ANNUAL GROUNDWATER MONITORING REPORT

HAZARDOUS WASTE MANAGEMENT UNIT 7
CALENDAR YEAR 1999

RADFORD ARMY AMMUNITION PLANT
RADFORD, VIRGINIA

Submitted to:

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TABLE OF CONTENTS

LIST OF APPENDICES

INTRODUCTION

This document represents the annual groundwater monitoring report for the permitted hazardous waste management unit HWMU-7 at the Radford Army Ammunition Plant (RFAAP) in Radford, Virginia. This report has been compiled in accordance with 9 VAC 20-60-570, sections E.1.b.2 and 3.

The report presents the following set of information for HWMU-7: basic information and unit identification, a description of the groundwater monitoring plan, a discussion of groundwater movement, an updated potentiometric map, a table of groundwater elevations and detailed statistical evaluations of the analytical data. In general, the report evaluates the analytical data from the four 1999 quarterly sampling events; these data were submitted previously to the VDEQ in quarterly monitoring reports for the unit.

SIGNATURE/CERTIFICATION

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I certify that I have prepared or supervised preparation of the attached report, that it has been prepared in accordance with industry standards and practices, and that the information contained herein is truthful and accurate to the best of my knowledge.

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HWMU-7 ANNUAL GROUNDWATER MONITORING REPORT

CALENDAR YEAR: 1999
REPORT DATE: March 1, 2000

Prepared for the Virginia Department of Environmental Quality - Waste Division (VDEQ-WD) in accordance with 9 VAC 20-60-570.

A. WASTE MANAGEMENT UNIT INFORMATION

UNIT NAME: Hazardous Waste Management Unit 7 (HWMU-7)
OWNER/OPERATOR: United States Army / Alliant TechSystems, Inc.

UNIT LOCATION: Radford AAP Main Plant Area, Radford, Virginia

CLASS: Hazardous Waste Management Unit
TYPE: Closed Holding and Neutralization Basin

B. GROUNDWATER MONITORING PLAN

MONITORING NETWORK
UPGRADIENT WELL: 7W12B
DOWNGRADIENT WELLS: 7MW5, 7MW6, 7WCA, 7W9C, 7W10B, 7W10C, 7W11B, 7W13
OBSERVATION WELLS: S7W9, 7W10, 7W11
(static water level measurements only)

MONITORING STATUS: Groundwater Quality Assessment Program

DATA COLLECTION STATUS:

Quarterly Event	March 12, 1999
Quarterly Event	May 25-26, 1999
Quarterly Event	July 20, 1999
Quarterly Event	December 13, 1999

C. GROUNDWATER MOVEMENT

The monitoring wells at HWMU-7 are screened entirely within either alluvium, weathered carbonate bedrock residuum or carbonate bedrock, or across the interfaces between two of the listed strata. The static water level measurements gathered during the 1999 quarterly monitoring events are summarized in **Table 1** (**Appendix A**). Groundwater fluctuations did not appear to exceed 1 to 2 feet annually, although individual wells tapping karst conduits could have experienced dramatic fluctuations following storm events. As shown on the HWMU-7 Potentiometric Surface Map for Fourth Quarter 1999 (**Appendix B**), groundwater movement

beneath the site is generally to the west towards the New River and to the northeast and southwest toward the unnamed intermittent drainages that flow into the New River north and south of the site.

For the purposes of this report, Darcian flow conditions were assumed for the alluvium, residuum, and karst carbonate bedrock beneath HWMU-7. As a result, the groundwater velocities were calculated by multiplying the hydraulic conductivity (determined from previously conducted slug tests) by the average hydraulic gradient across the site, and dividing by an assumed effective porosity for the aquifer materials. The average hydraulic gradient was determined by superimposing three evenly spaced flow line vectors over the Potentiometric Surface Map, measuring their lengths, calculating the head differential over the distances measured, and dividing the head differential by the length of the flow line vectors. The three calculated gradients were then averaged to a single value. Using this method, the average groundwater hydraulic gradient across the site based on Fourth Quarter 1999 groundwater elevations was calculated to be 0.015 ft/ft. Historical slug test data for the site yielded an average hydraulic conductivity of 5.1×10^{-6} ft/second. This value is consistent with literature values for karst carbonate rock and for clayey, silty sand and gravel alluvium and residuum (Domenico and Schwartz, 1990).

