2, 2025. Subject to change without notice as directed by DEQ.

RSL: Regional Screening Level - United States Environmental Protection Agency Region Regional Screening Level (RSL) (Tap Water; HQ=1;

Default 10-6); as of November 2024 (https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables). Subject to change without notice as directed by DEQ.

Note (1): For all GPS values based on the EPA MCL, DEQ ACL, or EPA RSL, the currently published values at the time of the sampling event will be used to evaluate all data for that sampling event, as well as for any verification sampling associated with that sampling event.

Note (2): Laboratory must be accredited for the analytical method, matrix, and target analyte (where applicable) by the Virginia Environmental Laboratory Accreditation Program (VELAP).

Note (3): For any monitoring event, if a GPS for a constituent in the table above is based on PQL, the Permittee will perform verification of a detection (i.e. value greater than the Detection Limit) of such a constituent using low-level analytical methods, if such methods are standard methods that are routinely available from commercial laboratories. Furthermore, the low-level analytical method will be used only if the PQL achievable by that method is less than, or equal to, the MCL/ACL/RSL for the subject constituent. If the verification event confirms a quantifiable detection (i.e. value greater than the PQL) above the applicable MCL/ACL/RSL, a revised background concentration will be established using low-level analytical methods, if appropriate, and the GPS will be updated based on the new background concentration if warranted.

ATTACHMENT V.G - BORING LOGS AND WELL CONSTRUCTION DIAGRAMS

V.G-A. HWMU-5 BORING LOGS AND WELL CONSTRUCTION DIAGRAMS

TABLE 1
Monitoring Well Survey Data
Hazardous Waste Management Unit 5
Radford AAP, Radford, Virginia

WELL ID	ELEVATION AT TOP OF PVC CASING (NAVD 88)	NORTHING (NAD 83)	EASTING (NAD 83)
5W8B	1788.45	3597013.8437	10889252.8779
5WC11	1789.14	3597013.7930	10889263.3700
5WC12	1789.20	3597026.8562	10889253.7294
S5W8	1783.91	3597056.3385	10889309.4175
5WCA	1779.28	3597208.7913	10889384.8283
5W5B	1773.94	3597294.1823	10889379.5167
5W7B	1773.79	3597348.5604	10889315.7553
5WC21	1773.71	3597353.5337	10889369.7108
5WC22	1773.72	3597348.9117	10889380.8472
5WC23	1773.10	3597343.9377	10889391.9867
S5W5	1771.23	3597495.8112	10889256.6655
S5W6	1770.69	3597387.7138	10889440.2909
S5W7	1775.59	3597373.2666	10889116.7232
5W9A	1760.66	3597536.6534	10889800.3133
5W10A	1769.93	3597864.5629	10889805.8722
5W11A	1764.95	3598022.7203	10889592.8933
5W12A	1772.46	3597548.9323	10889518.8907

DRAPER ADEN ASSOCIATES
Engineers • Geologists • Hydrologists

LOG OF: **5W12A** (1 of 1)

Project Number: **B03204-301**

Client:	**Radford Army Ammunition Plant**	Drilling Company:	**Davidson Drilling**
Project:	**HWMU-5 Well Installation**	Driller:	**Chase Davidson**
Location:	**RAAP HWMU-5**	Boring Method:	**Geoprobe + 3.25 in HSA**
Northing:	**3,597,548.93230000**	Easting: **10,889,518.89070000**	Logged by: **RGM**
Total Depth	**32.0'**	Elev GS: **1770.1** Reference: **Ground Surface**	Completion Date: **February 22, 2010**

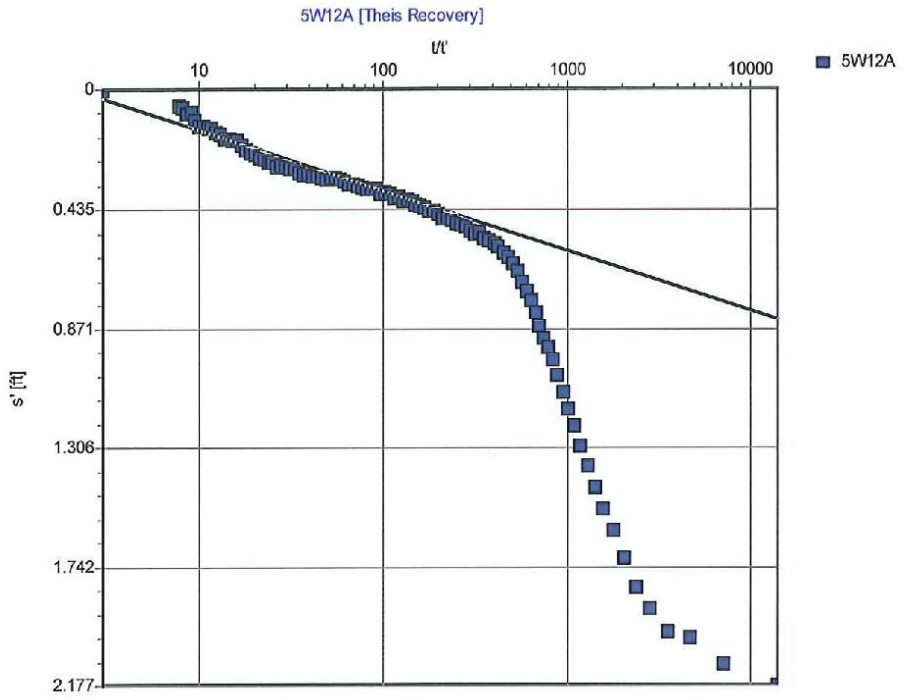
Samp ID	Blow Counts	N Value	Depth Scale	DESCRIPTION (USC)	Stratum Elev	PID (ppm)	WELL LOG	H2O	REMARKS
				Dark brown fine silty sand with plant matter, trace carbonate gravel, moist.	1769.9				Surface completion - ~2.5 ft locking stick up with 6x6x0.5 ft concrete well pad.
				Brown fine silty sand, trace plant matter, damp.	1769.1				
				Yellow brown fine clayey sand, moist, to mottled (yellow-brown, red-brown) fine clayey sand, damp.	1766.1				
				Mottled (yellow-brown, red-brown) fine sandy clay with black joint staining, dry.				▼	Depth to water 2/25/2010. Measuring point elevation 1772.46 ft msl (top of PVC). Hydrated bentonite in outer annulus of PVC. Riser - 2 in diameter schedule 40 PVC.
			10					1760.1	
					1759.1				
				Mottled (yellow-brown, brown) fine sandy silt, with black joint staining, trace coarse rounded sand, moist.	1757.1			1758.1	
				Mottled (yellow-brown, brown) fine silty sand with black joint staining, trace medium to coarse sand, moist.					
				Becoming wet at 17'.	1753.1			▽	Depth to water during drilling 2/19/2010.
					1750.6				
			20	Yellow-brown fine to coarse sand, trace rounded quartz gravel, wet. 1 ft recovery between 20-24 ft.					Screen - 2 in diameter schedule 40 PVC with 0.01 in precut slots. #2 sand in outer annulus of screen to 2 ft above screened interval.
				Yellow-brown fine to coarse sand, wet.	1746.1				
					1743.1				
				Mottled (yellow-brown, brown) fine silty sand, moist.	1742.6				
				Brown medium to coarse sand, trace silt, damp to yellow-brown, fine to coase sand, wet.					
			30		1739.1				
				Yellow-brown fine to coarse clayey sand with gravel, wet.	1738.1			1738.6	Pipe cap at bottom.
				Probe refusal on gray carbonate rock, residuum at 32 ft bgs.	1737.1			1738.1	
			40						

WELL_LOG RAAP HWMU-5.GPJ GENERAL WELL TEMPLATE.GDT 3/3/10

Draper Aden Associates
2206 S. Main St.
Blacksburg, VA 24060
Phone 540-552-0444

Pumping Test Analysis Report

Project: 5W12A Pump and Recovery Test
Number: B03204-301
Client: Radford Army Ammunition Plant



Pumping Test: **5W12A Pump and Recovery**

Analysis Method: **Theis Recovery**

Analysis Results:	Transmissivity:	3.42E-3 [ft²/s]	Conductivity:	1.25E-4 [ft/s]
Test parameters:	Pumping Well:	5W12A	Aquifer Thickness:	27.5 [ft]
	Casing radius:	0.084 [ft]	Unconfined Aquifer	
	Screen length:	20 [ft]		
	Boring radius:	0.29 [ft]		
	Discharge Rate:	1.8343583 [U.S. gal/min]		
	Pumping Time	70.718 [min]		

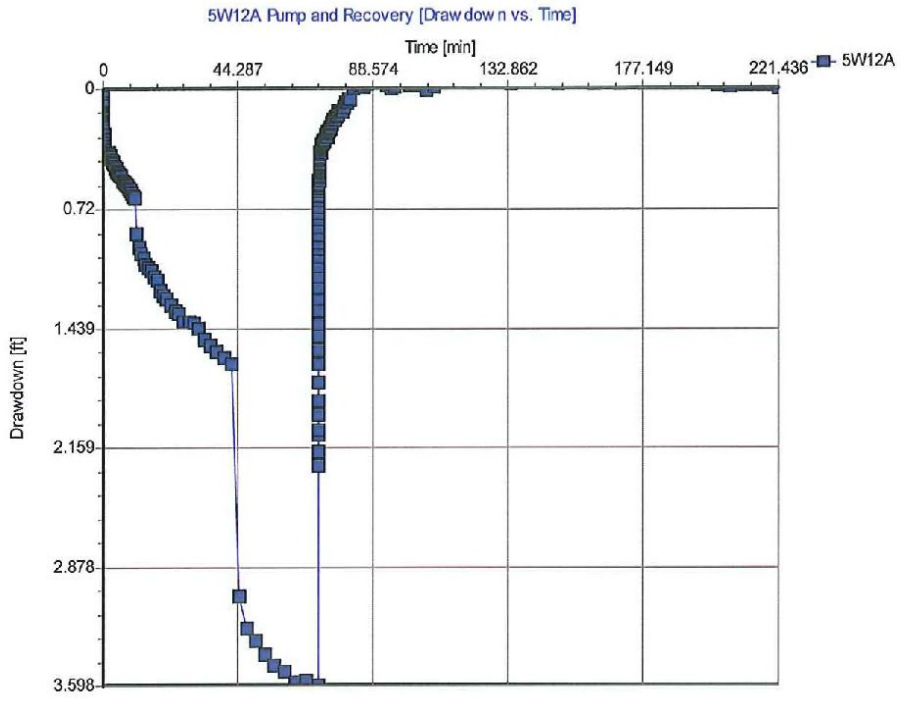
Comments: Depth to static water level measured from top of casing.
Manually adjusted best fit line.

Evaluated by: KMW-WDN
Evaluation Date: 3/3/2010

Draper Aden Associates
2206 S. Main St.
Blacksburg, VA 24060
Phone 540-552-0444

Pumping Test Analysis Report

Project: 5W12A Pump and Recovery Test
Number: B03204-301
Client: Radford Army Ammunition Plant



Pumping Test: **5W12A Pump and Recovery**

Analysis Method: **Drawdown vs. Time**

Analysis Results:

Test parameters:				
	Pumping Well:	5W12A	Aquifer Thickness:	27.5 [ft]
	Casing radius:	0.084 [ft]		
	Screen length:	20 [ft]		
	Boring radius:	0.29 [ft]		
	Discharge Rate:	1.8343583 [U.S. gal/min]		

Comments:
Time 0 - 9.949 minutes - pumping rate 1 gal/min.
Time 9.949 - 42.098 minutes - pumping rate 2 gal/min.
Time 42.098 - 70.718 minutes - pumping rate 3 gal/min.
Time 70.718 - 221.463 minutes - recovery.

Evaluated by: KMW-WDN
Evaluation Date: 3/3/2010

Draper Aden Associates
2206 S. Main St.
Blacksburg, VA 24060
Phone 540-552-0444

Pumping Test Data Report
Project: 5W12A Pump and Recovery Test
Number: B03204-301
Client: Radford Army Ammunition Plant | Page 1

Data observed at:	**5W12A**	**Pumping Test:**	**5W12A Pump and Recovery**
Distance from PW:	0 [ft]	Pumping Well:	5W12A
Depth to Static WL:	6.89 [ft]	Casing radius:	0.084 [ft]
Location:	HWMU-5	Boring radius:	0.29 [ft]
Recorded by:	DWK	Screen length:	20 [ft]
Date:	2/25/2010	Aquifer Thickness:	27.5 [ft]

	Time [min]	Depth to WL [ft]	Drawdown [ft]
1	0	6.89	0.00
2	0.005	6.87	-0.02
3	0.01	6.86	-0.03
4	0.015	6.86	-0.03
5	0.02	6.87	-0.02
6	0.025	6.88	-0.01
7	0.03	7.03	0.14
8	0.035	7.05	0.16
9	0.04	6.93	0.04
10	0.045	6.90	0.01
11	0.05	6.94	0.05
12	0.055	6.97	0.08
13	0.06	7.00	0.11
14	0.065	7.03	0.14
15	0.07	7.04	0.15
16	0.075	7.05	0.16
17	0.08	7.05	0.16
18	0.085	7.07	0.18
19	0.09	7.07	0.18
20	0.095	7.08	0.19
21	0.1	7.09	0.20
22	0.106	7.10	0.21
23	0.112	7.10	0.21
24	0.119	7.10	0.21
25	0.126	7.12	0.23
26	0.133	7.13	0.24
27	0.141	7.12	0.23
28	0.149	7.12	0.23
29	0.158	7.12	0.23
30	0.167	7.14	0.25
31	0.177	7.14	0.25

Draper Aden Associates
2206 S. Main St.
Blacksburg, VA 24060
Phone 540-552-0444

Pumping Test Data Report
Project: 5W12A Pump and Recovery Test
Number: B03204-301
Client: Radford Army Ammunition Plant

Data observed at:	**5W12A**	**Pumping Test:**	**5W12A Pump and Recovery**
Distance from PW:	0 [ft]	Pumping Well:	5W12A
Depth to Static WL:	6.89 [ft]	Casing radius:	0.084 [ft]
Location:	HWMU-5	Boring radius:	0.29 [ft]
Recorded by:	DWK	Screen length:	20 [ft]
Date:	2/25/2010	Aquifer Thickness:	27.5 [ft]

	Time [min]	Depth to WL [ft]	Drawdown [ft]
32	0.188	7.14	0.25
33	0.199	7.16	0.27
34	0.21	7.16	0.27
35	0.223	7.16	0.27
36	0.236	7.16	0.27
37	0.25	7.16	0.27
38	0.265	7.17	0.28
39	0.28	7.17	0.28
40	0.297	7.19	0.29
41	0.315	7.19	0.30
42	0.333	7.19	0.30
43	0.353	7.19	0.30
44	0.374	7.20	0.31
45	0.396	7.20	0.31
46	0.42	7.21	0.32
47	0.445	7.22	0.33
48	0.47	7.22	0.33
49	0.496	7.22	0.33
50	0.525	7.22	0.33
51	0.555	7.22	0.33
52	0.586	7.23	0.34
53	0.621	7.25	0.36
54	0.658	7.27	0.38
55	0.696	7.27	0.38
56	0.738	7.28	0.39
57	0.781	7.27	0.38
58	0.828	7.28	0.39
59	0.876	7.29	0.40
60	0.928	7.29	0.40
61	0.983	7.30	0.41
62	1.041	7.30	0.41

Draper Aden Associates 2206 S. Main St. Blacksburg, VA 24060 Phone 540-552-0444	Pumping Test Data Report Project: 5W12A Pump and Recovery Test Number: B03204-301 Client: Radford Army Ammunition Plant — Page 3

Data observed at:	**5W12A**	**Pumping Test:**	**5W12A Pump and Recovery**
Distance from PW:	0 [ft]	Pumping Well:	5W12A
Depth to Static WL:	6.89 [ft]	Casing radius:	0.084 [ft]
Location:	HWMU-5	Boring radius:	0.29 [ft]
Recorded by:	DWK	Screen length:	20 [ft]
Date:	2/25/2010	Aquifer Thickness:	27.5 [ft]

	Time [min]	Depth to WL [ft]	Drawdown [ft]
63	1.103	7.30	0.41
64	1.168	7.30	0.41
65	1.238	7.30	0.41
66	1.311	7.31	0.42
67	1.39	7.31	0.42
68	1.473	7.31	0.42
69	1.561	7.28	0.39
70	1.655	7.28	0.39
71	1.753	7.27	0.38
72	1.858	7.27	0.38
73	1.968	7.29	0.40
74	2.085	7.28	0.39
75	2.21	7.29	0.40
76	2.341	7.29	0.40
77	2.481	7.30	0.41
78	2.63	7.30	0.41
79	2.786	7.32	0.43
80	2.953	7.33	0.44
81	3.13	7.32	0.43
82	3.316	7.33	0.44
83	3.515	7.33	0.44
84	3.725	7.34	0.45
85	3.946	7.36	0.47
86	4.181	7.36	0.47
87	4.43	7.36	0.47
88	4.693	7.38	0.49
89	4.973	7.39	0.50
90	5.27	7.40	0.51
91	5.583	7.40	0.51
92	5.915	7.41	0.52
93	6.266	7.44	0.55

Draper Aden Associates 2206 S. Main St. Blacksburg, VA 24060 Phone 540-552-0444	Pumping Test Data Report Project: 5W12A Pump and Recovery Test Number: B03204-301 Client: Radford Army Ammunition Plant — Page 4

Data observed at:	**5W12A**	**Pumping Test:**	**5W12A Pump and Recovery**
Distance from PW:	0 [ft]	Pumping Well:	5W12A
Depth to Static WL:	6.89 [ft]	Casing radius:	0.084 [ft]
Location:	HWMU-5	Boring radius:	0.29 [ft]
Recorded by:	DWK	Screen length:	20 [ft]
Date:	2/25/2010	Aquifer Thickness:	27.5 [ft]

	Time [min]	Depth to WL [ft]	Drawdown [ft]
94	6.64	7.44	0.55
95	7.035	7.45	0.56
96	7.453	7.46	0.57
97	7.896	7.47	0.58
98	8.366	7.49	0.60
99	8.865	7.50	0.61
100	9.391	7.51	0.62
101	9.95	7.53	0.64
102	10.541	7.54	0.65
103	11.168	7.76	0.87
104	11.831	7.84	0.95
105	12.535	7.87	0.98
106	13.28	7.91	1.02
107	14.07	7.94	1.05
108	14.906	7.96	1.07
109	15.791	7.98	1.09
110	16.73	8.01	1.12
111	17.723	8.03	1.14
112	18.776	8.10	1.21
113	19.891	8.13	1.24
114	21.073	8.15	1.26
115	22.325	8.18	1.29
116	23.65	8.22	1.33
117	25.055	8.24	1.35
118	26.543	8.28	1.39
119	28.118	8.29	1.40
120	29.786	8.30	1.41
121	31.555	8.33	1.44
122	33.428	8.40	1.51
123	35.411	8.43	1.54
124	37.513	8.47	1.58

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Blacksburg, VA 24060
Phone 540-552-0444

Pumping Test Data Report

Project: 5W12A Pump and Recovery Test
Number: B03204-301
Client: Radford Army Ammunition Plant | Page 5

Data observed at:	**5W12A**	**Pumping Test:**	**5W12A Pump and Recovery**
Distance from PW:	0 [ft]	Pumping Well:	5W12A
Depth to Static WL:	6.89 [ft]	Casing radius:	0.084 [ft]
Location:	HWMU-5	Boring radius:	0.29 [ft]
Recorded by:	DWK	Screen length:	20 [ft]
Date:	2/25/2010	Aquifer Thickness:	27.5 [ft]

	Time [min]	Depth to WL [ft]	Drawdown [ft]
125	39.74	8.51	1.62
126	42.098	8.55	1.66
127	44.596	9.95	3.06
128	47.243	10.14	3.25
129	50.046	10.22	3.33
130	53.015	10.30	3.41
131	56.16	10.37	3.48
132	59.491	10.41	3.52
133	63.02	10.47	3.58
134	66.758	10.46	3.57
135	70.718	10.49	3.60
136	70.723	9.16	2.27
137	70.728	9.07	2.18
138	70.733	8.97	2.08
139	70.738	8.95	2.06
140	70.743	8.86	1.97
141	70.748	8.77	1.88
142	70.753	8.66	1.77
143	70.758	8.55	1.66
144	70.763	8.46	1.57
145	70.768	8.38	1.49
146	70.773	8.30	1.41
147	70.778	8.22	1.33
148	70.783	8.15	1.26
149	70.788	8.08	1.19
150	70.793	8.02	1.13
151	70.798	7.95	1.06
152	70.803	7.90	1.00
153	70.808	7.85	0.96
154	70.813	7.81	0.92
155	70.818	7.76	0.87

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Pumping Test Data Report
Project: 5W12A Pump and Recovery Test
Number: B03204-301
Client: Radford Army Ammunition Plant
Page 6

Data observed at:	**5W12A**	**Pumping Test:**	**5W12A Pump and Recovery**
Distance from PW:	0 [ft]	Pumping Well:	5W12A
Depth to Static WL:	6.89 [ft]	Casing radius:	0.084 [ft]
Location:	HWMU-5	Boring radius:	0.29 [ft]
Recorded by:	DWK	Screen length:	20 [ft]
Date:	2/25/2010	Aquifer Thickness:	27.5 [ft]

	Time [min]	Depth to WL [ft]	Drawdown [ft]
156	70.824	7.71	0.82
157	70.83	7.67	0.78
158	70.837	7.63	0.74
159	70.844	7.60	0.71
160	70.851	7.56	0.67
161	70.859	7.53	0.64
162	70.867	7.51	0.62
163	70.876	7.49	0.60
164	70.885	7.46	0.57
165	70.895	7.45	0.56
166	70.906	7.44	0.55
167	70.917	7.44	0.54
168	70.928	7.42	0.53
169	70.941	7.42	0.53
170	70.954	7.41	0.52
171	70.968	7.39	0.50
172	70.983	7.38	0.49
173	70.998	7.38	0.49
174	71.015	7.37	0.48
175	71.033	7.36	0.47
176	71.051	7.36	0.47
177	71.071	7.34	0.45
178	71.092	7.33	0.44
179	71.114	7.33	0.44
180	71.138	7.32	0.43
181	71.163	7.32	0.43
182	71.188	7.31	0.42
183	71.214	7.30	0.41
184	71.243	7.29	0.40
185	71.273	7.30	0.41
186	71.304	7.28	0.39

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Pumping Test Data Report
Project: 5W12A Pump and Recovery Test
Number: B03204-301
Client: Radford Army Ammunition Plant | Page 7

Data observed at:	**5W12A**	**Pumping Test:**	**5W12A Pump and Recovery**
Distance from PW:	0 [ft]	Pumping Well:	5W12A
Depth to Static WL:	6.89 [ft]	Casing radius:	0.084 [ft]
Location:	HWMU-5	Boring radius:	0.29 [ft]
Recorded by:	DWK	Screen length:	20 [ft]
Date:	2/25/2010	Aquifer Thickness:	27.5 [ft]

	Time [min]	Depth to WL [ft]	Drawdown [ft]
187	71.339	7.29	0.40
188	71.376	7.27	0.38
189	71.414	7.26	0.37
190	71.456	7.27	0.38
191	71.499	7.25	0.36
192	71.546	7.25	0.36
193	71.594	7.25	0.36
194	71.646	7.25	0.36
195	71.701	7.24	0.35
196	71.759	7.23	0.34
197	71.821	7.24	0.35
198	71.886	7.22	0.33
199	71.956	7.22	0.33
200	72.029	7.22	0.33
201	72.108	7.21	0.32
202	72.191	7.22	0.33
203	72.279	7.22	0.33
204	72.373	7.21	0.32
205	72.471	7.21	0.32
206	72.576	7.20	0.31
207	72.686	7.20	0.31
208	72.803	7.20	0.31
209	72.928	7.18	0.29
210	73.059	7.18	0.29
211	73.199	7.17	0.28
212	73.348	7.17	0.28
213	73.504	7.18	0.29
214	73.671	7.16	0.27
215	73.848	7.15	0.26
216	74.034	7.14	0.25
217	74.233	7.14	0.25

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Pumping Test Data Report

Project: 5W12A Pump and Recovery Test

Number: B03204-301

Client: Radford Army Ammunition Plant | Page 8

Data observed at:	**5W12A**	**Pumping Test:**	**5W12A Pump and Recovery**
Distance from PW:	0 [ft]	Pumping Well:	5W12A
Depth to Static WL:	6.89 [ft]	Casing radius:	0.084 [ft]
Location:	HWMU-5	Boring radius:	0.29 [ft]
Recorded by:	DWK	Screen length:	20 [ft]
Date:	2/25/2010	Aquifer Thickness:	27.5 [ft]

	Time [min]	Depth to WL [ft]	Drawdown [ft]
218	74.443	7.13	0.24
219	74.664	7.12	0.23
220	74.899	7.11	0.22
221	75.148	7.09	0.20
222	75.411	7.08	0.19
223	75.691	7.08	0.19
224	75.988	7.07	0.18
225	76.301	7.07	0.18
226	76.633	7.06	0.17
227	76.984	7.05	0.16
228	77.358	7.03	0.14
229	77.753	7.03	0.14
230	78.171	7.03	0.14
231	78.614	7.03	0.14
232	79.084	7.00	0.11
233	79.583	6.98	0.09
234	80.109	6.98	0.09
235	80.668	6.96	0.07
236	81.259	6.95	0.06
237	81.886	6.89	0.00
238	82.549	6.85	-0.04
239	83.253	6.84	-0.05
240	83.998	6.86	-0.03
241	84.788	6.88	-0.01
242	85.624	6.88	-0.01
243	86.509	6.86	-0.03
244	87.448	6.82	-0.07
245	88.441	6.81	-0.08
246	89.494	6.81	-0.08
247	90.609	6.85	-0.04
248	91.791	6.84	-0.05

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Pumping Test Data Report
Project: 5W12A Pump and Recovery Test
Number: B03204-301
Client: Radford Army Ammunition Plant
Page 9

Data observed at:	**5W12A**	**Pumping Test:**	**5W12A Pump and Recovery**
Distance from PW:	0 [ft]	Pumping Well:	5W12A
Depth to Static WL:	6.89 [ft]	Casing radius:	0.084 [ft]
Location:	HWMU-5	Boring radius:	0.29 [ft]
Recorded by:	DWK	Screen length:	20 [ft]
Date:	2/25/2010	Aquifer Thickness:	27.5 [ft]

	Time [min]	Depth to WL [ft]	Drawdown [ft]
249	93.043	6.88	-0.01
250	94.368	6.89	0.00
251	95.773	6.88	-0.01
252	97.261	6.85	-0.04
253	98.836	6.84	-0.05
254	100.504	6.87	-0.02
255	102.273	6.87	-0.02
256	104.146	6.86	-0.03
257	106.129	6.90	0.01
258	108.231	6.88	-0.01
259	112.816	6.85	-0.04
260	115.314	6.84	-0.05
261	117.961	6.85	-0.04
262	120.764	6.84	-0.05
263	123.733	6.83	-0.06
264	126.878	6.85	-0.04
265	130.209	6.85	-0.04
266	133.738	6.86	-0.03
267	137.476	6.85	-0.04
268	141.436	6.85	-0.04
269	145.436	6.86	-0.03
270	149.436	6.86	-0.03
271	153.436	6.85	-0.04
272	157.436	6.85	-0.04
273	161.436	6.87	-0.02
274	165.436	6.86	-0.03
275	169.436	6.86	-0.03
276	173.436	6.86	-0.03
277	177.436	6.86	-0.03
278	181.436	6.86	-0.03
279	185.436	6.86	-0.03

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Pumping Test Data Report

Project: 5W12A Pump and Recovery Test

Number: B03204-301

Client: Radford Army Ammunition Plant | Page 10

Data observed at:	**5W12A**	**Pumping Test:**	**5W12A Pump and Recovery**
Distance from PW:	0 [ft]	Pumping Well:	5W12A
Depth to Static WL:	6.89 [ft]	Casing radius:	0.084 [ft]
Location:	HWMU-5	Boring radius:	0.29 [ft]
Recorded by:	DWK	Screen length:	20 [ft]
Date:	2/25/2010	Aquifer Thickness:	27.5 [ft]

	Time [min]	Depth to WL [ft]	Drawdown [ft]
280	189.436	6.86	-0.03
281	193.436	6.87	-0.02
282	197.436	6.86	-0.03
283	201.436	6.87	-0.02
284	205.436	6.88	-0.01
285	209.436	6.87	-0.02
286	213.436	6.87	-0.02
287	217.436	6.87	-0.02
288	221.436	6.89	0.00

Site 5
Ground Water Monitoring Well Construction Details

Well I.D.	Ground Elevation	UTM Coordinates		Boring Termination Depth	Top of Well Screen	Total Well Depth	Screen Length	Comments
		Northing	Easting					
5W8B	1787.58	3,597,030	10,899,320	31.54	16.54	31.54	15	4,6
5W5B	1773.13	3,597,300	10,899,410	19.58	4.58	19.58	15	4,6
5W7B	1772.78	3,597,350	10,899,305	19.88	4.88	19.88	15	4,6
5WC21	1768.80	3,597,350	10,899,410	29.43	14.43	29.43	15	4,5
5WC22	1768.80	3,597,350	10,899,410	41.23	26.23	41.23	15	4,5
5WC23	1768.80	3,597,350	10,899,410	49.89	34.89	49.89	15	4,5
S5W5	1769.81	3,597,500	10,899,270	18.57	3.57	18.57	15	4,6
S5W7	1773.08	3,597,390	10,899,115	25.59	10.59	25.59	15	4,6
5W9A	1761.10	3,597,510	10,899,800	49	26.65	46.65	20	3,5
5W10A	1768.40	3,597,855	10,899,800	45	25	45	20	3,5
5W11A	1764.70	3,597,010	10,899,600	48	28	48	20	3,5

Comments:
1) Well construction details obtained from boring log.
2) Well screen length obtained from boring log.
3) Well screen length obtained from other data on file.
4) Well screen length assumed.
5) Total well depth obtained from boring log.
6) Total well depth obtained from field sampling log.

Attachment P

BORING LOGS AND WELL CONSTRUCTION DIAGRAMS

Appendix 2.

Well 5W8B (Background)

Betz-Converse-Murdoch-Inc. BCM

UNITS
W-8B

Drilling Log

Well Number W-8-B

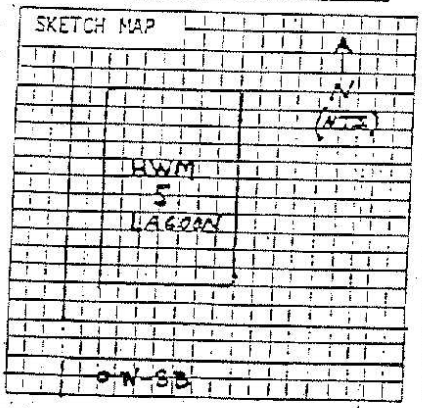
Client Corps of Engineers/Radford AAP
Project No. 00-0008-01
Well Location upgradient from lagoon No. 5
Driller/Company Dean/Cunningham
Drilling Method NX core Hole Diameter nominal 4" Date(s) Drilled 2/15 - 16/83
Sample Type split spoon/core Sample Interval 5' spoon No. Samples Retained 7
Surface Elevation 1787.58' Casing Top Elevation 1789.55' Total Well Depth 31.5
Casing Material and Size 2" ID PVC threaded couples Cased Interval(s) 0 - 16.5 (+2's
Grouting Type sand cement Grouted Interval 0-16.5 (incl 1'
Screening Material and Size 2" ID PVC 0.010" slots Screened Interval(s) 16.5 - 31.5
Packing Material and Size No. 1 sand Packed Interval 15.5 - 31.5
Depth to Static Water 17'4"* Date 2/18/83 Approx Well Yield <0.25 gpm
Development Method air Development Time 3 hours
Logged by: Peter B. Jacobson

Comments

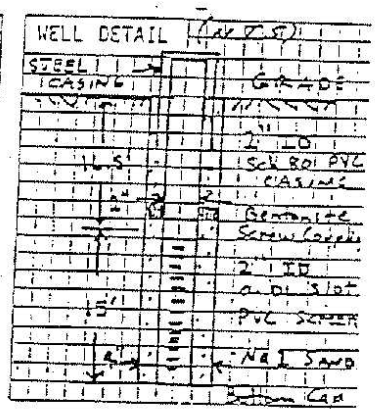
no core recovery

* measured from top of casing

SKETCH MAP



WELL DETAIL



Depth Scale	Sample	Spoon Blows	Description of Materials
0 - 1.5	spoon	1-5-6	medium brown to orange brown silty clay with angular pebbles
5 - 6.5	spoon	1-2-2	medium orange brown silty clay with minor fine sand
10 - 11.5	spoon	3-6-14	slightly moist mottled orange brown clay, minor silt and fine sand
14'4"			coarse sand and gravel layer
15 - 16.5	spoon	11-17-45	poorly sorted mix of sand silt gravel clay; coarsening downward; gravel ends at 17.5'
20 - 21.5	spoon	5-5-8	mottled orange/red brown clay, moist
25 - 26.5	spoon	1-2-2	wet soft brown clay with silt and fine sand
30 - 31.5	spoon	1-3-2	wet medium orange brown silty clay, minor sand
end of hole at 31.5'			

Appendix 3.

Well 5W5B (Point of Compliance)

Betz-Converse-Murdoch-Inc. BCM

UNIT 5
W-5B

Drilling Log

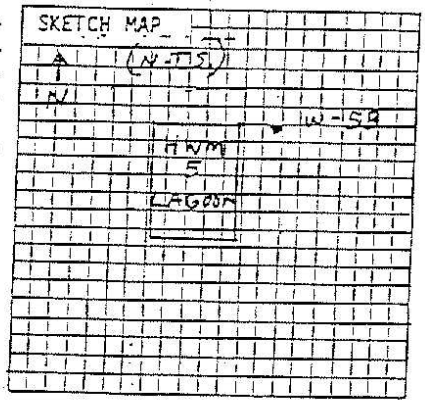
Well Number W-5B

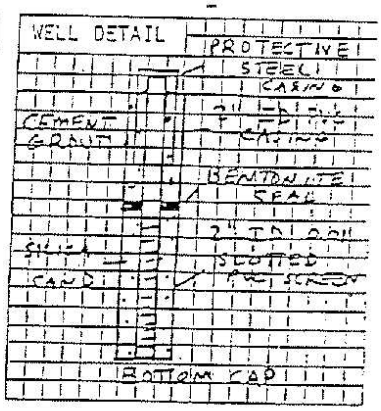
Client Corps of Engineers, RAAP, Radford, VA
Project No. 00-0008-01
Well Location East of HWM 5 Lagoon
Driller/Company M. Dean, Cunningham Core Drilling and Grouting Corp, Salem, VA
Drilling Method Fishtail Hole Diameter 4.5"
Sample Type Split Spoon Sample Interval 5'
Surface Elevation 1773.13 Casing Top Elevation 1775.08'*
Casing Material and Size 2" ID Sch. 80 PVC
Grouting Type Portland Cement with Sand
Screening Material and Size 2" ID 0.01 Slotted PVC
Packing Material and Size Fine to Coarse Silica Sand
Depth to Static Water 14.31 (T.O.C.) Date 8/19/83
Development Method Air
Logged by: D. J. Varner

Date(s) Drilled 8/17-18/83
No. Samples Retained 4
Total Well Depth 22'
Cased Interval(s) 0-10'
Grouted Interval 0-6'
Screened Interval(s) 10-20'
Packed Interval 8-20'
Approx Well Yield < 1 gpm
Development Time 4 hours

Comments
1) Drilling water obtained from RAAP hydrants
2) Replaces well W-5
3) Bentonite pellet seal in the 8-10' annular interval
Depth to water table measured from the top of the steel casing

*Top of steel casing





Depth Scale	Sample	Spoon Blows	Description of Materials
5-6.5	Spoon	2-3-4	Somewhat mottled buff to orange-brown fine sandy and silty clay
10-11.5	Spoon	4-7-9	Tan Clay with fine to coarse sand
15-16.5	Spoon	4-5-7	Tan clay with scattered sand
20-21.5	Spoon	2-2-4	Brown sandy-clay
22			End of hole

Appendix 4.

Well 5W7B (Point of Compliance)

Betz·Converse·Murdoch·Inc. BCM

UNIT 5
W-7B

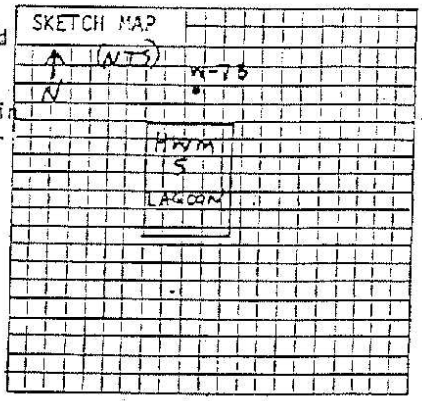
Drilling Log

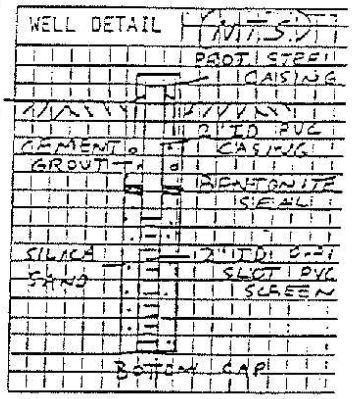
Well Number W-7B

Client Corps of Engineers, RAAP, Radford, VA — Project No. 00-0008-01
Well Location North of HWMS Lagoon
Driller/Company M. Dean, Cunningham Core Drilling and Grouting Corp, Salem, VA
Drilling Method Fishtail/Core — Hole Diameter 4.5" — Date(s) Drilled 8/18/83
Sample Type Split Spoon — Sample Interval 5' — No. Samples Retained 4
Surface Elevation 1772.78 — Casing Top Elevation 1774.90'* — Total Well Depth 20'
Casing Material and Size 2" ID Sch. 80 PVC — Cased Interval(s) 0-10
Grouting Type Portland Cement with Sand — Grouted Interval 0-5'
Screening Material and Size 2" ID 0.01 Slotted PVC — Screened Interval(s) 10-20'
Packing Material and Size Fine to coarse silica sand — Packed Interval 8-20'
Depth to Static Water 13.58' (T.O.C.) Date 8/19/83 — Approx Well Yield < 1 gpm
Development Method Air — Development Time 4 hours
Logged by: D. J. Varner

Comments
1) Drilling water obtained from RAAP hydrants
2) Replaces well W-7
3) Bentonite pellet seal in the 6-8' annular interval
4) Depth to water table measured from the top of the steel casing
5) Core size: HW

*Top of steel casing





Depth Scale	Sample	Spoon Blows	Description of Materials
5-6.5	Spoon	5-7-4	Light reddish-brown very silty fine sand with mica, black lignite, and some clay
10-11.5	Spoon	2-3-4	Light reddish-brown very silty fine sand with mica, black lignite, and some clay
15-16.5	Spoon	6-9-19	Orange-red and tan brecciated decomposed shale with a clay matrix and some lignite
20-21.5	Spoon	5-2-4	Orange-red and tan brecciated decomposed shale with a clay matrix and some lignite.
20			End of hole.

W-7B

Betz-Converse-Murdoch-Inc. BCM

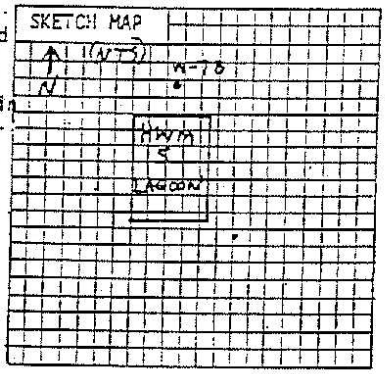
Drilling Log

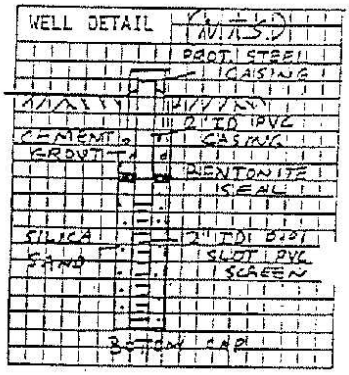
Well Number W-7B

Client Corps of Engineers, RAAP, Radford, VA — Project No. 00-0008-01
Well Location North of HWMS Lagoon
Driller/Company M. Dean, Cunningham Core Drilling and Grouting Corp, Salem, VA
Drilling Method Fishtail/Core — Hole Diameter 4.5" — Date(s) Drilled 8/18/83
Sample Type Split Spoon — Sample Interval 5' — No. Samples Retained 4
Surface Elevation 1772.78 — Casing Top Elevation 1774.90'* — Total Well Depth 20'
Casing Material and Size 2" ID Sch. 80 PVC — Cased Interval(s) 0-10'
Grouting Type Portland Cement with Sand — Grouted Interval 0-6'
Screening Material and Size 2" ID 0.01 Slotted PVC — Screened Interval(s) 10-20'
Packing Material and Size Fine to coarse silica sand — Packed Interval 8-20'
Depth to Static Water 13.58' (T.O.C.) Date 8/19/83 — Approx Well Yield < 1 gpm
Development Method Air — Development Time 4 hours
Logged by: D. J. Varner

Comments
1) Drilling water obtained from RAAP hydrants
2) Replaces well W-7
3) Bentonite pellet seal in the 6-8' annular interval
4) Depth to water table measured from the top of the steel casing
5) Core size: HW

*Top of steel casing





Depth Scale	Sample	Spoon Blows	Description of Materials
5-6.5	Spoon	5-7-4	Light reddish-brown very silty fine sand with mica, black lignite, and some clay
10-11.5	Spoon	2-3-4	Light reddish-brown very silty fine sand with mica, black lignite, and some clay
15-16.5	Spoon	6-9-19	Orange-red and tan brecciated decomposed shale with a clay matrix and some lignite
20-21.5	Spoon	5-2-4	Orange-red and tan brecciated decomposed shale with a clay matrix and some lignite.
20			End of hole.

Appendix 5.

Well 5WC21 (Point of Compliance)

HWMUS\S-WC2-1

BORING LOG

FROEHLING & ROBERTSON, INC.
FULL SERVICE LABORATORIES • ENGINEERING • CHEMIC
ONE HUNDRED YEARS OF SERVICE

Report No. M-52084

Client: Hercules Inc. DATE May 1987

Project: Radford Army Ammunition Plant Radford, Virginia

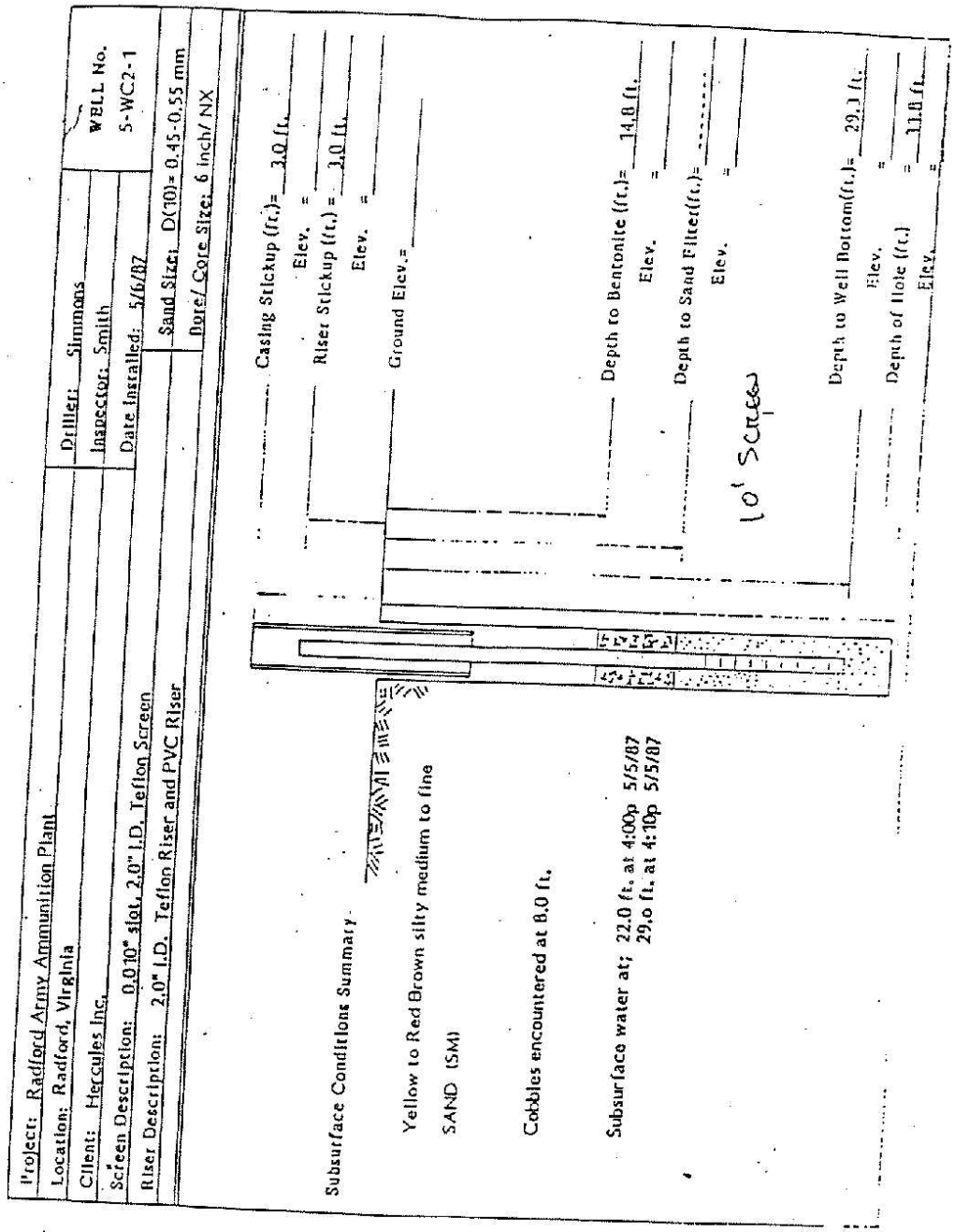
Boring No.: S-WC2-1 | Total Depth: 31.8 ft. | Elevation: -------- | Location: See Location Plan

Type of Boring: Hollow Stem Auger | Started: 5/5/87 | Completed: 5/5/87 | Driller: W. Simmons

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	Sample Blows	Sample Depth (Feet)	% Core Recovery	REMARKS
	0.0	Medium dense red brown silty fine SAND, trace mica (SM)	5 5 10	1.5		GROUNDWATER DATA
				3.0		
		-to-	4 5 9	4.5		
				6.0		
		Very loose to medium dense yellow brown silty medium to fine SAND (SM)		8.5		
			2 2 2	10.0		
		-ALLUVIUM-				
			2 14 6	13.5		
	16.5			15.0		
		Medium dense to very loose yellow brown silty coarse to fine SAND (angular rock fragments) (SM)				
			9 14 8	18.5		
				20.0		Subsurface water at: 22 ft. May 5, 1987 at 4:00 p.m. 29 ft. May 5, 1987 4:10 p.m.
		-RESIDUUM-	WH 1	23.5		
				25.0		*Weight of hammer
				28.5		
			1 2 3	30.0		
	31.8	Boring terminated at 31.8 ft.				

*No. of blows req'd. for a 140 lb. hammer dropping 30 in. to drive 2 in O.D., 1.375 in. I.D. sampler a total of 18 inches in three 6 in. increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N.

Scale 1"=5' unless otherwise noted


Project: Radford Army Ammunition Plant
Location: Radford, Virginia
Client: Hercules Inc.
Screen Description: 0.010" slot, 2.0" I.D. Teflon Screen
Riser Description: 2.0" I.D. Teflon Riser and PVC Riser
Driller: Simmons
Inspector: Smith
Date Installed: 5/6/87
Sand Size: D(10)= 0.45-0.55 mm
Bore/ Core Size: 6 inch/ NX
WELL No.
5-WC2-1
Casing Stickup (ft.)= 3.0 ft.
Elev. =
Riser Stickup (ft.) = 3.0 ft.
Elev. =
Ground Elev.=
Depth to Bentonite (ft.)= 14.8 ft.
Elev. =
Depth to Sand Filter(ft.)= ------
Elev. =
10' Screen
Depth to Well Bottom(ft.)= 29.3 ft.
Elev. =
Depth of Hole (ft.) = 31.8 ft.
Elev. =
Subsurface Conditions Summary
Yellow to Red Brown silty medium to fine
SAND (SM)
Cobbles encountered at 8.0 ft.
Subsurface water at; 22.0 ft. at 4:00p 5/5/87
29.0 ft. at 4:10p 5/5/87

Appendix 6.

Well 5WC22 (Point of Compliance)

HWMUS\5-WC2-2

BORING LOG

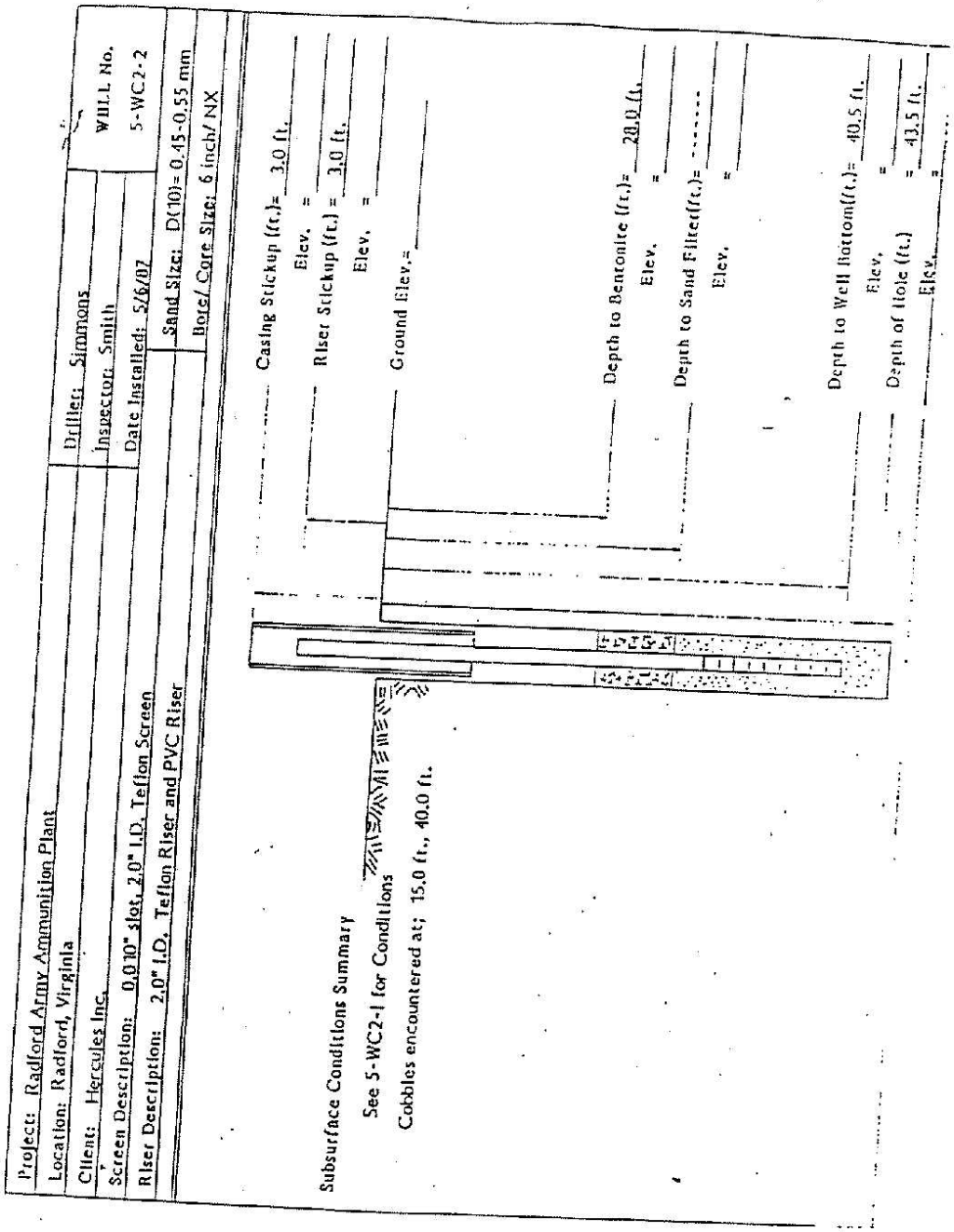
FROEHLING & ROBERTSON, INC.
FULL SERVICE LABORATORIES • ENGINEERING • CHEMICA
"ONE HUNDRED YEARS OF SERVICE"

Report No. 87-62084
Client: Hercules Inc. DATE May 1987
Project: Radford Army Ammunition Plant Radford, Virginia
Boring No.: S-WC2-2 Total Depth: 43.5 ft. Elevation: -------- Location: See Location Plan
Type of Boring: Hollow Stem Auger Started: 5/6/87 Completed: 5/6/87 Driller: W. Simmons

Elevation	Depth	DESCRIPTION OF MATERIALS (Classifications)	Sample Blows	Sample Depth (Feet)	% Core Recovery	REMARKS
	0.0	No sampling conducted, see S-WC2-1 for subsurface conditions				GROUNDWATER DATA
		Cobbles encountered at 15 ft.				
		Difficult augering at 35 ft. - 40 ft.				
		Boring terminated at 43.5 ft.				

No. of blows rec'd for a 140 lb hammer dropping 30 in. to drive 2 in O.D., 1 375 in. I.D. sampler a total of 18 inches in three 6 in. increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N.

Scale 1"=5' unless otherwise noted


Project: Radford Army Ammunition Plant
Location: Radford, Virginia
Client: Hercules Inc.
Screen Description: 0.010" slot, 2.0" I.D. Teflon Screen
Riser Description: 2.0" I.D. Teflon Riser and PVC Riser
Driller: Simmons
Inspector: Smith
Date Installed: 5/6/07
Sand Size: D(10)= 0.45-0.55 mm
Bore/ Core Size: 6 inch/ NX
WELL No.
5-WC2-2
Casing Stickup (ft.)= 3.0 ft.
Elev. =
Riser Stickup (ft.) = 3.0 ft.
Elev. =
Ground Elev.=
Depth to Bentonite (ft.)= 20.0 ft.
Elev. =
Depth to Sand Filter(ft.)= -------
Elev. =
Depth to Well Bottom(ft.)= 40.5 ft.
Elev. =
Depth of Hole (ft.) = 43.5 ft.
Elev. =
Subsurface Conditions Summary
See 5-WC2-1 for Conditions
Cobbles encountered at: 15.0 ft., 40.0 ft.

Appendix 7.

Well 5WC23 (Point of Compliance)

HWMU 5 \ S-WC2-3

BORING LOG

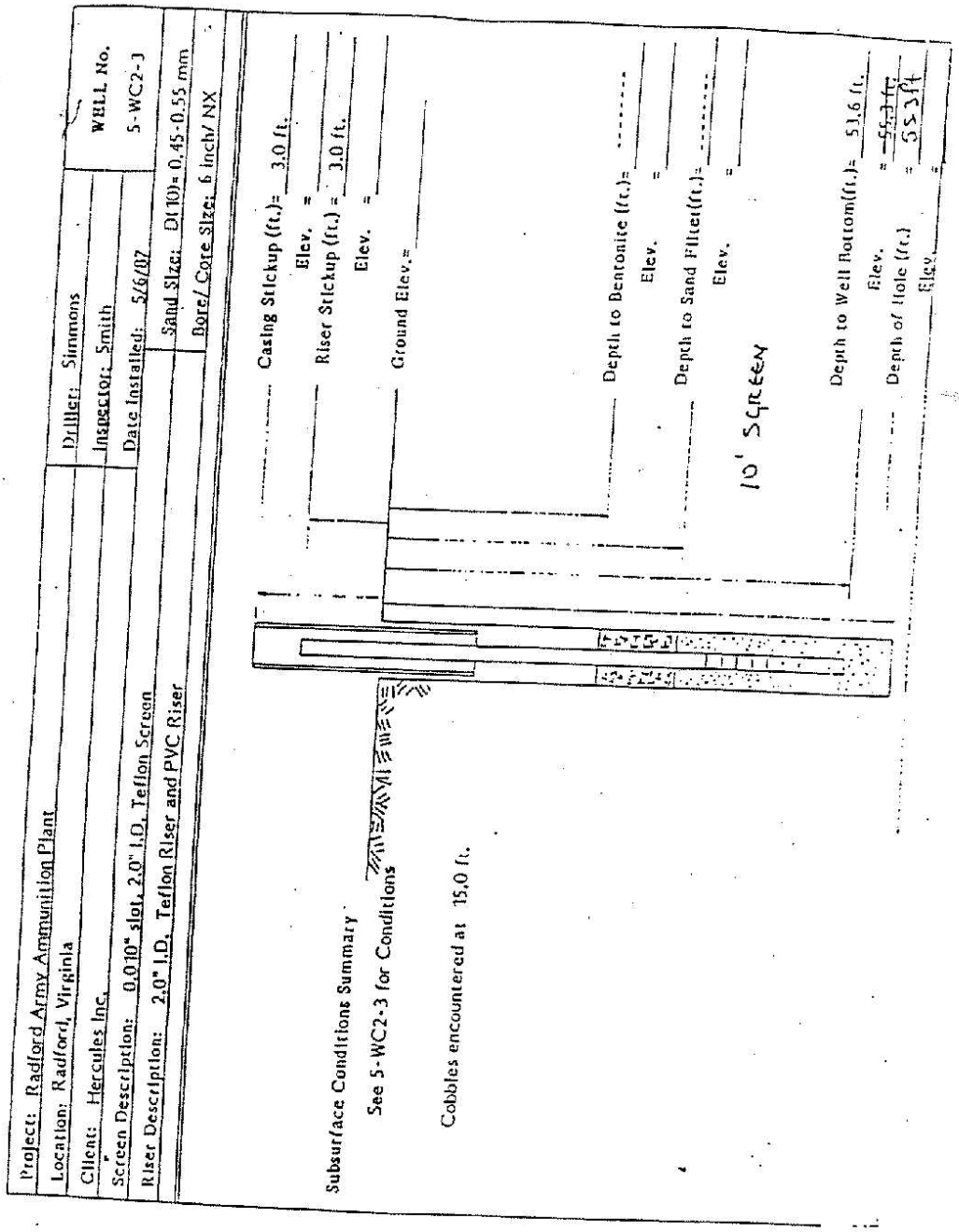
FROEHLING & ROBERTSON, INC.
FULL SERVICE LABORATORIES • ENGINEERING • CHEMICAL
ONE HUNDRED YEARS OF SERVICE

Report No. 0-62084
Client: Hercules Inc.
DATE May 1987
Project: Radford Army Ammunition Plant Radford, Virginia
Boring No. S-WC2-3 | Total Depth: 55.3 ft. | Elevation: ---------- | Location: See Location Plan
Type of Boring: Hollow Stem Auger | Started: 5/6/87 | Completed: 5/6/87 | Driller: W. Simmons

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	Sample Blows	Sample Depth (Feet)	% Core Recovery	REMARKS
	0.0	No sampling conducted, see S-WC2-1 for subsurface conditions				GROUNDWATER DATA
		Cobbles encountered at 15.0 ft.				
		Difficult augering at 53.0 ft. - 55.0 ft.				
		Boring terminated at 55.3 ft.				

*No. of blows required to drive a 140 lb. hammer dropping 30 in. to drive 2 in. O.D., 1.375 in. I.D. sampler a total of 18 inches in three 6 in. increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N.

Scale 1" = 5' unless otherwise noted


Project: Radford Army Ammunition Plant
Location: Radford, Virginia
Client: Hercules Inc.
Screen Description: 0.010" slot, 2.0" I.D. Teflon Screen
Riser Description: 2.0" I.D. Teflon Riser and PVC Riser
Driller: Simmons
Inspector: Smith
Date Installed: 5/6/07
Sand Size: D(10)= 0.45-0.55 mm
Bore/ Core Size: 6 inch/ NX
WELL No. 5-WC2-3
Casing Stickup (ft.)= 3.0 ft.
Elev. =
Riser Stickup (ft.) = 3.0 ft.
Elev. =
Ground Elev.=
Depth to Bentonite (ft.)=
Elev. =
Depth to Sand Filter(ft.)=
Elev. =
10' SCREEN
Depth to Well Bottom(ft.)= 51.6 ft.
Elev. = 5537ft
Depth of Hole (ft.) = 55.3ft
Elev. =
Subsurface Conditions Summary
See 5-WC2-3 for Conditions
Cobbles encountered at 15.0 ft.

Appendix 8.

Well S5W5 (Compliance Well)

55W5
MW-5

US ARMY ENVIRONMENTAL HYGIENE AGENCY

Army Pollution Abatement Program Study, Installation of MOnitoring Wells, Radford Army Ammunition Plant, Radford, VA, 3-9 April 1981 (USAEHA Control No. 81-26-8251-81)

DRILLING LOG

PROJECT RAAP 81-26-8251-81 DATE 5 April 81

LOCATION Site 5, north of lagoon next to building SR 1612 DRILLERS Smithson, Hoddinott; Craig, Gates (logger)

DRILL RIG Acker II, w/ 4 in continuous flight auger BORE HOLE MW 5

TD= 25ft.

DEPTH	SAMPLE TYPE / BLOWS PER 6 IN.	DESCRIPTION	REMARKS (water level: initial 7' 5", 24 hr. 8' 10")	
		Brown sandy silt with some gravel wet, plastic		13 ft of schedule 40, 2 in ID PVC casing
		Perched lense of water	10 ft of Concrete grout	
5 ft.	MB 5-10	Yellowish brown silty clay w/ some mica flakes		
10 ft	MB 10-15	same material	Bentonite; sand pack	screen
15 ft				

USAEHA Form 95, 12 Aug 74

US ARMY ENVIRONMENTAL HYGIENE AGENCY

Army Pollution Abatement Program Study, Installation of Monitoring Wells, Radford Army Ammunition Plant, Radford, VA, 3-9 April 1981, (USAEHA Control No. 81-26-8251-81)

DRILLING LOG

PROJECT RAAP 81-26-8251-81 DATE 5 April 81

LOCATION Site 5, north of lagoon next to building S.R.1612 DRILLERS Smithson, Heddinott Craig, Gates (logger)

DRILL RIG Acker II, w/ 4 in continuous flight auger BORE HOLE MW 5

DEPTH	SAMPLE TYPE / BLOWS PER 6 IN.	DESCRIPTION	REMARKS
	MB 10-20		10 ft of slotted 2 in ID, schedule 40, PVC screen (0.008-0.01")
20 ft		water at 20 ft yellow coarse medium sand - saturated	
		change in engine pitch Elbrook FM	2 ft of trap
25 ft		TD 25 feet	Depth of well 25 ft
30 ft			

USAEHA Form 95, 12 Aug 74

Appendix 9.

Well S5W7 (Compliance Well)

5507

MW-7

US ARMY ENVIRONMENTAL HYGIENE AGENCY

Army Pollution Abatement Program Study, Installation of Monitoring Wells, Radford Army Ammunition Plant, Radford, VA, 3-9 April 1981, (USAEHA Control No. 81-26-8251-81)

DRILLING LOG

PROJECT RAAP 81-25-8251-81 DATE 5 April 81

LOCATION Site 5, west of lagoon DRILLERS Smithson, Hoddinott

next to building S.R. 1603 Craig, Gates (logger)

DRILL RIG Acker II, w/ 4 in continuous flight Auger BORE HOLE MW 7

TD=26 ft

DEPTH	SAMPLE TYPE / BLOWS PER 6 IN.	DESCRIPTION	water level initial=14'10" 24 hr =10'10" REMARKS	
		Reddish brown silty clay dampmed plastic	Concrete	
			Bentonite	12 ft of schedule 40, 2 in ID PVC casing
			24.5 ft of sand pack	
5ft				
	MB 5-10	same material getting damper and more plastic		
10 ft				
		saturated silty medium coarse sand return on Auger- may have hit a lense of gravel		10 ft of slotted 2 in ID schedule 40 PVC screen
15 ft				

USAEHA Form 95, 12 Aug 74

US ARMY ENVIRONMENTAL HYGIENE AGENCY

Army Pollution Abatement Program Study, Installation of Monitoring Wells, Radford Army Ammunition Plant, 3-9 April 1981, (USAEHA Control No. 81-26-8251-81)

DRILLING LOG

PROJECT RAAP 81-26-8251-81 DATE 5 April 81

LOCATION Site 5, west of lagoon next to building S.R. 1603 DRILLERS Smithson, Hoddinott; Craig, Gates (logger)

DRILL RIG Acker II, w/ 4 in continuous flight Auger BORE HOLE MW 7

DEPTH	SAMPLE TYPE / BLOWS PER 6 IN.	DESCRIPTION	REMARKS
	M3 15-20	same material saturated	screen
20 ft			
			3 ft of sediment trap
25 ft		Elbrook FM (weathered gray clay residuum)	depth of well 26 feet
		26 ft TD	
30 ft			

USAEHA Form 95, 12 Aug 74

Appendix 10.

Well 5W9A (Compliance Well)

W9A
HWMU-5

Form No. 500

BORING LOG

FROEHLING & ROBERTSON, INC.
"ONE HUNDRED YEARS OF SERVICE"

Report No: ROM-62085 DATE: November, 1985

Client: Hercules, Inc.
Project: Monitoring Wells Radford Army Ammunition Plant Radford, Virginia
Boring No: W-9-A Total Depth: 49.0' Elevation: --- Location: See plan
Type of Boring: Hollow stem auger Started: 11-6-85 Completed: 11-6-85 Driller: W. Simmons, Sr.

Elevation	Depth	Description of Materials (Classification)	Sample Blows*	Sample Depth (Feet)	% Core Recovery	Remarks
	0.0	Asphalt and crushed stone				GROUNDWATER DATA
	1.5	Loose to medium dense brown fine sandy SILT little clay -ALLUVIUM-				—
			5-7-9	4.5–6.0		
			3-8-1	8.5–10.0		
	13.0	Soft orange-brown silty CLAY to clayey SILT (CL/ML) Relict structure -RESIDUUM-	2-1-1	13.5–15.0		Water level @ 16.0'
						Development Data: Sloshed for 2 hrs. Bailed down to 21'. Water level re-established at 16.0' after 1.5 hrs.
	39.0			39.0		Auger refusal @ 39.0'
	40.0					

*No. of blows req'd for a 140 lb hammer dropping 30 in. to drive 2 in O.D. 1.375 in I.D. sampler a total of 18 inches in three 6" increments.

Scale 1"=5' unless otherwise noted

BORING LOG

FROEHLING & ROBERTSON, INC.
ONE HUNDRED YEARS OF SERVICE

Report No ROM-62085 DATE November, 1985

Client: Hercules, Inc.

Project: Monitoring Wells Radford Army Ammunition Plant Radford, Virginia

Boring No.: W-9-A cont. | Total Depth: 49.0' | Elevation: --- | Location: See plan

Type of Boring: Hollow stem auger | Started: 11-5-85 | Completed: 11-6-85 | Driller: W. Simmons, Sr.

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	Sample Blows	Sample Depth (Feet)	% Core Recovery	RQD %	REMARKS
	40.0	Brown fine to medium grained SANDSTONE, changing to blue-gray fractured saccharoidal LIMESTONE and DOLOMITE			20%	0%	GROUNDWATER DATA
				44.0			
					30%	0%	
	49.0			49.0			
		Coring terminated @ 49.0'					

- 20' TEFLON SCREEN
- 10' PVC. 80
- ADAPTER
- 25' PVC. 40 & 3' CUTOFF)

No. of blows required for a 140 lb. hammer dropping 30 in. to drive 2 in. O.D. 1.375 in. I.D. sampler a total of 18 inches in three 6 inch increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N.

Scale 1" = 5' unless otherwise noted

Appendix 11.

Well 5W10A (Compliance Well)

W10A
HWMU-5

BORING LOG

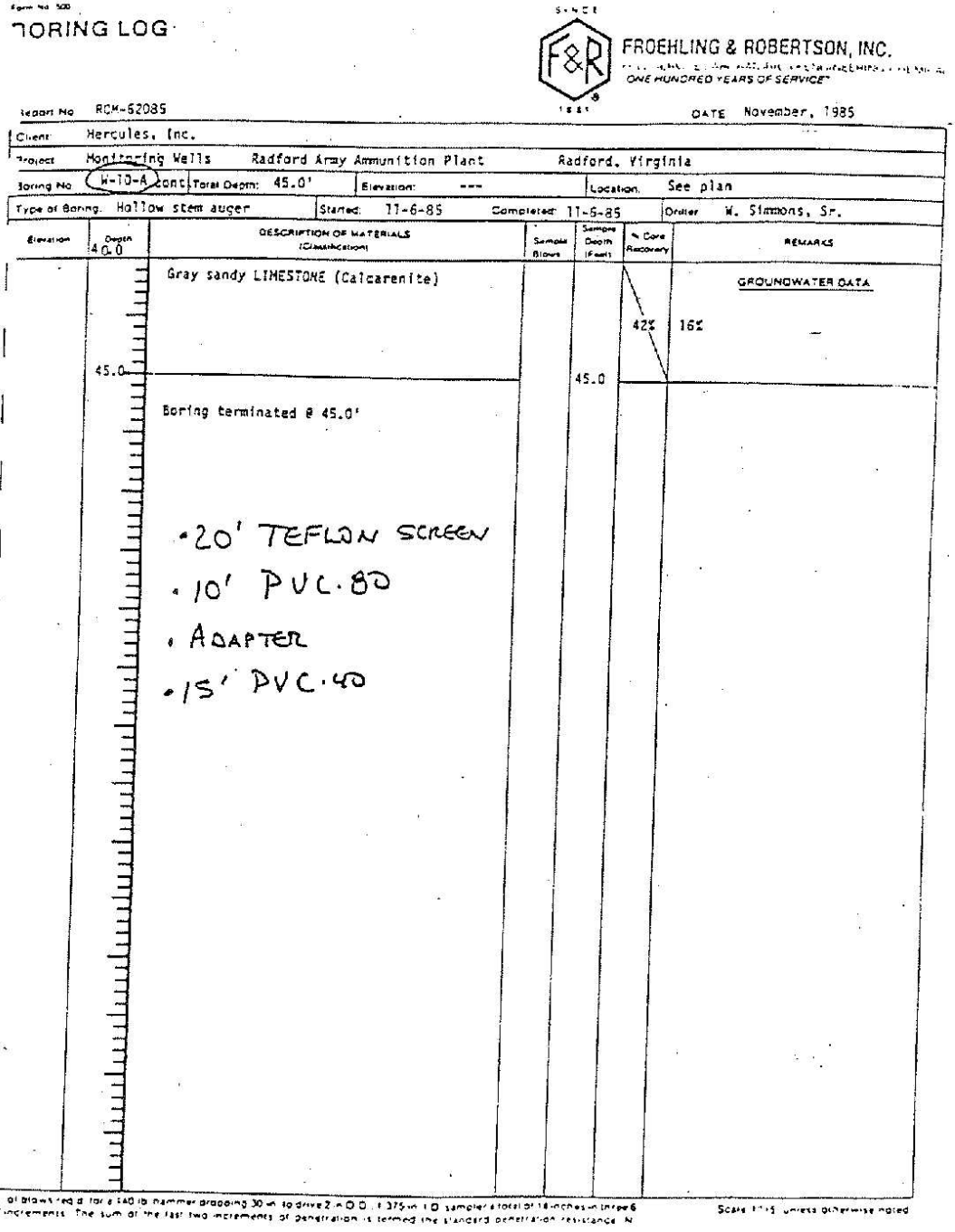
FROEHLING & ROBERTSON, INC.
ONE HUNDRED YEARS OF SERVICE

Report No ROM-62085 DATE November, 1985
Client Hercules, Inc.
Project Monitoring Wells Radford Army Ammunition Plant Radford, Virginia
Boring No W-10-A Total Depth: 45.0' Elevation: --- Location: See plan
Type of Boring: Hollow stem auger Started: 11-6-85 Completed: 11-6-85 Driller: W. Simmons, Sr.

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	Sample Blows	Sample Depth (Feet)	% Core Recovery	RQD %	REMARKS
	0.0	Brown fine sandy SILT; roots, organics					GROUNDWATER DATA
	1.0	Loose to medium-dense red brown fine sandy SILT with occasional cobble layers (ML) -ALLUVIUM-	5 10 10	4.5 6.0			—
			7 5 5	8.5 10.0			
			12 11 12	13.5 15.0			Water level @ 14.8'
	17.0	Medium-stiff gray-brown silty CLAY to clayey SILT, shale fragments, relict structure -RESIDUUM-	3 3 3	18.5 20.0			Development Data: Sloshed for 2 hrs. Bailed down for 1/2 hr. No change in water level.
			30	28.5	28.5		
	30.0	Gray green brecciated LIMESTONE and DOLOMITE, numerous calcite-healed fractures		30.0			* 50/0.5'
					22%	0%	
				35.0			
					12%	0%	
	40.0			40.0			

No. of blows required for a 140 lb. hammer dropping 30 in. to drive 2 in O.D., 1.375 in I.D. sampler a total of 18 inches in three 6 in. increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N.

Scale 1"=5' unless otherwise noted



BORING LOG

FROEHLING & ROBERTSON, INC.
ONE HUNDRED YEARS OF SERVICE

Report No RCM-62085 DATE November, 1985

Client: Hercules, Inc.

Project: Monitoring Wells Radford Army Ammunition Plant Radford, Virginia

Boring No: W-10-A cont. Total Depth: 45.0' Elevation: --- Location: See plan

Type of Boring: Hollow stem auger Started: 11-6-85 Completed: 11-6-85 Driller: W. Simmons, Sr.

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	Sample Blows	Sample Depth (Feet)	% Core Recovery	REMARKS
	40.0	Gray sandy LIMESTONE (Calcarenite)			42% 16%	GROUNDWATER DATA
	45.0	Boring terminated @ 45.0'		45.0		

- 20' TEFLON SCREEN
- 10' PVC.80
- ADAPTER
- 15' PVC.40

No. of blows required for a 140 lb. hammer dropping 30 in. to drive 2 in. O.D., 1.375 in. I.D. sampler a total of 18 inches in the 6 inch increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N.

Scale 1" = 5' unless otherwise noted

Appendix 12.

Well 5W11A (Compliance Well)

W11A
HWMU-5

BORING LOG

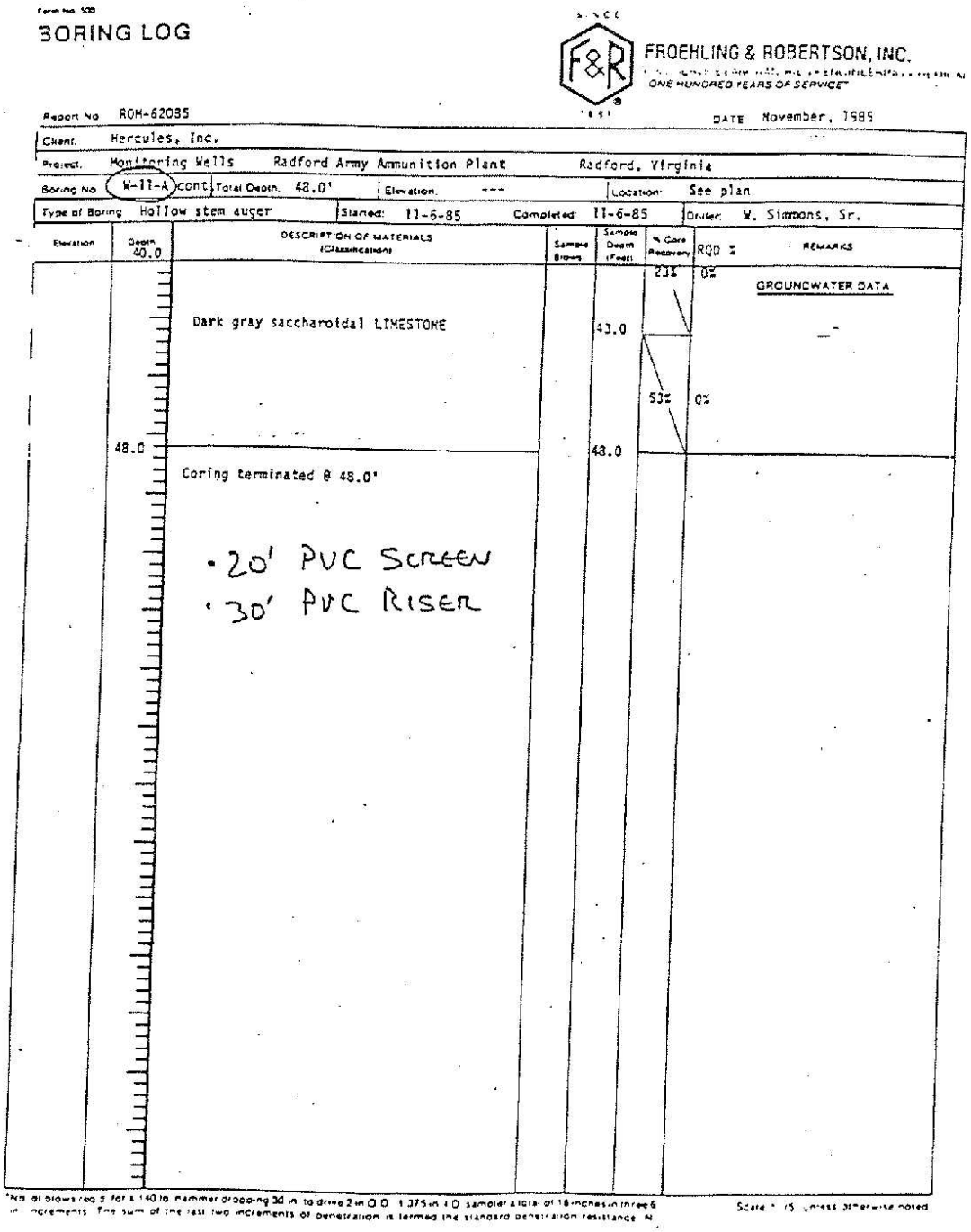
FROEHLING & ROBERTSON, INC.
ONE HUNDRED YEARS OF SERVICE

Report No. ROM-62085 DATE November, 1985
Client Hercules, Inc.
Project Monitoring Wells Radford Army Ammunition Plant Radford, Virginia
Boring No. W-11-A | Total Depth: 48.0' | Elevation --- | Location: See plan
Type of Boring: Hollow stem auger | Started: 11-6-85 | Completed: 11-6-85 | Driller: W. Simmons, Sr.

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	Sample Blows	Sample Depth (Feet)	% Core Recovery	RQD %	REMARKS
	0.0						GROUNDWATER DATA
	1.0	Brown fine sandy SILT; roots, organics					
		Medium-dense to dense brown fine sandy SILT to silty fine SAND (ML/SM) -ALLUVIUM-	9 11 11	4.5 6.0			
			4 9 22	8.5 10.0			
			12 7 11	13.5 15.0			Water level @ 14.8'
	17.0	Very soft yellow-brown coarse to fine sandy CLAY, some silt (CL) relict structure -RESIDUUM-	1 1 1	18.5 20.0			Development Data: Sloshed 2 hours. Bailed down to 19.0'. Recovered to 14.8' after 1.5 hrs.
	28.0	Gray-brown vuggy LIMESTONE, calcite healed fractures interbedded with gray-green -FAULT BRECCIA-		28.0	72%	30%	
				33.0	33%	7%	
	40.0			38.0			

No. of blows req'd for a 140 lb hammer dropping 30 in. to drive 2 in O.D. 1 3/8 in I.D. sampler a total of 18 inches in three 6 in. increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N.

Scale 1"=5' unless otherwise noted



BORING LOG

FROEHLING & ROBERTSON, INC.
ONE HUNDRED YEARS OF SERVICE

Report No ROH-62085 DATE November, 1985

Client: Hercules, Inc.

Project: Monitoring Wells Radford Army Ammunition Plant Radford, Virginia

Boring No W-11-A cont. Total Depth 48.0' Elevation --- Location: See plan

Type of Boring Hollow stem auger Started: 11-6-85 Completed: 11-6-85 Driller: W. Simmons, Sr.

Elevation	Depth 40.0	DESCRIPTION OF MATERIALS (Classification)	Sample Blows	Sample Depth (Feet)	% Core Recovery	RQD %	REMARKS
					23%	0%	GROUNDWATER DATA
		Dark gray saccharoidal LIMESTONE		43.0			
					53%	0%	
	48.0			48.0			
		Coring terminated @ 48.0'					

- 20' PVC Screen
- 30' PVC Riser

*No. of blows req'd for a 140 lb. hammer dropping 30 in. to drive 2 in. O.D. 1.375 in. I.D. sampler a total of 18 inches in three 6 in. increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N.

Scale 1" = 5' unless otherwise noted

Appendix 13.

Other Wells

H.WMU 5\5-WCA

BORING LOG

FROEHLING & ROBERTSON, INC.
FULL SERVICE LABORATORIES • ENGINEERING • CHEMICAL
"ONE HUNDRED YEARS OF SERVICE"
1887

Report No. G-62084 DATE May 1987

Client: Hercules Inc.

Project: Radford Army Ammunition Plant Radford, Virginia

Boring No.: S-WCA | Total Depth: 40 ft. | Elevation: -------- | Location: See Location Plan

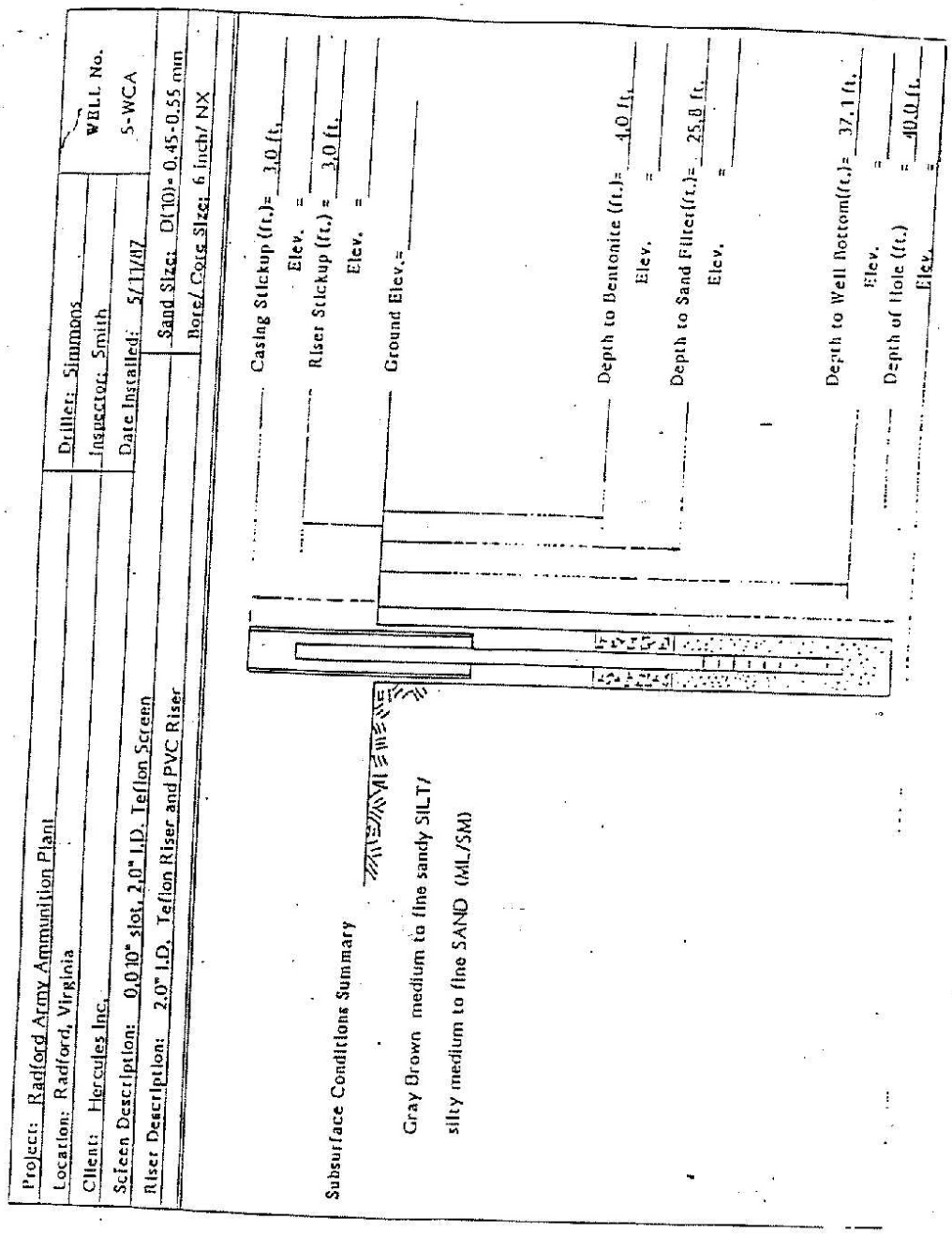
Type of Boring: Hollow Stem Auger | Started: 5/7/87 | Completed: 5/11/87 | Driller: W. Simmons

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	Sample Blows	Sample Depth (Feet)	% Core Recovery	REMARKS
	0.0	Very loose gray brown medium to fine sandy SILT, trace coarse subrounded sand (ML)		1.5		GROUNDWATER DATA
			3_2	3.0		
				4.5		
		Very loose gray braown fine sandy SILT (ML)	2_1	6.0		
		-ALLUVIUM-				
			2_4	8.5		
	11.5			10.0		
				13.5		
		Medium stiff gray to tan clayey SILT, manganese stains (ML)	2_4	15.0		
				18.5		
			2_3	20.0		
		Medium stiff to stiff mottled to gray silty fine SAND (SM) manganese stains		23.5		
			2_6	25.0		
		-grading to-				
		Stiff mottled to gray silty CLAY/clayey SILT (CL/ML)		28.5		
			3_7	30.0		
		-RESIDUUM-				
				33.5		
			3_9	35.0		
				38.5		
	40.0	Boring terminated at 40.0 ft.		40.0		

*No. of blows required for a 140 lb. hammer dropping 30 in. to drive 2 in O.D., 1.375 in I.D. sampler a total of 18 inches in three 6 in. increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N.