The estimated groundwater velocity across the site was calculated to be approximately 1.65×10^{-2} ft/day or 6 ft/year, based on the following:

- an average hydraulic conductivity of 5.1×10^{-6} ft/second;
- an average hydraulic gradient of 0.015 ft/ft; and
- an assumed effective porosity of 0.40, based on a representative range of porosities for karst carbonate rock, weathered residuum, and clayey, silty sand and gravel alluvium (Domenico and Schwartz, 1990).

The actual groundwater flow velocities in the carbonate bedrock may vary as much as one to two orders of magnitude from the velocity presented above, depending on water level conditions and the distribution of karst conduits.

D. STATISTICAL EVALUATIONS

D.1 HWMU-7 GROUNDWATER BACKGROUND CONCENTRATIONS

Background concentrations were calculated for each constituent in the groundwater monitoring program using the 1998-1999 quarterly analytical data from upgradient well 7W12B. The background concentration calculations were based on site wide 95% confidence, 95% coverage upper prediction intervals. When adjusted for multiple comparisons of the background data, the minimum required false positive rate was approximately 1%. Therefore, a 99% confidence level (0.01 false positive rate) was used for all individual comparisons. These coverage limits were only achieved for constituent data on which parametric prediction intervals were performed. In cases where non-parametric prediction intervals were computed to determine the background levels, the confidence level and error rate were calculated based on the

number of background data points available and number of future comparisons. Because the upper control limit of a non-parametric interval cannot be adjusted for multiple comparisons and an inadequate number of background data, the number of resampling events required was adjusted to account for the high error rates inherent in those situations. No confidence levels were defined in cases where the background data were 100% non-detected; the detection limits of such constituents were used to define their respective background levels.

D.2 HWMU-7 STATISTICAL ANALYSIS

Statistical evaluations were performed for HWMU-7 as specified in VHWMR 9 VAC 20-60-570. The statistical evaluations were performed in accordance with the procedures and guidance provided in the following documents:

- Virginia Hazardous Waste Management Regulations, 9 VAC 20-60-790 H and I;
- VDEQ Guidance for statistical analysis titled "Data Analysis Plan," undated;
- Interim Final Guidance for Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, USEPA, April 1989;
- Addendum to Interim Final Guidance for Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, USEPA, July 1992; and
- Statistical Methods for Groundwater Monitoring, Gibbons, R.D., 1994.

Statistical threshold values were computed for the 22 constituents for which HWMU-7 is currently monitored based on the concentrations of those constituents in upgradient (background) well 7W12B. The 1998-1999 quarterly monitoring data for well 7W12B were used for this purpose. Comparison statistical analyses were performed for all constituents which were detected in any downgradient well during Fourth Quarter 1999. Downgradient wells 7MW5 and 7MW6 were not sampled during Fourth Quarter 1999; therefore, comparison statistical analyses were performed for all constituents which were detected in wells 7MW5 and 7MW6 during Third Quarter 1999.

D.2.1 Background Data and Statistical Comparisons

Statistical analyses were performed using the 1998-1999 quarterly analytical results from upgradient well 7W12B as background data. Based on the percentage of non-detects and the distribution of the background data, methods of statistical comparisons varied. Background average, standard deviation and other descriptive statistical data were computed for all constituents and are presented in **Appendix C**.

The constituents listed below were 100% non-detected in the background data. The background threshold levels (BTLs) for these constituents were established as equal to their detection limits (DLs). Detections of these constituents in the downgradient wells during Fourth Quarter 1999 (Third Quarter 1999 for wells 7MW5 and 7MW6) were compared to these BTLs.