*Weight of Hammer

Scale 1"=5' unless otherwise noted


Project: Radford Army Ammunition Plant
Location: Radford, Virginia
Client: Hercules Inc.
Screen Description: 0.010" slot, 2.0" I.D. Teflon Screen
Riser Description: 2.0" I.D. Teflon Riser and PVC Riser
Driller: Simmons
Inspector: Smith
Date Installed: 5/11/87
Sand Size: D(10)= 0.45-0.55 mm
Bore/ Core Size: 6 inch/ NX
WELL No. 5-WCA
Casing Stickup (ft.)= 3.0 ft.
Elev. =
Riser Stickup (ft.) = 3.0 ft.
Elev. =
Ground Elev.=
Depth to Bentonite (ft.)= 4.0 ft.
Elev. =
Depth to Sand Filter(ft.)= 25.8 ft.
Elev. =
Depth to Well Bottom(ft.)= 37.1 ft.
Elev. =
Depth of Hole (ft.) = 40.0 ft.
Elev. =
Subsurface Conditions Summary
Gray Brown medium to fine sandy SILT/
silty medium to fine SAND (ML/SM)

5506
MW-6

Army Pollution Abatement Program Study, Installation of Monitoring Wells, Radford Army Ammunition Plant, Radford, VA, 3-9 April 1981, (USAEHA Control No. 81-26-8251-81)

US ARMY ENVIRONMENTAL HYGIENE AGENCY

DRILLING LOG

PROJECT RAAP 81-26-8251-81
LOCATION Site 6, northwest of lagoon next to building S.R. 1602
DRILL RIG Acker II w/ 4 in continuous flight auger
DATE 5 April 81
DRILLERS Smithson, Hoddinott Craig, Gates (logger)
BORE HOLE MW 5 6

TD= 25.5 ft

DEPTH	SAMPLE TYPE / BLOWS PER 6 IN	DESCRIPTION	Water level initial 9.5 ft 24 hr. 9' 7" REMARKS
		Brown silty clay, damp plastic	7 ft of concrete grout
			13.5 ft of schedule 40, 2 in ID PVC casing
5 ft	MB 5-10	Reddish brown silty clay--slightly damp, tight drilling	4.5 ft of Bentonite (may have a void above sand next to water table)
10 ft		softer drilling, same material, getter wetter	11.5 ft of sand pack
		saturated	
15 ft			screen

HSE-ES Form 78, 1 Jun 80
Replaces USAEHA Form 95, 12 Aug 74, which will be used.

US ARMY ENVIRONMENTAL HYGIENE AGENCY

Army Pollution Abatement Program Study, Installation of Monitoring Wells, Radford Army Ammunition Plant, Radford, VA, 3-9 April 1981, (USAEHA Control No. 81-26-8251-81)

DRILLING LOG

PROJECT RAAP 81-26-8251-81 DATE 5 April 81

LOCATION Site 5, northeast : of lagoon next to building S.R. 1602 DRILLERS Smithson, Hoddinott; Craig, Gates (logger)

DRILL RIG Acker II, w/ 4 in continuous flight Auger BORE HOLE MW 6

DEPTH	SAMPLE TYPE / BLOWS PER 6 IN.	DESCRIPTION	REMARKS	
		Reddish brown silty coarse to medium sand, saturated (water is flowing)	Sand pack	10 ft of slotted schedule 40, 2 in ID PVC screen ((0.008-0.010")
20 ft		Weathered Elbrook FM (red gray clay residuum over dolomite)		2 ft of sediment trap
25 ft		25.5 ft TD		Bottom of well 25.5 ft
30 ft				

USAEHA Form 95, 12 Aug 74

5508

MW-8

Army Pollution Abatement Program Study, Installation of Monitoring Wells, Radford Army Ammunition Plant, Radford, VA, 3-9 April 1981, (USAEHA Control No. 81-26-8251-81)

US ARMY ENVIRONMENTAL HYGIENE AGENCY

DRILLING LOG

PROJECT RAAP 81-26-8251-81 DATE 5 April 81

LOCATION Site 5, Background well, south of lagoon DRILLERS Smithson Haddinott, Craig, Gates (logger)

DRILL RIG Acker II, w/ 4 in continuous flight Auger BORE HOLE MW 8 TD= 34ft

DEPTH	SAMPLE TYPE / BLOWS PER 6 IN.	DESCRIPTION	water level initial=24 ft 24 hr.=14'11" REMARKS	
		gravel fill for road		
		Reddish brown sandy clay with some small gravels	8 ft of concrete grout	29 ft of schedule 40, 2 in ID PVC casing
5 ft				
		same material, wet, med plastic	5 ft of Bentonite	
10 ft				
		same material, getting wetter & sticky		
15 ft			sand pack	

HSE-ES Form 78, 1 Jun 80

Replaces USAEHA Form 95, 12 Aug 74, which will be used.

Army Pollution Abatement Program Study, Installation of Monitoring Wells, Radford Army Ammunition Plant, Radford, VA, 3-9 April 1981, (USAEHA Control No. 81-26-8251-81)

US ARMY ENVIRONMENTAL HYGIENE AGENCY

DRILLING LOG

PROJECT RAAP 81-26-8251-81 DATE 5 April 81

LOCATION Site 5, background south of lagoon DRILLERS Smithson, Hoddinott Craig, Gates (logger)

DRILL RIG Acker II, w/ 4 in continuous flight Auger BORE HOLE MW 8

DEPTH	SAMPLE TYPE / BLOWS PER 6 IN	DESCRIPTION	REMARKS
	MB 15-20	same material	21 ft of sandpack
20 ft			PVC casing
		same material	
25 ft			
30 ft			

HSE-ES Form 78, 1 Jun 80

Replaces USAEHA Form 95, 12 Aug 74, which will be used.

Army Pollution Abatement Program Study, Installation of MOnitoring Wells, Radford Army Ammunition Plant, Radford, VA, 3-9 April 1981, (USAEHA Control No. 81-26-8251-81)

US ARMY ENVIRONMENTAL HYGIENE AGENCY

DRILLING LOG

PROJECT RAAP 81-26-8251-81 DATE 5 Apr 81

LOCATION Site 5, background south of lagoon DRILLERS Smithson, Hoddinott Craig, Gates (logger)

DRILL RIG Acker II. w/ 4 in continuous flight Auger BORE HOLE MW 8

DEPTH	SAMPLE TYPE / BLOWS PER 6 IN	DESCRIPTION	REMARKS
		same material	5 ft of slotted schedule 40, 2 in ID PVC screen
35 ft		Refusal Elbrook FM Note: ran short of screen, therefore, 5 ft of screen was installed in the saturated zone instead of 10 feet.	bottom of well 34 ft.
40 ft			

HSE-ES Form 78, 1 Jun 80
Replaces USAEHA Form 95, 12 Aug 74, which will be used.

HWMU 5\S-WC1-1

BORING LOG

FROEHLING & ROBERTSON, INC.
FULL SERVICE LABORATORIES • ENGINEERING • CHEMICA
"ONE HUNDRED YEARS OF SERVICE"

Report No. C-62084 DATE May 1987
Client: Hercules Inc.
Project: Radford Army Ammunition Plant Radford, Virginia
Boring No. S-WC1-1 Total Depth: 53.5 ft. Elevation: -------- Location: See Location Plan
Type of Boring: Hollow Stem Auger Started: 5/5/87 Completed: 5/5/87 Driller: W. Simmons

Elevation	Depth (40.0)	DESCRIPTION OF MATERIALS (Classification)	Sample Symbol	Sample Depth (Feet)	% Core Recovery	REMARKS
		S-WC1-1 continued		45.0		GROUNDWATER DATA
				43.5		RQD = 23
				35.7		RQD = 7
				48.5		
				61.7		RQD = 0
	53.5	Boring terminated at 53.5 ft.		53.5		

*No. of blows required for a 140 lb. hammer dropping 30 in. to drive 2 in O.D., 1.375 in. I.D. sampler a total of 18 inches in three 6 in. increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N.

Scale 1"=5' unless otherwise noted

Form No. 500

BORING LOG

FROEHLING & ROBERTSON, INC.
FULL SERVICE LABORATORIES • ENGINEERING/CHEMIC
"ONE HUNDRED YEARS OF SERVICE"

Report No. GT-62084

DATE May 1987

Client: Hercules Inc.

Project: Radford Army Ammunition Plant — Radford, Virginia

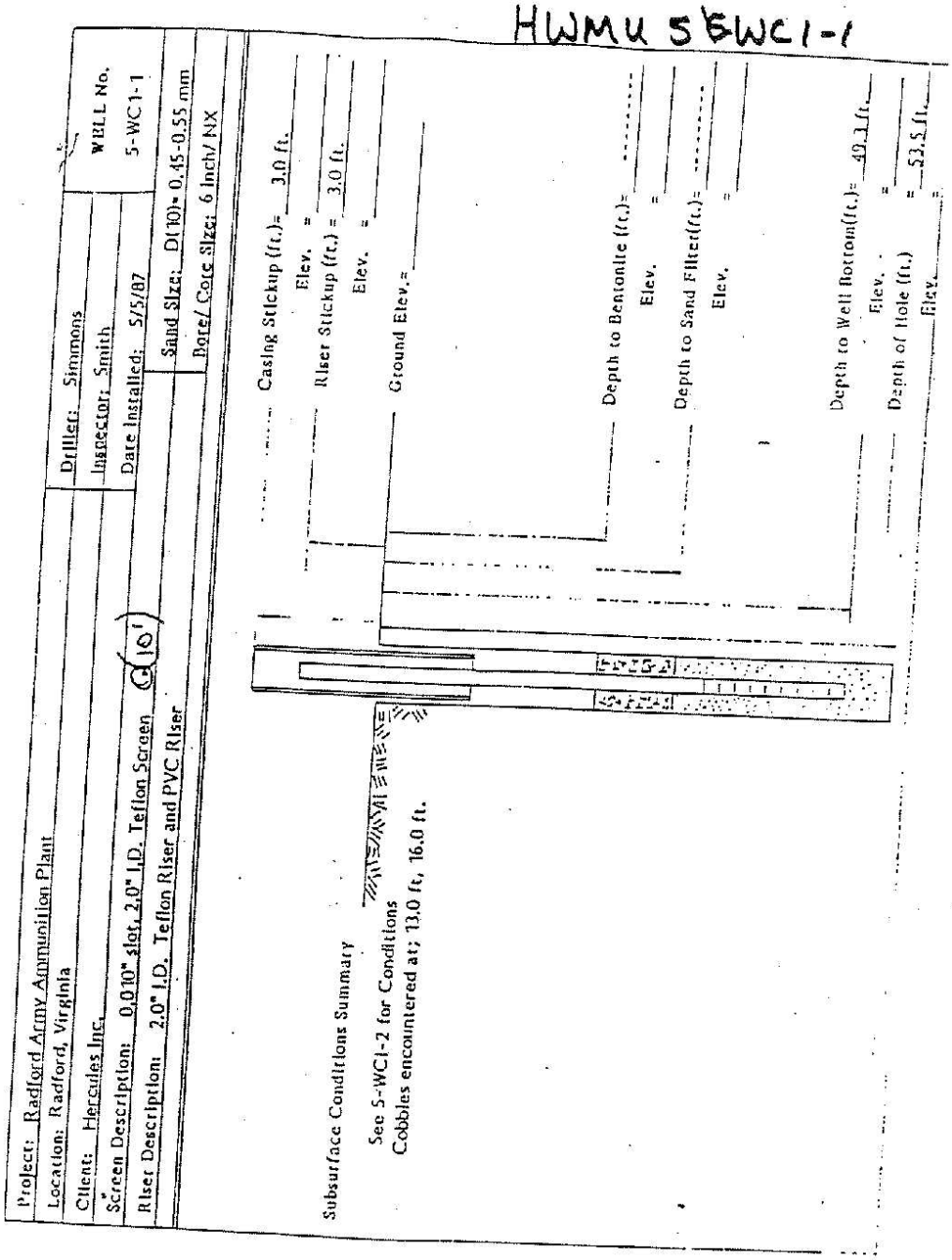
Boring No.: S-WC1-1 | Total Depth: 53.5 ft. | Elevation: -------- | Location: See Location Plan

Type of Boring: Hollow Stem Auger | Started: 5/5/87 | Completed: 5/5/87 | Driller: W. Simmons

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	Sample Blows	Sample Depth (Feet)	% Core Recovery	REMARKS
	0.0	No sampling conducted, see S-WC1-2 for subsurface conditions				GROUNDWATER DATA
		Cobbles encountered at 13.0 ft. and 17.0 ft.				
	33.5	Auger refusal at 33.5 ft.		33.5		
		Hard light gray dolomite, fractured and vuggy abundant calcareous infill, occasional shale infill; dolomite clasts in calcareous matrix: Probable slump structure		21 7	RQD = 0	
				38.5		

The # of blows recd. for a 140 lb. hammer dropping 30 in. to drive 2 in O.D., 1.375 in. I.D. sampler a total of 18 inches in three 6 in. increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N.

Scale 1" = 5' unless otherwise noted


HWMU 5 GWC1-1
Project: Radford Army Ammunition Plant
Location: Radford, Virginia
Client: Hercules Inc.
Screen Description: 0.010" slot, 2.0" I.D. Teflon Screen @ 10'
Riser Description: 2.0" I.D. Teflon Riser and PVC Riser
Driller: Simmons
Inspector: Smith
Date Installed: 5/5/87
Sand Size: D(10)= 0.45-0.55 mm
Bore/ Core Size: 6 Inch/ NX
WELL No. 5-WC1-1
Casing Stickup (ft.)= 3.0 ft.
Elev. =
Riser Stickup (ft.) = 3.0 ft.
Elev. =
Ground Elev.=
Depth to Bentonite (ft.)=
Elev. =
Depth to Sand Filter(ft.)=
Elev. =
Depth to Well Bottom(ft.)= 49.1 ft.
Elev. =
Depth of Hole (ft.) = 53.5 ft.
Elev. =
Subsurface Conditions Summary
See 5-WC1-2 for Conditions
Cobbles encountered at; 13.0 ft, 16.0 ft.

HWMU 5\ 5-WC1-2

BORING LOG

FROEHLING & ROBERTSON, INC.
FULL SERVICE LABORATORIES • ENGINEERING • CHEMICA
"ONE HUNDRED YEARS OF SERVICE"

Report No. 0-62084 DATE May 1987

Client: Hercules Inc.

Project: Radford Army Ammunition Plant Radford, Virginia

Boring No.: S-WC1-2 | Total Depth: 76.8 ft. | Elevation: -------- | Location: See Location Plan

Type of Boring: Hollow Stem Auger | Started: 5/1/87 | Completed: 5/1/87 | Driller: M. Simmons

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	Sample No. / Blows	Sample Depth (Feet)	% Core Recovery	REMARKS
	0.0	Very loose yellow brown silty medium to fine SAND (SM)				GROUNDWATER DATA
		-to-	1 1	4.5		
		Loose tan to red brown clayey medium to fine SAND, trace rounded coarse sand (SC)		6.0		
			2 2 7	8.5		
		-ALLUVIUM-		10.0		
			11 13 16	13.5		
	16.5			15.0		
		Loose orange brown medium to fine sandy SILT, trace angular coarse sand (rock fragments), manganese stains (ML)	6 7 3	18.5		
		-to-		20.0		
		Medium stiff orange brown clayey SILT, little medium to fine sand (rock fragments) (ML/MH)	2 1 3	23.5		
				25.0		
		-RESIDUUM-	15 4	28.5		
				30.0		
				33.5		
			1 1 2	35.0		Subsurface water at 34.5 ft. depth at 11:30 a.m. on May 1, 1987
	39.3	Auger refusal at 39.3 ft.		39.3		

*No. of blows req'd for a 140 lb. hammer dropping 30 in. to drive 2 in O.D., 1.375 in. I.D. sampler a total of 18 inches in three 6 in. increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N.

Scale 1"=5' unless otherwise noted

BORING LOG

FROEHLING & ROBERTSON, INC.
FULL SERVICE LABORATORIES • ENGINEERING • CHEMICAL
"ONE HUNDRED YEARS OF SERVICE"

Report No. Cs-62084 DATE May 1987

Client: Hercules Inc.

Project: Radford Army Ammunition Plant Radford, Virginia

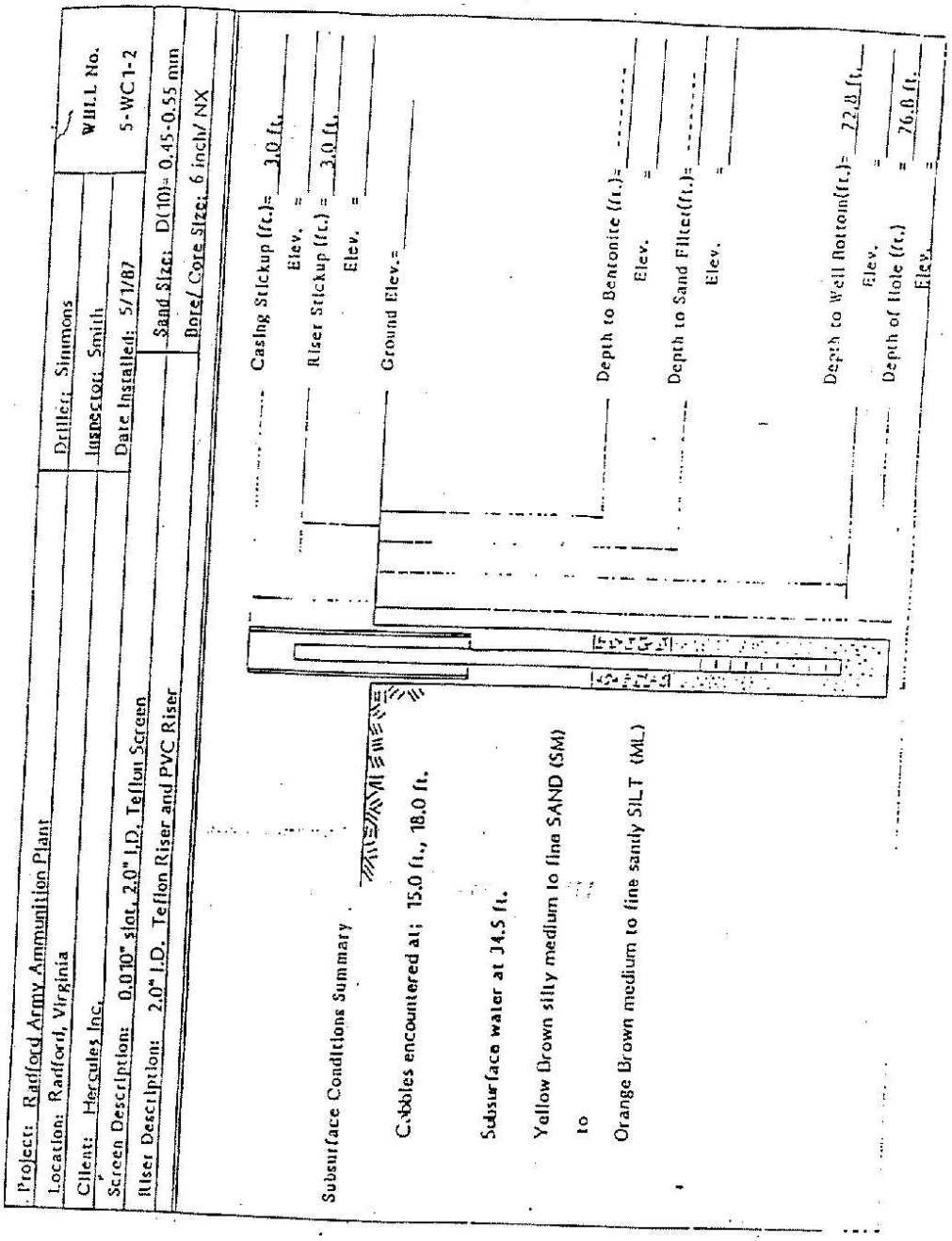
Boring No.: S-WC1-2 | Total Depth: 76.8 ft. | Elevation: -------- | Location: See Location Plan

Type of Boring: Hollow Stem Auger | Started: 5/1/87 | Completed: 5/1/87 | Driller: W. Simons

Elevation	Depth (Ft.)	DESCRIPTION OF MATERIALS (Classification)	Sample Blows	Sample Depth (Feet)	% Core Recovery	REMARKS
		Hard light gray dolomite, vuggy, fractured, with calcareous infilling, some with moderately developed crystals, occasional shale infill; occasional dolomite clasts in a calcareous matrix: probable flow structure		35.8		GROUNDWATER DATA
				44.3	RQD = 0	
				46.7	RQD = 7	
				49.3		
				34.9	RQD = 0	
				54.8		
				33.3	RQD = 0	
				59.8		
				25.8	RQD = 0	
				64.8		
				19.2	RQD = 0	
				69.8		
				88.3	RQD = 10	
				74.8		
	76.8			33.3	RQD = 0	
		Boring terminated at 76.8 ft.		75.8		

*No. of blows required for a 140 lb. hammer dropping 30 in. to drive 2 in O.D., 1.375 in. I.D. sampler a total of 18 inches in three 6 in. increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N.

Scale 1"=5' unless otherwise noted


Project: Radford Army Ammunition Plant
Location: Radford, Virginia
Client: Hercules Inc.
Screen Description: 0.010" slot, 2.0" I.D. Teflon Screen
Riser Description: 2.0" I.D. Teflon Riser and PVC Riser
Driller: Simmons
Inspector: Smith
Date Installed: 5/1/87
Sand Size: D(10)= 0.45-0.55 mm
Bore/ Core Size: 6 inch/ NX
WELL No.
5-WC1-2
Casing Stickup (ft.)= 3.0 ft.
Elev. =
Riser Stickup (ft.) = 3.0 ft.
Elev. =
Ground Elev.=
Depth to Bentonite (ft.)= ---
Elev. =
Depth to Sand Filter(ft.)= ---
Elev. =
Depth to Well Bottom(ft.)= 22.8 ft.
Elev. =
Depth of Hole (ft.) = 26.0 ft.
Elev. =
Subsurface Conditions Summary
Cobbles encountered at; 15.0 ft., 18.0 ft.
Subsurface water at 14.5 ft.
Yellow Brown silty medium to fine SAND (SM)
to
Orange Brown medium to fine sandy SILT (ML)

V.G-B. HWMU-16 BORING LOGS AND WELL CONSTRUCTION DIAGRAMS

Site 16
Ground Water Monitoring Well Construction Details

Well I.D.	Ground Elevation	UTM Coordinates		Boring Termination Depth	Top of Well Screen	Total Well Depth	Screen Length	Comments
		Northing	Easting					
16C-1	1836.78	3,601,325	10,892,905	70	55	70	15	1
16MW8	1815.82	3,601,520	10,893,440	76	66	76	10	1
16MW9	1808.88	3,601,480	10,893,420	79	69	79	10	1
16WC1B	1812.95	3,601,380	10,893,440	79.3	62	73	11	1
16WC1A	1812.61	3,601,380	10,893,440	100	82.5	93.5	11	1
16-1	1813.88	3,601,720	10,893,340	60	30	60	30	1
16-2	1808.78	3,601,560	10,893,560	77	52	77	25	1
16-3	1823.63	3,601,150	10,893,525	89.5	69.5	89.5	20	1
16-5	1739.50	3,601,830	10,894,020	50.71	35.71	50.71	15	4,6
16WC2B	1818.71	3,601,570	10,893,370	104	91	102.5	11.5	1
SPRING								

Comments:
1) Well construction details obtained from boring log.
2) Well screen length obtained from boring log.
3) Well screen length obtained from other data on file.
4) Well screen length assumed.
5) Total well depth obtained from boring log.
6) Total well depth obtained from field sampling log.

16WC2A
16C3
16CDH3

Attachment P

BORING LOGS AND WELL CONSTRUCTION DIAGRAMS

Appendix 1.	General Information
Appendix 2.	Well 16C1 - Background
Appendix 3.	Well 16MW8 - POC
Appendix 4.	Well 16MW9 – POC
Appendix 5.	Well 16WC1A – POC
Appendix 6.	Well 16WC1B – POC
Appendix 7.	Well 16-1 – Compliance Monitoring Well
Appendix 8.	Well 16-2 – Compliance Monitoring Well
Appendix 9.	Well 16-3 – Compliance Monitoring Well
Appendix 10.	Well 16-5 – Compliance Monitoring Well
Appendix 11.	Well 16WC2B – Compliance Monitoring Well
Appendix 12.	Well 16SPRING - Additional Sampling Point
Appendix 13.	Well 16WC2A – Piezometer
Appendix 14.	Well 16C3 – Piezometer
Appendix 15.	Well 16CDH3 - Piezometer
Appendix 16.	Other Wells

Appendix 1.

General Information

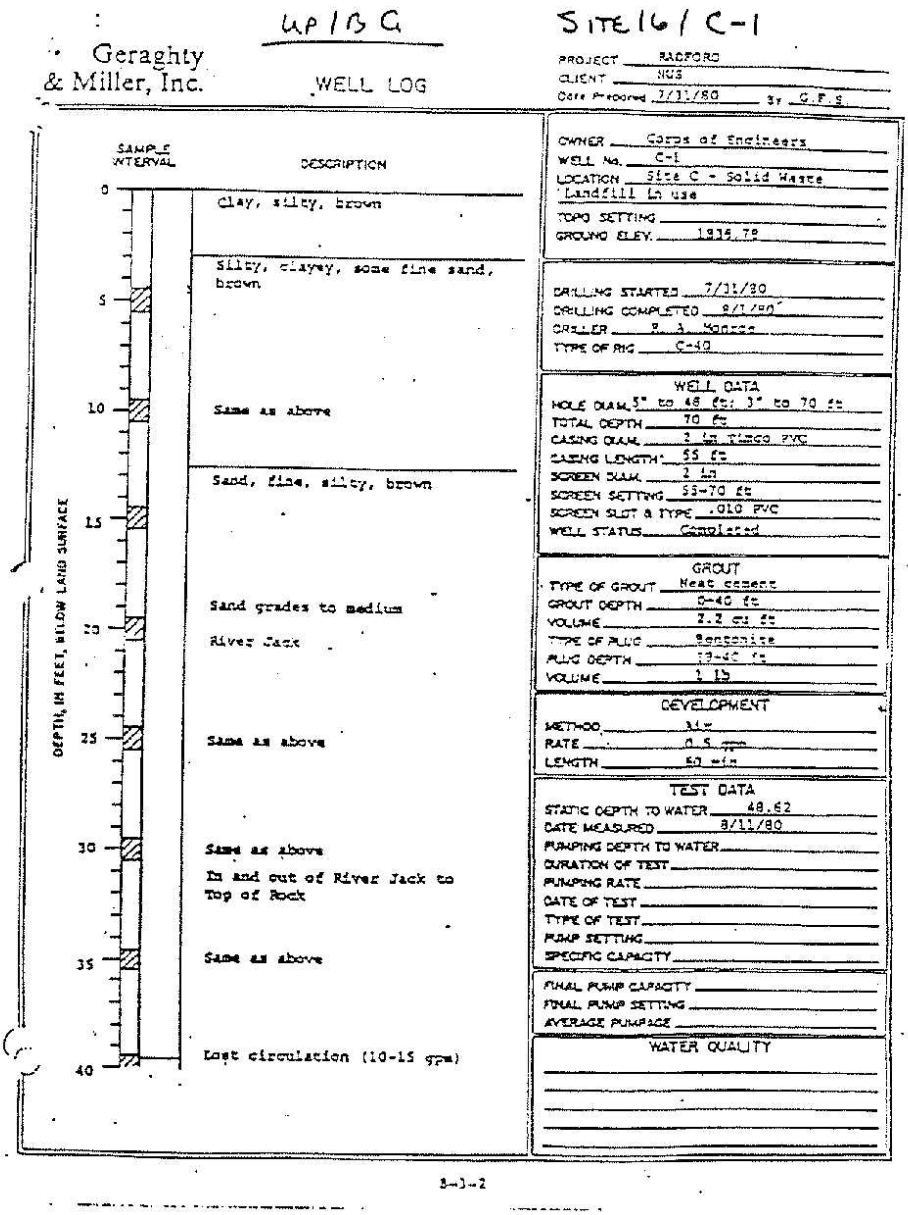
TABLE 3 - GROUND WATER MONITORING SYSTEM SUMMARY TABLE FOR HWMU 16

WELLS	TYPE	STATUS	TD	DATE DRILLED	BORING LOG	COMPLETE DIAGRAM	DATUM S.L.	T.O.C.	SCREEN LENGTH	SCREEN SIZE	SCREEN SLOT	SCREEN TYPE	SCREEN TOP	SCREEN BASE	GROUT TOP	GROUT BASE	ANNULAR SEALANT TOP	ANNULAR SEALANT BASE	FILTER PACK TOP	FILTER PACK BASE	Hydraulic conductivity K (ft/sec)	Hydraulic conductivity K (cm/sec)
C-1	UP/SG	ACTIVE	70.00	08/01/80	YES	YES	1838.78	1840.10	15.00	2.00	0.01	PVC	55.00	70.00	0.00	39.00	39.00	40.00	40.00	78.00		
MW-8	POC	ACTIVE	78.00	01/17/86	YES	YES			18.00	2.00	#10	TEFLON	58.00	76.00	0.00	54.00	54.00	56.00	56.00	79.00		
MW-9	POC	ACTIVE	78.00	08/22/88	YES	YES			10.00	2.00	#10	TEFLON	63.00	73.00	0.00	61.00	61.00	64.00	64.00	79.00		
WC-18	POC	ACTIVE	79.30	10/06/87	YES	YES	1812.04	1813.63	10.00	2.00	0.01	TEFLON	63.00	73.00	0.00	61.00	61.00	64.00	64.00	79.00	3.12E-04	8.51E-03
18-1	ASMT	ACTIVE	80.00	10/26/94	YES	YES	1813.84		30.00				30.00	80.00	0.00	57.00	57.00	62.00	62.00	79.30		
18-2	ASMT	ACTIVE	72.00	10/25/94	YES	YES	1806.78		25.00				47.00	72.00								
18-3	ASMT	ACTIVE	80.50	10/20/94	YES	YES	1823.83		20.00				60.00	80.00								
18-4	ASMT	ACTIVE	64.50	10/21/94	YES	YES	1736.50		20.00			SS										
C-3	ASMT	ACTIVE	70.00	07/28/80	YES	YES	1819.22	1822.16	15.00	2.00	0.01	PVC80	55.00	70.00	0.00	39.00	39.00	40.00				
COH-3	ASMT	ACTIVE	68.80	07/24/80	YES	YES			15.00	2.00		PVC	61.80	66.80								
WC-1A	ASMT	ACTIVE	83.50	10/05/87	YES	YES	1811.42	1813.41	15.00	2.00	0.01	TEFLON	63.50	83.50	0.00	77.50	77.50	82.50	82.50	100.00	9.14E-06	2.79E-04
WC-3A	ASMT	ACTIVE	80.50	10/31/87	YES	YES	1817.36	1818.97	10.00	2.00	0.01	TEFLON	59.50	69.50	0.00	53.00	53.00	58.00	58.00	82.00	5.02E-06	1.53E-04
WC-2B	ASMT	ACTIVE	102.50	10/19/87	YES	YES	1817.83	1819.84	10.00	2.00	0.01	TEFLON	92.50	102.50	0.00	86.00	86.00	91.00	91.00	104.00	3.37E-07	1.03E-05
SPRING	ASMT																					
16-4	UP	SWL	80.00	11/02/94	YES	YES	1836.03		35.00				45.00	80.00								
C-4	UP	SWL	70.00	07/28/80	YES	YES	1824.61	1827.71	15.00	2.00	0.01	PVC	55.00	70.00	0.00	39.00	39.00	40.00				
COH-2	UP	SWL	70.50	07/23/80	YES	YES	1824.10	1827.71	20.00	2.00			41.20	61.20	0.00	34.20	34.20	36.00	36.00	51.20		
DH-1	UP	INACTIV	73.00	07/19/80	YES	YES	~1840	~1843.6	10.00	1.50	NS	PVC	62.00	72.00	0.00	48.00	48.00	50.00	50.00	72.00		
DH-1A	COREH	INACTIV	84.00		YES	YES	~1840															
C-2		ABND	70.00	07/30/80	YES	YES	1805.20	1804.18	15.00	2.00	0.01	PVC	55.00	70.00	0.00	39.00	39.00	40.00				

03/14/95

Appendix 2.

Well 16C1 (Background)



UP/BG

SITE 16 / C-1

Geraghty & Miller, Inc.

WELL LOG

PROJECT RADFORD
CLIENT NUS
Date Prepared 7/11/80 By G.F.S

SAMPLE INTERVAL	DESCRIPTION
0	Clay, silty, brown
5	Silty, clayey, some fine sand, brown
10	Same as above
15	Sand, fine, silty, brown
20	Sand grades to medium River Jack
25	Same as above
30	Same as above In and out of River Jack to Top of Rock
35	Same as above
40	Lost circulation (10-15 gpm)

DEPTH, IN FEET, BELOW LAND SURFACE

OWNER Corps of Engineers
WELL No. C-1
LOCATION Site C - Solid Waste Landfill in use
TOPO SETTING
GROUND ELEV. 1815.79

DRILLING STARTED 7/11/80
DRILLING COMPLETED 8/1/80
DRILLER R. J. Monroe
TYPE OF RIG C-40

WELL DATA
HOLE DIAM. 5" to 46 ft; 3" to 70 ft
TOTAL DEPTH 70 ft
CASING DIAM. 3 in Timco PVC
CASING LENGTH 55 ft
SCREEN DIAM. 2 in
SCREEN SETTING 55-70 ft
SCREEN SLOT & TYPE .010 PVC
WELL STATUS Completed

GROUT
TYPE OF GROUT Neat cement
GROUT DEPTH 0-40 ft
VOLUME 2.2 cu ft
TYPE OF PLUG Bentonite
PLUG DEPTH 39-40 ft
VOLUME 1 lb

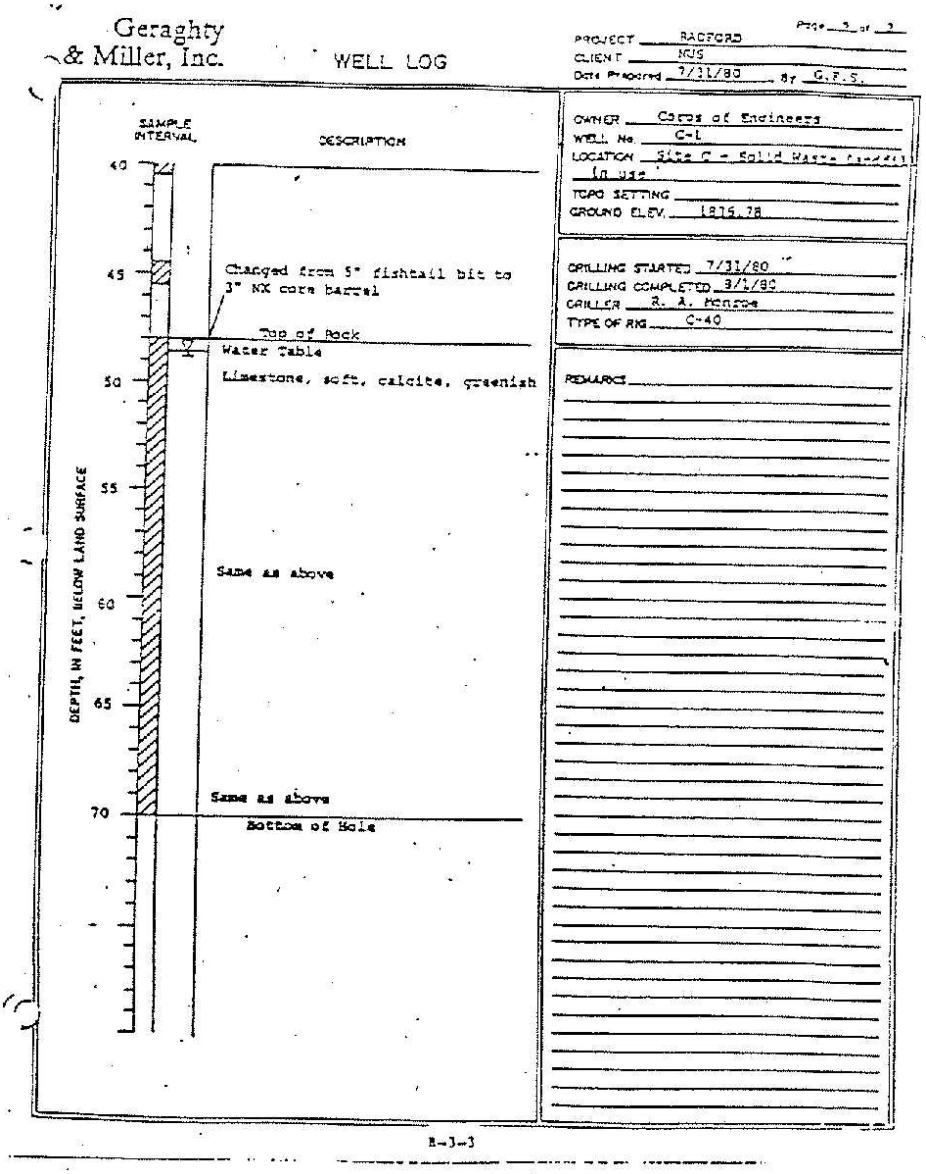
DEVELOPMENT
METHOD Air
RATE 0.5 gpm
LENGTH 60 min

TEST DATA
STATIC DEPTH TO WATER 48.62
DATE MEASURED 8/11/80
PUMPING DEPTH TO WATER
DURATION OF TEST
PUMPING RATE
DATE OF TEST
TYPE OF TEST
PUMP SETTING
SPECIFIC CAPACITY

FINAL PUMP CAPACITY
FINAL PUMP SETTING
AVERAGE PUMPAGE

WATER QUALITY

3-1-2



Geraghty & Miller, Inc.

WELL LOG

PROJECT RADFORD
CLIENT NUS
Date Produced 7/31/80 By G.F.S.

OWNER Corps of Engineers
WELL No C-1
LOCATION Site C - Solid Waste Landfill
In use
TOPO SETTING
GROUND ELEV. 1816.78

DRILLING STARTED 7/31/80
DRILLING COMPLETED 8/1/80
DRILLER R. A. Monroe
TYPE OF RIG C-40

REMARKS

SAMPLE INTERVAL

DESCRIPTION

DEPTH, IN FEET, BELOW LAND SURFACE

40
45
50
55
60
65
70

Changed from 5" fishtail bit to 3" NX core barrel

Top of Rock

Water Table

Limestone, soft, calcite, greenish

Same as above

Same as above

Bottom of Hole

B-3-3

Appendix 3.

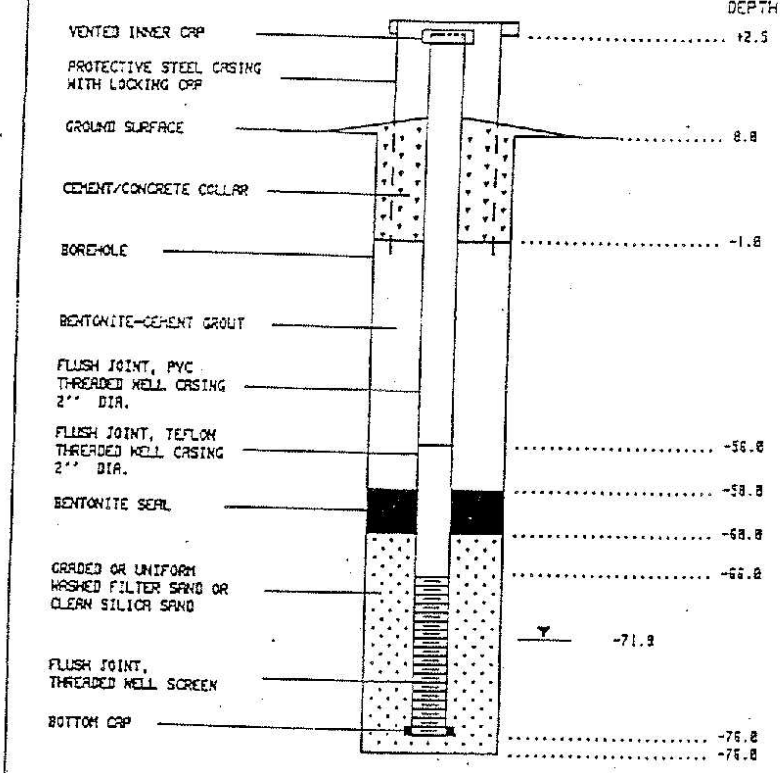
Well 16MW8 (Point of Compliance)

RAAP / Site 16 / MW-8

WELL CONSTRUCTION DETAILS FOR MW-8 Poc

BORING NUMBER: MW-8
WELL TYPE: 2 in, Sch.40 PVC, Flush Joint
SCREEN TYPE: 2 in, No.10 Slot Teflon
CASING TYPE: 4 in, Sch.80 Steel
DEVELOPMENT: Air Pressure/Surge

Contract No. V88I377
Date Water Level Obtained: 1-24-89



NOT TO SCALE

SCHNABEL ENGINEERING

SCHNABEL ENGINEERING ASSOCIATES
CONSULTING ENGINEERS

TEST BORING LOG

BORING NO: MW-8

PROJECT: MONITORING WELL INSTALLATION (MW-15) RAAP, RADFORD, VA
CLIENT: HERCULES, INCORPORATED
BORING CONTRACTOR: TERROCK CORPORATION
DRILL: CME-55
SHEET NO: 1 OF 2
JOB NO: V88137
ELEVATION:

WATER LEVEL DATA	DATE	TIME	DEPTH	CAVED
ENCOUNTERED	1-16	2:30	40.0	-
AFTER CASING PULLED	1-17	10:15	68.0	-
HR. READING	MONITORING WELL INSTALLED			

DRIVE SAMPLER	
TYPE	S.S.
DIA.	2" O.D.
WT.	140#
FALL	30"

CASING SIZE: 3-1/4"
DATE START: 1-16-89
DATE FINISHED: 1-17-89
DRILLER: R. EDWARDS
INSPECTOR: C. HALL

STRATUM	DEPTH FT.	ELEV.	BLOWS ON SAMPLE SPOON PER 6"	SYMBOL	IDENTIFICATION	REMARKS POC
A	1.0			S	FINE TO COARSE SILTY SAND FILL, WET - BROWN	FILL
A2					REFUSE, CONTAINS SANDY LEAN CLAY, PLASTIC, PAPER AND CINDERS, MOIST - BLACK AND BROWN	REFUSE
			7+11+14	S	do, PERCHED WATER AT 5 FT	
	7.0					
A1			3+4+5	S	FINE TO MEDIUM SANDY LEAN CLAY PROBABLE FILL, MOIST - BROWN	PROBABLE FILL
			4+3+4	S		
	19.0					
			5+5+5	S	FINE TO MEDIUM SANDY LEAN CLAY (CL), MOIST - BROWN AND GRAY	ALLUVIAL
			8+7+9	S		
	27.0					
B			6+8+10	S	FINE TO MEDIUM CLAYEY SAND (SC), CONTAINS IRON OXIDE, MOIST - BROWN AND BLACK	
			3+4+7	S	do, BROWN	
			3+4+5	S	do, WET	
			3+3+4	S		
			4+4+5	S		

SCHNABEL ENGINEERING ASSOCIATES
CONSULTING ENGINEERS

TEST BORING LOG

BORING NO: MW-8

PROJECT: MONITORING WELL INSTALLATION, HWM-16, RAAP, RADFORD, VA
CLIENT: HERCULES, INCORPORATED
BORING CONTRACTOR: TERROCK CORPORATION
DRILL: CME-55

SHEET NO: 2 OF 2
JOB NO: V891377
ELEVATION:
CASING SIZE: 3-1/4"
DATE START: 1-16-89
DATE FINISHED: 1-17-89
DRILLER: R. EDWARDS
INSPECTOR: C. HALL

WATER LEVEL DATA	DATE	TIME	DEPTH	CAVED
ENCOUNTERED	1-16	-	-	-
AFTER CASING PULLED	1-17	-	-	-
___ HR. READING	MONITORING WELL INSTALLED			

DRIVE SAMPLER	
TYPE	S.S.
DIA.	2" O.D.
WT.	140#
FALL	30

STRATUM	DEPTH FT.	ELEV.	BLOWS ON SAMPLE SPOON, PER 6"	SYMBOL	IDENTIFICATION	REMARKS
					FINE TO MEDIUM CLAYEY SAND (SC), MOIST - BROWN	
			2+2+2	S	do, BROWN AND BLACK	
B			4+6+8	S		ALLUVIAL
			3+3+3	S	do, TRACE GRAVEL	
			WOR+3+3	S	do, WET	
	72.0					
C					FINE TO MEDIUM CLAYEY SAND (SC), CONTAINS ROCK FRAGMENTS, WET - BROWN	LIMESTONE RESIDUUM
	76.0		WOH/24"	S		
					BORING TERMINATED AT 76.0 FT	

Appendix 4.

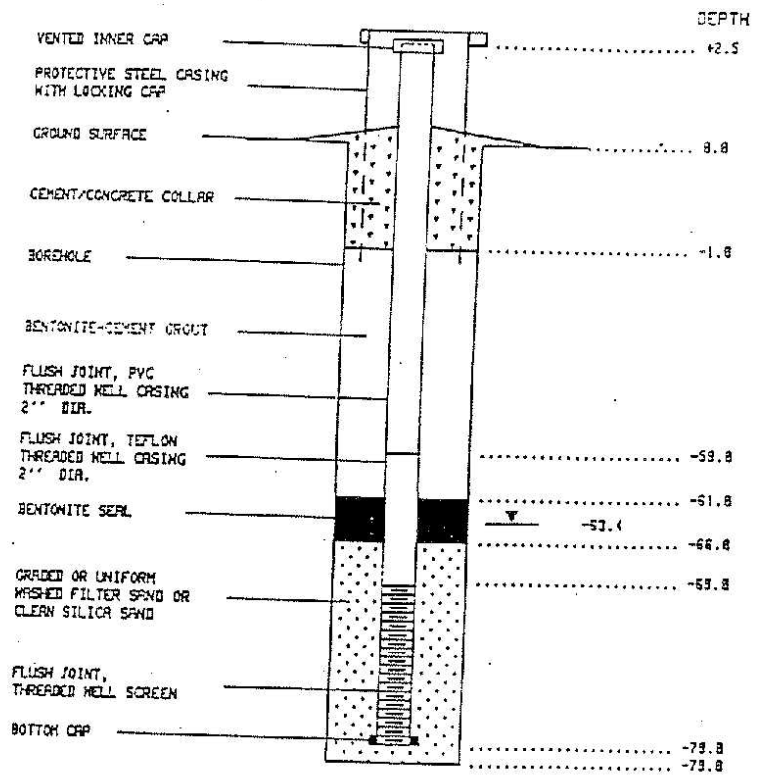
Well 16MW9 (Point of Compliance)

RAAP / SITE 16

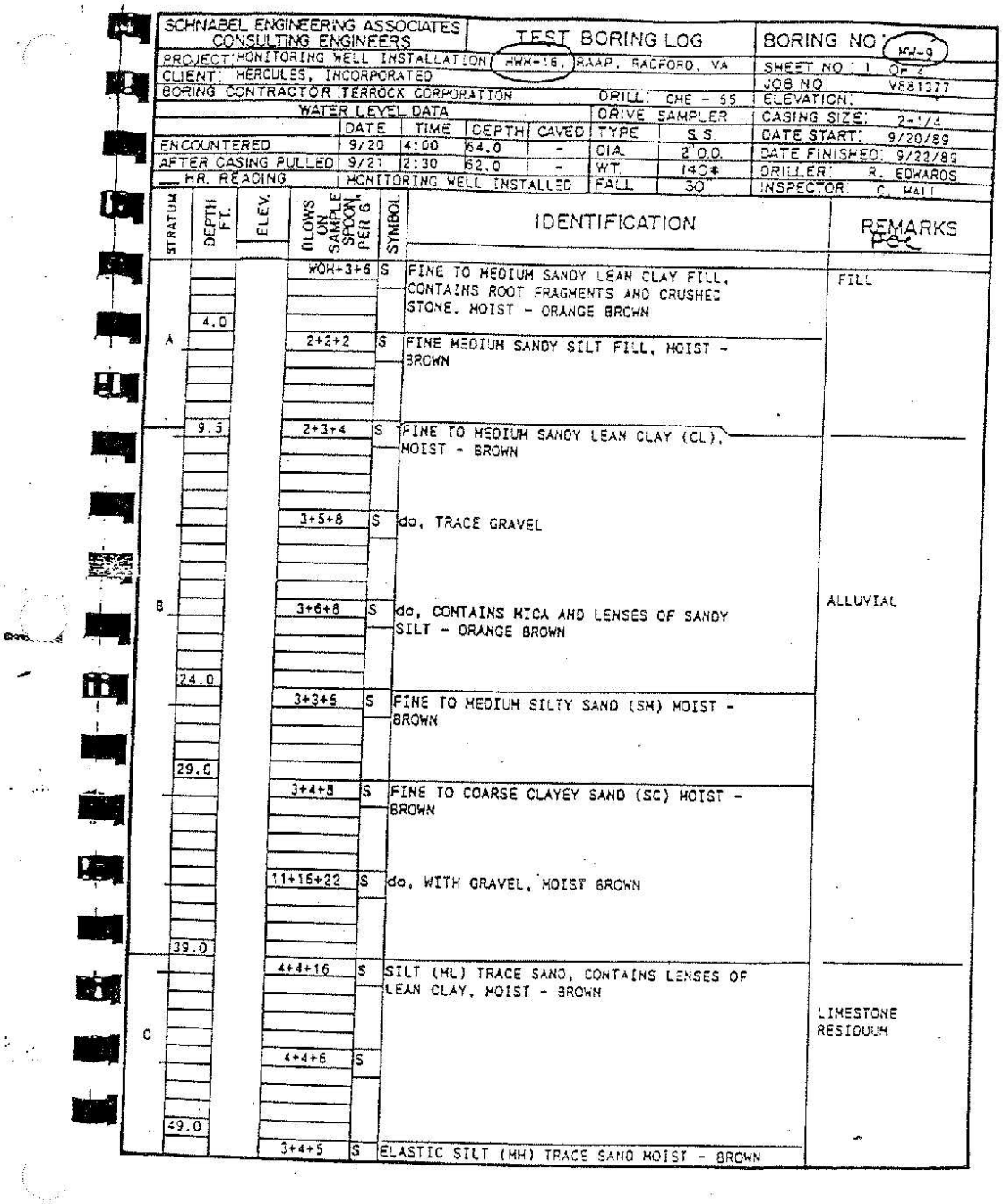
WELL CONSTRUCTION DETAILS FOR MW-9 / POC

BORING NUMBER: MW-9
WELL TYPE: 2 in, Sch.40 PVC, Flush Joint
SCREEN TYPE: 2 in, No.10 Slot Teflon
CASING TYPE: 4 in, Sch.80 Steel
DEVELOPMENT: Air Pressure/Surge

Contract No. V891377
Date Water Level Obtained: 9-25-89



SCHNABEL ENGINEERING



SCHNABEL ENGINEERING ASSOCIATES
CONSULTING ENGINEERS

TEST BORING LOG

BORING NO. MW-9

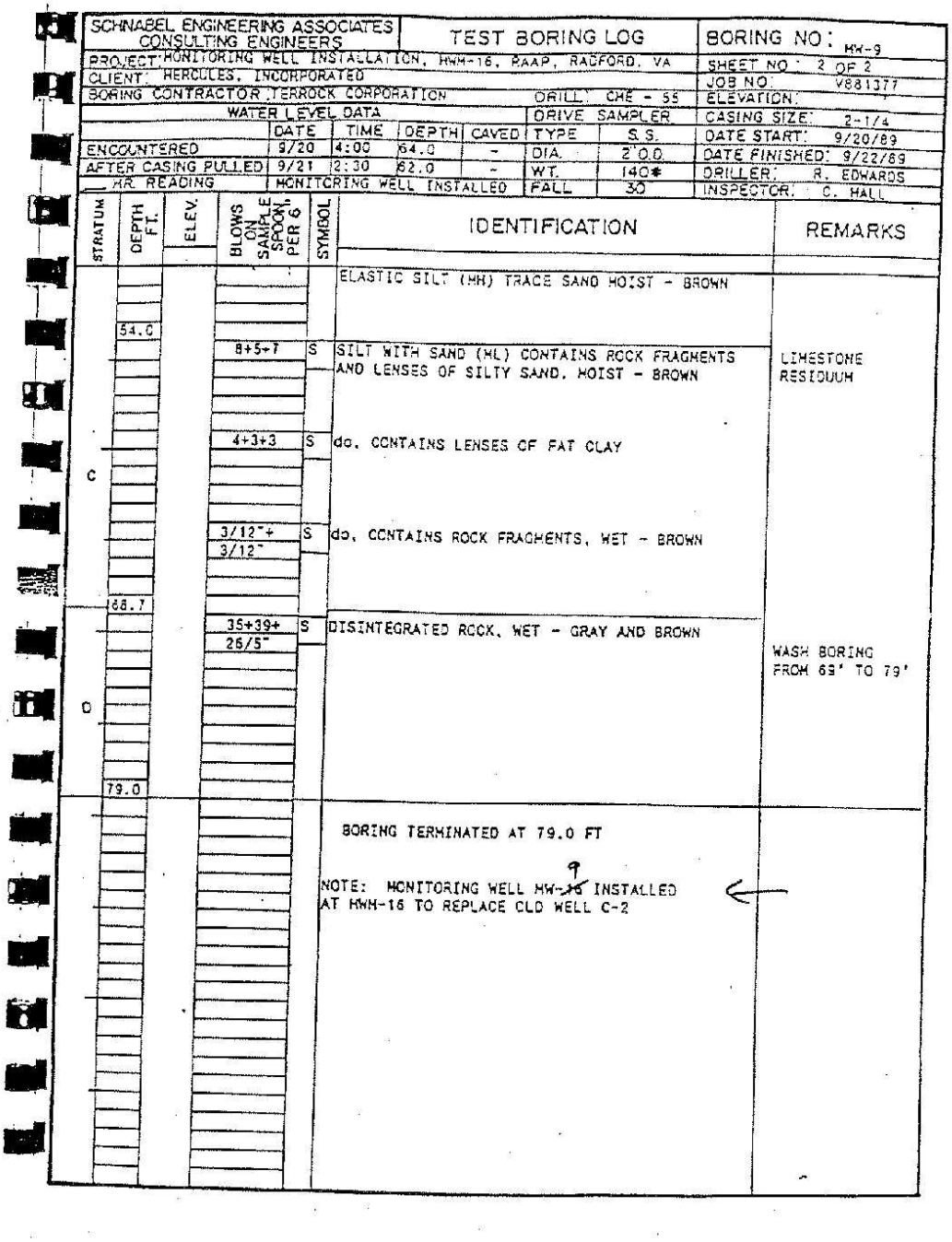
PROJECT: MONITORING WELL INSTALLATION (MW-16), RAAP, RADFORD, VA
CLIENT: HERCULES, INCORPORATED
BORING CONTRACTOR: TERROCK CORPORATION
DRILL: CME - 55
SHEET NO. 1 OF 2
JOB NO. V881377
ELEVATION:

WATER LEVEL DATA

	DATE	TIME	DEPTH	CAVED
ENCOUNTERED	9/20	4:00	64.0	-
AFTER CASING PULLED	9/21	2:30	62.0	-
__ HR. READING	MONITORING WELL INSTALLED			

DRIVE SAMPLER: TYPE S.S. | DIA. 2" O.D. | WT. 140# | FALL 30
CASING SIZE: 2-1/4
DATE START: 9/20/89
DATE FINISHED: 9/22/89
DRILLER: R. EDWARDS
INSPECTOR: C. HALL

STRATUM	DEPTH FT.	ELEV.	BLOWS ON SAMPLE SPOON PER 6"	SYMBOL	IDENTIFICATION	REMARKS
			WOH+3+6	S	FINE TO MEDIUM SANDY LEAN CLAY FILL, CONTAINS ROOT FRAGMENTS AND CRUSHED STONE. MOIST - ORANGE BROWN	FILL
	4.0					
A			2+2+2	S	FINE MEDIUM SANDY SILT FILL, MOIST - BROWN	
	9.5		2+3+4	S	FINE TO MEDIUM SANDY LEAN CLAY (CL), MOIST - BROWN	
			3+5+8	S	do, TRACE GRAVEL	
B			3+6+8	S	do, CONTAINS MICA AND LENSES OF SANDY SILT - ORANGE BROWN	ALLUVIAL
	24.0		3+3+5	S	FINE TO MEDIUM SILTY SAND (SM) MOIST - BROWN	
	29.0		3+4+8	S	FINE TO COARSE CLAYEY SAND (SC) MOIST - BROWN	
			11+16+22	S	do, WITH GRAVEL, MOIST BROWN	
	39.0		4+4+16	S	SILT (ML) TRACE SAND, CONTAINS LENSES OF LEAN CLAY, MOIST - BROWN	
C			4+4+6	S		LIMESTONE RESIDUUM
	49.0		3+4+5	S	ELASTIC SILT (MH) TRACE SAND MOIST - BROWN	



SCHNABEL ENGINEERING ASSOCIATES
CONSULTING ENGINEERS

TEST BORING LOG

BORING NO: MW-9

PROJECT: MONITORING WELL INSTALLATION, HWM-16, RAAP, RADFORD, VA
SHEET NO: 2 OF 2

CLIENT: HERCULES, INCORPORATED
JOB NO: V881377

BORING CONTRACTOR: TERROCK CORPORATION
DRILL: CME - 55
ELEVATION:

WATER LEVEL DATA

	DATE	TIME	DEPTH	CAVED
ENCOUNTERED	9/20	4:00	64.0	-
AFTER CASING PULLED	9/21	2:30	62.0	-
HR. READING	MONITORING WELL INSTALLED			

DRIVE SAMPLER
TYPE: S.S.
DIA.: 2" O.D.
WT.: 140#
FALL: 30

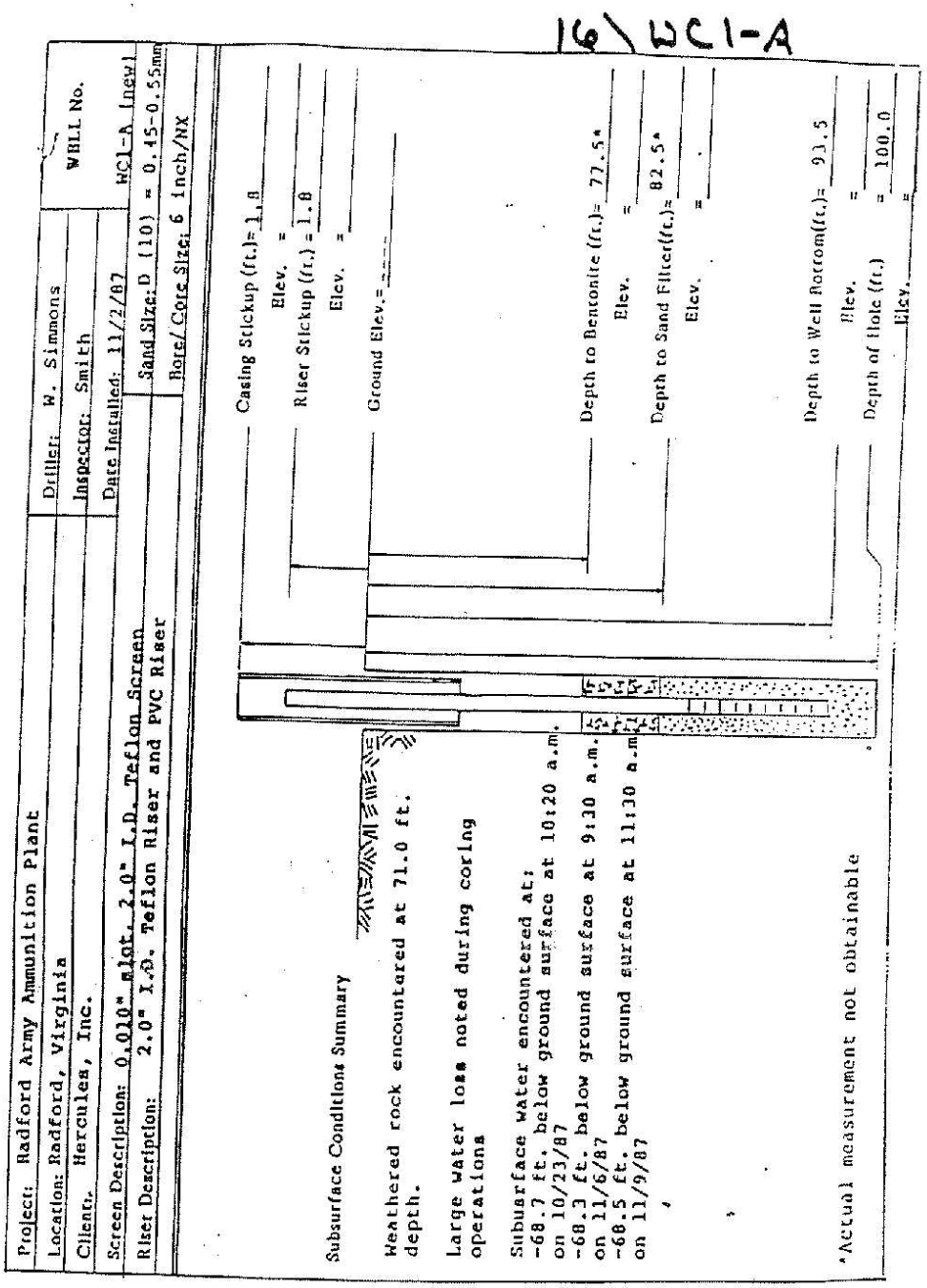
CASING SIZE: 2-1/4
DATE START: 9/20/89
DATE FINISHED: 9/22/89
DRILLER: R. EDWARDS
INSPECTOR: C. HALL

STRATUM	DEPTH FT.	ELEV.	BLOWS ON SAMPLE SPOON, PER 6"	SYMBOL	IDENTIFICATION	REMARKS
					ELASTIC SILT (MH) TRACE SAND MOIST - BROWN	
	54.0		8+5+7	S	SILT WITH SAND (ML) CONTAINS ROCK FRAGMENTS AND LENSES OF SILTY SAND. MOIST - BROWN	LIMESTONE RESIDUUM
C			4+3+3	S	do. CONTAINS LENSES OF FAT CLAY	
			3/12"+ 3/12"	S	do. CONTAINS ROCK FRAGMENTS, WET - BROWN	
	68.7		35+39+ 26/5"	S	DISINTEGRATED ROCK, WET - GRAY AND BROWN	WASH BORING FROM 69' TO 79'
D	79.0				BORING TERMINATED AT 79.0 FT	
					NOTE: MONITORING WELL MW-~~16~~ 9 INSTALLED AT HWM-16 TO REPLACE OLD WELL C-2	

HWMU-16 Boring Log and Well Construction Diagrams

Appendix 5.

Well 16WC1A (Point of Compliance)


16\WC1-A
Project: Radford Army Ammunition Plant
Location: Radford, Virginia
Client: Hercules, Inc.
Screen Description: 0.010" slot, 2.0" I.D. Teflon Screen
Riser Description: 2.0" I.D. Teflon Riser and PVC Riser
Driller: W. Simmons
Inspector: Smith
Date Installed: 11/2/87
Sand Size: D (10) = 0.45-0.55mm
Bore/Core Size: 6 inch/NX
WELL No.
WC1-A (new)
Casing Stickup (ft.)= 1.8
Elev. =
Riser Stickup (ft.) = 1.8
Elev. =
Ground Elev.= ____
Depth to Bentonite (ft.)= 77.5*
Elev. =
Depth to Sand Filter(ft.)= 82.5*
Elev. =
Depth to Well Bottom(ft.)= 93.5
Elev. =
Depth of Hole (ft.) = 100.0
Elev. =
Subsurface Conditions Summary
Weathered rock encountered at 71.0 ft. depth.
Large water loss noted during coring operations
Subsurface water encountered at:
-68.7 ft. below ground surface at 10:20 a.m. on 10/23/87
-68.3 ft. below ground surface at 9:30 a.m. on 11/6/87
-68.5 ft. below ground surface at 11:30 a.m. on 11/9/87
*Actual measurement not obtainable

HWMU 16\WC 1-A

BORING LOG

FROEHLING & ROBERTSON, INC.
FULL SERVICE LABORATORIES • ENGINEERS & CHEMIS
"OVER ONE HUNDRED YEARS OF SERVICE"

Report No. 0-62084

DATE November, 1987

Client: Hercules, Inc.

Project: Radford Army Ammunition Plant, Radford, Virginia

Boring No.: WC1-A	Total Depth: 68.2 ft.	Elevation: ----	Location: See Location Plan
Type of Boring: Hollow Stem Auger	Started: 10/5/87	Completed: 10/5/87	Driller: V. Simmons

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	Sample Blows	Sample Depth (Feet)	% Core Recovery	REMARKS
	0.0	No sampling conducted see WC1-B (new) for subsurface conditions				GROUNDWATER DATA Subsurface water encountered at: -67.8 ft. below ground surface at 1:50 p.m. on 10/5/87 -62.0 ft. below ground surface at 2:45 p.m. on 10/13/87
	10.0					
	20.0					
	30.0					
		Boring terminated at 68.2 ft.				

*No. of blows required for a 140 lb. hammer dropping 30 in. to drive 2 in O.D., 1.375 in. I.D. sampler a total of 18 inches in three 6 in. increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N.

Scale 1"=5' unless otherwise noted

16 of 22 WC1A

BORING LOG

FROEHLING & ROBERTSON, INC.
FULL SERVICE LABORATORIES • ENGINEERS & CHEMISTS
"OVER ONE HUNDRED YEARS OF SERVICE"

Report No. 0-62084

DATE November, 1987

Client: Hercules, Inc.

Project: Radford Army Ammunition Plant, Radford, Virginia

Boring No.: WC1-A (new) | Total Depth: 100.0 ft. | Elevation: ---- | Location: See Location Plan

Type of Boring: Hollow Stem Auger | Started: 10/20/87 | Completed: 11/2/87 | Driller: W. Simmons

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	Samples Blows	Sample Depth (Feet)	% Core Recovery	REMARKS
	0.0	No sampling conducted, see WC1-B for subsurface conditions				GROUNDWATER DATA Subsurface water encountered at: -68.7 ft. below ground surface at 10:20 a.m. on 10/23/87 -68.3 ft. below ground surface at 9:30 a.m. on 11/5/87 -68.5 ft. below ground surface at 11:30 a.m. on 11/9/87
	10.0					
	73.0	Auger refusal at 73.0 ft.		73.0		
		Highly fractured dolomite with calcite healed joints		78.0	15.0	RQD = 0
				80.0	37.5	RQD = 0
				83.0	22.2	RQD = 0
				86.5	30.9	RQD = 0
				91.5	56.7	RQD = 0
					24.2	RQD = 0

*No. of blows req'd. for a 140 lb. hammer dropping 30 in. to drive 2 in. O.D., 1.375 in. I.D. sampler a total of 18 inches in three 6 in. increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N.

Scale 1"=5' unless otherwise noted

BORING LOG

16-WC1-A

FROEHLING & ROBERTSON, INC.
FULL SERVICE LABORATORIES • ENGINEERS & CHEMIS
"OVER ONE HUNDRED YEARS OF SERVICE"

Report No. 0-62084

Client: Hercules, Inc. DATE: November, 1987

Project: Radford Army Ammunition Plant, Radford, Virginia

Boring No.: WC1-A (new) | Total Depth: 100.0 ft. | Elevation: ---- | Location: See Location Plan

Type of Boring: Hollow Stem Auger | Started: 10/20/87 | Completed: 11/2/87 | Driller: W. Stevens

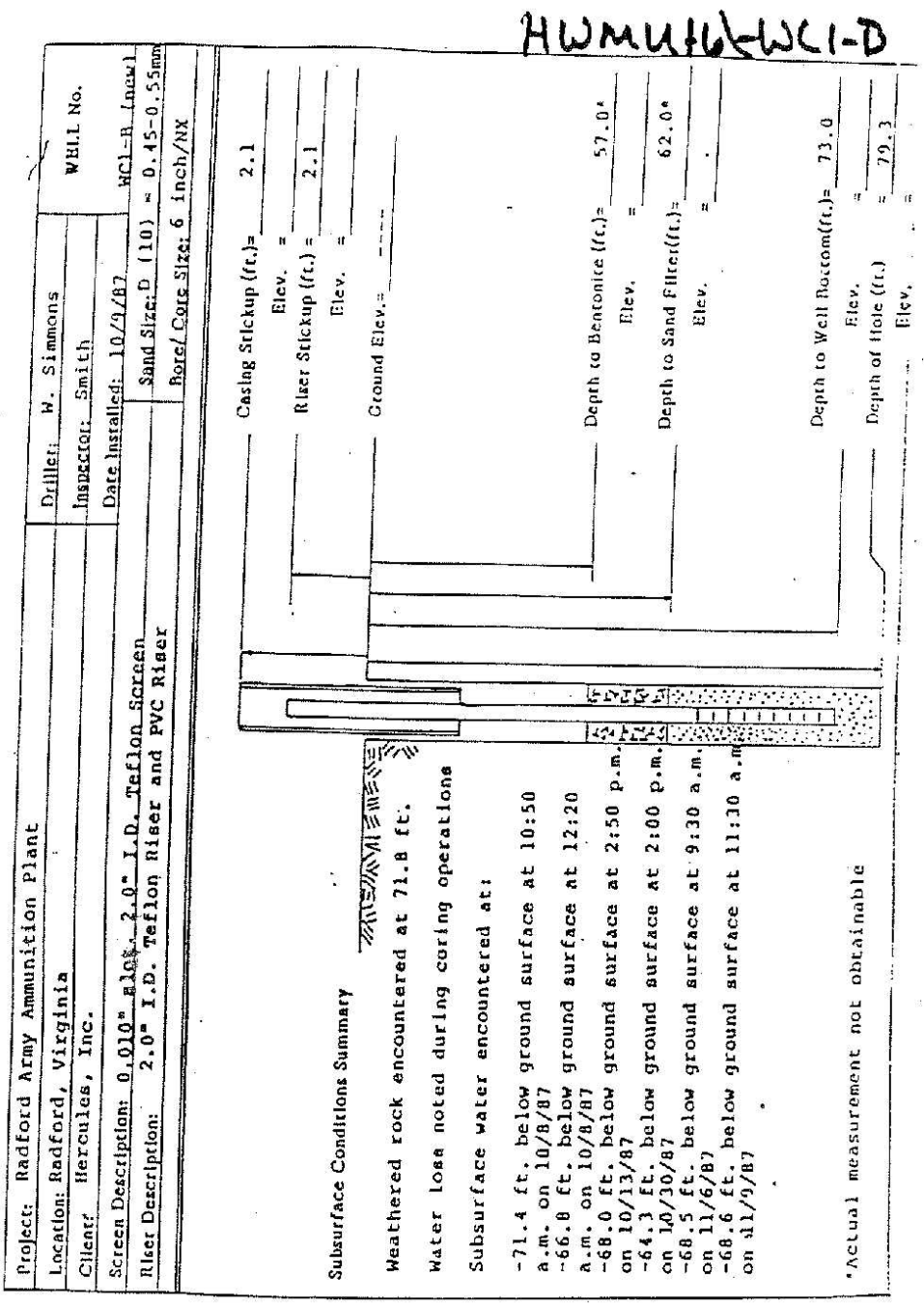
Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	Sample Blows*	Sample Depth (Feet)	% Core Recovery	REMARKS
95.0				96.5		GROUNDWATER DATA
					28.6	RQD = 0
100.0		Boring terminated at 100.0 ft.		100.0		

*No. of blows req'd. for a 140 lb. hammer dropping 30 in. to drive 2 in. O.D., 1.375 in. I.D. sampler a total of 18 inches in three 6 in. increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N.

Scale 1" = 5' unless otherwise noted

Appendix 6.

Well 16WC1B (Point of Compliance)


HWMU16-WC1-D
Project: Radford Army Ammunition Plant
Location: Radford, Virginia
Client: Hercules, Inc.
Driller: W. Simmons
Inspector: Smith
Date Installed: 10/9/87
WELL No.
WC1-D (new)
Screen Description: 0.010" slot, 2.0" I.D. Teflon Screen
Sand Size: D (10) = 0.45-0.55mm
Riser Description: 2.0" I.D. Teflon Riser and PVC Riser
Bore/Core Size: 6 inch/NX
Casing Stickup (ft.)= 2.1
Elev. =
Riser Stickup (ft.) = 2.1
Elev. =
Ground Elev.= ----
Depth to Bentonite (ft.)= 57.0'
Elev. =
Depth to Sand Filter(ft.)= 62.0'
Elev. =
Depth to Well Bottom(ft.)= 73.0
Elev. =
Depth of Hole (ft.) = 79.3
Elev. =
Subsurface Conditions Summary
Weathered rock encountered at 71.8 ft.
Water loss noted during coring operations
Subsurface water encountered at:
-71.4 ft. below ground surface at 10:50 a.m. on 10/8/87
-66.8 ft. below ground surface at 12:20 a.m. on 10/8/87
-68.0 ft. below ground surface at 2:50 p.m. on 10/13/87
-64.3 ft. below ground surface at 2:00 p.m. on 10/30/87
-68.5 ft. below ground surface at 9:30 a.m. on 11/6/87
-68.6 ft. below ground surface at 11:30 a.m. on 11/9/87
*Actual measurement not obtainable

BORING LOG

HWMU 16 WC1-B

FROEHLING & ROBERTSON, INC.
FULL SERVICE LABORATORIES • ENGINEERS & CHEMIS
"OVER ONE HUNDRED YEARS OF SERVICE"

Report No. 0-62084

Client: Hercules, Inc.

DATE November, 1987

Project: Radford Army Ammunition Plant, Radford, Virginia

Boring No.: WC1-8	Total Depth: 86.0 ft.	Elevation: ----	Location: See Location Plan
Type of Boring: Hollow Stem Auger	Started: 10/5/87	Completed: 10/7/87	Driller: W. Simmons

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	Sample Blows	Sample Depth (Feet)	% Core Recovery	REMARKS
	0.0	Loose orange to green brown medium to fine sandy SILT, trace clay, debris (ML)	3 3	1.5		GROUNDWATER DATA
				3.0		Subsurface water encountered at -68.5 ft. below ground surface at 1:20 p.m. on 10/6/87
				4.5		
		-FILL	2 6	6.0		
	7.0	Medium-stiff red brown silty CLAY some fine sand (CL)				
			3 3	8.5		
			4	10.0		
		to		11.5		
			5 8	13.0		
		Medium dense orange brown silty medium to fine SAND, manganese stains.		15.0		
			4 7	18.5		
			11	20.0		
			5 8	23.5		
			13	25.0		
			5 9	28.5		
			12	30.0		
		to		33.5		
			4 6	35.0		
			9	38.5		
			3 8	40.0		

*No. of blows required for a 140 lb. hammer dropping 30 in. to drive 2 in O.D., 1.375 in. I.D. sampler a total of 18 inches in three 6 in. increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N.

Scale 1"=5' unless otherwise noted

Form No. 306

BORING LOG

16\WC1-B

FROEHLING & ROBERTSON, INC.
FULL SERVICE LABORATORIES • ENGINEERS & CHEMISTS
"OVER ONE HUNDRED YEARS OF SERVICE"

Report No. 0-62084 | DATE November, 1987

Client: Hercules, Inc.

Project: Radford Army Ammunition Plant, Radford, Virginia

Boring No.: WC1-B | Total Depth: 85.0 ft. | Elevation: ---- | Location: See Location Plan

Type of Boring: Hollow Stem Auger | Started: 10/5/87 | Completed: 10/7/87 | Driller: W. Simmons

Elevation	Depth	Description of Materials (Classification)	Sample Blows	Sample Depth (Feet)	% Core Recovery	Remarks
	40.0	Medium dense brown coarse to fine SAND				GROUNDWATER DATA
			7-8-9	43.5		
		to		45.0		
		Medium dense yellow brown to tan SILT, some coarse to fine sand, trace shale fragments (ML)	4-6-9	48.5		
				50.0		
			10-11	53.5		
				55.0		
			4-5-5	58.5		
		-ALLUVIUM-		60.0		
	61.5	Medium stiff tan to brown SILT, trace medium to fine sand (ML)	*2-4	63.5		*Weight of Hammer
		-RESIDUUM-		65.0		
				68.5		*30/1 inch
	69.2	Auger refusal at 69.2 ft.		68.5 / 69.2		
		Highly fractured dolomite with calcity healed joints			**	** No Recovery
				74.2		
					6.6	RQD = 0
				79.2		

*No. of blows req'd. for a 140 lb. hammer dropping 30 in. to drive 2 in O.D., 1.375 in. I.D. sampler a total of 18 inches in three 6 in. increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N.

Scale 1"=5' unless otherwise noted

BORING LOG

HWMC 1-B

FROEHLING & ROBERTSON, INC.
FULL SERVICE LABORATORIES • ENGINEERS & CHEMI
"OVER ONE HUNDRED YEARS OF SERVICE"

Report No. 0-62084

Client: Hercules, Inc. DATE November, 1987

Project: Radford Army Ammunition Plant, Radford, Virginia

Boring No.: MCT-8	Total Depth: 86.0 ft.	Elevation: ----	Location: See Location Plan
Type of Boring: Hollow Stem Auger	Started: 10/5/87	Completed: 10/7/87	Driller: W. Simmons

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	Sample Blows	Sample Depth (Feet)	% Core Recovery	REMARKS
	80.0			81.0	*	GROUNDWATER DATA
						*50% Recovery
						RQD = 0
					**	**No Recovery
	86.0	Boring terminated at 86.0 ft.				

*No. of blows required for a 140 lb. hammer dropping 30 in. to drive 2 in O.D., 1.375 in. I.D. sampler a total of 18 inches in three 6 in. increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N.

Scale 1"=5' unless otherwise note

16\WC1-B

BORING LOG

FROEHLING & ROBERTSON, INC.
FULL SERVICE LABORATORIES • ENGINEERS & CHEMI
"OVER ONE HUNDRED YEARS OF SERVICE"

Report No. 0-62084

Client: Hercules, Inc. Date: November, 1987

Project: Radford Army Ammunition Plant, Radford, Virginia

Boring No.: WC1 B (new) | Total Depth: 79.3 ft. | Elevation: ---- | Location: See Location Plan

Type of Boring: Hollow Stem Auger | Started: 10/7/87 | Completed: 10/9/87 | Driller: W. Simmons

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	Sample Blows	Sample Depth (Feet)	% Core Recovery	REMARKS
	0.0	No sampling conducted see WC1-B for subsurface conditions				GROUNDWATER DATA Subsurface water encountered at: -71.4 ft. below ground surface at 10:50 a.m. on 10/8/87 -66.8 ft. below ground surface at 12:20 p.m. on 10/8/87 -68.0 ft. below ground surface at 2:50 p.m. on 10/13/87 -64.3 ft. below ground surface at 2:00 p.m. on 10/30/87 -68.5 ft. below ground surface at 9:30 a.m. on 11/6/87 -68.5 ft. below ground surface at 11:30 a.m. on 11/9/87
	10.0					
	20.0					
	71.8	Highly fractured dolomite with calcite healed joints	71.8	25.0		RQD = 0
			75.8	54.8		RQD = 0
	79.3	Boring terminated at 79.3	79.3			

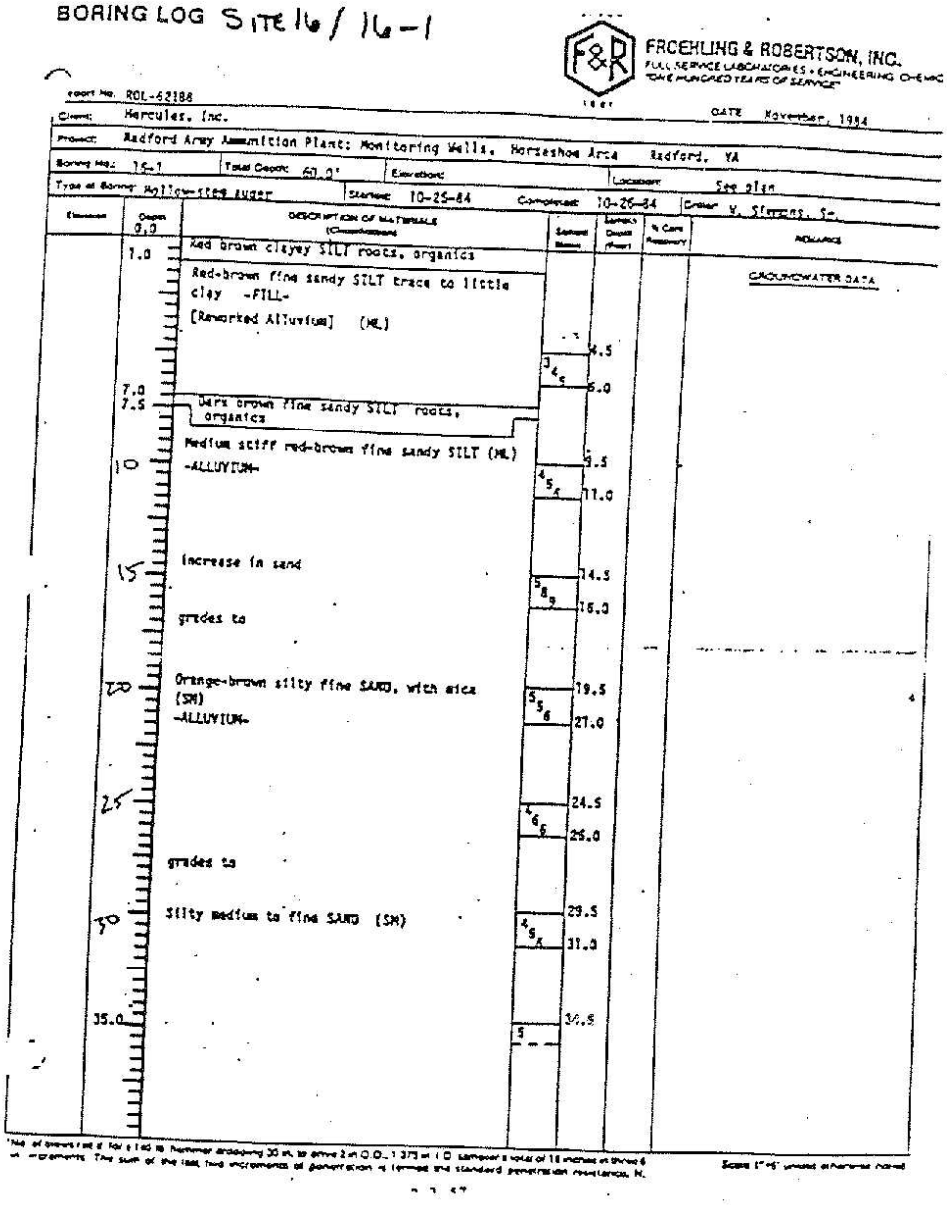
*No. of blows req'd for a 140 lb. hammer dropping 30 in. to drive 2 in O.D., 1.375 in. I.D. sampler a total of 18 inches in three 6 in. increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N.