Background Threshold Level (BTL) = Detection Limit (DL)				
Parameter	**Sample Size**	**% Non-Detects**	**DL (µg/l)**	**BTL (µg/l)**
Antimony	8	100	3	3
Mercury	8	100	0.2	0.2
Thallium	8	100	1	1
Cyanide	8	100	10	10
2,4-Dinitrotoluene	8	100	0.08	0.08
Benzyl alcohol	8	100	10	10
Butylbenzylphthalate	8	100	5	5
2,4-Dinitrophenol	8	100	50	50
2-Nitrophenol	8	100	5	5
4-Nitrophenol	8	100	10	10

Non-parametric prediction intervals were computed for all of the constituents for which the data from background well 7W12B satisfied one of the following two criteria, per VDEQ regulations and guidance as well as USEPA guidance:

- Percentage of non-detects was greater than or equal to 50 and less than 100; or
- Percentage of non-detects was less than 50, but data was not normally distributed.

Non-parametric upper prediction limits (UPL) were computed for 11 constituents which met one of the above two criteria. The background threshold levels for these constituents were set as equal to their UPLs, with one exception. For pH, a two-sided nonparametric prediction interval was computed; therefore, the BTL for pH consisted of a range between the lower prediction limit (LPL) and the upper prediction limit. The confidence level and false positive rate were calculated based on the number of background data points available and number of future comparisons. For all constituents, the confidence level was determined to be equal to 0.864, and the false positive rate was equal to 0.136. Since the upper control limit of a non-parametric interval cannot be adjusted for multiple comparisons and inadequate number of background data, the number of resampling events required was adjusted to account for the high error rates inherent in those situations. The number of confirmation resamples required for all constituents is 2. The background and relevant statistical data for these constituents are summarized below. Associated statistical computations are presented in **Appendix C**.

BTL = Upper Prediction Limit of Non-parametric Prediction Interval w/false positive rate=0.136 BTL for pH = LPL – UPL of two-sided Prediction Interval				
Parameter	**Sample Size**	**% Non-Detects**	**DL (µg/l)**	**BTL (µg/l)**
Arsenic	8	75	1	1
Barium	8	0	2	61
Cadmium	8	88	0.1	0.2
Lead	8	75	1	14
Nickel	8	88	15	18
Selenium	8	88	1	1
Silver	8	88	0.2	1.2
2,6-Dinitrotoluene	8	75	0.08	0.15
Bis(2-ethylhexyl)phthalate	8	75	10	67
Specific Conductivity	8	0	1 µS/cm	7020 µS/cm
pH	8	0	0.1 pH units	5.2 to 7.1 pH units

The constituent chromium exhibited normally distributed background data with less than 25% non-detects. A one sided parametric prediction interval was computed on the background data for this constituent. The UPL for this constituent was set as the BTL. The background concentration calculations were based on a site wide 95% confidence, 95% coverage upper prediction intervals. When adjusted for multiple comparisons of the background data, the minimum required false positive rate was less than 1% (0.01). A 99% confidence level (0.01 false positive rate) was used for all individual comparisons, which with the most conservative assumptions provided a site-wide false positive rate of <0.05. The background and relevant statistical data for this constituent are summarized below. The prediction interval computations for this constituent are presented in **Appendix C**.

BTL = UPL of one-sided Prediction Interval (exception pH) w/site-wide false positive rate<0.05 (individual comparisons false positive rate=0.01) BTL for pH = LPL – UPL of two-sided Prediction Interval				
Parameter	**Sample Size**	**% Non-Detects**	**DL (µg/l)**	**BTL (µg/l)**
Chromium	8	0	1	15.1.5

D.2.2 Results of Statistical Comparisons

The following table lists the constituents which were detected during the Fourth Quarter 1999 event (Third Quarter 1999 event for wells 7MW5 and 7MW6) at concentrations exceeding their respective background threshold levels (BTLs), and the downgradient wells in which they were detected.

Parameter	Monitoring Well(s)
Arsenic	7W13
Barium	7W10B
Nickel	7WCA
pH	7MW5, 7MW6, 7W10C, 7W13

Any HWMU-7 target constituents not listed above were not detected in the downgradient monitoring wells at concentrations exceeding their respective BTLs.

APPENDIX A

TABLES

APPENDIX B

FIGURES

APPENDIX C

HWMU-7 STATISTICAL ANALYSIS RESULTS