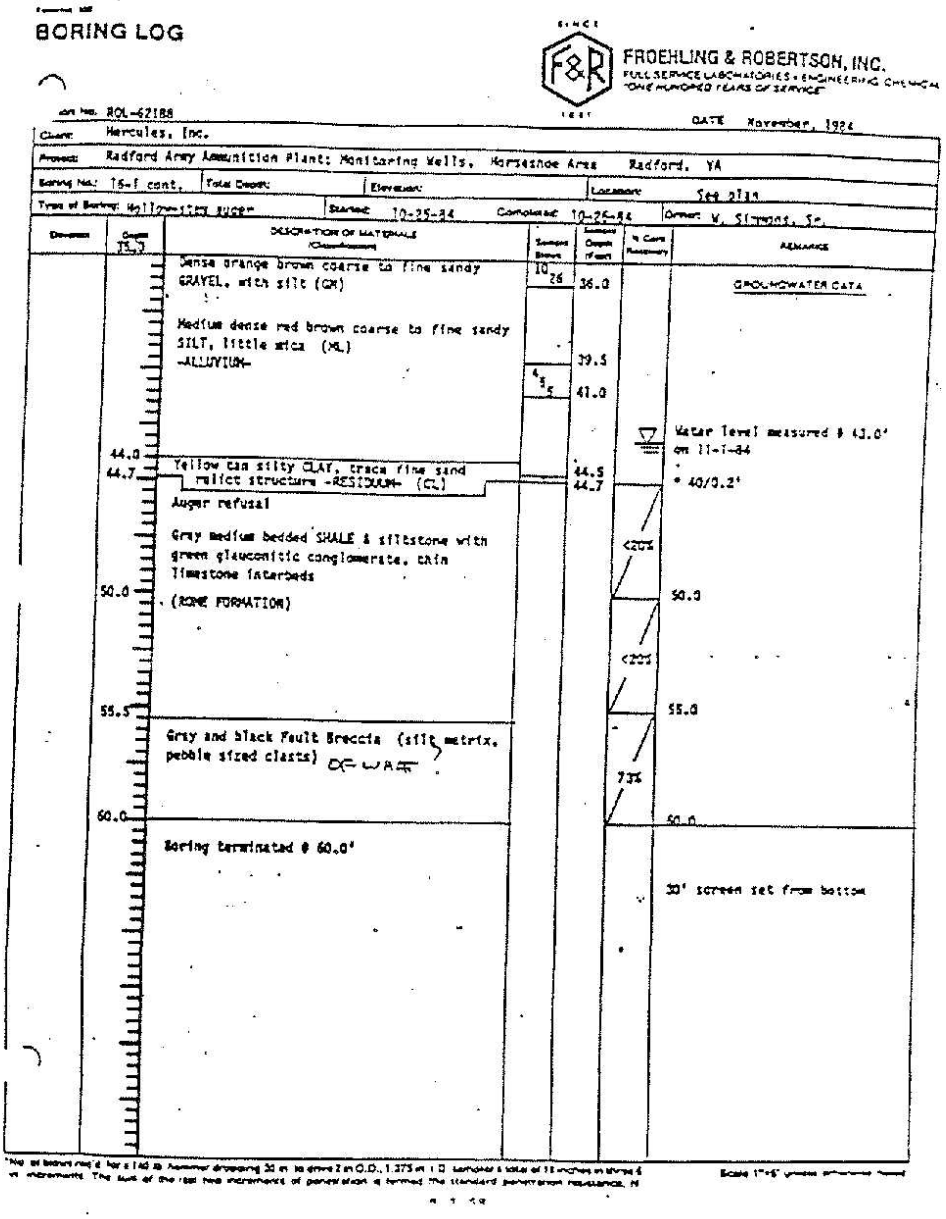
Scale 1"=5' unless otherwise noted

Appendix 7.

Well 16-1 (Compliance Monitoring)

BORING LOG SITE 16 / 16-1





BORING LOG

FROEHLING & ROBERTSON, INC.
FULL SERVICE LABORATORIES • ENGINEERING CONSULTANTS
ONE HUNDRED YEARS OF SERVICE

Job No. ROL-62188 DATE November, 1984
Client: Hercules, Inc.
Project: Radford Army Ammunition Plant: Monitoring Wells, Horseshoe Area Radford, VA
Boring No.: 76-I cont. Total Depth: Elevation: Location: See plan
Type of Boring: Hollow-stem auger Started: 10-25-84 Completed: 10-26-84 Driller: W. Simmons, Sr.

Elevation	Depth (ft.)	Description of Materials (Classification)	Sample Blows	Sample Depth (ft.)	% Core Recovery	Remarks
	15.7	Dense orange brown coarse to fine sandy GRAVEL, with silt (GM)	10 26	36.0		GROUNDWATER DATA
		Medium dense red brown coarse to fine sandy SILT, little mica (ML) -ALLUVIUM-	4 5 5	39.5 41.0		Water level measured @ 43.0' on 11-1-84
	44.0					
	44.7	Yellow tan silty CLAY, trace fine sand relict structure -RESIDUUM- (CL)		44.5 44.7		* 40/0.2'
		Auger refusal				
		Gray medium bedded SHALE & siltstone with green glauconitic conglomerate, thin limestone interbeds			<20%	
	50.0	(ROME FORMATION)				50.0
					<20%	
	55.5					55.0
		Gray and black Fault Breccia (silt matrix, pebble sized clasts) OF WAFF			73%	
	60.0					60.0
		Boring terminated @ 60.0'				30' screen set from bottom

*No. of blows required for a 140 lb. hammer dropping 30 in. to drive 2 in O.D., 1.375 in I.D. sampler a total of 12 inches in three 6 in. increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N

Scale 1"=5' unless otherwise noted

Appendix 8.

Well 16-2 (Compliance Monitoring)

Form No. 306

BORING LOG Site 16/16-2

FROEHLING & ROBERTSON, INC.
FULL SERVICE LABORATORIES • ENGINEERING CHEMICAL
"ONE HUNDRED YEARS OF SERVICE"
SINCE 1881

Report No. RCL-62188 | DATE November, 1984

Client: Hercules, Inc.

Project: Radford Army Ammunition Plant: Monitoring Wells, Horseshoe Area Radford, VA

Boring No.: 16-2 | Total Depth: 72.0' | Elevation: | Location: See plan

Type of Boring: Hollow-stem auger | Started: 10-23-84 | Completed: 10-25-84 | Driller: W. Simmons, Sr.

Elevation	Depth	Description of Materials (Classification)	Sample Blows	Sample Depth (Feet)	% Core Recovery	Remarks
	0.0	Red brown clayey SILT, trace sand, organics				GROUNDWATER DATA
	0.5	Medium dense red-tan fine sandy SILT, trace clay, small mica flakes (ML) -ALLUVIUM-	3-6-10	4.5 – 6.0		
			3-5-6	9.5 – 11.0		
		Grades to				
		Medium dense silty fine SAND, slight micaceous (SM)	3-4-7	14.5 – 16.0		
		Grading to				
		Dense red brown silty coarse to fine SAND, few gravel (SM)	12-12-12	19.5 – 21.0		
		Grading to				
		Dense red coarse to fine sandy GRAVEL, some silt (GM)	14-13-12	24.5 – 25.0		
	29.0	Medium dense yellow tan SILT trace fine sand & clay -RESIDUUM-	5-7-6	29.5 – 31.0		
		Auger refusal @ 33.5'; begin coring @ 33.5'		33.5		* 40/0.0'
	35.0					Lost water at 35.0'

*No. of blows req'd. for a 140 lb hammer dropping 30 in. to drive 2 in O.D., 1.375 in I.D. sampler a total of 14 inches in three 6 in. increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N.

Scale 1"=5' unless otherwise noted

R-1-59

BORING LOG

FROEHLING & ROBERTSON, INC.
FULL SERVICE LABORATORIES • ENGINEERING CHEMICAL
"ONE HUNDRED YEARS OF SERVICE"

Report No. RCL-62188
Client: Hercules, Inc. DATE November, 1984
Project: Radford Army Ammunition Plant; Monitoring Wells, Horseshoe Area Radford, VA
Boring No.: 16-3 cont. Total Depth: Elevation: Location: See plan
Type of Boring: Hollow-stem auger Started: 10-23-84 Completed: 10-25-84 Driller: V. Simmons, Sr.

Elevation	Depth	Description of Materials (Classification)	Sample Blows	Sample Depth (Feet)	% Core Recovery	Remarks
	35.0	Dove gray vuggy, conglomeratic fractured DOLOMITIC LIMESTONE, thin bedded to shaley in some sections			67%	GROUNDWATER DATA
	38.5	Conglomerate; limestone matrix, quartzite, pebbles, grades back to conglomeratic DOLOMITE with vugs, shaley partings			48%	
	40.5	Void in Rock			Void	
	43.5	Shows steep (> 45%) dip Black to gray shale & limestone clasts in conglomerate			72%	
					83%	
		Black SHALE fragments in conglomerate			62%	53.5 * 3.5' core run
	57.5	Angular fragments Fault Breccia Limestone matrix (sand-sized limestone particles) with angular fragments of shale and dolomite			98%	57.0
					87%	
	67.0	Mud seam - yellow tan clayey SILT				67.0
	69.0					
	70.0	Black calcareous thin bedded SHALE, highly deformed, steep dip			67%	

*No. of blows req'd for a 140 lb hammer dropping 30 in. to drive 2 in O.D., 1.375 in I.D. sampler a total of 18 inches in three 6 in. increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N.

Scale 1"=5' unless otherwise noted

BORING LOG

FROEHLING & ROBERTSON, INC.
FULL SERVICE LABORATORIES • ENGINEERING CHEMICAL
"ONE HUNDRED YEARS OF SERVICE"
1881

Job No. ROL-62188
Client: Hercules, Inc.
DATE November, 1984
Project: Radford Army Ammunition Plant: Monitoring Wells, Horseshoe Area Radford, VA
Boring No.: 16-Z cont. Total Depth: Elevation: Location: See plan
Type of Boring: Hollow-stem auger Started: 10-23-84 Completed: 10-25-84 Owner: W. Simmons, Sr.

Elevation	Depth 73.0	DESCRIPTION OF MATERIALS (Classification)	Sample Number	Sample Depth (Feet)	% Core Recovery	REMARKS
		See description on previous page				GROUNDWATER DATA
					95%	Water level measured @ 53.7' on 11-1-84
	77.0	Boring terminated @ 77.0'				25' screen set from bottom

Scale 1"=5' unless otherwise noted

R-1-61

Appendix 9.

Well 16-3 (Compliance Monitoring)

BORING LOG Site 16/16-3

FROEHLING & ROBERTSON, INC.
FULL SERVICE LABORATORIES • ENGINEERING CHEMICAL
"ONE HUNDRED YEARS OF SERVICE"

Report No. ROL-62188

Client: Hercules, Inc. DATE: November, 1984

Project: Radford Army Ammunition Plant; Monitoring Wells. Horseshoe Area Radford, VA

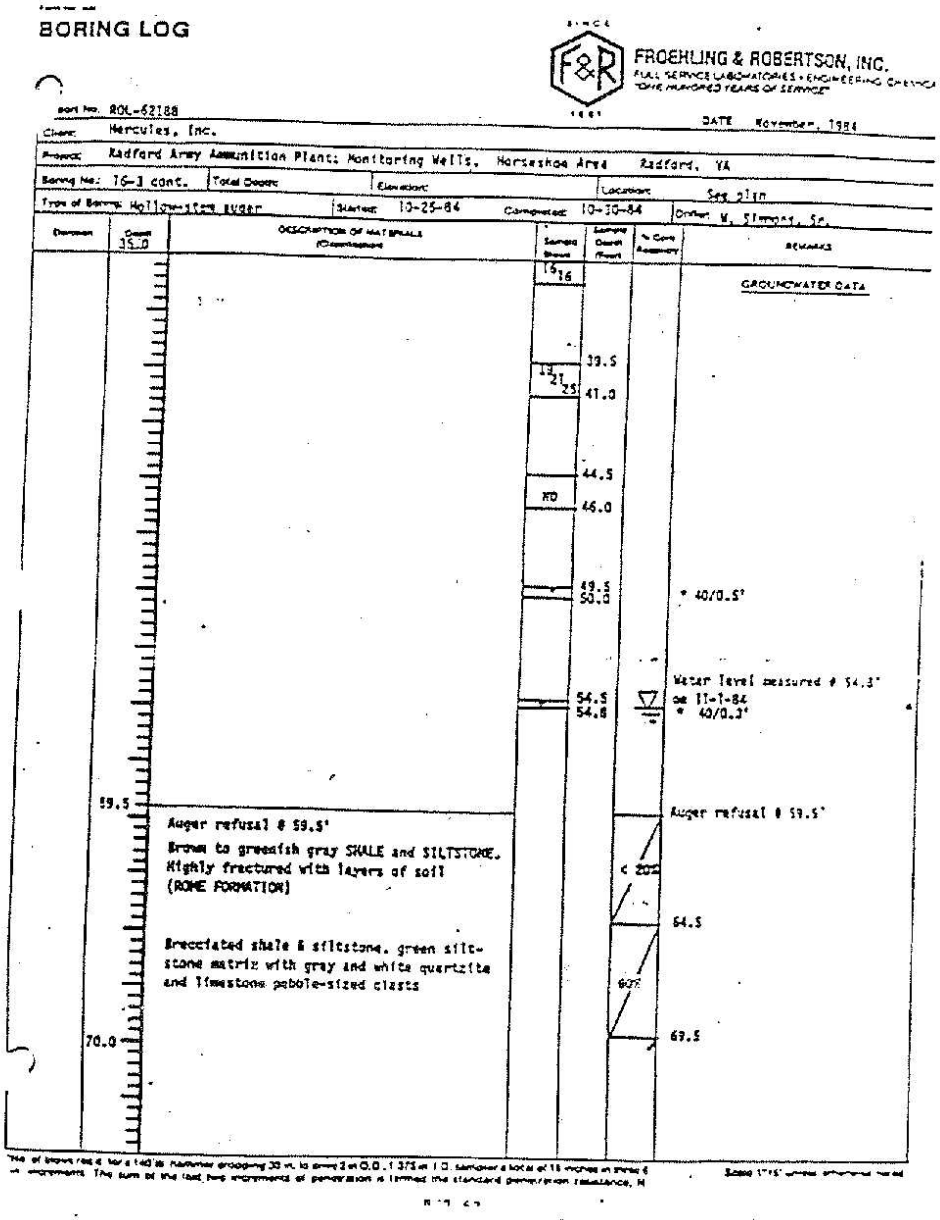
Boring No.: 16-3 | Total Depth: 39.5' | Elevation: | Location: See plan

Type of Boring: Hollow-stem auger | Started: 10-25-84 | Completed: 10-30-84 | Driller: V. Simmons, Sr.

Elevation	Depth	Description of Materials (Classification)	Sample Blows	Sample Depth (feet)	% Core Recovery	Remarks
	0.0					
	1.0	Red brown fine sandy SILT, organics				GROUNDWATER DATA
		Medium dense orange-brown silty fine SAND, little mica (SM)	[illegible] 7 8	[illegible].5 – 5.0		
		grades to				
		Orange-brown fine sandy SILT, little mica (ML) -ALLUVIUM-	3 4 7	9.5 – 11.0		
	13.5	Medium dense orange-brown gravelly coarse to fine SAND (SP) -ALLUVIUM-	7 7 7	14.5 – 16.0		
			12 10 1[illegible]	19.5 – 21.0		
	25.0	Stiff tan clayey SILT, shale fragments little fine sand (ML) -RESIDUUM-	9 12 18	24.5 – 26.0		
			15 19 19	29.5 – 31.0		
	35.0		12	34.5		

*No. of blows required for a 140 lb. hammer dropping 30 in. to drive 2 in O.D., 1.375 in I.D. sampler a total of 18 inches in three 6 in. increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N

Scale 1"=5' unless otherwise noted

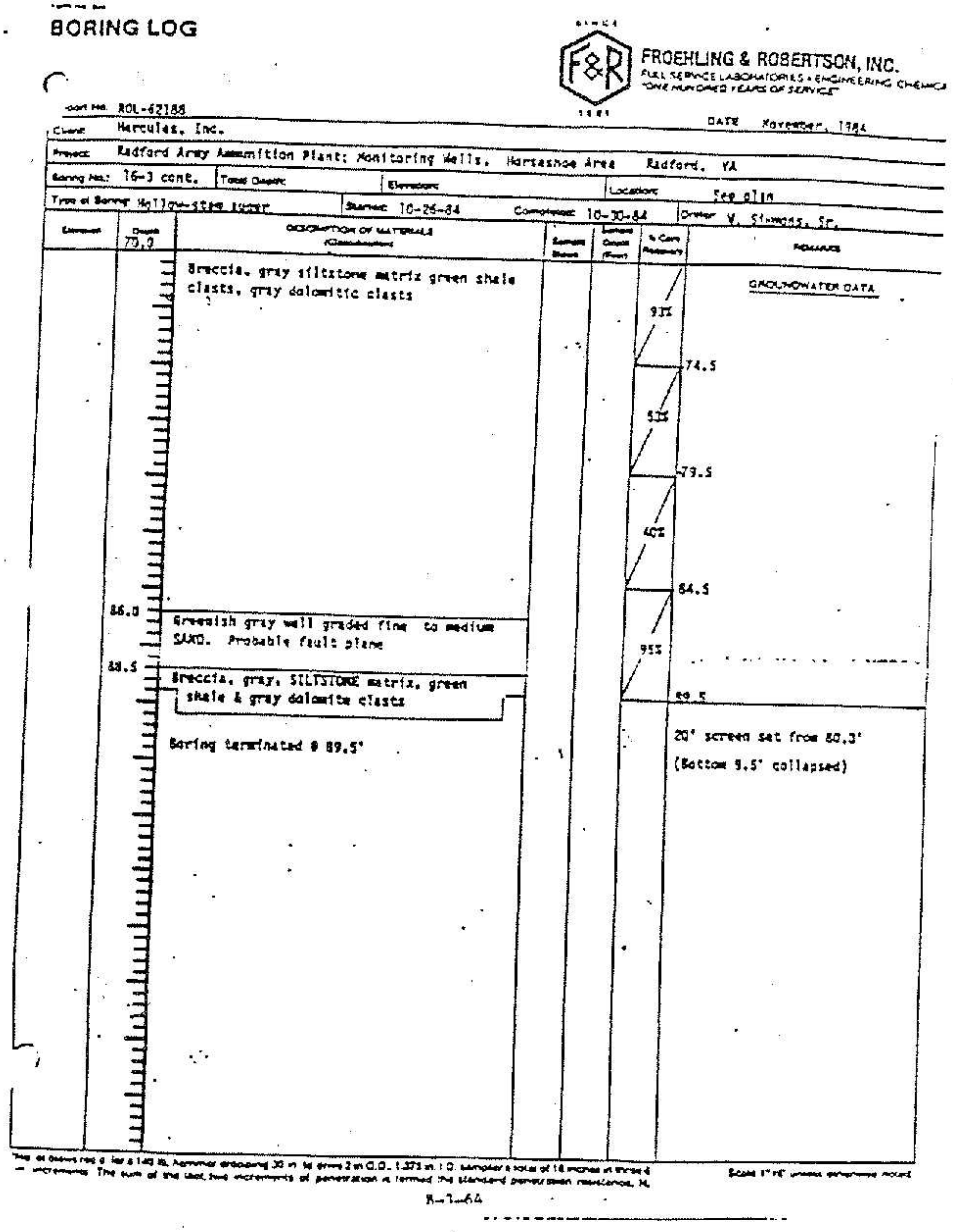


BORING LOG

FROEHLING & ROBERTSON, INC.
FULL SERVICE LABORATORIES • ENGINEERING OFFICES
"FIVE HUNDRED YEARS OF SERVICE"

Job No. ROL-62188 DATE November, 1984
Client: Hercules, Inc.
Project: Radford Army Ammunition Plant: Monitoring Wells, Horseshoe Area Radford, VA
Boring No: 16-I cont. Total Depth: Elevation: Location: See plan
Type of Boring: Hollow-stem auger Started: 10-25-84 Completed: 10-30-84 Driller: W. Simpson, Sr.

Elevation	Depth	Description of Materials	Sample Blows	Sample Depth (Feet)	% Core Recovery	Remarks
	35.0		16 16			GROUNDWATER DATA
			12 21 25	39.5 41.0		
				44.5		
			RD	46.0		
				49.5 50.0		* 40/0.5"
				54.5 54.8	▽	Water level measured @ 54.3' on 11-1-84 * 40/0.3"
	59.5	Auger refusal @ 59.5'				Auger refusal @ 59.5'
		Brown to greenish gray SHALE and SILTSTONE. Highly fractured with layers of soil (ROME FORMATION)			< 20%	
				64.5		
		Brecciated shale & siltstone, green siltstone matrix with gray and white quartzite and limestone pebble-sized clasts			60%	
	70.0			69.5		



BORING LOG

FROEHLING & ROBERTSON, INC.
FULL SERVICE LABORATORIES • ENGINEERING CHEMICS
ONE HUNDRED YEARS OF SERVICE

Job No. ROL-62188 DATE November, 1984
Client: Hercules, Inc.
Project: Radford Army Ammunition Plant; Monitoring Wells, Hartsnoe Area Radford, VA
Boring No.: 16-3 cont. Total Depth: Elevation: Location: See plan
Type of Boring: Hollow-stem auger Started: 10-26-84 Completed: 10-30-84 Driller: V. Simmons, Sr.

Elevation	Depth	DESCRIPTION OF MATERIALS	Sample Blows	Sample Depth (Feet)	% Core Recovery	REMARKS
	79.0	Breccia, gray siltstone matrix green shale clasts, gray dolomitic clasts			93%	GROUNDWATER DATA
					52%	74.5
					40%	79.5
					95%	84.5
	86.0	Greenish gray well graded fine to medium SAND. Probable fault plane				
	88.5	Breccia, gray, SILTSTONE matrix, green shale & gray dolomite clasts				89.5
		Boring terminated @ 89.5'				20' screen set from 80.3' (Bottom 9.5' collapsed)

K-1-64

Appendix 10.

Well 16-5 (Compliance Monitoring)

ASMT 100W-CMMOIENT

16-5
HWMU-16

BORING LOG

FROEHLING & ROBERTSON, INC.
ONE HUNDRED YEARS OF SERVICE

Report No. RDM-62085 DATE November, 1985

Client: Hercules, Inc.

Project: Monitoring Wells Radford Army Ammunition Plant Radford, Virginia

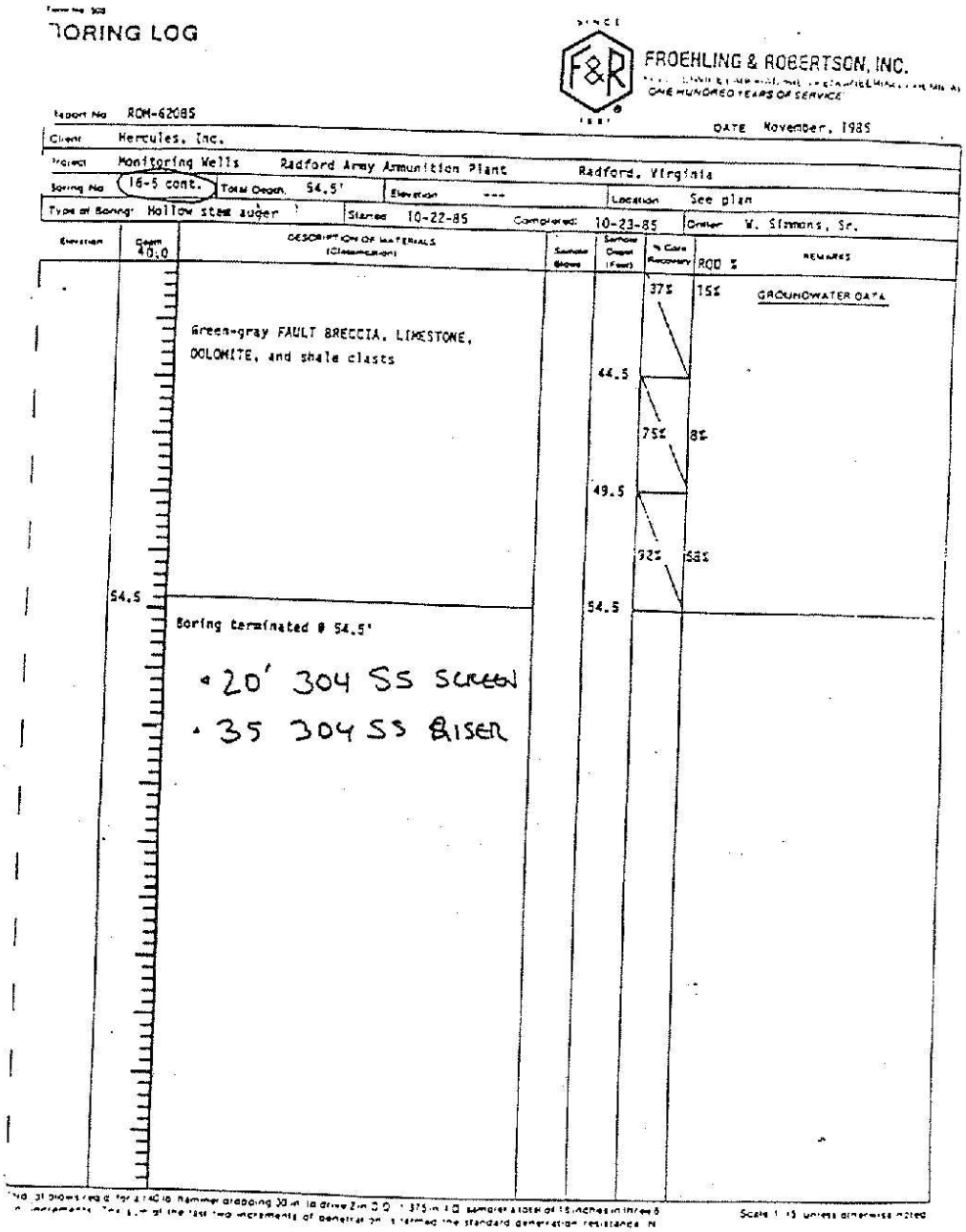
Boring No. 16-5 Total Depth: 54.5 Elevation: --- Location: See plan

Type of Boring: Hollow stem auger Started: 10-22-85 Completed: 10-23-85 Driller: W. Simmons, Sr.

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	Sample Depth (Feet)	% Core Recovery	REMARKS / RQD %
	0.0				GROUNDWATER DATA
	1.0	Brown fine sandy SILT			
		Loose brown fine sandy SILT, trace clay, mica flakes -ALLUVIUM-	1.5		
			3.0		
	4.0	Hard brown clayey SILT -RESIDUUM-	4.5		
	5.0		5.0		* 30/0.1'
		Blue gray dolomite, calcite healed fractures		95%	95%
			10.0		
				95%	92%
					Development Data: Slushed for 2 hrs. Bailed to 26.0'. Recovered to 16.9' after 24 hrs.
			15.0		
		Yellow-brown to green-gray fault breccia, LIMESTONE, DOLOMITE, and shale clasts		57%	27%
			20.0		
				86%	35%
			23.0		
				82%	0%
			25.0		
				0%	0%
			30.0		
				0%	0%
			34.5		
				97%	33%
	40.0		39.5		

*No. of blows required for a 140 lb. hammer dropping 30 in. to drive 2 in. O.D. x 1.375 in. I.D. sampler a total of 18 inches in three 6 inch increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N.

Scale 1" = 5' unless otherwise noted



BORING LOG

FROEHLING & ROBERTSON, INC.
ONE HUNDRED YEARS OF SERVICE

Report No. ROM-62085
Client: Hercules, Inc.
Project: Monitoring Wells — Radford Army Ammunition Plant — Radford, Virginia
Date: November, 1985
Boring No. 16-5 cont. — Total Depth: 54.5' — Elevation: --- — Location: See plan
Type of Boring: Hollow stem auger — Started: 10-22-85 — Completed: 10-23-85 — Driller: W. Simmons, Sr.

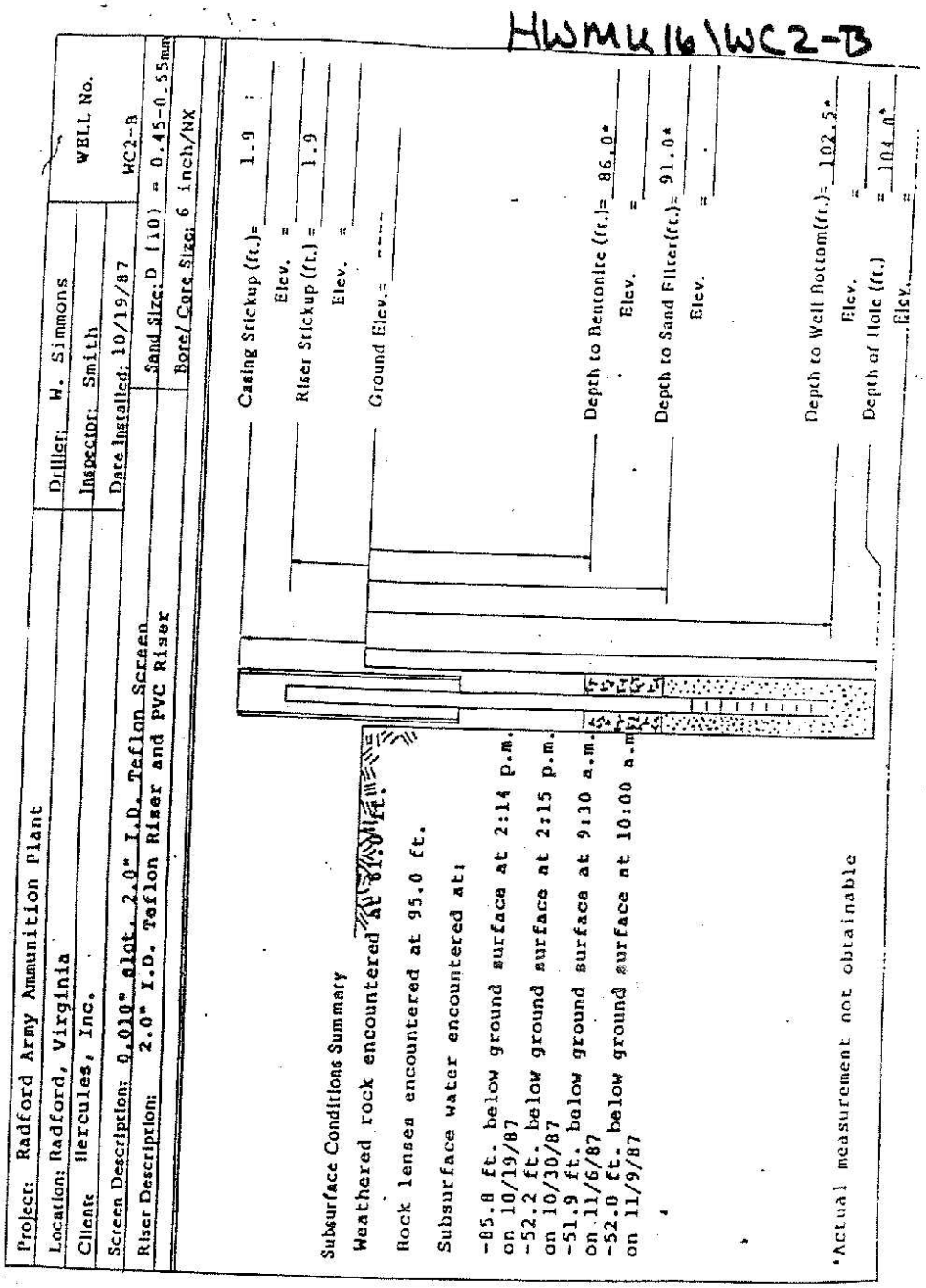
Elevation	Depth	Description of Materials (Classification)	Sample Blows	Sample Depth (Feet)	% Core Recovery	RQD %	Remarks
	40.0	Green-gray FAULT BRECCIA, LIMESTONE, DOLOMITE, and shale clasts		44.5	37%	15%	GROUNDWATER DATA
				49.5	75%	8%	
				54.5	92%	58%	
	54.5	Boring terminated @ 54.5'					

- 20' 304 SS screen
- 35 304 SS Riser

Scale 1" = 5' unless dimensions noted

Appendix 11.

Well 16WC2B (Compliance Monitoring)


HWMU16\WC2-B
Project: Radford Army Ammunition Plant
Location: Radford, Virginia
Client: Hercules, Inc.
Screen Description: 0.010" slot, 2.0" I.D. Teflon Screen
Riser Description: 2.0" I.D. Teflon Riser and PVC Riser
Driller: W. Simmons
Inspector: Smith
Date Installed: 10/19/87
Sand Size: D (10) = 0.45-0.55mm
Bore/Core Size: 6 Inch/NX
WELL No. WC2-B
Casing Stickup (ft.)= 1.9
Elev. =
Riser Stickup (ft.) = 1.9
Elev. =
Ground Elev.= ----
Depth to Bentonite (ft.)= 86.0'
Elev. =
Depth to Sand Filter(ft.)= 91.0'
Elev. =
Depth to Well Bottom(ft.)= 102.5'
Elev. =
Depth of Hole (ft.) = 104.0'
Elev. =
Subsurface Conditions Summary
Weathered rock encountered at 81.0 ft.
Rock lenses encountered at 95.0 ft.
Subsurface water encountered at:
-85.8 ft. below ground surface at 2:14 p.m. on 10/19/87
-52.2 ft. below ground surface at 2:15 p.m. on 10/30/87
-51.9 ft. below ground surface at 9:30 a.m. on 11/6/87
-52.0 ft. below ground surface at 10:00 a.m. on 11/9/87
*Actual measurement not obtainable

Form No. 300

BORING LOG

HWMU16\WC2-B

FROEHLING & ROBERTSON, INC.
FULL SERVICE LABORATORIES • ENGINEERS & CHEM
"OVER ONE HUNDRED YEARS OF SERVICE"

Report No. 0-62084

DATE November, 1987

Client: Hercules, Inc.

Project: Radford Army Ammunition Plant, Radford, Virginia

Boring No. WC2-8 | Total Depth: 104.0 ft. | Elevation: | Location: See Location Plan

Type of Boring: Hollow Stem Auger | Started: 10/14/87 | Completed: 10/19/87 | Driller: W. Simmons

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	Sample Blows	Sample Depth (Feet)	% Core Recovery	REMARKS
	0.0	Stiff brown clayey SILT, furnace slag and debris (ML)		1.5		GROUNDWATER DATA
			4 7 7	3.0		Subsurface water encountered at:
				4.5		-85.8 ft. below ground surface at 2:14 p.m. on 10/19/87
			3 3 8	6.0		-52.2 ft. below ground surface at 2:15 p.m. on 10/30/87
				8.5		-51.9 ft. below ground surface at 9:30 a.m. on 11/6/87
			10 8 9	10.0		-52.0 ft. below ground surface at 10:00 a.m. on 11/9/87
				13.5		
			5 5 11	15.0		
		Medium dense orange-brown medium-fine sandy SILT, debris (ML)		18.5		
			7 10 12	20.0		
				23.5		
			12 11 9	25.0		
				28.5		
		-FILL-	13 6 7	30.0		
	31.5	Loose yellow brown silty fine SAND, trace manganese stains (ML)		33.5		
			10 10 9	35.0		
				38.5		
			3 3 3	40.0		

*No. of blows req'd. for a 140 lb. hammer dropping 30 in. to drive 2 in. O.D., 1.375 in. I.D. sampler a total of 18 inches in three 6 in. increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N.

Scale 1"=5' unless otherwise noted

HWM 12 Hol WC2-B

BORING LOG

FROEHLING & ROBERTSON, INC.
FULL SERVICE LABORATORIES • ENGINEERS & CHEMIS
"OVER ONE HUNDRED YEARS OF SERVICE"

Report No. 0-62084

DATE November, 1987

Client: Hercules, Inc.

Project: Radford Army Ammunition Plant, Radford, Virginia

Boring No.: WC2-B | Total Depth: 104.0 ft. | Elevation: | Location: See Location Plan

Type of Boring: Hollow Stem Auger | Started: 10/14/87 | Completed: 10/19/87 | Driller: W. Simmons

Elevation	Depth 40.0	DESCRIPTION OF MATERIALS (Classification)	Samples Taken	Sample Depth (Feet)	% Core Recovery	REMARKS
		-to-				GROUNDWATER DATA
		Soft yellow brown to gray SILT, trace clay and coarse to fine sand sized particles	2 2 3	43.5 45.0		
		-ALLUVIUM-	1 1 1	48.5 50.0		
51.5						
				53.5 55.0		*Weight of RODS
		Very dense gray weathered rock		67.0 81.3		*30/3"

*No. of blows req'd. for a 140 lb. hammer dropping 30 in. to drive 2 in O.D., 1.375 in. I.D. sampler a total of 18 inches in three 6 in. increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N.

Scale 1" = 5' unless otherwise noted

BORING LOG

FROEHLING & ROBERTSON, INC.
FULL SERVICE LABORATORIES • ENGINEERS & CHEMIS
"OVER ONE HUNDRED YEARS OF SERVICE"

16 WC2-B

Report No. 0-62084

DATE November, 1987

Client: Hercules, Inc.

Project: Radford Army Ammunition Plant, Radford, Virginia

Boring No.: WC2-B | Total Depth: 104.0 ft. | Elevation: ----- | Location: See Location Plan

Type of Boring: Hollow Stem Auger | Started: 11/14/87 | Completed: 11/16/87 | Driller: W. Simmons

Elevation	DESCRIPTION OF MATERIALS (Classification)	Sample Blows	Sample Depth (Feet)	% Core Recovery	REMARKS
80.0					GROUNDWATER DATA
	Very dense gray weathered rock		93.5		
			93.7		*30/2"
104.0	Boring terminated at 104.0 ft.				

*No. of blows required for a 140 lb. hammer dropping 30 in. to drive 2 in. O.D., 1.375 in. I.D. sampler a total of 18 inches in three 6 in. increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N.

Scale 1"=5' unless dimensioned otherwise

Appendix 12.

Well 16Spring (Additional Sampling Point)

Appendix 13

Well 16WC2A (Piezometer)

AWMU 16\WC2-A

BORING LOG

FROEHLING & ROBERTSON, INC.
FULL SERVICE LABORATORIES • ENGINEERS & CHEMI
"OVER ONE HUNDRED YEARS OF SERVICE"

Recon No. 0-62084

DATE November, 1987

Client: Hercules, Inc.

Project: Radford Army Ammunition Plant, Radford, Virginia

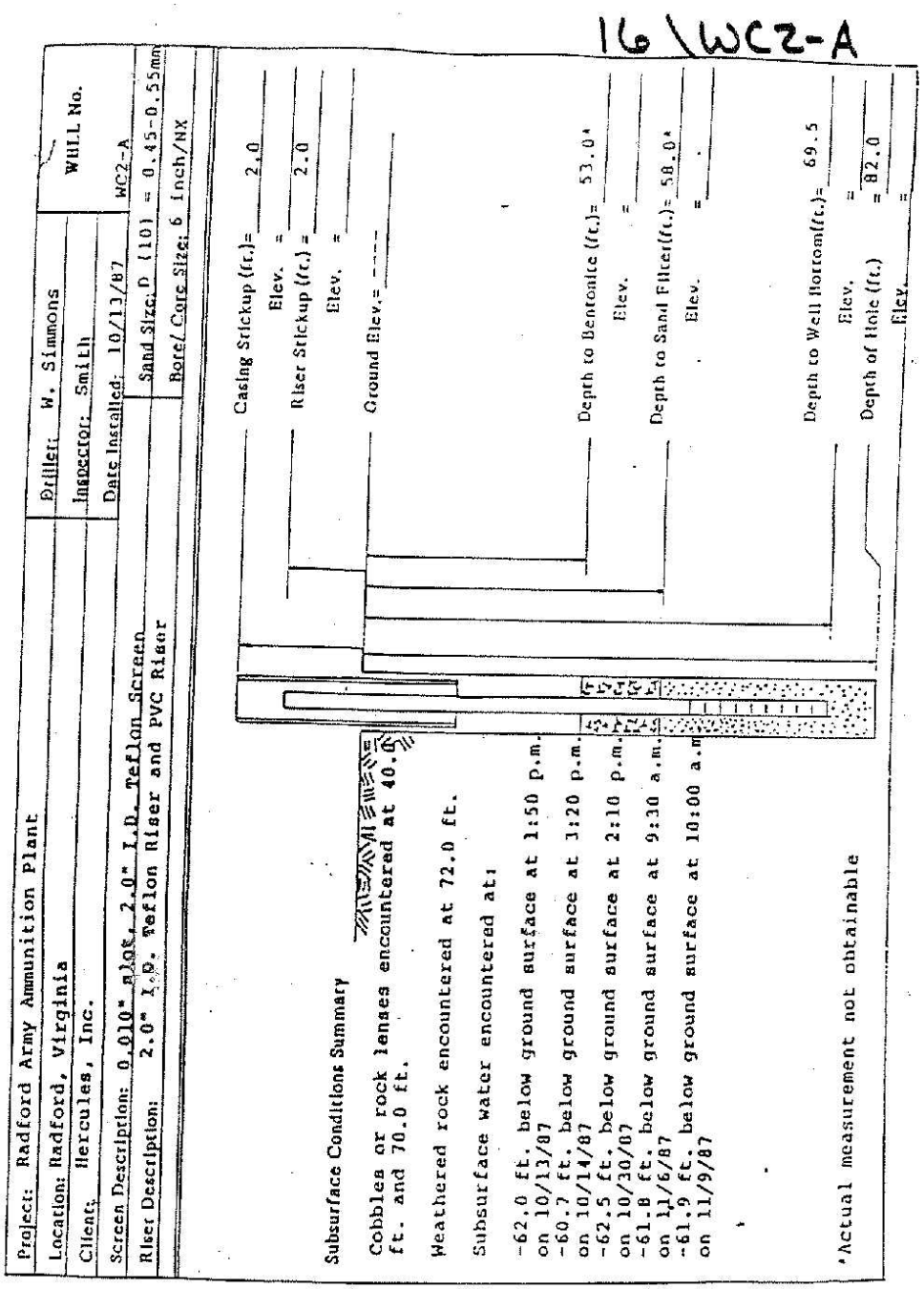
Boring No.: WC2-A | Total Depth: 82.0 ft. | Elevation: ------ | Location: See Location Plan

Type of Boring: Hollow Stem Auger | Started: 10/13/87 | Completed: 10/13/87 | Driller: W. Simmons

Elevation	Depth (Ft.)	Description of Materials (Classification)	Sample Blows	Sample Depth (Feet)	% Core Recovery	Remarks
	0.0	No sampling conducted, see WC2-B for subsurface conditions				GROUNDWATER DATA Subsurface water encountered at: -62.0 ft. below ground surface at 1:50 p.m. on 10/13/87 -60.7 ft. below ground surface at 3:00 p.m. on 10/14/87 -62.5 ft. below ground surface at 2:10 p.m. on 10/30/87 -61.8 ft. below ground surface at 9:30 a.m. on 11/6/87 -61.9 ft. below ground surface at 10:00 a.m. on 11/9/87
	10.0					
	20.0					
72.0		Auger Refusal		72.0		
		Highly fractured dolomite with calcite healed joints		77.0	**	** No Recovery
				10.0		RQD = 0
82.0		Boring terminated at 82.0 ft.		82.0		

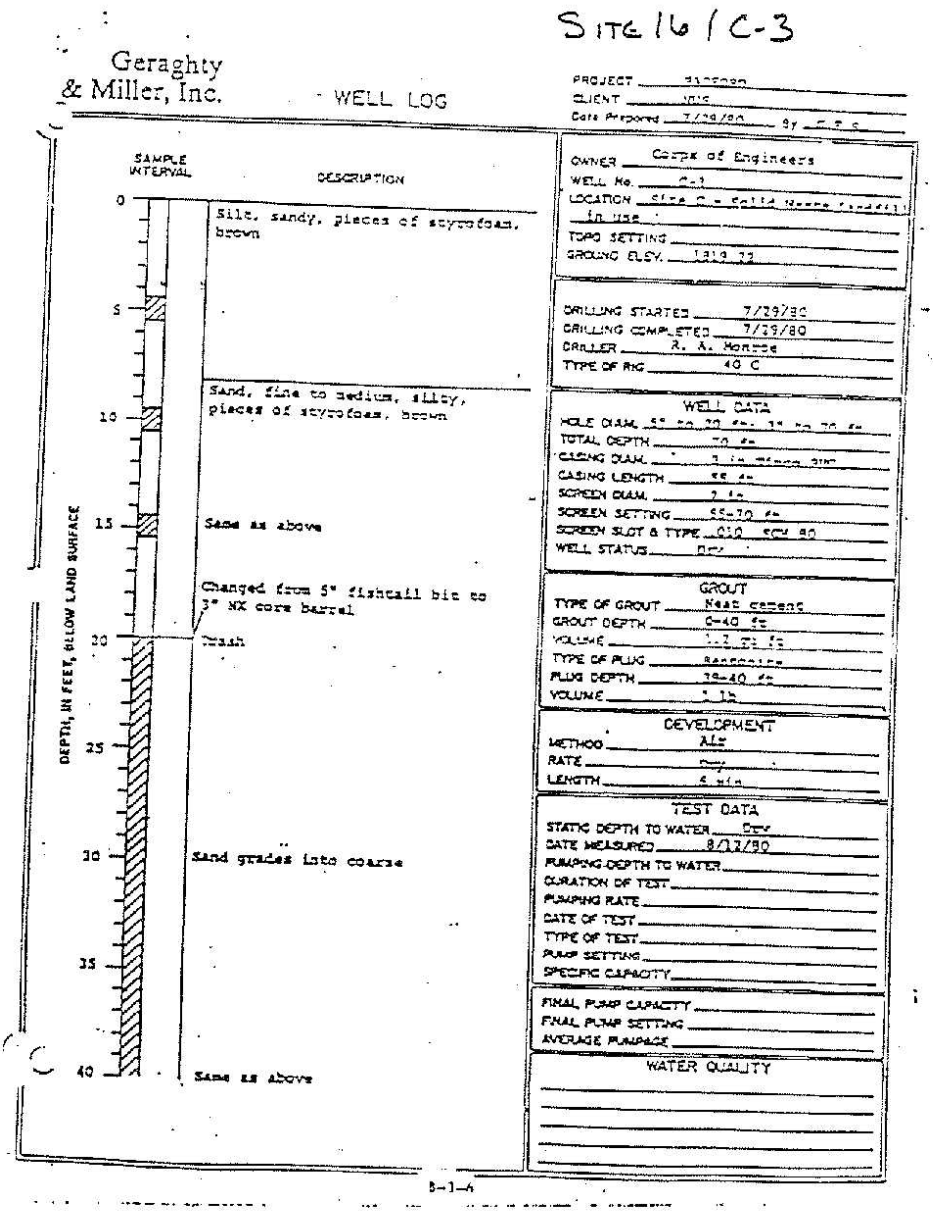
*No. of blows required for a 140 lb. hammer dropping 30 in. to drive 2 in O.D., 1.375 in. I.D. sampler a total of 18 inches in three 6 in. increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N.

Scale 1"=5' unless otherwise noted


16\WC2-A
Project: Radford Army Ammunition Plant
Driller: W. Simmons
Location: Radford, Virginia
Inspector: Smith
Client: Hercules, Inc.
Date Installed: 10/13/87
WELL No.
WC2-A
Screen Description: 0.010" slot, 2.0" I.D. Teflon Screen
Sand Size: D (10) = 0.45-0.55mm
Riser Description: 2.0" I.D. Teflon Riser and PVC Riser
Bore/Core Size: 6 Inch/NX
Casing Stickup (ft.)= 2.0
Elev. =
Riser Stickup (ft.) = 2.0
Elev. =
Ground Elev.= ----
Depth to Bentonite (ft.)= 53.0'
Elev. =
Depth to Sand Filter(ft.)= 58.0'
Elev. =
Depth to Well Bottom(ft.)= 69.5
Elev. =
Depth of Hole (ft.) = 82.0
Elev. =
Subsurface Conditions Summary
Cobbles or rock lenses encountered at 40.0 ft. and 70.0 ft.
Weathered rock encountered at 72.0 ft.
Subsurface water encountered at:
-62.0 ft. below ground surface at 1:50 p.m. on 10/13/87
-60.7 ft. below ground surface at 1:20 p.m. on 10/14/87
-62.5 ft. below ground surface at 2:10 p.m. on 10/30/87
-61.8 ft. below ground surface at 9:30 a.m. on 11/6/87
-61.9 ft. below ground surface at 10:00 a.m. on 11/9/87
*Actual measurement not obtainable

Appendix 14

Well 16C3 (Piezometer)



SITE 16 / C-3

Geraghty & Miller, Inc. — WELL LOG

PROJECT
CLIENT
Date Prepared 7/29/80 By

SAMPLE INTERVAL | DESCRIPTION | DEPTH, IN FEET, BELOW LAND SURFACE

0–5: Silt, sandy, pieces of styrofoam, brown
5–15: Sand, fine to medium, silty, pieces of styrofoam, brown
15–20: Same as above
20: Changed from 5" fishtail bit to 3" NX core barrel
20–30: Trash
30–40: Sand grades into coarse
40: Same as above

OWNER Corps of Engineers
WELL No. C-3
LOCATION Site C - Solid Waste Landfill
in use
TOPO SETTING
GROUND ELEV. 1319.72

DRILLING STARTED 7/29/80
DRILLING COMPLETED 7/29/80
DRILLER R. A. Monroe
TYPE OF RIG 40 C

WELL DATA
HOLE DIAM. 5" to 20 ft, 3" to 70 ft
TOTAL DEPTH 70 ft
CASING DIAM. 2 in plain pipe
CASING LENGTH 55 ft
SCREEN DIAM. 2 in
SCREEN SETTING 55-70 ft
SCREEN SLOT & TYPE .010 PCV 80
WELL STATUS Dry

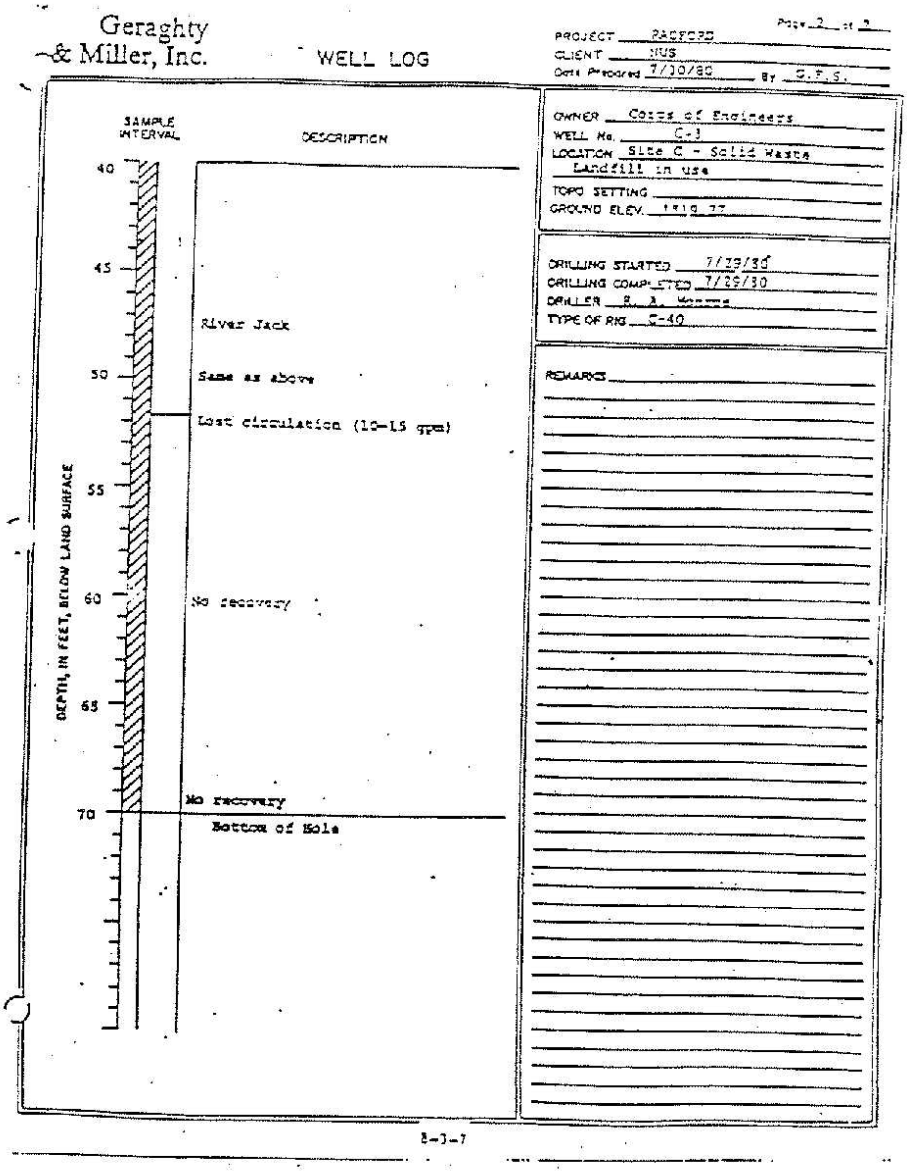
GROUT
TYPE OF GROUT Neat cement
GROUT DEPTH 0-40 ft
VOLUME 1.2 cu ft
TYPE OF PLUG Bentonite
PLUG DEPTH 38-40 ft
VOLUME 1 lb

DEVELOPMENT
METHOD Air
RATE Dry
LENGTH 5 min

TEST DATA
STATIC DEPTH TO WATER Dry
DATE MEASURED 8/12/80
PUMPING DEPTH TO WATER
DURATION OF TEST
PUMPING RATE
DATE OF TEST
TYPE OF TEST
PUMP SETTING
SPECIFIC CAPACITY
FINAL PUMP CAPACITY
FINAL PUMP SETTING
AVERAGE PUMPAGE

WATER QUALITY

B-1-A



Geraghty & Miller, Inc.

WELL LOG

PROJECT RADFORD
CLIENT AUS
Date Prepared 7/30/80 By G.F.S.

OWNER Corps of Engineers
WELL No. C-1
LOCATION Site C - Solid Waste Landfill in use
TOPO SETTING
GROUND ELEV. 1819.77

DRILLING STARTED 7/29/80
DRILLING COMPLETED 7/29/80
DRILLER R. A. Wooms
TYPE OF RIG C-40

REMARKS

SAMPLE INTERVAL

DESCRIPTION

DEPTH, IN FEET, BELOW LAND SURFACE

40
45
50
55
60
65
70

River Jack

Same as above

Lost circulation (10-15 gpm)

No recovery

No recovery

Bottom of Hole

B-1-7

Appendix 15

Well 16CDH3 (Piezometer)

Appendix 16.
Other Wells

Well 16-4
Well 16C-2
Well 16C-4
Well 16DH-2

BORING LOG

FROEHLING & ROBERTSON, INC.
FULL SERVICE LABORATORIES • ENGINEERING CHEMICAL
"ONE HUNDRED YEARS OF SERVICE"

Report No. ROL-42188
DATE November, 1984

Client: Hercules, Inc.

Project: Radford Army Ammunition Plant; Monitoring Wells, Horseshoe Area   Radford, VA

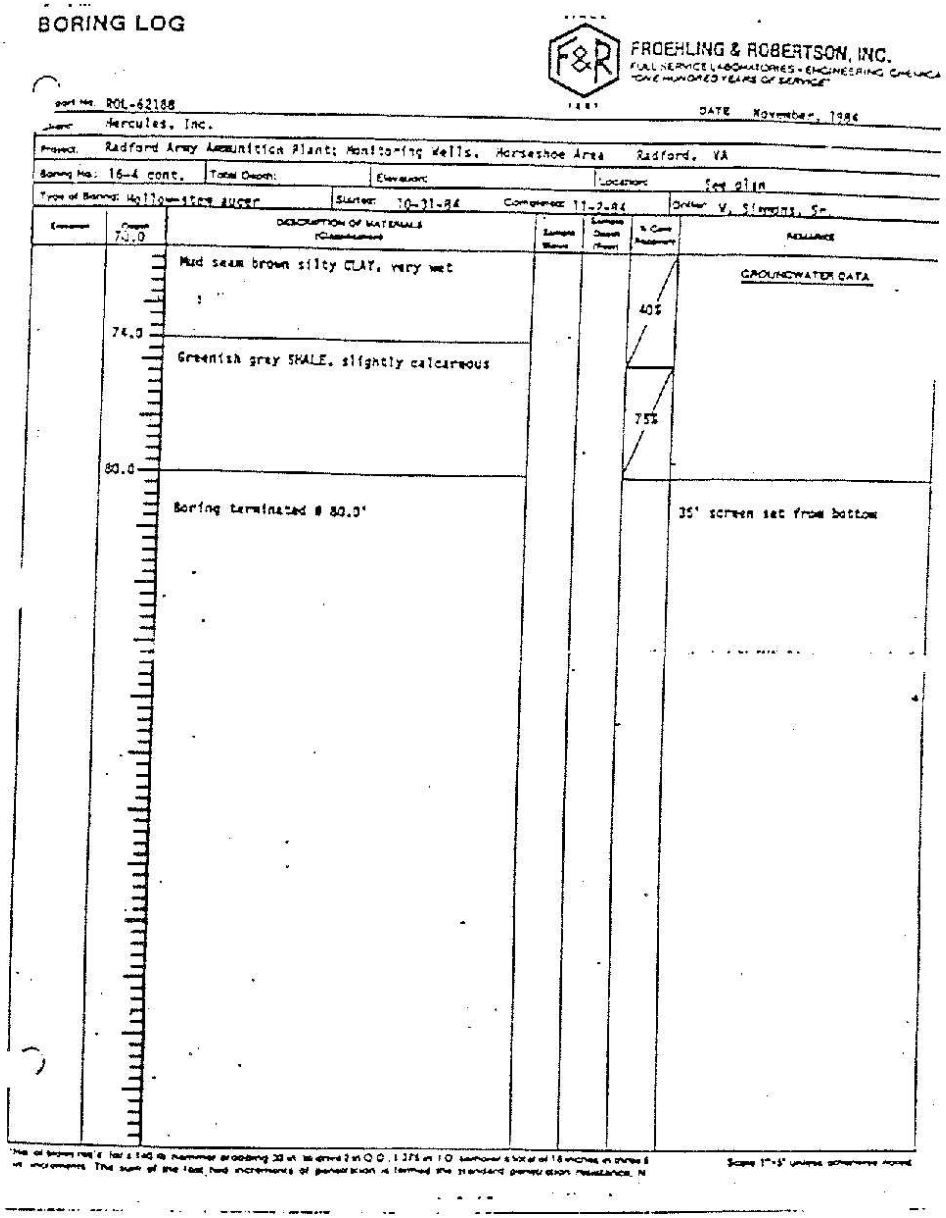
Boring No.: 16-4 cont.   Total Depth: Elevation: Location: See plan

Type of Boring: Hollow-stem auger   Started: 10-31-84   Completed: 11-2-84   Driller: V. Simmons, Sr.

Elevation	Depth 35.0	Description of Materials (Classification)	Sample Blows	Depth (feet)	% Core Recovery	Remarks
		Hard grey-tan clayey SILT, trace fine sand, relict structure -RESIDUUM-	24/30	36.0		GROUNDWATER DATA
		Weathered SHALE		39.5		
			12/14/25	41.0		
				44.5		
			20/.1	45.1		* 40/0.1'
						Water level measured @ 48.5' on 11-5-84
				49.5		
	50.0		*	50.0		* 50/0.5'
		Auger refusal - coring commenced. Highly fractured green and maroon thinly laminated SHALE with calcite-healed fractures and dolomitic laminae (ROME FORMATION)			27%	
				55.0		
					48%	
				60.0		
					57%	
				65.0		
					70%	
				70.0		

*No. of blows req'd. for a 140 lb. hammer dropping 30 in. to drive 2 in. O.D., 1.375 in. I.D. sampler a total of 18 inches in three 6 inch increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N.

Scale 1"=5' unless otherwise noted



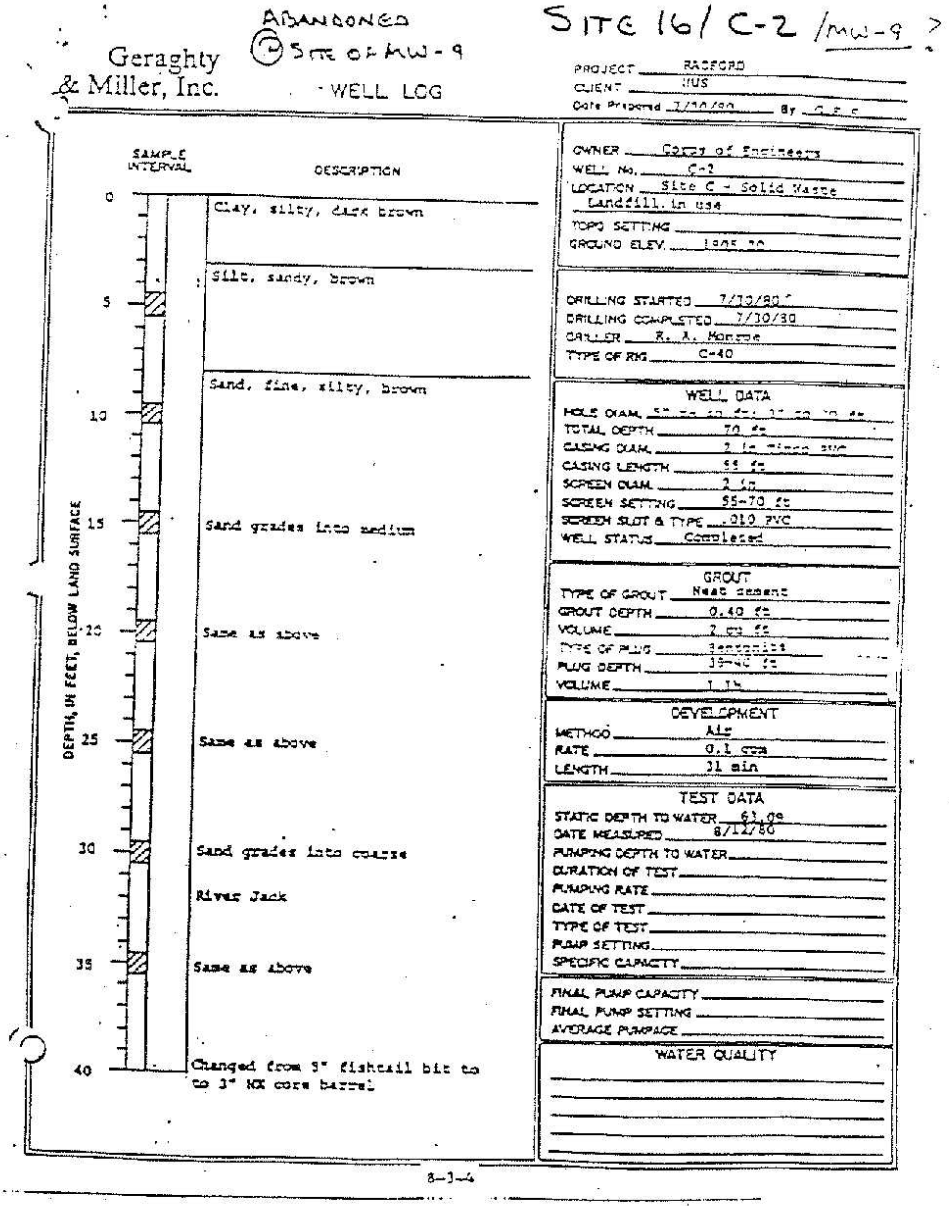
BORING LOG

FROEHLING & ROBERTSON, INC.
FULL SERVICE LABORATORIES - ENGINEERING CONSULTANTS
FIVE HUNDRED YEARS OF SERVICE

Job No. ROL-62188 DATE November, 1986
Client Hercules, Inc.
Project Radford Army Ammunition Plant; Monitoring Wells, Horseshoe Area Radford, VA
Boring No. 16-4 cont. Total Depth: Elevation: Location: See plan
Type of Boring: Hollow-stem auger Started: 10-31-84 Completed: 11-2-84 Driller V. Simmons, S.

Elevation	Depth 70.0	DESCRIPTION OF MATERIALS (Classification)	Sample Water	Sample Depth (Feet)	% Core Recovery	REMARKS
		Mud seam brown silty CLAY, very wet			40%	GROUNDWATER DATA
	74.0	Greenish gray SHALE, slightly calcareous			75%	
	80.0	Boring terminated @ 80.0'				35' screen set from bottom

Scale 1"=5' unless otherwise noted



ABANDONED
Site of MW-9

SITE 16/ C-2 /MW-9 ?

Geraghty & Miller, Inc. - WELL LOG

PROJECT RADFORD
CLIENT HUS
Date Prepared 7/30/80 By C.E.C

SAMPLE INTERVAL	DESCRIPTION
0	Clay, silty, dark brown
5	Silt, sandy, brown
10	Sand, fine, silty, brown
15	Sand grades into medium
20	Same as above
25	Same as above
30	Sand grades into coarse
	River Jack
35	Same as above
40	Changed from 5" fishtail bit to 3" NX core barrel

DEPTH, IN FEET, BELOW LAND SURFACE

OWNER Corps of Engineers
WELL No. C-2
LOCATION Site C - Solid Waste Landfill, in use
TOPO SETTING
GROUND ELEV. 1905.20

DRILLING STARTED 7/30/80
DRILLING COMPLETED 7/30/80
DRILLER R. L. Monroe
TYPE OF RIG C-40

WELL DATA
HOLE DIAM. [illegible]
TOTAL DEPTH 70 ft
CASING DIAM. 2 in Sch 40 PVC
CASING LENGTH 55 ft
SCREEN DIAM. 2 in
SCREEN SETTING 55-70 ft
SCREEN SLOT & TYPE .010 PVC
WELL STATUS Completed

GROUT
TYPE OF GROUT Neat cement
GROUT DEPTH 0-40 ft
VOLUME 2 cu ft
TYPE OF PLUG Bentonite
PLUG DEPTH 39-40 ft
VOLUME 1.14

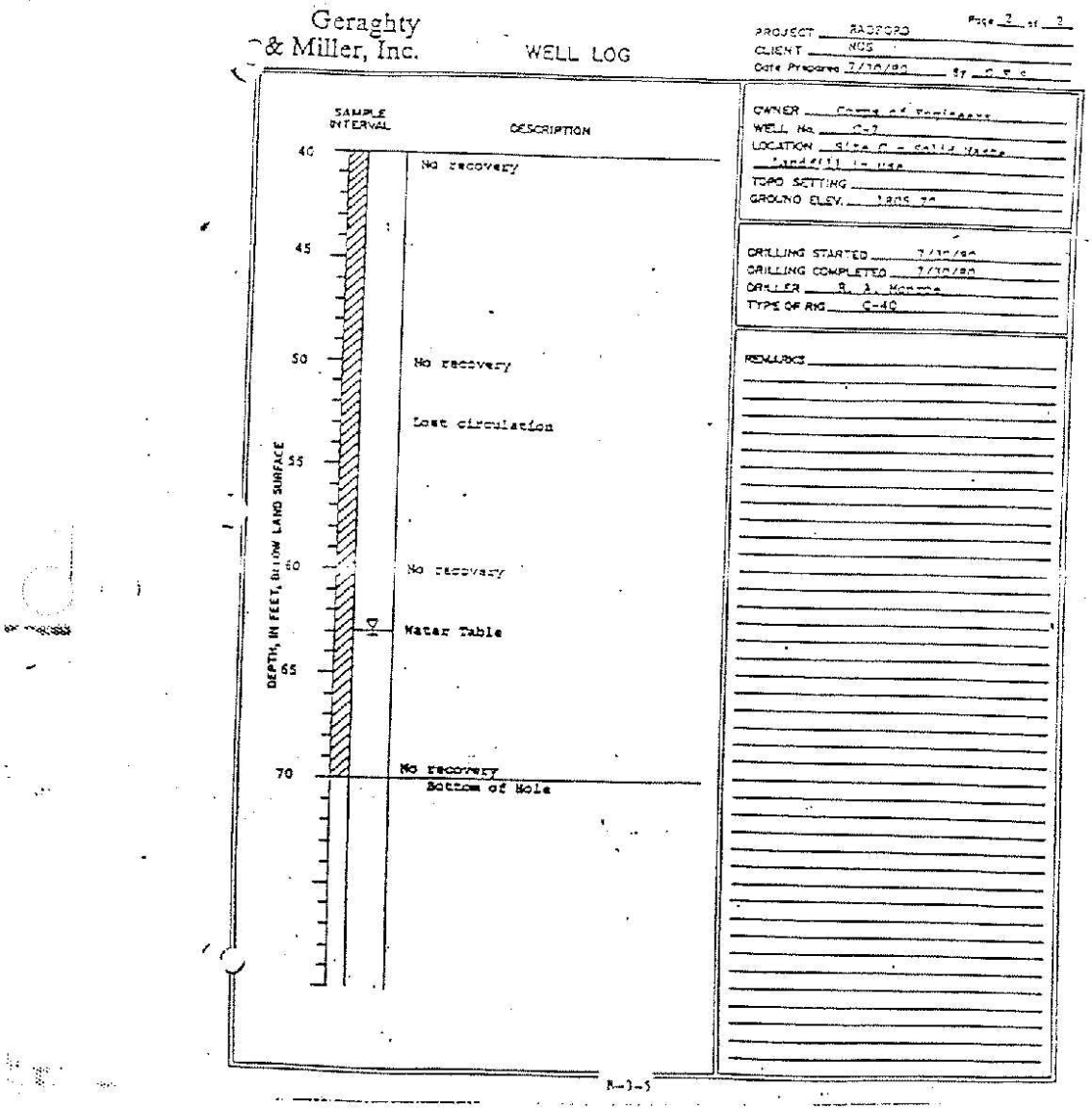
DEVELOPMENT
METHOD Air
RATE 0.1 cfm
LENGTH 31 min

TEST DATA
STATIC DEPTH TO WATER 61.08
DATE MEASURED 8/11/80
PUMPING DEPTH TO WATER
DURATION OF TEST
PUMPING RATE
DATE OF TEST
TYPE OF TEST
PUMP SETTING
SPECIFIC CAPACITY

FINAL PUMP CAPACITY
FINAL PUMP SETTING
AVERAGE PUMPAGE

WATER QUALITY

8-1-4



Geraghty & Miller, Inc.

WELL LOG

PROJECT RADFORD
CLIENT NOS
Date Program 7/10/80

OWNER County of Pulaski
WELL No. G-7
LOCATION Site G - Solid Waste Landfill in use
TOPO SETTING
GROUND ELEV. 1805.70

DRILLING STARTED 7/10/80
DRILLING COMPLETED 7/10/80
DRILLER B. J. Hamme
TYPE OF RIG C-40

REMARKS

SAMPLE INTERVAL

DESCRIPTION

DEPTH, IN FEET, BELOW LAND SURFACE

40 — No recovery
45
50 — No recovery
Lost circulation
55
60 — No recovery
Water Table
65
70 — No recovery
Bottom of Hole

Site 16 / C-4

Geraghty & Miller, Inc.

WELL LOG

PROJECT RADFORD
CLIENT NUS
Core Prepared 7/29/80 By G. E. S.

SAMPLE INTERVAL	DESCRIPTION
0	Silt, clayey, brown
5	Sand, fine, very silty, brown
10	Same as above
15	Same as above
20	Same as above
25	Same as above
	River Jack
	Changed from 5" fishtail bit to 3" NX core barrel
30	
35	In and out of River Jack to Top of Rock
40	Same as above

DEPTH, IN FEET, BELOW LAND SURFACE

OWNER Corps of Engineers
WELL No. C-4
LOCATION Site C - Solid Waste Landfill
TOPO SETTING
GROUND ELEV. 1871.61

DRILLING STARTED 7/29/80
DRILLING COMPLETED 7/29/80
DRILLER M. J. Dean
TYPE OF RIG CME-75

WELL DATA
HOLE DIAM. 5" to 27.5 ft; 3" to 70 ft
TOTAL DEPTH 70 ft
CASING DIAM. 2 in. Sch 40 PVC
CASING LENGTH 55 ft
SCREEN DIAM. 2 in.
SCREEN SETTING 55-70 ft
SCREEN SLOT & TYPE .010 PVC
WELL STATUS Completed

GROUT
TYPE OF GROUT Neat cement
GROUT DEPTH 0-40 ft
VOLUME 1.5 cu ft
TYPE OF PLUG Bentonite
PLUG DEPTH 38-40 ft
VOLUME 1 lb

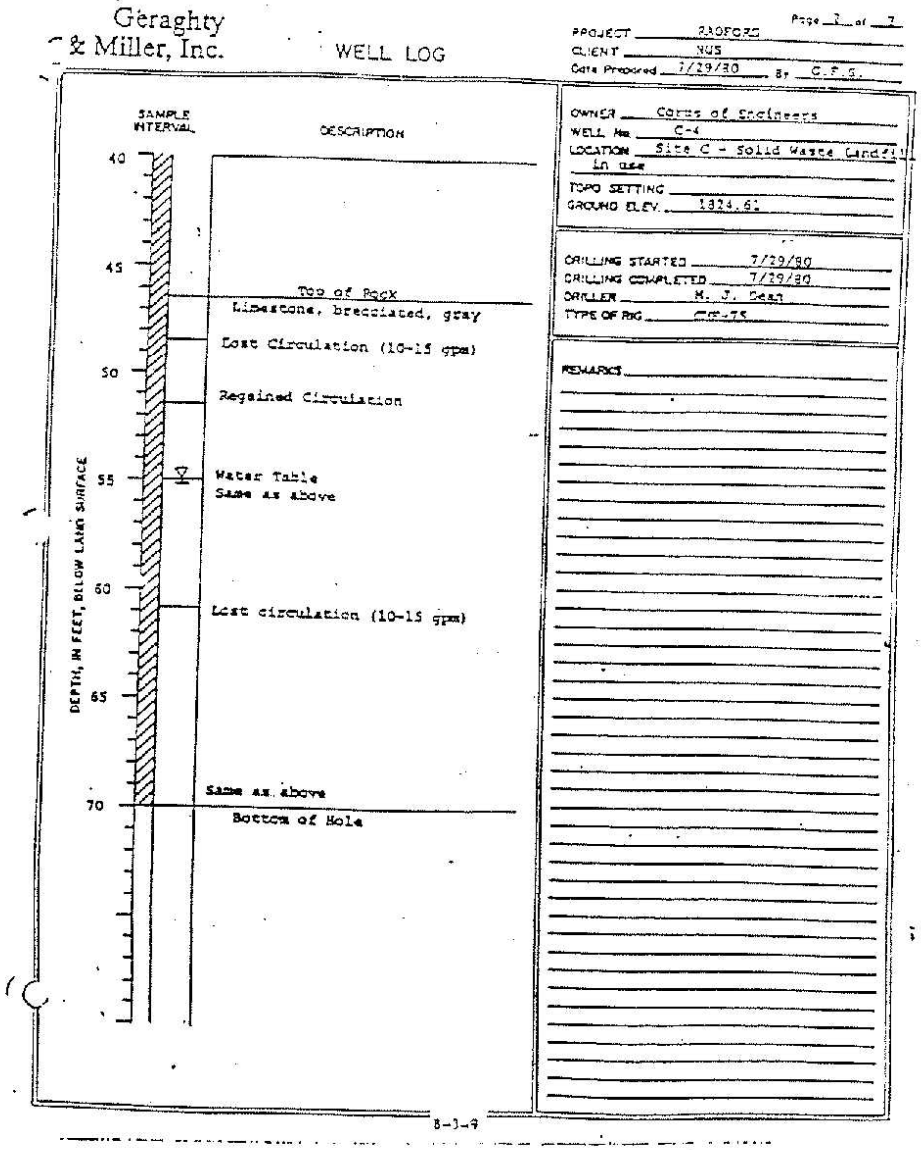
DEVELOPMENT
METHOD Air
RATE 0.1 cfm
LENGTH 15 min

TEST DATA
STATIC DEPTH TO WATER 54.96
DATE MEASURED 8/12/80
PUMPING DEPTH TO WATER
DURATION OF TEST
PUMPING RATE
DATE OF TEST
TYPE OF TEST
PUMP SETTING
SPECIFIC CAPACITY

FINAL PUMP CAPACITY
FINAL PUMP SETTING
AVERAGE PUMPAGE

WATER QUALITY

A-1-8



Geraghty & Miller, Inc.

WELL LOG

Page 3 of 7

PROJECT RADFORD
CLIENT NUS
Date Prepared 7/29/80 By C.F.S.

OWNER Corps of Engineers
WELL No. C-4
LOCATION Site C - Solid Waste Landfill In use
TOPO SETTING
GROUND ELEV. 1324.6'

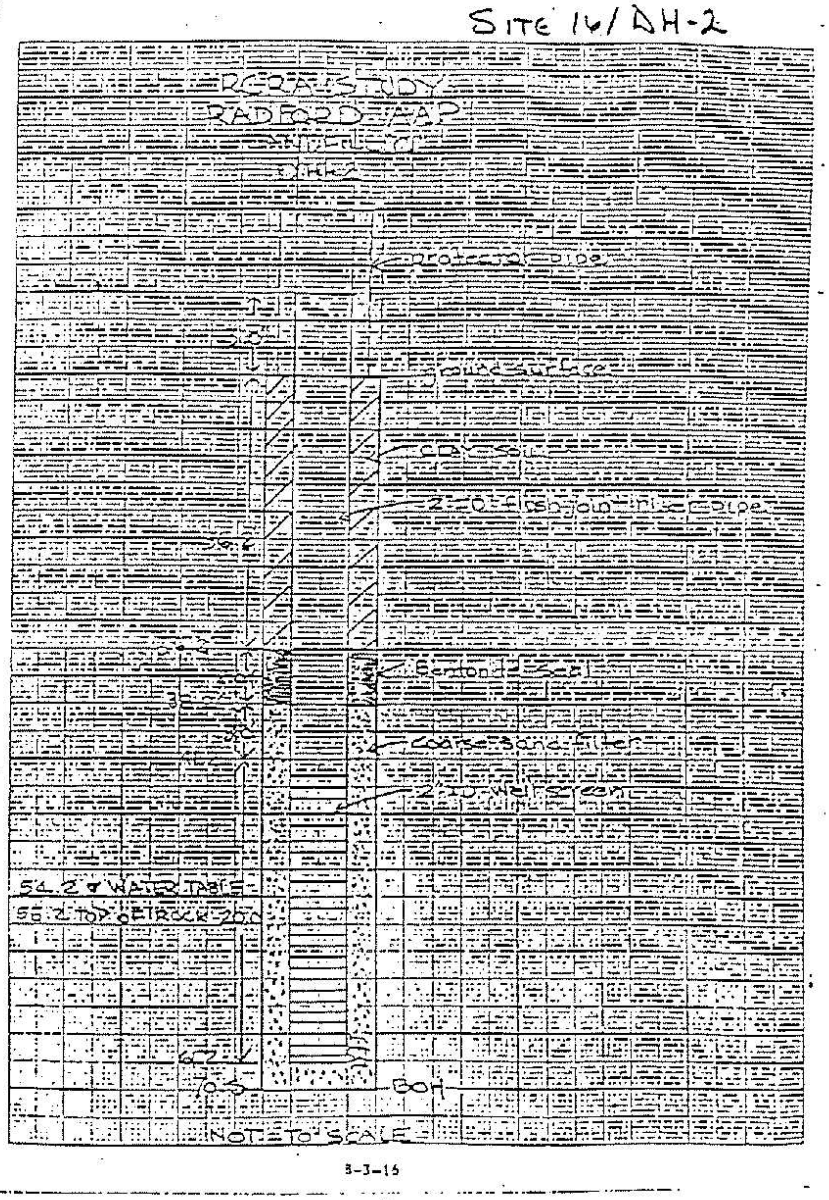
DRILLING STARTED 7/29/80
DRILLING COMPLETED 7/29/80
DRILLER M. J. Deal
TYPE OF RIG CME-75

REMARKS

SAMPLE INTERVAL	DESCRIPTION
	Top of Rock
	Limestone, brecciated, gray
	Lost Circulation (10-15 gpm)
	Regained Circulation
	Water Table
	Same as above
	Lost circulation (10-15 gpm)
	Same as above
	Bottom of Hole

DEPTH, IN FEET, BELOW LAND SURFACE: 40, 45, 50, 55, 60, 65, 70

8-1-9


SITE 16/DH-2
RADFORD AAP
NOT TO SCALE
8-3-16

SITE 16 / DH-2

Hole No. DH-2

DRILLING LOG

Division: NAD

Installation: [illegible]

Sheet 1 of 2 sheets

1. Project: LANDFILL C - RCRA STUDY

Size and type of bit: 3" OD [illegible]

Datum for elevation shown: MSL

Drilling agency: [illegible]

Manufacturer's designation of drill: CME - 75

Hole No.: DH-2

Total no. of overburden samples taken: Disturbed 11; Undisturbed 3

Name of driller: MARVIN [illegible]

Total number core boxes: 1

Direction of hole: Vertical

Elevation ground water: 54.2 (   )

Date hole: Started 17 JULY 80; Completed 23 JULY 80

7. Thickness of overburden: 53.3

8. Depth drilled into rock: 13.3

9. Total depth of hole: 70.5

Total core recovery for boring: 6.3 / 54 %

Elevation	Depth	Legend	Classification of materials	% Core recovery	Box or sample no.	Remarks
			2" topsoil		S-1	Split Spoon 3-3-6
			(CL) Clay, some silt & v. fn. to sand, med plast., red brn, moist			K(0-3) = .75 ft./day
					S-2	Split Spoon 3-4-5
						K(0-13) = .28 ft./day
					S-3	Split Spoon 4-4-7
						Shelby Tube 11.5-13
						K(0-15) = .22 ft./day
					S-4	Split Spoon 6-8-11
						K(15-20) = .37 ft./day
					S-5	Split Spoon [illegible]
						Shelby Tube 21.5-23
						K(20-25) = .29 ft./day
					S-6	Split Spoon 4-5-10
						K(25-31.5) = .17 ft/day
					S-7	Split Spoon 4-4-7
	32		CL - More Silt and fine sand			K(30-35) = .06 ft/day
					S-8	Split Spoon 3-3-4
						Shelby Tube 36.5-38
	38		(SM) SAND, very fine-fine some silt, yellow-brown moist			K(35-40) = .11 ft/day
					S-9	Split Spoon 6-11-16
						K(40-45) = .69 ft/day
	44		(SM) Some Gravel (1") below 44'		S-10	Split Spoon [illegible]
						K(45-50) = 16.2 ft/day

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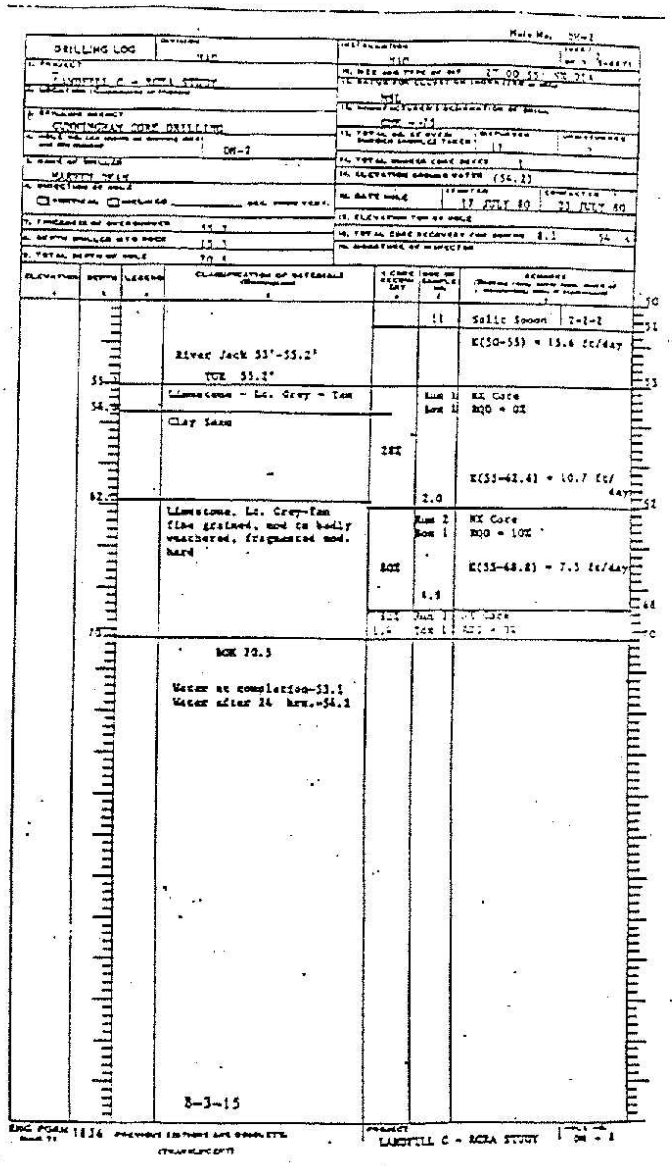
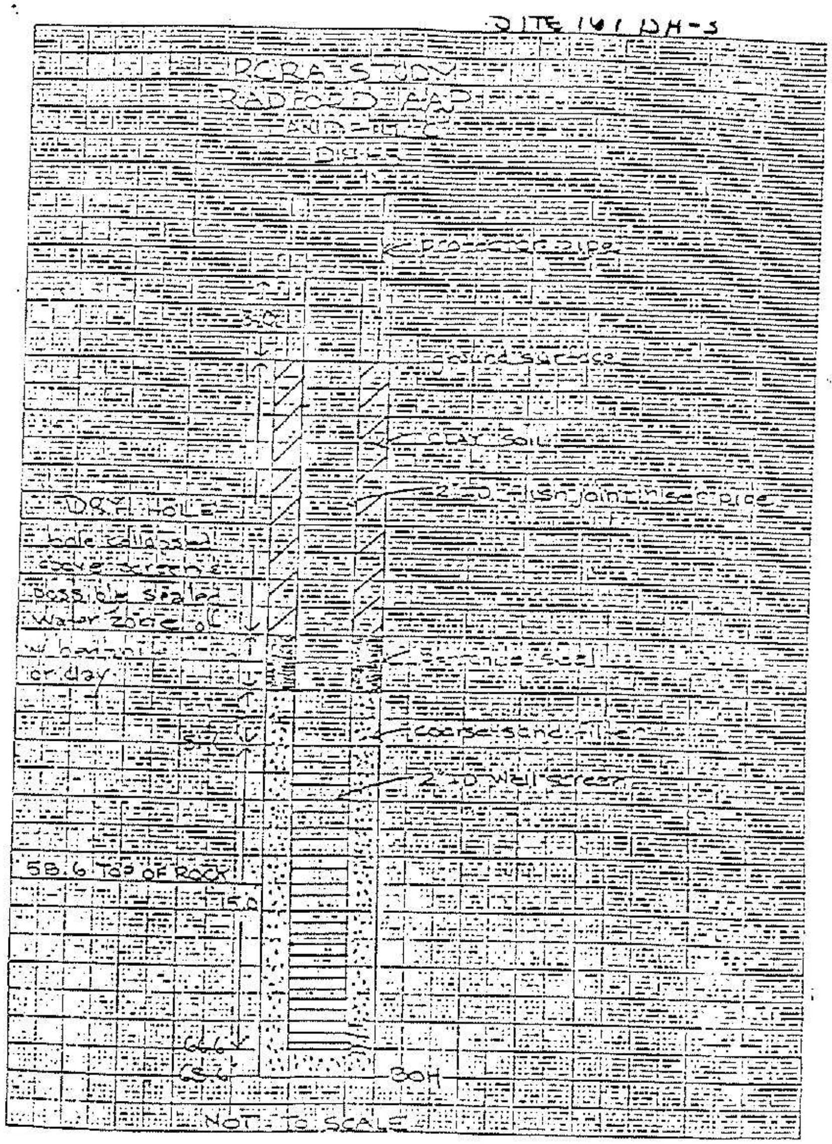
Project: LANDFILL C - RCRA STUDY

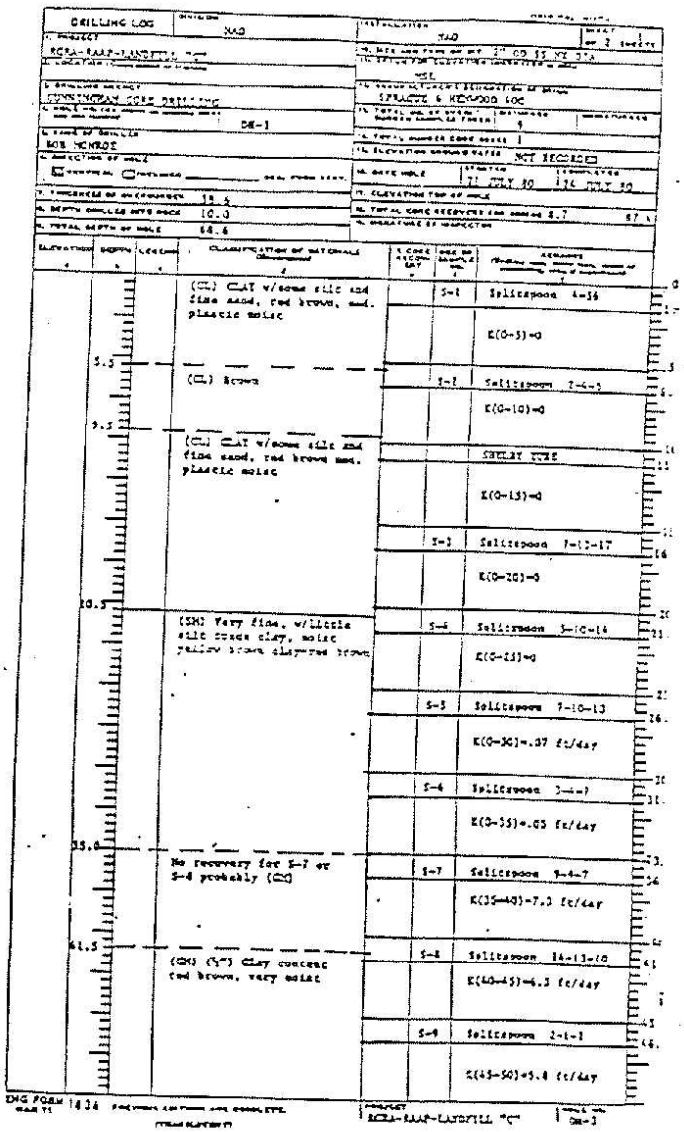
Hole No.: DH-2


DRILLING LOG
River Jack 53'-55.2'
TOE 55.2'
Limestone - Lt. Grey - Tan
Clay Seam
Limestone, Lt. Grey-Tan fine grained, mod to badly weathered, fragmented mod. hard
BOH 70.5
Water at completion-53.1
Water after 24 hrs.-54.1
8-3-15


RCRA STUDY
RADFORD AAP
DRY HOLE
CLAY SOIL
58.6 TOP OF ROCK
BOH
NOT TO SCALE

3-3-19

Site 16 / DH-3



8-3-17

Hole No. DM-1

DRILLING LOG

Division	NAD
Installation	NAD
Sheet	1 of 1 sheets
1. Project	RCRA-RAAP-LANDFILL "C"
2. Location	
3. Drilling Agency	CUNNINGHAM CORE DRILLING
4. Hole No.	DM-1
5. Name of Driller	BOB MONROE
6. Direction of Hole	[X] Vertical [ ] Inclined
7. Thickness of Overburden	54.6
8. Depth Drilled into Rock	10.0
9. Total Depth of Hole	58.6
10. Size and Type of Bit	
11. Datum for Elevation Shown	MSL
12. Manufacturer's Designation of Drill	SPRAGUE & HENWOOD 40C
13. Total No. of Over-burden Samples Taken	9
14. Total Number Core Boxes	1
15. Elevation Ground Water	NOT RECORDED
16. Date Hole	Started 31 JULY 80; Completed 31 JULY 80
17. Elevation Top of Hole	
18. Total Core Recovery for Boring	5.7 / 57 %
19. Signature of Inspector	

Elevation	Depth	Legend	Classification of Materials	% Core Recovery	Box or Sample No.	Remarks
			(CL) CLAY w/silt, sand & gravel v. moist med plastic red brown		S-10	Splitspoon 2-2-3
						K(50-55)=4.3 ft./day
					S-11	Splitspoon 2-2-3
						K(56-58.6)=7.4 ft./day
	54.6		Top 58.6 LIMESTONE - badly fractured lt.-dark gray, calcite healed fractures.	90	Run Box	NX Core RQD=0%
					4.2	K(58.6-64.6)= 2.6 ft/day
				50	Run 2 Box 1 2.1	NX Core RQD=0%
	68.6		BOH 68.6 Water level not recorded dry after installing monitoring well.			

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PROJECT RCRA-RAAP-LANDFILL "C" HOLE NO. DM-1

B-3-18

ATTACHMENT V.H - METHODOLOGY FOR GROUNDWATER WELL ABANDONMENT

The Permittees shall receive prior approval from the Department to abandon any monitoring wells and/or piezometers. Well abandonment activities must be completed in accordance with the Department's well abandonment policy (Recommended Well Abandonment Policy, VDEQ, July 10, 2015, or most recent policy). The following procedures shall be used:

V.H-A. Monitoring wells and/or piezometers will be abandoned by pressure grouting methods. Surface installations (protective covers or manholes) will be removed and an attempt to pull the casing string with the rig will be made. Once this has either been accomplished or has failed, grouting operations will commence as described below.

a. Monitoring well abandonment will be accomplished by lowering a tremie pipe to the bottom of the borehole.

b. Portland cement/bentonite grout will then be pumped down the tremie pipe until an even flow of consistent grout returns at the surface.

c. The tremie pipe will be removed from the borehole on completion of grouting operations and a minimum four inch thick and six foot diameter concrete cap will be constructed over the grouted borehole.

V.H-B. Removed casings will be steam cleaned, cut up into manageable sections, and disposed of as refuse.

V.H-C. All tremie rods and other downhole equipment will be steam cleaned prior to introduction into the hole or well.

V.H-D. All decontamination fluid will be containerized and handled pursuant to decontamination fluid handling procedures contained in Attachment V.B.

ATTACHMENT V.I - STATISTICAL PROCEDURES

V.I-A. HIGHLIGHTS

In accordance with 40 CFR 264.97(g), the Permittees shall collect an appropriate number of samples from the monitoring wells specified in Permit Section V.D or Permit Section VI.C. The Permittees shall ensure that an appropriate number of background samples for the preferred method of statistical analysis shall have been collected prior to the scheduled date of the statistical analysis.

Statistical analysis of the ground water data shall include the following:

- Outliers
- Testing of normality
- Evaluation of data below detection limits or quantitation limits
- Selection of statistical method
- Verification sampling strategy (optional)
- Comparison of point of compliance monitoring well data to the Concentration Limit specified in Permit Attachments V.F, VI.B, and VI.C (GPS) *(Ground Water Protection Standards - Concentration Limit of Constituents for Ground Water Protection).*

V.I-B. OUTLIERS

All data shall be investigated to verify outliers. An outlier refers to a data point that is an inconsistently large or small value. Outliers may be due to sampling, laboratory, transportation, or transcription errors. To remove the possibility of including data with this type of error, the Permittees should screen the historical data for each monitoring well and constituent for the existence of outliers (USEPA 1992, §6.2) using the method described by Dixon (1953). The Permittees shall receive approval from the Department before eliminating any outliers.

V.I-C. TESTING NORMALITY OF DATA DISTRIBUTION

The Permittees shall verify that the distribution of the monitoring data for the Hazardous Constituents is consistent with the assumptions of the selected statistical test method(s). The Permittees shall determine whether the distribution of the monitoring data is normal or lognormal using a multiple group version of the Shapiro-Wilk test. The monitoring data is log-normally distributed if, when the original monitoring data is transformed by taking the natural logarithms, the distribution of the transformed monitoring data is normally distributed.

The Permittees may use any other appropriate method for testing the distributional assumptions (see Gibbons 1994a for a review, also see USEPA

1992). However, the Permittees must demonstrate to the satisfaction of the Department that the alternative method can detect deviations from normality with similar power as the Shapiro-Wilk and Shapiro-Francia methods.

The Permittees is not required to test for normality when the percentage of non-detects or non-quantified values is greater than 50 percent.

V.I-D. EVALUATION OF MONITORING DATA BELOW DETECTION LIMITS OR QUANTITATION LIMITS

The Permittees shall evaluate the ground water monitoring data that is less than the laboratory detection limit or quantitation limit as specified below.

V.I-D.1. If the percentage of non-detects or non-quantified values is less than 25 percent, then the Permittees shall replace the non-detects or non-quantified values with one-half the laboratory limit of detection or quantitation in accordance with 40 CFR 264.97(h) and 264.97(i)(5).

V.I-D.2. If the percentage of non-detects or non-quantified values is between 25 percent and 50 percent, then the Permittees may adjust the mean and standard deviation using Atchison's method (USEPA 1992, §2.2.2 and Aitchison, 1955). An acceptable alternative to Aitchison's method is Cohen's maximum likelihood estimator (Cohen, 1961). Extensive tables and computational details are also provided in Gibbons, 1994a. The approach for selection between the two methods is described in USEPA (1992, §2.2.1.).

V.I-D.3. If the percentage of non-detects or non-quantified values is greater than 50 percent, then the Permittees may use a non-parametric method.

V.I-D.4. If 80 percent or greater of the data are non-detects, or if the data follow a Poisson distribution, then the Permittees may use an interval method which is based on the Poisson distribution (USEPA 1992, §2.2.4 and 2.2.5).

V.I-E. SELECTION OF STATISTICAL METHODS

V.I-E.1. Level of Significance (Performance Standards)

The Permittees shall select statistical methods that achieve a level of significance (Type I error) of no less than 0.01 for individual monitoring well comparisons, and no less than 0.05 for multiple comparisons, in accordance with 40 CFR 264.97(i)(2). However, these performance standards do not apply for prediction intervals, tolerance intervals, and control charts. The false positive rate for these interval methods or control charts may depend on the number of data points available from the background monitoring well(s) at the time of statistical comparison. A larger number of background data points can decrease the false positive rate for these tests.

If the Permittees uses an interval or other statistical method, and if the selected method requires additional samples, then the Permittees shall collect the additional samples prior to the date specified in Permit Section V.I.4. The statistical comparison shall not be delayed due to collection of an inadequate number of samples.

The false positive rate for a single constituent/well comparison shall not be lower than 0.01 unless the Permittees can demonstrate that an alternative false positive rate will provide at least 50 percent power to detect a 3 standard deviation increase above background levels and 80 percent power to detect a 4 standard deviation increase above background levels.

V.I-E.2. Selection Criteria

After determining the distribution of the data, the Permittees shall select appropriate statistical methods based on the following:

a. If the detection frequency is less than 20 percent (i.e. non-detects greater than 80 percent) and/or data are shown to fit a Poisson distribution, then the Permittees may use a Poisson prediction or tolerance limit.

b. If the detection frequency is less than 50 percent (i.e. non-detects greater than 50 percent) or transformation fails to bring about normality, then the Permittees may use a non-parametric method.

c. If the detection frequency is between 50 percent and 75 percent (i.e. non-detects between 25 percent and 50 percent), then the Permittees may use a parametric test performed with an adjustment for non-detects; Aitcheson's or Cohen's adjustments are recommended. Determination of the appropriate adjustment to be applied shall be based on the properties of the data set (USEPA, 1992, §2.2).

d. If the detection frequency is 75 percent or greater, then the Permittees may use an appropriate parametric test without adjusting for non-detects. Non-detects should be analyzed using one-half the limit of detection or quantitation.

V.I-E.3. Statistical Methods

a. Interval Methods

If the Permittees uses an interval method and the percentage of detects is greater than 50 percent, then the Permittees shall test the monitoring data from the background monitoring well(s) for normality. If the monitoring data from the background monitoring well(s) are normally or log-normally distributed, then the Permittees may use a parametric interval method. Appendix 2 (see below) provides the suggested minimum number of samples for calculation of parametric interval methods that are acceptable to the Department.

If the background monitoring well(s) monitoring data are neither normally nor log-normally distributed, then the Permittees may use either a non-parametric interval method or an interval method based on the Poisson distribution (if appropriate). Appendix 2 provides suggested test methods and recommended

minimum sample size requirements.

The Permittees may conduct a statistical analysis with a smaller data set than the suggested size at any time. However, these methods can lead to higher false positive or false negative rates with smaller samples sizes. For each sampling event, the Permittees shall calculate the appropriate interval for the background monitoring well(s) based on the method selected, and compare the monitoring data from each point of compliance monitoring well to the calculated upper limit. If the point of compliance monitoring well data exceeds the upper limit for any constituent, then the Permittees shall report that there has been a statistical increase of contaminants in the ground water, in accordance with Permit Section V.J or Permit Section VI.I.2.

b. Alternative Statistical Methods

The Permittees may use alternative statistical methods that meet the performance standards specified in 40 CFR 264.97(i). The Permittees shall obtain approval from the Department prior to using alternative statistical methods. If the Permittees selects any other statistical method not listed in 40 CFR 264.97(h), then the Permittees shall collect an appropriate number of samples and shall maintain the appropriate level of significance and power, as specified above.

V.I-F. VERIFICATION SAMPLING (OPTIONAL)

Verification resampling can be an integral part of the statistical methodology (USEPA, 1992, §5); however, it should be considered as a part of the statistical test and based on the site specific condition. Because the probability of an initial exceedance is very high for the site as a whole (considering only test wise false positive rates), the verification sample is considered as a part of the evaluation to conclude a statistically significant exceedance.

A pre-planned verification sample can be incorporated into the calculation of the statistical limits to calculate an upper limit using a smaller false positive rate. Without verification resampling, an attempt to minimize the false positive rates will lead to unacceptably large prediction limits. This will increase the false negative rates and decrease the power of the test to detect a release from the facility. All verification samples must be collected at the earliest time possible (prior to next scheduled sampling event) or as approved by the Department or as specified in this permit. The Department shall be informed of any planned verification resampling in advance.

Verification resampling can involve one or two samples. The Department's preferred strategy includes passing one verification resample or passing one of two verification resamples. Statistical analyses that incorporate verification samples must provide at least 50 percent power to detect a 3 standard deviation increase above background levels and 80 percent power to detect a 4 standard deviation increase above background levels.

V.I-G. COMPARISON OF GROUND WATER MONITORING WELL DATA TO

THE CONCENTRATION LIMITS SPECIFIED IN PERMIT ATTACHMENTS V.F, VI.B, AND VI.C

V.I-G.1. Comparison of Ground Water Monitoring Well Data to Background

In accordance with 40 CFR 264.92, the Permittees shall ensure that the Hazardous Constituents specified in Permit Attachments V.F, VI.B, and VI.C do not exceed the Concentration Limits (GPS) beyond the point of compliance. The Permittees shall compare the point of compliance monitoring data for each Hazardous Constituent to the Concentration Limit specified in Permit Attachments V.F, VI.B, and VI.C. If a 95% confidence upper limit calculated from the background ground water monitoring data exceeds the maximum contaminant levels (MCLs) taken from EPA's *Drinking Water Regulations and Health Advisories*, USEPA Regional Screening Levels for Chemical Contaminants at Superfund Sites (RSLs); Summary Table TR=1E-06, HQ=1), or alternate concentration limits (ACLs) approved by the Director, then Permit Attachments V.F, VI.B, and VI.C will specify the background a 95% confidence upper limit as the Concentration Limit.

If the Concentration Limit specified in Permit Attachments V.F, VI.B, and VI.C is based on background monitoring data, (i.e. tolerance or prediction limit), then the ground water monitoring data shall be compared to the Concentration Limit specified in Permit Attachments V.F, VI.B, and VI.C using a point comparison. If the ground water monitoring data exceeds the background based Concentration Limit specified in Permit Attachments V.F, VI.B, and VI.C, then the Permittees shall notify the Director of this finding in writing within seven days, in accordance with Permit Section V.I.

V.I-G.2. Comparison of Ground Water Monitoring Data to a Fixed- Standard

In accordance with 40 CFR 264.92, the Permittees shall ensure that the Hazardous Constituents specified in Permit Attachments V.F, VI.B, and VI.C do not exceed the specified Concentration Limit beyond the point of compliance. The Permittees shall compare the point of compliance monitoring data to the Concentration Limit specified in Permit Attachments V.F, VI.B, and VI.C .

If the Concentration Limit specified in Permit Attachments V.F, VI.B, and VI.C is based on a fixed-standard rather than background monitoring data, then the Permittees shall compare the ground water monitoring data to the Concentration Limit specified in Permit Attachments V.F, VI.B, and VI.C using the 95 percent lower confidence limit (LCL), computed from the last four sampling values (collected during the last 12 months).

Fixed-standards are based on the following:

- the maximum contaminant levels (MCLs) taken from EPA's *Drinking Water Regulations and Health Advisories* in effect at the time of the permit issuance;
- USEPA Regional Screening Levels for Chemical Contaminants at Superfund Sites (RSLs; Summary Table TR=1E-06, HQ=1)

- alternate concentration limits (ACLs) approved by the Director (DEQ ACLs, Health-based Risk Assessment Levels generated by the REAMs model, VURAM, or an equivalent method);

- Table 1 to 40 CFR 264 or,

- the Department accepted Quantitation Limit (QL) listed in SW-846, if the MCL, RSL, and/or ACL is less than the Department accepted Quantitation Limit (QL).

a. Parametric Confidence Interval

If the data are either normally or log-normally distributed, then the Permittees may use a parametric confidence interval to compare the ground water monitoring data at the point of compliance to the fixed- standard Concentration Limit specified in Permit Attachments V.F, VI.B, and VI.C. The Permittees shall calculate the 95 percent lower confidence limit (LCL) on the last four samples (collected during the last 12 months) and shall compare the calculated LCL to a fixed-standard Concentration Limit specified in Permit Attachments V.F, VI.B, and VI.C. If the calculated LCL of the ground water monitoring data exceeds the fixed-standard Concentration Limit specified in Permit Attachments V.F, VI.B, and VI.C, then the Permittees shall notify the Director of this finding in writing within seven days, in accordance with Permit Section V.I.

b. Non-parametric Confidence Interval

If the data are neither normally nor log-normally distributed, then the Permittees may use the minimum concentration from the last four samples (collected during the last 12 months) to compare the ground water monitoring data at the point of compliance to the fixed- standard Concentration Limit specified in Permit Attachments V.F, VI.B, and VI.C. If the minimum concentration of the ground water data exceeds the fixed-standard Concentration Limit specified in Permit Attachments V.F, VI.B, and VI.C, then the Permittees shall notify the Director of this finding in writing within seven days, in accordance with Permit Section V.I.

c. Alternative Statistical Methods

Alternative statistical methods for comparing the lower limits of ground water monitoring data at or beyond the point of compliance to the Concentration Limit specified in Permit Attachments V.F, VI.B, and VI.C based on a fixed-standard shall be approved by the Department prior to implementation. If the lower confidence limit or minimum concentration exceeds the fixed-standard Concentration Limit specified in Permit Attachments V.F, VI.B, and VI.C, then the Permittees shall notify the Director of this finding in writing within seven days, in accordance with Permit Section V.I.

V.I-G.3. Comparison of Ground Water Monitoring Well Data Using a Point Comparison (Non-statistical)

a. The Permittees may choose to use a point comparison (non-statistical approach), rather than one of the statistical methods specified above, to compare the point of compliance monitoring data with the Concentration Limit specified in Permit Attachments V.F, VI.B, and VI.C. If the point of compliance monitoring data exceeds the Concentration Limit specified in Permit Attachments V.F, VI.B, and VI.C, then the Permittees shall notify the Director of this finding in writing within seven days, in accordance with Permit Section V.I.

b. If fewer than the minimum of four concentration values have been collected during the last 12 months, then the Permittees may also use a point comparison (non-statistical approach) to compare the point of compliance monitoring data to the fixed-standard Concentration Limit as specified in Permit Attachments V.F, VI.B, and VI.C. If the ground water monitoring data exceeds the fixed-standard Concentration Limit specified in Permit Attachments V.F, VI.B, and VI.C, then the Permittees shall notify the Director of this finding in writing within seven days, in accordance with Permit Section V.I.

c. If a point comparison indicates that the point of compliance monitoring data exceeds the fixed-standard Concentration Limit specified in Permit Attachments V.F, VI.B, and VI.C, and the facility chooses not to use data from the previous three sampling events, then the Permittees shall collect additional samples (at least three additional samples are necessary to calculate a confidence interval) within the next 3 months and shall perform a statistical comparison to the fixed-standard Concentration Limit specified in Permit Attachments V.F, VI.B, and VI.C.

Appendix V.I.1. – COCHRAN'S APPROXIMATION TO THE BEHRENS-FISHER STUDENT'S T-TEST

Using all the available background data (n_b readings), calculate the background mean (X_b) and background variance (s_b^2). For the single monitoring well under investigation (n_m reading), calculate the monitoring mean (X_m) and monitoring variance (s_m^2).

For any set of data (X_1, X_2...X_n) the mean is calculated by:

$$\overline{X} = \frac{X_1 + X_2 + X_3 + \ldots X_n}{n}$$

and the variance is calculated by:

$$s^2 = \frac{(X_1 - \overline{X})^2 + (X_2 - \overline{X})^2 \ldots + (X_n - \overline{X})^2}{n - 1}$$

where "n" denotes the number of observations in the set of data.

The t-test uses these data summary measures to calculate a t-statistic (t^*) and a comparison t-statistic (t_c). The t^* value is compared to the t_c value and a conclusion reached as to whether there has been a statistically significant change in any indicator parameter.

The t-statistic for all parameters except pH and similar monitoring parameters is:

$$t^* = \frac{\overline{X}_m - \overline{X}_b}{\sqrt{\frac{s_m^2}{n_m} + \frac{s_b^2}{n_b}}}$$

If the value of this t-statistic is negative then there is no significant difference between the monitoring data and background data. It should be noted that significantly small negative values may be indicative of a failure of the assumption made for test validity or errors have been made in collecting background data.

The t-statistic (t_c), against which t^* will be compared, necessitates finding t_b and t_m standard (one-tailored) tables where,

t_b=t-tables with (n_b-1) degrees of freedom, at the 0.05 level of significance.

t_m=t-tables with (n_m-1) degrees of freedom, at the 0.05 level of significance.

Finally, the special weightings W_b and W_m are defined as:

$$W_b = \frac{s_b^2}{n_b}$$

$$W_m = \frac{s_m^2}{n_m}$$

and so the comparison t-statistic is:

$$t_c = \frac{W_b t_b + W_m t_m}{W_b + W_m}$$

The t-statistic (t^*) is now compared with the comparison t-statistical (t_c) using the following decision rule:

> If t^* is equal to or larger than t_c then conclude that there most likely has been a significant increase in this specific parameter.
>
> If t^* is less than t_c then conclude that most likely there has not been a change in this specific parameter.

The t-statistic for testing pH and similar monitoring parameters is constructed in the same manner as previously described except the negative sign (if any) is discarded and the caveat concerning the negative value is ignored. The standard (two-tailed) tables are used in the construction t_c for pH and similar monitoring parameters.

If t^* equal to or larger than t_c, then conclude that there most likely has been a significant increase (if the initial t^* had been negative, this would imply a significant decrease). If t^* is less than t_c, then conclude that there most likely has been no change.

A further discussion of the test may be found in Statistical methods (6th Edition, Section 4.14) by G.W. Snedecor and W.G. Cochran, or Principles and Procedures of Statistics (1st Edition, Section 5.8) by R.G.D. Steel and J.H.Torrie.

Table V.I-1 – Standard T-Tables for 0.05 Level of Significance

Degree of Freedom	one-tail t-values	two-tail t-values
1	6.314	12.706
2	2.920	4.303
3	2.353	3.182
4	2.132	2.776
5	2.015	2.571
6	1.943	2.447
7	1.895	2.365
8	1.860	2.306
9	1.833	2.262
10	1.812	2.228
11	1.796	2.201
12	1.782	2.179
13	1.771	2.160
14	1.761	2.145
15	1.753	2.131
16	1.746	2.120
17	1.740	2.110
18	1.734	2.101
19	1.729	2.093
20	1.725	2.086
21	1.721	2.080
22	1.717	2.074
23	1.714	2.069
24	1.711	2.064
25	1.708	2.060
30	1.697	2.042
40	1.684	2.021

Adapted from Table III of "Statistical Tables for Biological Agricultural and Medical Research" (1947, R.A. Fisher and F.Yates) [47 F R 32367, July 26, 1982]

Appendix V.I.2. – SUGGESTED MINIMUM SAMPLES

STATISTICAL TEST	PARAMETRIC	NON-PARAMETRIC	NON-PARAMETRIC INTERVAL %CONFIDENCE
CABF T-test	4	NA	NA
Wilcoxon Rank Sum	NA	5	NA
Confidence Interval	4	NA	NA
Tolerance Interval	8	19	95%
Prediction Interval	8	13	99% #
Poisson Prediction Interval	8	NA	NA
Shewhart CUSUM Chart+	8	NA	NA

NOTES:

* The above tests can be used with fewer samples, however it will increase the false positive rate.

\# Includes one verification re-sample, use 19 samples for a 95% Prediction Interval with no verification re-samples.

\+ For Intra-well testing only.

Appendix V.I.3. – STATISTICAL REFERENCES

Aitchison, J. On the distribution of a positive random variable having discrete probability mass at the origin, Journal of American Statistical Association, 50(272), 901-908 (1955).

Cohen, A.C. Tables for maximum likelihood estimates: Singly truncated and singly censored samples, Technometrics, 3, 535-541 (1961).

Gibbons, R.D. Statistical Methods for Groundwater Monitoring, John Wiley and Sons, Inc., 1994.

Gibbons, R.D. Some conceptual and statistical issues in analysis of groundwater monitoring data, Environmetrics, 7, 185-199 (1996).

USEPA. Statistical analysis of groundwater monitoring data at RCRA facilities. Addendum to Interim Final Guidance. Office of Solid Waste, July 1992.

USEPA. Statistical analysis of groundwater monitoring data at RCRA facilities - Interim Final guidance (April 1989).

MODULE VI - GROUNDWATER CORRECTIVE ACTION AND MONITORING PROGRAM FOR HWMU-5

VI.A. HIGHLIGHTS

The concentration of trichloroethene (TCE) in groundwater had historically exceeded the GPS in the POC Wells 5W5B, 5WC21, 5WC22 and 5WC23 since the issuance of the original permit for HWMU-5 on September 28, 2001. During 2008, TCE concentrations were less than historic levels in wells 5WC21, 5WC22 and 5WC23. Attachment VI.A provides the historical TCE concentrations in groundwater as provided in the Corrective Action Plan (CAP) published in April 2009. The Final CAP is maintained by the Permittee in the facility operating record.

In response to exceedences of the Groundwater Protection Standards (GPSs) at point of compliance (POC) wells for HWMU-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 HWMU-5. The CA is currently being implemented as follows:

The Permittee is implementing a groundwater CA and monitoring program focused on evaluating the natural attenuation of TCE and its daughter products [1,1-Dichloroethene (1,1-DCE), cis-1,2-Dichloroethane (cDCE), trans-1,2-Dichloroethene (tDCE), and Vinyl Chloride (VC)] in the subsurface at HWMU-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 is being 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.

On November 5, 2009, the Virginia Department of Environmental Quality (DEQ) approved the Final Class 3 Hazardous Waste Permit Modification for HWMU-5, which established this CA Monitoring Program to address TCE in groundwater. The approved Final Class 3 Hazardous Waste Permit Modification also revised the GPSs for HWMU-5 to incorporate the January 2009 DEQ Alternate Concentration Limits (ACLs). As a result, the GPS for total cobalt was reduced from the previous DEQ ACL of 313 ug/l used in the original permit to the HWMU-5 site-specific background concentration of 7 ug/l; this revision was made due to the reduction of the then-DEQ-calculated ACL for total cobalt to 4.695 ug/l. Total cobalt was never detected at concentrations greater than the previous GPS of 313 ug/l in any of the monitoring wells at HWMU-5. During the Second Quarter 2010 CA groundwater monitoring event, total cobalt was detected

in POC well 5WC21 at a concentration greater than the GPS of 7 ug/l. During a meeting between DEQ and RFAAP on May 4, 2011, it was determined that total cobalt would be added to the list of CA Targeted Constituents for HWMU-5. Semiannual monitoring for total cobalt as a CA Targeted Constituent began with the Fourth Quarter 2011 semiannual CA groundwater monitoring event; however, the addition was formally finalized in the Permit reissuance effective August 16, 2014.

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 VI.B. 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 HWMU-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 VI.B 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 HWMU-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 in accordance with the CAP).

VI.B.1 Design Conformance

The Permittee installed one (1) monitoring well (5W12A) in February 2010 to replace the Plume Monitoring Wells S5W5, S5W7, 5W9A, 5W10A and 5W11A. This monitoring network is specific to the monitoring of the Natural Attenuation Remedy. The location of the new well is specified in Permit Attachment II.A, Figure II.A-6. 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 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 VI.B, within a reasonable period of time, defined as in Permit Condition VI.B.7. 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 HWMU-5 generally as described in the CAP 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. 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 HWMU-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 Attachment VI.B 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 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 (tDCE), Vinyl Chloride (VC), and total cobalt] (Attachment VI.B), on a semiannual basis. In addition, groundwater samples collected during the first year of monitoring were 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 VI.B. 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 II.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 II.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:

   i. 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 Evaluation of MNA Program

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);

b. 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 outlined in the CAP. An example calculation is provided in Permit Attachment VI.A.

e. 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 per the approved 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 for TCE). 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 for three consecutive years, then contingency measures as defined in the CAP will be implemented.

b. 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] for TCE, 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 in-situ technology which can effectively meet the remediation objectives.

VI.B.9 Termination of CA/Remedy Program

The CA/Remedy (40 CFR 264.100) for HWMU-5 must continue until TCE and its daughter products' concentrations in groundwater have decreased below the GPSs specified in Attachment VI.B (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 HWMU-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 RSL. The GPSs for

TCE and its daughter products are listed in the Attachment VI.B. 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 Director 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.J.2. the compliance period during which the GPSs applies for HWMU-5 will continue until October 28, 2030, or until the Director approves clean closure of the unit. 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.J.2, 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 HWMU-5 shall be monitored with one

(1) upgradient groundwater monitoring well and five (5) downgradient POC Wells located as specified on Figure II.A-6 of Permit Attachment II.A. 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 monitored to ensure that contaminants, TCE and its daughter products are not moving downgradient away from HWMU-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 V.B, Sampling and Analysis Plan, "SAP") and the following schedule:

a. All the wells specified in Permit Condition VI.C.1. will be sampled at least semi-annually for the analysis of the current CA-targeted constituents listed in Attachment VI.B. 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 VI.B. Alternate/updated SW-846 methods for the contaminants listed in Permit Attachment VI.B 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 Permit Attachment VI.B 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 Attachment VI.B may be used, provided the analyte is quantified using the alternate/updated method. Proposed alternate/updated methods for the indicators listed in Attachment VI.B 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 (Attachment VI.C) using the EPA SW-846 Methods specified in Permit Attachment VI.C. The CA Annual Monitoring Constituents (Attachment VI.C) are based on the Compliance Monitoring List (Attachment V.D and V.F), 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 Attachment II.F.

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 V.H. 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 HWMU-5 (Permit Attachment V.E), MCL, ACL established by the Department, or RSL. The GPSs of the constituents annually to be analyzed are provided in Attachment VI.C.

The GPSs for TCE and its daughter products, together with their detection limits, background values, and applicable MCL/ACL/RSLs, are listed in Permit Attachment VI.B.

VI.E.2. Background concentrations established at the time of permit issuance are listed in Permit Attachment V.E. For any newly detected hazardous constituents, background values shall be established in accordance with 40 CFR 264.97(g) and as specified in Permit Attachment V.I. Background groundwater quality for a constituent or monitoring parameter shall be based on at least four (4) data points collected at the HWMU-5 Groundwater CA background monitoring well(s) during a period not exceeding one (1) year. An alternate sampling procedure may be used if approved by the Department.

VI.E.3. The Permittee shall use the most up-to-date USEPA MCL or DEQ ACL / EPA RSL (if no USEPA MCL has been promulgated) as the GPS for any GPS based on those regulatory values. If USEPA/ DEQ implements any changes to MCLs, RSLs, or ACLs, the GPS defined by that MCL/RSL/ACL will be updated to reflect the most current value established by USEPA/DEQ, and the most current updated value will be used for data evaluation. The currently published values at the time of the sampling event will be used as the GPS to evaluate all data for that sampling event, as well as for any verification sampling associated with that sampling event. Additionally, the Permittee shall submit a Class 1 Modification request biennially (every two years) to update all MCL, ACL, and RSL values listed in the Permit to the most current published values at the time of the modification request submission. If no changes have been made to the MCL, ACL, or RSL values for the constituents listed in the Permit for the preceding two years, then the Permittee can provide a letter to DEQ stating that no permit modification is necessary in lieu of a Class 1 modification request for that two year time period.

Any GPS based on a background value or site-specific ACL may be updated if new data become available. When available, the Permittee shall provide the Department with any new site-specific data for review. If the changes are significant enough to warrant a Permit modification, the Permittee shall submit a Class 1 Permit modification request to amend the associated GPS value(s).

VI.E.4. Pursuant Permit Condition I.J.2 the compliance period during which the GPSs

apply for HWMU-5 will continue until October 28, 2030, or until the Director approves clean closure of the unit. 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 V.B (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 V.B. Additionally, the laboratory must be accredited for the analytical method, matrix, and target analyte (where applicable) by the Virginia Environmental Laboratory Accreditation Program (VELAP).

VI.F.3 Samples shall be tracked and controlled using the chain-of-custody procedures specified in Permit Attachment V.B.

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 V.B.

a. 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.

b. 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 Attachment VI.B and annually the concentrations/values of hazardous constituents listed in Permit Attachment VI.C 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 Attachment VI.B are present at concentrations greater than the GPS (Permit Attachment VI.B) 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 Attachment VI.B 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 Permit Attachment VI.C (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 Permit Attachment VI.C. The following procedures shall be used:

VI.I.1. Methods of Comparison

a. If a single independent sample was collected at the monitoring well, the Permittee shall conduct a simple empirical comparison of the measured value to the GPS in accordance with Permit Attachment V.I (Statistical Procedures).

b. If multiple independent samples were collected from each monitoring well, a statistical comparison to the GPS, as approved by the Director, shall be conducted. Guidelines for method selection are contained in Permit Attachment V.I.

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 of the data being available from the laboratory 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. Maintenance and Operation of the Remedial System

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.

VI.J.3. Annual Appendix IX of 40 CFR 264 Data

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 Attachment VI.C 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:

a. The operator/owner certification signed and dated by an authorized representative of the Facility;

b. Copies of current potentiometric surface maps and static groundwater level elevations for each event during the period.

c. 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 HWMU-5 and progress is being made toward the remediation objectives. The evaluation shall also contain updated compliance timeframe predictions using the principles and methods as outlined in the CAP. An example calculation is provided in Permit Attachment VI.A.

h. 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. ASSURANCE OF COMPLIANCE

The Permittee shall demonstrate through the implementation of the groundwater monitoring and CA measures in 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 VI.C 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.

VI.M. 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 HWMU-5 shall be required if the Permittee or the Department has made any of the following determination:

a. 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. CA SCHEDULE

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

VI.N.1. Within 120 days from the effective date of the permit modification (November 5, 2009), monitoring well 5W12A specified under Permit Conditions VI.B.1 and VI.C.1.b was installed, on February 22, 2010. In accordance with Permit Conditions VI.D.3 and VI.J.2., details of the well's installation were 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., was 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, meeting the requirements of Permit Condition I.I.1 (Post-Closure Period Reduction) will allow the cessation of the MNA remedy.

ATTACHMENT VI.A - CORRECTIVE ACTION PLAN- TCE HISTORICAL DATA FOR HWMU-5

VI.A-A. HISTORICAL TCE CONCENTRATIONS IN GROUNDWATER FOR HWMU-5

Table A-1. Historical TCE Detections in Groundwater, Radford Army Ammunition Plant HWMU-5 (RAAP-042)
Corrective Action Plan, U.S. Army Environmental Command, Radford, Virginia

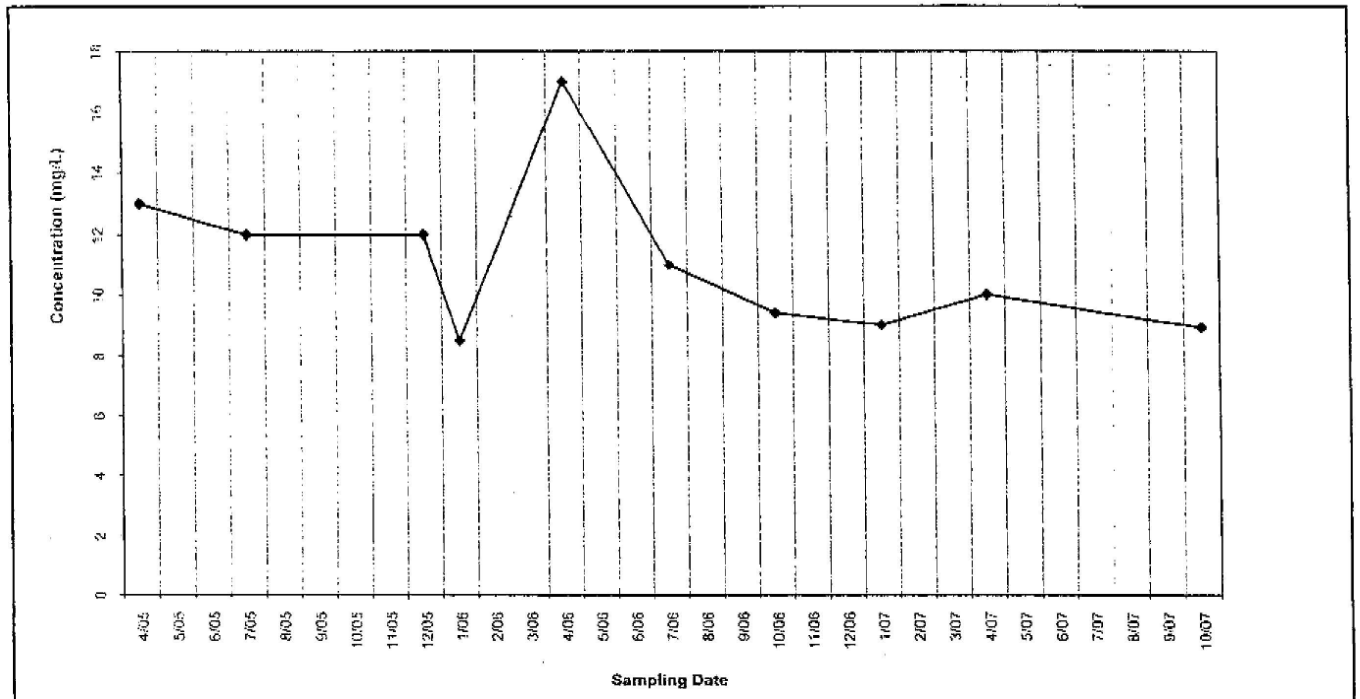
	Monitoring Well										
Date	5W8B	5W5B	SWC21	5WC22	5WC23	5W7B	S5WS	S5W7	5W9A	5W10A	5W11A
1st Qtr 1996	~	2.3	~	2.2	2.9	~	~	~	0.6 J	~	~
2nd Qtr 1996	~	5.7	0.4 J	3.8	4.5	~	~	~	0.7 J	~	~
3rd Qtr 1996	~	4.3	0.4 J	5	5.8	~	~	~	0.8 J	~	~
4th Qtr 1996	~	2.4	0.8J	6.2	5.3	~	~	~	0.6 J	~	~
1st Qtr 1997	~	2.5	1.8	7.4	6.6	0.2 J	~	0.1 J	0.3 J	~	~
2nd Qtr 1997	0.3 J	7.8	2.7	7.4	6.8	0.1 J	0.4 J	~	0.8 J	0.1 J	~
3rd Qtr 1997	~	6	2.4	8.4	8.7	~	0.2 J	~	0.5 J	~	~
4th Qtr 1997	0.8 J	9.4	1.2	8.9	2.8	0.3 J	0.3 J	~	0.3 J	~	~
1st Qtr 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	5.7	7.5	7.5	~	~	~	~	7.4	~
2nd Qtr 1999	~	15.9	5.6	6.7	6	~	~	~	0.2 J	~	~
3rd Qtr 1999	~	20.5	7.8	9.9	7.8	~	~	~	0.5 J	~	~
4th Qtr 1999	~	19.5	4.06	8.68	6.98	~	~	~	~	~	~
1st Qtr 2000	~	16.8	3.1	6.3	6.3	~	~	~	~	~	~
2nd Qtr 2000	~	13.2	3.9	5.7	5.5	~	~	~	~	~	~
3rd Qtr 2000	~	16.3	5.42	DRY	DRY	~	~	~	~	~	~
4th Qtr 2000	~	14.9	6.55	5.33	5.41	~	~	~	~	~	~
1st Qtr 2001	~	18.8	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	11.8	~	~	~	~	~	~
4th Qtr 2001	~	9.91	19.2	7.78	7.83	~	~	~	~	~	~
1st Qtr 2002	9.13	~	19.1	6.63	6.33	~	~	~	~	~	~
2nd Qtr 2002	~	9.84	16.6	7.03	6.25	~	~	~	~	~	~
3rd Qtr 2002	~	6.36	8.46	1.94	2.13	~	~	~	~	~	~
4th Qtr 2002	~	5.84	11.3	2.54	2.89	~	~	~	~	~	~
2nd Qtr 2003	~	4.2	26	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	~	8	22	6.2	6.8	~	~	~	~	~	~
3rd Qtr 2004	~	7	17	4.8	4.9	~	~	~	~	~	~
4st Qtr 2004	~	9.4	20	6.2	6.6	~	~	~	~	~	~
1st Qtr 2005	~	7.9	24	5.9	5.9	~	~	~	~	~	~
2nd Qtr 2005	~	13	16	5.5	5.8	~	~	~	~	~	~
3rd Qtr 2005	~	12	10	4.2	5.1	~	~	~	~	~	~
4th Qtr 2005	~	12	6.8	4.4	4.3	~	~	~	~	~	~
1st Qtr 2006	~	8.5	3.9	3.7	4.5	~	~	~	~	~	~
2nd Qtr 2006	~	17	4	4	4	~	~	~	~	~	~
3rd Qtr 2006	~	11	3.7	3.3	3.7	~	~	~	~	~	~
4th Qtr 2006	~	9.4	3.5	4.7	3.5	~	~	~	~	~	~
1st Qtr 2007	~	9	5.6	3.3	3.6	~					
2nd Qtr 2007	~	10	5.5	3.5	3.5	~					
4th Qtr 2007	~	8.9	2.5	3.4	3.6	~					

Notes:

~ - TCE not detected above laboratory detection limit
J - Trichloroethene was detected at a concentration greater than the detection limit but less than the quantitation limit. These results are estimates only
DRY - Monitoring wells 5WC22 and 5WC23 were dry during 3rd Quarter 2000. No samples were collected
NA - Not analyzed. The monitoring wells at HWMU-5 were not analyzed for trichloroethene during the 1st Quarter

11/14/2008
Table A-1

Page 1 of 1



Results of Mann-Kendall Test for Trend: DECREASING TREND
p value = 0.030 Note: p value < 0.05 indicates a statistically significant trend (95% confidence level).

Results of Sen's Estimator of Slope: DECREASING TREND
Median Slope Estimate = -4.4E-03 mg/L/day
95% Confidence Interval = -9.5E-03 to -2.2E-04 mg/L/day

ARCADIS

Concentration vs. Time Plot – TCE in Well 5W5B
RFAAP Unit-5, Radford, VA

Figure A-1

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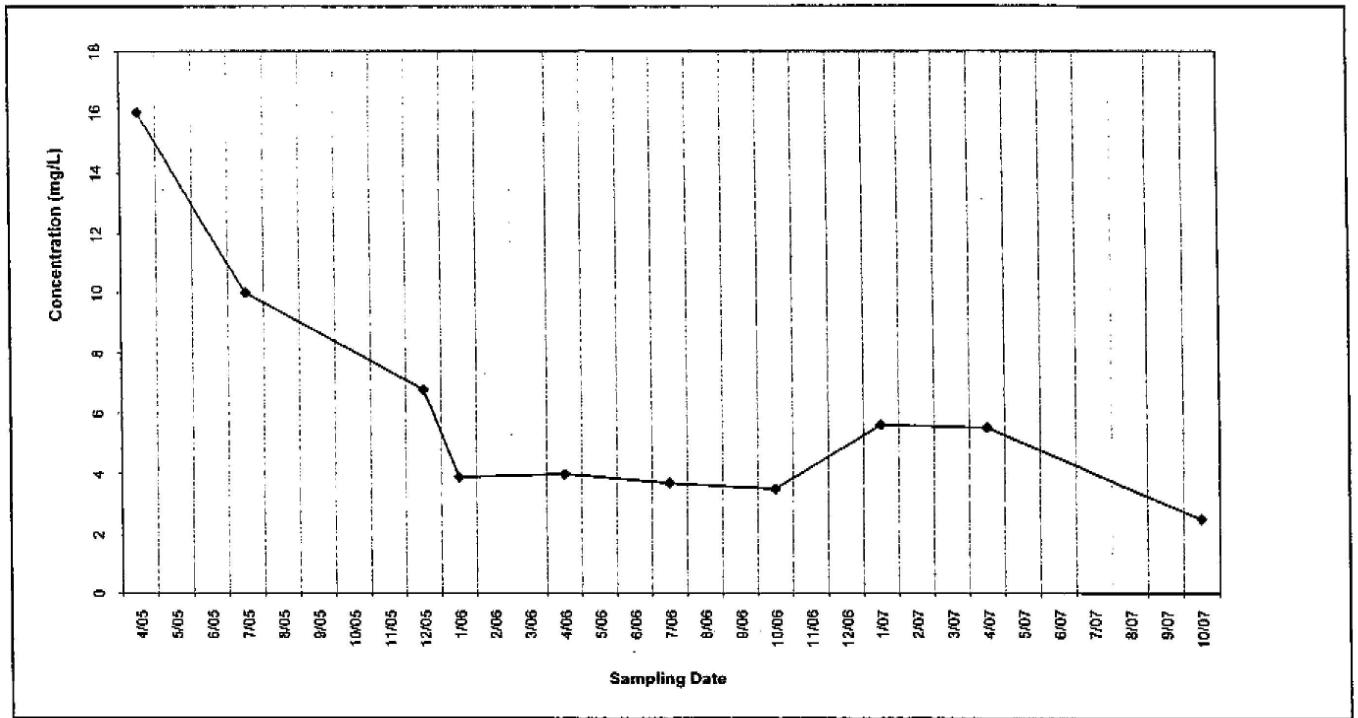

Results of Mann-Kendall Test for Trend: DECREASING TREND
p value = 0.008 Note: p value < 0.05 indicates a statistically significant trend (95% confidence level).

Results of Sen's Estimator of Slope: DECREASING TREND
Median Slope Estimate = -7.0E-03 mg/L/day
95% Confidence Interval = -1.9E-02 to -1.9E-03 mg/L/day

ARCADIS

Concentration vs. Time Plot – TCE in Well 5WC21
RFAAP Unit-5, Radford, VA

Figure A-2

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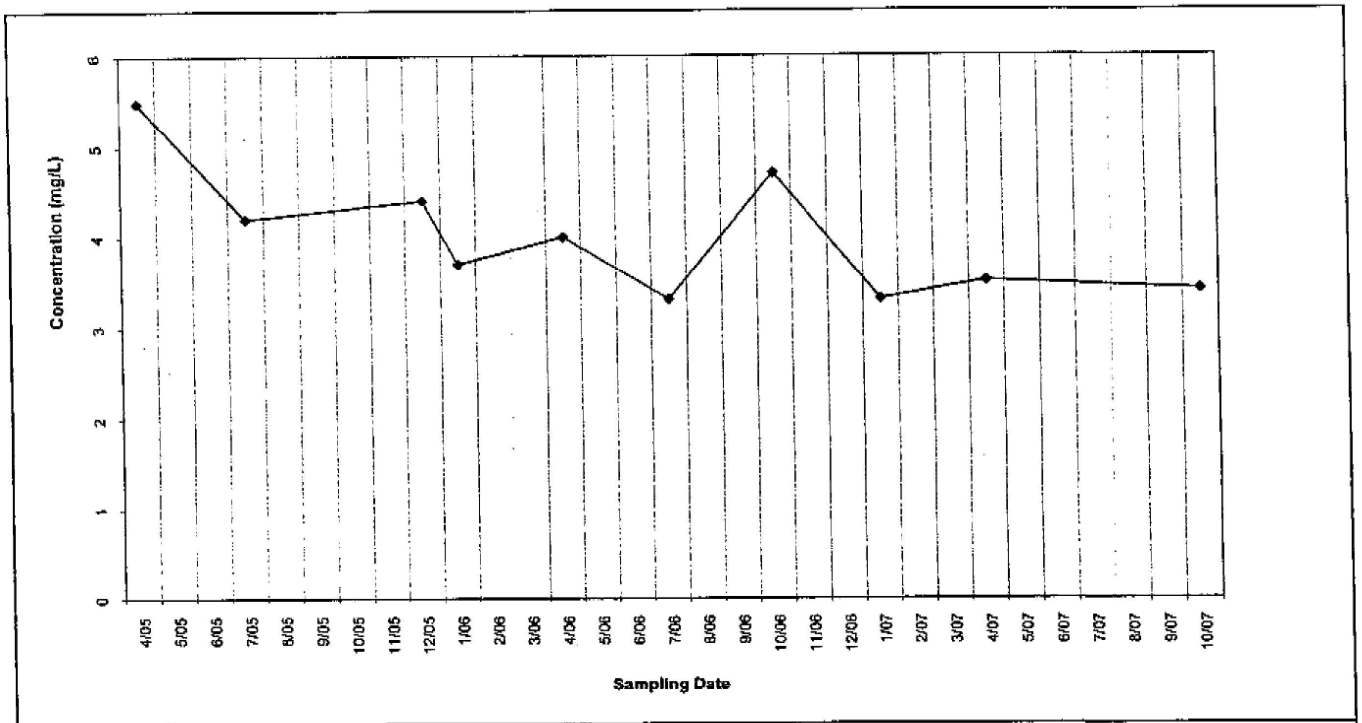

Results of Mann-Kendall Test for Trend: DECREASING TREND
p value = 0.030 Note: p value < 0.05 indicates a statistically significant trend (95% confidence level).

Results of Sen's Estimator of Slope: DECREASING TREND
Median Slope Estimate = -1.5E-03 mg/L/day
95% Confidence Interval = -3.5E-03 to -2.4E-04 mg/L/day

ARCADIS

Concentration vs. Time Plot – TCE in Well 5WC22
RFAAP Unit-5, Radford, VA

Figure A-3

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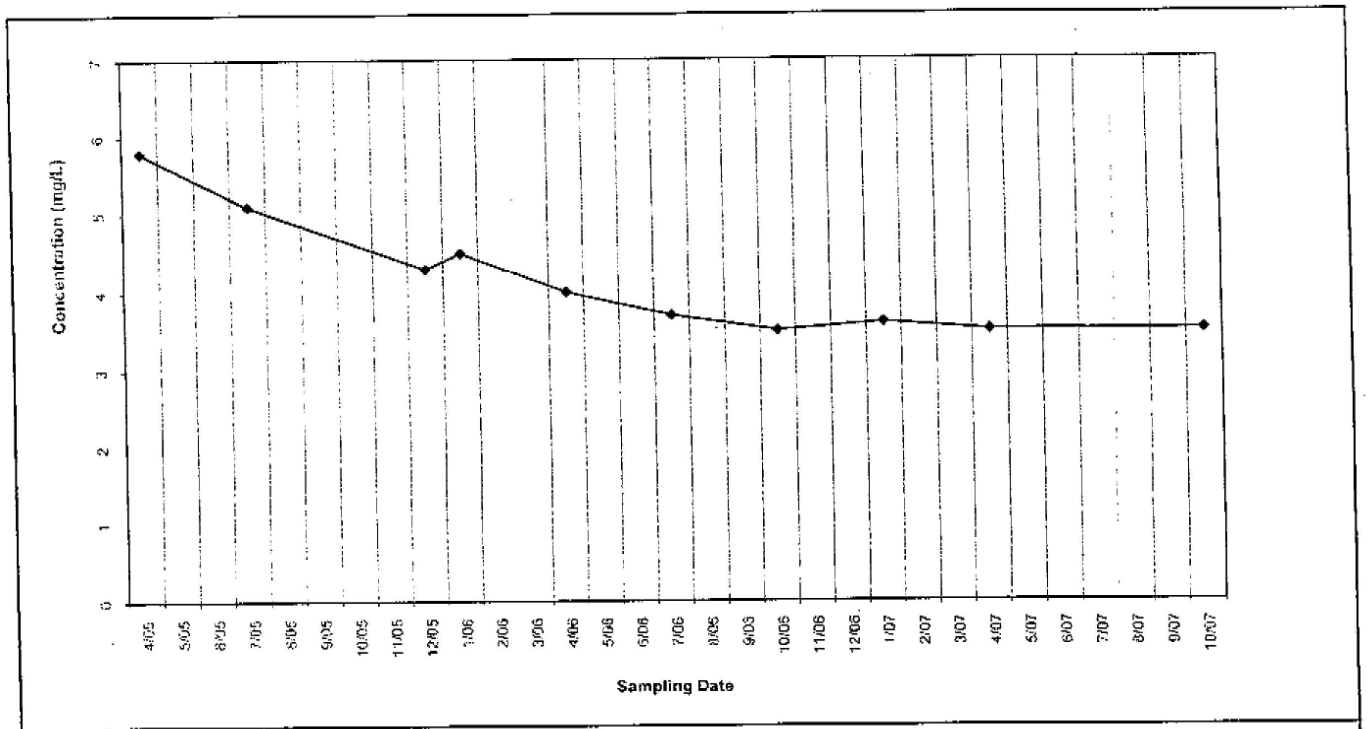

Results of Mann-Kendall Test for Trend:	**DECREASING TREND** ρ value = 0.000	Note: ρ value < 0.05 indicates a statistically significant trend (95% confidence level).
Results of Sen's Estimator of Slope:	**DECREASING TREND** Median Slope Estimate = -2.5E-03 mg/L/day 95% Confidence Interval = -3.7E-03 to -1.3E-03 mg/L/day	

ARCADIS

Concentration vs. Time Plot – TCE in Well 5WC23
RFAAP Unit-5, Radford, VA

Figure A-4

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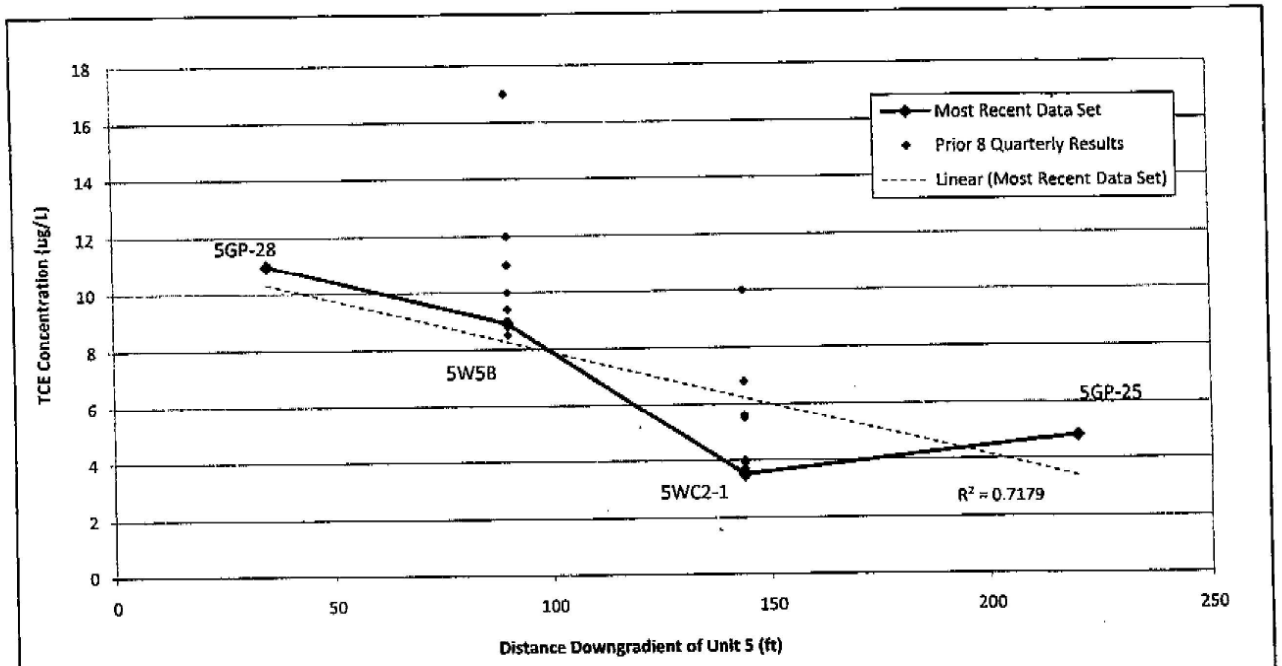
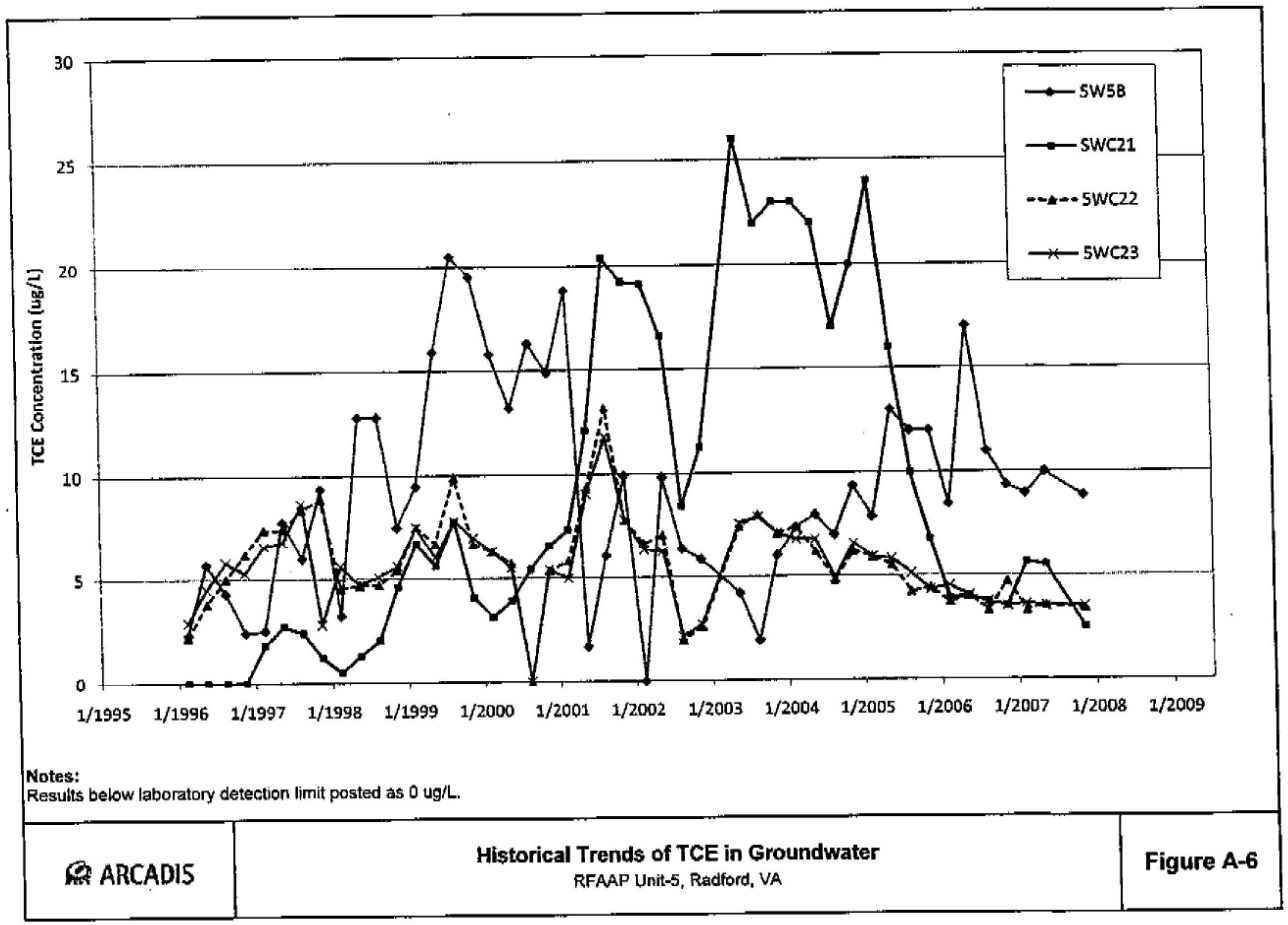


Notes:
Most recent data reflect 4th quarter 2007 results for monitoring wells 5W5B and 5WC2-1. Samples 5GP-25 and 5GP-28 were collected summer 2008.
Linear trend line is fitted to most recent data.
Prior 8 quarters of data available for wells only, spanning period 3rd quarter 2005 to 2nd quarter 2007.
TCE was not detected at downgradient wells 5W10A (815 ft NE) and 5W11A (865 ft NE) or cross-gradient wells 5W9A (565 ft NE) and S5W5 (262 ft N).

ARCADIS	**Concentration vs. Distance Plot – TCE in Groundwater** RFAAP Unit-5, Radford, VA	**Figure A-5**

G:\APROJECT\RAAP\Execution\RAAP-042\CAP\Appendices\Distance_concentration plot.xls - 11/10/2008



G:\APROJECT\RAAP\Execution\RAAP-042\CAP\Appendices\TCE Historical Table and Plot.xls - 11/10/2008

VI.A-B. EXAMPLE COMPLIANCE TIMEFRAME PREDICTION CALCULATIONS

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):

$$R_{composite} = 1 + \left(\frac{K_d \times \rho_{BD}}{\theta_{total}}\right) \quad \text{Eq. 1}$$

ρ_{BD} = bulk density of the soil. A value of 1.85 g/cm^3 was used assuming the total porosity of 30 percent.
Θ_{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_d = TCE partition coefficient in soil determined as follows:

$$K_d = K_{oc} \times f_{oc} \quad \text{Eq. 2}$$

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_{oc} = 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_{PV}) required to reduce the starting dissolved concentration (C_{start}) to a target concentration (C_{goal}) using the following equation:

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

Where:

N_{pv} = number of pore volume flushes
$R_{composite}$ = composite retardation coefficient (calculated as 2.02 for TCE)
C_{goal} = 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).

$$T = (N_{PV} * L)/V_S \qquad \text{Eq. 4}$$

Where:

T = predicted MNA timeframe
N_{pv} = 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.

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

Where:

t = predicted GPS remedial timeframe
C_{goal} = GPS (ug/L)
C_{start} = current constituent concentration (ug/L)
K_{point} = 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.

Appendix C-1

Predicted MNA Remedial Timeframe per CAP

Total Porosity =	30%	%	Estimated
log(Koc) =	2.22	--	USEPA 1996
f_{oc} =	0.001	--	USEPA 1996
Bulk Density =	1.85	g/cm^3	assumed value based on 30% total porosity
K_d =	0.17		Calculated; $K_{oc}*f_{oc}$
Retardation Coefficient =	***2.02***	--	***Calculated; 1+((Kd*Bulk Density)/total porosity)***

Groundwater Velocity =	15	ft/yr	Estimated
Spacing Between 5GP-028 and 5CW21 =	108	ft	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	ug/L	Given
Current TCE Concentration in 5CW21 =	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

Sample Date	TCE (ug/L)	ln TCE (ug/L)
4/18/2005	13.00	2.56
8/15/2005	12.00	2.48
11/18/2005	12.00	2.48
2/14/2006	8.50	2.14
4/18/2006	17.00	2.83
8/18/2006	11.00	2.40
11/18/2006	9.40	2.24
2/14/2007	9.00	2.20
4/18/2007	10.00	2.30
10/30/2007	8.90	2.19
4/28/2008	7.80	2.05
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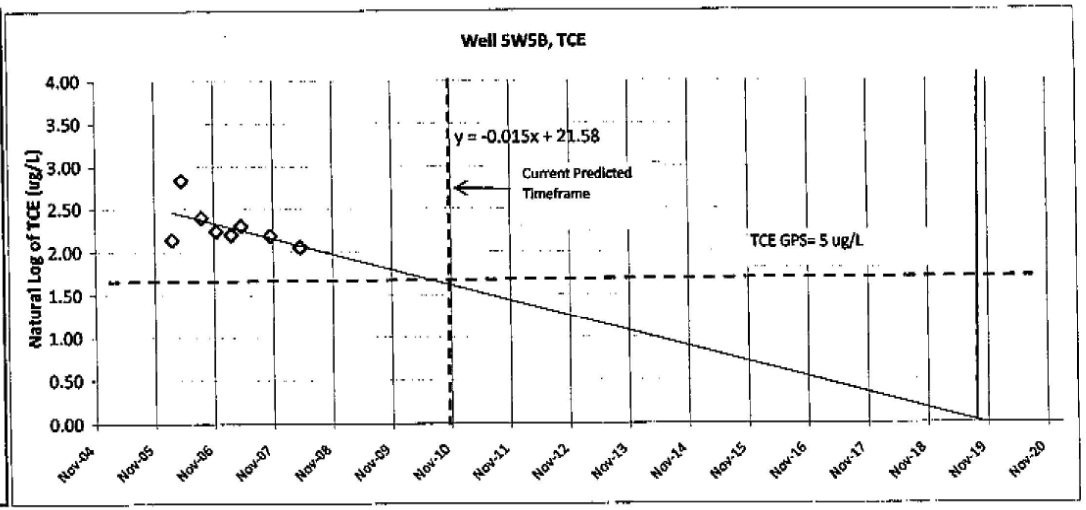

Last 8 rounds		TCE MCL	Estimated Rate and Time Required			Current MNA Timeframe Prediction	MNA Goal (per CAP)	MNA Ineffective Date (per CAP)
First Event	Last Event	ug/L	Rate (per day)	Rate (per year)	Time (years)			
2/14/2006	4/28/2008	5.000	0.0005	0.183	2.44	October-2010	October-2019	December-2026

Effectiveness Evaluation for MNA Remedy	Status	Condition
1) Is the current MNA remedial timeframe prediction less than the 2019 MNA Goal?	yes	If 'yes', then the remedy is considered effective and no additional action is required. If 'no' for 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 implemetned as defined in the CAP.

ATTACHMENT VI.B - GROUNDWATER CORRECTIVE ACTION TARGETED CONTAMINANTS- GPS AND SEMIANNUAL MONITORING LIST FOR HWMU- 5

Targeted CA Contaminants (Concentration Unit: µg/l)									
CONSTITUENTS	**Cas RN#**	**SW-846 Method**	**MDL**	**PQL**	**Back-ground**	**EPA MCL**	**DEQ ACL**	**EPA Tap Water RSL**	**GPS**
Trichloroethene (TCE)	79-01-6	8260	0.4	1	0.8	5	0.49	0.49	5
1,1-Dichloroethene (1,1-DCE; $H_2C=CCl_2$)	75-35-4	8260	0.3	1		7	8.2	8.2	7
cis-1,2-Dichloroethene (***c*DCE)**	156-59-2	8260	0.1	1		70	25	25	70
trans-1,2-Dichloroethene (***t*DCE)**	156-60-5	8260	0.8	1		100	68	68	100
Vinyl chloride (Chloroethene, VC; $H_2C=CHCl$)	75-01-4	8260	0.4	1		2	0.019	0.019	2
Cobalt, total	7440-48-4	6010/6020	1.0	5	7		6	6	7

MNA Indicators (First year of monitoring only)		
Indicator	**Analytic Method**	
Methane, Ethane & Ethene	RSK 175M	Anaerobic dechlorination
Nitrate/nitrite	9056	**Nitrate**: Electron acceptor by denitrifying bacteria
Sulfate	9056	**Sulfate/Sulfide**: Electron acceptor/Sulfate reduction
Sulfide	9034	
Total Organic Carbon (TOC)	9060B	

Field Parameters	
pH	
Temperature	
Dissolved Oxygen (DO)	DO: aerobic environments; electron acceptor
Oxidation-Reduction Potential (ORP)	Redox Potential: +500mV aerobic to -500mV anaerobic environments
Specific Conductivity	

NOTE:

CAS RN: Chemical Abstracts Service registry number.

SW-846: Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, EPA publication SW-846, Third Edition, Final Updates I (1993), II (1995), IIA (1994), IIB (1995), III (1997), IIIA (1999), IIIB (2005), IV (2008), and V (2015) (as updated).

MDL: Method Detection Limit;

PQL: Practical Quantitation Limit;

Background Values: calculated upgradient background concentrations (Permit Attachment V.E).

MCL: Maximum Contaminant Level (MCL) of USEPA National Primary Drinking Water Regulations (as of December 12, 2024) - The highest level of a contaminant that is allowed in drinking water. EPA,. Subject to change when it is updated.

DEQ **ACL:** Virginia DEQ's Alternate Concentration Limit (Default 10^{-6}), effective January 2, 2025 ; subject to change when it is updated.

RSL: USEPA Regional Screening Levels for Chemical Contaminants at Superfund Sites (HQ=1; Default 10^{-6}); as of November 2024 (https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables).Subject to change when it is updated.

GPS: Groundwater Protection Standard

Note (1): For all GPS values based on the EPA MCL, DEQ ACL, or EPA RSL, the currently published values at the time of the sampling event will be used to evaluate all data for that sampling event, as well as for any verification sampling associated with that sampling event.

Note (2): Laboratory must be accredited for the analytical method, matrix, and target analyte (where applicable) by the Virginia Environmental Laboratory Accreditation Program (VELAP).

Note (3): For any monitoring event, if a GPS for a constituent in the table above is based on a background concentration derived from a PQL, the Permittee will perform verification of a detection (i.e. value greater than the Detection Limit) of such a constituent using low-level analytical methods, if such methods are standard methods that are routinely available from commercial laboratories. Furthermore, the low-level analytical method will be used only if the PQL achievable by that method is less than, or equal to, the MCL/ACL/RSL for the subject constituent. If the verification event confirms a quantifiable detection (i.e. value greater than the PQL) above the applicable MCL/ACL/RSL, a revised background concentration will be established using low-level analytical methods, if appropriate, and the GPS will be updated based on the new background concentration if warranted.

ATTACHMENT VI.C - GROUNDWATER CORRECTIVE ACTION ANNUAL MONITORING LIST

Concentration Unit: µg/l

CONSTITUENTS	Cas RN#	SW-846 Method	MDL	PQL	Back-ground	EPA MCL	DEQ ACL	EPA Tap Water RSL	GPS	GPS Basis
Antimony, total	7440-36-0	6010/6020	0.6	2	3	6	7.8	7.8	6	MCL
Arsenic, total	7440-38-2	6010/6020	2	10	1	10	0.052	0.052	10	MCL
Barium, total	7440-39-3	6010/6020	1.3	10	172.87	2000	3800	3800	2000	MCL
Beryllium, total	7440-41-7	6010/6020	0.3	1	0.7	4	25	25	4	MCL
Cadmium, total	7440-43-9	6010/6020	0.2	1	1.45	5	1.8	1.8	5	MCL
Chromium, total	7440-47-3	6010/6020	1	5	5	100	--	--	100	MCL
Cobalt, total	7440-48-4	6010/6020	1	5	7		6	6	7	BKG
Copper, total	7440-50-8	6010/6020	1.7	5	18	1300*	800	800	1300*	MCL
Lead, total	7439-92-1	6010/6020	1	3	10	10*	10*	10*	10*	MCL
Mercury, total	7439-97-6	7470	0.2	2	0.9	2	0.63	0.63	2	MCL
Nickel, total	7440-02-0	6010/6020	2	10	106		390	390	390	ACL
Selenium, total	7782-49-2	6010/6020	3	10	1	50	100	100	50	MCL
Silver, total	7440-22-4	6010/6020	0.3	2	2.3		94	94	94	ACL
Thallium, total	7440-28-0	6010/6020	0.2	1	2	2	0.2	0.2	2	MCL
Vanadium, total	7440-62-2	6010/6020	2.5	10	17		86	86	86	ACL
Zinc, total	7440-66-6	6010/6020	7.3	30	75		6000	6000	6000	ACL
Acetone	67-64-1	8260	2	10	89		18,000	18,000	18,000	ACL
Bis (2-ethylhexyl) phthalate (DEHP)	117-81-7	8270	2	10	10	6	5.6	5.6	10	BKG
2-Butanone (Methyl ethyl ketone; MEK)	78-93-3	8260	1.7	10	21.3		5600	5600	5600	ACL
Chloroform	67-66-3	8260	0.4	1	0.5	80#	0.22	0.22	80#	MCL
Dichlorodifluoromethane	75-71-8	8260	0.4	1	1		200	200	200	ACL
1,2-Dichloroethane	107-06-2	8260	0.3	1	0.1	5	0.17	0.17	5	MCL
Diethyl ether	60-29-7	8260	1.1	12.5	12		--	3900	3900	RSL
Diethyl phthalate	84-66-2	8270	2.0	10	5		15,000	15,000	15,000	ACL

2,4-Dinitrotoluene	121-14-2	8270	2.1	10	0.18		0.24	0.24	10	PQL
2,6-Dinitrotoluene	606-20-2	8270	2.1	10	0.08		0.049	0.049	10	PQL
Methylene chloride (Dichloromethane)	75-09-2	8260	0.5	5	0.7	5	11	11	5	MCL
o-Nitroaniline; 2-	88-74-4	8270	1.0	10	20		190	190	190	ACL
p-Nitroaniline; 4-	100-01-6	8270	1.5	10	20		3.8	3.8	10	PQL
Nitrobenzene	98-95-3	8270	1.0	10	10		0.14	0.14	10	PQL
Toluene	108-88-3	8260	0.3	1	0.1	1000	1100	1100	1000	MCL
Xylenes (total)	1330-20-7	8260	0.4	3	0.1	10,000	190	190	10,000	MCL

NOTE:

CAS RN: Chemical Abstracts Service registry number.

SW-846: Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, EPA publication SW-846, Third Edition, Final Updates I (1993), II (1995), IIA (1994), IIB (1995), III (1997), IIIA (1999), IIIB (2005), IV (2008), and V (2015) (as updated).

MDL: Method Detection Limit;

PQL: Practical Quantitation Limit;

Background Values (BKG): calculated upgradient background concentrations (Permit Attachment V.E).

MCL: Maximum Contaminant Level (MCL) of USEPA National Primary Drinking Water Regulations (as of December 12, 2024) - The highest level of a contaminant that is allowed in drinking water. EPA,. * - action level. Subject to change when it is updated.

DEQ ACL: Virginia DEQ's Alternate Concentration Limit(Default 10^{-6}), effective January 2, 2025; subject to change when it is updated.

RSL: USEPA Regional Screening Levels for Chemical Contaminants at Superfund Sites (HQ=1; Default 10^{-6}); as of November 2024 (https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables). Subject to change when it is updated.

GPS: Groundwater Protection Standard

Note (1): For all GPS values based on the EPA MCL, DEQ ACL, or EPA RSL, the currently published values at the time of the sampling event will be used to evaluate all data for that sampling event, as well as for any verification sampling associated with that sampling event.

Note (2): Laboratory must be accredited for the analytical method, matrix, and target analyte (where applicable) by the Virginia Environmental Laboratory Accreditation Program (VELAP).

Note (3): For any monitoring event, if a GPS for a constituent in the table above is based on a background concentration derived from a PQL, the Permittee will perform verification of a detection (i.e. value greater than the Detection Limit) of such a constituent using low-level analytical methods, if such methods are standard methods that are routinely available from commercial laboratories. Furthermore, the low-level analytical method will be used only if the PQL achievable by that method is less than, or equal to, the MCL/ACL/RSL for the subject constituent. If the verification event confirms a quantifiable detection (i.e. value greater than the PQL) above the applicable MCL/ACL/RSL, a revised background concentration will be established using low-level analytical methods, if

appropriate, and the GPS will be updated based on the new background concentration if warranted.

Note (4): The GPS for p-Nitroaniline is based on the current Permit-specified PQL of 10 ug/l (February 2025) instead of the calculated background concentration of 20 ug/l. P-Nitroaniline was initially detected at HWMU-5 during annual monitoring for the constituents listed in Permit Attachment V.C during Fourth Quarter 2003 and subsequently added to the Compliance monitoring list for the Unit. During establishment of background for p-Nitroaniline at HWMU-5, the constituent was not detected in the upgradient well at concentrations greater than the then-current PQL of 20 ug/l; therefore, the background concentration for p-Nitroaniline was calculated as equal to the then-current PQL of 20 ug/l.

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

MODULE VII - SITE-WIDE CORRECTIVE ACTION

VII.A. CORRECTIVE ACTION FOR CONTINUING RELEASE; PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

The requirements of 40 CFR 264.101 were addressed by the Corrective Action Permit issued to the Permittees by EPA Region III which became effective on October 31, 2000. Since the issuance of the 2000 Corrective Action Permit, the EPA transferred the responsibility for renewal of the Permit to the DEQ Office of Financial Responsibility and Waste Programs. DEQ issued RFAAP the Facility's Hazardous Waste Management Permit for Corrective Action effective May 1, 2016. The Hazardous Waste Management Permit for Corrective Action issued by DEQ addresses implementation of the selected Remedy for Corrective Action Units (CAUs) at the RFAAP as well as ongoing obligations for future environmental compliance and cleanup. The terms and conditions of the Hazardous Waste Management Permit for Corrective Action issued by DEQ 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.

A list of CAUs addressed by the Hazardous Waste Management Permit for Corrective Action and a map depicting the locations of the CAUs are contained within the Part A Permit Application and Attachment II.A.

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

Copies of all notifications, cover letters for reports, and submissions made in compliance with the Hazardous Waste Management Permit for Corrective Action shall be provided to DEQ Office of Financial Responsibility and Waste Programs and shall be part of the facility's operating record..